THE ROLE OF DOUGLAS FIR IN AUSTRALASIAN FORESTRY

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SYNOPSIS

Douglas fir timber sold in New Zealand comprises about 5% of the exotic cut, produced mostly from three modern mills. It is acceptable in house-framing without preservative treatment, is sold ungraded, and has never been subject to price control. It originated in well-stocked stands which usually remained unthinned for forty years, with consequent suppression of the lower crown, reduction in knot size and branch life, and reduction in stem diameter growth rates; thus it is well suited to its major end use as framing. It adds further to the relatively abundant supplies of framing timber available, but is less versatile than radiata pine.

A third of the thinned volume (the smallest logs) has been used as rounds, with a consequent increase in overall profitability. The apparently greater value of Douglas fir, compared with radiata pine, is partly due to circumstances and partly to its particular merits.

Douglas fir from North America is the major species imported into Australia, and the effect of its absence from Australian afforestation is examined in relation to North American and New Zealand supplies. The North American old-growth resource still dominates the trade but export sources are likely to change to young-growth stands, and to hemlock. While there is a tariff advantage for New Zealand over North American supplies, the freight advantage is negligible.

The relative cost of production of the Australasian and the North American material is not known. The relative economics of Douglas fir and radiata pine in New Zealand have still to be assessed.

CURRENT TRADE IN DOUGLAS FIR

Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) is one of the great commercial timbers of the world and, because its qualities coincide with the market requirements and it is readily available from the north-east coast of the Pacific, it is of particular importance in the forest products trade between Australasia and North

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America. Details of Douglas fir imports are given in Tables 1 to 4. New Zealand domestic production is included in Table 5. Douglas fir comprised half the volume and value of Australian timber imports over the past two decades. Its position as the most important species of timber imported into New Zealand has altered recently and in 1965 imports of both redwood (*Sequoia sempervirens* (D. Don) Endl.) and western red cedar (*Thuja plicata* D. Don) equalled it in volume. Internationally, Canada is the premier exporter of Douglas fir and has tariff advantages in Australasia; but the bulk of the New Zealand and about half of the Australian imports come from the United States. There is a small export trade from New Zealand.

Most of the pre-1939 Australian imports were in the form of logs, but are now in large baulks for subsequent resawing (Commonwealth of Australia, 1960, 1963). Importation in this form allows timber merchants to hold stock which can be utilized in diverse ways; it also permits a large amount of re-manufacture and incurs a lower tariff (Table 6). These baulks are reportedly "bought at premium prices, of course, since they are cut from what would otherwise be peeler logs. Operations not integrated with peelers find this business a valuable and welcome outlet for their best fir logs and timber" (Anon., 1959). Comparative prices of the size classes imported are not available from Canada. However, the U.S.A. prices (Table 2) show a much lower c.d.v.* cost for the small sizes. Presumably the anomaly is due to differences in grade. The overall prices of the imported timber, which are on a c.d.v. at port or f.o.b. basis, compare reasonably well with North American wholesale prices (Table 7), as the latter exclude freight costs.

Consideration of direct substitution of these imports by production from exotic forests arises from the national forest policies of both Australia and New Zealand, and from the dominant position of Douglas fir in the timber trade. Only limited areas of three Australian states have climates suitable for Douglas fir and State afforestation is largely oriented towards radiata pine (*Pinus radiata* D. Don.). In contrast, New Zealand Douglas fir has always formed an important part of State afforestation but not of other ownerships. Its potential ihmportance in trade between Australia and New Zealand is possibly greater than current acreages suggest, owing to lack of resources in Australia and the established markets for Douglas fir there. Its relative advantage over radiata pine has been assessed as ". . . the Australian market may well be expected to absorb all the Douglas fir that New Zealand can export but it is unlikely that it will absorb a comparable proportion of radiata pine"; and again ". . . it is likely to bring 50 percent higher stumpages" [than radiata pine] (Spurr, 1961). These apparent advantages need to be evaluated and the ensuing discussion deals largely with New Zealand experience in this respect and concludes with a sideration of the desirability of establishing further areas of Douglas fir in Australia.

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* Current domestic value in country of origin.

TABLE 1: LONG TERM DOUGLAS FIR IMPORTS INTO AUSTRALIA

Years	Volume[1]				Value[2] f.o.b. basis			
Y.E. 30/6	*Million bd. ft*	*% ex U.S.A.*[3]	*% Softwood Imports*	*% All Timber Imports*	*£1,000 Stg*	*% Softwood Imports*	*% All Timber Imports*	*Av. Value s.stg/100 bd. ft*
Australia								
1936–40	255.0	—	18	17	997	22	20	7.8
1941–45	157.0	14	52	49	1,250	54	52	15.9
1946–50	429.0	41	53	49	8,047	59	49	37.5
1951–55	701.1	50	51	46	22,192	60	43	63.3
1956–60	829.9	43	68	51	28,436	73	51	68.5
1961–62	351.6	—	72	51	12,083	72	60	68.7
1961–65[4, 5]	869.3	44	73	[3] 53[5]	30,951	N.A.	N.A.	71.2
New Zealand								
Y.E. 31/12					*c.d.v. basis*			
1921–25	55.4	—	67	21	480	54	12	17.3
1926–30	80.2	—	44	25	565	33	14	14.0
1931–35	12.1	—	46	14	84	30	8	13.9
1936–40	24.8	—	57	14	209	40	8	16.9
1941–45	14.4	—	65	18	203	46	12	28.2
1946–50	45.6	—	75	27	1,215	61	24	53.3
1951–55	55.3	—	70	26	1,971	58	20	71.3
1956–60	44.2	—	57	19	1,623	47	14	73.4
1961–62	14.1	—	36	15	485	29	12	68.8
1961–64[7]	27.3	77	35	16	1,006	28	13	73.7

[1]Wilson, 1963.
[2]Wilson, 1964.
[3]U.S. Dept. Commerce, 1941–64.
[4]Division Timber Supply Economics, 1964.
[5]Oversea Trade 1963, 1964. 1965; estimated in part as not all categories have species specified.
[6]Yska, 1963.
[7]New Zealand Forest Service, 1963, 1964, 1965.

TABLE 2: RECENT DOUGLAS FIR EXPORTS FROM U.S.A. TO AUSTRALASIA

Year	*Timber Widths*								
Y.E. 31/12	*Less than 2 in.*		*2 in.–5 in.*		*5 in. +*		*Total*		
	Vol.[2]	*Val.*[3]	*Vol.*[2]	*Val.*[3]	*Vol.*[2]	*Val.*[3]	*Vol.*[2]	*Val.*[3]	*%*[4]
To Australia									
1959	3,618	98	12,400	85	61,791	62	77,809	67	26
1960	7,924	110	18,820	99	84,898	70	111,642	77	29
1961	5,405	82	11,928	81	31,051	57	48,384	65	18
1962	8,297	89	17,345	89	39,775	63	65,417	73	21
1963	8,149	103	18,354	97	57,746	64	84,249	75	23
1964	7,335	102	19,713	99	60,410	67	87,458	77	24
To New Zealand									
1959	115	129	1,917	88	3,973	59	6,005	69	2
1960	64	128	2,394	94	5,586	66	8,044	75	2
1961	239	78	2,758	86	3,732	54	6,729	68	2
1962	76	74	2,197	91	3,753	60	6,026	71	2
1963	188	100	1,652	106	2,754	62	4,594	80	1
1964	156	97	2,080	110	3,568	62	5,804	80	1½

[1]U.S. Dept. Commerce 1959–64.
[2]Volumes in 1,000 bd. ft.
[3]Values in shillings sterling/100 bd. ft, f.a.s. basis; correct to 1 shilling.
[4]Per cent. of U.S.A. Douglas fir timber exports (by volume).

TABLE 3: RECENT DOUGLAS FIR EXPORTS FROM CANADA TO AUSTRALASIA[1]

Year	To Australia Vol.[2]	Val.[3]	%[4]	To New Zealand Vol.[2]	Val.[3]	%[4]
1959	76,063	54	5	2,929	70	Negligible
1960	101,795	57	6	1,610	72	,,
1961	81,467	55	5	2,133	67	,,
1962	106,773	55	7	1,488	65	,,
1963	100,099	57	6	969	63	,,
1964	92,143	58	6	1,537	73	,,
1965	99,258	58	7	473	66	,,

[1]Canada, Dominion Bureau of Statistics, 1959–65.
[2]Volumes in 1,000 bd. ft.
[3]Values in shillings sterling per 100 bd. ft, f.a.s. basis, correct to 1 shilling.
[4]Per cent. of Canadian Douglas fir exports (by volume).

TABLE 4: NEW ZEALAND DOUGLAS FIR EXPORTS TO AUSTRALIA

Year Y.E. 30/6	Totals[1] Volume thousand bd. ft	Value[2] £	Relative value per 100 bd. ft[3] Ex N.Z.	Ex Canada	Ex U.S.A.
1956	Nil	—	—	—	—
1957	216	6	53.5	72.3	74.7
1958	668	21	63.2	64.5	67.3
1959	1,909	69	72.9	58.2	62.0
1960	4,168	159	76.6	71.8	74.5
1961	1,629	53	66.1	71.6	77.3
1962	1,829	54	59.8	59.0	69.3
1963	2,103	65	61.7	65.8	76.7
1964	2,942	101	68.6	69.2	78.2
1965	1,835	61	67.4	71.5	78.5

[1]Overseas Trade 1956–65.
[2]£000 sterling, c.d.v.
[3]Shillings sterling, correct to 0.1 shilling, c.d.v. basis.

