MARKET REQUIREMENTS FOR *PINUS RADIATA* CLEARWOOD: IMPLICATIONS OF LENGTH SPECIFICATIONS

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ABSTRACT

The term clearwood is defined as defect-free solid wood material of any length, so long as it is defect-free throughout the whole of its length. World wide the market for clearwood is estimated to be around 59 million m^3, of which the softwood component is some 22–23 million m^3. Analysis of the markets for clearwood reveals that they are niche ones, and frequently the lengths of clearwood actually required by these markets are quite short. Some markets, notably mouldings and veneers, require longer lengths. Many users such as small furniture/joinery manufacturers could use short length clears but are reluctant to shift away from the use of long lengths because of the perceived loss of flexibility.

New Zealand needs to develop markets for short length clears if it is to fully realise its investment in pruning. Standard blanks may well be the best way to utilise this material and markets for such material are being developed. Standard blanks may also help suppliers overcome some of the concerns about the lack of flexibility implied by the use of short lengths. The most cost-effective way of producing clears will depend upon the targeted niches and the suppliers' ability to modify the customers' preference for long lengths.

Keywords: clearwood; markets; length requirements; market size; substitutes; production methods; *Pinus radiata.*

INTRODUCTION

The last 20 years have seen New Zealand's exotic forest estate nearly treble in size from 465 000 ha in 1970 to 1 248 000 ha in 1990. Supplying the material base for an export industry provided the chief justification for expansion of the estate (New Zealand Forestry Council 1981a) throughout the whole of this period. However, neither products nor intended markets for the output of this forest estate were identified in detail before the expansion commenced (Sutton 1978), nor until the mid 1980s were these questions addressed in any systematic way (Kininmonth 1987). In part the failure to identify markets stemmed from a recognition of the inherent difficulty of identifying what the world might want 20 or more years hence (New Zealand Forestry Council 1981b). However, it also appears as if it was simply assumed (in some quarters at least) that profitable markets would exist for anything New Zealand could produce, and that therefore no attempt need be made to identify markets in any level of detail (Byron 1979; New Zealand Forest Service 1980).

In those studies which did take the market into consideration it was postulated that New Zealand's ability to quickly produce high-quality material of large dimension would provide entry into world markets. The main points in the argument (Sutton 1975) were that there will be a strong, and unsatisfied, world demand for clears and high grades of both sawntimber and plywood and that good market opportunities will exist for a supplier of such wood. The certainty of the conclusion can be challenged as, for example, by Byron (1979) who stated that it rests "on the disappearance of virgin stands around the world, which used to supply these grades, the fact that New Zealand has a climate to produce such timber cheaply by pruning plantation forests and the assumption that there will be no significant substitution of these grades of timber, so that high price premiums will continue".

As with any view of the future, disagreement is to be expected and can be found. Debate about appropriate futures is both normal and healthy. This paper examines the market requirements for clears and, in particular, the implications of length specifications.

CLEARWOOD: WHAT IS IT?

It is important from the outset to decide exactly what is meant by the term "clearwood". Although the term has been used widely in the New Zealand industry during the last 20 years, most of those using it have failed to define it adequately. Estimates of potential clearwood supply for, say, the year 2000 can vary from as little as 356 500 m^3 (Anon 1981c) to as much as 1.5 million m^3 (Sutton 1984), this variation being due in the main to the use of different definitions of the term "clearwood".

Sullivan (1984), while recognising that clearwood can be defined as wood that "has minimum grain distortion" and that such wood "occurs naturally between the branches or nodes of a tree", defined clearwood as "that timber sawn from outside the knotty core (occlusion zone) of an artificially or naturally pruned log". This is similar to a definition implied by R. Fenton, W.R.J. Sutton, and J.O. Drewitt in 1963 (unpubl. data) in a discussion of the effect of log size on clearwood yield. For Sullivan (1984) timber with the requisite grain distortion qualities but produced from the internodal region of a log is defined as factory or shop grade. These grades together with clearwood comprise the "finishing or dressing grades".

In developing clearwood grading rules in the early 1980s, Whiteside (1982), however, made no distinction between internodal timber and that from outside the occlusion zone of a pruned log. Whiteside proposed two clear grades and a cuttings grade, modelled on the US Western Wood Products Association's C and D select grades. Length requirements for the two clear grades were not defined, although in an evaluation of the grades all pieces of timber used were 2.4 m in length. The cuttings grade, however, does have some length restrictions with the requirements being for a "minimum of 70% of the length in clear cuttings one metre or longer, with a minimum length of two metres for at least one cutting per piece" (Whiteside 1982). From this it could be concluded that a clear cutting is any piece of defect-free timber 2 m or less in length, while clears are (presumably) any piece of defect-free timber longer than this.

New Zealand timber grading rules, however, permit a limited number of defects in the clears grade of exotic softwood timber. A limited amount of cup—the amount depending upon the width of the piece—is permitted. There is no restriction on sloping grain nor on stain, provided that it is "insufficient to impair a natural finish". Resin streaks and surface checks are also allowed, but the grading rules are not unambiguous as to the numbers permitted per piece. The rules state that in any piece only one resin streak "shall be permitted on *either* face or edge" provided that it is no more than 5 mm wide and no longer than 100 mm. Surface checks in turn are restricted to three 0.5-mm-wide 50-mm-long checks on *either* face or edge (New Zealand Standards Association 1988). The problem that arises is does the word *either* mean "each/every", "both", or "the totality of"? The first of these would allow up to four resin streaks per piece—one on each face or edge. The second would limit the number to two per piece—one on each pair of faces and edges—while the final option would restrict the number to one resin streak per piece.

