GROWTH RATES IN SOUTH WESTLAND TERRACE RIMU FOREST

1. GROWING STOCK AND INCREMENT IN VIRGIN FOREST

D. A. FRANKLIN

Forest Research Institute, New Zealand Forest Service, Rangiora

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ABSTRACT

In a 500 ha block of terrace rimu (**Dacrydum cupressinum** Lamb.) forest in Ianthe Forest, South Westland, 194 plots each of 400 m^2 were established systematically to determine growing stock and increment. The average growing stock was 309 m^3 of rimu and 10 m^3 of other merchantable species (mainly miro **Podocarpus ferrugeneus** G. Benn. ex D. Don) per hectare, but it was found that there was probably a serious shortage of striplings, saplings and poles if the forest was to be managed as a selection forest. The gross mean annual increment, determined from increment cores, was estimated to be 1.45 m^3/ha of rimu and 0.05 m^3/ha of other merchantable species. Two plots, each of 2 ha, were remeasured after 5 years and found to have mean annual increments of 3.43 and 2.81 m^3/ha, but it is likely that these plots are on sites which are of better quality than is typical of terrace forest. Because it is considered that the 500 ha block contains about 85% of the stocking of a fully stocked selection forest, it would be unwise to assume that this block, and probably most terrace forest, has a potential mean annual increment of more than 1.75 m^3/ha until more extensive remeasurements prove otherwise.

INTRODUCTION

The terrace forests of South Westland occur on flat to gently rolling fluvioglacial deposits. They are mostly dominated by rimu, and there are commonly 100 to 500 stems/ha of all sizes from 12.5 to 100 cm d.b.h. of this species. Miro is also quite common, but stems over 50 cm d.b.h. are rare and only about half the stems over 22.5 cm d.b.h. are considered merchantable by loggers, mainly because of heavy branching. Because the timber is not wanted by sawmillers, very few miro are logged. Kahikatea (*P. dacrydioides* A. Rich) is often dominant alongside rivers, major streams and on the more fertile sites, and silver pine (*D. colensoi* Hook.) is dominant on the most infertile sites, particularly those that have very poor drainage; both species occur only occasionally away from these sites. Kamahi (*Weinmannia racemosa* Linn. f.) and quintinia (*Quintinia acutifolia* Kirk) up to 30 cm d.b.h. are common throughout, but other species occur only occasionally.

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The forests are a mosaic of irregular and ill-defined groups of trees, the groups varying in size from a few metres in diameter to irregular strips hundreds of metres long. Within recognisable groups, the trees tend to be even-aged, the largest trees making the greatest diameter growth and the smaller trees being suppressed. At the present time these forests are being selectively logged with the intention of managing them in perpetuity. There are at least 15,000 ha, and possibly 30,000 ha, that can be treated in this way, most of the area occurring between the Waitaha and Cook rivers.

Studies were started in 1966 to determine the gross annual increment of virgin terrace forest in Ianthe Forest, and the stocking and size class distribution of merchantable stems. If the area is fully stocked and is an all-aged forest consisting mainly of one species (rimu), then the gross increment of virgin forest should give a reasonable estimate of the maximum increment that can be expected under selection management, i.e., it will measure the site potential. Data on stocking and size-class distribution are necessary to determine the suitability of the forest for selection management.

1. DETERMINATION OF INCREMENT FROM INCREMENT CORES

METHODS

The area studied is a 500 ha block of terrace forest in the north-eastern corner of Ianthe Forest, which appears to be typical of most forest available for selection management. Because existing plotless methods of sampling proved to be unworkable in this type of forest (Franklin, 1967), 137 plots 20 m square were located systematically 100 m apart on lines 200 m apart (2% sample) and a further 57 plots were established 200 m apart on lines 200 m apart (1% sample).

