THE CENTRE FOR TIMBER ENGINEERING

Scots Pine Timber Quality in North Scotland

Task 4. Market Development Study Part 4.2. Final Report

22 May 2008

Ivor Davies
Centre for Timber Engineering (CTE)
Napier University
Edinburgh
Scotland

Forestry Commission Scotland

HIE Highlands and Islands Enterprise Iomairt na Gaidhealtachd 's nan Eilean

Scottish Enterprise

Forest Research

Contents

Acknowledgements

CTE wishes to thank the project funders, Forestry Commission Scotland, Scottish Enterprise and Highlands & Islands Enterprise; the contract managers, John Risby and Elspeth Macdonald; the members of the project steering group; and the many individuals and businesses consulted during the research.

Summary

This study is one of the outputs of a partnership project to develop the economic potential of Scots pine in north Scotland. The client for this study is Forestry Commission Scotland, the project manager is Forest Research.

This report reviews the value added and local processing potential of Scots pine timber from northern Scotland. The market potential of a number of products are discussed and relevant development actions are identified.

Scots pine timber is prone to bluestain and contains frequent dead knots. If these characteristics are present the value added potential of the timber is limited. Control of bluestain and grading to select out dead knots are thus important wherever value addition is proposed.

Five products are identified as having particular potential. These are: playground equipment, stress laminated bridges, massive timber construction, external cladding, and wood modification. Other products such as post and beam construction have potential only if bluestain is controlled. Market development measures are identified for the five products.

1. Background to and scope of this study

This market study by Napier University's Centre for Timber Engineering (CTE) is the final output under Task 4 of a partnership-funded project titled *Scots Pine Timber Quality in North Scotland*. The client is Forestry Commission Scotland, the project manager is Forest Research. The objectives of Task 4 are to:

1. Examine and quantify existing and potential markets for Scots pine from North Scotland, focusing on higher value end-uses and opportunities for local processing

2. Identify a suite of possible actions which could be undertaken to further develop these markets, including options for different scales of operation, levels of investment and timescale

3. Consult Steering Group members and other key stakeholder regarding which of the proposed actions should be implemented and report on the consensus view, along with any particularly strong minority views

4. Produce a scoping report and a strategy for market development

This study follows the timber nomenclature in BS 7359 [1]. Where Scots pine as a species is being discussed this is indicated using the scientific name *Pinus sylvestris* or *P. sylvestris.* The term Scots pine itself is used to refer to UK grown timber while the term redwood refers to timber of the same species that is imported into the UK.

2. Method

At the start of this project a meeting was arranged with Elspeth Macdonald and Barry Gardiner, both as representatives of the project steering group and as the authors of the Task 1 report. This meeting and the subsequent phone conversations clarified the methods to be employed in this project and the associated timetable.

CTE holds a large resource of information on the markets for and uses of UK timber. Consequently, this study was based on a combination of desk research (using both material already held by CTE and reviews of other information) plus interviews with Scottish sawmillers and other stakeholders. The scoping study was circulated to the steering group for comment.

This final report incorporates the suggestions of the steering committee along with other comments received from timber processors and specifiers. The area covered by this study is broadly the Forestry Commission's Highland and Grampian conservancies.

3. Resource

The Task 1 report [2] has a number of findings relevant to the objectives of this study:

- There is in the order of 108,000 Ha of Scots pine in North Scotland; of which a third is owned by the Forestry Commission and the remainder by the private sector (including not-for-profit owners of various kinds).

- The average rotation length is 62 years.

- Felling and harvesting takes place throughout the year.

- Over half of the timber is sold as small roundwood to the panel product mills. Of the remainder, most is sold as fencing with only 6% of the total cut being made into other sawn timber products such as pallets, sleepers, or decking.

- The area of Scots pine forest under continuous cover forestry (CCF) is predicted to grow which, though it will result in an overall reduction in timber production, will tend to increase the amount of large diameter sawlogs being harvested.

- From the grower's perspective there is little demand for better quality logs and no price premium. Sawmillers refute this.

Based on the above, it appears likely that there are continuity of supply constraints affecting the availability of good quality logs. Moreover, anecdotal evidence suggests that the cost of selecting good quality logs is often prohibitive.

4. Timber properties of Scots pine

4.1. Main published information

The main timber properties of *Pinus sylvestris* are described in Table 1

Table 1: Main timber properties of *P. sylvestris* [3] [4] [5]

Sapwood	Width of 50-100 mm in homegrown timber and considerably less in imported pine particularly if slow grown.
Density	The density (kg/m^3) at 12% moisture content ranges from 500 to 540. The mean is 520. Unseasoned timber is about 800.
Seasoning	Rapid and well. The timber should be loaded into the kiln as quickly as possible due to the risk of bluestain. In the Handbook of Softwoods, kiln schedule M is recommended, or schedule F if colour is important. These may need to be modified by local experience.
Shrinkage	4.5% tangential shrinkage from green to 12% moisture content. The corresponding radial shrinkage is 3%. The movement class is medium.
Mechanical	Compared to imported redwood, home grown timber has slightly higher bending strength (MOR), side grain hardness and toughness. At a moisture content of 12%, Scots pine has an MOR of 89 N/mm^2 compared to 83 N/mm^2 for redwood. Similarly it is, is about 20% harder on the side grain and 15 to 30% more difficult to split.
Strength grades	The species can be machine graded C14 up to C27 depending upon defects such as knots or sloping grain. In Scots pine the GS visual grade corresponds to C14 while the SS grade is equivalent to C22.
Insect attack	The sapwood is susceptible to attack by the common furniture beetle
Fungal decay	The heartwood has variable natural durability ranging from class 3 (moderately durable) to class 4 (slightly durable). Like all timbers the sapwood is class 5 (not durable)
Treatability	Heartwood is either difficult or very difficult to treat with preservatives. The sapwood is easy to treat
Machining	Dependant upon growth rate. The fast growth rate of homegrown Scots pine means that the earlywood bands are wider than imported timber and thus have more tendency to tear. Homegrown timber generally works well though knots can loosen when dry; cutters need to be sharp to accommodate this. Nailing is generally good
Coating	Takes most coatings well though a stopper may be needed when light coloured water based coatings are used externally.
Gluing	Generally satisfactorily though resinous timber can cause problems.
General	Slower grown timber is preferred for joinery whereas fast grown timber is suitable for carcasing. Growth rate slows with age and the narrow ringed wood found in large trees is often of excellent quality, unless spiral grown.

