RED BEECH MANAGEMENT: IMPLICATIONS FROM EARLY GROWTH PLOTS

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SYNOPSIS

Growth rates of red beech (Nothofagus fusca) *pole stands in the Grey and Inangahua River valleys are greater on hill country than on the lower glacial and river terraces. Well-drained hill sites have yielded a mean annual increment of 10.5 m³/ha over a 70-year period, compared with 7.0 m³/ha on terraces. Early thinning of regeneration will lead to reduction in rotation length where the aim is to produce sawlogs or pulpwood. Delay in thinning results in considerable mortality and slow diameter growth. On the terraces it is possible, by carrying out one non-commercial and three commercial thinnings, to reduce the rotation for sawlog production to 90 years. This could be reduced further if smaller diameter roundwood could be utilized.*

INTRODUCTION

The wide distribution and large area of red beech *(Nothofagus fusca)* forests indicates that management of this species should be possible in several localities throughout New Zealand. However, "if we really intend sustained yield management of red beech and/or hard beech [*Nothofagus truncata*] . . . we must first think of all north Westland and western Nelson forests" (Holloway, 1965). The beech forests of this region are generally dominated by red beech on the alluvial terraces and dissected hill country, with hard beech on the dry terrace slopes or in association with mountain beech *(N. solandri)* on terrace tops (Morris, 1959). In the Maruia valley the dominant species in manageable forest is red beech (Conway, 1952).

Sustained yield production of the beech forests was anticipated in the 1930s when the required conditions for regeneration in cut-over and overmature forest were discussed (Foster, 1931; Birch, 1935, 1936; Jansen, 1938; and Field, 1939). Investigation into the silviculture of red beech was initiated in 1937 (Moorhouse, 1939) after similar work had commenced on silver beech *(N. menziesii)* in Southland (Birch, 1935). Conway (1952) proposed management of red beech for sawlog production to replace the beech-podocarp associations due to the inability of podocarps to regenerate rapidly or on a large scale. The production of 560 m³/ha, including thinnings, over a rotation of 120 years was contemplated. Conway also envisaged that red and silver beech would replace rimu *(Dacrydium cupressinum)* as the major indigenous sawtimber "with the reservation of rimu as high-grade special-purpose building

*Foresters, N.Z. Forest Service, Reefton and Ahaura, respectively.

and furniture timber". This did not eventuate owing to the high cost of sawing beech caused by hidden defect, growth stresses and seasoning problems. These factors, together with the competitive advantage of the more versatile radiata pine, have forced "beech timbers to the position of substitutes for the better-known softwood species" (Reid, 1965). During the 1950s thinning of beech pole stands commenced, mainly for the production of mining timber, with a view to eventual high-grade sawlog production. Many of these thinned stands were severely damaged by insect attack. At first *Nascioides enysi* was held to be responsible, but recently it appeared more probable that a fungus introduced by *Platypus* spp. was the causal agent (Dugdale, 1965). Current knowledge is discussed by Milligan (1972).

The increasing use of hardwood fibre for the pulp and paper industry has initiated intensive investigations into the pulping qualities and the available merchantable volumes of beech. This paper sets out the results of a study of red beech growth, leading to suggestions for possible management regimes and yields.

SAMPLE PLOT HISTORY

Areas of red and hard beech have regenerated following windthrow and mining activities throughout the region, giving rise to well-stocked pole stands. An investigation of these stands was made by Moorhouse (1939) in order to compile stand tables, to estimate possible mining timber production, and to establish permanent sample plots for growth studies. Of 23 plots established between Lyell and Staircase Creek, seven at Globe Hill and four at Staircase Creek have been remeasured (Conway, 1952). Of the remainder, ten were only temporary plots and two have not been remeasured or used in this study. The plots at Staircase Creek (Fig. 1) are in a stand established on alluvial gravel outwash, while the stand at Globe Hill arose on detritus from goldmining operations.

