The Opportunity for Manufacturing Joinery from Alternative Welsh Softwoods

Author - Callum Hill FIMMM (JCH Industrial Ecology Ltd.)

Executive Summary

The potential for the utilisation of alternative Welsh-grown softwood species (larch, Douglas fir, firs, western red cedar, cedars, hemlock, Corsican pine, Scots pine, lodgepole pine) has been appraised.

It is concluded that many of these species do have considerable potential, but that there is very little information regarding the timber quality of these species from a UK perspective. There is also an absence of data regarding the Welsh growing resource of some of the lesser species.

Some Welsh sawmills have the capability of processing these species, but many lack the necessary kilning facilities. Any serious use of this timber resource will require strategic investment to develop the supply chains and a commitment to maintaining long-term supply through planting initiatives.

The lack of up to date information regarding the properties of the timber from lesser softwood species is a serious barrier preventing the development of commercial products on a significant scale. There are also concerns regarding the long-term availability of alternative softwoods. A guaranteed stable supply is critical for the development of markets and encouraging investment. Production of alternative softwoods from woodlands needs to be seen as a legitimate management outcome alongside ecosystem services, recreation, landscape and conservation objectives.

The use of locally grown and processed timber in the built environment provides the potential for additional storage of carbon beyond the forest fence. At present, Welsh forests sequester 3% of the carbon emissions of Wales. Even with conventional construction methods the timber in each new house build stores 1.2 tonnes of atmospheric carbon dioxide. Increasing use of timber framing in house construction has the capability to increase this storage potential substantially.

Wood modification (thermal, impregnation, chemical) technologies all have potential for upgrading the properties of timber, with enhancements in dimensional stability and durability. Lamination technologies can be used to improve the mechanical properties of the timber. Despite the promise of these approaches, there has been little commercial development in Wales or the wider UK.

Research into the properties of the timber and development of products through demonstration activities is required. Sources of funding need to be explored in order to develop these projects, especially with regional European partners. A model for such a demonstration activity is the East of England Development Agency project 'low carbon supply chains for forest products in the east of England'.

Locally-sourced, sustainably produced timber used in long-life products has an important role to play in developing a sustainable bio-based Welsh economy.

1. Review of previous work on alternative softwood species in a UK context

When examining the possible uses of alternative softwood species for structural applications, mechanical behaviour and drying distortion are key properties to consider. However, it is striking how little information there is available on the UK-grown species. The main source of information on the UK-grown softwoods remains the work of Gwendoline M. Lavers (Lavers, 1967), the data of which has been republished several times, but is now seriously out of date.

The data reported by Lavers was almost exclusively for 'small clear' samples of wood, of small dimension (20mm x 20mm x 300mm) and knot-free. Consequently when attempting to determine strength classes using the small clears data, according to the European Standard EN338 and the specifications given in EN14801, the data over-estimates the grade because the weakening effect of the presence of knots and other defects is absent. For this reason, a model was used to predict possible strength grades of structural timber in the report on minor softwood species by Ramsay and McDonald (2013). The data from that report is shown in Appendix 1, along with values determined directly from the small clears given by Lavers (2002). Although of restricted practical use, the data in Appendix 1 clearly shows that all of the timbers in question are stiffness rather than strength limited, when it comes to allocating structural grades. However, such information can only be used as an indication and in order to obtain data that can be used for grading machines, it is necessary to conduct strength determinations on a statistically-meaningful number of structural-sized pieces of timber across a wide geographical area of the UK.

It can also be seen from Appendix 1 that Douglas fir stands out as a species of considerable interest for structural purposes. Traditionally, Douglas fir of N. American and Canadian origin was visually graded to 'Special Structural' SS (C24 in BS4978:2007), whereas UK-grown timber was attributed to 'General Structural' GS. However, when structural sized pieces of Douglas fir were tested at BRE the results showed that British-grown Douglas fir visually graded SS according to BS4978, met all the requirements for the C24 strength class (BRE, 2000). More recently, the BRE conducted a study of the BS4978 visual grading method used for softwoods and its applicability to Douglas fir (Suttie, 2014). In the Standard, the rate of growth (distance between growth rings) is used as a proxy for evaluating wood density. Since Douglas fir is generally fast grown, this leads to the timber being graded as GS. However, it was found that the method employed consistently underestimated the wood density and hence downgraded much of the timber from SS to GS. In a University of Bath study of Douglas fir timber from the south west of England and the Forest of Dean, it was found that slower grown trees satisfied the strength requirements for C22 grade and for the faster grown to C20 grade (Bawcombe, 2012). In addition, mature wood (fast grown C16, slow grown C18) was found to have much superior properties when compared to juvenile wood (fast grown C24, slow grown C28. However, the work was performed on small clears and the conclusions need to be treated with caution and represent the upper bound of what might be expected.

