NOTES ON THE ESTABLISHMENT AND THINNING OF OLD CROP DOUGLAS FIR IN KAINGAROA FOREST

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SYNOPSIS

An attempt is made to define the siting limits for old crop Douglas fir in Kaingaroa Forest. To do this it is necessary to trace the establishment history of the crop in some detail. In the early 1920s great care in establishment and species siting resulted in more than 90% of the planted area eventually forming a canopy. From 1925 to 1933, standards of establishment steadily deteriorated and species siting was largely ignored. Two-thirds of the 18,000 acres planted from 1930 to 1933 in Southern Kaingaroa failed. Evidence is presented to support the view that rabbit browsing and frosting were responsible for this heavy loss. From 1934 to 1936, a return to careful siting resulted in 90% success once more. Above 2,000 ft a.s.l. and up to 3,000 ft a.s.l. survival of young seedlings is negligible on slopes of less than 1 in 50 (1°). Slopes of 1 in 50 to 1 in 25 (2½°) support a scattered stocking, and on slopes of more than 1 in 25 full stocking is possible. Survival depends on frost levels. Adequate drainage of cold air is essential and this is strongly influenced by local topography.

Brief notes on site and stocking as they affect growth are followed by comments on thinning as it has been practised over a 20-year period. The practice, which is to some degree fortuitous, of heavily thinning (50 to 60% basal area removed) previously untended stands at 35 to 40 years of age has much to recommend it.

ESTABLISHMENT

(1) *Introduction*

Between 1920 and 1936 more than 45,000 acres of Douglas fir were planted in Kaingaroa Forest on all of the major sites and at altitudes between 600 and 2,800 ft a.s.l. The opportunity is thus available to evaluate the performance of this species over a wide range of conditions.

Of the 45,000 acres which were planted, a little over 30,000 acres eventually formed a stocked forest (more than 20% crown closure) at 30 years or more of age. A third of the planted area failed completely. Obviously any evaluation of site requirements must first determine the reasons for the widespread mortality. The available written records of the

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time are sparing in this respect and causes must be pieced together from fragmentary references, a knowledge of the present condition of the old crop, and experience with more recent plantings.

Mortality and understocking in young Douglas fir in Kaingaroa Forest commonly results from spring and summer frosts and from animal browsing; occasionally from smothering by competing vegetation. These prime causes may be aggravated by poor preparation, poor planting, or failure to replace dead trees.

It is proposed to examine the planting of the old crop Douglas fir in historical sequence because standards of establishment changed over the period concerned. Planting commenced in the north of the forest and moved progressively south, so that a historical division of the old crop tends to be geographical also.

(2) *Northern Plantings (up to 1929)*

Douglas fir was among the species used in the first trial plantings of exotic trees on the Kaingaroa Plains in 1897. In 1901 the plots at the present H.Q. site (2 × 0.5 acres) were replanted, largely with this species. These plots were finally clearfelled in 1956.

Douglas fir was not used for the main planting in Waiotapu Plantation in the early 1900s, the first full compartments (Cpts. 1088 and 1113) being established in 1915 on the plain itself. These compartments were pre-pitted and planted at 6 ft × 6 ft spacing by prison labour.

A steady programme of Douglas fir planting began in 1920 and up until 1929 an average of about 2,000 acres was established each year. During this period the forest north of the present half-mile strip was planted.

At the outset, the same care as had prevailed in establishment earlier in the century was exercised. In 1920 all Douglas fir compartments were pitted before planting. This work cost 10s. per 1,000 pits in good going (Cpts. 1073, Pt. Cpt. 1123) rising to £1 per 1,000 pits in rougher areas (Cpts. 1041, 1122). The first area of Douglas fir to be notch-planted was Cpt. 1121 (June, 1921). "The planting of this block is being carried out without digging pits. Poles are set out in straight lines 6 feet apart. The trees are planted 6 feet apart along the line of poles by making a cross cut in the ground with a spade. By planting in this fashion, the expense of pitting is dispensed with and a saving of at least 15/- an acre is anticipated" (Period report). Planting in Cpts. 1121 and 1120 cost 30s. an acre.

In the same year, notch-planting of radiata pine was tried on easy country in the Kaingaroa West (Waireka) Plantation and cost 21s. 3d. per acre, compared with 37s. 9d. per acre for pit plantings (overall). "The trees have not made the same growth as where it was pitted but the extra saving in establishing costs justifies the continuing of this work and it is proposed to do the whole (1922) area without pitting" (Period report). Wages for men at this time were 12s. to 16s. per day.