Interest in red beech silviculture then declined, but there was a resurgence in the 1950s, when three trials were established in north Westland. These were all on Ahaura soils over glacial, fan or river gravels. The first was at Half Ounce Creek in an area worked over by gold-miners; the second was at Waipuna in stands arising from windthrow (Fig. 2); and the third was at Starvation Point, in thicket stands which had regenerated after extraction of sawlogs.

Apart from treatment of thicket-sapling stands at Starvation Point, thinning in all plots has been subsequent to the development of "clear boles of desired length" for sawlog production, and has usually involved the removal of vigorous wolf trees.

ANALYSIS OF SAMPLE PLOT DATA

Remeasurement of the plots in 1972 was prompted by the possible establishment of a pulp industry within the region. In the evaluation of the plot data, some problems have been encountered. These are discussed below.

Consistency of Research

The plots at Globe Hill and Staircase Creek have been studied only intermittently, while those at Waipuna, Half Ounce Creek and Starvation Point have been measured regularly. Length of time between measurements at Globe Hill has allowed tree numbers to be overgrown or lost, and some trees have been inadvertently felled for mining timber and not recorded. Correct tree identification, and tracing individual tree measurements through the plot histories, has been possible. Photographs have been taken from time to time, but many of these are not identifiable.

FIG. 1: *Plot No. 51, Staircase Creek. Red beech stand, about 80 years old, immediately following thinning in 1952. Heights range from 27 to 34 m, and dbh from 25 to 45 cm.*

N.Z. Forest Service photo by J. H. G. Johns, A.R.P.S.

Determination of Age

Beech pole stands are sometimes formed from existing advance growth; "such seedlings may make up a large proportion of regenerated stands" (Kirkland, 1961). Ring counts from Globe Hill confirm that an early fire in the area released some advance growth and opened the area for additional seeding. The effective year of establishment is considered to be 1900, although Moorhouse estimated it to be 1893. The only other plots where age is in doubt are at Half Ounce Creek, and those established after a further fire at Globe Hill.

Volumes

The plot volumes given for the 1937 measurement at Globe Hill and Staircase Creek by Moorhouse were not updated following the 1952 remeasurement. However, sectional measurements are available for some plots, and this has enabled volume calculations to be made. The method used in 1937 is not applicable in present conditions owing to changes in tree taper caused by age and by thinning. The calculations made in the present study are based on sectional measurements at dbh, small-end diameter, and the mid-point, and on merchantable length taken as 10 cm outside bark. Piece size volumes were aggregated for diameter classes at intervals of 2.5 cm.

The volumes for Waipuna, Half Ounce Creek and Starvation Point have been calculated from the modified Waipuna Volume Table for red beech pole stands up to 30 cm dbh, and from the Universal *Nothofagus* Volume Table for Mature Beech for larger trees. These volumes have been calculated for small-end diameters of 15 cm unless otherwise stated.

Buffer Zone

In 1952 a ten metre strip round each plot was given the same treatment as the plots at Globe Hill. However, with subsequent height growth, much of the side light has been cut off. This is particularly noticeable on the steeper slopes and in the more heavily thinned plots, and may be significant enough to reduce the growth within the plots. The remaining plots are on terrace sites and will be less affected by side light.

Replications

Insufficient replications for any one treatment have been established to allow statistical satisfaction. However, the repetition of work on different sites, in different age classes, and over a period of time, allows for relative comparisons to be made.

