SILVICULTURE ON DUNE SANDS

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SYNOPSIS

Coastal drift sands used for exotic afforestation in the Auckland area exhibit a wide range of productivity. This is believed to be due to the influence of buried soils rather than variation within the sands. The sole species now used is radiata pine following experience over 28 years with several species. Stand development shows fast initial height growth with a mean top height averaging 83 ft at 20 years of age. Thinning regimes have shown extreme variation but basal area development trends are similar even in stands in which thinnings have been long delayed. Wood yields on sand are comparatively low, but operations are largely mechanized, costs low, and proximity to markets will ensure a good return.

The information presented in this paper is derived entirely from the two old-established sand dune forests in the Auckland Conservancy — Woodhill and Waiuku. It has deliberately excluded the tree planting stage, which in the present symposium is more appropriately linked with mechanization of operations discussed in the paper by Restall. An attempt is made to consider most of the remaining aspects of silviculture.

SOILS

The soil pattern is at once both simple and complex for, although there is yet little profile development on the sand surface itself, the effects of the buried former topography, drainage, and soil pattern are undefined and elusive. Wide variation observed in site capacity can at present be explained only by assuming a dominant influence from the landscape beneath. Surface soil profiles exhibit little variation throughout the forest. Accumulation and decomposition of surface organic matter begin immediately following the fixation with marram and lupin.

Examination of a limited number of soil profiles under radiata pine stands of increasing age up to 26 years reveals a progressively increasing surface organic layer, the development of a well-defined A_1 horizon, and some humus staining down to about 4 in.

The uniformity of the sands is well illustrated by the results of analyses by the Forest Research Institute in 1952 of thirteen samples from a wide range of sites at Woodhill. Phosphorus deficiency is generally regarded as a limiting factor in the growth of *Pinus radiata*. Analyses of total phosphate revealed a content of 560 to 800 parts per million in the topsoil and 439 to 930 parts per million at 18 in. These levels can be regarded as generally adequate for healthy development of radiata pine, and this is borne out by lack of response to phosphate dressings. Applications of up to one ton of phosphatic fertilizer in 1952 produced negligible response. No phosphate analyses are on record for Waiuku, but a dressing of 10 cwt of superphosphate per acre in 1955 in one plot produced a doubling of the current basal area increment rate by 1957, but a reversion to the previous level in 1959. Will (1961) reports that levels of foliar phosphorus at Woodhill are among the highest in the country.

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At neither forest has there been analysis of other major or minor elements. Attention is at present being directed by Forest Research Institute towards the nitrogen cycle and its influence on the tree crop but this investigation is in only the very early stages.

By inference from the soil map of lands east of and adjacent to the Woodhill dunes (N.Z. Soil Bureau, 1954), the submerged landscape carried soils derived from pumiceous sands, and in limited areas from andesite. Some of these soils are of medium natural fertility. Likewise, north-east of Waiuku there lies a fringe of sandy pumice soil, also of medium fertility. In both forests, low ridges of soft sandstone — or consolidated sand — lie exposed, suggesting that at least some of the previous landscape has been bared down to the parent material. These outcrops are not favourable to tree growth, in spite of a relatively high phosphate level.

CHOICE OF SPECIES

Species siting cannot conveniently take into account the unknown influences that lie beneath the dunes. As later data will show, there is a wide range of productivity on sites carrying radiata pine in both forests. Factors other than soil capacity dominate the selection of species. The primary consideration is resistance to saline winds, which effectively restricts the choice to *Pinus radiata, P. muricata* and *P. pinaster.* These three species dominated the planting programme from 1936 to 1942. During the twenty years from 1942, no fewer than 34 species were planted, mostly in small lots. These yielded nothing of significant value either as protective species behind the foredune, or as timber producers further back. The exception is possibly *Eucalyptus botryoides,* which is both resistant to sea winds and a producer of durable timber, but restricted in its local market value. Both *P. pinaster* and *P. muricata,* though healthy, have generally poor form, gross habit, and low volume production, and are not amenable to the production of high quality logs. *Pinus radiata* stands alone as the species with almost all the characteristics desired by the silviculturist and the wood user — good form, relatively light branching, deep crowns, adequate volume increment, low incidence of timber defects, and ease of handling in the nursery and field. For these reasons radiata pine is now the sole species used in all planting, other than small trials.