The numbers of striplings of merchantable species between 15 cm high and 2.5 cm d.b.h. were recorded as nil, one, two to five or more than five per plot for each species. The d.b.h. of every stem of merchantable species over 2.5 cm d.b.h. was recorded, and an increment boring was taken from every tree over 12.5 cm d.b.h. The location of the boring on the circumference of the tree was systematically altered by 90° in a N, E, S, W direction between consecutive trees to avoid directional bias.

Volumes were calculated using the 1965 Westland One-Dimensional Rimu Merchantable Volume Table (to a 12.5 cm top) because this greatly simplified field work and computations, and because a study (Franklin, 1971, Appendix 1) had shown that volumes calculated from this table closely agreed with volumes extracted by logging. For methods of calculating increment, see Franklin, 1966 and 1969. In this study the mean annual increment was calculated from the average growth over the last 50 years.

RESULTS

Stocking and Size Class Distribution

Total Stocking: The average stocking of merchantable species per hectare by 5 cm size classes is shown in Fig. 1, together with the stocking considered by Chavasse (1959) to be ideal for selection management of rimu based on a basal area of 41 m^2 of rimu per ha and a maximum diameter of 75 cm at breast height. Because rimu regeneration tends to occur in localised, crowded groups, many of the stems are not effective as potential crop trees and, therefore, it is unlikely that the ideal size-class distribution curve should be much flatter than that proposed by Chavasse. Compared with Chavasse's

