PRELIMINARY RESULTS ON THE EFFECTS OF SELECTION MANAGEMENT OF TERRACE RIMU FOREST

I. L. JAMES and D. A. FRANKLIN
Forest Research Institute, New Zealand Forest Service, Christchurch

(Received for publication 29 September 1977)

ABSTRACT

In a 2.5-ha area of terrace rimu forest 10 years after the first selection logging, tree losses through windthrow and other causes accounted for 4.4 m^3/ha/annum or 72% of gross increment. Regeneration of rimu at 308 stems/ha was sufficient for stand replacement so long as survival and growth rates are good. Growth of remaining crop trees increased by 11% in response to logging but mortality reduced the net annual increment to 1.69 m^3/ha. If growth and mortality continue at these rates it will require 62 years before the stand volume returns to pre-logging level.

INTRODUCTION

The terrace rimu forests of South Westland have been under sustained yield management since 1956. The first silvicultural system adopted, strip felling, involved clear-cutting alternate 80 × 800 m strips; the width of strips being determined from the effective spread of rimu seed from parent trees. Strip felling was abandoned in the mid-1960s mainly because regeneration in the felled areas was not as good as anticipated.

It was then decided to manage the terrace rimu forests by the selection system. The objectives were to "convert to normality" in four felling cycles over 120 years by removing individual trees or groups of trees over the whole forest area. One quarter of the stand volume was to be harvested initially, concentrating on large and malformed trees (Chavasse and Travers, 1966). The volume to be removed on subsequent felling cycles was not determined but it was calculated that the time required to replace an economic logging volume of 70 m^3/ha was forty to fifty years (Gover, 1972).

In 1966 a number of trial areas were established to measure the effects of selection logging. This paper summarises the results from one area of 2.5 ha in Wanganui State Forest, 10 years after the first logging.

METHODS

Within a 2.5-ha area of Wanganui State Forest every tree was identified and permanently marked. Records were made of diameter at 1.5 m (d.b.h.), location, height to 1st green branch, top height, crown density, and dominance. Within a 0.24-ha area, referred to later as Transect B, increment cores were taken from all trees to determine net diameter increment of the virgin stand. All trees were relocated and remeasured immediately after logging and at 3, 5 and 10 years after logging.

The Trial Area

The trial area is 8 km from the sea coast and 1.5 km from the Poeroa River on a terrace at 50 m altitude (Fig. 1). The soils are classified as Harihari recent gley soils. They are grey-brown, mottled, silty loams with little structure apart from a weak crumb formation on the A11 horizon. Otirian outwash gravels underlie these soils at a depth of 50-100 cm. Annual rainfall at Harihari is 3936 mm.

The virgin forest of the trial area is dominated by rimu (*Dacrydium cupressinum* Lamb.), with lesser numbers of silver pine (*Dacrydium colensoi* Hook.), miro (*Podocarpus ferrugineus* G. Benn. ex D. Don.), kahikatea (*Dacrycarpus dacrydioides* (A. Rich) de Laub.), *Weinmannia racemosa* Linn. f., *Quintinnia acutifolia* Kirk, and *Pseudopanax colensoi* (Hook. f.) Philipson. The understorey is a dense mixture of thickets of *Weinmannia racemosa, Quintinia acutifolia, Neomyrtus pedunculata* (Hook. f.) Allan, *Cyathea colensoi (Hook.* f.) Domin, *Dicksonia squarrosa* (Forst. f.) Swartz, *Dicksonia lanata* Col.,