4.2. Technical challenges affecting Scots pine

While Table 1 gives the main timber properties listed in the literature, these do not bring out the real challenges that face anyone seeking to add value to Scots pine timber. There are two main problems: bluestain and dead knots.

4.2.1. Bluestain

When felled, the sapwood of *P. sylvestris* is prone to a blue/black discoloration caused by stain fungi (Fig 1). Known as bluestain or sap stain, it normally occurs in irregular patches and is due to the coloured hyphae of various stain fungi species. The staining can occur quite quickly in warm weather, though other environmental factors are also relevant.

Fig 1. Bluestain on a recently felled Scots pine log

Once it is present in the timber, bluestain cannot be removed without causing further damage [6]. Bluestained timber loses much of its market value. This is due to its appearance and also to reductions in its toughness which make it unsuited to products subjected to mechanical stress. Coating properties are also changed in exterior use [7]. Consequently bluestain is a significant challenge facing Scottish timber processors seeking to use Scots pine for value added applications. The timber needs to be damp for an attack to start, though dry wood can be attacked if it is rewetted [6]. Bluestain can be prevented from occurring using several measures [7]:

- Winter felling and extraction from the forest
- In warm conditions moving the timber out of the forest without delay
- Sawing and drying the timber without delay
- Spraying the timber with water or ponding (to limit oxygen availability)
- Dip coating the timber with anti-sapstain fungicides

Anti-sapstain treatments are the most common control measure in the UK. However, some of these chemicals may come under pressure as ever tighter limits are set on the emissions from building products. Pentachlorophenol (PCP) is already being heavily regulated and wood product manufacturers are required to declare if their products have PCP emissions over 5×10^{-6} [8].

4.2.2. Dead knots

All knots weaken timber, mainly due to grain distortion around the knot, but dead knots (also known as non-intergrown or bark-ringed knots) have a tendency to loosen; this causes particular problems. Dead knots with a diameter over approximately 10 mm are the most problematic; small dead knots are normally acceptable.

Loose knots can dislodge when machining the timber making it unsuitable for most joinery uses. Even when these knots do not fall out, they are unsightly and so the value of the timber is reduced. Anecdotal experience at sawmills suggests that less than 10% of 'green' grade sawlogs are free of large dead knots. Dead knots are not usually visible on the surface of a log and there is no commercial method of selecting out logs with dead knots at present.

A review of the potential for growing quality Scots pine timber [9] identified several silvicultural techniques that affect knot characteristics, of which the most important was high initial stocking. The wide spacing in many Scots pine stands is unlikely to produce timber free of dead knots.

Dead knots are common in the early years of growth while old trees will tend to have an outer zone of timber which is largely knot free. A grading trial of such timber at Balmoral Estate [10] showed encouraging results. Unfortunately there is little commercial incentive for growers to produce large logs at present although the move towards CCF may favour older trees [2]. Wherever large dead knots occur in a piece of timber the wood processor can either reject the piece or attempt to remove or hide the defect. There are three options.

- Plug cutting – machining out the knot and filling the hole with a circular or elliptical plug of timber
- Defect cutting – cross cutting the board either side of the knot and gluing together the cut ends using a finger joint
- Veneering – gluing on a surface layer of high quality timber

4.3. Other wood processing issues

While bluestain and dead knots are the main technical challenges facing anyone seeking to add value to Scots pine, there are a few other issues that are relevant in some cases. These are natural durability, appearance grading, sand blasting characteristics, and the reaction to fire class.

4.3.1. Natural durability

As already outlined *P. sylvestris* has variable natural durability. All the sapwood is classed as being not durable while the durability of the heartwood varies, mainly according to its position in the tree bole. In most timber species, the wood from the centre of the tree around the pith has inferior mechanical, durability, and stability properties to the outer mature heartwood. This inferior timber is termed juvenile wood. The diameter of this zone varies with species – in some such as western red cedar the zone is narrow, corresponding to the first 5 growth rings; in most softwood species the juvenile wood is assumed to extend to around 10 to 15 growth rings; while in a few species, such as *P. sylvestris* this zone extends to around 20 rings [7]. This is mainly why the heartwood of *P.sylvestris* is classed in EN 350-2 [4] as having variable natural durability. The outer heartwood might be class 3 (moderately durable) but the zone of juvenile wood is generally only class 4 (slightly durable).This means that, at UK forestry rotations of around 60 years, the majority of the heartwood will be made up of juvenile heartwood. While this does not matter for many purposes, where the timber is being used for its natural durability or stability there is no substitute for the mature heartwood found in old trees [7] [11].

In Norway there is a tradition where living *P. sylvestrus* trees were stressed some years before felling to improve the decay resistance of the sapwood when subsequently felled. Two techniques were employed, crown removal and wounding of the bole. Crown removal involved cutting away virtually all of the crown - this had the effect of converting much of the sapwood zone of the tree into heartwood. Wounding involved damaging the cambium and sapwood by partial bark removal and by boring or cutting into the timber, this caused a reaction where sapwood in the affected areas filled with wound resin. It is believed that such techniques allowed sapwood to be used externally in out of ground contact conditions. If so this may be one of the factors explaining why log buildings in Norway were sometimes constructed without the sapwood being first removed from the logs. In the past twenty years these techniques have been revived on a small scale experimental basis in Norway although the results thus far have been inconclusive. Initially it was believed the trees needed to be stressed between 5 and 10 years before felling, but this proved ineffective and so longer periods are now being investigated [12].

Similar techniques may be evident in the few remaining Scots pine trees in the Highlands that were exploited for ‘fir candles’. The practices are described in Grant (1995) [13] and a few modified trees can still be seen in Guisachan native pine wood near Cannich.