The New Zealand Standard also recognises two cutting grades. No.1 must be capable of yielding cuttings of at least 1 m in length, a minimum of 2.0 m of cuttings per piece, and at least 70% of the total length of the piece in cuttings. Cuttings from the No.2 grade need be no longer than 0.6 m, total cuttings per piece need be no more than 1.8 m so long as this is 70% or more of the total length of the piece. Permitted defects in cuttings are identical to those in the clear grade (New Zealand Standards Association 1988). This means the same problems of ambiguity arise. A case undoubtedly exists for an amendment to the New Zealand Standards which would remove the ambiguity with respect to permitted defects. However, the fact that ambiguity exists within the New Zealand Standards serves to highlight the difficulty in defining terms such as clears and clearwood.

Other definitions of clearwood can be found too. Although the New Zealand Standard has no restriction on grain distortion, most other definitions do. The requirements for minimum grain distortion are generally similar for most definitions; however, length provisions can, and do, vary markedly. Sutton (1978) divided clear timber into two categories—minimum length 1.2 m and minimum length 2.4 m. The 1981 Forestry Conference Processing Options Working Party (New Zealand Forestry Council 1981c) considered specifically only "clear timber in defect-free 6 metre lengths". Bennett (1986) offered three scenarios of future New Zealand clearwood production, two of which were based on clearwood being defined as lengths of 3 m and over. Fenton et al. (1971), as well as partitioning clearwood into lengths under and over 3.66 m (12 ft), counted anything in excess of 0.3 m (1 ft) as a clearcutting. This latter length (0.3 m) is one also considered by Park (1985), and one that will be discussed later. One can also find definitions which include fingerjointed material as being equivalent to, or at worst a very close substitute for, clearwood.

The market however, does not distinguish between defect-free material produced from pruned and from unpruned logs. Because of this, definitions which use this distinction are rejected. So too are those which include fingerjointed material as being identical to clearwood. Accordingly, in this paper the term clearwood will be used for any defect-free (as defined by Whiteside 1982) material, of undefined length, so long as it is defect-free throughout the whole of that length.

As has already been stated, various length definitions have a marked impact on the potential clearwood availability—a variation of over 1 million m^3 in potential supply at the year 2000 is shown above as the result of differences in definition of long or full length clears. In practice, most clearwood definitions have a minimum length requirement of some 2 to 3 m. This type of restriction results in estimates that some 20–30% of sawn output, virtually all from pruned logs, would be likely to qualify as clearwood. But work such as that of Fenton *et al.* (1971) or that reported in the FRI Annual Report for 1983 (Forest Research Institute 1984) reveals that the total amount of "finishing type" timber could be as much as double the clearwood estimate based on this sort of length restriction. In addition, this work also reveals that much of this extra material could be produced from unpruned logs. A question that therefore arises quite naturally is "How short is too short to be defined as a clear?"

CLEARWOOD LENGTH REQUIREMENT

There is no easy way of answering the question of what should be the minimum length for a clear. However, one possible way of setting a lower bound may be to determine the minimum clear length used or required by the industries that have been targeted as markets for New Zealand's clearwood. This approach also offers the advantage of ensuring that discussion is focused upon what is wanted by the market. One of the notable features of most of the recorded clearwood definitions is that they are based upon growing/silvicultural considerations rather than the market.

Sutton (1975) nominated furniture, interior joinery, exterior joinery (weatherboards and window frames), and stairs as uses for clearwood. Discussion of features which could limit the acceptability of *Pinus radiata* D.Don in these end uses was, however, limited to "the only aspect of quality which may prevent a universal acceptance of New Zealand grown radiata [pine] as a finishing timber is the ring width. ... Although this has no effect on the wood-finishing properties some discriminating buyers may be prejudiced or genuinely want wood with a close-grained wood appearance. However, this is not likely to affect the market prospects greatly since not all buyers will be prejudiced". This allowed Sutton to conclude that the "impressive performance of radiata pine clears confirms that this grade is a most acceptable alternative to the world's major finishing softwoods" (Sutton 1975, p.160).

Coppens (1980) suggested that pine clearwood could be seen as a substitute for the tropical hardwoods that traditionally have been used in furniture manufacture. The New Zealand Forest Service (1980) and the 1981 Forestry Conference (New Zealand Forestry Council 1981b) both suggested that it be used to produce high quality veneers and decorative plywood as well as furniture and furniture components. Sutton (1975) also mentioned the possibility of veneers and plywood, concluding that "it is reasonable to assume that, apart from the possible visual unattractiveness, clear radiata [pine] veneer and plywood is a substitute for the major conifers" (p.161).

While plywood and veneers were seen as the likely major uses for clearwood at the 1981 Forestry Conference, the Conversion Planning Project, concluded some 6 years later, was much less certain of this future. The processing options outlined at the 1981 conference envisaged the establishment of some 10 to 20 new ply mills in the period to 2001. The Conversion Planning Project, however, projected minimal growth in ply production for the period to 2000, with at best one new plant being built (Theron 1988). The view that there may be not much expansion in the New Zealand ply and veneer industry is still widely accepted. However, the potential importance of these industries as users of clearwood is perhaps somewhat greater than would be implied by this. This is because of changes in attitude which have resulted in the acceptance of log exports as a natural part of the export product mix (Gibbs 1988; Ministry of Forestry 1990) and experimental shipments of pruned logs to Japan for use by that country's ply industry.

