Potential End-Use Applications of Lodgepole Pine in Ireland

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SUMMARY

During the next decade lodgepole pine will become available to the home market in large quantities. To date its potential as a high end-value product has not been realised. Optimising this potential will be paramount to its success as a new commercial species available to the processing and manufacturing industries. An outline is given of its timber properties and its silvicultural management in Ireland. The realisation of the potential of lodgepole pine will be in import substitution. The extent and value of the relevant import markets is indicated and the status of the processing and manufacturing industries which should provide the impetus for substitution are surveyed. A TASKFORCE has been set up to provide a technical and commercial input to ensure an optimised utilisation of this new commercial species.

INTRODUCTION

Lodgepole pine (*Pinus contorta* Dougl. ex Loud.), was first introduced into Ireland in 1884. Several trees were planted as specimens in Cong, Co. Galway (O'Driscoll, 1980). However, it was not until 1916 that lodgepole pine was first planted with a commercial intend at Avondale, Co. Wicklow. Experimental plots of South Coastal and Inland provenances were layed out for the selection of commercially viable varieties that were most suitable for Irish conditions. A number of these trees are still extant. The performance of the South Coastal provenance was quite impressive. On the strength of this, the Director of Forestry, A. C. Forbes, initiated the promotion and planting of lodgepole pine. Large quantities of seed of the South Coastal type were imported from Washington and Oregon coastal regions of the United States of America (U.S.A.). The precise origins are unknown (Lines, 1957). The first commercial lodgepole pine forest was planted in 1918 at Ballyhoura, Co. Cork (Edwards, 1955; Lines 1957). At present lodgepole pine accounts for 26% of the state owned forests and 21% of the total national afforestation (Purcell, 1982; Review Group on Forestry, 1955).

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During the 1980s, for the first time large volumes of lodgepole pine will mature and will be brought onto the Irish timber processing and manufacturing market. The wood quality and the timber properties of this fast grown species are not sufficiently known to decide on the most suitable end-use applications. In this paper, a background on the wood quality aspects of lodgepole pine will be given along with some of the existing technological and commercial realities.

Lodgepole Pine and its Origin

Lodgepole pine had its origin in the north-west of North America, where it was also known as "Shore" or "Beach pine". Lodgepole pine is a pioneering species, hence, it is adaptable to various growth conditions, both geographically and ecologically. Geographically, it grows between 31° to 64° northern latitudes on the western side of the Rocky Mountains. Within this area, it is found from sea level to 2,000m in British Columbia and up to 3,800m in the south west of the U.S.A. (Edwards, 1954). Ecologically, lodgepole pine has a great capacity to adapt to diverse and often adverse growing conditions. As a pioneering species it can withstand the affects of exposed conditions, infertile sites, competing vegetation, extreme seasonal temperatures and high levels of rainfall (Edwards, 1954; Lines, 1966). It is successful on most soil types, except on the heavier soils, where penetration by the taproot is inhibited (Edwards, 1954). The natural variation within lodgepole pine is probably greater than in any other softwood species. Edwards (1954) reports that by IUFRO agreement, the various provenances of lodgepole pine are actually various ecotypes of the species. Separation into different races is still continuing. Two distinct types of lodgepole pine are recognised, "coastal" and "inland". The coastal type is generally found along the coast at an elevation up to 170 metres, while the inland type is found further inland and at an elevation generally higher than 330 metres. Their phenotype characteristics are quite different, principally in their growth and branching habits. The coastal type has a denser growth habit with heavier branching (Lines, 1966).

Some Silvicultural Aspects of Lodgepole Pine in Ireland

Being a pioneer species lodgepole pine was planted mainly on poorer sites where Sitka spruce would not perform adequately or not at all (Brazier, 1980). Up to 1963, three provenances were planted in Ireland, South Coastal, Lulu and Inland. The volume of production of Lulu and Inland provenances did not

meet expectations and only South Coastal has been planted since then. South Coastal is the more vigorous of the three provenances. The average annual volume production fo South Coastal is yield class 12 (Fitzsimons, 1982). However, South Coastal does have some problems. It does not grow as straight as the other two provenances. Macdonald (1954) found however, that of the fast growing coastal types one in three trees had a straight stem. Macdonald did not quantify the parameters which qualified a straight stem. South Coastal also branched more profusely and the branch members were generally greater. Lines (1957) was of the opinion that stands which had trees with bad stem form and heavy branching, came originally from seedlots of true scrubby shore pine. In contrast, the stands of good form and finer branching came from the forest areas of good growth, but still near the coast. The coastal types that had their seed origin in the states of Washington and Oregon appeared to produce trees that had the greatest growth in height (Macdonald, 1954). The variability in growth appeared also to have been influenced by environmental conditions, such as soil types, spacing and exposure (Lines, 1957). There is no single best provenance in lodgepole pine. The "best" provenance is that which is best suited to a particular end-use and offers a compromise on stem form (Lines, 1966).

The actual silvicultural regime that is applied to lodgepole pine is determined mainly by three factors:

1. End-use products and their market,
2. Stability of the crop during its life,
3. Profitability to the grower.

In this paper the discussion will be restricted to the implications of silvicultural management on timber quality and its effect on the end-use products and their market.