TABLE 5: NEW ZEALAND DOUGLAS FIR PRODUCTION

Year Y.E. 31/3	*Ex Kaingaroa and Whaka Forests*[1] Pulp and Sawlogs[2]	Round Produce Vol.[2]	Round Produce % Production	% Waipa Supply[3]	*New Zealand* Sawn Timber[4] Vol.	Sawn Timber[4] % of Exotic Cut	State Forest Log Total[2]	Residual Surplus Available for Pulp[2, 5]
1950	114	57	33	33	1.2	0.8	—	Nil
1951	293	173	37	37	1.9	1.0	—	,,
1952	329	197	37	37	2.4	1.0	—	,,
1953	475	379	44	44	2.7	1.2	—	,,
1954	450	452	50	50	3.6	1.5	—	,,
1955	647	549	46	51	4.0	1.4	—	,,
1956	1,700[6]	493	22[6]	44	3.8	1.3	—	800
1957	1,584	543	26	56	4.5	1.6	—	500
1958	2,060	652	24	47	6.4	2.3	—	450
1959	2,387	638	21	34	6.7	2.1	—	950
1960	2,515	548	18	33	12.6	3.6	......	Nil
1961	2,823	490	15	29	12.3	3.1	—	200
1962	3,012	497	14	31	13.8	3.6	3.5	800
1963	3,585	288	7	15	14.7	3.9	3.7[7]	800
1964	3,950	377	9	15	18.5	4.7	4.3	600
1965	—	—	—	—	24.5	5.2	5.3	400

[1]These two forests produce 90 to 98% of the State Forest Douglas fir supply.
[2]Log volumes in thousands of cu. ft.
[3]Waipa mill was the largest producer of Douglas fir timber until 1956.
[4]Yska, 1963; N.Z. Forest Service, 1964, 1965. Volumes in million bd. ft.
[5]Residual figure, after allowing a conversion factor of 5.0 for sawlogs.
[6]Sales to Tasman Pulp & Paper Co. began.
[7]This figure appears to be an underestimate, as Kaingaroa and Whaka production alone exceeded it.

TABLE 6 : TARIFFS ON DOUGLAS FIR TIMBER IMPORTS

Category	Ex Canada 1960[1]	Ex Canada 1964[2]	Ex U.S.A. 1960[1]	Ex U.S.A. 1964[2]	Ex New Zealand 1960[1]	Ex New Zealand 1964[2]
			INTO AUSTRALIA			
Rough-sawn 6×12 and larger	4.8	7.2	5.6	8–8.8	Free	—
4×6 to 12×6	7.2	12.4	8.0	13.2	Free	—
Less than 4×6	9.6	12.4–24	10.4	14–24.8	Free	14.4
			INTO NEW ZEALAND[3]			
Cross-section of over 150 sq. in., & over 25 ft long	—	7.5	—	8.5	—	—
Other sizes	—	9.5	—	10.5	—	—

Values are in shillings sterling/100 bd. ft.

[1]Commonwealth of Australia, 1960.
[2]Commonwealth of Australia, 1964.
[3]New Zealand Tariff, as amended, 1/1/1966.

TABLE 7: COMPARATIVE PRICES OF DOUGLAS FIR TIMBER

Timber Dimensions (in.):	*4×1*	*4×1⅝*	*4×2 Studs*	*4×2 to 12×2*	*Export prices to Aust.*[9]
New Zealand (domestic):					
North Island[1]	60.50	—	—	85.5–115.5	—
South Island[2]	59.25	—	—	75.5–96.75	78.53
Canada[3]	—	—	38.57[4]	46.42[5] 47.14[6]	58.25
United States[7]	41–68.00 (No. 3 to No. 1 common)	53–54.00 (Standard and better)	44.00	56.7[8] (No. 1 common)	77.25

All prices are in shillings sterling/100 bd. ft.

The New Zealand timber is sold ungraded, and Canadian shipments are mixtures of grades; hence only broad comparisons can be made from these figures.

[1]New Zealand Forest Service, 1964a. Price free on rail.
[2]New Zealand Forest Service, 1965b. Price free on rail.
[3]Cooper Widman, 1964.
[4]60/25/15 — namely 60% construction, 25% standard, and 15% utility grades; free at shipside.
[5]75/25 — 75% construction, 25% standard; at mill.
[6]60/20/20 — grades as for (4), price at mill.
[7]From Table 16.
[8]FAO, 1965. Mean of average price for 1964 at mill in U.S.A.
[9]"Current domestic value in country of origin" basis.

AUSTRALASIAN RESOURCES OF DOUGLAS FIR

The extent of Douglas fir planting is given in Table 8. The New Zealand figures were checked from three sources:

(1) The age-class distribution as given to the 1957 British Commonwealth Forestry Conference (Weston, 1957) and supplemented by figures from subsequent annual reports (N.Z. Forest Service, 1957–65). These gave a total area of 63,241 acres in State forests, plus 2,000 acres privately owned.

(2) New Zealand's planted area summary in the 1957 Annual Report, together with later figures — giving a total area of 63,954 acres on State forests.

(3) Exotic forest survey figures based on accurate boundary relocation gave an overall area of 62,436 acres in State forests, plus 2,900 acres privately owned (T. Wardrop, pers. comm.).

Clearly, the area established is about 62,500 acres of State and 3,000 acres of private ownership. Australian statistics are less definite, the available data giving a total area of about 3,500 acres in State forests (Table 8). Since 1951 the rate of planting has increased in both New South Wales and New Zealand (Table 9), and the New Zealand post-1960 figures would have been greater still if nursery programmes had not been upset by the untested use of simazine weedkiller, to which Douglas fir proved susceptible. The reported figures of 2,944 acres planted per year on New Zealand State forests from 1956 to 1960 (Spurr, 1961) is too high — an annual acreage of 2,500 was not achieved until 1965. Recently it has been reported that about 500 acres per year will be planted

TABLE 8: AREAS OF STATE DOUGLAS FIR PLANTATIONS

(in acres)

Year Planted	*New Zealand acres*[1]	*New Zealand acres*[2]	*%*	*New South Wales acres*[4]	*Victoria acres*	*Tasmania acres*[7]
1901–10	1,184	220	0.3	—	—	—
1911–20	1,184	960	1.5	—	—	—
1921–30	18,963	19,130	30.2	73	More	183 by
1931–40	15,681	14,350	22.7	4	than	1956
1941–50	2,822	3,520	5.6	Nil	2,000[5]	—
1951–60	—	13,110[3]	20.7	89	Nil[6]	—
1961–65	—	11,951	18.9	1,080	Nil	—
Total	—	63,241	100.0	1,246	2,000	183

[1] New Zealand Forest Service Annual Report 1957 — Appendix VI.
[2] Weston, 1957.
[3] New Zealand Forest Service Annual Reports 1951–65.
[4] New South Wales Forestry Commission, Annual Report 1964, and internal reports.
[5] Forestry Commission of Victoria 1957.
[6] Forestry Commission of Victoria Annual Reports 1958–64.
[7] Forestry Commission of Tasmania, 1957.

Areas in other Australian states and territories are negligible.

TABLE 9: RECENT AFFORESTATION WITH DOUGLAS FIR

Year	*New Zealand* *State Forests* *Area (acres)*	*New Zealand* *State Forests* *% Afforestation*	*Major Private Companies* *Area[1] (acres)*	*New South Wales* *State Forests* *Area (acres)*	*New South Wales* *State Forests* *% Afforestation*
1951–55	4,140	16.5	—	Nil	—
1956–60	8,970	24.6	410	89	0.3
1961–65	11,951	15.3	2,120	1,080	4.4

[1]This area is understated, not all firms replied.
Afforestation with this species under the Farm Forestry Scheme has been negligible.

in New South Wales (Anon., 1965a). There is a slight change in the published policy in Victoria where it has been reported that further establishment of Douglas fir would not take place (Forests Commission Victoria, 1957), but subsequent reports (Forests Commission Victoria, 1962–4) indicate that it would be considered for suitable sites.

Geographically, about two-thirds of the total area of Douglas fir planting in New Zealand is within 60 miles of Rotorua, in areas which initially supplied the Waipa State Mill, and subsequently the Tasman Pulp & Paper Co. also.

QUALITIES OF AUSTRALASIAN DOUGLAS FIR TIMBER

The end use of Douglas fir timber, when the tree is grown as an exotic to at least 50 years of age, is essentially as framing timber, with minor outlets for round produce and for such uses of board as laths, tile battens and in farm buildings. The contrast in density between the early and latewood of an annual ring (an increase of 100% or more according to Harris & Orman, 1958) together with a relatively low number of rings per inch produce inequalities of texture that are unsatisfactory for most dressed timbers. While quarter-sawn edge-grain stock from slow (seven or more rings per inch) and evenly grown logs may, if clear of knots, be suited for high-grade flooring and joinery, it is unlikely that this will be grown deliberately in New Zealand plantations. It would require too long a rotation. For example, on Site Quality I (Duff, 1956) it would be possible to prune to 18 ft on a tree of 36 ft top height within 15 years, and the diameter/age regime should then ideally be:

Approximate d.b.h.o.b.	*Age*	
5.0 in.	15 yr	Butt log pruned to 18 ft in three lifts
7.0 in.	22 yr	Bark and stubs excluded; clearwood formed
17.0 in.	57 yr	Tree grows at seven rings per inch

At 57 years of age a 5 in. shell of clearwood would be formed at d.b.h. from which it might be possible to saw clear 4 × 1 timber from the butt logs. To reach a more reasonable d.b.h. of 21 in. a perfectly tended stand would take 80 years, which is twice the time that radiata pine requires to produce first-class finishing timber, in clear grades (Reid, 1953). Even with heavy thinning, the 100 largest stems per acre of Douglas fir after 50 years of age will grow only at six rings or more per inch (Spurr, 1963). Greater volume of finishing grades could be produced from shorter rotations of radiata pine. The appropriate balance of finishing timber from Douglas fir has been indicated by the statement: "it is desirable to prune a small percentage of the trees to be handled on long rotations to provide clears for joinery . . . and large diameter logs for plywood" (Reid, 1962).