NURSERY PRACTICE

This may be dismissed briefly, for there are no radical departures from standard practice to warrant discussion. Planting stock, particularly for machine planting, must be large, for only deep planting gives an acceptable survival rate. Autumn broadcast sowing is the rule with the aim of producing sturdy well-wrenched stock 18 in. high. The contention that trees for dune establishment should be grown in a sand nursery is without solid foundation and supplies for future programmes will come from a nursery on alluvial soil. Woodhill nursery itself has suffered badly from attacks by white-fringed weevil (*Graphognathus leucoloma*) and black beetle (*Heteronychus sanctae-helenae*). A measure of control over the latter is obtained with dieldrin, but no satisfactory treatment for white-fringed weevil has been found and losses are occasionally heavy.

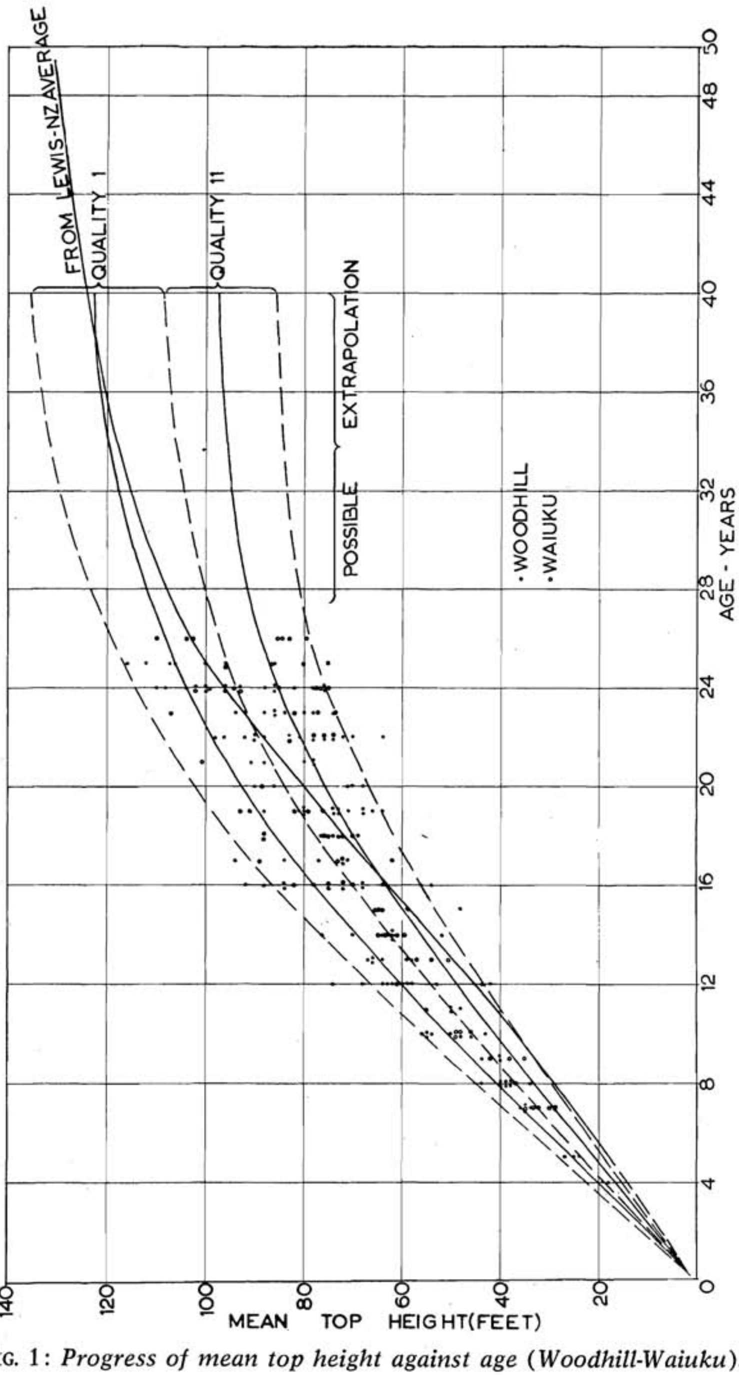


FIG. 1: *Progress of mean top height against age (Woodhill-Waiuku).*

GROWTH OF *PINUS RADIATA*

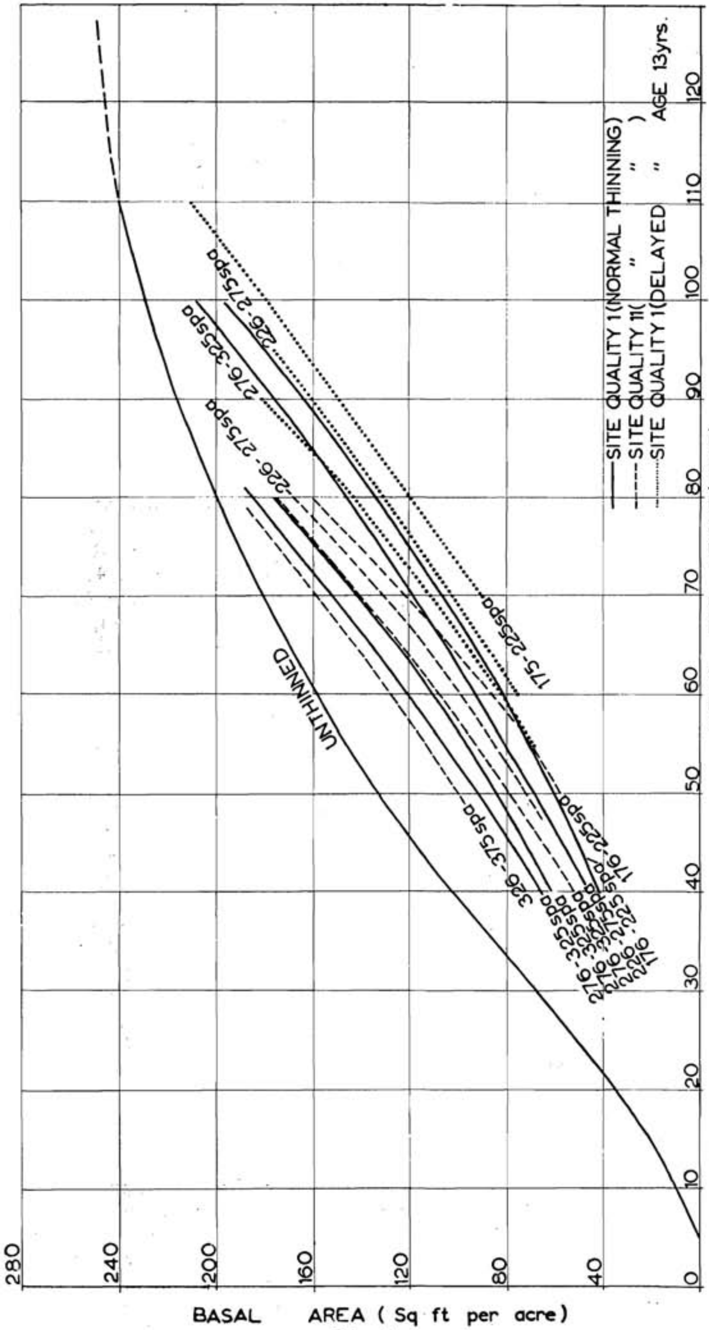
Systematic collection of increment and yield data was begun relatively recently at Woodhill. Apart from one set of permanent sample plots established on a low quality site in 1951, there has been practically no intensive measurement until 1962. In this year, 60 half-acre permanent increment and yield plots were established through the forest to cover a wide range of sites and previous thinning practices. The situation is a little better at Waiuku where 100 fifth-acre permanent plots were established and measured in 1955, and re-measured in 1960, and increased by a further 40. Unfortunately, in 1955 height sampling was by strata only and it is not possible to trace increment of individual plots, thus reducing the value of the data. The discussion which follows is therefore based on the examination of combined data from Woodhill and Waiuku, representing one measurement only of stands up to 26 years of age.

Mean top height is plotted against age in Fig. 1, and curves are drawn on the basis of a division into two site qualities. The resultant site index range is from 66 to 101 with the division between quality classes at 83. Superimposed upon this graph for purposes of comparison is Lewis' universal curve (1954) for unthinned stands of *P. radiata* in New Zealand. The significant local features are early height development, in excess of the national average, a crossing over at about twenty years, and a probable flattening off in height increment, suggested by extrapolation of the curves to 40 years. It seems probable that the final mean top height at age 40 on site quality I will seldom exceed 125 ft. It is clear that any height predictions earlier than 20 years of age, using the universal table for unthinned *P. radiata*, can lead to gross over-estimates.

