

NEW ZEALAND  
JOURNAL OF FORESTRY SCIENCE

New Zealand Forest Service,  
Forest Research Institute, Rotorua

*Editor: J. B. Lowry*

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VOLUME 8

NOVEMBER 1978

NUMBER 2

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RECRUITMENT, GROWTH AND SURVIVAL OF RIMU  
SEEDLINGS IN SELECTIVELY LOGGED TERRACE  
RIMU FOREST

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ABSTRACT

A study of regeneration of rimu following selection logging of terrace rimu forest showed best recruitment on sites which had moderate to severe soil disturbance. Dense fern and hardwood regrowth limited both rimu regeneration and growth rates after 4 years. Average growth rates of seedlings established early after logging was 6 cm/annum.

INTRODUCTION

Studies of yield predictions for a Westland terrace rimu forest under selection management have indicated that timber yields beyond the second harvesting will depend greatly upon the success of recruitment obtained after the first harvesting (James and Franklin, 1977). The recruitment is needed not only to replace harvested trees but also to transform the unbalanced tree size distribution, which is typical of virgin stands, into the characteristic negative exponential distribution of a managed selection forest. Just how much recruitment is needed will depend upon the growth, survival, and harvesting rates of rimu throughout a full rotation.

This paper provides some estimates of recruitment, early growth and survival of rimu seedlings after selective logging in two stands of high volume terrace rimu forest. The first stand (0.5 ha), in Wanganui State Forest adjacent to a site described previously (James and Franklin, 1977) contained a volume of 259 m<sup>3</sup>/ha of which

65 m<sup>3</sup>/ha was harvested in April 1966. The other stand (2 ha) is 17 km further north-east in Ianthe State Forest and had a volume of 357 m<sup>3</sup>/ha before 116 m<sup>3</sup>/ha was harvested in 1969. Both areas were scarified by a small crawler tractor before harvesting to increase the area of disturbed ground.

### METHODS

In both stands, transects were placed at regular 20 m intervals across the direction of logging and subdivided into contiguous 40 × 40 cm plots. Immediately after harvesting each plot was recorded as having one of the following ground conditions:

- A. Undisturbed ground.
- B. Lightly disturbed ground with scattered ground vegetation and live roots still present in the humus.
- C. Pure humus, free of ground vegetation and with no live roots.
- D. Thoroughly mixed humus and mineral soil with no ground vegetation or live roots.
- E. Areas of dense slash, standing trees, logs, or ground under water either permanently or for long periods.

The transects were then used to estimate the density of recruitment by counting the numbers of rimu and other podocarp seedlings present at 3, 5, and 10 years after harvesting at Wanganui and 3, and 5 years at Ianthe.

In August 1966, six plots each 8 m<sup>2</sup> were placed in the Wanganui stand; two plots on undisturbed ground cleared of shrubby vegetation, two on disturbed ground consisting of a mixture of litter, humus, and reddish brown A<sub>11</sub> and A<sub>12g</sub> horizon soil, and two on extraction tracks consisting of thoroughly mixed G<sub>1</sub> and G<sub>2</sub> horizon grey-blue mineral soil.

Because the stand was harvested too late to benefit from the peak of the 1966 seedfall, each quadrat was sown with 225 g of semi-clean unstratified rimu seed which had been collected from the same area the previous March. For the next six years rimu seedlings under one year old were counted and marked with coloured plastic sticks and the fate of older seedlings was recorded. In June 1972 and in August 1976 the heights of all seedlings were measured to the nearest centimetre.

A similar study was initiated in 1970 in the Ianthe stand after logging. A total of 70 quadrats, each 0.28 m<sup>2</sup>, were established in pairs in association with 35 seed trays also of 0.28 m<sup>2</sup> area (design follows Beveridge, 1965). The quadrats encompassed the same three soil conditions as the 8 m<sup>2</sup> Wanganui plots and also full, partial, and open shade conditions. Unfortunately, the data proved insufficient to compare both the shade and ground stratifications. Once again seedlings were located and permanently marked for five subsequent years.

