DOUGLAS FIR, JAPANESE LARCH, AND EUROPEAN LARCH IN PURE AND MIXED STANDS

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ABSTRACT

An area in Kaingaroa Forest containing unthinned adjoining blocks of the same age of pure *Pseudotsuga menziesii* (Mirb.) Franco (Douglas fir), *Larix kaempferi* (Lamb.) Carr. (Japanese larch), and *Larix decidua* Miller (European larch), and of mixtures of Douglas fir with Japanese larch, and Douglas fir with European larch was studied for growth trends over a 13-year period from age 19 to 32 years. Two thinning treatments (unthinned control and thinned to 500 stems/ha at age 19 years) were tested in permanent sample plots established in the pure and the mixed blocks.

When Douglas fir was planted in mixture with Japanese larch on this site it became dominated and supressed by the larch species. However, when planted in mixture with European larch almost the reverse occurred, although the mixture could not be considered to be successfully self-thinning at age 32 years. When thinned at age 19 years, Douglas fir was more responsive in subsequent basal area growth than the two larch species.

Thus, although early growth of Japanese larch was superior on this site, Douglas fir is likely to be the most productive of the three species at final rotation. Results from this study support the case that manual thinning to achieve a desired regime should remain the preferred management technique for Douglas fir in New Zealand.

Keywords: mixtures; self-thinning; growth; *Pseudotsuga menziesii*; *Larix kaempferi*; *Larix decidua*.

INTRODUCTION

Douglas fir is the second-most important species in New Zealand's forest industry. The current area of Douglas fir is approximately 45 000 ha, representing 3.5% of the total area of plantation forests. A survey completed in 1976 (unpubl. data) found that about 13% (5858 ha) of New Zealand Douglas fir plantations were in the form of mixtures with other species. Most of the stands concerned (70%, 4100 ha) were in the North Island. During the survey all the North Island mixed stands were visited to note their success or failure as potential productive units. At that time objectives for planting Douglas fir in mixtures included:

(1) The mixture would be self-thinning, with the Douglas fir suppressing the second species at the time when thinning is desirable;

(2) The second species in the mixture would provide a more versatile production thinning component (Douglas fir has no market as pulpwood in New Zealand and is difficult to treat as roundwood);
(3) The second species might be poison thinned (Douglas fir was considered difficult to poison thin successfully);
(4) The area planted in Douglas fir might be increased when seed supply was limited;
(5) Establishment conditions might be ameliorated by providing shelter with quick-growing alternative species;
(6) A more palatable species than Douglas fir might be used, which would be browsed first and give early warning of browsing pressure.

Numerous species have been tried in mixture with Douglas fir to achieve one or more of the above objectives. Selection of the second species in the mixture has been determined largely by site factors and the proposed silvicultural prescriptions. The most commonly planted secondary species in mixture with Douglas fir (Table 1) were *Pinus nigra* Arn., *Larix* spp., *Pinus contorta* Dougl., and *Pinus ponderosa* Laws. A considerable proportion (approximately 38%) of mixtures resulted from the blanking and interplanting of areas where establishment had been unsatisfactory. Most of the stands visited in the 1976 survey were less than 20 years old and were still at an early stage where little interaction had occurred between species. Where domination of one species over the other had occurred, the result appeared to be site specific.

TABLE 1–Area in 1976 of Douglas fir mixtures by secondary species

Secondary species	Area (ha)
Larix spp.	1461
Pinus nigra	1924
Pinus contorta	1119
Pinus ponderosa	873
Pinus radiata	144
Populus spp.	59
Cupressus spp.	37
Eucalyptus spp.	4
Pinus muricata	6
Thuja plicata	49
Tsuga heterophylla	3
Chamaecyparis lawsoniana	101
Picea spp.	24
	5858

New Zealand Douglas fir has been infected with Swiss needle-cast fungus (*Phaeocryptopus gaeumannii* (Rohde) Petrak) since about 1959 (Hood & Kershaw 1975). As a result, and in order to maintain vigorous healthy crowns, stand management of Douglas fir has been modified since the early 1970s to include waste thinning (at 15–18 m height to 500 stems/ha) as standard treatment. This implies that a self-thinning mixture would have to achieve its objective early (by approximately 20 years) to be a viable management option.

During the survey of Douglas fir mixtures an area was found that offered an opportunity to compare growth rates of Douglas fir and two larch species in pure and mixed stands. This area allowed the establishment of an experimental trial with permanent sample plots that were measured over the next 13 years, the results from which are given here.