Silvicultural Management and Timber Quality

The quality of timber and its intrinsic properties can be influenced by various types of silvicultural management. These management practices strongly influence the quality of the log that is produced. The properties that are of primary concern in lodgepole pine, South Coastal provenance, are stem form and the extent and intensity of branching.

A. *Stem Form*

The causes of stem form distortion or basal sweep appear to be many and varied. The main predisposing factors seems to be (Hendrick, 1984):

1. Low root/shoot ratio of transplant stock,
2. The method of planting,
3. The method of ground preparation.

Basal sweep, results in commercial loss of the lower part of the bottom log – the most valuable section of the tree. The crooked sections of the log must be discarded since it is not possible to process these sections with the standard log conversion systems. Basal sweep can affect the stem up to 3 metres from ground level. Even if small section sizes, such as pallet wood, are extracted, the yield from a sawlog can still be as low as 30%. Sweep measurements made at 1·3m can give a reasonably accurate estimate of log yield that can be expected (Fitzsimons, 1982).

The effect of the leaning of the stem on wood quality is principally in the formation of compression wood. The behaviour of timber containing appreciable amounts of compression wood differs from timber free of such compression. In compression wood, the tracheids are shorter and have a thicker cell wall. Stability, shrinkage, strength and density are generally appreciably affected. In a study on the effect of compression wood on the strength properties of Sitka spruce, Dhubhain found that planks containing more than 10% compression wood will rupture in a brash fashion, while over 20% compression wood will actually lead to a decrease in the strength properties of the timber (Dhubhain, Evertsen and Gardiner, in press).

B. *Branches and Knots*

The intensity and extent of branching is the second most important factor that affects timber quality. Although knots may be aesthetically desirable in the case of pine furniture, their presence can result in significant degrading effects when grading this material for joinery and other high value end-uses. Knot size and position in the machined joinery section has a great influence on the quality grade when graded in accordance with the relevant timber standard. Even though 'live' knots in lodgepole pine machine well they do increase the wear and tear on processing machinery. Techniques, such as finger-jointing, have been developed to cut out severe knots and produce knot-free timber lengths.

Relatively knot-free timber can be produced through several silvicultural management practices. Pruning, spacing and thinning regimes can be used to reduce the intensity of branching. Spacing and thinning will of course affect the growth rate as well. O'Kelly (1952) suggested that it would be necessary to prune lodgepole pine as early as the 14th year. This was recently confirmed by Fitzsimons who indicated that thinning and pruning beyond the

age of 12 could adversely affect the stability of the crop (pers. comm.). Phillips (1980) found that even though spacing did increase both the stem volume and the diameter of branches, the branch/stem ratio remained virtually unchanged. The number of branches per whorl did not increase with wider spacing either. The ultimate effect of thinning and spacing did however result in an increase in the total knot volume in the log. O'hEigeartaigh, Evertsen and Stephen (1985), demonstrated for Sitka spruce that at the time of log conversion, the effective knot volume in a log could be reduced by rotating the log into an optimal position. A reduction of up to 12% in the cumulative knot volume of the sawn timber could be achieved.

Phillips (1979; 1980) carried out a preliminary evaluation of the effect of pruning, thinning and spacing on timber grade out-turn in lodgepole pine, yield classes 12-14. These findings showed that with intensified silvicultural management, timber quality could be improved. The economics of this intensive management will depend on the end-use products manufactured from these trees. In the same study, Phillips (1979) could not find a relationship between branch size and overall grade.

Wood Properties of Lodgepole Pine

The quality of a timber and its end-use application is determined by the interaction and cumulative expression of individual wood properties. These properties can best be described when grouped into two separate categories that deal with the intrinsic wood properties and the performance of wood as a material.

A. *Intrinsic Wood Properties*

This category refers to those wood functions which have an influential role in the determination of the quality of wood and the likely level of its performance.

1. *Wood density* is a property generally associated with the mechanical strength properties of timber and paper pulp yield. Lodgepole pine has a somewhat different type of wood from that of Scots pine and Corsican pine, and could be placed between the soft pines, such as yellow pine (*Pinus strobus*) and the harder pines, including Scots pine (*Pinus sylvestris*). Wood density values varying from 415-372 kg/m^3 have been reported (Anon., 1955, 1960). The variation is due principally to provenance and growth conditions (Brazier, 1980). Density is an intrinsic wood property that can be genetically passed on. The variations that exist between provenances and between individual trees, can be exploited to the

benefit of crop and tree quality improvement through selective breeding programmes.

2. *Growth rate* is greatly influenced by growth conditions. In one of the consignment reports, carried out by Princes Risborough Laboratories, an average growth rate of 4·5 growth rings/2·5mm was found (Anon., 1960). Vigorous growth is generally evident during the first 10-15 years after which a tapering off occurs (Anon., 1967b).

3. *Fibre length* is important to the quality of paper products. It plays a significant role in the tearing strength of paper. Fibre length varied between provenances (Brazier, 1980; Henderson and Petty, 1972), between trees in a stand and within the tree (Taylor et al., 1982). Within the tree, the juvenile wood produces a shorter fibre than the adult wood. Similarly, in compression wood the fibre can be up to 30% shorter when compared with "non-compression wood" fibres in the same ring (Henderson and Petty, 1972).

