A REVIEW OF DOUGLAS FIR IN NEW ZEALAND

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Abstract

This paper summarizes the papers presented, and the discussion which took place, at a symposium held at Rotorua in 1974. Its purpose was to examine current knowledge of, and attitudes to, the role of Douglas fir in New Zealand as a forest crop and as a source of wood products. The symposium examined silvics, wood properties, marketing, current management and future prospects for the species in New Zealand.

INTRODUCTION

In September 1974 some seventy people — sawmillers, papermakers, marketing experts from private and government industries, forest managers, forest consultants and scientists — met in Rotorua, to take part in the fifteenth forest management symposium organized by the New Zealand Forest Research Institute.

Their topic was "A Review of Douglas Fir in New Zealand" and they had already received nearly fifty papers dealing with all aspects of the use of this species in New Zealand. Eventually a full record of the discussions and papers will be published as part of the FRI Symposium series. The intention here is to present a summary of the main points made during the four days of formal discussion and the two field trips. In a condensed version such as this it is inevitable that a good deal of useful discussion and data is left out. The author apologizes for this and for any misrepresentations of statements by participants that may have accidentally occurred.

The Symposium was divided into five sections:

(1) The "silvics" of Douglas fir

(2) Wood properties of Douglas fir

(3) Marketing of Douglas fir

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(4) Current management of Douglas fir

(5) Future prospects for Douglas fir in New Zealand.

In the main, this summary will follow that sequence.

THE IMPORTANCE OF DOUGLAS FIR IN NEW ZEALAND

In New Zealand, Douglas fir (*Pseudotsuga menziesii*) plantations occupy 47 000 ha, or about 7% of the total exotic forest estate. More than 90% of this area is in State forests and over half the area is within the Rotorua Conservancy. Little interest in the species has been shown by the private sector, and data presented to the symposium by T. Fraser revealed that the area of new planting in State forests had dropped until it represents only 4% of current efforts. It is estimated that 5% of current wood production from exotic forests comes from Douglas fir. Almost all of this (93%) comes from State forests, mainly from thinning operations, as clearfelling has so far been confined to poor quality stands.

Douglas fir is probably New Zealand's second most important exotic species, but its place next to radiata pine (80% of stocked area, 66% of current wood production) is still relatively minor.

In opening the symposium, C. Bassett stated that the Forest Service was in the process of developing a new policy for the future of Douglas fir and that the symposium, by gathering together all the available facts about the species and providing a forum to discuss their implications, could facilitate this policy-making process. In the discussions, comparisons were made with New Zealand's principal forest species, radiata pine. It is fair to say that throughout all sessions two doubts about Douglas fir permeated the discussions: (1) The effect of the Swiss needle cast disease *Phaeocryptopus gaeumannii* on growth, and (2) The comparatively poor economics of Douglas fir as a forest species.

SILVICS OF DOUGLAS FIR

Seed Source

Although Douglas fir has been planted in New Zealand for about 100 years, it is only since 1927 that accurate records have been kept of the origin of imported seed. It is commonly believed that the plantings between 1915 and 1928 came mainly from seed collected in Washington State and that most seed since then has come from there, with some from Oregon and British Columbia and, recently, some from California. The rankings of the best 15 provenances, as determined from a trial series established in 1959, were presented in a paper by M. D. Wilcox. This trial, planted over six sites throughout New Zealand, had been evaluated according to five criteria: height,

growth, diameter growth, straightness, wood density, and needle retention (*i.e.*, resistance to needle cast), and an index of performance derived. Of the five best provenances, four came from California. Some indication of the improvement potentially available by using these strains was given by G. B. Sweet. He said that in the North Island two provenances (642 and 654) which had been established over a considerable area, and were thus likely sources of seed supplies in the future, contained about 30% more volume on an average tree by age 15 than trees from the Kaingaroa seed sources we have used in the past.

The chances of breeding for resistance to *Phaeocryptopus* were reckoned to be small. Sweet pointed out that there appears to be a negative correlation between needle retention and growth, the slower growing provenances often being most immune to needle cast. A Mexican species, *Pseudotsuga flauhaulti*, has caused interest as it appears to have a higher needle retention than ordinary Douglas fir of Kaingaroa or Californian origin, and growth in the few areas where it is represented in New Zealand appears to be fair. However, as no stand of *Pseudotsuga flauhaulti* is older than seven years, it is too soon to judge the importance of the species. Dr Sweet explained that the best source of seed available at present is from two stands of the Californian strain — 654. If thinned, these would yield enough seed to plant 2 000 ha per year and the stands would be more vigorous than those derived from the seed stands used to date.

Specifications for Planting Stock

The correct height of seedlings for planting out was discussed. There is considerable variation in the height of two-year-old seedlings throughout New Zealand, and seedling size can cause problems in successfully establishing plantations. This is because small seedlings can go into "check" and pause for a year in their growth and because weeds can more easily compete with small seedlings. E. H. Bunn related experience at Pureora forest where the use of large stock had avoided "growth check". A. N. Cooper strongly advocated the use of three-year-old seedlings which were often at least 60 cm high. His experience at Whaka forest was that seedlings as tall as this saved at least one release cutting, and despite the extra nursery cost it was generally acknowledged that this would reduce costs overall.

The successful use of nitrofen as a nursery weedicide was reported by J. C. Van Dorsser; before the advent of this chemical, weed control had been a problem for nurserymen, as Douglas fir is susceptible to many of the common weedicides that can be used with radiata pine.

