

SOME WOOD CHARACTERISTICS OF NEW ZEALAND-GROWN WESTERN RED CEDAR (*THUJA PLICATA* D. DON)

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ABSTRACT

Wood samples of western red cedar (*Thuja plicata* D. Don) from four New Zealand State forests (Whakarewarewa, Waiotapu, Mahinapua, and Conical Hill) were examined for wood density, moisture content, shrinkage characteristics, and extractives content. On the basis of these data and of other observations on locally grown red cedar, a comparison is made with North American material.

The local product is of comparable or slightly superior wood density to that of western red cedar in its native habitat (published mean basic density 310 kg/m^3). The two North Island sites averaged 330 to 340 kg/m^3 , and the South Island sites 310 to 320 kg/m^3 . The New Zealand timber is characterised by saturated heartwood (average moisture content $>200\%$) and needs to be dried carefully to avoid checking and collapse. Shrinkage tends to be greater and dimensional stability poorer than North American western red cedar. The average extractives content is also lower, and so natural durability might be expected to be less.

Western red cedar is an attractive and useful timber for both interior and exterior use, but as a forest tree has proved disappointing in many parts of New Zealand. It could be a useful minor species on moist sheltered sites and, given appropriate silvicultural treatment, could produce a valuable specialty timber.

INTRODUCTION

Western red cedar (*Thuja plicata* D. Don) is an important softwood timber species of the Pacific Northwest from Alaska to northern California, where it has a reputation for being straight-grained, highly durable, and dimensionally stable. Traditional uses include poles, posts, shakes, shingles, exterior construction, and interior panelling. High quality logs find a ready market, but demand for the lower grades is limited (Barton and MacDonald, 1971). Low wood density (310 kg/m^3) and high extractives content (sometimes in excess of 30%)

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have handicapped the development of this species as a source of pulpwood.

North American red cedar also has a significant place in the New Zealand joinery trade, being used in both interior and exterior applications. Imports of sawn timber peaked in 1966-67 at 27 000 m³ (cf. Douglas fir 10 000 m³, redwood 9 000 m³, and other softwoods 5 000 m³) but had dropped to 5 000 m³ by 1973 (cf. Douglas fir 3 000 m³, redwood 11 000 m³, and others 2 000 m³), according to the N.Z. Forest Service (1975).

Small areas of western red cedar were planted in New Zealand forests from Auckland to Southland conservancies during the early decades of this century, but the results were highly variable owing to site differences, and further plantings were greatly restricted. An exception to the generally slow growth was in the Southland Conservancy, where mean annual increments of the order of 20 to 25 m³/ha/yr up to 50 years of age have been recorded. Small plantings have continued on the better sites in this area. Weston (1968) gave the total area of western red cedar as about 500 ha.

Little is known of the wood properties of New Zealand-grown western red cedar as few of the early plantings have been utilised, and volumes have been too small to have an impact on local markets. Harris and Kripas (1959) described the properties of a single 42-year-old stem from Whakarewarewa State Forest Park and suggested that clear timber of this species could be valuable. It was noted that the moisture contents of sapwood and heartwood samples were 258 and 233% respectively, and some difficulty was experienced in drying. Collapse and honeycombing occurred, particularly in material from the butt log. Wetwood (*i.e.*, saturated heartwood) is known to occur in some western red cedar in its native habitat and can contribute to collapse on kiln drying (Bramhall and Wellwood, 1976).

MATERIALS AND METHODS

During 1977, thinning operations were carried out in the 0.5 ha block of 67-year-old western red cedar in Cpt 19, Whakarewarewa S.F.P. Discs were obtained from the top and bottom ends of 10 logs (5 m long) on the skid site and taken to the Forest Research Institute (FRI) for analyses of some physical properties. The freshly cut discs were reduced to small blocks representing 10-year growth periods from the pith outwards along two radii, and the samples were used to assess moisture content, basic density, and shrinkage characteristics.

Increment core samples were obtained from Cpt 11, Waiotapu S.F., planted in 1906 and unthinned. Two pith-to-bark cores were collected from each of 15 dominant and co-dominant trees, and moisture content, basic density, and extractives content were measured. The Whakarewarewa and Waiotapu stands are about 20 km apart, but the latter is at higher elevation and exposed to the south. Mean diameter of the Waiotapu sample trees was about 200 mm, compared with 450 mm in the thinned stand at Whakarewarewa.

Disc samples from 12 freshly cut butt logs of 66-year-old red cedar were air-freighted from Conical Hill S.F., Southland, to FRI for moisture content and density analyses. This stand, planted in 1911 (Cpt 308), had a mean d.b.h.o.b. of 287 mm, mean height of 28.9 m, and a total volume of 716 m³/ha. Data from an earlier shipment of six discs from Mahinapua S.F., Westland Conservancy, have also been used in this report.

Basic densities for wood blocks were determined from green volumes (by water immersion) and oven-dry weights. With increment core samples, the method of maximum moisture content was used (Smith, 1954). The moisture contents of fresh wood samples were calculated from the weight loss between the green and oven-dry conditions. Extractives were assessed in the increment core samples from Waiotapu S.F. by refluxing with methanol in a Soxhlet apparatus.