4.3.2 Appearance grading

Joinery timber has its own grades which are distinct from those used in structural grading; they are termed appearance grades or joinery grades. Although a European Standard is published giving appearance grades for all European softwoods [14] this is rarely used for imported redwood. Instead most Scandinavian sawmills continue to use the grades in the so called ‘Blue

Book' [15]. Grades A1 to A4 are usually combined into an 'unsorted grade' while the more knotty timber is sold separately as grades B and C and D. In the UK joinery timber is usually specified using British Standard BS 1186-3 [16]. In this norm, Class 2 is equivalent to the Blue Book's unsorted grade while class 3 broadly corresponds to Grade B. Similar joinery grades are given in European Standard EN 942 [17]. Virtually no UK softwood is appearance graded at present.

4.3.3 Sand blasting

Experience in Scotland suggests that Scots pine gives poor results when used for sand blasting. The timber tends to have a 'hairy' appearance with loose fibres which are costly to remove. Thus, while Scots pine is occasionally used for sand blasted signs, western red cedar or green (unseasoned) European oak are preferred due to their crisper finish.

4.3.4 Reaction to fire (spread of flame characteristics)

Building Regulations sometimes require that timber for internal panelling or external cladding is treated to achieve specific reaction to fire characteristics. The reaction to fire class of timber is density dependant with low density species supporting faster spread of flame than timber over 400 kg/m^3. Untreated, the reaction to fire class of *P. sylvestris* is class 3 to BS 476-7 [18] or Euroclass D s1-d2 to EN 13832 [19].

The reaction to fire class of timber can be reduced using a flame retardant. The sapwood of *P. sylvestris* has good treatability characteristics and so can achieve class 0 (Euroclass B s1-d2) reaction to fire when pressure impregnated with a type LR (leach resistant) fire retardant [20]. A number of flame retardant surface coatings are also suitable for use with *P. sylvestris* though only one of these is leach resistant and thus suited to external use.

4.4. Processing options

Given that most Scots pine logs contain dead knots and some may also be blue stained, manufacturers of value added timber products are understandably reluctant to risk buying Scots pine when predictable supplies of imported sawn redwood are easily obtainable. The grading trial of Scots pine timber carried out at Balmoral Estate [10] identified a production scenario that might maximise the availability of high quality joinery timber while not disrupting existing markets or sawmill production.

The approach involved developing a market for falling boards – the outer boards left over when timber products are sawn from the central part of a log. Although this approach is not viable at all mills it nonetheless may have potential:

- The timber producer sells their timber to the sawmill in the normal way
- The mill processes the timber and sells the central part of the logs to existing markets such as fencing
- A manufacturer buys a proportion of the falling boards graded to a mutually agreed quality specification

This approach has the advantage that it is well integrated with existing sawmill production and minimises the financial risk for a manufacturer as they are only buying timber they know is suitable for their needs.

Alternatively the manufacturer could buy the falling boards ungraded. These could then be sorted into a high and low grade - the better timber used for value added products while the low grade is used for utility products such as sarking.

5. Potential value added products

The remainder of this report reviews products which may offer potential to add value to Scots pine sawlogs. Decking and other well established sawn timber products from Scots pine have been omitted because their market potential is already well known and there seemed little benefit in repeating this information. Instead a number of lesser known products have been evaluated using ten criteria drawn from the foregoing research or from discussions with local wood processors or other interested parties.

Each product is discussed below with their potential assessed using a scoring from -10 to +10 against each criterion (giving a total score ranging from -100 to +100). While not 'scientific' this evaluation is more or less objective and transparent. The criteria are:

1) Potential to accommodate blue stain – As outlined above blue stain is common in Scots pine and can prevent it being used in many applications.

2) Potential to accommodate dead knots – As with blue stain, the presence of large dead knots can limit the product potential

3) Evidence of market potential using Scots pine or a similar softwood– If the product is made in *P sylvestris* or equivalent then there may be potential

4) Time to commercialisation – Products which can be brought to market quickly are generally the most attractive

5) Technical restrictions – Changes in building regulations or other technology legislation may make some products unviable

6) Interest expressed from an existing wood processor in the area – Local or national manufacturing interest is very relevant

7) Suitability for a Caledonian, regional or localness brand – suitability for product branding is a strong marketing advantage

8) Market size – Very small markets are not cost effective while extremely large are unrealistic given the timber's continuity of supply constraints

9) New technology that could add value but is untested with Scots pine – An emerging technology such as wood modification may give new potential

10) Intellectual property or other barriers to competition – If the product is patentable or requires very specialist equipment to make this is an advantage.

5.1.1. Post and beam buildings

Several UK firms produce post and beam buildings. Carpenter Oak and Woodland is the largest Scottish business in this sector though Neil Sutherland Architects and Northwoods Construction have both created viable design-build companies in the Highlands using this approach. The techniques of post and beam in the UK (predominantly with oak) have been reviewed in a recent book published by TRADA Technology [22]. The design and construction is specialised and thus unsuited to mainstream builders. Local sourcing is a strong selling point.

Most post and beam buildings in Scotland use Douglas fir due to its ease of working, movement characteristics, and absence of blue stain (Fig. 2). Availability is becoming an increasing issue for lengths over 5 m. Scots pine would be an alternative, providing the timber was unstained. Scots pine is available in long lengths although the sections used would need to be changed. The 16th Century roof of Castle Grant is the oldest softwood roof in the UK and illustrates what can be achieved with Scots pine timber from Strath Spey [23]. Probably the most viable contemporary approach would be to build up the posts using standardised sections of say, 80 mm thick, overlapped and fixed together with bolts and proprietary fixings. This approach is used occasionally and appears to offer scope for development. Both of the firms mentioned above have expressed interest in using local Scots pine. However, as there is no way of removing bluestain from timber this may limit the market.

Fig 2. An office building near Inverness built largely from local timber.

The post and beam frame is Douglas fir whilst the suspended floor is made from I joists manufactured in Forres (using a panel product made largely from local Scots pine)

Table 2. Summary evaluation of post & beam buildings

Criteria	Score	Reasoning
1) Blue stain OK?	-10	Blue stain unsightly in buildings
2) Dead knots OK?	10	Knots are usually OK
3) Market in Scots pine/redwood etc	5	Historical use + Douglas fir & larch
4) Time to commercialisation	0	blue stain will limit the market
5) Technical restrictions?	0	none
6) Local manufacturer?	0	blue stain will limit the market
7) Branding potential?	10	Localness a strong selling point
8) Sizable market?	10	Several viable firms
9) New technology?	0	None
10) IP or other entry barrier?	5	Specialist skills needed
Total score (maximum 100)	**30**	

5.1.2. Flooring

Considerable work has been done to develop the market for solid hardwood flooring from Scottish timbers. The main challenges being: poor continuity and quality of timber supply; price competition from imports; and undercapitalisation. Nonetheless a few small businesses such as Cromartie Timber have succeeded in creating a viable niche. Scots pine has been used occasionally but its low density, blue stain and knots have limited take-up. The markets for and manufacturing of solid timber flooring is described in Davies *et al* [24] and the installation methods are reviewed by Lee [25].