Site Limitations

It has long been recognized that Douglas fir does not thrive on many of the sites used for forestry in New Zealand. D. H. Revell presented a review of overseas experience of siting problems and a prediction method he had developed for New Zealand which could be used to determine the number of trees expected to survive and the number of malforms expected under various site conditions. American studies have shown the major limitation to Douglas fir in its native habitat to be moisture availability. This is in turn a function of soil characteristics, topography and regional climate. Reports from Britain and Europe add the further constraints of susceptibility to late frosts and an intolerance to exposed conditions. Experience with Douglas fir in New Zealand has confirmed that these same limitations apply here.

Revell found it necessary to divide the 139 North Island sites which he investigated into three broad regions, as relatively low correlations were obtained between performance and site factors when all sites were considered together. In the northern part of the North Island, heavy, poorly drained clay soils and exposure, particularly to salt winds, were the major limitations. In the central North Island there is a general decline in performance at altitudes above 900 m. Adequate air drainage is essential to avoid frost problems, and again soils must be free-draining. Exposure is the major limitation on the east coast of the North Island and good growth is found only on sites protected from north-west winds. However, Douglas fir does show a greater tolerance to some limitations than does radiata pine. Above 650 m in the North Island and about 500 m in the South Island the potential for Douglas fir is greater. The heavy, wet snowfalls that sometimes occur at these altitudes damage Douglas fir less than radiata pine, and Douglas fir appears to be more windfirm on many sites.

These observations were confirmed by many foresters present. J. H. Holloway said that, at high altitudes at Tapanui, Douglas fir had generally withstood exposure to wind and had suffered less snow damage than radiata pine. These were the factors that had influenced the use of Douglas fir in the Waipori plantation of the Dunedin City Corporation, M. W. Hetherington reported; particularly the relative freedom from damage by snow.

Opossums were said to be a limiting factor in Westland. G. P. S. Allen reported that animal control measures sufficient to protect Douglas fir plantations were not warranted when radiata pine did well at present levels of animal concentration.

Early Establishment

The use of chemical sprays to release Douglas fir from competing vegetation has often been unsuccessful in the past.

D. S. Preest emphasized that spraying should not occur while trees are actively growing, and that picloram or dicamba should not be used as pre-plant sprays unless this is done 6 to 12 months in advance of planting. Hormone sprays such as 2,4,5-T ester can be used in concentrations of less than 4 kg and preferably 2 kg per hectare for over-spraying, and Douglas fir has shown a high degree of tolerance to over-sprays of simazine, atrazine and caragard. Many foresters declared that Douglas fir should be planted only on sites that are virtually weed free.

Branch Size Variation

The variation in branch size with different stocking levels was documented by R. N. James and D. H. Revell. The lack of a spacing trial in Douglas fir meant that data had to be gathered from stands in which variation from planned stocking levels appeared to have been present since initial mortality after planting. The first result of their investigations was an observation about the branching pattern of Douglas fir. Unlike radiata pine where the branches tend to grow in a curved fashion towards any light gap in the canopy adjacent to the tree, in Douglas fir the branches grow in a more strictly radial pattern. Thus a branch growing into a light gap would be large and one growing in competition with neighbouring trees under a shaded canopy, small in diameter. In radiata pine the curved branches tend to crowd together in the well-lit portions of the canopy and this tends to have an averaging effect on branch size. Stands of Douglas fir which do not have an even stocking will consequently produce poor grades of sawn timber from that part of the tree with the enlarged branches.

Results from Pureora forest, where Douglas fir had been established on cutover native forest, showed that irregular stand development could also cause enlarged branches. There growth had been irregular because the trees had emerged at different times from dense, competing weed growth. Compared with Kaingaroa forest, where stand development had been more even, the index used to compare branch diameters was greater at the higher stockings. To restrict the size of the branch size index (mean diameter of the 16 largest branches per log) on the first log to 2.5 cm, an initial stocking at about 1 700 stems/ha is required; 3.8 cm will require 1 000 stems/ha and 5 cm will require only 500 stems/ha successfully established.

Pathology of Douglas fir

The most important recent development affecting the "silvics" of Douglas fir has been the discovery in New Zealand of the needle-cast fungus *Phaeocryptopus gaeumannii* and of the

dramatic effect this is having on the growth of the species. Consequently a great deal of time during the symposium was devoted to discussing the implications of this disease. R. J. Cameron presented a paper written in conjunction with P. Alma and I. A. Hood on the pathology of Douglas fir. He contended that Douglas fir was suffering from a pathogenic disease complex in which *Phaeocryptopus* and the larvae of various lepidopterous insect species combined to produce substantial defoliation. This was particularly so in older stands, aged between 30 and 50 years, which were overstocked, and where individual trees were growing under competition-induced stress.

It appears that our experience with *Phaeocryptopus* is repeating that of some European nations who have also grown Douglas fir as an exotic forest tree. In the 1930s European foresters were so alarmed by the apparent effects of the disease that planting of Douglas fir was discontinued in many areas. Plantings were not resumed in quantity until about 20 years later when much more regard was paid to selection of seed source, siting and particularly silviculture.

Cameron suggested that *Phaeocryptopus* may not in itself be the primary cause of the decline in growth of Douglas fir, but that the infection is a secondary effect brought about by the state of growth stress in old stands where thinning has been delayed. Not everybody agreed with this suggestion. C. Bassett thought the evidence for growth stress as a primary cause of the decline was poor, but there was general agreement that the unthinned condition of many of our older stands had certainly allowed the fungal pathogen to have an increased effect. Cameron was pessimistic about the chances of restoring infected stands to good health but strongly suggested that silvicultural systems for Douglas fir be re-examined with the objective of planting at wider spacing, thinning earlier and more frequently, and adopting shorter rotations. The purpose of adopting this type of regime would be to encourage maximum growth on individual trees in order to make them less susceptible to any disease; pruning may, however, be necessary to maintain wood quality, it was suggested.