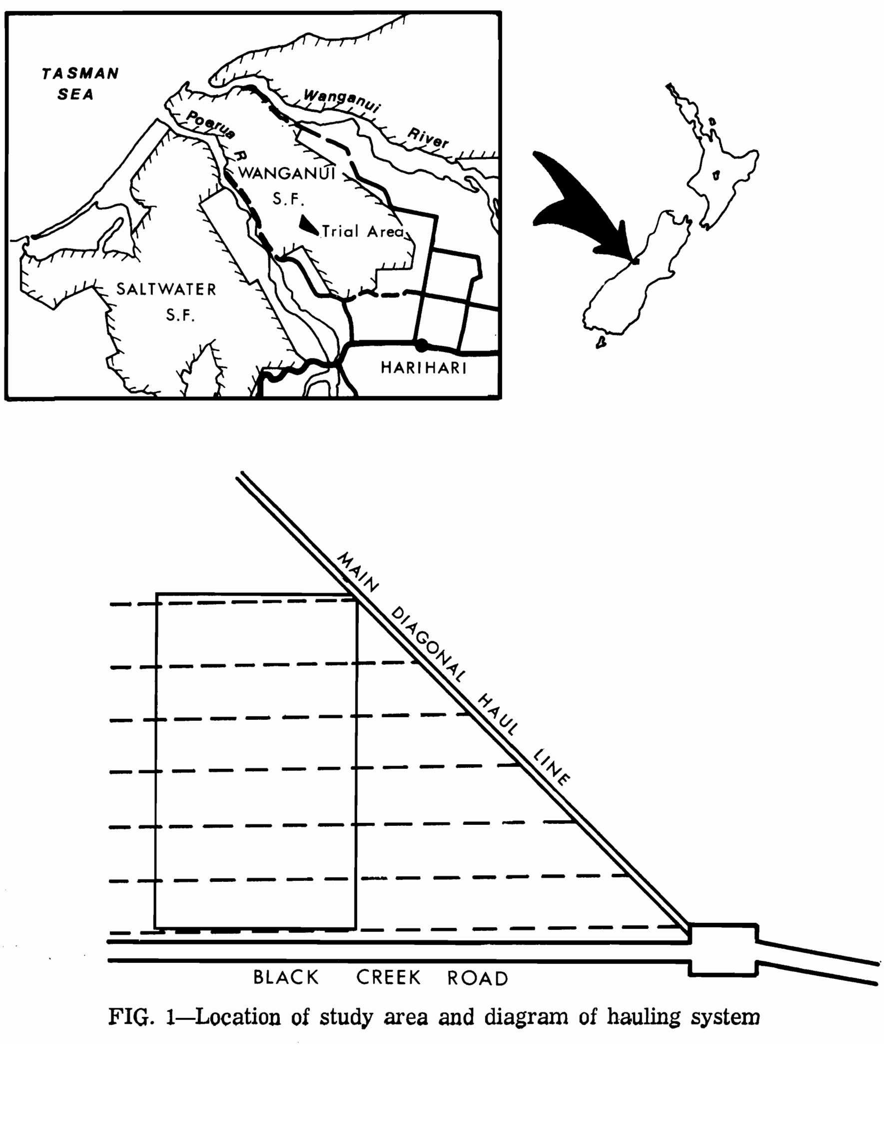

FIG. 1—Location of study area and diagram of hauling system

Griselinia littoralis Raoul, *Histiopteris incisa* (Thunb.) J. Smith, *Blechnum capense* (L.) Schlecht and *Blechnum discolor* (Forst. f.) Keys.

This forest is classified from National Forest Survey data as P1 (high-volume podocarp terrace forest on seaward morainic slopes) but it is just adjacent to a lower hill slope of P3 (more variable high-volume podocarp forest of lower hills and terraces) (Chavasse, 1962). It contains higher volumes of podocarps than the National Forest Survey estimate of 307 m^3/ha for the 286 ha of P1 forest in Wanganui State Forest (Table 1) (Mt Hercules Working Plan). However, there are difficulties in making direct comparisons because of mensurational differences. The National Forest Survey data were calculated from the 1952 Universal Rimu Volume Table (Duff, 1952) for stems greater than 30 cm d.b.h. making adjustments for flanges and rot. The trial data are derived from the 1965 Westland one-dimension rimu volume table (Duff and Burstall, 1965) using all stems greater than 10 cm d.b.h. No adjustments for poor form were made. The latter system has been found to provide a better estimate of extracted volumes (Franklin, 1971).

TABLE 1—Merchantable composition of the virgin stand. Includes all stems greater than 2.5 cm d.b.h.

Species	Density (stems/ha)	Mean Diameter cm	Basal Area m^2/ha	Volume m^3/ha
Rimu	377.4	37.8	47.3	487
Miro	52.9	32.0	3.2	32
Kahikatea	9.5	24.1	0.3	3
Silver pine	3.3	19.6	0.1	—
Total	443.3	37.0	50.9	523

The net mean annual volume increment for the period 1915-65 (4.14 m^3/ha) was determined from increment cores of 111 trees in Transect B. This growth rate is much higher than recorded for P1 forest in Ianthe State Forest (1.50 ± .05 m^3/ha; Franklin, 1973), and for the Canterbury University Plots in Mahinapua State Forest (1.88 m^3/ha; Chavasse, 1960).