The Forestry Commission published a study (The Minor Species Project) of the potential of UK grown western hemlock, western red cedar, grand fir and noble fir (Aldhous and Low, 1974). Further work has been recently conducted by Edinburgh Napier University on Douglas fir, larch, Norway spruce, western hemlock, western red cedar and noble fir, but this has not yet been published.

Woodland Heritage funded a project to study the silvicultural and timber utilisation potential of the minor conifer species in Great Britain. The project investigated larch, Douglas fir, grand fir, noble fir, European and Pacific silver firs, western hemlock, western red cedar, coastal redwood, Japanese cedar, Nootka cypress, Lawson and Leyland cypresses, Monterey cypress and monkey puzzle. The outcome of this study, undertaken by the Aberdeen-based forestry consultant Dr. Scott McG. Wilson, was reported upon recently (Wilson, 2014). This very useful and timely report found that many of the 'minor' conifer species in the UK were planted in sheltered valley sites in Wales, the Marches and south-west England. These sites are now classified as plantation on ancient wood sites (PAWS), for which the current policy is to seek restoration to species more applicable to ancient woodlands. Consequently, there is a continuing reduction in the number of productive stands which are able to supply alternative softwoods. Uncertainty in supply will certainly impact negatively on any potential investment in processing capacity for lesser softwoods.

The East of England Development Agency commissioned a study (Low carbon supply chains for forest products in the East of England), which was undertaken by InCrops Ltd., BRE, FC, and Norwich Business School in 2010 (French et al., 2010). The aim of this project was to investigate the feasibility of using more locally produced wood in construction and what barriers were preventing this from taking place. This study comprised a mapping exercise, forest characterisation, supply chain modelling, and strength testing of Corsican pine. In studying the supply chains, it was decided to concentrate on those companies that were members of one or more trade bodies within the forest products industry. This was based on the assumptions that these would represent the larger operators in the region and that they would also represent 80% of the sector turnover in the region (Based on the Pareto 80/20 rule). A range of potential products were modelled in order to examine possible markets for locally harvested timber (inside-out beams, hardwood windows, enhanced flooring, laminated beams, hardwood flooring, exterior cladding). In all cases it was concluded that the value proposition for these products was good. The main barriers to the use of locally produced wood were the development of supply chains. Such an initiative would serve as a useful model for a Welsh demonstration project.

To summarise the current state of knowledge regarding lesser softwoods: in terms of structural grade timber, Scots pine (C20), larch (C20), and Corsican pine (C16) all show promise. Cedar is a timber that is highly valued in Japan as a construction timber and western red cedar is used in high value bespoke joinery, such as conservatories. Western hemlock has a reputation for producing low quality timber, but this appears to be undeserved. The true firs appear to be more problematical, but have a good reputation in North America. A detailed examination of the properties of the alternative UK softwood species is given in Appendix 2. It is clear from the knowledge available that UK grown alternative softwoods have the potential to produce high quality timber, but this needs to be demonstrated.

It is apparent from the survey of published work, that technical information on alternative softwoods in a UK context is limited. This lack of information is one barrier to the use of such species in high value applications.

2. The Welsh softwood resource

Woodlands in Wales cover 14% of the land area (NFI 2011 Woodland Map Wales – National Forest Inventory Report) of which approximately 50% is planted with coniferous species, with public ownership accounting for 38% of the woodland area. Seven tree species comprise 96% of the Welsh softwood resource, with Sitka spruce representing 55% of the standing volume (Fig. 1).