Some of those writing on the subject of clearwood markets for *P. radiata* have been quite pessimistic (e.g., Bennett 1986). *Pinus radiata* undoubtedly does have an image problem, reportedly being regarded as suitable only as a packaging timber by wood users in a number of markets. Frequently this judgement about *P. radiata* has been formed with little or no experience of the timber (*see* McPherson 1990). The image problem should be surmountable and most who have written about *P. radiata* clearwood appear to feel that, while it may find a niche in the decorative ply and veneer markets, the main uses are likely to be in the furniture, componentry, joinery, and mouldings industries (*see* Sutton 1986). Perhaps the most notable feature of much of the New Zealand literature surveyed, however, is its lack of detailed analyses of market size, features, or requirements. This lack of detailed information has been noted. Parrott (1980), for example, commented on a number of specific deficiencies with respect to clearwood market information and Woods (1986) made the point that in general it appears as though forestry, like much of the New Zealand agricultural sector, has been production rather than market driven for much of the last 20 years.

Evidence of market analysis by forest processing companies tends to be anecdotal because of the proprietary nature of such studies and also because of their commercial value. However, information available about what New Zealand companies are presently exporting as clears—particularly as blanks and furniture components—shows that there are reasonable grounds for regarding short lengths as clearwood. This is particularly true when discussing material for the furniture componentry and joinery sectors (*see*, for example, Carey 1980, or Challis 1989).

Araman (1982), in a study which looked at the part sizes needed to manufacturesolid wood furniture and kitchen cabinets, stated that "while lengths up to 6 feet [2.13 m] long are needed ... 78% of requirements are equal to or less than 4 feet [1.22 m] long". Similar results were noted for veneered and upholstered furniture and kitchen cabinets. Carson (1988) reported van Wyk as finding in an investigation of overseas and local New Zealand demand for clear sawn timber that "70% of all clearwood, excluding mouldings, is used in lengths less than 1.5 m, and 90% in lengths less than 2.5 m".

Araman *et al.* (1982), as a result of analysis of individual part sizes used by major United States furniture and kitchen cabinet companies, proposed that such parts should be produced from a combination of standard blanks. They claimed that these could be combined in such a way that any product could be produced with no more than 10% wastage of the total volume of the standard blanks. Standard blanks were defined as "pieces of solid wood (which may be of edge-glued construction) of a predetermined size and quality". This definition, with perhaps some note being made of the allowance of edge-gluing, need not be inconsistent with the definition of clearwood being used in this paper. The clear hardwood blank sizes (transformed to metric units) recommended by Araman and his co-workers are given in Table 1.

Although Araman's work refers specifically to hardwoods, it is unlikely that softwood furniture blank lengths would be significantly different from those given since cabinets and furniture made from either softwoods or hardwoods are likely to be of similar dimensions.

TABLE 1–Recommended hardwood blank standard sizes for furniture and cabinet manufacture (cm)

Nominal thickness						
	1.59	1.91	2.54	3.18	3.81	5.08
Intended product finish thickness						
	0.95	1.27	1.91	2.54	3.18	4.19
Actual blank thickness						
	1.27	1.59	2.22	2.86	3.49	4.46
Blank lengths						
Clear quality/66-cm-wide blanks						
	33	36	38	38	38	38
	38	43	46	46	46	46
	43	48	53	53	53	53
	46	56	64	64	64	64
	56	64	74	74	71	71
	66	74	84	84	81	81
	79	79	97	97	89	89
	91	89	114	114	102	102
	107	104	127	127	114	114
	119	119	152	127	127	127
	147	190	190	152	152	152
	218	254	254	178	178	178
					216	229

Source: Transformation of part of Table 37 of Araman *et al.* (1982)

One feature of the information presented in Table 1 is the shortness of most blanks. Of the 71 proposed, 53 (just on 75%) are less than 1.2 m long, and the longest is only 2.54 m. The frequency of internode length in the second log of the progenies of various *P. radiata* breeding strategies employed in New Zealand has been measured (Forest Research Institute 1984) (Fig. 1, Table 2). Based on these results, most of the blank lengths proposed by Araman *et al.* (1982) could be cut from the internodes of any of the second logs from *P. radiata* seedlots currently being grown. The main differences between different tree types/ breeding strategies, i.e., long internode *v.* short internode, would not be the overall yield of clears but rather the length of the average piece and the amount of docking required to obtain clear pieces from multinodal logs (Carson 1988).

Should furniture, solid componentry, and (possibly) joinery (*see* Anon 1986a, b) be seen as the major uses for clearwood, then ample evidence exists to support the inclusion of even the very short lengths within the clearwood definition. For products other than furniture and componentry, details about length requirements are hard to obtain. Carey (1980) provided data indicating that the United States millwork and mouldings industries use material in 8 to 16 ft (2.43 to 4.86 m) lengths. These figures were supported by Sullivan (1984) and for a number of European markets as well (UNCTAD/GATT 1985). The latter study indicated that, as with the furniture and componentry industry, the typical dimensions of builders' woodwork are quite small, varying with the product, and for similar products, from country to country. This inter-country variation in standard sizes for wood for similar end-uses, e.g., windows or doors, was also noted by Lindgren (1987).