Table 3. Summary evaluation of flooring

Criteria	Score	Reasoning
1) Blue stain OK?	-10	Blue stain unsightly in buildings
2) Dead knots OK?	-10	large knots not acceptable
3) Market in Scots pine/redwood etc	5	occasional local pine, larch
4) Time to commercialisation	5	quick to develop on small scale
5) Technical restrictions?	0	none
6) Local manufacturer?	0	no
7) Branding potential?	10	Localness a strong selling point
8) Sizable market?	0	the market is very limited
9) New technology?	0	none
10) IP or other entry barrier?	0	none
Total score (maximum 100)	**0**	

5.1.3. Manufacturing joinery

Small amounts of Scots pine timber are used in one-off furniture and fittings and there may be scope to increase this slightly or to develop batch production. Several Highland businesses have experimented with this approach including: Roy Tylden-Wright who revived a local type of 19th century pine chair; Neil Sutherland Architects used local pine for flooring, skirting boards, and wall panelling; and Russwood who explored waney edged boards as internal panelling. Nor-Build also use some Scots pine. Kitchens seem the most obvious market to develop, particularly if branded

through association with well known estates. This market is, however, cyclical and thus probably unsuitable as a stand alone business.

Table 4. Summary evaluation of manufacturing joinery

Criteria	**Score**	**Reasoning**
1) Blue stain OK?	-10	Blue stain unsightly in buildings
2) Dead knots OK?	5	Occasional knots can be cut out
3) Market in Scots pine/redwood etc	10	Historical & current use
4) Time to commercialisation	10	quick to develop
5) Technical restrictions?	0	none
6) Local manufacturer?	5	possibly if blue stain OK
7) Branding potential?	10	Strong
8) Sizable market?	5	Yes but cyclical
9) New technology?	0	none
10) IP or other entry barrier?	0	none
Total score (maximum 100)	**35**	

5.1.4. Log buildings

In Scandinavia P. sylvestris was the traditional timber for constructing log buildings and it continues to be used today. Log building can be a viable niche market in Scotland although there are three issues that need to be addressed.

1. Traditional log builders in Scandinavia normally removed the non durable sapwood from the logs before use (Fig 3). Alternatively the logs were protected from wetting using timber cladding or the silvicultural techniques outlined in section 4.3.1. Nowadays wood preservation is often used to protect the timber. Unfortunately, despite documented evidence [12] that these techniques are necessary to achieve a long service life in coastal conditions, many log builders fail to remove the sapwood. In such cases British Standard BS 8417 [26] notes that external sapwood can fail in 15 years in the UK. Large eaves can be used to protect the logs from wetting but a wall-height/eaves-depth ratio of at least 4:1 is required.

2. Most hand-built log buildings constructed in Scotland tend to be ‘folksy’ in character and this necessarily limits their market. This has been recognised in Finland where considerable work has been done to develop a contemporary log building aesthetic [27]. The resultant designs, often in laminated kiln dried timber, retain the performance advantages of log buildings while having greater mass market appeal.

3. Timber is a poor insulator, relative to a material such as mineral wool. Consequently, log walls cannot by themselves achieve the U-value requirements of modern building regulations. For comparison, a 150 mm thick log wall has a U-value of around 0.75 while a timber framed and clad wall of the same thickness can be insulated to 0.35 or below [28]. Building regulations are not concerned with energy efficiency as such but rather with the carbon consumption of a building. Until recently, this meant that a poorly insulated wall could be compensated for elsewhere by, for example, using a

carbon neutral heating system. This is becoming difficult and log walls will probably need to be insulated to comply with future regulations.

In most cases massive timber (see below) is probably a more viable approach.

Fig 3. This Norwegian log building is being restored using traditional techniques which include removal of all sapwood

Table 5. Summary evaluation of log buildings

Criteria	**Score**	**Reasoning**
1) Blue stain OK?	-10	Blue stain unsightly in buildings
2) Dead knots OK?	10	Knots are acceptable
3) Market in Scots pine/redwood etc	10	current use but DF preferred
4) Time to commercialisation	0	take up of new designs unknown
5) Technical restrictions?	-10	Emerging building regulations
6) Local manufacturer?	10	yes
7) Branding potential?	10	Localness
8) Sizable market?	5	no
9) New technology?	0	none
10) IP or other entry barrier?	0	none
Total score (maximum 100)	**25**	

5.1.5. Massive timber construction

Lamination is frequently proposed as a means of improving the marketability of timber. This gives opportunities to remove defects (defect cutting) plus increase the strength, stability and size of the timber components that can be produced. Glue laminated beams (glulam) are the best known product of this type although a growing range of laminated timber components are becoming available. These are collectively termed engineered wood products (EWP).

The current range of EWP includes: glulam, laminated veneer lumber (LVL), parallam, massive timber elements, I joists, and several others. Some of the options are outlined in a recent report by BRE [29]. Only I joists are currently manufactured as a production item in the UK. This business, James Jones Timber Systems in Forres, has been very successful.

There are a few other UK firms making laminated timber components to order. Cowley Structural Timber and In-wood are the best known businesses in this sector. These companies are not tied to one type of EWP but instead mainly produce one-off components for particular building contracts. Examples include laminated oak sections for the debating chamber of the Scottish Parliament, curved LVL for Dundee's Maggie Centre, and a growing number of finger jointed gridshells in larch and other timbers. In-wood, for example, uses sweet chestnut to make specialist structural glulam and finger jointed cladding boards. Discussions with these firms suggest that this flexible approach is generally more viable in the UK than being tied to one type of product. This contrasts with, for example, New Zealand where several companies specialise in producing glulam. The different market conditions may be due to:

1. New Zealand glulam is made from Radiata pine where the distance between knot clusters (the inter-nodal length) is 100 to 150 cm; this is much greater than the 20 to 40 cm found in Scots pine.