The stem diameter distribution (Fig. 2) has a skewed distribution with a mode near 40 cm and mean of 35 cm d.b.h. The excess of stems in the larger size classes is a well-recognised characteristic of virgin stands (Troup, 1928) and is not necessarily a reflection of regenerative ability. With a differential for growth and mortality rates between the small and large tree sizes such apparently unbalanced distribution may represent a stable forest structure. The transformation of such a stand into a managed selection forest requires careful intervention in order to increase the stock of small stems at the same time as the proportion of larger stems is reduced by harvesting.

First Harvesting

The trial area of 2.5 ha was included in an approximately 15-ha area logged by ground hauler in April-May 1966. A bull-block was used to produce a herringbone hauling pattern so that all extraction lines within the trial area ran parallel NE-SW and were 30 m apart (Fig. 1). Before logging the extraction lines were cut by staff of

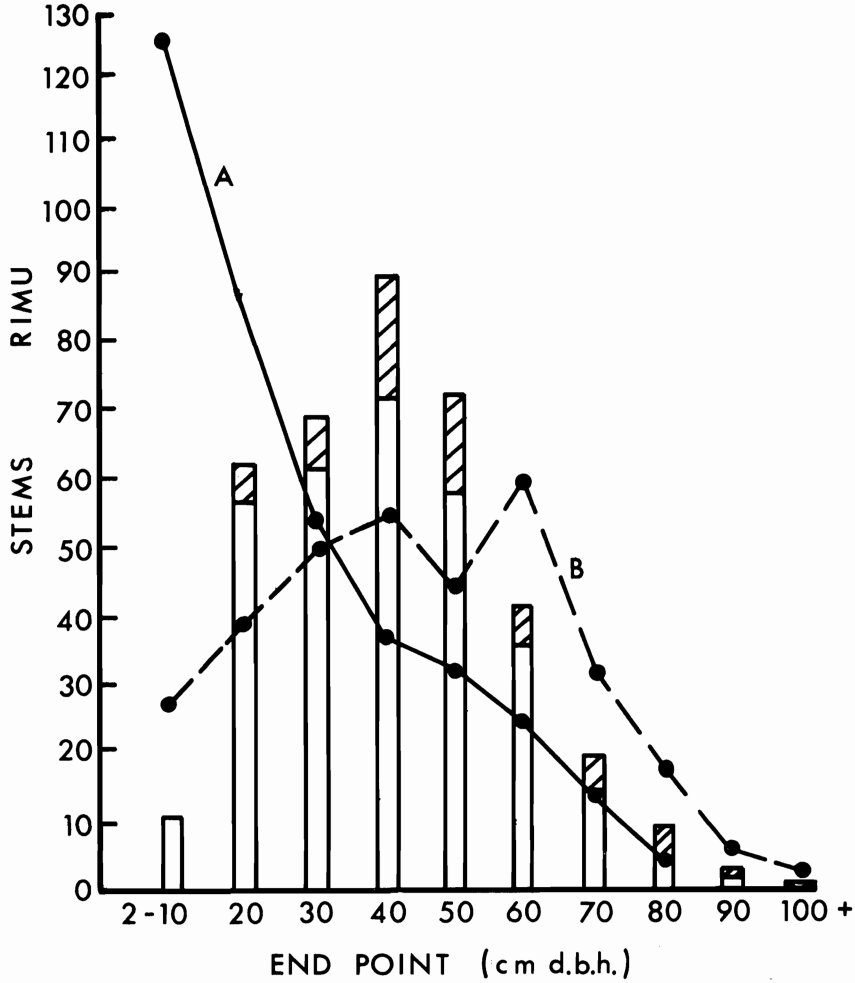

FIG. 2—Rimu size distribution (stems/ha by diameter class) before and after harvesting (hatched region). Curves A and B give data from two other stands (Franklin, 1971) for comparison.

Westland Conservancy and the trees to be harvested were marked by staff of the Forest Research Institute.