In 1922, the expected savings in notch-planting were realized. The average cost for the Kaingaroa Plains Plantation was 16s. 5d. per acre and much of the established area was notch-planted Douglas fir.

Further economies were effected in 1923 when notch-planting became universal (to remain the standard practice) and spacing was increased from 6 × 6ft to 8 × 8 ft. A cost of 8s. to 10s. per acre became general, dropping as low as 6s. per acre in the early 1930s at the height of the economic depression.

TABLE 1: AREA OF NORTHERN STANDS

Year established	*Area established*	*Current area*
1915	351	286
1920	102	97
1921	1526	1526
1922	1280	1198
1923	2842	2713
1924	1173	1089
1925	2615	2203
1926	1994	1888
1927	3187	2911
1928	1589	1306
1929	1798	1322
	18,457	16,539

In Table 1, the area planted initially is compared with the current stocked area of the same age class. This gives a measure of the success of establishment. The exclusion of small felled areas of roads and landings and the inclusion of area gained by outward growth of edge trees introduces slight discrepancies in the "current" area but these are of little significance.

If old records and 1941 aerial photographs are examined, a steady decline in the success of these plantings is evident.

The 1920 to 1924 plantings were all made within a few miles of the present Headquarters. This is sited on a high plain at 1,700 to 1,800 ft a.s.l. — a flat or very slightly rolling surface — subject to heavy frosts at any time of the year. To the east of the high plain, a long dissected slope falls in steps to the Galatea Plains (600 ft a.s.l.). In 1915, Cpt. 1113 had been established on or close to the eastern fall and adjacent to Cpt. 1088 on the plain. Much of the Douglas fir in the latter compartment had been badly frosted. Recognition of the sensitivity of the species to unseasonal frosts on areas of poor air drainage is evident in the plantings of 1920 to 1924. These plantings skirted around the edge of the plain and only climbed on to it where nearby deeply incised gullies provided some drainage for cold air *(e.g.,* Cpts. 1073, 1095, 1096, 1097). On

the plain itself, *Pinus nigra* and *Pinus ponderosa* were used and the latter species was also used on flat and frosty valley floors of some hilly Douglas fir compartments *(e.g.,* Cpts. 1066, 1121). Survival was high and the only frost failures in some 5,600 acres planted from 1920 to 1924 occurred in small pockets on the plain some 35 to 40 chains from the nearest major gully system (Cpts. 1073, 1096, 1097). Up until 1923, at least, good preparation invariably preceded planting, and blanking and release cutting were pursued as required. Rabbits were a continuing nuisance to new plantings but were largely controlled. Both of the Kaingaroa stations generally employed a rabbiter who poisoned, dogged and trapped throughout the year. The whole labour force was on occasions employed in combating this pest, which constantly re-invaded from adjacent burnt properties, particularly in the Reporoa area. From the period reports it is clear that the problem was carefully watched at all times, and that steps were taken as necessary. The resultant stocking of Douglas fir is complete on flatter areas, with small and insignificant pockets of failure on the slopes.

The first poorly stocked areas (Cpts. 1128, 1149) appear in 1924, probably as a result of inadequate preparation; although in a report of July, 1925 it is stated that "rabbits are playing havoc on blocks planted last year".

From 1925 to 1929, all plantings were made on sites well suited to Douglas fir but the earlier standard dropped (and has seldom been achieved since) and failure was commonplace. This resulted in poorly stocked stands rather than a complete loss. The country planted was, in general, rolling or steep, between 600 and 1,600 ft a.s.l. and located on the eastern dropover. With the increasing tempo of planting (of the forest as a whole) preparation was sometimes poor and blanking and release cutting were not practised. Although rabbiting is usually listed in programmed work, there is little detailed mention of the measures taken and the impression is gained that work was sporadic. Continual reference is made to numerous and troublesome rabbits on the southern boundary and these were poisoned periodically with carrots grown at Wairapukao nursery. The impressive tally of animals caught at the nursery in 1928 suggests a healthy surrounding population despite such poisoning. The failure of planted flats in otherwise favourable rolling areas is commonplace (Kaiwhatiwhati, Troutbecks, Towai plantings) — a pattern apparent in current rabbit-infested plantings. In some areas the pattern of failure is diffuse *(e.g.,* Cpts. 1247, 42, 52W) and in others the erratic pattern of rows suggests that planting took place through heavy scrub (Pt. Cpts. 1133, 1136, 1242, 53).