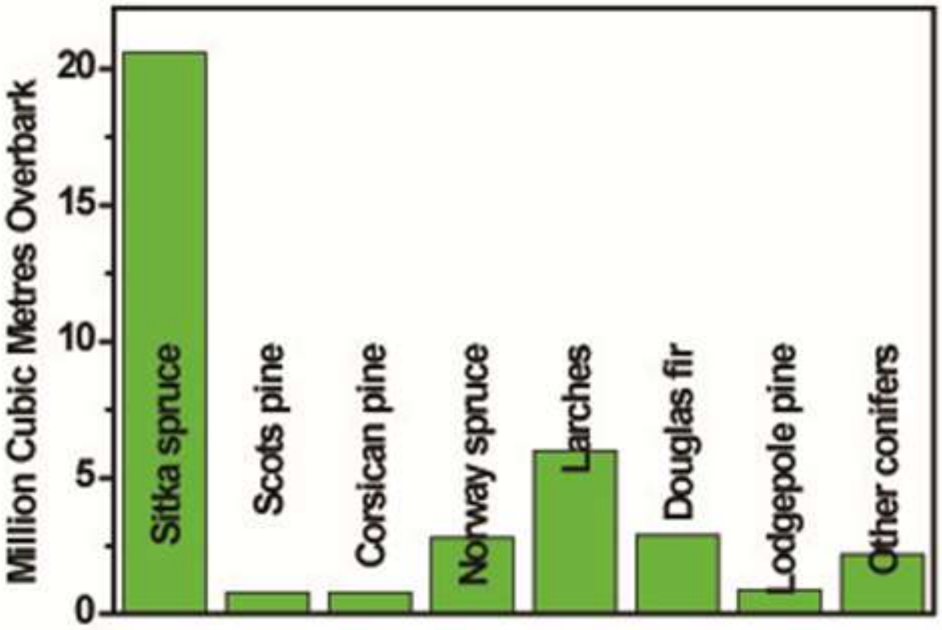

Figure 1: The current Welsh softwood standing resource by volume

The next most planted softwood species are the larches followed by Norway spruce, Douglas fir, the lodgepole, Corsican and Scots pines. However, there are other minor softwood species that are not specified in the national forestry statistical reports.

Softwood yield is predicted to remain relatively stable until 2027, with increased yields of Sitka spruce, but a decrease in production of larch (FC, 2014). There is also a projected increase in Corsican pine until 2027. Softwood yields are thereafter expected to decrease. Prediction of yields is based upon various assumptions and on the best information available at the time. However, climate change is certain to make an impact upon forestry in Wales and this makes forecasting a more difficult task. In a 2008 report on the impact of climate change on forestry in Wales, it was concluded that although a milder climate would allow for a higher productivity from forests, there was also a much higher level of risk associated with severe storm events, pests and pathogens and forest fires (Ray, 2008). Pathogens are potentially the greatest unknown factor affecting prediction of yields. Two pathogens are already seriously affecting coniferous species in the UK. These are:

- *Dothistroma septosporum* responsible for red band needle blight
- *Phytophora ramorum* causing dieback and mortality in larch and Douglas fir

The unpredictable appearance of pathogens can have a devastating effect on tree populations and is one argument against the over-reliance on one species for commercial forestry. The diverse composition of Welsh commercial forests is for this reason an advantage and something that should be encouraged to increase the resilience of plantations.