RESULTS AND DISCUSSION

Moisture Content

It was immediately obvious on examining all the western red cedar wood samples that the heartwood is consistently saturated. Moisture content was lowest in the inner heartwood and highest in the outer heartwood and tended to decrease with increasing height in the stem. Individual samples ranged in moisture content from 133 to 366% in the heartwood and from 177 to 306% in the sapwood. The overall mean of 223% corresponded very well to the mean of 225% (range 182 to 274%) determined for the Mahinapua discs and 209% (range 121 to 346%) for Conical Hill. Breast height moisture content of the Waiotapu cores averaged 201% (154 to 268%).

North American sources quote sapwood and heartwood moisture contents of 200 to 250% and 30 to 60%, respectively (McIntosh and Meyer, 1972; U.S. Dept. Agric., 1974), although Bramhall and Wellwood (1976) noted that wetwood in red cedar seemed to be more prevalent in certain localities, particularly in the higher rainfall coastal forests and where drainage is poor. The wetwood condition appears to be characteristic of this species grown in New Zealand.

Wood Density

Both Canadian and United States western red cedar have been quoted as having a mean basic density of 310 kg/m^3 (Kennedy, 1965; U.S. Dept. Agric., 1974), although a more restricted survey in the interior of British Columbia arrived at a mean of 329 kg/m^3 (Smith, 1970). Harris and Kripas (1959) determined that the mean density of the stems they examined was 310 gm/m^3 .

Polge (1964) examined breast height samples from 15 trees growing in France and found the highest density adjacent to the pith (450 kg/m^3), decreasing outwards for about 20 rings and thereafter remaining constant at about 320 kg/m^3 . In a study of 73 trees varying in age from 40 to 237 years, Wellwood and Jurazs (1968) showed that density decreased outwards from the pith at all stem levels and that consequently there was an increase in mean density with height in the tree.

Figure 1 compares radial density trends in material from four New Zealand sites. Each area showed a different pattern, as follows:

Whakarewarewa: Marked decrease for about 20 rings, then an increase outwards. Mean 336 kg/m^3 .

Waiotapu: Gradual decrease from pith to bark. Mean 341 kg/m^3 .

Mahinapua: Decrease from the pith outwards (more rapid than Waiotapu). Mean 315 kg/m^3 .

Conical Hill: Decrease to a minimum of 298 kg/m^3 in the second decade, followed by an increase to a maximum of 352 kg/m^3 in the fourth decade, then a sharp decline outwards. Mean 320 kg/m^3 .

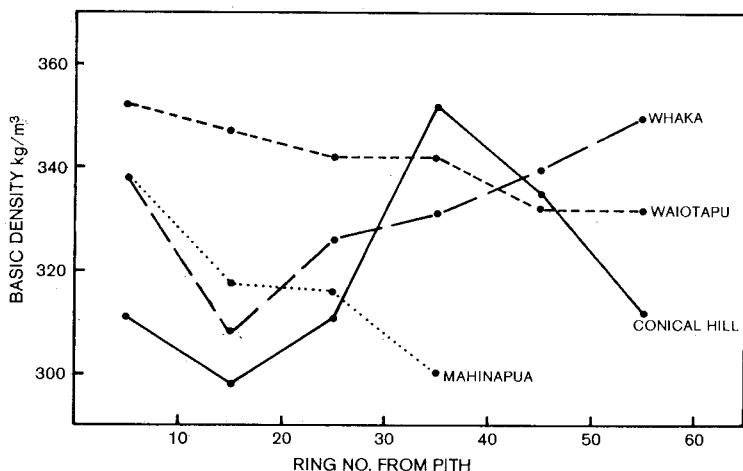


FIG. 1: Comparison of radial density trends at four locations.

Although the radial patterns vary appreciably relative to one another, the actual ranges of mean densities within sites (e.g., 298 to 352 kg/m³ at Conical Hill as an extreme case) and between sites (315 to 341 kg/m³) are small in comparison with the variability recorded for other exotic softwoods in New Zealand. A typical radial increase for radiata pine grown in Kaingaroa S.F., for instance, might be from 350 to 450 kg/m³ over rings 1 to 20 from the pith, a change of about 30% (Cown, 1974a). Outerwood densities have also been reported to vary by about 30% according to the latitude and altitude of the site in, for example, radiata pine (mean 440 kg/m³), Corsican pine (mean 470 kg/m³), and Douglas fir (mean 450 kg/m³) (Harris, 1965, 1966; Cown, 1974b). Thus, western red cedar growing in New Zealand produces a wood of much lower (310 to 350 kg/m³) and much more uniform density than the more important exotics.

Comparison of the top and bottom discs from the Whakarewarewa logs revealed a slight increase in density with height over the 5 m length. This corresponds to the findings of Wellwood and Jurazs (1968) but is in contrast to the normal decrease in density with increasing height found in other exotics in New Zealand.