In summary, failure is attributed to browsing and smothering. The old crop northern stands have few lessons to teach in the siting of Douglas fir, because of the care with which this was done initially and the undoubted suitability of all areas planted latterly.

Douglas fir has a remarkable capacity to close canopy and form a respectable stand from quite patchy beginnings, but

the result is a loss in volume and a considerable deterioration in timber quality. The 1920-23 H.Q. stands are among the finest exotic plantations in the country and in both yield and quality demonstrate the worth of careful establishment.

(3) *Central Plantings (1930 to 1933)*

From 1930 to 1933, the Douglas fir stands between the present half-mile strip and the Napier-Taupo road were established (as well as 3 or 4 compartments further north). In 1930, Douglas fir began to share in the "boom" and almost 7,000 acres were planted in June and July of that year. By 1933, a further 11,000 acres had been established, thereby doubling the area of pre-1930 stands in four years. All planting was at 8 × 8 ft spacing using the notch technique. Preparation under the pressure of massive plantings was often hurried and inadequate — there are numerous records of lines having to be cut before planting could proceed through heavy scrub. The earlier care in siting was largely abandoned. The rabbit-control measures were thinly spread over the enormous planting block. The net result of this haste is most clearly summarized as follows:

	Period	
	1915-29	*1930-33*
Locality	Northern	Central
Area established (ac)	18,457	17,913
Current area (ac)	16,539	5,280 pure; 955 mixed
Survival	90%	35%

Despite the heavy losses experienced in the 1930-1933 block, a record of only 196 acres of blanking can be found.

The most convenient subdivision of the block is by locality — as shown in Table 2.

The Waimaroke Douglas fir was planted on the western slope between an altitude of 2,080 ft a.s.l. on the high plain

TABLE 2: AREA OF CENTRAL STANDS CURRENT AREA.

Locality	*Area established*	*Current area* *Pure*	*Mixed*	*Major establishment year*	*Compt. numbers*
Waimaroke	5594	824	380	1930	200 to 235
Rotopapa	319	187		1931	252
Wainuki	1860	830		1930	275 to 294, 344
Western boundary	976	104		1931	327 to 337
Waipouri	818	563		1931	483 to 509
Otamatea	2468	803		1932	556 to 567
Waimihia North	5864	1955	575	1931-3	542 to 547 and 580 to 644
	17,899	5266	955		

and 1,100 ft a.s.l. on the western boundary of the forest. The general fall of the slope is about 1 in 27 but local gullies are considerably steeper. Over the greater part of this block, both general and local slope is sufficient to prevent the accumulation of cold air which leads to unseasonal frosting of Douglas fir seedlings. Good survival on unbroken slopes as slight as 1 in 30 at even higher altitudes is not uncommon. Some other reason for the failure of 80% of the plantings must therefore be sought. At this time, mortality surveys were made of all plantings in the first year. For Waimaroke Douglas fir, mortality ranged from 5% to 30%. Rabbits are specifically mentioned as prime causes in only two compartments (Cpt. 203 — 30%; Cpt. 218 — 5 to 10%). However, adjacent radiata pine compartments planted at the same time are recorded as suffering heavy browsing losses. Although insufficient preparation is also recorded in Douglas fir (Cpts. 214, 217, 205 and 233 were line cut while planted), it is considered that rabbit browsing over two years or more accounted for the bulk of the failure. "The 1930 planting mortality count is completed and shows a heavy percentage of deaths mainly due to the depredations of rabbits" (Period report 3/1931). In 1930 only three rabbiters were employed over the whole of Southern Kaingaroa Forest, parts of which were described as "infested". However, immediately after the 1931 mortality count, for a period of two months, rabbiting was the main operation and thenceforth, until mid-1936, 7 to 10 men were continuously employed on dogging, trapping and poisoning. From mid-1931 to the end of 1932, about 2,000 rabbits a month were consistently dogged or trapped and the skins saved where suitable. In 1933 the monthly average dropped to about 1,000 and the following year to 700, indicating some measure of control. In addition, poisoning was used extensively. Even so, rabbits were still numerous. In July, 1932, they were reported as "thick on Run 59 and causing havoc in young trees".