2. Steel prices in New Zealand have tended to be relatively high which has given glulam a competitive advantage which does not exist in the UK where steel is cheap.

3. Glulam is a bulky product which is expensive to import into New Zealand giving local producers an advantage. This is different to the UK where import costs from European glulam manufacturers are low.

One niche where engineered wood products may be a viable production item in the UK is massive timber elements. Massive wood (or Brettstappel) first emerged in Germany where sawmills developed methods of constructing structural wall and floor slabs from stacks of boards nailed, doweled or glued together. These methods have most of the advantages of log buildings with none of the disadvantages. Although the material costs are higher than conventional timber frame there are several advantages including: rapid on-

site construction, air-tightness, fire resistance, carbon sequestration and hygroscopicity (which helps regulate the indoor climate).

There are now manufacturers in several countries - the Austrian market is particularly strong. Most current producers glue their panels together and use high grade timber although there is one Norwegian firm using a dowelled system which can accommodate low grade boards. Massive timber elements are being imported into the UK in increasing quantities although the strengthening Euro may affect this.

Interest in massive wood is growing rapidly throughout the UK and two Scottish firms are now in the process of setting up as importers. One of these plans to use a dowelled system based on low grade timber while the other is developing a joint venture with an Austrian company making laminated sections. If these initiatives are successful there may be scope to use Scottish softwood including Scots pine. Several of the forthcoming Highland Housing Fair buildings will probably be made of massive wood.

Table 6. Summary evaluation of massive timber construction

Criteria	**Score**	**Reasoning**
1) Blue stain OK?	-10	Blue stain unsightly in buildings
2) Dead knots OK?	5	Knots may be acceptable
3) Market in Scots pine/redwood etc	10	Yes
4) Time to commercialisation	10	happening rapidly
5) Technical restrictions?	0	none
6) Local manufacturer?	5	Central Scotland
7) Branding potential?	10	Localness
8) Sizable market?	10	Yes
9) New technology?	10	Yes
10) IP or other entry barrier?	10	Yes
Total score (maximum 100)	**60**	

5.1.6. Craft products

There is a small niche for craft products made from local timber. That said, the perceived value of wooden craft items tends to be lower than similar sized objects made of glass or metal. Moreover, the experience of craft retailers suggests that products made of bland looking timber tend to sell faster than identical products made from more characterful wood. There may be some scope to develop a ‘Caledonian pine’ range which could help sustain a small business. Woodschool, for example, have developed an identity based on products made from Scottish timber. There may even be a small niche for craft products which are blue stained. Mark-ups in the giftware sector are often in the region of 240%. It is thus a highly competitive market and very few Scottish producers currently have the design, commercial or technical capacity to compete with imports. The total volume of Scots pine timber used by craft businesses would be negligible

Summary evaluation of craft products

Criteria	Score	Reasoning
1) Blue stain OK?	-10	Blue stain usually unsightly
2) Dead knots OK?	0	Occasional knots can be cut out
3) Market in Scots pine/redwood etc	5	occasional use
4) Time to commercialisation	-10	large take-up unlikely
5) Technical restrictions?	0	none
6) Local manufacturer?	0	no
7) Branding potential?	10	Strong
8) Sizable market?	0	no
9) New technology?	0	none
10) IP or other entry barrier?	0	none
Total score (maximum 100)	**-5**	

5.1.7. Fencing

This is already one of the commonest uses for Scots pine timber and there may be scope to expand the market, both for high volume commodity fencing products and for market niches such as decorative garden fencing. Because Scots pine has low natural durability the timber has to be preservative treated by impregnation before it can be used in full external exposure.

Table 7. Summary evaluation of fencing

Criteria	Score	Reasoning
1) Blue stain OK?	10	Blue stain acceptable
2) Dead knots OK?	10	Knots are acceptable
3) Market in Scots pine/redwood etc	10	Yes
4) Time to commercialisation	0	unknown
5) Technical restrictions?	0	none
6) Local manufacturer?	10	yes
7) Branding potential?	0	none
8) Sizable market?	0	Yes but commodity based
9) New technology?	0	none
10) IP or other entry barrier?	0	none
Total score (maximum 100)	**40**	

5.1.8. Acoustic barriers

Acoustic barriers are mainly used alongside major roads to reduce the sound impacts on neighbouring housing. Barrier materials include concrete, earth and timber. Napier University has recently undertaken a comprehensive review of this market on behalf of a UK company. While the full report is commercially confidential, some of the findings can be summarised:

Acoustic barriers reduce directly transmitted noise between the source and the noise-sensitive area. To achieve this, the barrier has to continuously interrupt the source-receiver line of sight and have a minimum surface density of 12 kg/m^2. The barriers should be positioned as close to the noise source as possible. The most common barrier material is 25 mm thick preservative treated redwood or whitewood. The normal barrier height is 2.5 m while the

typical length is 150 – 250 m. The market has been growing consistently for several years driven by ever more demanding policies limiting sound pollution. Cost effectiveness and ease of installation are usually the key customer criteria. Design is covered by European Standards EN 1794-1 [30] and EN 1794-2 [31].

There has been some UK interest in producing this product and it may be suitable for a large sawmill already producing fencing. Dead knots are, however, a significant barrier to the use of Scots pine. Acoustic fencing is, moreover, a fiercely competitive market and there is little point in competing with imported products on price. There may be scope to develop a new product based on, for example, a distinctive appearance or a proprietary prefabricated system. Napier has already done some work on developing such a system. The proposed system is more expensive than existing prefabricated panels but, because it is stiffer than existing products, fewer support posts are needed and so installation is speeded up and the overall costs are reduced. However, Napier does not foresee that the system is patentable, nor does it appear relevant to Scots pine due to loose knots.