Overall, the mean densities are higher by up to 10% than the values reported for North American red cedar, and there would appear to be a slight decrease in density with increasing latitude. The South Island material was found to be closer to the 310 kg/m³ quoted by Kennedy (1965) and the U.S. Dept. Agric. (1974).

Extractives Content

Barton and MacDonald (1971) gave 10.2% as the mean extractives content of western red cedar grown in Canada. The volatile constituents which are responsible for most of the natural durability (e.g., thujaplicins) constitute only 0.2 to 1.2% of the total extractives, depending on tree age and position in the log. Most of the extraneous materials are phenolic substances, about half of which are soluble in cold water.

Within a stem cross-section there is a general pattern of increasing extractives content from the pith to the latest-formed heartwood (Cartwright, 1941; MacLean and Gardner, 1956; Jurazs and Wellwood, 1965). Mean heartwood extractives content decreases with height in the stem, whereas the sapwood value increases (Barton and MacDonald, 1971). It is thought that the heartwood substances are stable within the wood and that there is little change at any one position as the trees age. Thus the inner heartwood of older trees has a similar

amount of extractives to the new heartwood of young trees. Heartwood colour becomes progressively lighter as the phenolic content increases.

The results of methanol extraction of the Waiotapu cores showed a pattern which followed that described above, but a clear distinction between heartwood and sapwood levels was obscured because of the sampling method, which involved 10-ring periods. Heartwood extractives averaged 4.8% at the pith and increased to around 6% in the outer zone. Sapwood contained 1.4% material soluble in methanol.

Shrinkage Characteristics

Table 1 compares shrinkage values for western red cedar determined in Canada, the United States, and New Zealand (Whakarewarewa S.F.P., Cpt 19).

TABLE 1: SHRINKAGE DATA FOR WESTERN RED CEDAR

	<i>Shrinkage % (Green to Oven-dry)</i>			<i>Vol.</i>
	<i>Long.</i>	<i>Rad.</i>	<i>Tang.</i>	
Canada (Kennedy, 1965)	—	2.1	4.5	7.8
United States (U.S.D.A., 1974)	—	2.4	5.0	6.8
New Zealand	0.16	2.9	7.4	8.4

The New Zealand material was found to exhibit greater shrinkage in all directions than the North American and hence would be more liable to degrade during drying.

The collapse of wetwood mentioned earlier is an extreme form of shrinkage which occurs above the fibre saturation point. From the literature it appears that two conditions are prerequisites for the occurrence of this severe defect; *i.e.*, a large proportion of the wood cells must be saturated, and permeability must be low. This feature is fairly common in North American red cedar and air drying is sometimes recommended prior to kiln drying (Bramhall and Wellwood, 1976). Some 25 mm boards cut from the Whakarewarewa thinnings and stacked for air drying showed obvious signs of collapse and some end-splitting.

CONCLUSIONS

Western red cedar is a species of minor importance in New Zealand forestry. Weston (1968) placed it fifth in terms of area planted in species other than pines, after Douglas fir, larch, Lawson's cypress, and Monterey cypress. The timber,

however, is still being imported from North America in significant quantities for the joinery trade and there are indications that the growing popularity of shakes and shingles could lead to an increase in demand for this species.

The small areas of red cedar planted in New Zealand have been very variable in yield, reflecting the need for careful site selection; but some areas, notably in Southland, have shown a mean annual increment of 20 to 25 m³/ha up to age 50 years (Weston, 1968). The Whakarewarewa stand, planted in 1910 at 1.5 × 1.5 m and twice thinned, had a mean height of 38 m and mean diameter of 660 mm in 1977. However, many of the stems were showing both the fluting and the heart rot characteristic of the species in its native habitat.

Wood density of the locally grown timber is comparable or slightly superior to the imported material, but fresh moisture content is extremely high (averaging in excess of 200%), necessitating slow air drying to avoid collapse and checking. Shrinkage values are greater and dimensional stability poorer than in the North American timber, so it may be less suitable for exacting applications.

The reputation for durability of western red cedar timber was gained mainly on the basis of the old-growth stands in which there is an increase in thujaplicin levels (and hence natural durability) across the heartwood for several hundred rings. New Zealand-grown red cedar, even after a 60- to 80-year rotation, will have a considerably lower extractives content and would be expected to show less durability. On the other hand, penetrability of such stems would be greater and preservative treatment could be administered if necessary (Jurazs and Wellwood, 1965).

Planting of western red cedar should be restricted to moist well-drained sites in cool areas where the trees can reach merchantable size before heart rot becomes a major source of degrade. A high-quality product would require not only careful siting but also regular thinning to maintain diameter increment and pruning to remove persistent branches on the lower stem. Under these circumstances, both thinnings and final crop timber would be a valuable source of posts and poles, weatherboarding, fencing, and decking material. The highest grades would best be employed in more exacting applications such as interior panelling and joinery, where the attractive appearance and ability to take stains can be used to advantage. Although considered an excellent timber for shingles in North America, the suitability of the relatively wide-ringed New Zealand produce for this purpose has not been tested.

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