## RESULTS AND DISCUSSION

### (a) *Seedfall and Recruitment*

Annual records of rimu seedfall collected at Glasses' Road, Wanganui State Forest (3 km from the Wanganui Experimental Area; Fig. 1) show a strong cyclic pattern of 1-2 poor seed years alternating with 2-3 good years (Franklin, 1968). There had been two good years in 1965 and 1966 prior to the harvesting of the Wanganui stand but

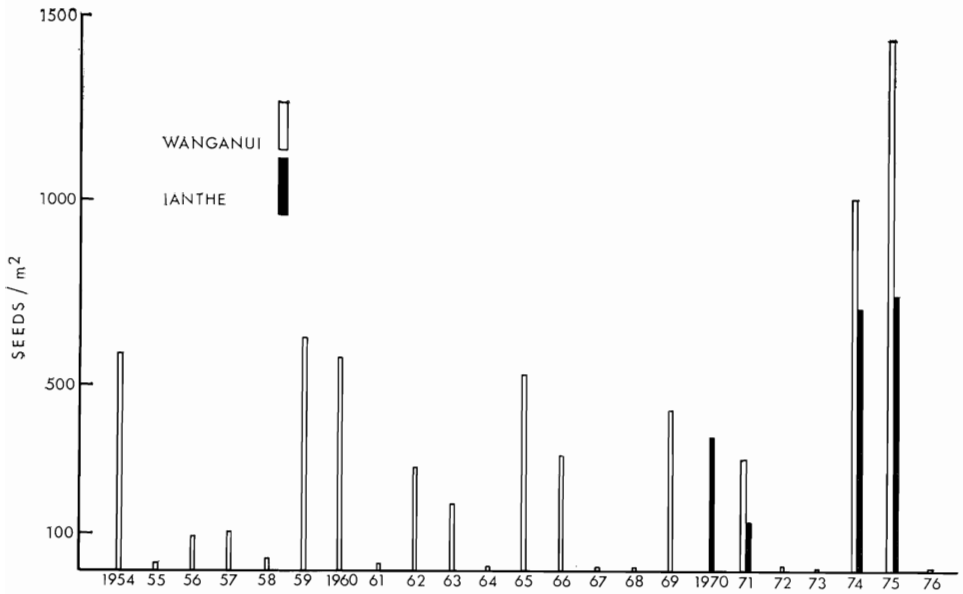


FIG. 1—Annual rimu seedfall at Wanganui and Ianthe State Forests.

unfortunately the peak of the 1966 seedfall had passed when harvesting was complete. Two poor seed years then followed so that the stand did not receive a plentiful seed source until 1969.

Despite this, the transect data show good recruitment of rimu seedlings in August 1969 (11 300 seedlings/ha). Most seedlings were found in either pure humus or mixed mineral soil (Table 1). In 1971, after two further good seed years, the number of rimu seedlings had increased (14 400 seedlings/ha) and again most were found on well disturbed ground. By 1976 mortality outweighed recruitment as seedling densities had declined to 9200 seedlings/ha.

The Ianthe stand was logged one month prior to a good seed year (1969) and had two further good seed years in 1970 and 1971. Three years after harvesting the number of rimu seedlings was 6400 seedlings/ha (Table 1). Once again rimu seedlings were the most abundant on mixed mineral soil and to a lesser extent on pure humus. By 1975 numbers had declined to 4700 seedlings/ha after two poor seed years.

On both the Wanganui and Ianthe areas the numbers of other podocarp species increased at each assessment after harvesting. Silver pine (*Dacrydium colensoi*) were found mainly on undisturbed and lightly disturbed ground whereas miro (*Podocarpus ferrugineus*) and kahikatea (*Dacrycarpus dacrydioides*) were more evenly distributed but at low densities.

Results of the annual assessments of marked seedlings show in more detail the relationship between recruitment and seedfall for the first five years after harvesting (Fig. 2). Recruitment rates at Ianthe were initially high following two good seed years in 1969 and 1970 but then remained relatively constant for three years despite two poor and one good seed year. At Wanganui, recruitment bore little relationship to seedfall

TABLE 1—Density of podocarp seedlings (seedlings/ha) in experimental areas

Species	Year	Ground conditions					Mean
		A	B	C	D	E	
a. In Wanganui State Forest (0.5-ha stand)							
Rimu	1969	2,860	12,360	21,600	18,220	850	11,310
	1971	5,710	7,150	29,990	23,760	2,540	14,410
	1976	4,640	5,200	18,600	13,860	2,540	9,260
Other Podocarps	1969	6,780	3,250	6,600	2,380	—	2,640
	1971	7,140	4,550	6,600	3,170	—	4,740
	1976	7,140	7,800	7,800	13,070	13,560	9,680
No. Plots		173	95	103	156	73	
b. In Ianthe State Forest (2-ha stand)							
Rimu	1972	1,510	1,760	3,920	21,290	2,590	6,490
	1975	3,170	4,270	5,320	8,910	1,300	4,790
Other Podocarps	1972	1,610	980	2,740	860	3,890	1,500
	1975	2,720	1,760	2,490	960	1,300	2,100
No. Plots		1,187	246	347	577	143	

A, undisturbed; B, lightly disturbed; C, pure humus; D, mixed mineral soil; E, slash and water-logged (see text).