Decline in Growth

The seriousness of the disease complex was emphasized in a series of papers by J. Beekhuis, M. G. McGreevy and W. G. Wooff. First Beekhuis, using FRI permanent sample plot data, presented a series of graphs which illustrated long-term growth trends for Douglas fir in the R.24 plot series at Kaingaroa Forest. In all plots growth had recently declined. This decline had occurred in stands which varied in age from 34 to more than 50 years, and in each case dated from 1969 or a little earlier (see Fig. 1). The consistency of these results suggests

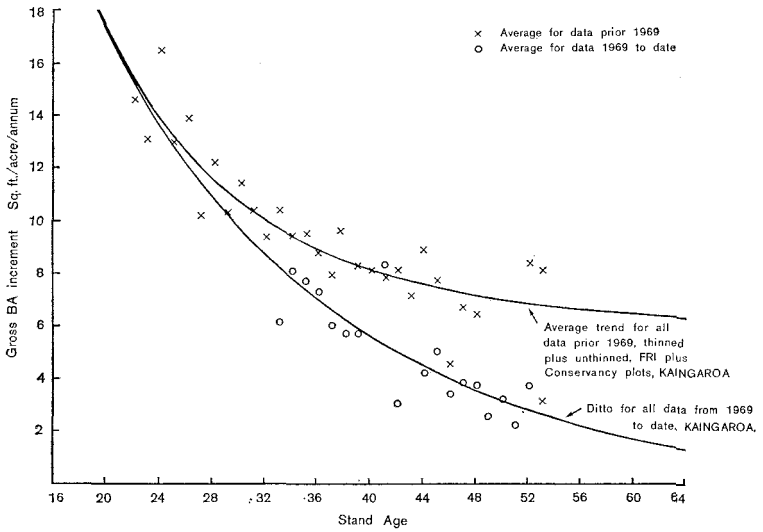

FIG. 1: *Graph showing decline in Douglas fir growth rate at Kaingaroa from 1969 onwards.*

a pathogenic effect, either by *Phaeocryptopus* alone or in association with other agencies. By contrast, plot data from the South Island showed no consistent pattern of drop off in growth, even in unthinned old crop stands. This corresponds with a general lack of *Phaeocryptopus* infection in the South Island.

A comparison of increments between radiata pine and Douglas fir on better sites was also presented, showing that "gross production" mean annual increment peaked for radiata at about age 30 and for Douglas fir at about 43 years. A series of graphs based on individual tree measurements in 76 plots in Kaingaroa forest was presented by McGreevy. He also concluded that a sharp decline in basal area increment had occurred in both heavily and lightly stocked stands.

Further evidence of the drop off in increment came from a paper by W. G. Wooff of the mensuration section, Kaingaroa forest. In an approach similar to that of Beekhuis, he compared present growth trends with trends based on long-term measurements of sample plots. The fall off in growth is dramatic and can be dated as occurring since 1965 in the prime sites of northern Kaingaroa, and from 1970 in the stands at Waimihia in the south. D. A. Elliot said he suspected the disease had first developed in the northern stands and spread to the south. He said that he had calculated the annual volume loss in Kaingaroa forest, as a result of the reduced increment, as 140 000 m^3, a volume so large that he thought it of only aca-

demic interest to debate the precise cause. The point was that Douglas fir in New Zealand is becoming extremely sick and a strenuous effort to cure the ill was justified, he said.

There was considerable discussion both during the formal session and during the field trips about what could be done to remedy the decline in growth. Cameron rejected any idea that the "clock could be put back" to the disease-free condition. He explained the effect of *Phaeocryptopus* on the tree. The effects appear to be greatest in older, unthinned stands because these trees produce less new foliage each year and, when premature needle fall reduces the needle cover to only 1- and 2-year-old needles, the reduction in photosynthetic potential is greater than in younger trees where the current year's foliage covers a bigger area. The reduced photosynthates restrict the growth of wood and also the formation of ephemeral feeding roots. With the reduced root system the effects of the recent dry years would be magnified, resulting in an even greater decline in foliage growth. It was observed in Europe that once trees started to decline they did not easily recover.

Preliminary results of spraying trials by I. A. Hood were circulated. These indicated that the disease could be controlled on seedlings, but on forest trees, although infection levels had been reduced, the disease had not yet been controlled. The possibility of using early thinnings to prevent trees from ever reaching the position where growth declined was suggested. E. H. Bunn put forward the "simple philosophy" that if the foliage was reduced to 1- and 2-year-old needles only, then it was important to have these spread over as deep a mantle as possible and that the way to do this was by thinning and keeping a deep crown. Silviculture schedules to achieve this were discussed in a later session.

WOOD PROPERTIES OF DOUGLAS FIR

Intrinsic Properties of Douglas fir

J. M. Harris summarized the intrinsic characteristics of Douglas fir and explained their influence in the utilization of the species. The wood adjacent to the pith contains a relatively high proportion of latewood and, unlike radiata, is often denser and stronger than wood 5 to 10 rings from the pith. Because the corewood does not shrink excessively along the grain, spiral grain is seldom serious and, because compression wood is relatively uncommon and causes few problems even when present, sawn Douglas fir is comparatively free of the distortion we associate with the seasoning of radiata pine. It is this stability when drying that has enabled Douglas fir to be sold unseasoned. The alternate bands of hard, dense latewood and soft, less dense earlywood give Douglas fir important and useful properties as sawn timber.

At its best, the wood is strong and rigid, properties that are very desirable in building timber. On the debit side, however, this grainy appearance is a disadvantage for finishing lines, the low density wood tends to "pick" out during machine dressing, paints and varnishes are absorbed differentially, and the different shrinkage and wearing often cause paint to lift. For the same reasons, Douglas fir sawn timber has a tendency to split on nailing.