RESULTS

Site Differences

There is a great difference in the growth rate and vigour of red beech pole stands on hill country compared with those

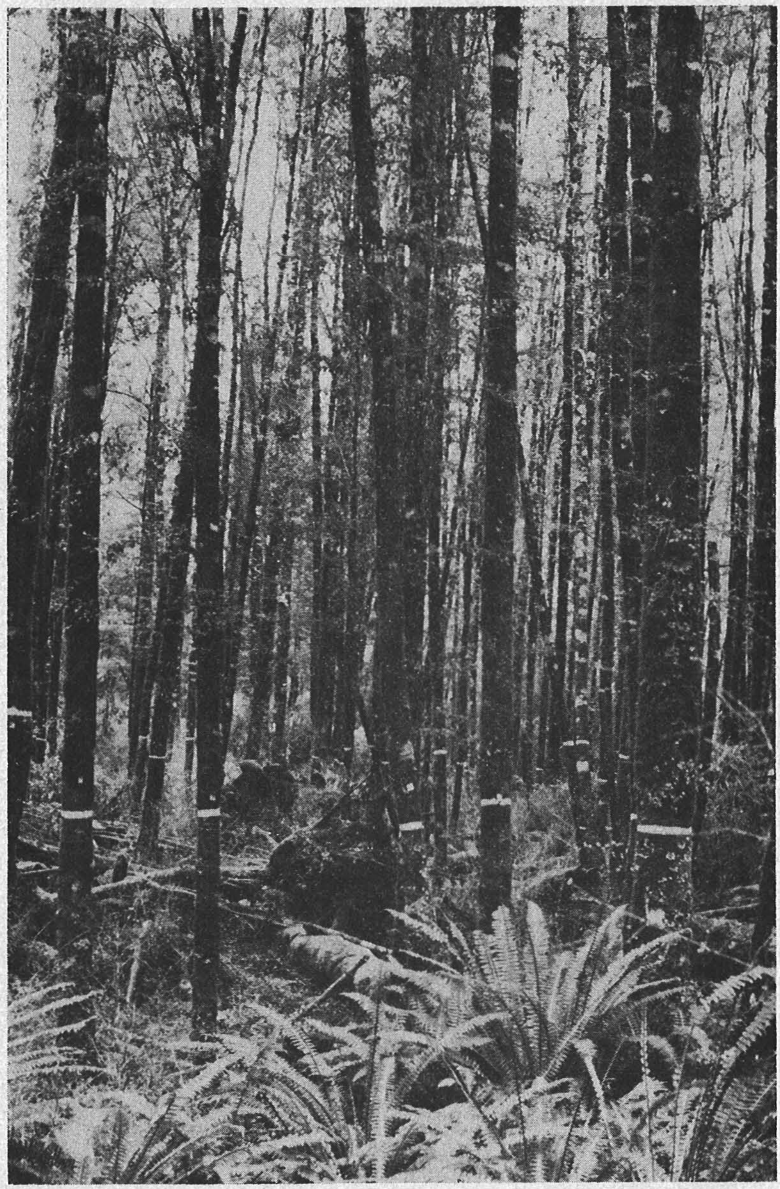

FIG. 2: *Plot 4, Waipuna, on a terrace site, in 1968, aged 55 years. Note the relatively small diameter in relation to stand height.*

N.Z. Forest Service photo by P. A. Allan on the lower terraces (Table 1). On the terraces there is a greater range of growth rates, but this is not large on the three terrace sites sampled.

TABLE 1: GROWTH OF UNTHINNED RED BEECH POLE STANDS ON HILL AND TERRACE LAND

Site	*Age (yr)*	*s.p.ha*	*Basal area (m^2/ha)*	*Volume (m^3/ha)*
Hill country	72	1730	66.6	734.7
Terraces	72	909	52.8	475.8

Comparison between Virgin and Second-growth Stands

Total volumes per hectare are higher in second-growth stands than in virgin forest (Table 2). It is as yet not possible to make a direct comparison; the pole stands are mainly located on the "better class sites of the district" (Moorhouse, 1939), while the figures for virgin forest are averages derived from the 1971 beech inventory with no defect allowance.