Other podocarps: silver pine, kahikatea and miro.

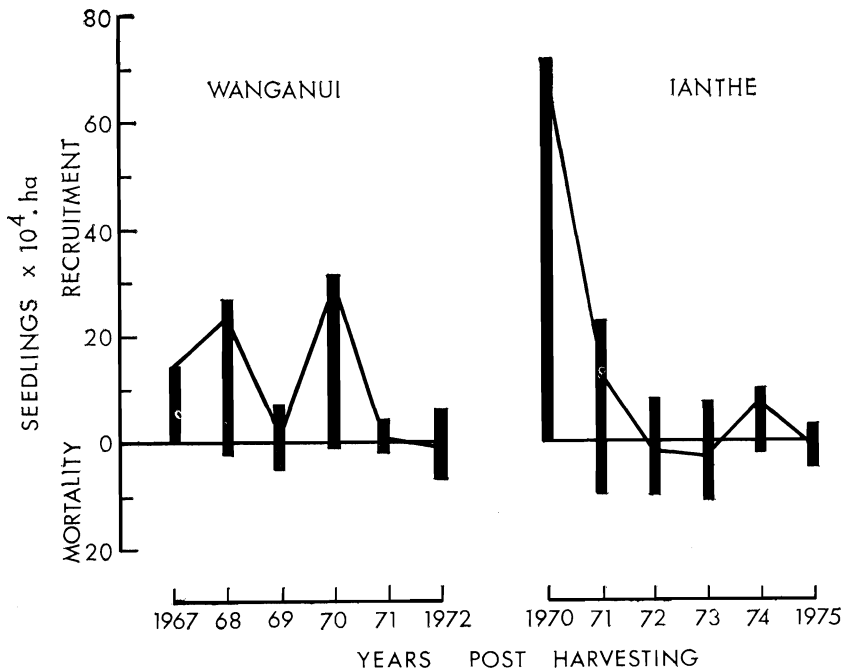


FIG. 2—Recruitment and mortality for marked seedlings; continuous line represents annual net gain or loss.

for the two years after the 1967 sowing, but then responded to the 1969 seedfall. It would appear from the first three years' data at Wanganui that some rimu seed could have remained dormant in the forest litter for one or possibly even two years after seedfall, although small quantities of seed fell even in poor years.

The mortality rate of rimu seedlings (i.e., the proportion of seedlings of age  $t$  which do not survive, to age  $t + 1$  years) varied between 2-15% in both stands (Fig. 3). This