METHODS

The trial area was located in Cpt 1230 of Kaingaroa Forest, at an altitude of 370 m, with a Taupo sandy silt soil type (a deep volcanic pumice soil derived from airfall tephra). Along the northern edge of the compartment, blocks of at least 4 ha had been planted in Japanese larch, European larch, Douglas fir/Japanese larch mixture, and Douglas fir/European larch mixture. The rest of the compartment was a pure stand of Douglas fir. All species were aged 19 years when the trial was established, having been planted in 1957. The mixtures had been planted with the ratio of two rows of Douglas fir to one of larch.

Treatments applied in May 1976 were designed to examine two management options: (1) to leave each stand unthinned, and follow the development of the pure and mixed stands; (2) to waste thin both pure and mixed stands at age 19 years and leave the best 500 stems/ha. As most of the compartment had already been thinned, the area available for this study was limited. Plot size was 0.1 ha, with 5-m buffer zones around each plot. There were two replicates of each treatment except for the Douglas fir/Japanese larch mixture where, because of an initial lack of sufficient unthinned area, only one waste-thinned plot could be established, and this was modified to test thinning to the best 500 stems/ha drawn from both Douglas fir and Japanese larch.

RESULTS

Age 19 Years

Measurements at the time of trial establishment (age 19 years) (Table 2) were taken in winter and so green crown height could not be measured on the larch species. At this age the Japanese larch was already showing superior growth in both diameter and height, while the growth of the European larch and Douglas fir had been approximately equal. This was also emphasised in the mixtures where the Japanese larch had begun to dominate the Douglas fir; in the other mixture both species were approximately equal in size.

Growth From 19 to 32 Years

As height growth was unaffected by thinning treatment, height data across all plots were combined for each species. Height growth for pure stands of each species from age 19 to 32 years is given in Fig 1. The initial difference in height (5.5 m) between the Japanese larch and the Douglas fir at age 19 years was not maintained over the following 13 years. Douglas fir clearly showed a faster height growth rate through this period.

Basal area growth trends for the pure stands of each species are given in Fig. 2. Basal area growth of the Japanese and European larch was similar and the early differences between them at age 19 years were maintained. However, for Douglas fir in both thinned and unthinned treatments basal area growth during the 13-year period was clearly greater than

TABLE 2–Summary of stand parameters at age 19 years

Species	Pure/ mixture	Stocking (stems/ha)	Basal area (m^2/ha)	Dbh (cm)	PMH (m)	Green crown height (m)	Total volume (m^3/ha)
Douglas fir							
unthinned	Pure	1320	32.87	17.8	17.5	8.6	204.5
thinned	Pure	500	16.23	20.4	17.5	6.9	117.2
Japanese larch							
unthinned	Pure	2025	49.78	17.7	22.2		383.3
thinned	Pure	500	20.09	22.6	21.7		176.8
European larch							
unthinned	Pure	1560	30.49	15.8	18.2		196.6
thinned	Pure	500	15.81	20.1	17.4		104.2
Douglas fir /							
European larch	Mixture	1320	26.71	16.1	17.8	6.8	167.2
unthinned		645	16.98	16.9	16.8		103.8
Douglas fir thinned /							
European larch							
felled	Mixture	500	15.66	20.0	17.6	5.9	112.9
Douglas fir /							
Japanese larch	Mixture	1015	12.12	12.4	16.6	7.0	71.6
unthinned		735	28.55	22.2	20.2		205.4
Douglas fir thinned /							
Japanese larch	Mixture	180	5.09	19.0			
thinned		320	16.05	25.6	19.1		127.9