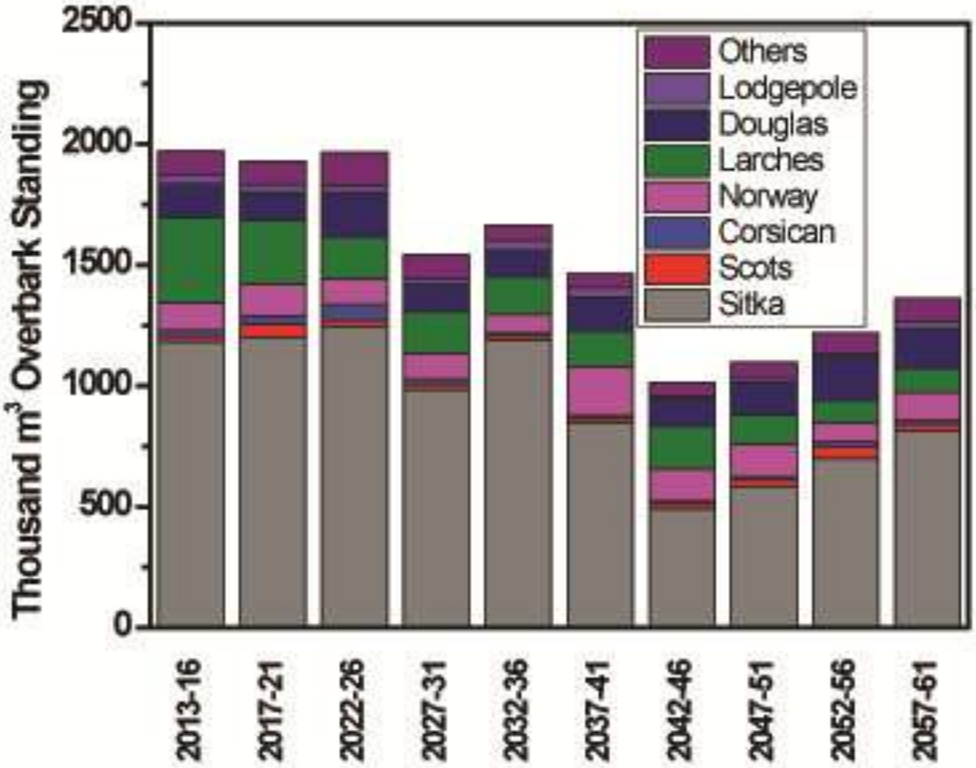

Fig. 2: Predicted yields of softwood from Welsh forests over the next 50 years

3. Potential

A survey of woodland enterprises in Wales was undertaken by Endaf Griffiths of Wavehill on behalf of Forestry Commission Wales (now NRW) in 2010. It was estimated that there were 1,900 timber-related enterprises in Wales, of which the majority were small businesses and sole traders. It was also estimated that approximately 19,000 jobs were sustained by the timber industry in Wales. The forest industries sector in Wales has a gross value added of £455.7 million and employs between 8,500 and 11,300 people (Welsh Government, 2014). The secondary processing sector (SIC (Standard Industrial Classification) 16) (excluding paper and paper products) has a GVA of £147.7 million. However, this analysis does not include businesses that are wholly or partially supported by the forestry sector, but are not included in the SIC 16 and therefore underestimates this contribution. This Wavehill report appears to no longer be available, but a useful summary of this and other studies is given by Marsh (2013). In the Woodlands for Wales Indicators report 2013-2014, it was reported that nearly 90% of timber used by secondary wood processors came from outside of the UK and only 5% from Wales. The report states that an increased use of Welsh-grown timber is a desirable outcome, contributing both to a reduced carbon footprint and providing economic benefits (Welsh Government, 2014). There is clearly a huge potential for increasing the use of Welsh timber in secondary products, provided it is fit for purpose. This needs to be demonstrated to secondary processors and there also has to be a guaranteed supply of timber in the future. This supply guarantee can only come from a firm commitment by Welsh Government to support new planting of alternative softwood species.