Fibre length can also be promoted through selective breeding programmes. It is claimed to be the easiest intrinsic property to alter through tree breeding (Taylor et al., 1982). Lodgepole pine does produce a moderately long fibre suitable for paper making (Anon., 1967b). In a study by the Princes Risborough Laboratory on lodgepole pine, fibre length measurements were compared with Sitka spruce and Scots pine. Lodgepole pine had a fibre length of 2·4mm, while Scots pine fibres were 2·5mm and Sitka spruce 3·0mm (Anon., 1960, 1966).

4. *Compression wood* is one of two types of reaction wood formed by the tree, generally to counteract adverse effects of environmental factors to which the process of wood formation is subjected. The fibres in compression wood are shorter and have a greater cell wall thickness. Compression wood has an adverse effect on the quality of the timber, regardless of its end-use destination. In lodgepole pine the occurrence of compression wood is common. It is largely induced by the lean of the stem in the direction of the prevailing wind. In the Princes Risborough Laboratory study reaction wood was found both on the shortest and longest radii – this coincided with the south-west and north-east cardinal points respectively (Anon., 1966). The prevailing wind is from the south-west. The occurrence of compression wood often appears to be throughout the stem, distributed in a spiral fashion along it (Fitzsimons, 1982). There does not seem to be a specific association between the formation of compression wood

and provenance (Anon., 1967a; Brazier, 1980).

5. *Slope of Grain* in timber affects the stability of the material, especially during drying. In severe cases, degrading of the mechanical strength properties can result. In lodgepole pine slope of grain has been shown to be of minor importance and is unlikely to be associated with provenance selection (Anon., 1960, 1966, 1967a & b; Brazier, 1980). Inclined grain has been found in both the butt logs and nodal areas, and is due to basal sweep and the heavy branching habit respectively (Anon., 1960, 1967a).

6. *Heartwood and sapwood* are of interest, especially with regard to the lack of natural durability which is particularly evident in the sapwood area. Sapwood generally occupies the outer 13-15 annual rings – approximately 44-85% of the stem cross section, depending on the height of measurement along the stem. With an increase in height, the number of rings in sapwood is slightly less, but the proportion of sapwood area increases (Edwards, 1955; Brazier, 1980). This is less than in Scots pine, where up to 75-88% of a cross section can be sapwood (Anon., 1955, 1960; Brazier, 1980). Some variability appears to exist in sapwood width between provenances on any one site (Brazier, 1980). In contrast to species like Douglas fir, lodgepole pine does not show a great colour differentiation between heart and sapwood areas (Edwards, 1955).

B. *Properties Influencing Performanace and End-Use*

The interaction of the intrinsic wood properties affects the behaviour and performance of timber, which in turn strongly influences its end-use application.

1. *Drying:* Lodgepole pine behaves in a stable manner when air or kiln dried. Little splitting, checking or collapse develops. the distortions (spring, twist, bow and cup), that do occur, are generally of an insignificant nature. The loosening of dead knots, can pose a major problem (Anon., 1955, 1967a). Lodgepole pine has been dried under relatively severe conditions without any adverse degrade (Edwards, 1955; Anon., 1966; Brazier, 1980). A drying schedule with a temperature of 82°C and 12% humidity has been successfully used. Recent drying experiment showed however that both the sawing pattern and the size of the timber section played a significant role. Boxed heart sections of 75×115mm, used in joinery manufacture, were more liable to split than smaller section sizes. It appears that adult wood was more stable than juvenile wood (Anon., 1967b). A variation in stability is found to occur between provenances. Inland provenance generally performs better (Brazier, 1980).

2. *Strength:* The physical and mechanical strength properties of lodgepole pine were found to lie between that of spruce and Scots pine (Gallagher, 1979), although the strength properties of Irish grown lodgepole pine were somewhat better than those of Irish grown spruce (Dunleavy, 1969; Anon., 1970). Grading studies carried out by Knaggs (1978) and Phillips (1979, 1980) have shown that a major factor causing degrade in Irish grown lodgepole pine is the presence of knots. These were the result of heavy branching, especially in the South Coastal provenance.

3. *Durability:* Lodgepole pine is a non-durable wood species. When the exposed sapwood area of a log or sawn timber is not dried rapidly it is very susceptible to blue-stain infection. The effect of the blue-stain infection is purely of an aesthetic nature and does not affect the strength properties of the timber. Infected timber has however, had a tendency to absorb a greater amount of preservative. The commercial implication of blue-stained timber is generally a down grading of the quality and the sales price of the material. Heartwood is the more naturally durable section, but it is less permeable to preservatives than the sapwood. In the heartwood, the aspiration of border pits prevents the diffusion of preservative throughout the section.

In preservation experiments, lodgepole pine has been pressure treated with creosote. The sapwood was found to be readily permeable, while the heartwood showed only minimal absorption (Anon., 1966, 1967b). The Electricity Supply Board carried out treatment trials of lodgepole pine transmission poles and found that the uptake of creosote by this species was greater than in other species more commonly used for transmission poles. Consequently, this would render the use of lodgepole pine in transmission lines too expensive (O'Kelly, 1952). Copper/Chrome/Arsenic and organic solvent preservatives have also been successfully used on sawn lodgepole pine timber (Gallagher, 1979).