The Wainuki plantings located on Wainuki-High Level roads illustrates the difficulty of separating the effects of site from those of animal damage. The flat portions of all compartments (at 2,000 to 2,100 ft a.s.l.) have failed completely. In most instances this is clearly the result of frost damage and is recorded as such for Cpt. 344. A slight elevation with consequent drainage of cold air allowed some survival. In Cpt. 292, good stocking is, for example, present on mounds rising 40 to 80 ft above the general level of the flats. A slope of 1 in 28 (2°) carries a fair stocking and a slope of 1 in 15 (4°) a complete stocking. However, in Cpts. 293, 294, 276 and 277, failure occurred on tussock patches even when these were on slopes above the severe frost level and survival appears to have been associated with scrub. The tussock patches were quite probably foci of concentration for rabbits. The frosty flats were, of course, tussock clothed.

South of Waimaroke, the western boundary compartments occupying similarly favourable sites failed. In Cpt. 337, 27% mortality in the first year is recorded as due to rabbits. The poor seed strain H.O.27/40 in Cpt. 327 failed completely. This

seedlot is also relatively poor in survival in the Waipouri Douglas fir stands which show high survival except on failed frost flats.

The Otamatea Douglas fir compartments, located on river terraces at the confluence of the Rangitaiki and Otamatea streams, could be a classic area for the study of frost effects. Much of this area is flat and lies between 2,100 and 2,300 ft a.s.l. The main flats have slopes as slight as 1 in 250 (Cpt. 566) to 1 in 400 (Cpt. 567) and here failure is complete. Slopes of 1 in 50 (1°) carry a scattering of survivors (Cpts. 560, 565) and slopes of 1 in 21 (3°) to 1 in 25 (2½°) a full stocking (Cpts. 556, 557 and 560). On mounds rising to a maximum of 100 ft above the flat, stocking is excellent. Good stocking descends to within 20 ft of the level of the plain and a scattering of hardy survivors occurs on any minor elevation thereon. Survival is without doubt related to air drainage. The scattered survivors on the plain are repeatedly cut back by frosts during the growing season, giving a grotesquely hedged appearance. Globular trees 3 to 4 ft in height may be found — a dense ball of intertangled branches surrounding a sturdy gnarled trunk. Remarkably enough, occasional trees in these extreme sites are of near normal appearance and are obviously worth propagating. Severe frost damage up to 30 ft or more above ground level may be observed in spring and summer on the plain — which presents a paradox because survival may be excellent on mounds less than 20 ft high.

The Waimihia North stands, straddling the High Level Road immediately north of the Napier-Taupo Road, cover a wide range of sites. Altitude ranges from 2,200 to 2,520 ft a.s.l. The failure of more than half the planted area is attributable to both frost and rabbit browsing. At the highest altitude, slopes of 1 in 50 carry a scattering of trees and slopes of 1 in 15 (4°) a full stocking. To the west of High Level Road, failure is complete on the flat high plain at 2,200 to 2,300 ft a.s.l. Mortality of 20% or more was commonplace in the first year and was recorded as due to frost (Cpts. 580, 586, 594, 593, 626, 633, 638), rabbits (Cpts. 542, 547, 617, 626, 630, 644), and horses (Cpt. 639). A particularly heavy unseasonal frost in early 1934 caused severe first-year losses *(e.g.* Cpt. 633 38%).

The failed areas in Waimaroke and Waimihia North were replanted in *Pinus contorta, Pinus nigra* and *Pinus ponderosa* from 1936 onwards.

Despite the obscuring effect of animal damage, the Central plantings demonstrate that Douglas fir cannot be expected to survive at all on slopes of 1° or less, above 2,000 ft a.s.l., but that full stocking can be achieved on remarkably slight slopes (+ 3°) provided the downward flow of cold air from these slopes is unimpeded.