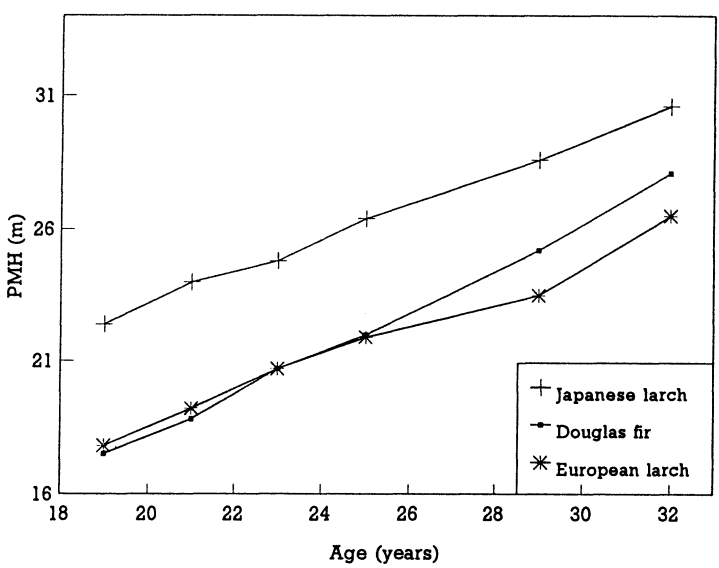

FIG. 1–Height growth of pure stands of Douglas fir, Japanese larch, and European larch

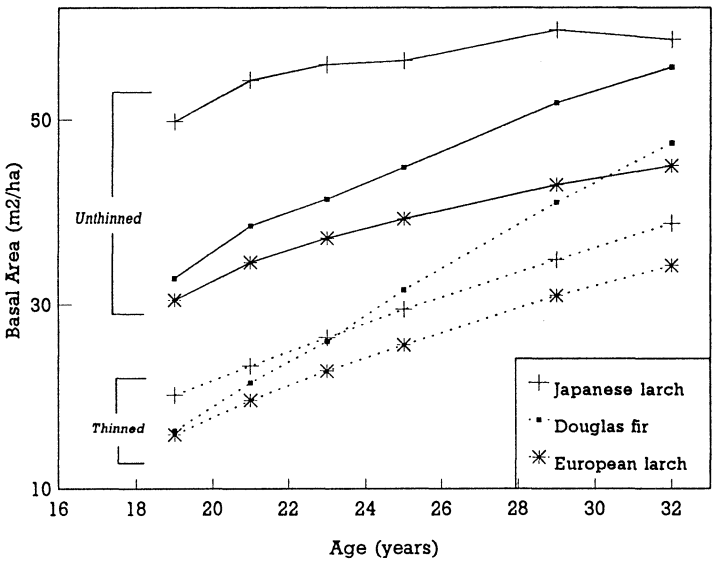

FIG. 2–Basal area growth of pure stands of Douglas fir, Japanese larch, and European larch.

for either of the larch species. Thus, although the latter responded to thinning, their response was much less than that of the Douglas fir.

The basal area growth of the Douglas fir/Japanese larch mixture is given in Fig. 3. The domination of Japanese larch in this mixture increased, with superior basal area growth during this period. In the Douglas fir/European larch mixture, Douglas fir showed superior

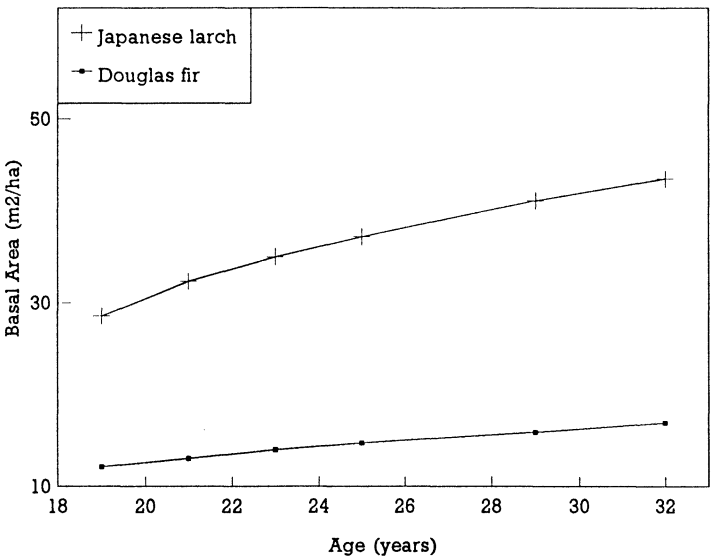

FIG. 3– Basal area growth of a Douglas fir and Japanese larch mixture

basal area growth (Fig 4), almost the reverse of what occurred with the Japanese larch mixture. Where the Douglas fir/European larch mixture was thinned to the best 500 stems/ha of Douglas fir only, a substantial response occurred. The basal area of the manually thinned plots now exceeds that of the slower self-thinning mixture. Stand parameters at age 32 years, including mean annual increment (MAI), are summarised in Table 3. The MAI of the mixtures were considerably better than those of the pure stands, except for the Japanese larch.

