

structure. This will probably involve conventional planting or perhaps seeding, although the results of the latter action are often very variable.

There is a misconception circulating at present that all wilding trees are valuable. To be sure, profits have been made from wilding trees growing close to the parent stand. This is known as 'fringe' spread where the trees are so close together that the form and branching is commercially acceptable. Such spread rarely extends more than 200 m from the parent stand. By far the majority of wilding-affected land is covered in 'distant' spread (or outlier trees) where the trees are widely spaced with consequent poor form (very tapered) and large branches. The chances of profiting directly from these trees is minimal – in fact they are a costly nuisance if the area is to be developed into pasture or trees. Their only value may be in the longer term when they eventually produce dense fringe spread of their own.

In summary then, natural wilding invasion or "forestry by default" is not generally supported because it often leads to stands of the wrong species on the wrong site, and of poor age structure and form.

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A brief history of Douglas fir in New Zealand

Douglas fir (*Pseudotsuga menziesii*) is an extremely important tree species in North America, dominating huge areas of the West. It has a reputation for good health and vigour, combined with excellent timber properties.

It was introduced to New Zealand in 1859, at the same time as *Pinus radiata*, by J.B. Acland of Canterbury. It grew well enough to be selected by the newly created State Forest Service as an important timber species, with a growth rate second only to radiata pine (*Pinus radiata*).

The earliest large-scale plantings date from about 1896, using seed whose origin is unknown. Seed importations for large-scale plantings from 1930 were from Washington State, where superb stands of Douglas fir were easy to access, and it is thought that earlier importations came from there also.

These first stands grew very well, starting slowly, as if the newly planted seedlings needed to consolidate their root



Douglas fir seedling and cone.

systems and provide thick and bushy foliage as a protection against browsing. Radiata pine is far ahead in height five years after planting, but from then on Douglas fir growth rate (volume per

hectare) catches up, due to its ability to carry a much higher stocking.

Douglas fir has remained secondary to radiata pine for forest planting, mainly due to the need to wait longer before harvest-

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ing. Private timber companies were not interested in growing Douglas fir, as timber residues were not easily converted to pulp, as was the case with radiata.

Research on seed sources for Douglas fir commenced in 1955, with comprehensive seed collections organised over most of the natural range of the species. Provenance trials were planted out on a wide range of forest sites in 1957 with seed obtained from seed suppliers in America, then in 1959 with seed collected by Egon Larsen to fill out gaps in the 1957 trial. There was an abundance of seed from Fort Bragg, so two large blocks were planted out as potential seed stands. (See table.)

The 1960s saw a number of studies performed on wood properties, as timber became available from production thinning. Timber quality was good, with strength similar to Douglas fir grown in America and hence able to enjoy the good reputation gained by imported Douglas fir.

Health of the Douglas fir stands had been excellent, regardless of silviculture, but the advent of the needlecast fungus *Phaeocryptopus gaeumannii* (first detected in 1959) gave foresters much cause for concern. This disease had always been present in the natural stands, and New Zealand had enjoyed superior growth rates in its absence. The needlecast spread slowly, reaching Nelson in 1969 and taking 20 years to spread to the south



Douglas fir

of the South Island.

Ian Hood (a pathologist at FRI) studied *Phaeocryptopus* in depth in both New Zealand and British Columbia. His conclusions were as follows:

- (a) While no provenance was immune to the disease, the provenances from the coastal zones were slower to become infected than provenances from interior sites.

- (b) The stands of Douglas fir in the coastal regions had the highest level of *Phaeocryptopus* of any population in the native habitat. Coastal provenances had less infection than others if planted in drier areas.

First assessment was on the provenance tests at age five, which indicated that the coastal Californian provenances were faster growing. The relationship of early growth to real growth rate was not clearly understood, but action was taken to import seed from two promising areas (Santa Cruz and Arcata), which was planted as potential seed stands.

In 1969 the tree improvement group initiated a breeding programme with Douglas fir. Plus trees were selected in existing stands of Douglas fir (of presumed Washington origin) in 1969 and 1970 and progeny tests were planted in 1971. Experiments on grafting and control-pollination of Douglas fir were successfully carried out by FRI staff. Also at this time, Ross Wylie (a forester at Golden Downs forest in Nelson) selected his own plus trees and planted a grafted seed orchard.

Further tests were planted with commercial seedlots in 1971 and 1974 to strengthen knowledge of seed sources. During this period (in 1972) a major assessment was made on the provenance trials, as they were then 13 years or older from planting. This assessment showed clearly that seed from coastal California,

1959 Douglas fir trials, 30 year basal areas of best provenances

Basal area (square metres) and plot tree stockings are expressed per hectare.