(4) *Waimihia South Plantings (1934 to 1936)*

The final block of old crop Douglas fir plantings was in the extreme south-west of the forest between altitudes of 1,700 and 2,800 ft a.s.l. Much of this block is deeply dissected

by the heads of gullies falling to Lake Taupo. It is apparent that the failure of Douglas fir on the frost flats of the Central area strongly influenced siting in Waimihia South. Douglas fir was here confined to sloping ground and flats were planted in ponderosa, Corsican or lodgepole pines. The boundary between the Douglas fir and the pines was often a straight line drawn across the toe of the slopes. Excellent survival up to almost 3,000 ft a.s.l. resulted from this care. Of the 9,359 acres originally planted, 8,555 were classed as stocked in 1967 *(i.e.,* 91%). Such poor stocking as exists (1,000 acres) results from planting through heavy scrub and fern and not subsequently releasing (Cpts. 744, 745, 690, 693).

GROWTH AND YIELD

General growth trends for Douglas fir on pumice soils are covered fully by Spurr (1963). The data here are largely supplementary.

(1) *Site*

Although differences in soils are apparent in the various pumice showers found through Kaingaroa Forest, the main factors affecting potential tree growth result from differences in altitude and local topography. On flat areas, with poor air drainage, complete failure of Douglas fir is commonplace and in the immediate periphery height growth may be retarded. But wherever air drainage has been adequate, height development at any given age appears to fall within a relatively narrow band — over a wide range of altitudes. This contrasts markedly with radiata pine, in which height development falls off above 2,000 ft a.s.l. Recent assessments over large areas have revealed that Douglas fir stands at 600 to 1,500 ft a.s.l. (1926 to 1929 age classes) at one extreme and 1,700 to 2,800 ft a.s.l. (1934 to 1936 age classes) at the other show identical average growth in top height. Stands in both areas lie close to Spurr's mean curve for pumice land (which corresponds to the mean of Kaingaroa Forest sample plots). Sample plots lie largely in the site index range of 75 to 90ft mean top height at 30 years.

(2) *Stocking*

The range of site, as expressed by top height growth, is comparatively narrow. Major differences in volumes per acre at any given age are related to stocking and result from differences in early survival. Low initial stocking results not only in depressed yields but also in decreased timber quality.

The magnitude of loss in yield may be gauged from a recent assessment of Waimihia South stands (172 tenth-acre plots). Stocking per acre is correlated with basal area as shown in Table 3. The averages by types are given in Table 4.

TABLE 3: WAIMIHIA SOUTH 1967 ASSESSMENT
(MEAN AGE 32 YEARS)

s.p.a.	*B.A./acre (sq. ft)*
100	140
200	220
300	285
400	335
500	380
600	410
700	420

TABLE 4: WAIMIHIA SOUTH — TYPE AVERAGES

	Type A	B	C
No. of plots	100	52	20
Mean s.p.a.	502	358	245
Mean B.A./acre	373	309	200
M.T.H. (ft)	86	82	78
Mean d.b.h. (in.)	11.7	12.6	12.3
Mean d.b.h. top 100 s.p.a. (in.)	16.2	17.1	16.7
Total volume/acre	11,184	9,101	5,685
Volume/acre to 5 in. s.e.d.	10,404	8,580	5,416
Volume/acre to 10 in. s.e.d.	5,096	4,972	3,391

SILVICULTURE

Although high pruning has been practised over thousands of acres, it is not intended to review the expected gains or losses from this operation, much of which was belated by current standards.

(1) *Thinning — Northern Stands*

The thinning regime for Kaingaroa Douglas fir has developed as markets allowed, within the framework of the old crop age-class distribution. Until the early 1950s markets were practically non-existent and until the mid-1950s they were limited. Large-scale operations began as the demand by Waipa State Sawmill expanded and Tasman Pulp and Paper Co. Ltd commenced sawing in 1956. From 1947 to 1966, some 7,000 acres have been thinned, mainly the oldest and best stocked stands. (The 1926 to 1933 age classes are at present virtually untouched.) The excellent stocking of these stands has resulted in the production of large volumes of round produce, which until recently has been in strong demand, as well as good quality sawlogs. The condensed age-class distribution of thinned stands has resulted in an increase in the age of first extraction thinning from 25 years initially to 42 to 47 years at present.

Extraction has been carried out with crawler tractors, working where necessary from contoured extraction tracks, and to a limited degree by winch.

(2) *1947 to 1953*

In 1947, in the absence of markets, thinning to waste commenced in Cpt. 1152 (8 × 8 ft, 1925) and up until 1953 proceeded through similar stands in Cpt. 1153 and Cpt. 1226. Extraction of produce, where practicable, was limited to a few poles, rails and strainers or to sawlogs, to an 8 in. top). The latter operation yielded about 900 cu. ft/acre at 27 years of age.