4. *Machining Properties:* Lodgepole pine machines very easily and gives a good surface finish upon planing (Edwards, 1955; Anon., 1966, 1967b). It stands up well to mortising and profile cutting (Gallagher, 1976). Lodgepole pine has a gradual transition from earlywood to latewood, giving it a very uniform texture and colour (Brazier, 1985). The timber causes only slight dulling effect when machined (Anon., 1955). Good machinability and uniform texture are primary requirements for successful usage in joinery manufacture.

Availability of Lodgepole Pine

In the assessment of the potential end-use of fast grown lodgepole pine in Ireland, the log availability and quality will greatly influence the demand on this species by the various end-use markets. In this section the availability of lodgepole pine in the period 1988-1997 will be summarised. Four categories of timber material can be distinguished.

1. Large sawlog, with a top diameter greater than 20cm.
2. Small sawlog, logs with a top diameter between 14 and 20cm.
3. Pulpwood size logs, with a top diameter between 7 and 14cm.
4. Forest and sawmill residue.

With the increasing volume of mature lodgepole pine coming to hand, the availability of the first three categories, as projected by the Forest Service, will be discussed (L. P. O'Flanagan, pers. comm.).

The total production of lodgepole pine is made up of three provenances, South Coastal, Lulu and Inland. These provenances make up 72%, 19% and 9% respectively of the total volume produced (Evertsen, 1986). In the decade leading up to the year 2000, lodgepole pine will produce a volume of 350,000m^3. The mean annual availability during 1988-1992 will be 290,000m^3, while 412,000m^3/annum will be available during the following five year period (Table 1). The total volume produced will be forthcoming from both clearfellings (45%) and thinnings (55%). Between these two harvesting categories, large sawlog, small sawlog and pulpwood will be produced (Figure 1).

Table 1: Total volume (000m^3) of lodgepole pine roundwood available during 1988-1997. (L. P. O'Flanagan, Forest Service).

	Pulpwood	**Small Sawlog**	**Large Sawlog**	**Total**
1988-92	1075	250	125	1450
1993-97	1515	360	175	2060
TOTALS	2590	610	300	3510

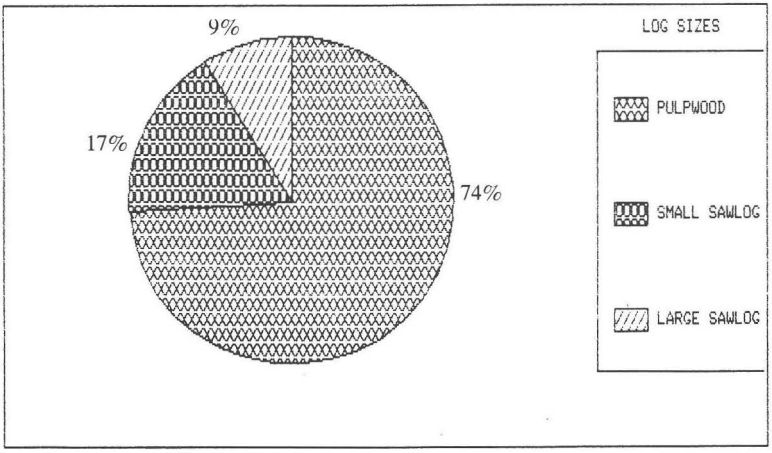

Figure 1 The availability (%) of lodgepole pine log sizes during 1988-97 (all provenances). (Forest Service)

Considering the problems with stem form and subsequent optimal primary processing in the sawmill, the actual volume of pulpwood will most certainly be increased by the sawmill generated residues. Fitzsimons (1982) estimated a conversion rate of 32%, while Atanackovic and Evertsen (unpublished date) determined recently a conversion rate of 38% for home-grown lodgepole pine. Assuming a mean conversion rate of 35%, then 590,000m^3 of sawlog residue will be produced during the next decade in the form of butt-ends, slabs and sawdust. With pulpwood, this would produce approximately 3,180,000m^3, 91% of timber volume harvested, for the timber reconstitution industry.

Potential End-Use Markets for Lodgepole Pine

In North America lodgepole pine has been used over the years for a diverse range of products. It was lodgepole pine that provided the sleepers for the "GRAND TRUNK PACIFIC RAILWAY" through the Prince George region in Canada during 1913-1914. Lodgepole pine was used in a great diversity of both

high and low end-value products. These ranged from telephone and transmission poles to pit-props, piling, fencing and packaging. In Alberta it is used as one of the major construction, carpentry and joinery timbers (O'Kelly, 1952; Anon., 1955; Edwards, 1955). During the last number of years, the Canadian producer BALFOUR initiated an export campaign, promoting the use of Canadian grown lodge pole pine as a joinery material in the United Kingdom (Kloos, 1986).

Lodgepole pine has also been successfully used in the manufacture of reconstituted timber products. Ramaker et al. (1976) have successfully used lodgepole pine in the manufacture of flakeboard, while Taylor et al. (1982) successfully veneered lodgepole pine for the production of structural plywood. Lodgepole pine has also been used for high grade paper pulp suitable for newsprint, wrapping paper and high-grade printing paper (Edwards, 1955).