The first trees marked for removal were those with limited chance of survival to the next felling cycle due to bad lean, broken crowns, or rot defect. Slower growing trees then were marked within the area of Transect B using increment core data. Over the remainder of the area trees which appeared to have poor vigour on the basis of small crowns, lack of crown freedom, and open scraggy crowns (Chavasse and Travers. 1966) were marked for removal (Franklin, 1965). Finally, the required extraction volumes (25% of virgin volume) were completed by thinning trees of all merchantable sizes from dense patches.

During logging the extraction lines were unfortunately shifted slightly. As a consequence 22.7 m^3/ha of the volume removed comprised unmarked trees. This was in part compensated for by the logging gangs leaving 15.6 m^3/ha of marked trees behind. Nonetheless, the efficiency of selection suffered.

An assessment after logging showed that 7% (5.9 stems/ha) of remaining trees had been damaged by either side-swipe debarking, root damage along extraction lines, or crown damage. Smaller trees and poles were more frequently damaged than larger trees (Franklin, 1969).

Despite the constraints of hauler logging the final pattern came very close to that of individual tree selection. A higher proportion of trees was removed in the vicinity of extraction lines because of physical damage, but nevertheless there were few gaps wider than 20 m within the trial area. Larger gaps occurred at the junction of the parallel extraction lines with the four main-axis extraction lines. These were caused by changing the haul direction at the bull-blocks.

The total volume removed was 122 m^3/ha which constituted 23% of the virgin volume (Table 2). In terms of numbers of trees, 19% of rimu less than 50 cm d.b.h. and 24% of larger rimu were either harvested or destroyed. Of the minor species, 14% of the miro and 17% of kahikatea trees were removed. It was not possible to harvest more of the larger rimu in the first logging without exceeding the allowable cut or causing excessive forest openings. Now that the poorer quality trees have been removed it is expected that the next felling cycle should allow greater harvesting of larger trees.

RESULTS

Mortality

Tree losses in the plot for the 10 years since harvesting amounted to 39 rimu, 1 kahikatea, and 5 miro. The volume lost was 44.4 m^3/ha/10 years or 11% of the residual volume after logging, and 72% of the gross increment (Table 2). Losses in the first 5 years approximately equalled those for the second period. Small poles and large

TABLE 2—Summary of volume data (m^3/ha) for the 10 years following logging

	Species				
	Rimu	Miro	Kahikatea	Silver pine	Total
Total volume before logging	487.7	32.3	3.3	0.4	523.8
Destroyed or removed by logging	114.5	7.5	0.8	0.1	122.5
As % of original	23%	22%	24%	25%	23%
Volume remaining after logging 1966	373.2	25.2	2.5	0.3	401.3
Windthrow 1966-76	31.4	0.8	—	—	32.2
Standing deaths 1966-76	10.0	2.1	0.1	—	12.2
Total mortality 1966-76	41.4	2.9	0.1	—	44.4
As % of post-logging volume	11%	11%	4%		11%
Volume 1976	388.9	26.1	2.7	0.4	418.2
Gross annual increment 1966-76	5.71	0.38	0.03	0.01	6.13
Net annual increment 1966-76	1.57	0.09	0.02	0.01	1.69

trees had the highest mortality rates (Fig. 3). Approximately one-third of trees that died had some form of logging damage such as debarking, crown breakage, or severe root disturbance.

The trees that died were classified into windthrow (those uprooted or with bole of living tree snapped) (20 trees) and those either standing dead or collapsed (25 trees).

Windthrow trees were mainly co-dominant trees in the larger size classes (Fig. 3). Although the sample size is small, there is a tendency for the direction of fall to be away from either N or SE (Fig. 4). The SE wind is known locally as the "gorger" and is somewhat similar in velocity and gustiness to the "nor'wester" of Canterbury.