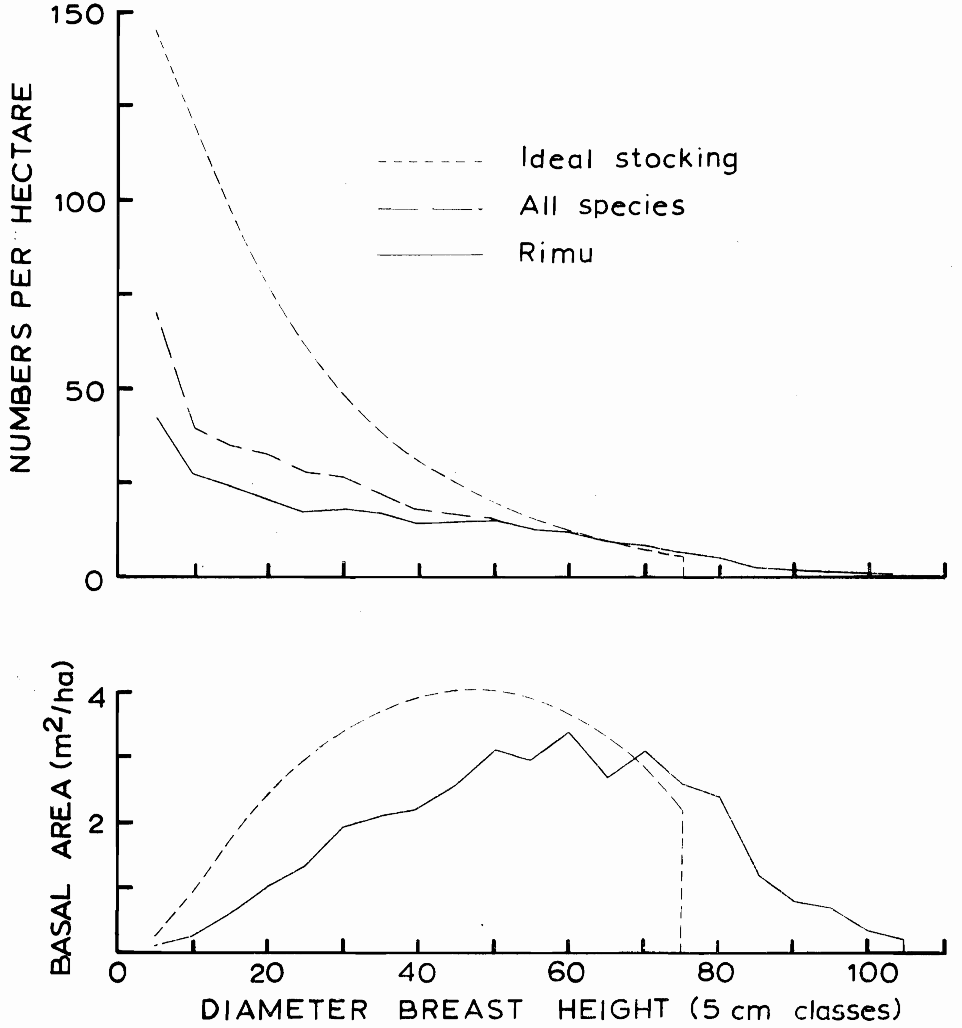

FIG. 1—Size class and basal area distribution in the 500 ha block, compared with the distribution in a normal selection forest.

ideal, which has lower numbers in the smallest size classes than most European selection forests, the terrace forest at Ianthe is understocked, particularly with poles and small trees. In addition, miro saplings and poles form a significant proportion of the total, and none of these is likely to become a large tree.

Saplings: Of the 194 plots, 40% are not stocked with saplings of merchantable species 2.5 to 7.5 cm d.b.h. and 46% are not stocked with saplings 7.5 to 12.5 cm d.b.h. The percentages of plots not stocked with rimu saplings are 57% and 64% respectively. Most stocked plots contain only one to four saplings, less than half of which are rimu, but occasional plots contain very numerous rimu saplings which greatly increase the average stocking.

Striplings: 32% of the plots are not stocked with rimu striplings, and a further

12% contain only one stripling each. Because rimu striplings tend to occur only where there are saplings, and because plots stocked with these small stems tend to be restricted to certain areas, in particular to areas alongside drainage channels or areas containing silver pine, there are quite large areas where striplings and saplings of rimu are rare.

Basal Area: From the diagram of basal areas (Fig. 1), it can be seen that the deficiency of basal area of rimu in the smaller size classes at Ianthe is almost equalled by the basal area of trees over 75 cm d.b.h. In fact the average basal area of rimu in this block of forest is 34 m^2/ha, which is 83% of Chavasse's figure of 41 m^2/ha.

Volume Data

The average volume of rimu per plot is 12.4 ± 0.9 m^3 at the 95% confidence level. If the standard error for a hectare is taken as $= \sqrt{\frac{25s^2}{n}}$ where s^2 = variance of plots, the average volume per hectare is 309 ± 4.5 m^3, of which 97% is merchantable (over 22.5 cm d.b.h.). There is also an average merchantable volume of about 10 m^3/ha of other species (mainly miro). Within the area covered by this study, a total of 20 ha has been measured for other experimental work. The average volume per hectare on this 20 ha is 335 m^3 of rimu (from the one-dimensional tables) and 8 m^3 of other species (actually cruised).

Increment Data

The mean annual increment of rimu is 1.450 ± 0.035 m^3/ha at the 95% confidence level, and other species have a mean annual increment of 0.055 m^3/ha. Although the average mean annual increment is about 0.47% of the total volume, the percentage on individual plots varies from 0.1% on plots dominated by large trees, to 1.5% in some pole stands.

The average increment, both diameter and volume, for all size classes of rimu in this block is shown in Fig. 2. Diameter growth rates are, on the average, greatest when