For plywood and veneer the minimum length requirement depends to a large degree on the targeted market. Japan uses a 6 × 3 ft (1.82 × 0.91 m) panel size (Fenton 1984), New Zealand 2.4 × 1.2 m, and the United States 8 × 4 ft (2.44 × 1.22 m). The minimum pruned

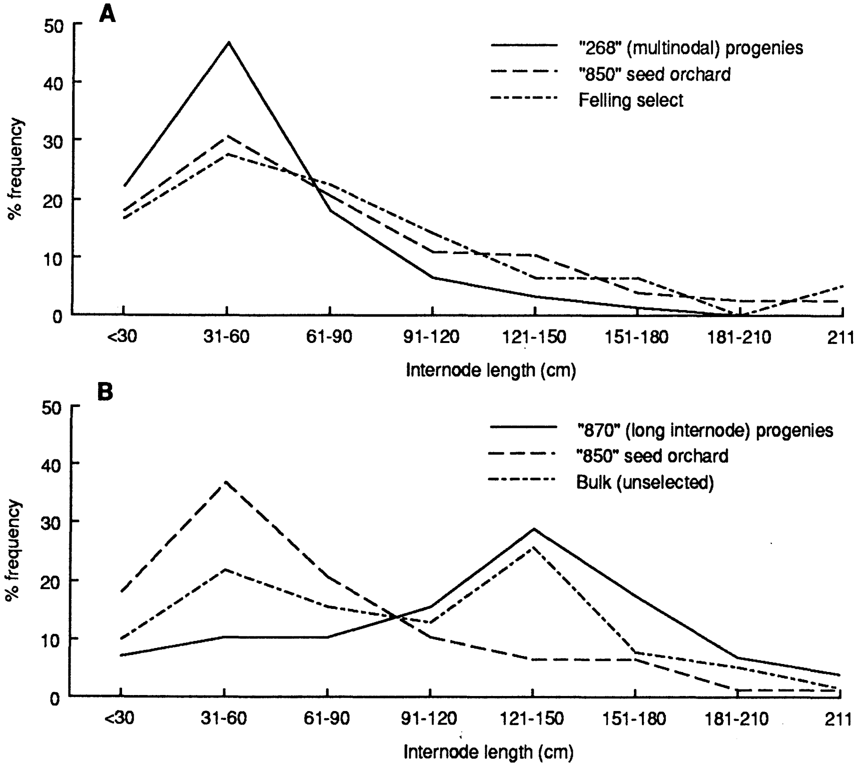

FIG. 1–Frequency of internode lengths in the second log, by seedlots. A: wind-pollinated test of short internode progenies; B: wind-pollinated test of long internode progenies. Source: Forest Research Institute (1984)

TABLE 2–Distribution of internode length for various seedlots

Internode length (cm)	Percentage of internodes of this length for the various seedlots					
	"Short Internode"			"Long Internode"		
	"268"	"850"	Felling select	"870"	"850"	"Bulk"
≤30	22.1	13.0	16.7	7.1	13.0	10.0
31–60	46.3	30.8	27.6	10.3	35.9	21.8
61–90	13.0	20.5	22.5	10.3	20.5	15.4
91–120	6.4	10.9	14.1	15.4	10.3	12.8
121–150	3.2	10.3	6.4	23.9	6.4	25.7
151–180	1.3	3.9	6.4	17.3	6.4	7.7
181–210	0	2.6	0	6.7	1.3	5.2
≥211	0	2.6	5.2	3.9	1.2	1.7

Source: Derived from Fig. 1.

bole length for plywood and veneer production depends somewhat upon the market, but would appear to be of the order of 1.8 to 2.4 m. This is about the length that is generally considered as constituting clear material. It is also apparent from Fig. 1 that only a very small fraction of internodal material would be available in these lengths.

If panelling and weatherboard uses provide the main markets for clearwood, acceptable lengths will apparently vary from little more than 1 m through "stud" length (about 2.4 m) to 5–5.5 m. Reports on tropical timbers used for these purposes indicate that acceptable minimum lengths vary with species, but that importers typically seek shipments in which average lengths are some 3 to 4.5 m (*see* Anon 1989b). The biggest problem, however, in targeting this market is that it may well be a declining one. The loss by solid wood of market share in residential exterior cladding is a phenomenon that has been observed in the United States, New Zealand, and Australia (Evison & Revington-Jones 1990). For door manufacture, lengths up to 4.8 m are required (Lindgren 1987) although the longest piece needed is more commonly in the 2–2.5 m range (Anon 1985; McPherson 1990).

In summary, this rather brief survey of clearwood length requirements by end-use suggests that the identification of markets is very important. For the ply, veneer, panelling, and moulding markets minimum acceptable material length would appear to be 2–2.4 m. Few bolts of this length will be produced in *P. radiata* without pruning. If, however, the major markets for clearwood are in the furniture and componentry industries, then almost any length down even to 0.15 m (*see* Mason 1988) could be regarded as clearwood, and the potential supply of clearwood from even unpruned trees is very large—perhaps as much as 3 million m^3 from the projected harvest of 20 million m^3 for the early years of next century.