The requirements for satisfactory framing timber are strength, straightness and stiffness, which depend on the basic density and shrinkage characteristics of the stem wood as well as the size and condition of the branches. Investigations have been made of the basic density characteristics of New Zealand-grown timber of Douglas fir, and it was found to be as dense and as strong as North American material from second-growth stands (Harris and Orman, 1958). Their analysis included silvicultural considerations and recommended an initial spacing of 6 × 6 ft, with subsequent thinning to maintain not less than five rings per inch, in order to achieve a desirable basic density and a reasonable growth rate (Harris and Orman, *op. cit.*). In practice, much of the Douglas fir established before 1923 and after 1940 has been planted at 6 × 6 ft; 8 × 8 ft spacing was generally used in the intervening years. It has been suggested that, as the differences between these spacings tend to disappear with age, ". . . economic analysis may well eventually point to the 8 × 8 ft as being the most profitable in that the reduced necessity for early thinning might more than counterbalance any eventual reduction in wood quality" (Spurr, 1961).

Inequalities of wood properties affect lamination to some extent, as scarf joints between late and early wood cause greater variability in the properties of random joints; although this effect can be minimized by good design (G. Stanger, pers. comm.).

The qualities of Douglas fir for round produce are discussed later. Its relative imperviousness to preservatives, apart from diffusion processes, has not proved to be a disadvantage as yet.

THE DEVELOPMENT AND TENDING OF NEW ZEALAND DOUGLAS FIR

For New Zealand a succinct account of silviculture is available (Weston, 1957) together with supplementary information (Spurr, 1961; Hinds, 1962). Yield figures for unthinned (Duff, 1956) and thinned stands (Spurr, 1963) have been published, and further data on timber quality are available (Hinds and Reid, 1957). The following discussion is concerned primarily with the economics of forestry and the course of future trade, together with those silvicultural details not fully dealt with in earlier work. To date, the silviculture has been ideal if the end use is to be framing timber. The stands in State forests were generally well planted and resulted in relatively full establishment. Failed areas were few and soon showed up either as complete failures or by having small (4 to 6 ft) trees which persisted as such. In contrast, radiata pine will often survive on severe (namely, frosty) sites and, although badly malformed, will continue to grow taller; the resultant trees and stands possessing excessive malformation, often with 40 to 60% of the stand volume accounted for by malformed trees. Karioi forest, in the central part of North Island, provides a documented example of the different development of the two species, since a series of trial plots were established there in 1927–31 on open, fertile sites subject to heavy frost. Over the first ten years, the Douglas fir on two sites was reported as a total failure: "a few scattered trees survive but have made little progress" and "the Douglas fir are to be abandoned" (Ohakune District local research register). However, as shelter from adjacent stands of hardy pine species increased, the Douglas fir trees recovered and are now 90 ft tall. Details of reports of early development are given in Appendix 1. Comparable, but undocumented cases occurred elsewhere — *e.g.*, compartment 1088 in Kaingaroa forest. Provided air drainage is good and exposure limited, Douglas fir has higher altitudinal limits than radiata pine and is less susceptible to snow damage. These characteristics have not, as yet, been important in New Zealand in complementing the range of sites available to Douglas fir, but the reverse seems true in recent New South Wales afforestation. The most extensive commercial stands at higher altitudes in New Zealand are again in Karioi Forest and approach the 3,000 ft contour. On these sites development of radiata pine is excessively malformed. Undoubtedly the generally better stem form of Douglas fir, with absence of multiple leaders and less gross branching characteristics, are major advantages over untended radiata pine.

Row-by-row mixtures of Douglas fir with either larch (*Larix decidua* Mill.), lodgepole pine (*Pinus contorta* (Dougl.)) or Corsican pine (*Pinus nigra* Arn. (Laricio)) have been used occasionally. The mixture with larch is used to increase the acreage of Douglas fir when nursery stock is locally scarce; the larch is eventually overtopped, despite its initially faster height growth, and a largely self-thinning crop develops. Similar reasons of shortage of planting stock lead to mixture with lodgepole pine, but the outcome is less certain because the height growth of a good strain of the pine may be greater. The management policy is to favour "the best species" — axiomatically assumed to be Douglas fir — and to poison out the pine. Further reasons for mixtures, more especially with Corsican pine, are to provide an intermediate yield of pine posts from country of easy topography, and to have a "self-thinning" mixture on steeper areas, where this pine is usually overtopped on all but the most difficult sites. Mixtures with pine species occupy only a minor part of the areas currently afforested.

In pure stands the canopy is generally complete by top height 20 to 25 ft and lack of mortality, when combined with good establishment, leads to rapid suppression of the butt log branches and their relatively early death. Apart from branches on wolf trees and on open grown trees in canopy gaps, branch diameter is usually

Unthinned stand of Douglas fir at age 33 yr. Planted in 1921 at 6 × 6 ft spacing; low pruned in 1937. (Cpt. 1123 Kaingaroa S.F.).

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

less than 1.5 in. in most stands. Height growth, once canopy is complete, is fairly rapid (Duff, 1956) and stem mortality does not seem to be as severe as in second growth stands in the U.S.A. (Table 10).

TABLE 10: RELATIVE STOCKING — NEW ZEALAND AND PACIFIC NORTH-WEST DOUGLAS FIR

Age Years	*Site Spacing*	*New Zealand*[1] *S.Q. I* *6×6 ft*	*8×8 ft*	*Pacific N.W.*[2] *S.I.180* *Fully stocked*	*S.I.190*	*New Zealand S.Q. II* *6×6 ft*	*8×8 ft*	*Pacific N.W. S.I.150 Fully stocked*
10	....	1,120	590	—	—	1,150	610	—
20	....	850	490	756	654	990	550	1,210
30	....	590	370	483	408	770	450	735
40	....	450	300	335	282	620	380	510
50	....	380	270	248	208	530	340	377

All stocking figures in stems per acre.
[1]Duff, 1956.
[2]McArdle *et al.*, 1961.

The original New Zealand figures for top height at age 50 (Duff, 1956) were conservative (Spurr, 1963) and age 40, rather than 50, is probably a better age for inter-country comparisons. The effect is a conservative bias in taking American Site Index 180 as equivalent to the New Zealand Site Quality I; if comparisons are made with still higher quality American sites, the relatively greater stocking in New Zealand is even more marked. Furthermore, the stocking in unthinned New Zealand sample plots is, in fact, greater than the earlier figures suggest. Mortality is markedly less than in unthinned radiata pine stands in most areas, and hence thinning can be delayed to age 40 to 45 without undue loss in volume.

The branching characteristics have been reported as horizontal (Hinds & Reid, 1957) in contrast to the generally angular branching of radiata pine, but it is likely that the pendulous nature of the relatively thin branches gives this effect; the branches where they leave the trunk are at angles comparable to those of pines. This is exemplified in published photographs (Plate 4 of Weston, 1957; Plates 1 and 3 of Harris and Orman, 1958; and in plates of the Annual Report, New Zealand Forest Service, 1955). Consequently, degrade of wood due to crescents of bark on the upper side of knots does occur but, since the major use is framing and not boards, this defect is of less consequence than in radiata pine. The branching pattern has been described as lacking defined nodes (Reid, 1963) and, in general, the branching is less clustered than, for example, Corsican pine. In a minority of trees the branching is more or less in annual clusters but, even in these, large numbers of small branches (0.1 to 0.5 in. diameter) occur between major whorls. The net effect is to greatly reduce the number of boards which it would be possible to grade as equivalent to Factory (New Zealand Standard Specification 169) or as North American Shop grades; again, as the timber is for framing, this is not important. The more dispersed nature of the branching pattern results in less chance of concentration of defects and,

Douglas fir on completion of thinning to 160–220 stems per acre 39 yr. Cpt. 1113, Kaingaroa S.F. See frontispiece for present dimensions.

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

TABLE 11: GREEN CROWN LEVELS IN NEW ZEALAND DOUGLAS FIR

Locality and Plot No.	*Spacing (ft)*	*Unthinned Plots*												*Heaviest Thinned Plot*
		Age 20–29			*Age 30–39*			*Age 40+*						
		Age (yr)	*G.C.L. (ft)*	*Top Height (ft)*	*Age (yr)*	*G.C.L. (ft)*	*Top Height (ft)*	*Age (yr)*	*G.C.L. (ft)*	*Top Height (ft)*	*Years Recorded (yr)*	*Total Ht Growth (ft)*	*Loss of Crown Depth (ft)*	*Green Crown Level at Last Comparable Measurement*
Kaingaroa R20	6×6	26	31	70	38	75	102*	—	—	—	12	32	44	70
Kaingaroa R22	8×8	25	20	67	31	44	85*	40	82	116	15	49	62	65
Kaingaroa R23	8×8	29	48	84	38	80	106*	—	—	—	9	22	32	66
Kaingaroa R24	8×8	21	24	55	—	—	—	—	—	—	—	—	—	—
		27	41	68	36	86	104*	—	—	—	15	49	62	50
Kaingaroa R38	8×8	20	23	55	—	—	—	—	—	—	—	—	—	—
		29	54	84	—	—	—	—	—	—	9	29	31	45
Kaingaroa R214	8×8	19	17	49	27	42	73	—	—	—	8	24	25	—
Karioi WN57	8×8	28	37	70	31	39	77	—	—	—	—	—	—	—
		—	—	—	34	46	84*	—	—	—	6	14	9	35
Golden D. N100	8×8	—	—	—	32	57	96*	—	—	—	—	—	—	—
Hanmer C88	8×8	26	17	54	35	39	67	—	—	—	9	13	22	—
Hanmer C112	8×8	25	23	61	35	52	83	—	—	—	10	22	29	—
Dusky S37	8×8	27	25	58	31	40	66	—	—	—	—	—	—	—
		—	—	—	37	59	86	—	—	—	10	28	34	48
Dusky S39	6×6	27	37	70	30	39	78	—	—	—	—	—	—	—
		—	—	—	37	66	90	—	—	—	10	20	29	—
Tapanui S44	8×8	26	28	65	35	59	92	—	—	—	9	27	31	—

* Extrapolated from previous measurements.