TABLE 2: COMPARISON OF VIRGIN FOREST AND SECOND GROWTH STANDS ON HILL AND TERRACE LAND

Location	*Site*	*Volume (m^3/ha)*	
		Virgin forest	*Pole stands*
Ahaura District	Hill	243.8 (399.2)*	—
Reefton District	Hill	231.1 (308.5)	736.6
Ahaura District	Terraces	191.3 (309.8)	354.2
Reefton District	Terraces	324.2 (338.5)	475.6

*The figures in parentheses are total volumes of all species present.

The Effect of Thinning Red Beech Pole Stands

(a) *Height growth*: Thinning tends to reduce height growth (Table 3).

TABLE 3: HEIGHT GROWTH OF THINNED STANDS AT STARVATION POINT

Treatment	*Mean height (m)*		
	*1958**	*1970*	*Difference*
Control	4.6	12.3	7.7
Light thinning	4.9	11.1	6.2
Heavy thinning	6.0	12.6	6.6

*After thinning.

(b) *Diameter growth*: "Light crown thinning and low thinnings . . . have an appreciable effect on the growth of the smaller trees, often allowing them to grow at a faster rate (in diameter) than the dominants" (Franklin, 1965). Heavy thinning stimulates diameter growth, particularly of the larger trees (Table 4).

TABLE 4: DIAMETER GROWTH IN THINNED STANDS AT GLOBE HILL

Treatment	*Mean dbh (cm)* 1952	1971	*Difference*
Of all trees:			
Control	16.0	22.1	6.1
Moderate thinning	21.1	25.7	4.6
Heavy thinning	21.6	27.9	6.3
Of the largest 250 trees per hectare:			
Control	30.2	33.5	3.3
Moderate thinning	29.2	35.1	5.8
Heavy thinning	28.2	36.3	8.1

(c) *Basal area growth*: The net basal area for hill country becomes fairly static between 55 and 70 m^2/ha, whereas on terrace country the range is between 45 and 55 m^2/ha. In unthinned stands, basal area increment appears to maximize between 30 and 50 years, although on terrace country maximum growth may be attained at an earlier age. With frequent

TABLE 5: STOCKING AND VOLUME GROWTH OF THINNED STANDS

Location and Treatment	*s.p.ha*	*p.m.a.i. (m^3/ha)*			*m.a.i. (m^3/ha)*		
Globe Hill	1971	1937-52	1952-71		1971		
(10 cm top)							
Control	1730	18.1 (1937-71)			10.2		
Moderate thinning	1127	18.9	19.9		11.0		
Heavy thinning	815	15.2	17.2		9.3		
Waipuna	1970	1960-63	1963-66	1967-70	1963	1966	1970
(15 cm top)						(a)	
Control (Plot 1)	1275	10.8	12.6	18.5	3.4	5.4	4.6
Moderate thinning (Plot 3)	692	9.4	10.6	28.3	2.7	4.0	4.5
Heavy thinning (Plot 7)	534	8.9	12.4	10.6	3.2	4.4	4.0
Half Ounce Creek	1957	1951-54	1954-57		1951	1954	1957
(15 cm top)							
Control	880	7.5	18.7		4.3	4.4	4.9
Moderate thinning	410	8.1	26.2		4.9	5.0	5.8
Heavy thinning (b)	222	11.4	6.6		4.7	4.1	4.2

Note (a) Volumes to a 10 cm top.
(b) Drop in increment from 1954 to 1957 owing to mortality from insect damage.

thinning the annual basal area increment can be maintained at about 1.4 m^2/ha. The length of time between thinnings will increase with stand age as the diameter growth will be on fewer trees.

(d) *Volume growth*: The volume growth on thinned plots is shown in Table 5.