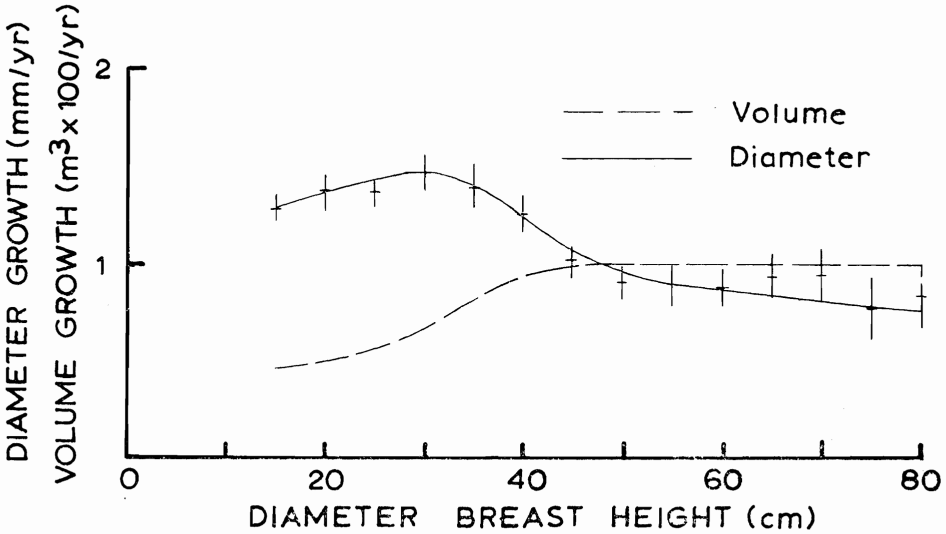

FIG. 2—Average diameter and volume growth in the 500 ha block. Crosses represent mean diameter growth ± standard error for each size class.

the trees are about 30 cm d.b.h.; they then decrease fairly rapidly until the trees are 50 to 55 cm d.b.h., and then decrease much less rapidly. For volume, average growth rates increase rapidly in trees between 25 and 40 cm d.b.h., and then remain the same at 0.01 m^3/tree/year. It must be stressed that these are average values; healthy trees growing on favourable sites can grow very much faster than this.

The plots can be split into two populations based on the presence or absence of silver pine. Unfortunately, no record was kept of the presence of silver pine trees and poles, so the division has had to be based on striplings and saplings. Although this is not entirely satisfactory, experience in the field indicates that there is probably a high correlation between the presence of striplings and the presence of mature silver pine. In those plots where there are one or more striplings of silver pine, the mean annual increment of rimu is 1.345 ± 0.090 m^3/ha at the 99% confidence level, whereas in those plots where silver pine is absent, the mean annual increment is 1.925 ± 0.124 m^3/ha at the 99% confidence level. These differences are unlikely to be a product of chance ($t = 4.59$; d.f. = 192; $p < 0.001$) but are probably due mainly to the lower stocking (222 trees/ha v. 267 trees/ha) and lower mean d.b.h. (37.0 cm v. 39.4 cm) of the plots containing silver pine.

2. DETERMINATION OF INCREMENT FROM SUCCESSIVE MEASUREMENTS

METHODS

Two plots, each of 2 ha, were established in terrace rimu forest in Ianthe Forest in 1966 and all stems of merchantable species over 2.5 cm d.b.h. were cleaned, tagged and accurately measured for breast height diameter at a fixed point. Both plots were lightly logged over for silver pine in 1967 and both were remeasured in 1971. Volumes were calculated using the 1965 Westland One-Dimensional Rimu Merchantable Volume Table (to a 12.5 cm top).

RESULTS

Stocking and Size Class Distribution

The average stocking of merchantable species in 1966 by 5 cm size classes for both plots is shown in Fig. 3. The size class distribution in plot A approaches that of Chavasse's ideal selection forest but more than half of the saplings and poles are miro or silver pine and therefore are not likely to contribute to the future merchantable stocking. The stocking of saplings and poles on plot B is very low and again many of these are miro or silver pine. On both plots the smaller size classes tend to be confined to the wetter sites and are not spread evenly over the whole of the plots.

Increment

The average volumes per hectare in 1966 and 1971, together with losses and increment in the intervening years, are given in Table 1. In 1966, total volumes were comparable on both plots, but plot A had a greater volume of poles, of both rimu and of other species, than plot B. Between 1966 and 1971, about half the mortality of rimu on both plots was due to windthrow, but mortality was much greater on plot B than plot A. Most of the volume loss of other species on both plots was due to felling of silver pine, and windthrow was rarely the cause of natural mortality. The total gross volume increment averaged 3.43 m^3/ha/annum on plot A and 2.81 m^3/ha/annum on plot B, and on both plots this more than offset losses due to natural mortality.