Table 8. Summary evaluation of acoustic barriers

Criteria	**Score**	**Reasoning**
1) Blue stain OK?	10	Blue stain acceptable
2) Dead knots OK?	-10	Loose knots are a problem
3) Market in Scots pine/redwood etc	10	Yes
4) Time to commercialisation	10	few barriers if knots are OK
5) Technical restrictions?	0	none
6) Local manufacturer?	5	some interest
7) Branding potential?	0	none
8) Sizable market?	10	huge
9) New technology?	0	none
10) IP or other entry barrier?	0	none
Total score (maximum 100)	**35**	

5.1.9. Garden and landscaping products

A large number of garden products are already made in pressure treated Scots pine or redwood. These include log-roll edging, posts and rails for fencing, pergolas, planters, and decking. While some of these are well designed and marketed there appears to be scope for product innovation.

Environmental issues are a key marketing advantage. These are manifested through a growing interest in organic gardening, vegetable growing, and wildlife gardening and can be evidenced by the popularity of books on these subjects and the success of companies such as Wiggly Wigglers who started of selling worm composting kits and have now diversified. The public interest in anything to do with recycling also appears to be insatiable.

One of the most commercially attractive areas may be a branded product range that avoids the use of biocidal wood preservatives and instead uses one of the recently developed wood modification process such as furfurylation

or acetylation (see below). The products that could be made include: compost bins, recycling stores, screens for plastic containers such as ‘wheelie bins’ and fencing and wind breaks, edging, decking, and small bridges.

There may also be scope to develop larger landscaping products in preservative treated or wood modified Scots pine. These may include decking and some of the other products discussed above along with a new range of benches, tables, signs, and way-makers. Robust vandal resistance is the key market requirement. Woodscape is the leading company supplying timber products to this market at present. The annual External Works catalogue [32] gives a comprehensive review of the products in this sector. Pedestrian and light vehicular bridges are a related market niche – this is reviewed below.

Table 9. Summary evaluation of garden & landscape products

Criteria	**Score**	**Reasoning**
1) Blue stain OK?	10	Blue stain acceptable
2) Dead knots OK?	10	Yes
3) Market in Scots pine/redwood etc	10	Yes
4) Time to commercialisation	10	development work not large
5) Technical restrictions?	0	none
6) Local manufacturer?	5	some interest
7) Branding potential?	10	Considerable
8) Sizable market?	10	yes
9) New technology?	5	possibly (furfrulation)
10) IP or other entry barrier?	5	possibly (furfrulation)
Total score (maximum 100)	**75**	

5.1.10. Playground equipment

Most of these products are currently imported but, given the growing interest in local sourcing amongst parts of the public sector, there may be opportunities for a Scottish product range. To be viable the range would have to be designed to the same high standards as the imported products. The External Works catalogue [32] reviews this sector.

Table 10. Summary evaluation of playground equipment

Criteria	**Score**	**Reasoning**
1) Blue stain OK?	10	Blue stain acceptable
2) Dead knots OK?	10	Yes
3) Market in Scots pine/redwood etc	10	Yes
4) Time to commercialisation	0	probably considerable time needed
5) Technical restrictions?	0	none
6) Local manufacturer?	0	no
7) Branding potential?	0	little
8) Sizable market?	10	yes
9) New technology?	5	possibly (furfrulation)
10) IP or other entry barrier?	5	possibly (furfrulation)
Total score (maximum 100)	**50**	

5.1.11. Pedestrian and light vehicular bridges

The market for small timber bridges is mature and very competitive; nonetheless, there may be niche opportunities. Most pedestrian and light vehicular bridges in timber are supplied by three main firms using tropical hardwoods or pressure treated softwood. The Territorial Army are also a significant supplier as they will erect basic steel girder bridges at cost as part of their training programme. A few small suppliers also exist; Strong Bridges for example, make a truss bridge in pressure treated larch.

Napier University has been developing stress-laminated timber (SLT) bridges for several years and the Forestry Commission's Geoff Freedman has recently completed a PhD at Napier on this topic. Stress-lamination involves using a group of rectangular sawn timbers compressed together by steel bolts passing though predrilled holes in the wide face of the timbers. The bolts are tightened against external bearing plates and the resultant friction between the laminates makes the assembly into a solid structural deck (Fig 4). The bridges are particularly strong when in an arch form [33]. Because of its good treatability characteristics Scots pine is very suited to this product. SLT is a very cost effective way of building a bridge for pedestrian or light vehicle use .

Most of the SLT bridges made to date have been designed and manufactured by the Forestry Commission for their own use. This approach necessarily limits the scale of operation and does not provide a commercial incentive to grow or innovate. Thus, although the engineering design of SLT bridges is now understood there may be potential to extend their use by developing alternative handrails and other details and by involving a commercial firm in production and sales. Consequently if a private company was able sell the bridges and offer improved handrail designs the commercial potential of SLT may be considerable.

Table 11. Summary evaluation of SLT bridges

Criteria	**Score**	**Reasoning**
1) Blue stain OK?	10	Blue stain acceptable
2) Dead knots OK?	10	Yes
3) Market in Scots pine/redwood etc	10	Yes
4) Time to commercialisation	10	rapid if manufacturer interested
5) Technical restrictions?	0	none
6) Local manufacturer?	5	Already made in Scotland
7) Branding potential?	10	Considerable
8) Sizable market?	5	adequate
9) New technology?	10	SLT is new
10) IP or other entry barrier?	0	none
Total score (maximum 100)	**70**	

Fig 4. A stress laminated bridge being tested at Napier University

5.1.12. External cladding

Research by CTE [34] suggests that in 2004 the UK market for external timber cladding was between 1.2 – 1.6 million m^2 per annum. Cladding suppliers believe the sales have more than doubled in the past 3 years; in which case the current market for timber cladding in the UK stands at around 2.5 to 3 million m^2 per annum. The market is dominated by imports with Canadian western red cedar being the most common timber choice. Other species include Siberian larch, North American Douglas fir, American white oak, imported European oak and several wood modified timbers. A small amount of European redwood is used as external cladding in the UK, though no figures are available. The main UK timber used for cladding is larch (Fig 5). TRADA Technology are currently researching the market in detail.

In principle, the mature heartwood of Scots pine has a similar natural durability to larch and can be used externally without preservative treatment, however, as the zone of low durability juvenile heartwood is relatively wide this will usually prevent Scots pine being used for its natural durability. The sapwood is not durable. Consequently Scots pine will normally require preservative treatment or wood modification before it can be used as external cladding.