After considering the intrinsic properties of the wood, Harris identified structural timber as the end product best suited for New Zealand-grown Douglas fir and said that therefore we should concentrate on maintaining and improving the intrinsic properties which lead to dimensional stability and strength. He identified wood density as the most important of these.

Results from an examination of provenance trials containing 46 seed sources have shown consistent differences in wood density produced by the different provenances, and although wood properties are by no means independent of the conditions under which the trees are grown, there is a means indicated here of eventually increasing the strength of our Douglas fir. Although within a given provenance wood density is inversely correlated with growth rate, this does not apply when trees are thinned. Here there is likely to be an increase both in latewood percentage and latewood density which together may compensate for the lowered density that would otherwise result from the increase in radial growth. The link between seed lot (provenance) and wood density that is apparent in many older stands throughout New Zealand provides a guide for the rationalization of cutting schedules. Stands which even at the age of 40 have yet to produce dense outerwood should be felled before stands of superior wood density.

Douglas fir as a Raw Material for Pulp Products

Douglas fir is a very important source of raw material for pulp and paper on the West Coast of North America. There, kraft pulps manufactured from Douglas fir characteristically have a high tear factor. J. M. Uprichard reported that in this region it is a common practice to use this feature by blending Douglas fir pulp with pulps from other species such as hemlock (*Tsuga heterophylla*) to boost the overall tear strength. Although mechanical (disc refiner) pulps of Douglas fir have adequate strength they are not as "bright" as other species commonly used, and thus Douglas fir is not commonly used for this purpose either alone or in mixture.

Although Douglas fir is not used for groundwood pulp in New Zealand at present, laboratory investigations have shown that refiner groundwood pulps of good papermaking quality could be made. When pulps made from radiata pine/Douglas fir chip mixtures were examined, it was found that the

surprisingly high rate of 30% Douglas fir could be tolerated without appreciably lowering pulp brightness. New Zealand experience with Douglas fir chemical pulps is similar to that overseas. The pulps have a good tear index, little changed by beating, and are suitable for products such as sack kraft, packaging and bag papers. In general the addition of Douglas fir to a mill finish which is predominantly radiata pine will increase the tearing strength of final pulps. Uprichard commented that this could be useful if radiata pine pulpwood rotations reduce to about 15 years since the addition of Douglas fir, even of thinnings aged 15 to 20 years, would improve the tear strength of the pulp.

W. J. Mitchell commented that at the Tasman Pulp and Paper Co. they were no longer segregating species for the newly installed continuous digester. He said that, based on only two months' operating experience, Tasman were producing high tear pulp from wood which includes a proportion of Douglas fir. The species is also suitable for the production of both fibreboard and particle board. Uprichard reported that only minor adjustments would need to be made to the standard methods of manufacture if Douglas fir were used in quantity instead of radiata pine. He cautioned that particle board made from a high proportion of Douglas fir would be darker in colour than that presently produced. Speakers from the floor suggested this might not be a problem as rimu is sometimes used and this produces a dark but salable board.

Preparation and Use as a Sawn Timber

Because it will rot in conditions of high decay hazard, such as ground contact, Douglas fir does not in strict technical terms rate as a naturally durable timber. However, in its most common use as a "built-in" structural timber, it is sufficiently durable to be used untreated. A. J. McQuire pointed out that this is an advantage not only because it cuts production cost but also because, by cutting out a process, it saves time when timber is urgently required. Small diameter rounds are very suitable as post and pole material and they can be treated satisfactorily with pentachlorophenol in oil. However, although the plant required for this process costs little and is simple to operate, the preservative (a petro-chemical) is expensive and Douglas fir posts are now dearer than pine posts treated with CCA salts. McQuire was of the opinion that, as long as there was a supply of pine posts available, Douglas fir would be uneconomic as an alternative source.

The aparent advantage of Douglas fir in not requiring preservative was queried. McQuire explained that while untreated radiata pine is very susceptible to attack from the common house borer, Douglas fir timber, although not immune, suffers

attacks only rarely and these are invariably restricted to the outer three rings of sapwood.

J. A. Kininmonth reminded the symposium that, since most Douglas fir sawn timber was used unseasoned, kiln drying of the timber was not an important factor in the utilization of the species. He did, however, review the seasoning studies carried out at the Forest Research Institute and Waipa State Mill. These covered both laboratory and commercial trials and the results could be summarized by saying Douglas fir dries uniformly and at least as rapidly as radiata pine". In trials designed to test its comparability with radiata pine, Douglas fir timber had much less tendency to warp and markedly less twist. Results of these studies have also indicated that branch size is the most important factor leading to warping. There is a greater tendency for flat sawn boards of Douglas fir to surface check than is usual in radiata pine and intergrown knots usually develop radial and circumferential cracks; another incentive to reduce knot size.

Douglas fir as a source of timber for engineering purposes was assessed by C. R. Hellawell. He compared the basic stresses (*i.e.*, permissible stresses for permanent loading of clear wood) for New Zealand Douglas fir, U.S. Oregon and New Zealand radiata pine. New Zealand Douglas fir and North Island radiata pine are both assigned the same values for bending (modules of elasticity and maximum fibre stress as a joist) and these are both inferior to Oregon from America. The relatively low bending properties were said to be a major disadvantage in competing for an "Oregon" image. There is wide variation in Douglas fir strength properties throughout New Zealand, and this is reflected in the design values assigned — no advantage is gained at present over radiata pine. Harris added that the variation is much more random and less related to local environment than that of radiata pine; he suspected that it was more attributable to genetic causes than was the variability of radiata pine.