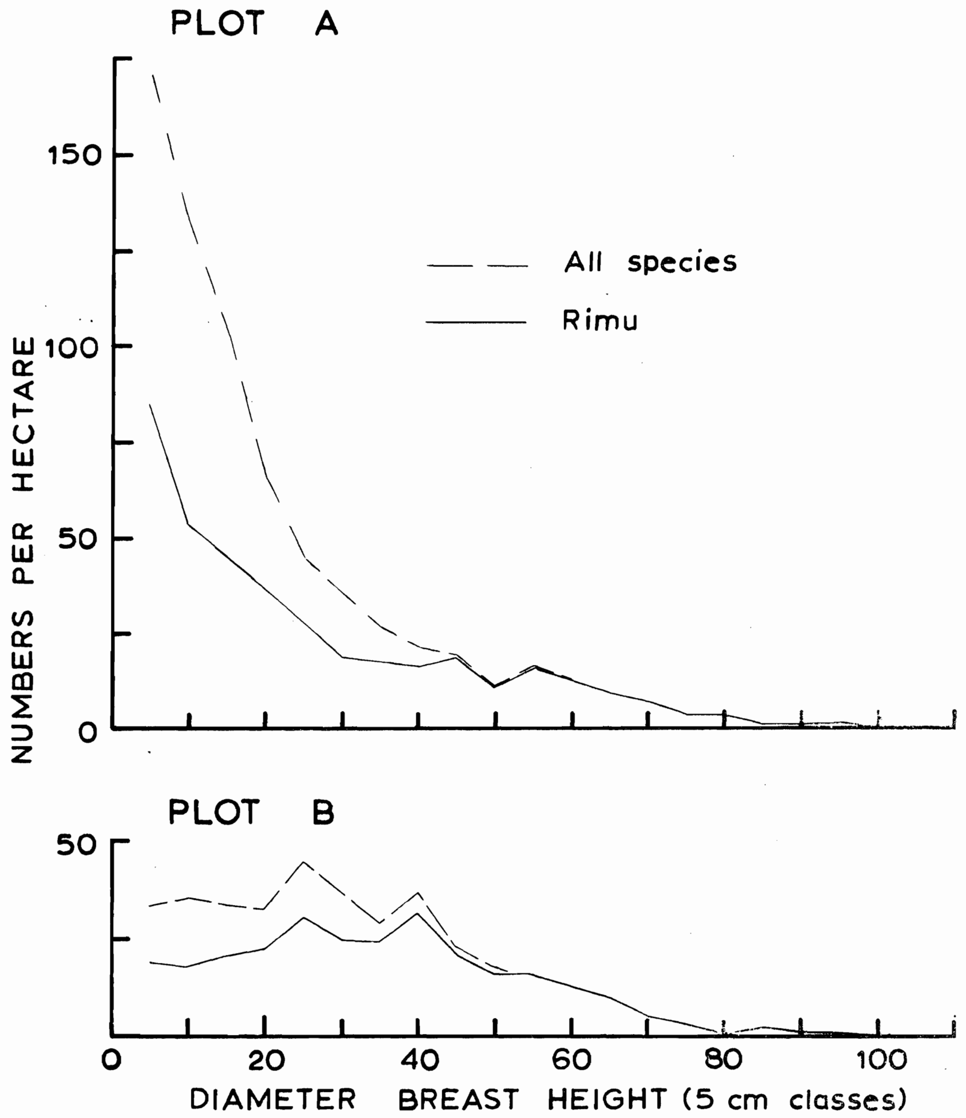

FIG. 3—Size class and basal area distribution in plots A and B.

The average increment, both diameter and volume, for all size classes of rimu in both plots is shown in Fig. 4. In plot A, the pattern of growth is similar to that in the previous study, but growth rates are much faster, particularly in the larger size classes, and diameter growth rates are greatest, on the average, when trees are about 40 cm d.b.h. In plot B, growth rates are not quite as fast but the greatest diameter growth is made by the largest trees.