PAST SILVICULTURE

Before further considering stand development, a brief appreciation of the history of pruning and thinning is appropriate. Sand fixation and afforestation programmes were conceived for the purpose of protecting farmland, highway and railway from the advancing wall of sand. Protection was the paramount consideration and available money was required to go as far as possible toward meeting that aim. There was also an understandable reluctance on the part of the early administration (to whom forestry was almost a closed book) to thin and risk losing hard-won vegetative cover. As a result, there was little attention given to pruning or thinning, so that when the Forest Service assumed control in late 1951 some 800 acres had been pruned to 6 ft, mainly at Waiuku, and only a negligible area had been pruned to 16 ft and thinned. From 1952, a concerted effort to eliminate arrears was directed initially at the older age classes and then to progressively younger stands. An analysis of records reveals that the effective result is a range at pruning and first thinning of 8 to 21 years of age, the majority certainly in excess of 12 years of age.

The irregular pattern of thinning was further aggravated by cessation in 1955 of all thinning to waste owing to anticipation of a market for a substantial volume of small thinnings. Thinning was resumed again in 1959. While thinning of 1944–47 age classes was still late, it represented an improvement on earlier practice. By the time 1948 and younger stands were pruned and thinned, there was greater appreciation of the need for timely treatment.



SITE QUALITY 1(NORMAL THINNING)
SITE QUALITY 11(")
SITE QUALITY 1(DELAYED ") AGE 13yrs.
MEAN TOP HEIGHT (FEET)
BASAL AREA (Sq ft per acre)
UNTHINNED
226-275spa
276-325spa
175-225spa
326-375spa

Fig. 2

CURRENT AND FUTURE PRACTICE

Turning back to stand development, Fig. 2 illustrates basal area per acre plotted against mean top height separately for unthinned stands and for stands first thinned prior to mean top height 45 ft, and for those first thinned later than mean top height 45 ft. They are further grouped into stocking classes at 50 stems per acre intervals. The curve representing unthinned stands indicates a maximum basal area of 240 sq. ft at 40 years, compared with the universal yield table figure which exceeds 300 sq. ft. Unlike height development, which initially exceeds the average and falls off after 20 years, basal area increment is consistently less throughout.

Figure 2 is an attempt to group a mass of data on stands of various densities, site qualities and stages of first thinning in such a way that some pattern can be derived. The following features are significant. Apart from an anomalous curve in the 276 to 325 stocking, basal areas for a given mean top height are consistently higher for S.Q.II stands than for those of S.Q.I. For any given stocking class and mean top height, basal area is lower in the delayed stands owing to depression of growth prior to thinning. The result is that thinning to the same stocking gives a lower basal area than in comparable stands thinned on due date. Regardless of site quality or thinning delay, the basal area response to thinning shows the same trend, and in practice the main result of delay is a lengthening of the rotation and a more rapid rise in the green crown.

The pattern will be simplified in the future as thinning intensities become more standardized and no longer will be delayed.

Figure 4 shows the rise of green crown in stands up to 90 ft mean top height which have received approximately normal thinnings. The current pruning schedule is given in Table 1.

TABLE 1: PRUNING SCHEDULE

Pruning Height (*ft*)	*Mean Top Height* (*ft*)	*Height Green Crown* (*ft*)
0/8	25	5
8/18	35–40	10–13
18/27	45–50	16–19
27/36	55–60	22–26

The pressure of demand is unlikely to permit a rotation exceeding 40 years in forests near to Auckland. It is worth considering on theoretical grounds the justification for second log pruning from 18 to 36 ft. The average diameter b.h. of final crop trees on S.Q.I at 40 years is not expected to exceed 19 in. On the current pruning schedule using Auckland Conservancy taper tables (Duff and Burstall, 1952) for unthinned stands, clearwood outside knotty cores will be less than 3 in. The conclusion is at present that only on the upper quality I sites is pruning warranted beyond 18 ft.

The effect of past thinning practices on mean top diameter is illustrated by Fig. 3, where mean top d.b.h. is plotted against mean top height. Data are limited for the upper part of the unthinned stand curve as few older areas remain unthinned. The trend shown is that which would be expected — *i.e.,* a slight increase in mean top d.b.h. in thinned stands.