J. S. Reid attempted to put the comparisons between Douglas fir and radiata pine in perspective. He was disturbed that radiata pine had got itself established as a standard basis for timber comparisons. Such a standard, he said, would discredit timber as a material, radiata pine being nondescript, utilitarian and mediocre to the degree that it is almost essential to process it in a fancy way before it could be used. Radiata poles he claimed were a serious discredit to wood! Dissent was equally vigorous. R. E. Parrott claimed that radiata pine had many advantages over Douglas fir as a timber and that these more than counterbalanced the disadvantages. He claimed that radiata was easier to nail, nailed without splitting, did not shed paint on the latewood bands, and was a less variable commodity to market. In his opinion radiata pine poles were

fine and had the advantage of being easier and cheaper to treat with preservatives.

The subject of Reid's paper was "Limitations of Douglas fir for Sawn Timber"; these he listed as uneven texture in the wood, difficulty of preservation, indifferent shearing strength and side *hardness,* and variation in density, defects and strength. Of these he thought the last category extremely important and a threat to the reputation of the species as producing strong timber at the top of the general utility grade.

Grading rules and Quality specifications

G. S. Brown introduced the Kaingaroa Forest Log Specifications for Douglas fir and reviewed their successful application in the Rotorua region both for local supplies and for export. The practical difficulties in applying grading rules were explained by J. K. Spiers. He reminded the meeting of previous comments about variations in wood quality and said this applied to logs too. Every forest manager endeavours to avoid waste and maintain a reasonable standard of utilization "so there is a tendency to push the rough stuff on to the market". At present Douglas fir logs which do not meet the specification could be sold to Japan and this greatly helped the application of log grading rules.

Draft visual grading rules for Douglas fir for the domestic market have been prepared by the Forest Service and are at present being considered by the Standards Association of New Zealand. I. D. Whiteside said that the rules contain no provisions relating to pith, growth rate or latewood percentage, as machine grading studies have shown that for the stress levels required no restrictions based on these factors are necessary. There are also no provisions relating to wood density, but this is because there is no practical way of visually grading timber on this characteristic.

Whiteside has carried out intensive investigations of the quality of Douglas fir from Kaingaroa forest using the stress grading machine as a research tool. His first conclusion was that, although stands planted at 1.8×1.8 m yielded the best timber quality, stands planted at 2.4×2.4 m could also yield high quality timber but only if fully and evenly stocked — a result which confirmed the investigations into branch size. With both visual and machine stress grading, grade recoveries in Kaingaroa Douglas fir, even from stands of low stocking, are substantially better than from stands of old crop Kaingaroa radiata pine. Whiteside identified cross grain as the most serious degrading defect in Douglas fir timber and said this was invariably associated with knots, the effect of the cross grain increasing with increasing knot size.

An investigation closely related to that of Whiteside was reported by J. R. Tustin. His objective had been to determine

the relative importance of branch size and wood density in determining strength. The study was conducted in a stand planted at 2.4 × 2.4 m where most of the trees were of above average wood density. The age of the study trees was 51 years and mean d.b.h. was 56 cm. A sample of second logs was sawn and these were chosen so that as far as was possible all factors other than branch size and wood density were held constant. Results showed that effects were additive but that branch size was much more important in determining strength than wood density. A decrease in branch diameter of 2.5 cm has an effect on stiffness equivalent to an increase in density of about 150 kg/m^3. Tustin said the implications of his study were, first, that timber quality is in the hands of the silviculturist insofar as he can manipulate branch size, and, secondly, that we should accept what density gains we can achieve by using our best provenances. However, he said the most important implication follows from the grade results presented. If we grow Douglas fir for use as a general framing timber in 4 × 2 inch (100 × 50 mm) sizes, then a 5.0 cm *branch index* can be accommodated. If, however, we want a high percentage of structural grades in these dimensions, then a *branch index* of 3.8 cm will be required to get 70%, by machine stress grading, in these classes. We now have the silvicultural knowledge to predict branch size and the resultant grade out-turn. "The question to resolve is what dimensions and what proportion of structural grades we should have as our target."

In discussion, Harris supported Tustin's contention that, although branch size was more important in determining strength than wood density, nevertheless an increase in wood density was still an important consideration for provenance selection or selective breeding.

The difference in percentage allocation between visual stress grading and machine stress grading shown in Table 1 was commented on by many delegates. Whiteside emphasized that visual grading will remain the grading method for commercial concerns for some time to come, although he agreed with Tustin that, if structural timber is to be used for engineering purposes, then the implementation of machine stress grading is very important. The choice of grading method could affect the branch size range adopted as the target. T. R. Cutler affirmed the interest of commercial operations in machine grading but added that at the moment the addition of the required machines would mean an additional cost to produce a class of wood for which there was no market.

E. H. Bunn commented that for the category where the branch size index ranged from 33 to 43 cm, the difference between 34 and 74% of the timber in the structural grades would probably justify the installation of grading machines, although for the fine-branched material sawn at the moment where the

TABLE 1: GRADE OUT-TURN IN RELATION TO BRANCH SIZE
(from Tustin and Wilcox)

	Second Log Branch Size											
	Small (18-28 cm)				*Medium (33-43 cm)*				*Large (48-58 cm)*			
Stress Grade	*1000f*	*800f*	*Fram-ing*	*Re-ject*	*1000f*	*800f*	*Fram-ing*	*Re-ject*	*1000f*	*800f*	*Fram-ing*	*Re-ject*
Percent recovery visual stress grades	22	59	19	—	3	31	54	12	2	9	50	39
Percent recovery machine stress grades	74	20	6	—	42	32	23	3	12	24	52	12

out-turns are 81 or 94%, depending on the system, machine grading probably is not justified. The discussion on machine grading was likened by Harris to indigenous sawmillers of the 1920s discussing gang saws. He said that, when the crops we were planting now come to maturity, machine grading will have changed dramatically and failure to plan for machine grading of future timber supplies was not being realistic.

MARKETING OF DOUGLAS FIR

Of the three complex processes involved in wood production, silviculture, utilization and marketing, it was generally acknowledged that marketing is the least understood.