To optimise the return on lodgepole pine grown in Ireland, import substitution would be the obvious objective. In order to do this effectively, "product groupings" with the most rewarding returns should be identified and evaluated.

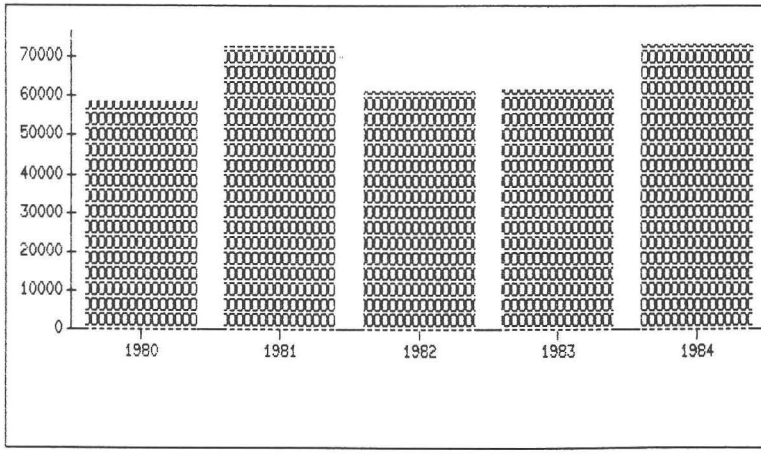

Figure 2 Annual import values (£000) of softwood products and sawn timber during 1980-84. (Central Statistics Office)

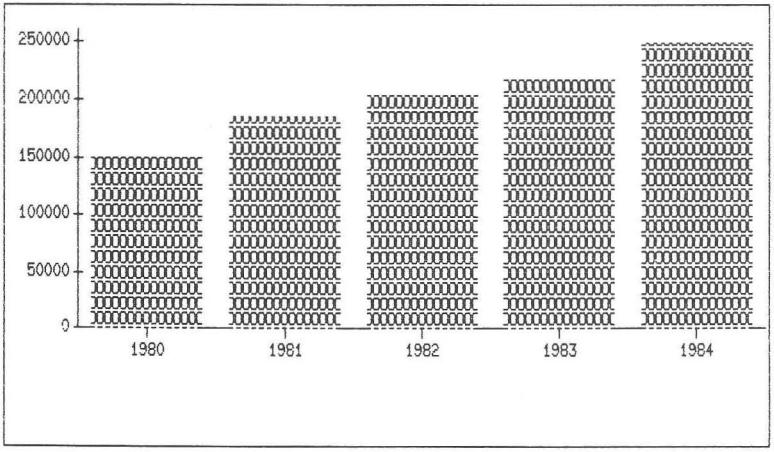

Figure 3 Annual import values (£000) of paper and paper products during 1980-84. (Central Statistics Office)

1. *Sawn timber and reconstituted timber products.* The information on softwood imports from the Central Statistics Office (CSO) records can basically be divided into ten product groupings. Since no distinction is made between softwood species in the import records of the CSO, the relevance and value of potential import substitution by lodgepole pine can be assessed by first examining those product groupings which have a significant monetary value. In addition, the suitability of lodgepole pine for the products in these product groupings needs to be evaluated.

The import of softwood and softwood products has maintained a steady trend over the five year period between 1980 and 1984. The annual import bill fluctuated between £58,000,000 and £71,000,000 (Figure 2).

Three product groupings in particular had a significant impact on the cost of imports. The import cost relevant to these three product groupings accounted for 92% of the total softwood import

bill for the 1980-1984 period. Individually, the product groupings of sawn timber, reconstituted wood and builder's carpentry and joinery, accounted for 61%, 19% and 12% of the imports respectively. During the 1980-84 period this amounted to an average of £64,000,000 a year.

2. *Paper and paper products.* Lodgepole pine, as a species, is considered to be suitable for paper manufacturing. The paper and paper products available on the market greatly vary in their requirements for specific wood properties. These requirements are generally met by a combination of a specific pulping process and a specific timber species or mixture of species. At present Ireland does not have a paper pulp manufacturing industry. Hence, paper pulp and a substantial amount of paper and paper products have to be imported. During the period 1980-1984, the annual paper import bill to Ireland nearly doubled, from £149,000,000 to £250,000,000 and this pattern is continuing (Figure 3). The category of paper and paper products imports is very diverse. Principally, three product groupings are of significance and account for 93% of paper and paper products imports:

(i) packaging and packaging related materials.

(ii) newsprint and writing paper.

(iii) tissue types of paper.

On average these groupings accounted for 54%, 27% and 12% respectively, of the annual import bill over the period 1980-1984. In monetary terms packaging and packaging related materials amounted to an annual average value of £107,000,000. Printing, newsprint and writing papers were valued at an annual average of £54,000,000, while tissue types of paper accounted for an annual average of £24,000,000 over the same period. The general trend in all cases showed a continual annual increase during the 1980-84 period.