Source: Unpublished data, New Zealand Forest Research Institute Permanent Sample Plots.

Definitions: Green Crown Level: The average height, for a number of sample trees predominants, to a point on the stem between the lowest green branch and the lowest green whorl, but not necessarily midway. (H. Beekhuis, pers. comm.)

Top Height: The mean height of the 100 trees of largest diameter per acre.

with the small branch sizes of the timber milled to date, favours the use of the species for framing.

Details of the development of the green crown level in New Zealand Douglas fir are given in Table 11; in unthinned stands the base of the green crown is at 30 to 40 ft by about top height 70 ft, and by top height 100 ft it is approximately 75 ft. The critical age for the rapid and technically desirable death of the lower crown is between 30 and 40 years. As with natural stands in North America and in European plantations, branches are strongly persistent and natural pruning is as slow as, or slower than for radiata pine (Fenton and Familton, 1961). Until 1962 the great majority of thinning operations had occurred at or after age 40, and hence in the three or four lowest sawlogs the branches were dead and relatively small. This condition was therefore fixed for any subsequent yield from the most important part of the remaining trees. Much of the timber sawn from top logs (namely, from the green crown of second thinnings at age about 55) has been of poor quality, being degraded by large live knots of more than 2 in. diameter. The remarkable reaction of Douglas fir to delayed and very heavy thinning (Spurr, 1961) is achieved at the inevitable cost of enlarged branches in the remaining crown above about 75 ft. If the species is to be grown on long rotations, timber from these upper log-height classes will occur more frequently and will be akin to box grade of radiata pine. Economically, this material may be more than compensated for by the excellent grades of framing from the lowest three or four log-height classes. In calculating the value of long rotations, prolonged height growth and the ensuing development of further heavy branches after thinning will have to be assessed against increased log diameters in the three or four lowest logs. Removal of the lower dead branches by falling trees during thinning operations certainly reduces the incidence of future defects, provided a sufficiently long time interval elapses between thinning and clear felling (Fenton, 1966); it is rarely sufficient to produce long clear lengths, but this is of less importance for framing than for board timber.

The persistence of tree branches and the dense shade under the canopy make marking difficult in thinnings unless stands are 0/8 ft pruned. Douglas fir bark is thin on young trees and this, combined with a large number of short, wire-like branches (1 ft long and up to 0.2 in. diameter) make secateurs preferable to saws for pruning. Spurr (1961) and Reid (1962) have pointed out that pruning is desirable but not essential in this species, and an internal Forest Service directive rates its priority below that of pine species. This view is entirely correct but, as the fragmentary data assembled in Table 12 show, up to 1963 a far greater percentage and a physically greater area of Douglas fir than of radiata pine had been pruned in State forests. Selective pruning 0/18 and 8/18 ft of 25- to 30- and occasionally 35-year-old trees was carried out throughout the 1950s despite labour shortages, while on many forests young radiata pine remained unpruned. Although it has been advocated that even old (75 years) Douglas fir can be pruned at a profit (Smith, 1956) New Zealand experience has shown delayed pruning is not very profitable if recovery of clear boards is sought (*e.g.*, Fenton, 1966).

TABLE 12: TENDING — NEW ZEALAND DOUGLAS FIR IN STATE FORESTS

Year Y.E. 31/3	*Pruning to 18–20 ft*		*Production Thinning*		*% State Exotic Log Production*	*% all Exotic Forest Log Production*[3]
	Kaingaroa Forest[1]	*All New Zealand State Forests*[1]	*Kaingaroa Forest*[1]	*All New Zealand State Forests*[1]		
1945–50	627	N.A.	305	N.A.	—	—
1951–61	14,458	N.A.	3,460	N.A.	—	—
1962	210	261	459	N.A.	7.8	3.0
1963[2]	0	150	438	707	8.5	3.1
1964	0	449	665	749	7.0	2.8
1965	0	—	1,031	1,122	7.9	3.5

[1]Areas in acres.
[2]New Zealand Forest Service, 1963–65; corrected figures for 1963 are given above.
[3]Figures decreased by effect of Japanese log trade in radiata pine.

Some additional strength in framing timber could result 20 years after pruning, if modified sawing patterns were used, but this would involve increased sawing cost and lower conversion. It would not affect the stiffness of the timber (Sunley, 1962). Possibly rotary veneer would be an outlet to justify the cost of pruning since some Canadian data suggest face veneer is recoverable within 25 years of pruning (Smith and Walters, 1961).

Thinning with extraction of Douglas fir, on country of easy topography, has hitherto been delayed until a large volume could be cut. A range of operations is shown in Table 13. On steeper country tractors are still cheaper than haulers, but the thinning intensity is greater. Steep country results in higher costs, particularly if haulers are used, and residual stocking is lower. By thinning at age 30, the reduced yield is associated with both higher costs and lower realizations, resulting in minor or even negative returns. The obvious disadvantage in the management of Douglas fir is the long time interval before thinning is both profitable and technically desirable. On one private forest, wider spacing allows thinning at age 24 (Spurr, 1961). The resultant stands may produce coarser timber than from later thinnings of more closely spaced stands but this material has been accepted to date by the market.

In Southland a few limited areas of 40- to 50-year-old stands have now been thinned three or four times, using horses for extraction. Yields have varied from 1,200 to 2,000 cu. ft per acre and the costs of 7d to 10d per cu. ft have been comparable with those of mechanized operations despite the lower volume yields.

Thinning intensities have been heavy, partly to recover the operating costs of the tracked tractors and mechanized loaders used to date. The use of cheaper equipment such as wheeled farm tractors has not been followed for extraction operations in New Zealand, despite the generally favourable topography of the stands thinned to date. The volumes extracted per acre have generally been inflated by clear fellings along road lines and yields of 4,500 to 5,000 cu. ft per acre, as reported by Spurr (1961), are likely to be more accurate than the 5,000 to 7,000 cu. ft shown by the earlier internal figures (Table 13).

The extent of thinning, the volumes extracted and the estimated end use of the material are shown in Tables 5 and 12. Thinning on country of easy topography has been, and is, profitable not because all costs are lower than for other species, but because returns are higher. Nevertheless, some costs are lower, notably hauling, where the lower green weight of Douglas fir allows greater volumes on tractor hauls and logging trucks than for pine species; green weights are 47, 58 and 62 lb/cu. ft for Douglas fir, radiata and Corsican pine, respectively (Hinds and Reid, 1957).

UTILIZATION OF THE DOUGLAS FIR PLANTATIONS

From 1941 until the mid 1950s Douglas fir and larch (*Larix decidua* Mill.) dominated the round-produce market, which was of small scale, and pines were rarely used. This was due both to the difficulty of seasoning pine rounds and to the presence of three — later two — State-owned treatment plants using oil-soluble

TABLE 13: TYPICAL THINNING COSTS, DOUGLAS FIR IN NEW ZEALAND STATE FORESTS

Year	*Forest*	*Compt.*	*Age*	*Spacing (ft)*	*Volume per acre Extracted*[1] *(thousand cu. ft)*	*Total Yield of Operation (thousand cu. ft)*	*Stocking S.P.A.*[2] *Initial*	*Residual*	*Man-hour Production (cu. ft)*	*Topography*	*Extraction Method*	*Costs per cu. ft on Skids (d)*
1964	Kaingaroa	1104	41	8×8	5.5	374	400	160	54	Rolling	Tractor	8.9
		1122	41?	6×6	10.0	225	400 [sic]	160	49	Rolling	Tractor	9.3
		1120	53	6×6	9.5	179	525	90	21	Steep	Hauler	17.7
		697	30	8×8	6.5 [sic]	120	390	170	31	Rolling	Tractor	14.2
	Dusky	16	39	8×8	4.0	148	700	200	42	Easy	Horse	12.6
1963	Kaingaroa	1097										
		1102	41	8×8	5.5	826	600	140	66	Undulating	Tractor	6.9
		1123C	43	6×6	5.8	98	860	220	18	Steep	Hauler	20.5
		1120B	43	6×6	N.A.	141	860	220	23	Steep	Hauler	16.2
		1095B	41	8×8	N.A.	89	500	200 [say]	24	Steep	Hauler	16.5
		1123	42	6×6	6.5	100	650	160	51	Undulating	Tractor	9.0
		1149	40	8×8	7.6	467	460	120	64	Rolling	Tractor	7.8
		697	30	8×8	3.0	15	400	200	26	Flat	Tractor	10.9
	Whaka	4A	58	2nd thin.	2.7	222	127	63[3]	87	Flat	Tractor	7.0[4]
		7C	57	2nd thin.	4.7	47	220	60–100	65	Steep	Tractor	7.9
1962	Kaingaroa	1102	39	8×8	5.5	1,044	400	150	70	Flat to rolling	Tractor	6.7
		1123	41	6×6	5.8	133	860	220	17	Steep	Hauler	20.7

[1]These yields are estimates supplied at the time; they are probably overstated.
[2]Figures are only estimates.
[3]Figures are high.
[4]Costs inflated by rate of bonus paid.

Source: Unpublished figures, New Zealand Forest Service. All operations are on a bonus or piecework basis; the most accurate costs are those of the larger scale operations.

preservatives. These plants were sited near forests which included stands of larch and Douglas fir. In 1955 one of these was replaced by a large pressure plant, which also used only oil-soluble preservatives. In the mid 1950s, competition with sawn timber treated by cheap diffusion methods caused pressure plants using multi-salt water-soluble preservatives to break into the round-produce market, which until then had been almost monopolized by round produce treated at the two State-owned oil-soluble plants (Fenton, 1962). The importation, through the 1950s, of hardwood posts — largely from New South Wales — at the same time that "hundreds of thousands of acres were crying out for thinning" (Hinds, 1962) illustrates strikingly how slowly the treatment of pine round produce started, although, once under way, progress was very rapid. Now there are over two hundred widely distributed treatment plants utilizing pines, while only one further plant — in addition to the original two — is available to treat Douglas fir.