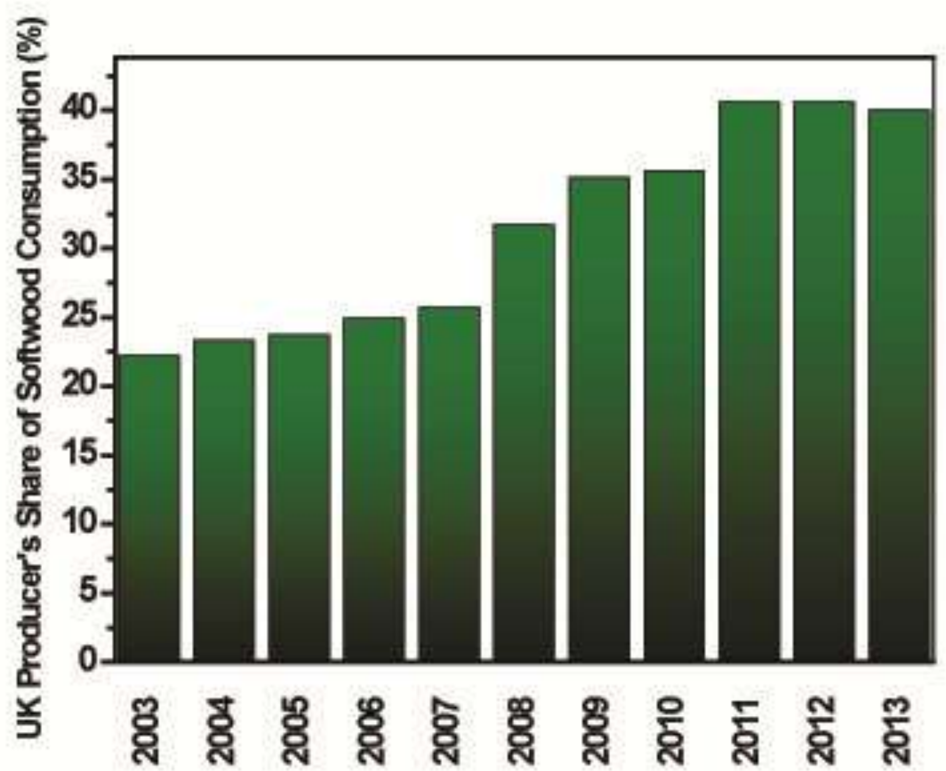

Fig 3: UK grown softwood share of the UK softwood market

In 2012 the UK was the third largest net importer of forest products, after China and Japan. Due to major investments by the high capacity UK sawmilling industry and helped by a relatively weak pound, the UK produced timber share of the softwood market has been increasing until recently (Fig. 3). The total UK market has been relatively static over the past few years, and was of the order to 8.6 million m^3 in 2013, of which UK timber had 40% of the market by volume. It is striking that the Welsh secondary processing industry uses only 5% of Welsh grown timber. The high volume UK sawmilling industry has specialised in the conversion of Sitka spruce (and to a lesser extent Scots and Corsican pine) using high throughput continuous flow mills. These mills are optimised for processing uniform material in the 30-60 cm diameter class, producing standardised material. There is less capability for the processing of major conifers in diameter classes above 60 cm and for some conifers in any diameter class, with the exception of high quality Douglas fir stems. Some species, such as western hemlock and grand fir have come to be regarded as economically non-viable.

In 2007, just prior to the economic recession, the total usage of softwoods in the UK housing market was 6.4 million m^3, of which only 1 million m^3 was from UK-grown sources. Of this 6.4 million m^3, only 622,000 m^3 was used in the construction of new properties, of which there were 22,000 in 2007. This equated to an average of 2.8 m^3 of timber per property. In 2012, the volume of imported planed timber products was 1.77 million m^3, up from 1.63 million m^3 in 2011. Rough sawn volumes in 2012 were 2.99 million m^3, up from 2.90 million m^3 in 2011. Further processed imported softwood goods, as a proportion of all imported softwoods was 37%, up from 36% in 2011 and 29% in 2010. The majority of sawn softwood imports come from Sweden (46%), Latvia (14%) and Finland (13%). UK producers have enjoyed a price advantage over imported softwood and investments made by the UK sawmilling sector has enabled increasing penetration of the construction market as well as a consolidation of the leading position held by UK producers in the pallet, packaging and fencing sectors. However the UK pound has increased in value against the Euro and the Swedish Krona, which will continue to erode any price advantage. If softwood timber can be obtained cheaply from abroad, then other considerations have to be applied in order to incentivise the use of Welsh timber.

The Social Value Act (2013) requires public bodies to consider how the services that they commission and procure could improve the economic, social and environmental well-being of the local community. This social value is defined as ‘the additional benefit to the community from a commissioning/procurement process over and above the direct purchasing of goods services and outcomes’. This social value can be realised in a variety of ways, including using local suppliers to provide services, thereby stimulating the local economy. Also included is stimulating demand for environmentally-friendly good, services and works and contributing to climate change mitigation targets. There is increasing realisation of the importance of local supply chains for supplying the construction sector (e.g., Dean, 2010). This represents an opportunity for the development of a Welsh softwood supply chain. Further guidance on how local timber can be specified and stay within public procurement rules is considered in an FC Scotland report (Davies, 2009).