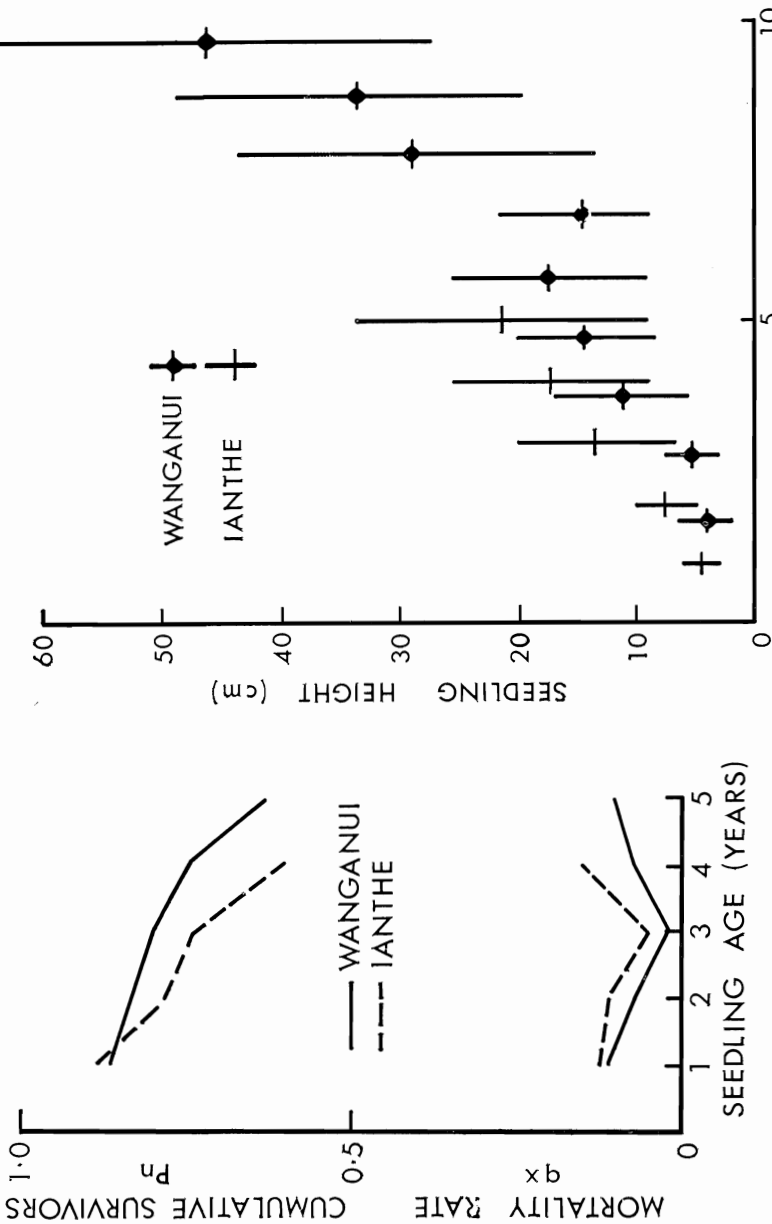


FIG. 3—Annual mortality rate and cumulative survival of rimu seedlings at Wanganui and Ianthe study areas.

FIG. 4—Height growth of rimu seedlings at Wanganui and Ianthe study areas.

meant that between 55-60% of one-year-old seedlings survived five years. Survival of Wanganui seedlings after ten years was 50% indicating that the mortality rate fell to 1-2% in the second five-year period.

The difference in height growth of seedlings between the two areas was not significant (Fig. 4). In both areas the mean height of five year old rimu seedlings varied between 15-23 cm but well grown seedlings were 30-40 cm high. Only vigorous specimens were above the dense regrowth of fern and hardwoods.

Growth from 6-10 years was calculated from measurements in the Wanganui stand in 1976. The apparent negative growth in seven years is a reflection that seedlings recruited three years after logging were shorter at age 7 than seedlings recruited one year after logging were at age 6. The 10-year-old seedlings had a mean height of 46-cm with the better seedlings reaching 60-70 cm. Although there was insufficient data to make a valid comparison, it appears from observation that height growth is much greater on disturbed rather than undisturbed ground.

### CONCLUSIONS

A moderate degree of soil disturbance is necessary to obtain good recruitment of rimu seedlings. In the two stands studied approximately 40% of the area had moderate to severe disturbance from scarification and harvesting. As a result the densities of seedlings are high. There are sufficient seedlings present at Wanganui to tolerate mortality rates up to 3% annually and still provide over 1000 stems into the 10 cm d.b.h. size class in 90 years hence.

On all logged areas there was a dense regrowth of *Blechnum discolor*, *B. capense*, *Dicksonia lanata*, *D. squarrosa*, *Histiopteris incisa*, *Weinmannia racemosa*, *Quintinia acutifolia*, *Cyathea colensoi*, and *Paesea scaberula*. The lightly disturbed ground was recolonised first but by 3-4 years there was little bare ground remaining anywhere in the stands. The regrowth begins to limit rimu recruitment after four years and appears to limit height growth of seedlings which appear three or more years after harvesting.

It can be reasonably expected that mortality rates will be greatest during the first 10 years while seedlings are competing with fern and hardwood regrowth. Once seedlings extend through the regrowth mortality should decline at least below 1% and height growth should increase beyond 6 cm/year. The better 10-year-old seedlings now extend above the fern and hardwood regrowth, and have no further overhead competition apart from the canopy of the main stands. In virgin stands rimu seedlings have to compete with a number of vegetation tiers, and may take over 100 years to extend 4-5 m through the hardwood canopy. If the 10 year old seedlings continue at their present height growth of 6 cm/year they should be 6-7 m high at 100 years.

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