R. K. Usmar reviewed the market for Douglas fir logs. He emphasized that, because the resource of this species is mainly owned by the State, Government policy is all-important in deciding the marketing pattern. Because of the relatively small resource, the State has always been able to sell all the Douglas fir it wishes to and this was expected to continue. Only 18 sawmills throughout the whole of New Zealand produce Douglas fir timber, and of $8.5 million worth produced last year, $7.7 million was produced in the Rotorua region.

During the symposium field trips, stands of heavily infected Douglas fir were inspected and considerable debate followed as to the practicality of wholesale felling for export. Usmar referred to this debate. He affirmed that in the unlikely event that emergency felling of our Douglas fir resource was required the produce could be sold, but stressed that a much better price would be obtained if the market could be built up gradually and in an orderly fashion. Although emphasizing that he had no intention of selling prime logs to overseas buyers, Usmar said that, if this were done, an indicative stumpage would be 74 c/cu. ft or $26/m^3, a point to be borne in mind when estimating the profitability of future forests. C. J. Mount-

fort suggested that, as radiata pine stumpages were not much less than this figure, and as the rotation length was about half, a decision to grow logs for export made on the grounds of profitability would surely be a decision to grow radiata pine. W. D. Studholme reported stumpages of $1.78 per cubic foot ($63/m^3$) being received by the Selwyn Plantation Board. This was profitable despite the lengthy rotation, he claimed.

The market for sawn timber was described by D. A. Tyler. Like Usmar, he claimed that the limit to sales was scarcity of supplies, not reluctance of the market. The solid background of traditional acceptance and preference in our immediate trading region meant that markets were secure. An advantage to the sawmiller was the lack of further processing requirements after sawing and dressing. Although the bulk of sawn Douglas fir is used within New Zealand, exports are important and for this premiums of up to 30% may be realized. An important constraint to further exports is the poor service and high cost of shipping. He summed up by declaring that "Douglas fir is a very valuable trading asset for the future and it shows every indication of enjoying continued strong support as a preferred timber". Another sawmiller, K. J. Trevor, claimed that Douglas fir has increased in popularity over the years but this position might reverse if prices rose too much more than those of treated radiata pine.

J. W. Syme queried the estimates of demand. He said it was a year since the Douglas fir market had been larger than our ability to supply, and that at present there was virtually no market in Australia for our Douglas fir timber. Markets were also poor in Guam, Fiji and Noumea. In the longer term, Syme agreed that there were good market prospects in Australia, but only at prices similar to the local market — not at extravagant premiums.

An appeal was made to clarify the prime selling points of Douglas fir. Whereas emphasis had been placed on strength and stiffness during the session on wood quality, Bunn suggested that dimensional stability and the fact that it does not need preservative treatment were more pertinent to the sawmiller and salesman. Whiteside added another feature — the ability to sell 95% of production at prices equivalent to No. 1 framing.

The Australian market was reviewed by R. E. Parrott. He pointed out that each main centre supported a different style of market and that we have been most successful on the Sydney market. He traced the beginning of timber imports into Sydney and the development of re-sawing facilities by Sydney timber merchants. For 50 years this industry has bought large flitch sizes which it then sawed to meet local demand. This pattern of trading puts definite limits on our sales prospects for timber sawn to final dimension. At the moment, radiata

pine is unsalable in Sydney but Douglas fir is, because it supplements supplies from the American North-west. Parrott stressed the need to examine the long-term intentions of the Australians towards their own forestry development. At the moment imports of forest produce into Australia are second in cost only to petroleum products. The Australians are trying to change this, they are aiming for self-sufficiency in wood products by planting a lot of radiata pine. When these plantations come to maturity there is likely to be tariff protection against Douglas fir and a customer preference for radiata pine. In the long term Parrott saw better prospects for New Zealand to sell radiata pine on the Sydney market than Douglas fir. The other Australian market of importance to New Zealand is Melbourne, and here radiata pine is a preferred species. Parrott gave high shipping charges as the limiting influence on this market.

P. Hindle supported these remarks about freight. He claimed that freight constituted about one-third of the selling price of Douglas fir in Australia.

W. R. J. Sutton's "Review of Douglas Fir in North America" was presented by Tustin in Sutton's absence. The main points were: Douglas fir occupies only 6% of the commercial forest area of U.S.A. and only 3% in Canada. It nonetheless remains the most heavily exploited species because access is easy, virgin stands are of high quality, and the markets are well developed. The cut in both countries exceeds the increment. Eighty-three percent of the timber is used primarily for construction purposes and grades from mature coastal stands are very good indeed — grades from second growth stands, while nowhere near as good, will still be adequate for construction purposes. Examples of highly complex grading rules and price lists were given, considerable premiums for high grades are evident, but unlike New Zealand there is a complete absence of premiums for width. If "Utility" grade, roughly equivalent to No. 1 framing, is assigned a price index of 100, "Economy" or box grade is worth only 32, but "Select Structural" 163.

R. T. Fenton began the presentation of his paper by reminding the symposium that they were discussing the marketing of first-rotation Douglas fir which was in the main of good quality, the stands having been well established and kept dense. Only recently, with the opening up of the poorer stands, has quality become variable. He said he was surprised how much large-sized Douglas fir and hemlock was still available in North America (over 1 600 million cubic metres) and in agreement with some earlier speakers he said in his opinion there would be no "price bonanza" for our Douglas fir.