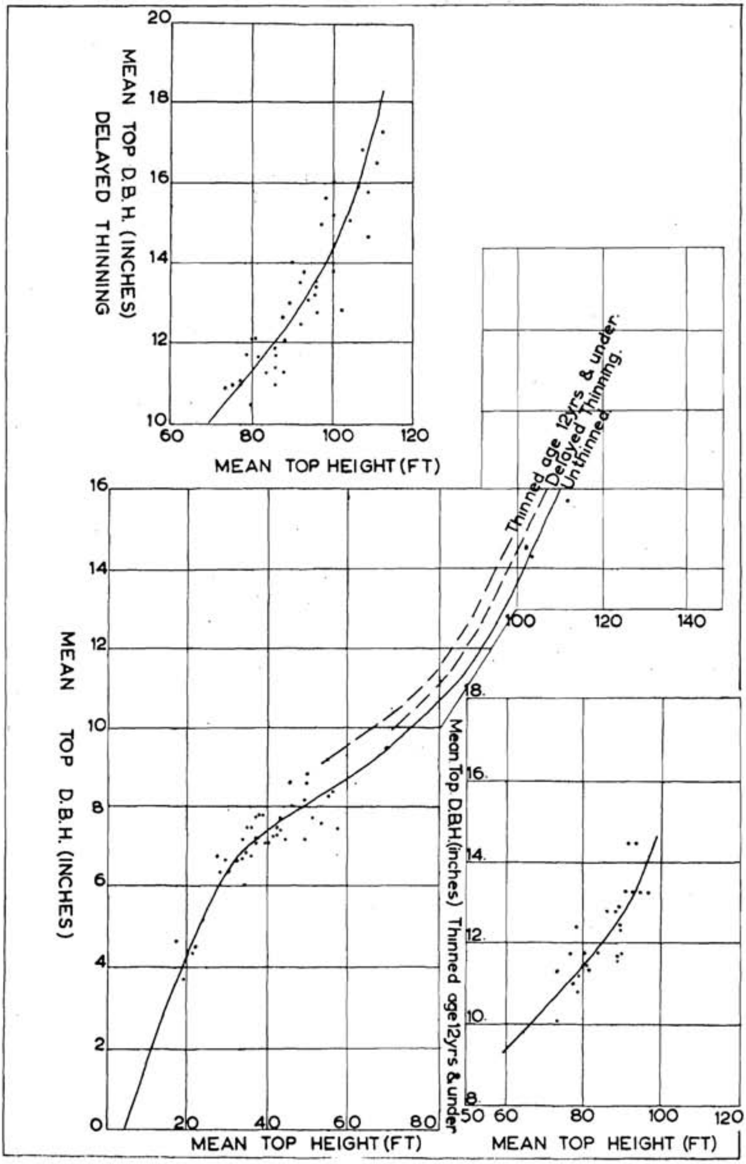


Fig. 3

As indicated in Fig. 2, past thinning practices have varied considerably and appreciable areas now have depressed diameters, with consequent loss of clearwood. The illustration which follows in Table 2 is the current tentative thinning schedule, with relevant stand data.