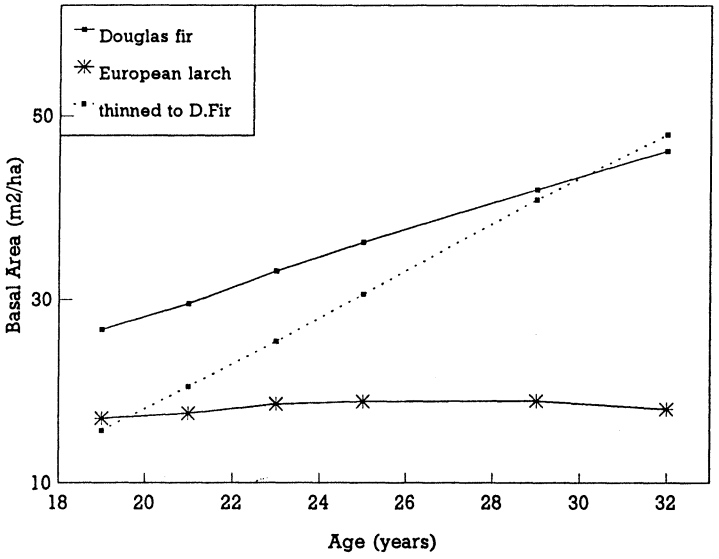

FIG. 4–Basal area growth of a Douglas fir and European larch mixture

DISCUSSION

Left unthinned, the early rapid growth of Japanese larch up to age 32 years made it the most productive of the three species measured on this site. From the growth trends in height and basal area, Douglas fir could be expected to surpass the productivity of the Japanese larch prior to age 40 years. When thinned at age 19 years to 500 stems/ha, Douglas fir proved more responsive than both larch species, achieving approximately 68% better basal area growth than either larch species for the 13-year period.

The growth of these species planted in mixture indicates clearly how important it is to match the species with the site. On this site Japanese larch proved to be too fast-growing in the first 15–20 years to be a suitable secondary species to Douglas fir. European larch proved more suitable but still had not been completely suppressed by age 32 years. Compared to the growth in basal area achieved from manual thinning at age 19, this self-thinning mixture was not very successful.

The effect of thinning treatment on branch size has not been recorded in this study. As indicated by green crown height (Table 3) it could be expected that differences in branch size would occur between manually thinned and self-thinned stands and this would have resultant effects on log quality.

TABLE 3–Summary of stand parameters at age 32 years

Species	Pure/ mixture	Stocking (stems/ha)	Basal area (m^2/ha)	Dbh (cm)	PMH (m)	Green crown height (m)	Total volume (m^3/ha)	MAI (m^3/ha /yr)
Douglas fir								
unthinned	Pure	915	55.6	27.8	28.3	17.9	528	16.5
thinned	Pure	500	47.5	34.8	27.8	15.8	499	15.6
Japanese larch								
unthinned	Pure	1155	58.6	25.4	31.4	22.3	608	19.0
thinned	Pure	500	38.8	31.5	29.8	20.0	458	14.3
European larch								
unthinned	Pure	1045	45.1	23.5	26.2	17.9	397	12.4
thinned	Pure	500	34.3	29.6	26.9	18.4	335	10.4
Douglas fir /								
European larch	Mixture	890	46.2	25.7	29.6	19.2	470	
unthinned		415	18.0	23.6	25.4	19.5	170	20.0
Douglas fir thinned /								
European larch								
felled	Mixture	495	48.0	35.1	29.3	16.9	496	15.5
Douglas fir /								
Japanese larch	Mixture	545	16.9	20.0	28.1	19.8	189	19.9
unthinned		645	43. 5	29.4	31.5	20.7	449	
Douglas fir thinned /								
Japanese larch	Mixture	180	13.2	30.5	28.3	18.1	139	15.1
thinned		320	30.2	34.7	28.4	19.6	346	

CONCLUSIONS

Although Japanese larch showed superior early growth on this site, measurements of growth from age 19 to 32 years indicated that Douglas fir is likely to be the most productive of the three species at the end of the rotation. If thinned by age 20 years, Douglas fir was more responsive than the two larch species measured and is likely to show superior financial returns. Planting Douglas fir/larch self-thinning mixtures entails considerable risk and uncertainty, as Douglas fir may be dominated by the secondary species if the choice of species is not carefully matched to the site. Manual thinning to achieve a designed regime and log quality is likely to remain the preferred management technique for Douglas fir in New Zealand.

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REFERENCE

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