However, the presence of a very good and relatively unchallenged market for posts and poles was a major reason why the thinning of Douglas fir was profitable initially — the price of the end product was not controlled and good profits (stumpages) could be made from round produce (Fenton, 1962). Owing to the peculiarities of the treatment industry at the time the produce was marketed, it was then fair to say "natural round thinnings from Douglas fir are a far more easily marketed item than thinnings from *P. radiata*" (Reid, 1953). The proportion of thinnings utilized for round produce from Kaingaroa (which with Whaka forest was the major source of supply) is shown in Table 5. Today, in areas other than those supplying the two State plants and one large private plant, the situation is reversed. The pine round produce is easier to utilize as an intermediate crop, and profitability falls as the thinning of Douglas fir extends to forests not supplying the State plants, and round-produce markets are unavailable; this reversal of circumstances has occurred within ten years (compare Reid, 1953, with Reid, 1962). Further, the situation is approaching where pole supplies from Douglas fir will lapse, owing to limited planting in the 1930s (Fenton, 1962) and failure to retain subdominants in thinned stands to fill the gap. It is possible that pine will replace Douglas fir in the future pole market; the reversal of opinion to favour pine poles has been recent, and is based on changes in technology.

The actual merits of Douglas fir in New Zealand as a round product are, of course, high; but comparisons with pine (given in Table 14) are difficult to finalize. Recent development of the oscillating pressure method of preservation, which has marked advantages for treating large cross-sections of pine (New Zealand Forest Service, 1965) may give a decisive lead to pine. Failures in treated Douglas fir poles to date have usually been traced to poor penetration, deriving partly from inadequate seasoning. It is still debatable what constitutes a sufficient degree of penetration, but customer preference may change to the more deeply penetrated pines. The idea of wider spacing resulting in wider sapwood "so that posts may be treated throughout" (Spurr, 1961) is incorrect, since increases in the width of sapwood over the almost universal width of 0.4 in. required by specification does not improve the

TABLE 14: RELATIVE MERITS OF DOUGLAS FIR AND RADIATA PINE AS ROUND PRODUCE

	Douglas Fir	*Radiata Pine*
Form:		
Posts	Generally good.	Usually adequate — larger branches.
Poles	Generally good.	Usually rough, except from specific — usually phosphate deficient — sites, where form is good.
Strength:		
Poles	Good, if treatment temperature and pressure are not severe.	Adequate (Hellawell, 1965). Both species require reasonable care in peeling and preparation.
Air Seasoning:		
Posts	Easy — no decay.	Usually adequate in summer.
Poles	Easy — no decay.	Summer only; preferably in covered stacks.
Preservative	Oil-soluble only.	Oil- or water-soluble.
Penetration	Difficult; minimum specification 0.4 in. in 70% of pieces. Heartwood impervious.	Easy in sapwood which can be completely treated. Heartwood impervious.
Preservative loading	Reasonably easy to achieve; is high in treated zone.	Easy to achieve.
Costs	Higher preservative costs.	Fairly high seasoning risk — require covers in damp climate.
Limitations	Oil-treated poles generally unacceptable in urban areas. Only three treatment plants available.	Water treated material heavy, unless Lowry process used, and requires reseasoning.

treatability of the round; in fact, the amount of pre-treatment seasoning required is increased.

Sales of round produce enabled the major Douglas fir thinning operations to benefit from a profitable diversion of small material from the sawmill. Contemporaneously, small pine sawlogs had still to be converted to low-grade timber at a heavy cost. Other important effects included "a fillip to the interest and morale of forest staff" (Hinds, 1962) and the beginning of piecework rates and other incentive schemes to stabilize the labour force; these effects linked together Douglas fir and profit in New Zealand forestry. Throughout the 1950s, by contrast, pine stands remained a source of net expenditure, apart from clear felling operations.

Douglas fir sawn timber was as favourably placed as round produce when, from 1950, thinnings first found a steady market. Although Douglas fir production increased steadily, until it comprised 5% of the 1965 exotic cut, the overall volume reaching the market has been small, the balance being almost all of pine (Table 5). The figures are not entirely accurate as mills included some larch timber in with Douglas fir. Such a practice is damaging to export and domestic trade because, although larch combines the highest density with the best branch characteristics of the New Zealand exotic timbers, enough of it is subject to excessive distortion on drying to make general acceptance difficult. With most old (40 yr) Douglas fir stands in State forests concentrated near the two State mills, the Forest Service produced the bulk of the timber until the Tasman Pulp & Paper Company began sawmill operations early in 1956. The volume of Douglas fir timber on the market was too small to render it subject to price control and this, together with its name, the price of equivalent imports, and its intrinsic good quality for framing, enabled the local material to be sold at a price margin above that of pine species. Although it was earlier thought to be susceptible to *Anobium*, it is now found that preservation against this insect is unnecessary. Hence it possesses a further advantage — the main authority providing home finance, the State Advances Corporation, specifies that pine building timber should be preservative treated while Douglas fir can remain untreated; at least half of most cross-sections of Douglas fir timber are of *Anobium*-resistant heartwood. The same authority specifies smaller sizes of (ungraded) Douglas fir than of radiata pine in such positions as sub-floor joists. In Australia, the Division of Forest Products recommends the two species for framing uses on the basis of "Radiata pine . . . sawn full to size should be used in the same nominal sizes as Douglas fir (which is cut scant) if . . . unseasoned, and provided they are graded to equivalent grading rules. In the dry condition radiata pine should be interchangeable with unseasoned Douglas fir of the same grade" (Anon. 1966). Radiata pine's success as an exotic has caused a re-examination of its qualities in its native California, where it ws recently assessed by being equivalent to Douglas fir as a structural timber (Cockrell, 1959).

A major advantage of Douglas fir was that it could be sold ungraded, and so the problem of disposal of low grades did not arise. At the same time, the sawn material originated from relatively uniform logs — the larger thinnings of 35- to 40-year-old stands established at 6 × 6 ft and comprising, in the main, the suppressed, subdominant and low co-dominant crown classes. Sawn, these represented the best of the Douglas fir timber of that age class as, wood density considerations apart, these trees had the smallest branches and the shallowest green crowns. Poor quality Douglas fir timber is inferior for most uses to radiata pine (Reid, 1962) but proportionately little was present in timber from these first thinnings.

The sustained sale of New Zealand-grown Douglas fir in Australia began in 1957, and grew quietly until a strike on the American north-west coast in 1959 presented a most favourable marketing opportunity in Sydney. A demand arose for New Zealand Douglas fir framing which was shipped in 3 and 4 × 2 in. and 6 and 8 × 4 in. sizes (New Zealand Forest Service, 1960). This material had an advantage due to tariff differentials, although naturally the large baulks of the North American trade could not be matched from the New Zealand stands then available. "New Zealand exporters created considerable goodwill by refraining from taking advantage of the shortage. However, as with construction grade (of radiata), orders slumped immediately Canadian Douglas fir began to arrive" (New Zealand Forest Service, 1960), and have not been maintained on a comparable scale since. Some slight increase in price did, in fact, seem to occur, as shown in Table 4, but this was probably due to the export of larger sizes; a positive price size differential exists in New Zealand. There was a diversion of roundwood from pulp to sawtimber, and an overall increase in Douglas fir production in 1954–60.

Douglas fir began to be marketed in New Zealand under a set of peculiarly favourable economic conditions which, together with the quality of the material produced, resulted in a generally profitable series of operations, as long as land of easy topography was worked. It received a misguided priority in pruning, owing to lack of appreciation of timber qualities and end use requirements despite clear leads on the subject (Reid, 1953) and at a cost of further neglect of radiata pine stands. The extensive pruning of Douglas fir at that time emphasizes three trends which have influenced New Zealand exotic tending since it began on an appreciable scale after 1945:

(1) Only Douglas fir was worked profitably in thinning operations, and this led to a concentration of effort — especially pruning — on this species.

(2) The tending of radiata pine, with its critical timing, was not widely understood before 1960; "catching up with the backlog" was a prevailing policy (*e.g.*, New Zealand Forest Service Annual Reports 1952, p. 15; 1958, p. 36; 1959, p. 30; 1961, p. 15; *et al.*).

(3) It seemed naturally more promising to work with a profitable species, but no analysis was made as to why it was more profitable.

Douglas fir continues to pay higher overall stumpages than radiata pine (with some exceptions) but as the silviculture it has received has been ideal for its end use, and that received by the present sawlog supplies of radiata pine has been nugatory, it is debatable that: ". . . the quality of the timber is so much better than that of radiata pine that much higher stumpages can be expected" (Spurr, 1961). This "better quality" is true of current supplies, but is doubtfully attributable to the future.

Some North American Pacific Coast prices and stumpages for Douglas fir and pine timber are given for comparative purposes in Tables 15 and 16. Relatively, the Canadian western pine resource is very limited and the figures are of less consequence than those from the U.S.A. Stumpages, of course, reflect costs of production as much as realizations and are less appropriate sources of comparison than timber prices. A further qualification is that North American prices vary frequently; but those shown in Tables 15 and 16 cover a representative range. The relative value of the two groups has been discussed (Reid, 1953): "The pines provide the cream of the forest crop with their even texture, ease of sawing, seasoning and machining — high qualities for finishing" and "I suggest that our *P. radiata* on managed forests could

TABLE 15: RELATIVE NORTH AMERICAN STUMPAGES

Year	United States[1] Douglas Fir	Ponderosa Pine	Sugar Pine	Southern Pine	British Columbia[2] Douglas Fir	Western Pines	All Species
1910–19	1.03	1.35	1.75	1.33	—	—	—
1920–29	1.20	1.80	2.17	1.79	—	—	—
1930–38	1.05	1.40	1.91	2.16	—	—	—
1940–49	4.09	3.77	4.25	5.61	—	—	—
1950–54	10.70	13.62	16.79	16.84	5.4	13.2	4.5
1955–59	15.57	12.05	14.92	17.20	5.5	13.1	4.2
1960–63	14.43	8.11	11.13	14.45	4.9	9.5	2.9

Stumpages are in pence sterling per cu. ft.