Fig 5. Scottish grown larch used to clad a housing development near Inverurie

Redwood cladding is generally appearance graded to the Scandinavian ‘Blue Book’ [15] although the grades may be quoted to British Standard BS 1186-3 [16]. Recently a suite of European Standards [8] [35] [36] were published for cladding and these contain appearance grading rules for pine; unfortunately these standards have attracted criticism and are currently being rewritten. Small dead knots are not generally a performance limitation with modern rainscreen cladding; nonetheless the UK market currently expects the appearance of the timber to be largely knot free. Large dead knots may affect the fire performance of timber cladding and so they should be removed. Anecdotal evidence suggests that only around 10% of sawlogs will yield relatively knot free timber. Although little Scots pine is used for cladding at present there may be potential to develop a niche market for locally sourced timber providing large dead knots can be graded out.

The reaction to fire class (spread of flame characteristics) of timber is often important when it is used as external cladding. In some cases the timber will have to be pressure impregnated or coated with a leach resistant fire retardant. Scots pine is very suited to these processes.

Wood modification is beginning to impact on the timber cladding market – the most relevant processes are furfrulation and acetylation (both are chemical modification processes) and several thermal modification processes such as Thermowood and Plato Wood. These are discussed below.

CTE will be issuing a comprehensive manual for timber cladding in late 2008 [34]. This will incorporate evidence-based construction details derived from

exposure trial and fire testing. A UK timber cladding association is also being formed.

Table 12. Summary evaluation of external cladding

Criteria	Score	Reasoning
1) Blue stain OK?	10	Blue stain is acceptable
2) Dead knots OK?	-10	no (careful grading needed)
3) Market in Scots pine/redwood etc	10	Yes
4) Time to commercialisation	10	rapid if dead knots ok
5) Technical restrictions?	0	none
6) Local manufacturer?	10	considerable interest
7) Branding potential?	10	Localness a strong selling point
8) Sizable market?	10	yes
9) New technology?	10	Wood modification
10) IP or other entry barrier?	0	no
Total score (maximum 100)	**60**	

5.1.13. Wood modified Scots pine

Various wood modification processes have recently been commercialised as non-biocidal alternatives to timber preservation [37]. There can be summarised as:

- **Thermal modification**: heating the timber to around 200°C in an oxygen free environment improves timber's dimensional stability and slightly increases decay resistance. Various brand names are available. A small pilot plant is operating in Wales. To date thermal modification has not worked with UK softwood (knotty timber burns) however there is commercial interest if knot-free Scots pine can be obtained.

- **Chemical modification:** Two processes have been commercialised. Both involve impregnating a permeable timber species with a chemical which is then cured in-situ to make it leach proof (Fig 6). Furfurylation uses furfuryl alcohol (trade names Visor Wood and Kebony) while acetylation uses acetyl anhydride (trade name Accoya). Both processes may have commercial relevance to Scots pine although, because of set-up costs, the treatment would probably have to be carried out abroad. There is commercial interest in developing a chemically modified Scots pine product (Fig 6)

Timber grading would be an issue with these products and technical development would be needed. Nonetheless the product would have commercially attractive barriers to competition and a strong localness value.

Fig 7. The cladding on this building has been made from Scottish grown Scots pine which has been Furfurlated in Norway. This was a demonstration project but if chemical modification could be developed using UK timber there would be considerable commercial interest.

Table 13. Summary evaluation of wood modification

Criteria	**Score**	**Reasoning**
1) Blue stain OK?	10	Blue stain is acceptable
2) Dead knots OK?	-10	no (careful grading needed)
3) Market in Scots pine/redwood etc	10	Yes
4) Time to commercialisation	5	probably slow
5) Technical restrictions?	0	none
6) Local manufacturer?	10	considerable interest
7) Branding potential?	10	Localness a strong selling point
8) Sizable market?	10	probably
9) New technology?	10	possibly
10) IP or other entry barrier?	5	probably
Total score (maximum 100)	**65**	

5.2. Summary of product opportunities

Table 14. Prioritised outline of product opportunities

	1) Bluestain OK	2) Dead knots OK	3) Markets in pine or comparable timber	4) Time to commercialisation	5) Technical restrictions	6) Local manufacturer interest	7) Branding potential	8) Market size	9) New technology	10) Intellectual property etc	Score
Garden equipment	10	10	10	10	0	5	10	10	5	5	**75**
SLT bridges	10	10	10	10	0	5	10	5	10	0	**70**
Wood modification	10	-10	10	5	0	10	10	10	10	5	**65**
Massive wood	-10	5	10	10	0	5	10	10	10	10	**60**
External cladding	10	-10	10	10	0	10	10	10	10	0	**60**
Playground equipment	10	10	10	0	0	0	0	10	5	5	**50**
Fencing	10	10	10	0	0	10	0	0	0	0	**40**
Acoustic barriers	10	-10	10	10	0	5	0	10	0	0	**35**
Batch joinery	-10	5	10	10	0	5	10	5	0	0	**35**
Post & beam	-10	10	5	0	0	0	10	10	0	5	**30**
Log buildings	-10	10	10	0	-10	10	10	5	0	0	**25**
Flooring	-10	-10	5	5	0	0	10	0	0	0	**0**
Crafts	-10	0	5	-10	0	0	10	0	0	0	**-5**

6. Next steps

Based on Table 14, the five most attractive prospects for value addition in Scots pine appear to be garden equipment, SLT bridges, massive wood, external cladding, and wood modification. In most cases work will be needed to identify manufacturers who are potentially interested. If possible these should of course be located in north Scotland although a timber buyer in central Scotland may also be relevant. The next steps are:

- **Garden equipment –** The manufacturer will need design assistance to develop a product range. Wood modification should be assessed.
- **SLT bridges**. The manufacturer will need help to develop a suite of handrail and other non-structural components. Thereafter although the deck structure and abutments of each bridge will be individually designed by a civil engineer, the manufacturer will be able to customise each bridge
- **Massive wood** Given that two companies in central Scotland are already entering this market, all that is required is to ensure that Scots pine is fully considered as one of the timber options.
- **External Cladding**. Obtaining significant quantities of relatively knot free timber is the key challenge. If this is possible then design is needed to develop a system. Wood modification needs assessing particularly the scope for setting up a thermal modification plant in Scotland
- **Wood modification**, A grading trial is needed. If suitable timber can be obtained then the two or three potential processes should be evaluated, this will involve durability tests and other laboratory work. A preliminary trial of acetylation using Scots pine falling boards cut from sample logs used in Task 2 of this project is planned for 2008.