There are possibilities of improving the properties of timber through various wood modification technologies. There has been considerable research undertaken by Coed Cymru on the thermal modification of a variety of wood species, including many of the softwood species considered in this report. The temperatures used for this work are somewhat lower than those normally used for large-scale thermal wood modification processes. Thermal modification can improve the dimensional stability and biological durability of the wood to some extent, but the primary purpose of the Coed Cymru work was to improve the appearance and machinability of the wood. Thermal modification has also been applied to improve the properties of end-grain flooring. Thermal modification requires a lower capital expenditure compared with other modification process. This is a promising technology that has been widely adopted throughout Europe (over 75 reactors producing more than 0.25 million m^3), yet has not seen any commercial development in the UK to date.

Other modifications to improve the durability of wood include acetylation and impregnation with a polymerisable resin. Acetylation is currently commercialised in Europe by Accys technologies (Accoya) [www.accoya.com]. The production facility in the Netherlands uses imported radiata pine primarily (mostly for doors and windows), although other woods are also now being used, such as alder and beech (for decking and cladding). The main requirement is to have a timber that is permeable, hence the requirement for wood with a wide sapwood band, such as radiata pine. Corsican pine is a possible candidate, but it is questionable whether there is any sense in exporting the timber for value to be added outside of Wales. The capital cost fo an acetylation plant if high and it is very unlikely that a solid wood acetylation plant would be a viable commercial proposition in Wales. Furfurylation is a promising technology that is commercialised in Norway (Kebony) [www.kebony.com] and also requires a permeable wood species to be effective. The Kebony process uses Scots pine for cladding and decking. Variation in the impregnability of Scots pine has been noted, with faster grown trees from warmer climates being easier to impregnate. There is certainly potential for an impregnation modification process to be established in Wales, as well as a thermal modification process for which preliminary research has been conducted already by Coed Cymru.

Critical to creating the demand pull for Welsh-grown timber is the development of chain of custody procedures along with the ability to brand the timber as ‘home-grown’. The development of certified local supply chains is something that should be encouraged under the auspices of the Grown in Britain campaign, which was launched in 2013 and is in the early stages of development. A central feature is a certification scheme which is designed to increase visibility of home grown timber by licensing woodlands, timber and timber products that are grown in the UK. The Grown in Britain licensing scheme compliments and integrates with other well proven forest certification schemes such as the Forest Stewardship Council (FSC) and the Programme for Endorsement of Forest Certification (PEFC). This type of regional branding has worked well in the food and drink sectors. Branding home grown timber may add some value to the resource in niche markets but is perhaps unlikely to have a significant effect on volume markets without encouragement from the Welsh Government to kick start the process.

The EU Timber Regulation came into force in December 2010, prohibiting the marketing of illegally harvested timber and timber products in the EU market as of 3rd March 2013. This requires that a due diligence system (DDS) is applied at all stages of the supply chain. Operators who do not wish to develop a DDS of their own have to use the services of an EU approved monitoring organisation. An operator is a first placer of timber on the market, i.e. an importer or a producer of timber derived from EU forests. Traders in timber and timber products have to keep records of where timber or timber products are bought from or sold to, unless the customer is a final consumer. Guidance on good practice on exercising due diligence in establishing the legal origin of timber, is given in PAS 2021. The woodland area in the UK is 3.1 million hectares, of which 1.4 million hectares are independently certified as sustainably managed. In 2013, 56 sawmills held chain of custody certificates, 32 did not hold certificates and 89 were reported as ‘certification status unknown’ (Source: FC Statistics 2014). In Wales, the total area of woodland managed to the UK Forestry Standard is now 203,000 ha, up from 123,000 ha in 2001. The most commonly encountered certification schemes are the Programme for the Endorsement of Forest Certification (PEFC) scheme and the Forest Stewardship Council (FSC) scheme. PEFC is an umbrella international organisation that endorses national or sub-national schemes. More information can be found at the DEFRA Central Point of Expertise on Timber (CPET).