OTHER DIMENSIONS

While the focus of this discussion is length, the other two dimensions width and thickness warrant at least brief mention. It appears that, for solidwood uses, thicknesses for generic clearwood/finishing timbers are, at least in nominal terms, somewhat more standard throughout the world than are length requirements. The greatest variation seems to come from the use of imperial rather than metric units in some markets, most notably in North America, and the fact that the metric equivalents of imperial sizes are not exact conversions (e.g., 2 inches is 50.8 mm not 50 mm, the metric equivalent). Commonly traded imperial thicknesses range from 3/4 of an inch through to 2 inches in quarter-inch steps (*see* Araman 1982; Anon 1985; McPherson 1990). The metric equivalents of these are 16, 25, 32, 38, 44, and 50 mm, all of which are also traded (*see* Anon 1985; McPherson 1990). For a nation wishing to move substantial volumes of generic clear material it may be most appropriate to concentrate production into one or two thicknesses (e.g., 25 and 32 mm) as has been proposed for North American hardwood exports to Japan and Europe (Araman 1987). If, instead, niche markets for components are concentrated on, then the thickness of the various pieces, and the width as well, will be dictated by the buyer.

As with thickness, there are a variety of width requirements While these depend upon the intended end-use of the material, some general observations may be made. Apart from componentry the smallest width mentioned with some regularity (*see* McPherson 1990) is 1.5 inches (38 mm). More commonly the widths mentioned are 2, 4, 6, or 8 inches (50, 100, 150, and 200 mm). Frequently the requirements are couched in the form of a minimum width, e.g., 6 inches (150 mm), and wider with an additional requirement that average width of the material in the shipment be of some specified level (*see*, for example, Anon 1989b). As with thickness, a seller of generic clears may be best to concentrate on a few specific widths—or on edge-glued standard-sized blanks.

MARKET SIZE

Thus far much of this analysis has been production driven. If, instead, it was market oriented a number of other factors would need to be taken into account. Among the important ones are market size (i.e., how big is the market for clearwood), market structure (i.e., is the market dominated by a few large companies or made up of a lot of little ones), distribution channels, trade barriers, substitution of/for clearwood, the suitability of *P. radiata* for the targeted markets, risk and uncertainty, and (if consideration is going to be given to producing clears from unpruned material as well as, or instead, of pruned logs) the relative costs of producing clears by pruning *v.* defecting.

Maughan (1986) concluded from a survey of the New Zealand domestic timber market that the "higher" board grades had historically accounted for about 8% of sawntimber consumption. He went on to claim that it was unlikely that this proportion would change significantly during the next 20 years—a period where very limited growth in the market size is expected. Fenton (1984) showed the Japanese market for furniture—which presumably uses higher board grades—accounting for some 6.5 to 7.5% of total sawntimber use for the period 1970–83. United States softwood sawntimber consumption by broad end-use category (Anon 1985) is similar to that applying in New Zealand. The bulk of European apparent consumption of sawn softwoods is in construction (56 to 82% depending upon the country). Furniture accounts for 3 to 8% of the consumption of sawn softwoods, and 15 to 40% of the use of hardwoods (Anon 1986b). If, on the basis of this, one were to assume that around 5% of total world sawn softwood production is consumed as higher/clear grades, then based on the current world production/consumption figures (FAO 1988) the implied world softwood higher grades market would be some 18 million m^3, and hardwood demand (assuming some 25% of hardwoods are consumed as higher grades) about 29 million m^3. These figures would imply a total world market for higher grades of about 47 million m^3,or about 10% of total sawntimber production.

Many of the recent predictions of future sawntimber demand suggest either static or very slight growth in consumption over the next 20 years (*see* Dykstra & Kallio 1984). The latest FAO projections are more optimistic, projecting production/consumption to increase to 589 million m^3 by the year 2000, a growth rate of about 1.7% per annum (FAO 1988). Taking the FAO projections and assuming a similar split by end use to that apparently ruling at present, worldwide the consumption of higher grades in the year 2000 might be of the order of 59 million m^3, of which the softwood component would be some 22–23 million m^3 (this could be somewhat conservative as it fails to take account of any softwood substitution for hardwoods but assumes that the current split will continue).

New Zealand, with a year 2000 pruned log supply of some 2.4 million m^3 (Burrows *et al.* 1987) and a total sawlog harvest approaching some 16 million m^3, could conceivably produce sufficient clearwood to supply between 4 and 10% of the total world demand. This may not seem to be a sufficiently large percentage to warrant any concern. However, other producers, notably the Finns who supply a similarly small percentage of total world industrial wood production, have rejected the validity of the small country perfect competitor assumption (Seppala 1988). The reason for rejection is that globally the forest industry is very home-market oriented. Some 80% of world production is not traded internationally but is instead consumed in the country where it is produced. Consequently, any country which exports a large proportion of its production can be a significant force in international trade.

Forest products trade shows some similarities with trade in agricultural products (de Rees 1986), where it may be noted that New Zealand with, depending upon the product, between 0.3 and 8% of total world production of commodities such as sheep meat, dairy products, and beef (Ojala 1980) is a significant international supplier.

A further complication in forest products trade is that it is strongly regionalised (Horgan 1988; Franceson & Nagy 1988). Taking these two factors into account, i.e., small percentage of total production traded and trade being highly regional, could mean that the world market for internationally traded finishing timbers in the year 2000 could be as little as 12 million m^3 per annum (this figure has been derived on the assumption that the percentage of finishing timbers traded internationally is similar to that given by FAO figures for current trade in sawntimber, i.e., approximately 20% of the production is traded internationally). Trade in softwood finishing timbers is a subset of the total trade and on current figures could account for as little as 40% (4.8 million m^3). Finally, because of the regionalisation of trade, the total world market may not be readily open to New Zealand softwood exports. Even if New Zealand is not confined to an Asia/Pacific regional market it is potentially a very significant producer, particularly if the world market it is competing for is only of the order of 5 million m^3 per annum. The whole question as to the size of the clearwood market is one requiring much more research.