Lodgepole Pine in the Present Irish Wood Processing Industry

Both the sawmilling and manufacturing industries were surveyed and questionnaires were specifically formatted for both sections of the industry. A total of 130 survey circulars were distributed. The selection of the companies that were circulated with the questionnaire was made by the following method:

(a) sawmills known to have a minimum output of 1000m^3 per annum were included – this amounted to a total of 37 sawmills,

(b) in the case of the manufacturing industry, two groups of manufacturers were distinguished, the joinery and the furniture manufacturers. The number of joinery companies was quite large. A selection was made by selecting those manufacturers who contribute most significantly to the joinery market. A total of 56 joinery manufacturers were circulated. The furniture manufacturers were selected form the "Directory of Irish Furniture and Floor Coverings Manufacturers" (Irish Goods Council). Manufacturers that used pine were included. A total of 37 furniture manufacturers were circulated.

Even though not all companies that made returns used home grown lodgepole pine they did contribute to the survey by submitting their experiences. The sawmilling industry responded with a 35% return rate (13 out of 37 questionnaires).

Of the sawmills that responded 62% were using lodgepole pine. The majority of those mills did not process more than 500m^3 of lodgepole pine per year. Only 15% of the mills processed in excess of 5000m^3. Their product outlet was mainly pallet production. The majority of mills would not process more lodgepole pine, primarily because there was no specific demand for it (23% of the sawmill which did handle less than 500m^3 of lodgepole pine per year, did not find that they obtained a profitable return from it).

Claims of conversion rates varied from between 60% to 38%. A sawmill claiming a 60% recovery rate defined half of its product range as furniture. Sawmills that claimed a lower conversion rate were geared to the pallet and the fencing markets. Apart from the Dundrum sawmill (Forest Service), no other sawmill appeared to produce lodgepole pine for use in joinery manufacture.

Of the mills surveyed 88% did not experience any great difficulty in obtaining lodgepole pine, although it was obtained mostly as a minor species in mixed lots. That it was obtained in mixed lots and that the log quality of lodgepole pine was perceived as poor, may have influenced the opinion of the trade that lodgepole pine was over-priced. In addition, there was no demand for greater quantities of lodgepole pine, especially with poor stem form. The trade, however, did not eliminate the possibility of the use of lodgepole pine in the future. This attitude should make the acceptance of more straight stemmed material easier.

There was a divided opinion on the occurrence of knots; 44% considered knots to be frequent while a further 44% considered the knot occurence to be excessive. The latter group produced

solely for the pallet market, while the former group produced for both the pallet and furniture markets. (56% found the knots in sawn timber to be in the range of 20-40mm in diameter).

Blue-stain: The majority of sawmills found blue-staining of the timber a severe problem. The food industry does not accept pallets which contain blue-stained timber. In the furniture industry, the staining renders the material unacceptable. The blue-stain causing fungi thrive especially on freshly cut surfaces. Hence the time lapse between felling, conversion and drying is critical. 78% of the sawmills claimed to receive their logs within two weeks after felling and 44% converted the logs within one week of reception at the mill. Conversion was achieved by all mills within four weeks after reception at the mill.

In the survey 67% of the mills found that blue-stain occurred in the majority of their logs before conversion. When no blue-stain was present at the time of conversion, blue-stain developed on the sawn timber before drying. Subsequent to sawing, the timber was generally stickered for kiln drying and left uncovered. The majority of sawmills kiln-dried their sawn timber, commencing within seven days after log conversion.

The overall sawmillers' opinion of lodgepole pine was that it was a poor quality raw material that had a bad stem form and was knotty. There was great variation in log quality, especially between stands and between forests. However, selected logs were highly praised.

The manufacturing industry: This industry (furniture manufacturers; joinery manufacturers) responded by returning 14 out of 92 questionnaires – a 15% return rate. Of the eight survey returns made by the furniture industries, only two companies stated that they had used lodgepole pine. Two major reasons appeared to be central to the very limited usage of lodgepole pine in the furniture manufacturing industry:

1. The industry did not know the properties of this timber, and
2. Twenty five percent stated that they did not know where the material could be bought.

One of the two companies that did use lodgepole pine ceased using this species on the basis of their experience with one experimental batch. In their experience the main disadvantages were blue-stain in 30% of their stock upon kiln drying and "moisture pockets" along the timber length which caused the moisture content to vary between 10 and 20%. In spite of these

problems this manufacturer still has an open mind about the use of lodgepole pine in furniture manufacture.

The second company produces 1500 furniture units ($40m^3$) per year and used lodgepole pine exclusively. They considered however that the quality of the material available was poor and thought that a quality grading system was needed, especially if this pine was to be extended into more upmarket products. They also felt that the supply of timber was very limited and erratic. The company purchased their timber kiln dried, but found that the timber was affected by excessive shrinkage, twist, and loosened knots upon kiln drying. Blue-stain occurred in approximately 10% of the stock. Whenever blue-stain did occur it was severe and rendered the material unsuitable for the intended end-use. Lodgepole pine machined easily and gave a smooth surface finish, better than that of Scots pine. Lodgepole pine was also considered to be easy wearing on machining tools and compared favourably with Scots pine. No glueing or nail and/or screw holding problems had been experienced. The surface-coating finishes such as sealer, stain and clear finish did not pose any problems.

None of the six joinery companies that returned the questionnaire used home grown lodgepole pine in the manufacture of joinery. The primary reasons were that they did know the properties of the timber and they did not know where the material could be bought.