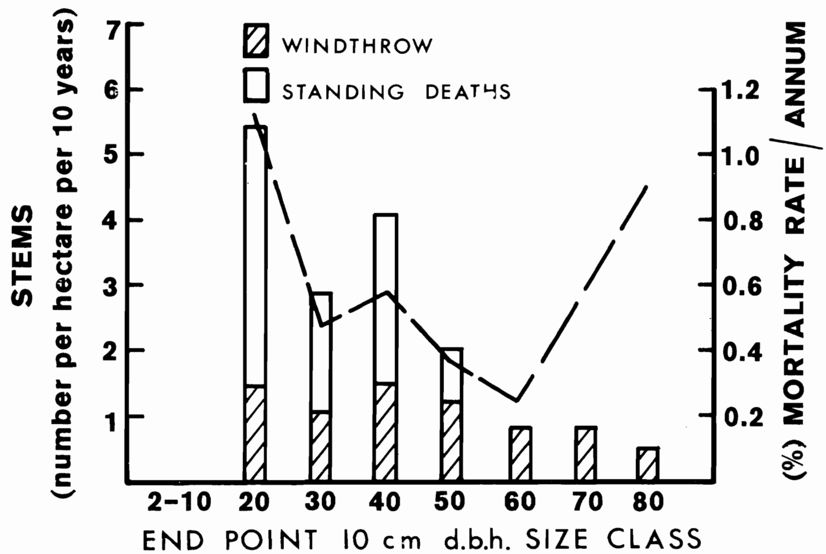

FIG. 3—Size distribution and mortality rate of rimu losses, in the 10 years since harvesting.

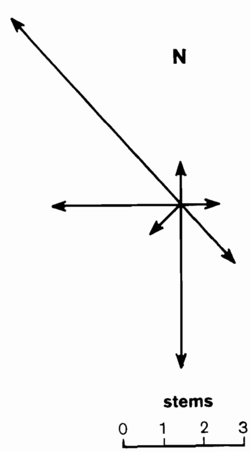

FIG. 4—Direction of fall of windthrown trees.

The trees that either collapsed or died standing were mainly suppressed or sub-dominants (84%). The remaining 16% were co-dominants which had all suffered logging damage.

Recruitment

There was a heavy seedfall in the autumn preceding harvest. but little seed fell in 1967 and 1968 (Franklin, 1968). However, there were heavy seedfalls in 1969, 1970 and 1971, but by this time a fern ground cover had established on disturbed sites.

In 1976 the density and percentage stocking of all podocarp seedlings between 10 cm high and 1 cm d.b.h. were assessed. Six belt transects of 1 × 200 m were established at regular spacing over the trial area. The number and height of podocarp seedlings were recorded in 1200 1 × 1 m plots along the transects.

The densities of rimu, miro, and silver pine seedlings were all around 300 stems/ha and the stocking of the 1 × 1 m plots was between 1-2% (Table 3). The majority of seedlings were less than 40 cm high. Rimu seedlings were most frequent in the areas disturbed by logging. Silver pine and miro seedlings, in contrast, were distributed throughout the trial area.

TABLE 3—The number, density, and percentage stocking of podocarp seedlings

Species	Seedling numbers		Density	Stocking
	10-40 cm high	40 cm high to 1 cm d.b.h.	stems/ha	%
Rimu	35	2	308	1.9
Silver pine	31	5	299	1.6
Miro	29	8	308	2.5
Kahikatea	5	2	58	0.1

Growth Rates

Over the whole trial area the mean annual diameter growth of rimu was 0.163 ± 0.091 cm and miro 0.137 ± 0.066 cm. Maximum diameter growth of rimu occurred between sizes 50-70 cm d.b.h. (Fig. 5). Two other growth functions are given in Fig. 5 (Franklin, 1973; Plot A and Plot B) from stands growing on similar sites. The three growth functions show a relationship with stand structure or stage of stand development (Fig. 2). In Franklin's Plot A, a young stand, growth is maximum between 30-50 cm. In the present stand suppression has begun to limit numbers and growth of smaller trees. Plot B, an older stand, shows more severe suppression of medium-small trees and maximum growth is not reached until trees are greater than 60 cm d.b.h. Large dominant trees have similar growth rates in all three stands.

The diameter growth of individual trees of the present stand within the area of Transect B are compared before and after logging (Fig. 6). The mean diameter increment of these trees increased from 0.165 to 0.184 cm/annum. Individual trees which responded most were generally of smaller size (less than 30 cm d.b.h.) and had poor to moderate growth rates before logging. Trees having good growth before logging on average continued to grow at similar rates after logging.