TABLE 1—Volume data, plots A and B
(m^3/ha)

	PLOT A			PLOT B		
	Poles	Trees	Total	Poles	Trees	Total
Rimu						
Volume in 1966	11.98	317.18	329.16	7.36	336.92	344.28
Losses	0.03	3.17	3.20	0.30	8.16	8.46
Increment	2.07	13.71	15.78	0.73	12.67	13.40
Volume in 1971	14.02	327.72	341.74	7.79	341.43	349.22
Other species						
Volume in 1966	7.38	16.05	23.43	1.66	13.80	15.46
Losses	0.76	0.81	1.57	0.15	2.67**	2.82**
Increment	0.77	0.60	1.37	0.15	0.49	0.64
Volume in 1971	7.39	15.84	23.23	1.66	11.62	13.28
All species						
Volume in 1966	19.36	333.23	352.59	9.02	350.72	359.74
Losses	0.79	3.93	4.77*	0.45	10.83**	11.28**
Increment	2.84	14.31	17.15	0.88	13.16	14.04
Volume in 1971	21.41	343.56	364.97	9.45	353.05	362.50

* Includes 2.07 m^3/ha felled
** Includes 2.33 m^3/ha felled

DISCUSSION

Both studies show that there is probably a big deficiency in the smaller size classes if this forest is to be managed as a selection forest, and observations in the field indicate that this is probably true of most of the forest that is immediately available for selection management. Thus, to promote normality, recruitment of regeneration will need to be encouraged as much as possible. Logging in the first felling cycles should concentrate on removing trees over 70 to 75 cm d.b.h. because the diagrams of size class distribution show that relatively few trees are larger than this, and therefore mortality can be expected to be high once trees reach 70 cm d.b.h.

The standing volume of 319 m^3/ha on the 500 ha block is somewhat less than the 352 m^3/ha given by National Forest Survey data for this type of forest in the area, but well within the probable limits of error of the latter figure. The volumes on plots A and B agree closely with the National Forest Survey figure, but both these plots are situated in stands where there are few gaps.

The calculated increment of rimu (1.45 m^3/ha) on the 500 ha block is less than half that (3.5 m^3/ha) calculated by Chavasse (1959) as being the maximum obtainable under selection management in fully stocked terrace forest which receives optimum treatment. Chavasse remeasured plots established at Mahinapua 27-28 years previously by the Canterbury School of Forestry. Although he did not give volume increments for these plots, the average diameter increments by size classes were very similar to those on the 500 ha block and the stocking was generally less, so that it is unlikely that volume increment averaged more than 1.5 m^3/ha.