Discussion

At present lodgepole pine comprises 21% of the total afforestation in Ireland. During the next decade, large volumes will be brought onto the timber processing and manufacturing markets for the first time. In contrast to North America, lodgepole pine grows at a much faster rate in Ireland. In anticipation of the maturing and coming on stream of this species, options for optimal end-use utilisation should now be examined.

End-use application and choice of timber products is strongly influenced by log quality and timber properties. Concise silvicultural management of lodgepole pine is crucial to the improvement of log quality. Basal sweep and heavy branching are the principal factors that affect log quality. These factors appear to be peculiar to the South Coastal provenance, which was selected over the Inland and Lulu provenances for its greater volume production. Planting techniques and green pruning are the key management practices to achieve the log quality improvements required. Fitzsimons (Forest Service) has found that intensive

management can be applied up to the age of 13. Beyond this age, crop stability can be impaired.

The potential range of end products for lodgepole pine is substantial. The primary objective in utilising this species is as a substitute for costly paper and timber imported products. From the literature it is evident that lodgepole pine can be used in both low and high end-value products.

Sawlog: Large sawlog will comprise 9% of the total volume of lodgepole pine available during the next decade. Due to bad stem form a mean log conversion rate of 35% could be expected. This would produce 105,000m^3 of sawn timber over the decade, enough to provide for ± 15% of the needs of the joinery industry. (Imported Red Deal for the joinery market is valued at approximately £270/m^3 of rough sawn timber).

The volume of pulpwood that will become available is forecast at 259,000,000m^3 during the next decade. In addition to this, 65% of sawlog will be sawmill residue in the form of crooked butt ends, slabs, bark and sawdust. Of this volume 13% can be accounted for as bark and 5% as sawdust. Hence an additional 485,000m^3 can be added to the pulpwood category, which will comprise 91% of the total volume of lodgepole pine to be harvested during the decade.

Potential end-uses for pulpwood material is in reconstituted products, such as paper pulp, various types of reconstituted boards and various types of laminated timber products. All of these could be classified as high end-value added products. Paper and paper products imports into Ireland amounted to an average of £200,000,000/annum during 1980-84. If the expected volume of pulpwood becoming available during the next decade were to be processed to paper pulp, at a pulp yield of 45% and a wood density of 450 kg/m^3-550,000 tons of paper pulp could be produced, at a market value of £250/ton, this would value at approximately £140,000,000.

In the case of reconstituted timber products, medium density fibre boards and laminated products would belong in a similar high end-value product range. In addition to substituting imported products the manufacture of paper pulp and laminated products in particular will also initiate the establishment of new industries in Ireland.

The present timber processing and manufacturing industries do not appear to optimise the potential utilisation of lodgepole pine. The primary outlet for the sawmilling industry using this pine appears to be pallet wood: it is used in very limited quantities in the manufacturing industry. This situation is largely

due to this pine being seen as of inferior quality and also due to a lack in awareness of its existence and of its potential.

These attitudes can be changed through educational and promotional programmes. Inferior quality of the sawn timber is largely due to blue-stain and knots. The former can be effectively solved through sawn timber production management by the introduction of a chemical treatment after sawing. When knots are not desirable finger-jointing can be used to produce knot-free material. The introduction of these non-traditional practices, should be carried out in conjunction with an appropriate product marketing initiative. The creation of awareness and introduction of new manufacturing technology will be vital in the continuing development of the processing and manufacturing timber industry.

In anticipation of optimising the utilisation of fast grown lodgepole pine a lodgepole pine TASKFORCE was set up in 1986. Input to the TASKFORCE is at present concerned with the sawn timber potential of the pine, particularly in the joinery industry. Although pulpwood material will comprise 91% of the total lodgepole pine volume available during the next decade, the processing of pulpwood would require the initiation of new industry. Rationalising available volumes of sawlog has an immediate input into existing industries and also contributes directly to import substitution.

Conclusion

The potential of fast-grown lodgepole pine in Ireland is very encouraging. However, to optimise this potential, an intensive programme of education, and of the development of the growing, processing and manufacturing industry is required. The major volume influx of available lodgepole pine will commence by the early to mid-1990s. The preparation of industry in order to absorb this potentially high end-value timber will be of great importance if we are to optimise a heretofore considered inferior raw material. Using a TASKFORCE format, developments in the growing, processing and manufacturing industries should be promoted by:

1. intensification of silvicultural management practices through breeding programmes, selective thinning / respacing and green pruning:

2. identification and examination of potentially high end-value product areas;

3. encouraging the introduction and development of new products and associated technologies in the existing industries;

4. identification of new industries, in particular those directed at import substitution; and

5. developing the potential and marketing of lodgepole pine both as a raw material and as a finished product.

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REFERENCES

ANON. 1955. Properties of thinnings home-grown lodgepole pine (*Pinus contorta*). Progress report I – Consignment No. 821. Department of Scientific and Industrial Research, Forest Products Laboratory. Princes Risborough.

ANON. 1960. Properties of thinnings home-grown lodgepole pine (*Pinus contorta*). Progress report II – Consignment No. 1027. Departemnt of Scientific and Industrial Research, Forest Products Laboratory. Princes Risborough.