MARKET STRUCTURE

The importance of market location and structure is shown in Carey's 1980 study of the potential for clear *P. radiata* in the United States. He concluded that the sales potential of this product to the United States furniture industry was limited because:

(1) The industry is concentrated in the eastern United States and freight costs from New Zealand would impose significant barriers.

(2) Hardwoods are traditionally preferred to softwoods, and when pine is used it is knotty pine, not clearwood.

(3) Companies from Oceania have tried to break into this market with only modest success.

Carey (1980) also found that the furniture industry is characterised by a "fairly large number of modest size firms"—a situation which "tends to raise total sales and servicing costs". A large number of firms of modest size would appear to be a feature not only of the United States furniture industry but also of the New Zealand (P. J. Kerr pers. comm.), Australian (Challis 1989), and United Kingdom industries (R. Cooper pers. comm.). Thus the problem of raised sales and servicing costs is likely to be a general one. An additional complication may arise from barriers to trade. In general, both tariffs and non-tariff barriers are greater for more highly processed products such as furniture componentry and blanks, than for unprocessed raw materials (Bourke 1986).

A large number of modestly sized firms is a feature not only of the furniture industry but also of other potential clearwood-using industries. Glass (1988), Lindgren (1987), UNCTAD/GATT (1985), and McPherson (1990) all document similar structures to the builders' woodwork/millwork/joinery industries in a variety of different regions/countries. Millwork is not a large consumer of softwood lumber relative to other wood uses but it is important with regard to the higher-valued grades. In the United States it accounts for some 3% of total consumption by volume, but about 13% by value (*see* Glass 1988). "Length and width, rather than thickness, are the main dimensions of interest. Long length and wide width softwood lumber have historically commanded a price premium over other lumber ... [with] millwork a potential use for large dimension softwood lumber possessing favourable utilisation properties" (Glass 1988).

McPherson (1990) highlighted the conservatism of this sector, the preference for long length material, and a reluctance to use blanks/componentry. He reported the comments of one United Kingdom bespoke joiner as summarising the views of that sector. This joiner stated that components were not wanted as the business is in non-standard joinery. Componentry, however, leads to standardisation and the more standardised joinery becomes the less work there would be for this part of the industry. There is also a view that foreign-machined parts are far too poor in quality to use, being bent and inaccurate in size. While these views undoubtedly limit the present scope for selling anything other than long random length boards, they should ultimately be able to be overcome through good quality control, marketing, and education. The almost universal concern about the cost of clear timber and about the willingness of customers to pay a price sufficient to cover the cost of producing it in the form that it is now obtained may well prove to be a good starting point for any programme designed to modify industry's current attitudes.

Ply and veneer industries are not nearly as atomistic as either the millwork or furniture industries. Most countries have only a few, relatively large, producers making a limited range of products. Sheet or panel size varies from country to country (*see* earlier section), but in general will require a minimum log length of 2–2.4 m. Dealing with an oligopolistic market may be somewhat easier for New Zealand suppliers. However, there are a number of other areas requiring further research, including the potential impact of substitution and/or of technology (*see*, for example, Spelter & Sleet 1989).

SUBSTITUTES FOR CLEARWOOD

Sutton (1975) dismissed the possibility of substitutes affecting the market for solid wood. His argument was that, contrary to popular belief, reconstituted wood products were complements rather than substitutes for solid wood. He also argued that the energy crisis had strengthened the position of solid wood. In Sutton's view, even if some products should prove to be substitutes for solid wood the "product least likely to be affected by substitution is the best quality wood—clears" (Sutton 1975 p. 180). Abel (1977), however, provided compelling evidence from both New Zealand and overseas that products such as particleboard are substitutes for solid wood, not complements. His data would suggest that some 40 to 60% of the European board grade markets have been lost to substitutes over the 16-year period 1960–76. The magnitude of the loss was to a degree masked by post-war reconstruction (initially) and the general growth in the European economy throughout this period.

The rather sanguine view that reconstituted products will not challenge solid wood, and especially not clearwood, will almost certainly be questioned by a number of those who simply look at the literature. Apart from the impact of reconstituted board products on solid wood one finds reference to products such as Scrimber (Australia) and Parallam (a MacMillan Bloedel product), which are intended to compete against structural timber. In addition, one finds concern about possible impacts of rising price on demand for clears

(McPherson 1990). This suggests that the usual economic results of high prices, namely substitution, will work for this segment of the demand too. It was recently reported, for example, that MacMillan Bloedel has announced plans to build a composite wood products plant at Deerwood, Minnesota. The plant will manufacture an aspen fibre product which it is proposed will "substitute for high-grade clear softwood lumber of the kind normally used for intricate woodwork such as windows and door fittings" (Anon 1989a).