Had these thinnings been undertaken earlier, it is probable that volume growth would have been better than the figures given in Table 5. At Globe Hill the average is 10.1 m^3/ha/yr to a 10 cm top. At Waipuna (extrapolating from current data) increment is expected to be 5.9 m^3/ha/yr at 60 years, while at Half Ounce Creek the mean figure is 5.4 m^3/ha/yr for 81 years (to a 15 cm top) (Fig. 3). The latter are both on terraces, but

FIG. 3: *Sample plot at Half Ounce Creek in 1954. The stand has received a moderate thinning to 570 s.p.ha.*
N.Z. Forest Service photo by J. H. G. Johns, A.R.P.S.

it is expected that early thinning of comparable stands would result in a mean m.a.i. of 7 m^3/ha/yr on a rotation of 70 to 80 years.

The thinned plots at Globe Hill, on hill country, show marked differences in volume growth owing to aspect. On north-facing slopes there is a mean volume of 562 m^3/ha, but on southerly aspects the figure is 730 m^3/ha. The difference is attributed to the tops competing for light and growing outwards on northerly aspects, leading to reduced merchantable lengths (Fig. 4). Early heavy thinning on such sites should reduce competition and lead to increased volume growth.

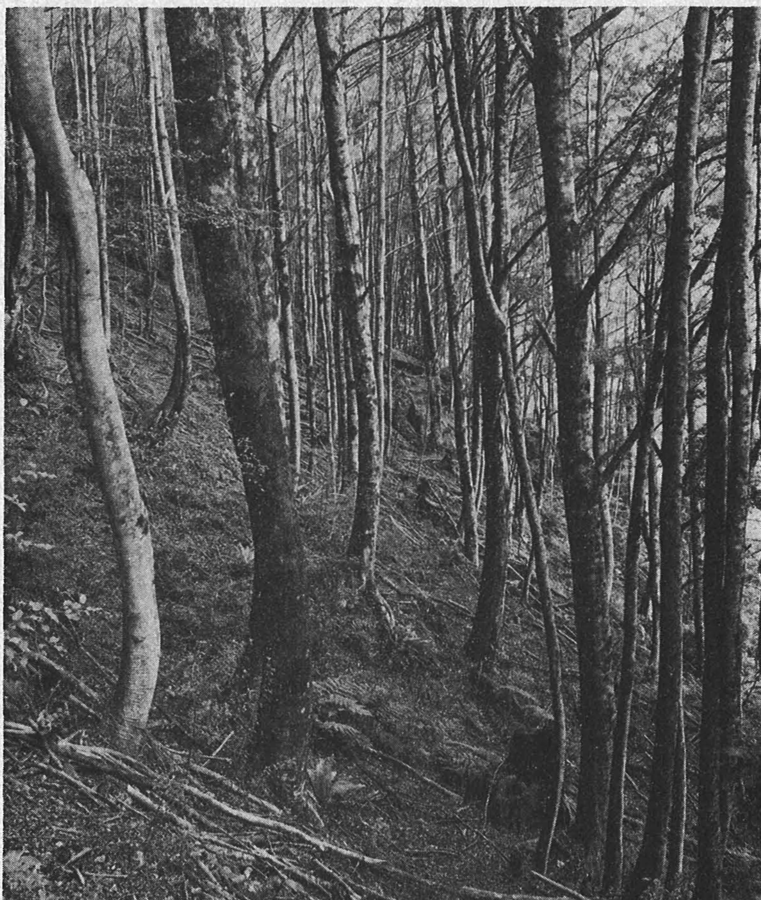

FIG. 4: *Plot N.58, Globe Hill, in 1950, showing strong branching on a northerly face.*

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DISCUSSION

The results of these studies show that the rotation required for the production of both sawlogs and pulpwood could be reduced by undertaking thinnings at appropriate times. A good deal of flexibility is possible during the first 30 years, but it seems desirable to undertake early heavy thinning of regeneration when the stand is between 4 and 5 m in height. This should be designed to reduce stands to a workable stocking of about 1500 s.p.ha, to induce wind-firmness, and to allow room for the growth of the most vigorous trees. Silvicultural regimes have been designed for the production of sawlogs, or of pulpwood, but these have not been evaluated from an economic point of view.