ANON. 1966. Properties of thinnings of home-grown lodgepole pine (*Pinus contorta*). Progress report No. III. H.G.T.R. Committee Paper No. 142.

ANON. 1967a. Report on the properties of lodgepole pine timber from nine seed provenances. H.G.T.R. Committee Paper No. 85.

ANON. 1967b. Properties of thinnings of home-grown lodgepole pine (*Pinus contorta*). Progress report No IV. H.G.T.R. Committee Paper No. 145.

ANON.1970. The properties of Irish-grown contorta pine. Report No. 2. Forest Products Department, Institute for Industrial Research and Standards, Dublin, Ireland.

ANON. 1985. Review Group on Forestry. Report to the Minister for Fisheries and Forestry. Government Publications Sale Office, Dublin 2, Ireland.

BRAZIER, J. D. 1980. *Pinus contorta* as an exotic species. Proceedings of the IUFRO working party meeting 1980 on *Pinus contorta* provenances (S2-02-06) in Norway and Sweden. Research note No. 30. Swedish University of Agricultural Sciences, Department of Forest Genetics. Garpenberg, Sweden.

BRAZIER, J. D. 1985. Coniferous woods. Proceedings of Inst. of Char. For. "Growing timber for the Market", pp 50-58.

DIRECTORY OF IRISH FURNITURE AND FLOOR COVERINGS MANUFACTURERS. Published by the Irish Goods Council. Merrion Hall, Strand Road, Dublin 4, Ireland.

DHUBHAIN, A., J. A. EVERTSEN and J. J. GARDINER. 1987. The Influence of Compression wood on the the Strength Properties of Sitka spruce. (In press).

DUNLEAVY, J. A., L. U. GALLAGHER and D. T. FLOOD. 1969. The properties of Irish-grown contorta pine (*Pinus contorta* Dougl.). Report No. 1. Forest Products Department, Institute for Industrial Research and Standards, Dublin, Ireland.

EDWARDS, M. V. 1954. A summary of information on *Pinus contorta* with special reference to its use in Europe. Part I. For. Abstr. 15(4):389-396.
EDWARDS, M. V. 1955. A summary of information on *Pinus contorta* with special reference to its use in Europe. Part II. For. Abstr. 16(1):3-13.
EVERTSEN, J. A. 1986. The potential of home-grown lodgepole pine. Research Report. Forest Products department, Institute for Industrial Research and Standards, Dublin 9, Ireland.
FITZSOMONS, B. 1982. An investigation of the effects of poor stem form and sawmill recovery on coastal lodgepole pine. Irish Forestry 39(1):30-37.
GALLAGHER, L. U. 1979. The properties of Irish-grown lodgepole pine. Internal report. Forest Products department, Institute for Industrial Research and Standards, Dublin, Ireland.
HENDERSON, J. and J. A. PETTY. 1972. A comparison of wood properties of coastal and interior provenances of lodgepole pine *Pinus contorta* Dougl. ex. Loud. Forestry 45(1):49-57.
HENDRICK, E., N. O'CARROLL and A. R. PFEIFER. 1984. Effect of ploughing direction and method on the stem form of South Coastal lodgepole pine. Irish Forestry 41(2):66-77.
KLOOS, J. 1986. Balfour separate the joinery wood from the trees. Timber Trades Journal 336(5695):19-20.
KNAGGS, G. 1978. Visual stress grading of Sitka spruce and lodgepole pine. Research note. Forest Products Department, Institute for Industrial Research and Standards, Dublin, Ireland.
LINES, R. 1957. *Pinus contorta* in Ireland, 1955. Forestry 30(2):139-150.
LINES, R. 1966. Choosing the right provenance of lodgepole pine. Scottish Forestry 20:90-103.
MACDONALD, J. A. B. 1954. The place of *Pinus contorta* in British sulviculture. Forestry 27:25-30.
O'DRISCOLL, J. 1980. The importance of lodgepole pine in Irish forestry. Irish Forestry 37(1):7-22.
O'hEIGEARTAIGH, M., J. A. EVERTSEN and E. STEPHEN. 1985. Estimating knot volumes in wood. Operation Research and Management Science Society of Ireland Annual Conference. Dublin, Ireland.
O'KELLY, P. F. 1952. *Pinus contorta* as a forest tree in Ireland. Irish Forestry 9(1):28-33.
PHILLIPS, H. 1979. Wood quality/Grading study. Proceeding 13th Forestry Student Symposium. University College Dublin, Ireland.
PHILLIPS, H. 1980. Tree form/Wood quality/Grading study. Forest and Wildlife Service, Internal report.
PURCELL, T. J. 1982. The availability of Irish timber. Conference Proceedings "Opportunities for Irish Timber". Forest Products Department, Institute for Industrial Research and Standards, Dublin, Ireland.
RAMAKER, T. J. and W. F. LEHMANN. 1976. High-performance structural flakeboards from Douglas fir and lodgepole pine forest residues. USDA Forest Research Paper FPL 286. Forest Products Laboratory, Madison, Wisconsin, U.S.A.
TAYLOR, F. W., E.I.C. WANG and M. N. MICKO. 1982. Differences in the wood of lodgepole pine in Alberta. Wood and Fiber 14(4):296-309.