Fenton reviewed the history of Douglas fir utilization in New Zealand. Nearly all the early supplies came from Kaingaroa or Whaka State Forests and initially up to half went to the

round produce plant. The timber was of uniformly high quality so there was no need to grade, there was no price control, and the volumes were only a trivial percentage of our exotic forest cut. An analysis of the sizes cut by the biggest sawmillers shows that between 15 and 21% is to 25 mm sizes and 35 to 50% in 100 × 50 mm sizes. Fenton summed up by saying that for its prime use, as a structural timber, it was probably better than radiata pine but the ultimate market test will come when people are asked to pay for the true difference in costs. Just as it was agreed that sawmilling was a business, so was forestry, and, once the selling price of Douglas fir was raised to cover the true cost of growing, he believed it would be unmarketable. However, at present prices and levels of supply, a market would continue to exist.

Discussion during the whole session revealed that there was a large measure of disagreement as to the future of New Zealand Douglas fir markets. Cutler was amazed at the pessimistic view being taken and reminded the symposium of Harris' comments concerning stress grading. He suggested that in 40 years' time the full potential of the species would be realized and our principal competitors will be managing second-growth stands with a higher cost structure than the present virgin stands. He "would certainly expect to get far better [prices] in future". Fenton countered this by saying that these conditions would apply for all the softwoods New Zealand chose to grow, not just Douglas fir.

CURRENT MANAGEMENT OF DOUGLAS FIR

The reasons given by the various organizations represented at the symposium for establishing plantations of Douglas fir were listed by C. Bassett. The most popular reason was "pathological insurance" including "avoidance of monoculture" and "diversification". Next was to grow a special-purpose timber, third was for amenity reasons, and fourth was longevity (*i.e.*, where long-term cover was required on land that could not withstand frequent clearfelling. There were other reasons advanced by individual organizations, including Head Office policy, fire protection, windfirmness and high rate of return.

G. M. O'Neill questioned the Forest Service representatives on their attitude to future plantings. Auckland Conservancy foresters claimed they were reluctant to plant more Douglas fir and only did so because of Head Office directives.

B. Keating from Wellington Conservancy stated that there was no intention to plant more Douglas fir in production forests in his region. The main reason was a shortage of future wood supplies and using Douglas fir on sites which could support radiata pine was seen as delaying wood supplies and dissipating resources. The contrary opinion was expressed by

J. Ure of Rotorua Conservancy. He saw a need to maintain continuity for the wood supply which already came from his region and noted that Douglas fir also had other advantages such as acceptability to environmentalists which made it a valuable species in special circumstances. Ure acknowledged the fall-off in increment that was currently being experienced. If this had not occurred he would advocate an increase in area, but with the disease present he would maintain the *status quo*.

From the South Island, R. E. J. Wylie explained that there were plans to continue the current rate of planting (200 ha/annum) in the Nelson region for some years. He suggested that Douglas fir had advantages in this region not present in others. He claimed that, since the effect of *Dothistroma pini* had been less in Nelson than it had in Rotorua, *Phaeocryptopus gæumannii* might also turn out to have less effect. The wide differences in wood yield for age between radiata pine and Douglas fir in other areas was not found in Nelson, Wylie claimed. That fact, together with grade out-turns of 90% of the log in framing quality timber, make Douglas fir an attractive proposition for Nelson.

Resistance to snow damage was seen as an asset by K. M. Lamb of Canterbury Conservancy, and he thought Douglas fir would be used at altitudes where this was a problem. On sites where either radiata pine or blue strain *Pinus muricata* would thrive, Douglas fir would not be used.

G. P. S. Allen from Westland explained that opossum attack had ruled out using Douglas fir in his Conservancy.

Southland Conservancy plantings will be concentrated in radiata pine, said G. J. Molloy, although limited plantings of Douglas fir would continue in special areas. He pointed out that diversification of species was catered for in Southland by the 16 000 ha of native beech forest which would be managed on a sustained yield basis. The export market was seen as a profitable outlet for Douglas fir but basically the low growth rates ruled out large plantings.

On behalf of N.Z. Forest Products Ltd, B. J. Allison explained his company's involvement with Douglas fir. Initially Douglas fir had been planted on the advice of two overseas consultants; however, in the mid-sixties the company had realized the great extent of the market for their products and the delay in wood supply that would be caused by planting Douglas fir. They then switched to radiata pine. Another reason for dropping Douglas fir was the slow initial growth of the species and the high cost of release-cutting which followed, especially in indigenous cut-over.

A paper by C. J. Mountfort which contained a new method of yield prediction for Douglas fir was presented. Mountfort had used his method to calculate the growth of several likely silvicultural options for the future management of Douglas fir.

Four regimes were discussed: a plant and fell regime, a conventional regime involving delaying thinning until 40 years, a method with waste thinning at 50 ft (20 years), and a regime with a first thinning to waste at 20 ft height or 10 years. There was widespread acceptance at the symposium for the need to adopt a new silvicultural approach, and it was agreed that the old regimes in which dense stockings were retained for long periods could not be repeated now that the *Phaeocryptopus* disease complex has become established.

Discussion centred on the last two of the regimes suggested by Mountfort with fairly wide agreement that some form of thinning to waste will be incorporated in most future regimes. Several speakers mentioned the physical difficulty of waste-thinning a stand at height 50 ft and others the enormous quantity of wood left on the ground after such an operation, constituting both a fire and biological risk. Maintenance of timber quality and full yields were identified as the two prime considerations in determining the precise timing of the first thinning and the residual stocking to be left after it. The many silvicultural options for which growth rates and yields were calculated by Mountfort provide a good base for forest managers to make these decisions for their own situations.

FUTURE PROSPECTS FOR DOUGLAS FIR

In the final session the delegates concentrated on defining the role of Douglas fir in their forests. To help them, and to bring the discussions of the previous sessions to a head, four "cases" for Douglas fir were argued. Three cases — those based on economics, national forest resource planning, and species diversification — did not support an extention of Douglas fir plantings and only where values other than those of wood production alone were considered did the speakers present a positive case for further planting of the species. Forest Research Institute symposia are not decision-making forums and no attempt was made to define a consensus of opinion on the role of Douglas fir, nor indeed would this have been possible. Discussion during the session was robust to the point of acrimony, and it would be fair to say that opinions on the role of Douglas fir remained divided to the end.