[1]U.S.D.A. 1964. Stumpages are for National Forests, and are averaged over 10 and 5 year periods; yearly fluctuations are considerable.
[2]British Columbian Forest Service, Annual Reports. Stumpages are as bid; lower stumpages apply to 'tree farm' licence areas.

TABLE 16: COMPARATIVE TIMBER PRICES OF DOUGLAS FIR AND PINE — WESTERN U.S.A.[1]

Prices in shillings sterling per 100 bd. ft.

Grade	Size (in.)	Ponderosa Pine	Sugar Pine*	Douglas Fir
C and better	6×1	185.4	213.6	124.8
		184.4	198.5	118.5
	12×1	214.7	—	136.7
		210.8	—	142.0
D Select	6×1	116.2	141.2	99.8
		115.0	137.8	106.3
No. 1 Shop	1¼	99.2	98.3	79.6
	thick	98.4	103.2	76.5
No. 1 Common	1 in.	96.5	—	—
		91.5	—	—
No. 2 Common	4×1	72.5	75.1	68.3[2]
		73.5	72.6	57.0
No. 3 Common	4×1	45.5	46.7	40.3*
		44.6	49.2	41.0*
Framing Timber —				
Std and better	4×1⅝	47.9	—	54.1
		44.7	—	53.0
Std and better	Studs	43.0	—	43.8
		41.6	—	44.5
Utility	4×1⅝	26.6*	—	32.9
		29.1*	—	32.4
Economy	1⅝	16.8	—	12.6
		19.3	—	10.9

[1]Western Wood Products Association, 1966A and 1966B.
[2]No. 1 and No. 2 Commons.
All prices are for dry timber; those for the pines include dressing. Prices are gross, f.o.b., for the last two weeks of December, 1965.
* Widths not specified.

possess the same advantages over Douglas fir . . . which western pines have in the U.S.A." and, further, "Douglas fir is, of course, a remarkable constructional timber, but the grades required for most construction need not be clears and prices for constructional timbers are always lower than for finishing". New Zealand-grown radiata pine and North American ponderosa pine (*Pinus ponderosa* Laws) have been considered elsewhere to be quite comparable (Vaughan, 1965). Historically, from about 1910 until as recently as 1955, the differentials in stumpage between sugar (*Pinus lambertina* Dougl.) and ponderosa pines and Douglas fir in the U.S.A. have markedly favoured the pines; since 1956, however, the stumpage/price relation has been reversed. The North American supply and market situation is referred to later, but the spectacular development of a structural veneer market, and increased demand for saw timber exports, together with an increasing shortage of accessible old growth log supply (Haley, 1963; Anon., 1963) are primarily responsible for the current differential. Timber prices, as against those for logs of pines and Douglas fir, still maintain a considerable differential in favour of pines for the high-quality board grades; Douglas fir maintains a price margin for the best framing grades.

The amount of Douglas fir used in the pulp industry in New Zealand is limited; only a very small resource is available to two of the integrated mills, while the third chips about one-third of its log intake of this species. This proportion corresponds with that utilized by the larger State mill as round produce, although the latter is, of course, much more profitable as stumpage. The growing diversion of sawmill residues to pulp mills in the Douglas fir regions of North America could be followed eventually by the large sawmills in New Zealand, but pines will be preferred to Douglas fir as a pulpwood resource (Reid, 1962). The trend to chip residues has been criticized in North America, where it was contended that, as timber is always more profitable than pulpwood chips, it would have been preferable to concentrate on innovation in sawmilling, rather than accept the volume of waste produced as a low value product (Guthrie and Armstrong, 1961).

THE NORTH AMERICAN RESOURCE

Any study of the relative profitability of Australasian forestry demands at least some assessment of the current and future North American supply. It has already been indicated that Australia is an important market for U.S. exports of Douglas fir, but of lesser significance in the substantially greater export trade of Canada. The persistence of the United States exports to Australia is interesting in view of its own position as the largest importer of Douglas fir timber, and the distinct market preference there for this species (Haley, 1963). The presence of representatives of the two largest U.S. timber companies, and of the British Columbia Lumber Manufacturers Association in Australia, and the recent extension of sales outlets on the Sydney market (Anon., 1965b) by one of the world's largest timber companies, indicate that North American sales will be a permanent feature of the Australian market. Some indication of the level of competition is shown by Weyerhaeuser Company's 1964 timber production of 1,588 million bd. ft, 8% of which was exported, and over a third of whose exports went to Australia (Anon., 1965c).

The continued dominance of Douglas fir on the Australian timber market is more remarkable in view of the large increase in finishing quality lines of South-east Asian light hardwoods available since 1950 and the reorientation of Canadian framing sales efforts to hemlock (*Tsuga heterophylla* (Rev.) Sarg.), renamed "Canada pine" in 1962 (B.C.L.M.A., 1964). Both Canada and the United States have sought to broaden the basis of their timber exports, with decreasing reliance on European (particularly United Kingdom, Italian and West German) markets, which are subject to severe and increasing competition from the Soviet Union. One difficulty in analysing a given species or market is that it cannot be considered in isolation (Worrell, 1966) and this certainly applies to an internationally traded species such as Douglas fir; but these interrelated market influences are only acknowledged here.

The tempo of development in forest industry in North America is rapid, and while published information is usually of an excellent standard, the generalizations which follow are drawn from data constantly being modified. For example, resources are based on definitions of timber-sized trees of 11.0 in. d.b.h. in the U.S.A. and 9.0 in. in British Columbia, and changes in utilization standards may greatly alter projections. Comprehensive data are included in the references given, and the account which follows deals only with the major trends as they affect Australasia.

Old growth (over 160 years) Douglas fir is by far the most important timber sawn on the entire Pacific West Coast of North America, comprising over half the cut in 1952 (Guthrie and Armstrong, 1961). It has been estimated that only 1% of this cut in the Douglas fir region was then of pole timber (Guthrie & Armstrong, 1961); later figures, however, show that, in western Washington and Oregon, 15% of the cut is from young growth stands (Anon., 1963). In 1962, 16% of the United States Pacific Coast cut came from trees of 19 in. d.b.h. and under (Anon., 1965d).

In British Columbia, the shift in timber harvesting has been both from the coast to the inland areas, and to other species, rather than to the coastal young growth Douglas fir stands. The predominance of Douglas fir in the overall cut has been reduced from round 70% in 1940 to 35% in 1965 (British Columbia Forest Service annual reports). Simultaneously there has been a tendency for costs to rise, owing to smaller log size, increased freight and a reduction in grade outturn due to increased defect. Scaling defects ranging from 35 to 60% of gross volume have been recorded for inland Douglas fir (McIntosh, 1964). However, the net cost of production has not increased appreciably, as a result of increased efficiency (Guthrie and Armstrong, 1961). Hemlock now almost equals Douglas fir in overall timber production — 22 and 26.5%, respectively, in 1964 (B.C.F.S., 1964) and outproduces Douglas fir by over a third in the coastal region. The hemlock resource consists largely (84%) of old growth stands, whereas Douglas fir old growth now comprises only 32% of the total area of the species (McKee, 1959). Hemlock has always been a more important source of pulpwood, being favoured for sulphite pro-

TABLE 17: SOME UNITED STATES THINNING COSTS[1]

Place	*Age*	*Volume per Acre*[2] *Extracted Thousand cu. ft*	*Total Yield of*[2] *Operation Thousand cu. ft*	*Man-hour Production cu. ft*	*Topography*	*Extraction Method*	*Cost per cu. ft on Skids*[3] *(d.)*
Hemlock[4]	50	0.66	33	33	Gentle	Horse	7.1
McCleary	55	0.5 to 1.0	161	48	Moderate	Tractor	6.8
Hood Canal	65	0.8	80	46	Gentle	Tractor	7.4
Big Creek	70	1.2	120	37	Easy	Horse & Tractor	8.0

[1]Worthington and Staebler 1961.
[2]Converted from board feet by a factor of 5.5.
[3]Cost in pence sterling; half of the miscellaneous costs apportioned to felling and extraction.
[4]Produce was 8 ft pulpwood from Hemlock, and both saw and pulp logs from the other areas. These were all natural stands and in Hemlock and McCleary, species sorting was required.

duction (Guthrie and Armstrong, 1961), but the greatest and most important change in utilization has been the spectacular increase of the pulp and paper industry — particularly for kraft pulps by the sulphate process; Douglas fir — mostly in the form of chipped sawmill residues — is now an important raw material for the pulp industry.

Douglas fir is overwhelmingly the main species used in the west coast plywood industry, although quality standards and requirements have dropped sharply over the last decade. In plywood, as in timber, there has been a shift to other species; these comprised 9% of the softwood plywood produced in Canada in 1964, compared with 2% in 1960 (Haley, 1964). In the United States, southern pine plywood production is increasing rapidly, although Douglas fir still made up 87% of all the logs used in 1963 (U.S.D.A., 1964).