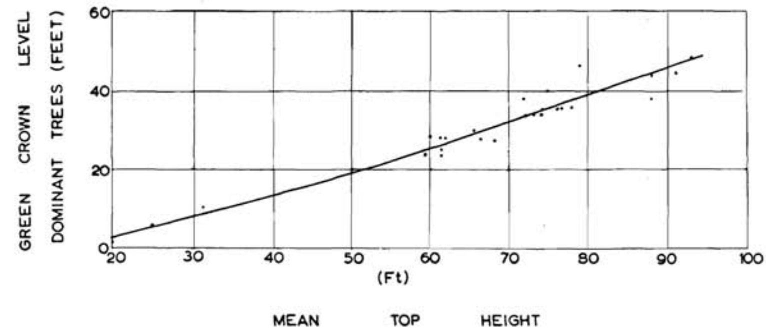


Fig. 4

TABLE 2: THINNING SCHEDULE

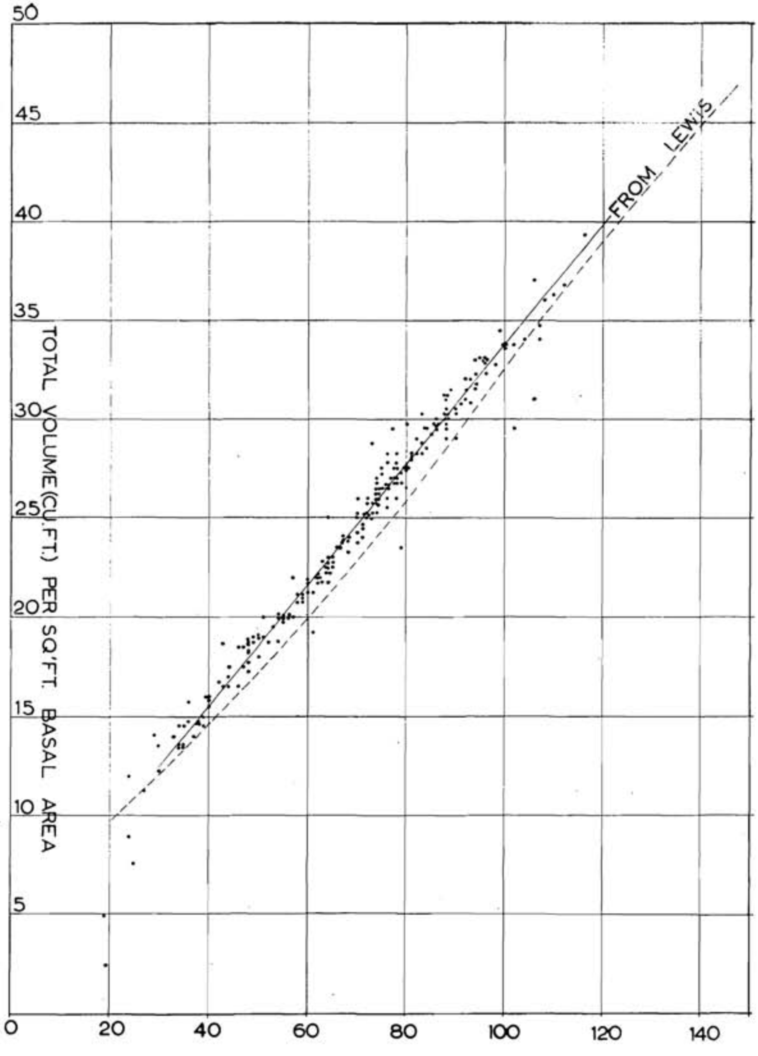
Thinning	*Mean Top Ht (ft)*	*Age on S.Q.I Sites*	*Stocking B**	*Stocking A**	*Basal Area (sq. ft/ac.) B**	*Basal Area (sq. ft/ac.) A**	*% Spacing B**	*% Spacing A**	*Yield cu. ft total*	*Cumulative Yield cu. ft total*
1	40	9	700	225	110	45	20	35	1,000	1,000
2	85	18	200–250	120	150	95	18	24	1,600	2,600
3	105	25	120	80	150	110	19	24	1,300	3,900
Clear-fell	125	40	80	—	160	—	20	—	6,600	10,500

* Before and After thinning respectively.

Volumes have been calculated from the line in Fig. 5 depicting volume per square foot basal area on mean top height.

The latter half of the schedule is purely conjectural. Alternative theoretical schedules have been considered but these do not increase the expected total yield. Nevertheless, in view of the recent commitment of part of this forest to industry for production of both sawlogs and chipwood, it is quite probable that this schedule will be modified by experience. The important features to stress are that final yield and maximum d.b.h. are relatively low for a 40-year rotation on S.Q.I. Although it is logical to assume a longer rotation for S.Q.II, the intricate mosaic pattern of sites will probably mean in practice that few lower quality stands will be of sufficient area to be left standing after adjacent stands are felled. No volume data are presented for S.Q.II but undoubtedly the yield will be very low.

Some of the information presented, and in particular the low yields, may suggest that sand dune silviculture is not as attractive as first thought. However, when one considers that practically all establishment is mechanized, and easy topography reduces tending and logging costs, the prospect improves. Add to this a considerable freight advantage, compared with forests more distant from the Auckland market, and the outlook becomes rosy. Henceforth assured markets will take much of the uncertainty out of silviculture, and enable practices to be laid on a solid silvicultural and economic foundation.



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MEAN TOP HEIGHT (FEET)

Fig. 5

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