The aim in thinning these 8 × 8 ft stands was to leave a residual stocking of 230 s.p.a. (thinning to waste at 21 to 22 years of age) reducing to about 190 s.p.a. when extraction thinning commenced (24 to 25 years of age). The results may be judged from the assessed averages in Table 5.

TABLE 5: 1967 ASSESSMENT DATA 8 × 8 FT STANDS

Period thinned	*No. of plots*	*s.p.a. 1967*	*B.A./acre 1967 (sq. ft)*	*Ht in 1967 (ft)*	*Mean age at thinning*	*Estimated B.A./ acre after thinning* (sq. ft)*
1948-50	39	172	289	124	24	112
1951-53	21	186	283	123	25	134

*Based on local variable density yield table (Elliott, 1969).

In 1949, thinning of the oldest 6 × 6 ft stand (Cpt. 1113, 34 years) began. The compartment was variously thinned, with and without extraction. To begin with, a stocking of 220 to 230 s.p.a. was left. To effect economies in extraction thinning, the residual stocking was lowered to 120 to 140 s.p.a. early in 1950, leaving co-dominants as the crop. This was raised to 180 to 200 s.p.a. later in 1950 as the result of a price rise. A gale in early 1951 created havoc in the more heavily thinned stands and the residual stocking then settled down to 200 to 220 s.p.a. The subsequent growth of these stands is shown in Table 6. The tabulated information is derived from permanent sample plot R101 and the estimate of total production from compartment records.

TABLE 6: GROWTH IN COMPARTMENT 1113, THINNED 1951, AGE 36

Year	*B.A./acre (sq. ft)*	*s.p.a.*	*Total stem volume (cu. ft/acre)*
1951	207	216	7,023
1954	239	216	8,559
1957	266	214	10,386
1960	297	214	12,220
1963	325	212	14,596
1966	351	212	16,068
Estimated total production	440		19,000

These data indicate that good yields can be obtained at 10 to 15 year intervals. In fact, a second thinning in 1966 reduced the stand to 110 s.p.a. and 200 sq. ft of basal area per acre.

During the period 1947 to 1953. an average of 270 acres per year was thinned.

(3) *1954 to 1958*

During this period thinning was concentrated in the 6 × 6 ft stands of the 1921-22 age classes (32 to 37 years of age). The aim was to leave 190 s.p.a. and 150 sq. ft/acre basal area. Results are given in Table 7.

Both residual s.p.a. and basal area were steady throughout. An average of 308 acres a year was thinned.

TABLE 7: ASSESSMENT DATA, 1967, 6 × 6 FT STANDS

Period thinned	*No. of plots*	*Stems per acre, 1967*	*B.A./acre 1967 (sq. ft)*	*Ht in 1967 (ft)*	*Mean age at thinning*	*Estimated B.A./ acre after thinning (sq. ft)*
1955-58	35	163	245	124	34	169

(4) *1959 to 1966*

Over this period both 6 × 6 ft and 8 × 8 ft stands were thinned. In the general working plan prescription a residual stocking of 160 s.p.a. to 240 s.p.a. was laid down. An average of 170 s.p.a. was envisaged in 8 × 8 ft stands and 190 s.p.a. in 6 × 6 ft stands. Results are given in Table 8.

TABLE 8: 1967 ASSESSMENT DATA

Period thinned	*Spacing (ft)*	*No. of plots*	*s.p.a. 1967*	*B.A./acre 1967 (sq. ft)*	*Ht in 1967 (ft)*	*Mean age at thinning*	*Estimated B.A./ acre after thinning (sq. ft)*
1959-62	8 × 8	44	135	197	123	38	156
1959-62	6 × 6	48	156	220	123	39	175
1963-66	8 × 8	78	127	189	122	41	174
1963-66	6 × 6	33	132	188	123	44	179

It will be noted that thinnings were heavier than prescribed, which is commonly the case. Intensity varied considerably from year to year. A residual basal area of 180 sq. ft/acre in 8 × 8 ft stands and 190 sq. ft/acre in 6 × 6 ft stands was the general peak, the average being pulled down by heavier thinnings in some years.

Hauler thinned stands, which were thinned very heavily (down to 70 s.p.a.), are not included in the above totals.