The volume increment actually measured on plots A and B was much higher, partly

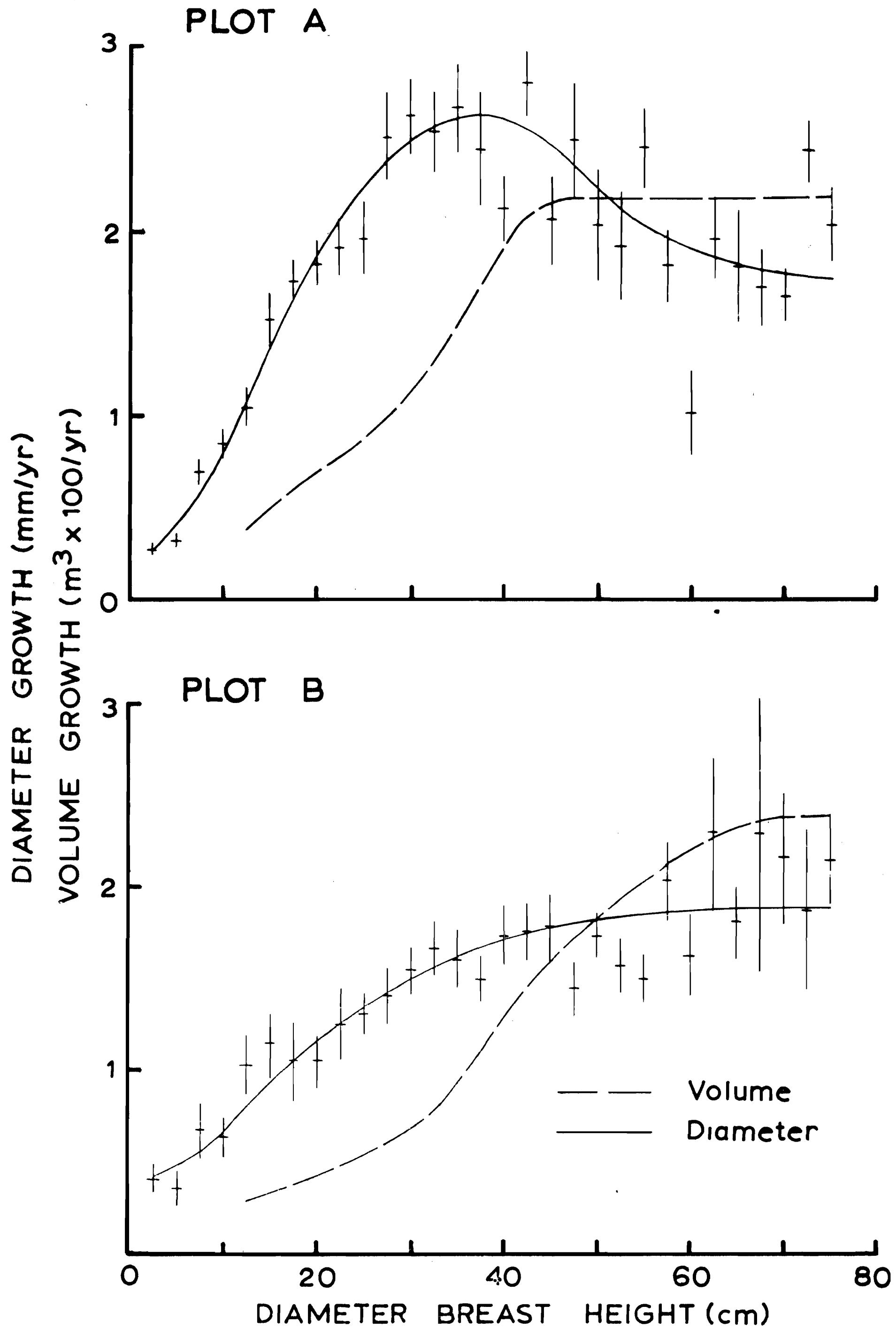

FIG. 4—Average diameter and volume growth in plots A and B. Crosses represent mean diameter growth ± standard error for each size class.

because of higher stocking and possibly also because the sites are more fertile, the plots being situated close to major streams and probably receiving ground water from nearby slopes. The forest on plot A is a mosaic, and therefore the pattern of growth is similar to that on the 500 ha block and at Mahinapua, where the fastest diameter growth is made by small trees. On plot B the forest is much more uniform and thus the fastest diameter growth is made by the largest trees because few of the smaller trees are dominant or even co-dominant.

If the size class distribution on the 500 ha block conformed to Chavasse's ideal distribution, the increment data for this block indicate that each size class over 15 cm d.b.h. would be putting on approximately the same increment in terms of m^3/ha. Because the volume is 87% and the basal area 83% of that for a normal forest as calculated by Chavasse, the present mean annual increment is probably about 85% that of a fully stocked forest under selection management. Thus, unless selective logging greatly improves the site potential, it would be unwise to assume that this block, and probably most terrace forest, has a potential increment of more than 1.75 m^3 of merchantable timber per hectare per annum until more extensive remeasurement data prove otherwise.

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N.B. Many of the measurements for these studies were made in imperial units. These have been converted to metric measurements using standard conversion factors of three significant figures **except** that 1 in. and 2 in. diameter classes have been converted to 2.5 cm and 5.0 cm classes respectively.

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