The view that high energy costs will favour solid wood can also be questioned. Concerns about energy have abated somewhat since the 1970s and early 1980s; now the environment and "greenhouse impacts" seem to be of more topical concern. Nevertheless, while it is true that the energy required to grow, harvest, and process wood into roughsawn timber is small relative to that needed to produce some substitutes (Fraser *et al.* 1979), energy costs are not the most significant costs in manufacturing products (NZER&DC 1979). Moreover, the total energy involved in a solid wood or wood substitute product when that product is finally delivered to the consumer may be remarkably similar. For the solid wood product the energy costs involved in drying (perhaps double those involved in getting the timber to the green roughsawn stage), further manufacture, and any wastage must be considered, in addition to those to the green roughsawn stage. Similar considerations apply to the substitutes, although frequently these are manufactured to final product state in a single process. The whole subject of the energy cost advantage of solid wood over other products is much more complex, and less clearcut, than would be suggested by some comparisons and is deserving of a considerable amount of further research.

NOVEL WAYS OF EXPANDING THE CLEARWOOD SUPPLY

Even if it is accepted that environmental concerns favour solid wood over other products, and even if the markets for clears remain undisputed by other products—both propositions that one might wish to take issue with for the same reasons as Samuelson (1976) did with the claim that "wood is our most important necessity"—there still remains the possibility that significant quantities of "clear" material could, with the use of technology, be produced from low(er) quality logs which at present are not used in the production of this material. *Pinus radiata* internodes are such that significant quantities of short wide clears could be produced from unpruned logs (Fig. 1, Table 2). Whether this is acceptable as clearwood depends upon what is/are the market(s) for clears but at least one article (Mason 1988) has claimed that *P. radiata* clearwood recovery could be increased 50–100% simply through better bucking and manufacturing methods.

Pinus radiata, and in particular unpruned *P. radiata*, is not the only material with potential to produce short length clears, which could be suited to a furniture industry. Several studies have been carried out in North America which have looked at the potential of directly manufacturing furniture parts from low-grade aspen logs. As one study (Wengert 1988) reported, "furniture parts sell, depending upon the species, for between $1000 and $1500 per MFBM of parts"—NZ$730 to $1100/m^3. Conversion efficiencies for aspen to furniture parts are estimated as being of the order of 30% and the potential of this type of operation is described as "very large". The work of Araman and his co-workers suggests that a similar comment applies to most United States hardwoods.

But, as some of the earlier discussion has demonstrated, the markets for clears are not simply markets for short length material. Many users of clear timbers express very strong preferences for material to be at least 2 m long, and preferably 4 to 5 m in length (*see* McPherson 1990 p.123). Unfortunately, *P. radiata*, regardless of tree breed, produces very few internodes are greater than 2.1 m (Table 2). However, several mechanisms exist for dealing with this demand for longer lengths.

Among the alternatives are:

(1) Education so that the demand for longer lengths is modified;

(2) Silvicultural management (e.g., pruning) to produce the desired material;

(3) The use of processing technology, e.g., sawing between the defects, to produce the desired material from what is available.

As yet there is no evidence of a concerted campaign by any producer, let alone the New Zealand industry, to educate users of clearwood away from long lengths. Because of this the first option will not be pursued in this paper.

With some 43% of the national exotic estate being managed on pruning regimes (Novis *et al.* 1989; New & Rawley 1989) it is clear that the second of these three options has received reasonably wide acceptance. An interesting point is that this option does not mean that the need to develop markets for shorter length clears has been avoided. Pruning regimes will produce a range of clear lengths for two reasons. Firstly, within the estate there is evidence of variable pruning heights, ranging from 2 to 8 m (Manley *et al.* 1987). The second reason has to do with log geometry (i.e., log taper and size of the defect core). Even if all logs were pruned to exactly the same height, taper and log shape variations as well as variations in the defect core would mean that a variety of clear lengths would be produced. Having variable pruning heights only serves to compound this. Unless markets are developed that are able to accommodate the total range of clear material produced, a proportion of it may well find itself diverted to non-clearwood end uses, at non-clearwood prices, with a concomitant loss of some of the pruning investment.

The third possibility has to a degree already been foreshadowed in the discussion of the definition of clearwood and in the material about standard blanks. One of the main advantages claimed for New Zealand forestry is an ability to produce large logs quickly. The wide flitches that can be produced from this type of material are those best suited to producing longer length componentry through SDR (saw, dry, rip, and then defect) type systems (*see* Gatchell 1987; Wengert 1988). These systems allow for the possibility of missing, in some pieces at least, the defects associated with each internode. Assuming that defects occur only at a node and that their distribution across a flitch is uniform, then the narrower the board being cut the greater will be the probability that the defects associated with a particular node will be avoided. Appropriate rip width for SDR systems is an interesting optimisation problem, the solution of which depends upon a number of factors including the way defects are distributed within flitches and price premiums (if any) for both length and width.

Producing clears in the manner outlined may involve significant wastage of sawn material; this needs to be quantified. This loss/wastage may not be as great as some might envisage—Wengert (1988), for example, suggested an overall conversion rate of 30% for aspen logs whose volume averaged only some 0.022 m^3 per 2.5-m-long bolt. The cost of defecting clears out of knotty material needs to be estimated. As well, predictions of the likely effect of technology changes and tree breeding on this are needed.

One of the technological changes that would perhaps warrant consideration is computerised laser cutting of flitches (*see* Barnekov *et al.* 1986; McMillin *et al.* 1984). There are already claims that the advantages of laser cutting in, for example, reducing kerf width to around 0.5 mm and in its ability to stop cutting at any location, are sufficient to justify the use of such systems in furniture manufacture (Hubert *et al.* 1982; McMillin *et al.* 1984). Such systems would offer greater flexibility than SDR systems in that the cutting pattern could/would be variable from one flitch to the next—and with this should come reductions both in wastage and in processing unsuitable flitches.