It is the Pacific coastal, as against the inland, regions of both Canada and the United States which supply the great majority of the export timber, and as the domestic market is being increasingly gained by the interior mills, interest in exports from the coastal areas intensifies (Guthrie and Armstrong, 1961). Overall grade outturns are difficult to obtain, but a recent survey of the United States timber industry showed a decline of clear-cutting grades; in the "Douglas fir region" of western Oregon and Washington, Douglas fir itself produced 62% and hemlock 17% of these grades (Anon., 1965e). Nationally, Douglas fir provided 18% and hemlock 4% of the current production of these higher grades; and it appears that high-grade hemlock will increase at the expense of Douglas fir (Anon., 1965e). Timber grade outturns were not mentioned in analyses of financial returns of British Columbian Douglas fir, although log grades were incorporated (Haley, 1963). Some actual grade results of young-growth Douglas fir from the United States showed, for the instance quoted, an excellent outturn of 31.9% Select Structural; 53.8% No. 1; 12.1% No. 2 and only 2.2% No. 3 for logs of 8 to 21 in. diameter (Worthington and Staebler, 1961). It is not known if such yields are characteristic; vagaries of spacing in the naturally regenerated young growth stands, which were more or less unmanaged at the time of their origin, will control the grade potential. No detailed figures on the extent of thinnings and utilization of young growth stands are available; thinning is currently assessed as being a marginal operation, and while techniques have recently been analysed (Worthington and Staebler, 1961; Willison, 1965) they do not include any methods new to Australasia. Costs are similar to those in New Zealand, but the volume extracted per acre is much less (Tables 13 and 17).

The United States yield tables have been revised several times (McArdle *et al.*, 1961) and the trends shown in them have been reported as agreeing with those of the best stocked permanent sample plots there (Williamson, 1963). Data for British Columbia are more limited, where yield tables for thinned stands depend partly on British and German results (Warrack, 1959). The main use of the yield tables appears to have been to estimate future resources, rather than as a current tool of management.

The impression gained from North American literature is that the second growth cut currently provides less than 15% of the overall cut; but, if industry develops techniques for utilizing the resource at costs similar to today's, the volume available is sufficient to provide for a formidable timber production. The biggest gaps in the data are the future costs and methods of production of this material, its grades, and their acceptability on the market. Extensive second growth stands elsewhere in the U.S.A., particularly in the south and north-east, are now successfully marketed. As far as competition on the Australasian market is concerned, it should be noted that Canadian stumpages are low, and, although United States stumpages for national forests are higher, much of the potential export resource is owned by private companies. In the Douglas fir region of western Oregon and Washington, the four largest companies own 3.49 million acres, which is 13.7% of the commercial forest of the area (Mead, 1964). The Federal government, through several agencies, owns 51% of the standing timber on 38% of the forest in this area (Mead, *op. cit.*). The lower Canadian stumpage is equivalent to a price advantage of around 13 shillings per 100 bd. ft if other costs of production are equivalent.

It is not possible to decide whether Australia or New Zealand can produce from their exotic plantations at costs competitive with the very large North American second-growth resource. The advent of management into these stands in the decades to come will be a deciding factor as to the level of profitability of New Zealand-grown Douglas fir. The labour costs in the Pacific North-West are high, and the costs of thinnings to date have not been lower than in New Zealand. The tariff advantage of about 10d per cu. ft in favour of New Zealand, when the current tariff is phased out in eight years' time, will gradually become of greater importance as the cost of large dimension virgin stock will inevitably rise, owing to competition for a diminishing resource. It is, however, an adage of the stock exchange not to rely on tariffs for profitability. Freight to Sydney on packaged softwood from New Zealand was 25s 9d sterling per 100 bd. ft in 1965 and Canadian freight to Adelaide was given as 26s 8d in 1963; so there is a negligible freight advantage: these rates can fluctuate (Commonwealth of Australia, 1963).

In summary, the North American supply shows a sharp and increasing drain on the old-growth resources but, despite this, the price of exports to Australasia has increased little over the past decade. The quality of clearwood available from Douglas fir will decrease as utilization shifts to the extensive young growth resource; the extra cost of logging and sawing these smaller logs will be compensated to some extent by their more favourable location, particularly in Washington, for export. Replacement of Douglas fir by hemlock will increase, and the grade potential of this substitute is high. There appears to be little thinning, but a considerable potential for it, and although the sawmill industry is not ideally equipped to deal with a small-log supply, the growing pulp and paper industry may reduce the cost of integrated utilization. Overall, there is plenty of log volume available. The national trends, in any case, are less appropriate indications when the export industry is so actively an interest of very large and well organized private companies.

THE CURRENT AUSTRALASIAN MARKET

Imports of Douglas fir into New Zealand are now on a small scale; the true demand for these imports is difficult to assess as, in addition to the tariff, they are restricted by a stringent set of import controls necessitated by a perennial shortage of overseas exchange. Data on the grades imported are not available, but these are thought to include "'fairly large quantities of No. 2 clears brought in specifically for manufacture of joinery, shop fittings and ladders" (J. S. Reid, pers. comm.). The structural grades for such uses as purlins in industrial buildings, scaffold planks and other uses where strength and stability are required, can be supplied from the exotic Douglas fir stands at costs equivalent to current imports. High quality clears for internal joinery can be largely supplied, two or three decades hence, from pruned pines, and continuation of current programmes will effect this substitution. Grades for ladders and other specialized uses would be a logical outcome from small areas of pruned Douglas fir if autarchy is to dominate policy. New Zealand has ample supplies of good grades of framing timber available from its first rotation of Corsican and radiata pines (Fenton, 1960, 1966) and as these stands age the proportion of higher framing grades increases. The Douglas fir estate adds still further to these supplies. Domestically, however, this framing is almost always used in a green (unseasoned) condition.

The New Zealand domestic market is one on which the competitive strengths of Douglas fir and radiata pine can be examined to some extent. The small available volume of Douglas fir results in a limited scarcity value, as the bulk of the framing used, after a decade of promotion and persuasion, is of pine. Douglas fir has a superficial price premium of round 16 shillings sterling gross per 100 bd. ft for 4 × 2 in. as against 4 × 2 pine No. 1 Framing grade; for all practical purposes in building this premium reduces to 1s 6d to 3s 6d per 100 bd. ft, as the pine has to be preservative treated, while the Douglas fir is accepted untreated. The result, as far as the forest is concerned, is a higher net stumpage for Douglas fir. Both timbers are readily accepted, and the net margin of 1s 6d to 3s 6d reasonably represents the amount of consumer preference for Douglas fir.

The overall Australian timber grade requirements are also difficult to assess; data on grades imported, as presented to Tariff Board hearings, are given in Appendix 2. They are not very specific, but indicate that a quarter of the imports are mainly clear timber used for finishing lines, and the balance is of merchantable grades for framing. This pattern of imports contrasts with those of, for example, West Germany and the United Kingdom, where most of the imports are clears, or of grades suitable for joinery (Anon., 1965f). Hence, in Germany "freedom of knots is demanded wherever possible for all purposes" and leads naturally to a policy of pruning for the exotic Douglas fir (Hilf and Maisenbacher, 1962). This need not apply to substitution for the major use — construction — in Australia, but the available plantation softwoods should be pruned if high grades for joinery are required. The attitude to pruning in Australia has varied between States and over time; Queensland has maintained a consistent programme of pruning (of butt logs) and South Australia — with the most extensive current resources — by contrast, has maintained since 1938 a consistent policy of not pruning. Currently the four remaining states regard pruning as an integral part of their plantation silviculture and so, in the future, may have equivalent grades available to match imports of joinery grade Douglas fir. The equivalent cost of production is not known.

The value of imports in maintaining markets for wood until equivalent local supplies become available is considerable, and increase of timber prices, owing to tariffs, may increase substitution. This view has been urged by exporting interests when opposing tariff increases in Australia (Anon., 1964a *et al.*), and the form of the tariff bears hardest on these high grades. Log supply in North America is such that the clear grade potential of large flitches must decrease as the old growth stands decrease; high grades will still be available, but more probably in small-sized timber. In New Zealand the shortage of high-grade joinery timber for external uses has led to suspension of tariffs on western red cedar and redwood. The correct balance between a penal tariff and a fair degree of protection is debatable and, while protests are made in the United States against Canadian tariffs on Douglas fir timber (Anon., 1964b), a proposal that the United States should reduce its tariff against Canadian softwood plywood was vigorously protested (Anon., 1965g).

The limiting factor governing successful substitution of Douglas fir by exotic pine for framing in Australia will be neither the actual strength of the timber, nor the presence of knots, but the stability of the product under conditions of low equilibrium moisture content in the summer. Owing to absence of pruning, framing grades are regarded as the highest grades in South Australia and a study showed that logs smaller than 13.5 in. s.e.d. "are undesirable for scantling (framing) because of subsequent excessive spring, . . . that the juvenile core should be avoided and that scantling should be sawn as far from the pith as possible" (Lewis, 1965). Similar work confirms that "sawing out a square of 3 or 4 in. minimum dimension surrounding the pith" avoids most of the unstable material (Boyd, 1964). These conclusions agree with those of South African work in utilizing similar pines. Technically, final fellings from exotic radiata pine plantations would be suitable as a source of replacement of imported framing. Because of circumstances, however, this technically suitable framing has not had its acceptability tested on the market.