Sawlog Regime

Table 6 sets out the stocking, mean dbh and basal area that could be expected for a sawlog regime in stands on terrace country. Better growth is likely on hill country. The table was compiled from basal area increment figures and average diameter increments found in heavily thinned stands, data for which are not included in this paper.

TABLE 6: PROPOSED SAWLOG REGIME

Age (yr)	*s.p.ha*	*Mean dbh (cm)*	*dbh of 250 largest trees per ha (cm)*	*Basal area (m^2/ha)*	
13	1483	8.6	13.5	8.5	
20	1483	12.9	18.8	19.7	
30	1483	17.5	27.2	35.8	Before thinning
30	988	20.1	27.2	31.2	After thinning
50	988	28.4	37.3	62.2	Before thinning
50	494	29.2	37.3	33.1	After thinning
60	494	34.8	41.9	46.8	
70	494	37.3	46.5	56.0	Before thinning
70	198	37.6	45.7	22.3	After thinning
80	198	43.2	49.5	29.1	
90	198	48.3	53.3	36.0	Clearfell

The cost of regular thinnings undertaken in accordance with the schedule in Table 6 is such that, to make this regime economic, the price for sawlogs will have to be fairly high. This is especially so because the criteria used in selection for thinning is to favour trees of good form, rather than coarser vigorous trees, and this reduces the mean tree diameter in the final crop. For example, in the Globe Hill plots, the mean dbh of heavily thinned stands in 1937 was 23 cm; in moderately thinned stands it was 24 cm; but in the unthinned control plot it was 29 cm.

Pulpwood Regime

Vigour is important in maximizing volume growth in the minimum length of time required to obtain a piece size that can be handled economically. Maximizing basal area growth in the first 20 years of a pulpwood regime would be important, even if it were achieved at the expense of height growth. By thinning to 1500 s.p.ha at about 10 to 14 years, and to 1000 s.p.ha at age 20, wind-firmness could be reasonably assured on most sites for another 40 years. Different regimes will be required for hill and terrace country.

(a) *Hill country:* As the basal area growth declines at the age of 35 to 40 years, an increase in merchantable height growth, and consequent volume increment, should proceed unhindered until clearfelling at 50 to 60 years old. The expected m.a.i. of 10.5 m^3/ha/yr would give a pulpwood yield of 630 m^3/ha in 60 years.

(b) *Terraces:* Because of lower productivity, the regime on terrace land should be designed to maximize early growth on a rotation of 40 years or less, if thinning is to be undertaken. If no thinning is considered possible, then the most suitable regime appears to be to clearfell untreated stands when they reach about 70 years of age.

(c) Other factors: The relatively low increments for red beech are due in part to the long establishment period. By using advance growth it should be possible to reduce rotations by as much as ten years. This would be particularly important where short regimes are contemplated.

Because of a rather small range of diameters found in pole stands, as compared with the very wide range found in virgin forests, they present an attractive logging proposition that will allow the use of specialized logging systems with high productivity. This will be particularly advantageous for both clearfelling and for thinning for pulpwood to permit continuing vigorous growth in the main crop trees, on terrace country. In contrast, the hill country will have to carry a higher standing volume for comparable logging costs, and this in turn will dictate longer rotations.

CONCLUSIONS

Effective management of red beech depends on adequate establishment of regeneration, either as advance growth, or within a year of clearfelling the original crop, followed by early heavy thinning. Such treatment should allow growth rates of at least 10.5 m^3/ha on hill country over a rotation of 60 years, and about 7.0 m^3/ha on the lower terraces. The higher terraces, with poorer soils, may be less productive and may require enrichment with exotic species.

In order to produce a final crop of about 200 s.p.ha with a mean dbh of 50 to 55 cm, a sawlog rotation of about 90 years would be required. Pulpwood rotations would be a good deal shorter, but the economics of logging may determine the rotation length; the optimum size for pulpwood trees is not yet determined.

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