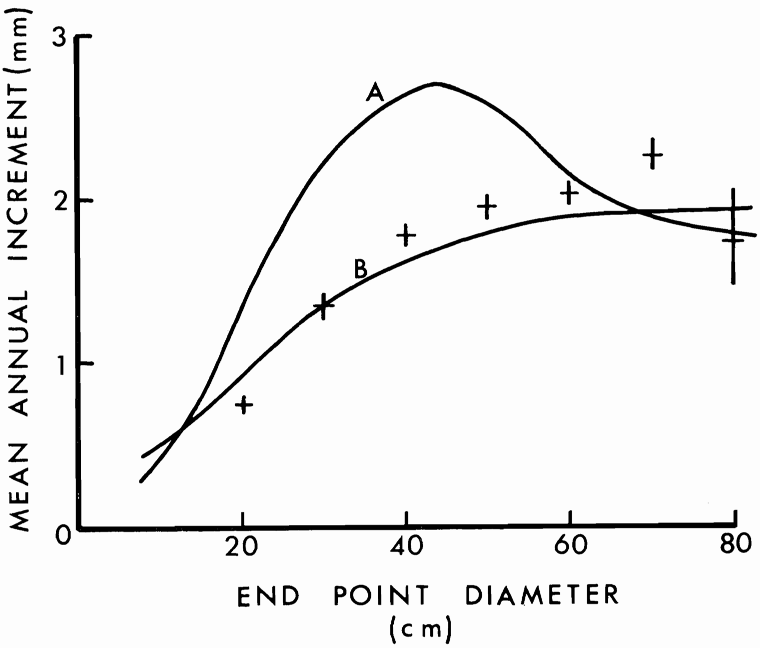

FIG. 5—Rimu diameter growth for the study area compared with Franklin's (1971) stand A and B.

The fastest growing trees (diameter growth greater than 0.3 cm/year) were distributed throughout the trial area but with a slight tendency to be more widely spaced. They were either dominants (23%) or co-dominants (71%) and were large trees with medium to dense crowns.

CONCLUSIONS

It is still too soon to judge from this study whether the selection system is a feasible silvicultural technique for similar terrace rimu forests. The main doubt is whether there is sufficient natural recruitment following harvesting. To provide a sufficient number of small trees in the stand from existing small seedlings will require optimistically high growth and survival rates. It also should be remembered that the bulk of the small seedlings on the trial area are still less than 40 cm high and have not yet emerged beyond the dense ground fern. Instead of the risky process of relying on natural regeneration after harvesting it may well be preferable to guarantee the quantity and distribution of seedlings by planting of nursery raised stock.

It is also of concern that 72% of the gross increment of the trial stand was lost to mortality, mainly windthrow. There is at present little comparative data available concerning mortality rates in virgin stands so that the exact influence of harvesting on mortality, which emphasises the need to remove all dead tress at harvesting, particularly those exposed to the SE wind. There are further possibilities of reducing windthrow