The Economics of Douglas fir

Fenton presented the results of a profitability model for a forest of 10 000 ha on a good site, established and managed in perpetuity in Douglas fir. The regime envisaged was a conventional one: trees would be established at 1.8 × 2.4 m, thinned without yield to 740 stems/h at age 20, and thinned with yield to 370 stems/ha at age 35. Clearfelling would be at age 55. As no measures to guard against *Phaeocryptopus* have been de-

vised, none were incorporated in the model which essentially reflected the pre-disease situation, an assumption which would increase the calculated profitability. Depending on whether social costs are included or not, the internal rate of return (IRR) is slightly less or more than 6%, whereas under the same putative conditions a radiata pine forest grown for the export log trade could have an IRR of up to 14%. At an interest rate of 10%, Douglas fir was calculated to cost more than 9 times as much to grow (per unit volume) as radiata pine. Fenton said he had subjected the results to a sensitivity analysis by altering the most important costs and returns, and his conclusion was that future afforestation with Douglas fir had "no show" of making the Treasury criterion of 10% IRR.

His analysis was criticized on the grounds that a more valid comparison would have been to use a poorer site quality more typical of Douglas fir plantings. Fenton countered this claim by pointing out that, because of its sensitivity to many site factors tolerated by radiata pine, Douglas fir has been consistently planted on good sites and in the model he had assumed an average site index for both Douglas fir and radiata pine. To another claim that comparing a Douglas fir forest where only 45% of the volume was exported to a radiata pine forest based entirely on exports was not fair, Fenton pointed out the small difference in realizations between domestic and export sales for Douglas fir and the fact that doubling the value of returns from clearfelling only increases the rate of return from 6 to 7½%.

M. R. Hosking presented the planner's view of Douglas fir. He said that, while the stocked area of Douglas fir would decline as a percentage of the New Zealand resource, the annual volume harvested would in fact nearly double by the year 2010. The principal implication of using Douglas fir to fulfil national planning targets was a delay in realizing the target, Hosking said, and another important implication was the reduced profitability already detailed by Fenton. Hosking found no comfort for the proponents of Douglas fir among the additional reasons usually quoted to justify forestry in marginal areas such as stimulation of employment opportunities and promotion of regional development. Such additional considerations apply even more to the faster growing radiata pine, he said. Hosking concluded that the use of Douglas fir could not be justified "in consideration of national economic development objectives" and that any such justification must be sought elsewhere. He said foresters "must determine whether the continued use of the species in production forestry at present is based more on sentiment and tradition than economic reality".

In reply to questions about the future supply of Douglas fir for special uses, Hosking said that the present resource, man-

aged on a sustained yield basis, could give a stable supply at about twice the present level (although the full effect of the disease complex is as yet unknown). There was considerable discussion as to whether the industrial users of Douglas fir would be prepared to pay for the additional cost of growing this species. P. Hindle said that as long as the price was the same to all processors, a premium would be paid as the timber was preferred for uses such as roof tresses.

J. G. Groome said that it goes without saying there will be a ready market for any Douglas fir produced, but Tustin accused the private forestry sector of being "tricky runners" in advocating that the Government grow Douglas fir while growing none themselves.

Fenton reviewed the risks involved in plantation forestry using exotic species. He said that theoretically the sequence of pathological events that could lead to a forestry disaster were: first, an exotic species may be susceptible to an indigenous pathogen; second, even if this is not so, pathogens adapted to the species may eventually arrive from the country of the species' origin; thirdly, that in any case the ubiquitous pathogens like *Armillaria* or *Hylastes* will represent an ever-present danger of rising to epidemic proportions; and, last, all these conditions are accentuated by the practice of monoculture. Unfortunately, there is no way of predicting which species will suffer from what. Fenton pointed out that so far New Zealand foresters had combated this theoretical sequence of events by diversification away from our principal species of radiata pine. He pointed out that this had incurred a considerable opportunity cost and had been entirely unsuccessful — the alternative species having been the ones to suffer from disease. An alternative defence was offered. This would include the rigorous evaluation of alternative species, including their silviculture, but would place most emphasis on locking up the remaining merchantable stands of native timber as a strategic reserve. The discussion did not reveal any enthusiasm for planting Douglas fir as a precaution against damage to radiata pine.

Enthusiasm was present, however, for the point of view propounded by G. B. Wilkinson. As Wilkinson said, he was promoting an attitude rather than an analysis, an attitude of environmental awareness. He identified two important constraints to forest management that have recently developed. The first is the need to have the public involved in decisions associated with national resource management; secondly, the enactment of legislation — a trend only now beginning — which will force planners to note the wishes of the people.

Two types of forest zones were envisaged. Production zones, largely of radiata pine, would be grown with a view to maximizing returns, and would be freed of artificial constraints

such as the gestures towards aesthetics common in many production forests today. Other zones, while also producing some timber, would be largely free from economic constraints and would be planned for aesthetic and visual qualities rather than timber production. These zones would be managed to approximate a natural forest and would have a mixture of species and age classes. In these circumstances Douglas fir was seen as "the N.Z. Foresters' Gift", its ability to regenerate under its own canopy lending itself admirably to management under a selection system.

Many speakers supported these concepts. Some suggested that the extra cost of recreation areas could be recovered by charging admission to these areas, as in fact is done in private woodlands around Rotorua. Other speakers rejected any attempt to set a value on amenity forests or attempt to recover costs. In this role, at least, most of those present felt that Douglas fir (with other species) had a definite part to play.