In addition it would be beneficial to assess the scope for branding some of these products either as ‘Caledonian pine’ or through association with a particular location or estate.

7. Conclusions

This scoping study has identified the main challenges and opportunities facing the development of value added products from Scots pine. The challenges include:

- Bluestain and dead knots are identified as the key timber constraints which will need to be addressed (through stain control and appearance grading) before there is much scope for value addition

- Continuity of supply of suitable quality logs is also an issue

- The cost of selecting good quality timber may be prohibitive

Several opportunities are identified

- A number of potential products may have potential, ranging in scale from giftware through to post and beam buildings. Five of these appear to have considerable potential. These are: garden equipment, SLT bridges, massive wood, external cladding, and wood modification.

- A range of actions have been proposed to help develop these opportunities.

- The potential of branding should be explored.

References

[1] BS 7359:1991 *Nomenclature of commercial timbers including sources of supply.* BSI, London.

[2] Macdonald E & Gardiner B. *Draft Report of Task 1: Survey of Current Utilisation of Scots Pine*. Unpublished report to Forestry Commission Scotland, Scottish Enterprise, & Highlands and Islands Enterprise. February 2007.

[3] Building Research Establishment. 1977. *A handbook of softwoods.* Department of the Environment. Watford.

[4] EN 350-2. 1994. *Durability of Wood and Wood Based Products – Natural Durability of solid Wood. Part 2. Guild the natural durability and treatability of selected wood species of importance in Europe.* BSI, London.

[5] TRADA Technology, 1996, *Strength graded British grown softwood.* WIS 26. High Wycombe.

[6] Carey J., 1991. *Bluestaining of timber in service: its cause, prevention and treatment.* IP9/91. BRE, Watford.

[7] Tsoumis G., 1991. *Science and Technology of Wood.* Van Nostrand Reinhold, New York.

[8] EN 14915:2006. *Solid wood panelling and cladding – Characteristics, evaluation of conformity and marking*. BSI, London.

[9] Worrell R. and Ross I., 2001. Growi*ng Scots Pine for Quality Timber*. Cairngorm Partnership, Grantown on Spey.

[10] Davies I. 2003. *A Grading Trial of Scots Pine Sawlogs from Balmoral Estate.* Commercially confidential study for Balmoral Estate.

[11] Ridout B., 2000. *Timber Decay in Buildings*. E & FN Spon, London.

[12] Larsen K. E. and Marstein N., 2000. *Conservation of Historic Timber Structures.* Butterworth Heinemann. Oxford.

[13] Grant I. F., 1995. *Highland Folk Ways*. Birlinn, Edinburgh.

[14] EN 1161-1: 2000. *Sawn timber. Appearance grading of softwoods. European spruces, firs, pines and Douglas fir and larch*. BSI, London.

[15] The Association of Swedish Sawmillmen 1997. *Nordic Timber grading rules for pine and spruce sawn timber* (the Nordic Blue Book) 2nd Edn Stockholm.

[16] BS 1186-3 1990. *Timber for and workmanship in joinery. - Part 3: Specification for wood trim and its fixing*. BSI, London.

[17] BS EN 942:1996. *Timber in joinery – General classification of timber quality.* BSI, London.

[18] BS 476-7 1997. *Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products*. BSI, London.

[19] BS EN 13501-1 2002. *Fire Classification of construction products and building elements Part 1: Classification using test data from reaction to fire tests.* BSI London.

[20] Wood Protection Association, 2006 *Industrial Flame Retardant Treatment of Solid Timber and Panel Products*. Derby.

[21] BRE ,2007. *Adding Value to Home-grown Timber. A report to the Scottish Forest Industries Cluster.* Scottish Enterprise, Glasgow.

[22] Ross P, Mattem C & Holloway A. 2007. *Green Oak Construction*. TRADA Technology, High Wycombe.

[23] Lee U., 2002. Native timbeonstruction: Strathspey's unique history. In: *Scottish Woodland History Discussion Group Notes, 7*. pp 23-9.

[24] Davies I, Burns B & Nelson D. 2001. *The Production and Marketing of Scottish Hardwood Flooring*. Highland Birchwoods, Munlochy.

[25] Lee U (undated) *A guide to the installation and maintenance of solid hardwood flooring.* Robert Gordon University, Aberdeen.

[26] BS 8417:2003. *Preservation of timber – Recommendations*. BSI, London.

[27] Heikkila J. In Search of Urban Log Architecture. In: *Proc of 8th World Conf. on Timber Engineering*. Vol 3. pp 33-39. Lahti, Finland. June 2004.

[28] Edvardsen K I & Torjussen L, Eds. 2000. *Trehus - Händbok 45.* Norwegian Building Research Institute, Oslo. (in Norwegian)

[29] http://www.forestryscotland.com/pages/download.asp

[30] EN 1794-1: 2003. *Road Traffic Noise Reducing Devices – Non Acoustic Performance. Mechanical Performance and Stability Requirements.* BSI, London.

[31] EN 1794-2: 1998. *Road Traffic Noise Reducing Devices – Non Acoustic Performance. General Safety and Environmental Requirements*. BSI, London.

[32] http://www.endat.com/ewc.cfm

[33] Freedman G & Kermani A, Development of Long Span Stress-Laminated Timber Arch Bridges. In: *Proc. 8th World Conf. on Timber Eng. Vol .2* pp 301-307 June 14-17 2004 Lahti, Finland.

[34] Davies I (in preparation). *Designing the Timber Façade*. To be published by arcamedia, Edinburgh.

[35] EN 14519: 2005. Solid softwood panelling and cladding – Softwood machined profiles with tongue and groove. BSI, London

[36] EN 14146: 2006. Solid softwood panelling and cladding – machined profiles without tongue and groove. BSI, London.

[37] Hill C. 2006. *Wood Modification: Chemical, Thermal and Other Processes.* John Wiley & Sons, Chichester.