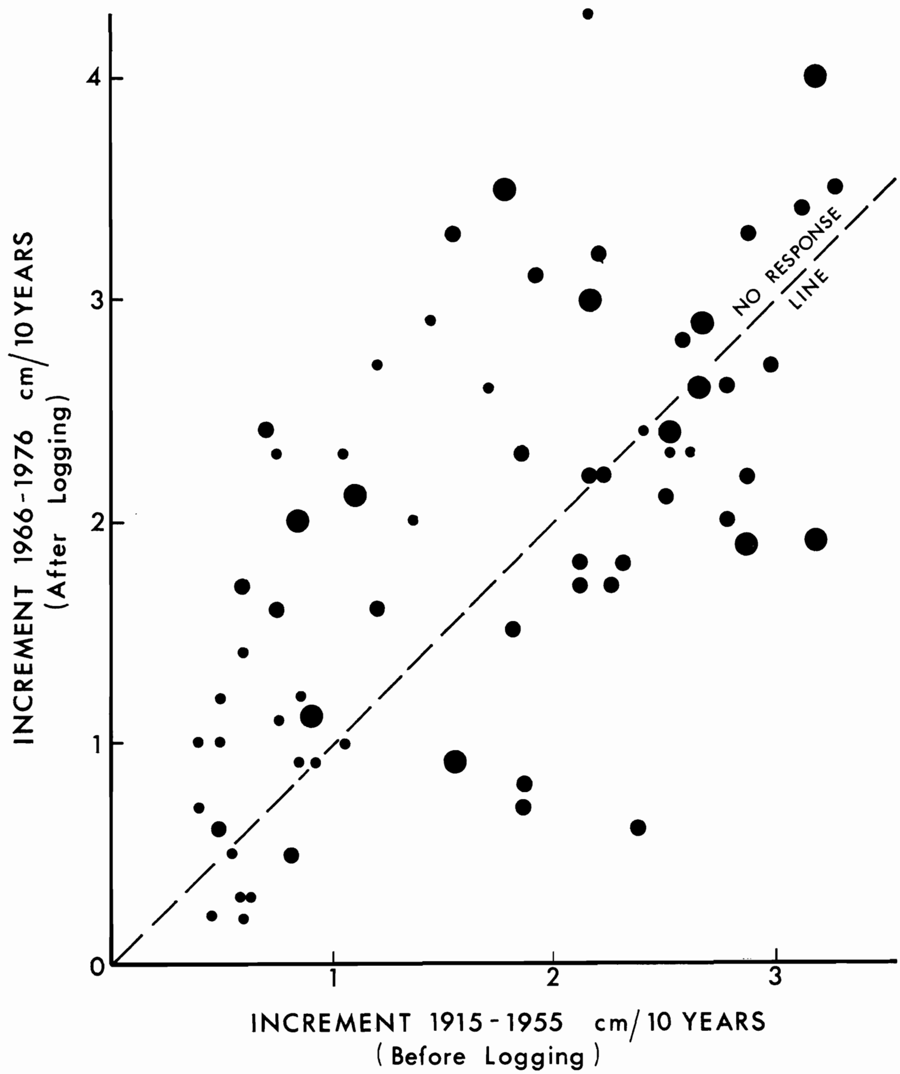

FIG. 6—Comparison of individual tree growth of rimu before and after harvesting. Trees of less than 30 cm d.b.h., 30-50 cm d.b.h., and greater than 50 cm d.b.h. respectively, are shown by symbols of increasing size.

effects through tree marking methods, and altering size and shape of felled areas at the time of harvesting, and salvage.

Ignoring windthrow, the increment of remaining trees increased by approximately 11% since logging. Despite this, a simple linear projection of volume yield using the post-logging net volume increment indicates it will be 62 years before the stand returns to pre-logging volume. Yield of the next and subsequent 40-year felling cycles therefore may not be able to continue at 25% of standing volume.

ACKNOWLEDGMENTS

The authors wish to thank the staff of the Forest Research Institute, in particular G. R. Whiteside, who have assisted over the past 10 years in the establishment and remeasurements of the Wanganui State Forest Experimental Area. Assistance has also been received from the N.Z. Forest Service officers of Westland Conservancy at Hokitika and Harihari.

REFERENCES

CHAVASSE, C. G. R. 1960: A study of vigour in rimu trees in Westland and the implications of the study for even-aged and selection forestry. **N.Z. For. Serv.,** unpubl.

——— 1962: Forests, soils, and landforms of Westland. **N.Z. For. Serv., For. Res. Inst., Information Series 43.**

CHAVASSE, C. G. R. and TRAVERS, W. W. 1966: Growth habits of rimu in Westland's terrace forests and their implications for forest management. **N.Z. J. For. 2(1):** 4-19.

DUFF, G. 1952: Universal rimu volume table 1952. **N.Z. For. Serv., For. Res. Inst.**

DUFF, G. and BURSTALL, S. W. 1965: 1965 **Dacrydium cupressinum** volume table, Westland Conservancy. **N.Z. For. Serv., For. Res. Inst.**

FRANKLIN, D. A. 1965: Recognition of the vigour of rimu trees in terrace forest by their crown and bark characteristics. **N.Z. For. Serv., For. Res. Inst., Silvicultural Report 51.**

——— 1968: Biological flora of New Zealand 3. **Dacrydinum cupressinum** Lamb (Podocarpaceae) Rimu. **N.Z. J. Bot. 6:** 493-513.

——— 1969: Trials to improve regeneration in terrace rimu forests, Westland. **N.Z. For. Serv., For. Res. Inst., Indigenous Silvicultural Report 2.**

——— 1971: Studies in terrace rimu forests, South Westland. **N.Z. For. Serv., For. Res. Inst., Indigenous Silvicultural Report 6.**

GOVER, R. K. 1972: Management of South Westland terrace podocarp forest under a selection logging system. **N.Z. J. For. 17(2):** 256-63.

Working Plan for the Mount Hercules Working Plan Area, Westland Conservancy. **N.Z. For. Serv.,** unpubl.