PRUNED *VERSUS* UNPRUNED LOGS

The choice between pruning and defecting unpruned logs is an economic one. In one sense pruning can be regarded as simply another form of defecting, and the problem as one of choice of the most cost-effective form of this. This attitude may be contrasted with ones that see other reasons as justifying pruning, e.g., improved access or greater flexibility. An argument sometimes advanced for intensive tending (pruning) regimes is that the cost of producing wood in such regimes is little more than in unpruned structural sawlog regimes and that therefore such regimes should be favoured because of increased flexibility (of end-use). Others (e.g., W.B. Stuart unpubl. data) have suggested that the heavy commitment of resources in the early years (front-end loading) implied by such regimes makes them risky and imposes a significant cost on the unpruned component of their output. There is an urgent need to quantify the various aspects of this argument, and to try to determine their relevance. In addition there is a need to quantify the cost of producing clearwood via intensive silviculture as opposed to an alternative such as improved sawing technology.

Because pruned clearwood is a joint product, i.e., it is produced along with unpruned sawlogs and fibre material, there is no unique correct way of allocating the costs of these regimes to the various outputs. Rather than asking the question "What does it cost to produce a pruned clearwood log?" and then trying to contrast this with the cost of clears from unpruned material—a process which is likely to lead only to disputes over the allocation of costs to the various output components—it may be more relevant, and constructive, to ask "Do sustainable prices exist for the output of a pruning regime?" (The wood sustainable is used here in the sense of Baumol et *al.* (1977) in that an output price vector is said to be sustainable if it is such that there is no incentive for a rival firm to enter the market for any of the products with lower prices than those being asked).

One cost allocation scheme which satisfies this requirement is to set the cost of each output at its minimum cost of production in a purpose-designed regime. Over the years a number of analyses of the average cost of various regimes have been reported. Sutton (1975), for example, showed average breakeven growing costs increasing between 60 and 100% (depending on the interest rate) when going from a minimum-cost sawntimber regime to a "maximum quality" (i.e., clearwood) one, while Whiteside *et al.* (1989) showed a cost increase of about 25% for a pruned over an unpruned regime. If one makes the assumption that in going from one regime to the next, e.g., pulpwood to unpruned sawlog to pruned regime, one does not affect the quality of the products produced by the previous regime (i.e., pulpwood or unpruned sawlogs are of similar quality regardless of regime), then it would appear as though the relative costs of producing pulpwood, unpruned sawlogs, and pruned sawlogs in the various *P. radiata* regimes employed in New Zealand are of the order of 1:2:4.

Absolute costs are affected markedly by the choice of discount rate. However, for rates in the range of 5 to 10%, the range commonly employed in New Zealand forestry, the impact of discount rate on relative cost is slight. For discount rates of around 10% "one" would appear to be of the order of $20/m^3 (*see* NZER&DC 1979), implying a cost of production for pruned logs of some $80/m^3. The question of whether to prune or not would, under the assumptions outlined, become one of whether or not the processing of pruned logs as opposed to unpruned ones yielded a minimum of an extra $40/m^3 processed. If it does then the allocation scheme outlined would be sustainable. Even if returns are insufficient to make the outlined allocation scheme sustainable this does not prove that sustainable prices do not exist. Sharkey (1981) outlined a number of rules which may be used to calculate sustainable prices, including one where goods with the most elastic (absolute values) demands are priced at or near their marginal cost. With some commentators suggesting that supply conditions are best for the lower quality logs (pulp and unpruned sawlogs) this rule would see these priced nearest to their marginal cost and any subsidisation that this implied being made up by the pricing of the pruned component.

DELPHI STUDY

The Delphi study of sawntimber markets carried out as part of the Conversion Planning Project (Theron 1988) provided a mean year 2000 projection of export demand for higher grades (clears, cuttings, and factory) of some 641 000 m^3, with an interquartile range of 420 000 to 785 000 m^3. All except the most doctrinaire definitions of clears used in this paper suggest that New Zealand should be able to produce sufficient long length clears alone to meet the whole of this demand. Thus the Delphi study results, if taken seriously, might be seen as suggesting that there is an urgent need to develop a better understanding of the market(s), and a better market-related justification than that currently offered for pruning.

CONCLUSION

It is now more than 20 years since the (80 stems per acre) 200 stems/ha board regime was first proposed. It is time that the whole basis for reliance on this regime was re-examined. The re-examination should begin from an understanding of the market. Questions that need addressing are: What are the markets for clearwood? What are the appropriate markets for New Zealand clearwood to target? How big are they? How great is the threat of substitution? And finally, arising from the answers to these, what is the most cost-effective way of producing material to supply these markets? A review of this kind could ultimately lead to changes in:

- tree improvement strategies
- silvicultural regimes
- harvesting methods
- log processing (e.g., component sawmills, laser scanning)
- New Zealand marketing strategies.

There are markets for clears but they are niche markets and under greater threat from substitutes/technology than has been acknowledged in the past. While many of these niches currently use, and express a desire to continue to use, clear material in lengths of 3–6 m, these length requirements would, in the main, appear to be determined by history rather than by any fundamental process requirement. Length preferences may well be able to be modified towards shorter pieces, in which case world clearwood supply could be considerably increased. Even should such modification prove difficult it would be to the advantage of the New Zealand industry to try to develop markets for shorter length clears, if only to ensure that past investment in pruning is fully utilised.

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