(5) *Thinning Intensity and Yields*

Until recently no detailed record has been available of the condition of the Douglas fir stands prior to thinning. The intensity of thinning can therefore be arrived at only indirectly.

By using available information on the condition of well-stocked stands (comparable to those which have been thinned) at age 25 and projecting this from the local yield table (Elliott, 1969), the general trends indicated in Table 9 are calculated.

TABLE 9: ESTIMATED AVERAGE GROWTH OF WELL STOCKED NORTHERN STANDS

Age	*M.T.H.* (ft)	*B.A./ acre* (sq. ft)	*s.p.a.*	*Mean d.b.h.* (in.)	*Total volume* (cu. ft)	*4 in. top volume* (cu. ft)	*6 in. top volume* (cu. ft)
			8 × 8 FT SPACING				
20	53	190	500	8.3	3726	3280	2380
25	67	250	480	9.8	6195	5700	4770
30	82	305	450	11.1	9248	8690	7680
35	95	346	410	12.4	12,155	11,550	10,700
40	108	379	365	13.8	15,133	14,530	13,620
			6 × 6 FT SPACING				
20	53	228	860	7.0	4471	3620	1970
25	67	295	800	8.2	7310	6430	4530
30	82	344	720	9.3	10,430	9490	7610
35	95	380	625	10.6	13,349	12,550	10,810
40	108	412	505	12.2	16,451	15,630	14,310

The table accords well with recent assessment in unthinned stands of about age 40.

It should be emphasized that the spacings are nominal and that, in the 8 × 8 ft stands, particularly, the distance between rows and between trees is most variable. Part of the reason may be found in the following comment (1922): ". . . the men are becoming more accustomed to (notch) planting, the greatest difficulty being to get them to space the trees along the line correctly. The slow men are always inclined to take long steps to keep up with others, the fast men doing the same to keep ahead. . . ."

Using the table of average growth and the estimated residual basal areas shown in the previous section, it is apparent that first thinnings from 1955 to 1966 have generally removed 50% to 60% of the total basal area. This is a particularly heavy thinning by most standards. The yield per acre has ranged from 4,500 cu. ft in 1955 to 7,000 cu. ft in 1965. No steady rise is apparent and large fluctuations in yield correspond to varying thinning intensities from year to year — *e.g.*, in 1960 a yield of over 7,000 cu. ft/acre corresponded to a residual basal area of 145 to 150 sq. ft/acre in both 6 × 6 ft and 8 × 8 ft stands. Two years later yield dropped to 5,200 cu. ft/acre and residual basal areas rose to 190 sq. ft/acre.

(6) *Thinning — Southern Stands*

The thinning of Waimihia South stands commenced in the early 1960s. Yields, of sawlogs only, have been 2,000 to 3,000 cu. ft/acre, thinning to a prescribed residual stocking of 200 s.p.a. No assessment data are available from thinned stands. A small amount of windthrow has occurred after thinning. (No significant windthrow has occurred in northern stands since the Cpt. 1113 blow in 1951 — despite the heavy thinning intensity.)

(7) *Thinning — General*

The partly fortuitous practice of leaving the stand unthinned until about age 35 has given good results and might well be the most satisfactory initial treatment. The tight stocking has reduced branch size and resulted in the early death of branches. Recent studies by Whiteside (unpubl., 1968) show that branch size is one of the most important factors in determining the strength of Douglas fir timber. The heavy first thinning has stimulated rapid diameter growth of the finely branched bole and produced a high thinning yield which, together with good average piece size (the result of delay), has maintained the extraction cost at a low level.

There are insufficient basic data to be adamant about the economic advantages of any given schedule. The species is silviculturally extremely flexible, mainly as a result of low rates of mortality and good growth over a wide range of conditions — which will complicate rather than simplify the choice of schedules for the post-war stands. This choice and the ultimate rotation length should be influenced to a large extent by costs of utilization (logging and sawing). These aspects of Douglas fir management are well covered by Fenton (1967a, b).

There would appear to be little point in thinning to waste and the earliest that extraction thinning is likely to be attempted is 25 years of age. A thinning from below (with outrow tracking) at this age could yield 1,000 cu. ft/acre with close utilization, and could increase piece size 10 years later by 50% (compared with an unthinned stand).

In general, a regime which allows basal areas to build up to 300 sq. ft/acre (or more) before a thinning leaving not less than 150 sq. ft/acre will ensure rapid rates of growth and high thinning yields.

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