The overall cut of about 234 million bd. ft from Australian softwood plantations (year ending 30/6/65) was about half that of the New Zealand production of 472 million bd. ft (year ending 31/3/65); and Australian production of other softwoods is less than 100 million bd. ft per year. Overall Australian timber usage, on a *per capita* basis, is only of the order of 140 to 165 bd. ft compared with 280 in New Zealand. One result of this relatively low production has been far less difficulty in selling the exotic softwoods than in New Zealand, and marketing is still dependent on box uses for 40% of sales (Ladkin, 1965). Generally, the Australian exotic log supply has contained a high proportion of thinnings — small logs suitable only for boxmaking. Outlets for Dressing grades have been established, producing lines generally equivalent to the top of New Zealand Merchantable grade (namely, reasonably tight surfaces, but allowing some cone-stem holes). Because of a modest overall cut, derived largely from small logs unsuitable for framing, and a relatively easy sale for box-board uses, Australian production of framing grades of radiata pine has been negligible. Even in the south-east of South Australia, said to be 10 to 15 years ahead of the rest of Australia, only 1.5 million bd. ft of radiata was used for framing in 1962 (Ladkin, *op. cit.*). Imports of New Zealand construction grade are also small — *i.e.*, two to four million bd. ft per year — despite the fact that half the New Zealand exotic cut is for framing. This is partly due to the traditional use of unseasoned framing within New Zealand, and partly due to its inability to compete with the current grades of imported North American Douglas fir.

Production of pine framing would also act against the sales of hardwoods, which are used unseasoned for framing and supply much of the forest revenue in states other than South Australia. The price premiums in favour of Douglas fir, in comparison with hardwood framing in the Sydney and Melbourne markets, were given as 1.6 and 52.8 shillings sterling per 100 bd. ft in 1963 and 9.2 and 56.8 shillings sterling per 100 bd. ft in 1960 (Commonwealth of Australia, 1963, 1960). The results of the relative effects of royalty and freight are discussed in Tariff Board reports (Commonwealth of Australia, *op. cit.*) where it was concluded that in Western Australia, Victoria and Tasmania unseasoned hardwood framing "has a decided price advantage over Douglas fir in their intrastate markets and little Douglas fir is used in home production in those States".

Currently, then, North American Douglas fir remains a major source of framing timber, and faces competition mainly from Australian indigenous hardwoods. It has sustained this position for at least four decades under both relatively low and high tariffs. This situation will be subject in the future to five major influences: two North American and three Australasian. The dual North American influences are the decline of the old growth resource, which supplies the large baulks currently favoured by Australian importers, together with efforts to divert consumption to the relatively more abundant old-growth hemlock resource and to young-growth Douglas fir. Competition will come from the New Zealand exotic Douglas fir, which will be able to compete with American young-growth material on equal terms, as far as quality is concerned, owing to the more intensive management of plantations. The ultimate tariff advantage should react in favour of the New Zealand produce. Australian and New Zealand grown radiata pine has yet to establish commercially what is possible technically — its suitability as acceptable framing in Australia. The exploitation of this market potential depends on a reasonably high level of production standards, on price, and on sustained sales promotion. It seems possible that this will be stronger from New Zealand than from the Australian states (excepting South Australia) because:

(1) There will be continued pressure to maintain sales of indigenous Australian hardwoods, owing to considerations of rural employment, to maintenance of revenues, and to established practice and equipment for converting this material.

(2) The generally large size of new (post-1950) exotic sawmills in New Zealand, well equipped to saw and season framing.

(3) The availability over the next decade of increasing quantities of larger and older trees, whose main outlet for profitable utilization is either as finger-jointed or as framing timber (Fenton, 1966). This pressure of supply, whose only alternative market is an export trade of logs, provides an urgent incentive that is lacking in Australia.

THE FUTURE OF DOUGLAS FIR IN AUSTRALASIAN AFFORESTATION

Examination of the current supply of timber in Australia leads to the conclusion that Douglas fir still commands a major market. The opinion of the Australian Tariff Board in 1960 "that Douglas fir imports met a demand which could not be adequately met from Australian sources" (Commonwealth of Australia, 1960) is reasonable. In future, however, use of correctly seasoned and preferably stress-graded radiata pine could replace Douglas fir as framing, while the pine is superior for finishing uses where strength is not important. The major need now is a knowledge of the relative cost of production of the alternatives, and this is the subject of current research. The true competitive position will ultimately depend on price, and such current advantages of Douglas fir as its availability in large sizes for profitable recutting for grade will decrease as large old-growth supplies decrease.

The North American material will still come from natural stands and bear the costs of stumpage and utilization only. However, United States Federal stumpages of round 14 pence per cu. ft are higher than the 5 to 8 pence per cu. ft paid for Australian hardwoods (Commonwealth of Australia, 1960, 1963) and are equal to the stumpages paid for indigenous softwoods in New Zealand.

On end-use considerations only, there is little need for Australia to plant Douglas fir, as equivalent timber is potentially available from radiata pine and the object of expanded afforestation is to replace imports. To do this by growing Douglas fir instead of radiata pine as an exotic would take from 20 to 30 years longer, and market preference for the species would have to be sustained by imports during this period to benefit from its current market reputation.

About two-thirds of Australian state plantations are of radiata pine, and the degree of biological risk involved by concentration on one species is debatable. Much of the remaining area is unsuitable for radiata pine (and Douglas fir), and in any case provides a considerable degree of diversification. Furthermore, no serious pathological outbreaks have affected well-sited radiata pine in Australia, although sustained productivity following successive monocultures is less certain. The maintenance of very large areas of indigenous hardwoods, albeit on extensive management with low rates of increment, present further considerable diversification. Quantifying the degree of risk, or even deciding what proportion of a given species should be grown, is impossible but it is feasible to calculate the cost of diversification if slower growing species are used to replace radiata pine on good sites. Apart from establishment on sites which present limitations for radiata pine, there is no compelling reason why afforestation of Douglas fir should be extended in Australia.

The proportion of radiata pine in New Zealand State forests is just under 50%, and about 10% is planted with Douglas fir. Moreover, the preponderance of radiata pine in private forests alters these proportions tc about 60% radiata pine and 6½% Douglas fir in the million acres of exotic softwood forest. On present evidence it is improbable that indigenous production will be maintained for much more than 30 years. Pathological troubles have been more serious in New Zealand than in Australia, although quantitative assessments of their net effects are lacking. The well-established series of age classes of Douglas fir provides a good basis for future management, and this species has formidable merit in the low mortality of unthinned stands up to 45 to 50 years of age. This attribute favours its being planted on the extensive steep areas available for afforestation, which cannot be thinned economically with current techniques. The alternative of 20- to 25-year-old crops of radiata pine for pulpwood remains untried. Extension of the area under Douglas fir to between a fifth and a quarter of the exotic estate is suggested.

The disadvantages of further establishment of Douglas fir are the longer period before profitable thinnings can be made, when compared with radiata pine (35 instead of 20 years); and, more important, its more restricted range of end uses. Diversifying planting with this species involves a concurrent risk of diminishing market outlets. The superor versatility of radiata pine in utilization, and its formidable early increments, should continue to make this the premier species in New Zealand afforestation. Douglas fir is a valuable species, and extended future plantings are justified by considerations of biological diversification, its suitability for management in steep country, and its timber qualities.

It remains to assess the relative profitability of these two species.

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APPENDIX 1: DOUGLAS FIR — RADIATA PINE DEVELOPMENT KARIOI STATE FOREST, CENTRAL NORTH ISLAND

Year	*Douglas Fir*	*Radiata Pine*
	Altitude 2,200 ft; level site on old pasture.	
1927	Plots established.	
1941	A few scattered trees survive, but have made little progress and have no value as far as growth records are concerned.	
1965	Good form trees 77–88 ft high; 14–18 in. d.b.h.	Rough butt logs; reasonable form above. 106–115 ft high; 23–26 in. d.b.h.
	Altitude 2,400 ft; almost level site with slight undulations.	
1929	Plots established (both species on north side of *P. contorta* stands).	
1934	Plots are to be abandoned, a failure, trees badly frosted.	A large proportion of failures, trees suffering from *Phomopsis.*
1941	A few have survived, but are malformed and badly frosted.	41 ft high; a good average stocking with trees of a fair quality.
1943	Majority killed by frost and survivors still show severe frosting to 10 ft. Even slight deviations show marked improvement on survival and growth.	48 ft high.
1946		65 ft high; 12–16 in. d.b.h. The superiority of this stand is probably due to its being on a slight rise, reducing frost and *Phomopsis* damage.
1965	78–87 ft high, 17–23 in. d.b.h. A dense stand of good form trees overall; some butt logs rough.	110–124 ft high; 20–38 in. d.b.h. Normal form trees.
	Altitude 2,700 ft, on a slight slope to south, with a steeper slope beyond plot boundary giving good air drainage.	
1928	Plots established (radiata on south side of Douglas fir).	
1934	Well stocked and making good growth.	
1939		Survive in patches and much *Phomopsis* present.
1941	29 ft high, freedom from frost contrasts to other plots.	36 ft high. Poorly stocked and heavily malformed.
1947	43 ft high.	
1952	50–55 ft high.	
1965	87–97 ft high; 16–18 in. d.b.h. A good looking crop despite wide initial spacing.	100–110 ft high; 24–29 in. d.b.h. Poor overall survival, badly malformed butt and second logs.

(Earlier observations from local records, 1965 measurements by the writer.)

APPENDIX 2: AUSTRALIAN DOUGLAS FIR IMPORTS — GRADE AND END USES

New South Wales Imports

78% Merchantable grades, 22% Clears grade. Described as:

Merchantable — Suitable for structural purposes but not for dressing.

Selected merchantable — Better grade of merchantable, suitable for dressing.

No. 2 Clears — Good generally, but not entirely free from minor faults.

No. 1 Clears — Specially selected.

End Uses

Use	*Victoria* %	*South Australia* %
Industrial construction	55	26
Industrial uses	30	12
House building	15	62

(Based on a Forest and Timber Bureau Survey.)

It was stated that "a large proportion of Douglas fir (in New South Wales) was known to be used for home buildings . . . almost certainly more than in South Australia".

All data above from Commonwealth of Australia, 1960.

A later Tariff Board hearing (Commonealth of Australia, 1963) contained the following details:

New South Wales imports: "About 25% clear grades."

Victoria: About 10% clears in the last three years, and percentage is falling.

South Australia: About 5% clears.

Clear grades are also used for ladders, scaffolding planks.

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