Seedlot	Provenance	Location of trial sites											
		Kaingaroa		Gwavas		Rapanui		Golden Downs		Hanmer		Rankleburn	
		BA	Spha	BA	Spha	BA	Spha	BA	Spha	BA	Spha	BA	Spha
530	Kaingaroa, NZ	46	556	48	701	49	536	59	824	56	639	63	598
575	Summit, Oregon			57	598	63	515	41	577	49	556	73	618
578	Glacier, Washington			51	639	57	680	44	639	39	453	66	618
580	North Bend, Oregon	39	474	55	618			47	577	52	618	72	639
584	Olney, Oregon	57	618	54	639	60	639	44	618	62	680	71	680
603	Eel River, California			64	598	57	618	46	618	56	598	77	639
631	Darrington, Washington	46	536	55	618	49	536	47	618	49	618	60	577
635	Florence, Washington	46	536	59	577			50	598	48	556	74	618
636	Deadwood, Oregon	44	577	53	639	53	536	50	618	57	598	77	618
641	Four Mile, Oregon	29	309	63	618	66	639	50	639	55	598	62	598
642	Berteleda, California	64	845	77	866	75	495	50	598	56	639	83	639
647	Mad River, California	33	350	71	639	67	598	50	598	62	598	81	660
649	Dehaven, California	50	515	66	639	68	577	45	598	56	577	76	618
654	Fort Bragg, California	44	495	71	660	67	536	60	639	54	577	70	618
658	Stewart Point, California	53	536	65	598	65	536	50	577	62	598	63	515
659	Stinsons Beach, California	48	495	68	639	52	474	45	598	68	618	64	536
660	Santa Cruz, California	49	556	70	639	71	556	41	495	69	618	81	556

NB: the last five provenances arise from south of the 40th parallel, Central California.

and to a lesser extent from coastal Oregon, produced trees of superior growth to seed in current use, including the seed origin of the selected plus trees.

This assessment demonstrated the superiority in New Zealand of Douglas fir provenances from the coastal "fog-belt" of the western USA, so called because fog blankets the coast up to 16 km inland in summer, contributing summer moisture not normally available in a continental climate. There was also a trend for higher growth rate from seedlots originating in the southern end of the range in California, even at trial locations at the south of the South Island.

Interest in planting Douglas fir appeared to be waning at this time, partly due to uncertainty over the effect of the needlecast, and partly due to an awareness of the better cashflow generated by the shorter rotation length of radiata pine.

Extensive damage caused to radiata pine stands by cyclones such as BERNIE (1983) and BOLA (1987) caused a rethink of the role of Douglas fir. Stands of Douglas fir suffered broken branches, but weathered storms without blowdown or stem breakage. An equally important advantage of the species is its capacity to withstand heavy snowfalls, especially in the South Island at higher elevations, which usually cause blowdown and breakage of radiata pine.

In 1988 PROSEED (the NZ tree seed company) funded the selection of plus trees from the best coastal fog-belt provenances in the Douglas fir provenance tests. By this time the tests had been thinned (in 1976) to leave approximately 30 trees from the original 144 per plot. All trees in the best provenances were measured over six sites, then the best tree per plot was selected. Some mortality problems, and an earlier thinning trial complicated the measurements, summarised in the table.

The selected trees were grafted into a seed orchard in Canterbury over the next three years. PROSEED and the Forest Research Institute also funded a seed collection from southern coastal California, with the primary objective of widening the genetic base to include previously untried provenances.

South Island foresters became increasingly interested in the possibilities of Douglas fir, especially in the MacKenzie basin and increased their research efforts with the species. In 1992, a North American Douglas fir stand management cooperative became interested in gaining access to New Zealand data on Douglas fir plantation management. This became an opportunity to create a New Zealand Douglas fir cooperative, coordinating research on all possible areas of interest.

A Douglas fir cooperative was formed

in February 1993, with strong support from industry for research projects covering a wide spectrum of research fields, and it is also linked to a North American stand management cooperative. The North American cooperative is funding a substantial amount of work in forest management which will result in the production of a Douglas fir version of STANDPAK.

A project of the New Zealand Douglas fir cooperative is the collection of seed from 200+ Douglas fir trees in the southern fog-belt zone. Cone collection is completed, and extraction of the seed is underway.

Other cooperative projects in progress are drying and machining clear timber, nutritional work, herbicide work, thinning and pruning trials, seed orchard research, and the formulation of a breeding strategy.

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Rangeland tree establishment – machine planting and direct seeding

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The South Island high country covers between one-quarter and one-third (depending on one's definition) of the island. It contains a high percentage of readily accessible land, flat with a light vegetation cover, much of which can be easily traversed in 4WD vehicles. When faced with the prospect of having to establish large quantities of trees on such a vast area of relatively flat land, thoughts often turn to easier and potentially cheaper establishment techniques than hand planting. Two possibilities are machine planting and direct seeding, both of which have been tested in the high country.

Machine planting

There are large areas of the high country ideally suited to machine planting and the method has many advantages. Costs are cheaper at around 15 cents/tree, compared to 25-45 cents/tree (depending on terrain) for hand planting (Belton, 1991). Planting rates are higher at around 600-1000

trees/hour for two people compared to 100-200/hour for two hand planters, and the quality can be consistent and generally good. The New Zealand Forest Research Institute Ltd (NZFRI) has investigated the comparative survival and growth of trees planted in the high country by machine and conventionally by hand in ripped and unripped ground. Differences were insignificant except on one site at Ribbonwood Station where machine-planted Douglas fir averaged 1.9 m in height at year four compared to 1.7 m for hand-planted in ripped ground and 1.6 m for hand-planted into unripped ground (Baker and Ledgard, 1991).

However, probably the greatest advantage as far as a high-country farmer is concerned is the ease with which machine planting can be slotted into a busy spring schedule. The operation takes considerably less time and effort than hand planting and there is no need to organise large labour gangs and the accommodation and food that goes with them. All that is needed is a tractor (which most farmers have) plus driver, a planting machine and an operator. With such a set-up 5-10 ha can be planted daily. Machine planting is

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