One of the desired outcomes of the Woodland for Wales strategy is that Welsh woodlands continue to contribute to reducing the carbon footprint of Wales. Carbon sequestration by Welsh woodlands was estimated to be slightly more than 1.4 million tonnes of carbon dioxide per annum (Buys et al., 2014; WAG, 2014). Welsh woodlands are projected to continue as net carbon sinks at least until 2050. In 2010, Wales emitted 44.1 million tonnes of carbon dioxide equivalents, carbon sequestration by woodlands represents 3% of this total. By harvesting the timber in a sustainable manner (i.e. harvest no more in a year than is grown in a year) and using the timber in long-life products in the construction sector, the benefits of carbon storage are realised way beyond the lifetime of the tree. The built environment becomes, in effect, an extension of the forest. But this requires the political will to ensure that more home grown timber is used in new building. Welsh government has estimated that 14,000 new homes are required every year in Wales for the next 15 years to meet housing needs. Assuming that each house requires 2.8 m^3 of sawn softwood, this equates to a demand of slightly more than 39,000 m^3 of softwood. One cubic metre of softwood at a density of 400 kg m^{-3}, stores approximately 120 kg of atmospheric carbon, which is equivalent to 440 kg of atmospheric carbon dioxide. The means that even with a minimal input of timber in a construction, each house will store 1.2 tonnes of atmospheric carbon dioxide. The quantity increases with greater wood use in a dwelling, both due to direct storage and also due to the substitution effect, where higher embodied energy materials are replaced by wood. If Wales is to play its part in reducing carbon emissions, the role of local grown timber in the built environment needs to be analysed very seriously. Such an analysis is outside the scope of this report.

Alternative softwood species have the potential to contribute to the bio-based economy in Wales, through the development of localised supply chains, with both economic and environmental benefits. However, competing in an international market remains a problem for locally grown timber.

4. DISCUSSION

The use of alternative softwood species in Wales is limited due to a lack of supply chain infrastructure and a lack of knowledge of the properties and availability of the timber. There is a requirement for the development of virtual supply chains to match production with demand and a need to disseminate knowledge about the properties of the alternative species. These virtual chains require the development of an up to date database of timber availability to allow for effective communication between growers, primary and secondary processors and end users. This can be developed through the mechanism of ‘exemplar’ demonstration projects and underpinned through a strategic approach to supply chain development to ensure that once the demand has been created, it is essential that this can be matched from the supply side. The public sector can play a very important role in kick-starting this process through procurement measures, which include local sources of timber as part of the specification.

The supply chain needs to be addressed. The processing of this timber is reliant on the smaller sawmills in Wales, where the lack of kilning facilities is a serious barrier to commercial development. Timber tends to be cut to order and there is no significant stocking of Welsh-grown alternative softwoods. The production of Sitka spruce predominantly uses highly mechanised systems, requiring significant levels of investment. The return on the investment comes from the high levels of productivity with small margins and reliant upon long-term contracts. BSW Newbridge-on-Wye has made considerable investment in its capability to process Sitka spruce and will also be processing increasing quantities of larch in the future. Such long-term investments can only be made if the supply is guaranteed.

Much of the alternative softwood resource that is available comes from the national strategic timber reserve created from plantings between the 1920’s and 1960’s. Many of these sites are now considered to be PAWS, with the long-term conservation aim of reconversion to native woodland. A blanket strategy where all softwoods apart from Sitka spruce are replaced by native species will jeopardise the prospects of using some potentially valuable commercial timbers. A more balanced approach meeting the aims of conservation balanced against the economic and environmental benefits of using local timber in long-term products needs to be developed. There is an urgent need to rebalance the management priorities of our forests, so that production is also viewed as a legitimate objective, alongside recreation, conservation and ecosystem services (Cameron, 2011). Without assured supply into the future, the commercial sector will not risk investing in the necessary infrastructure. It is more likely that much of this potentially valuable timber will be used as an energy source, where the benefits of carbon storage are lost immediately.

The economic viability of the supply chain depends upon whether there is a sufficient quantity of timber available within a given radius to ensure continuity of supply. According to Aldhous and Low (1974) a minimum annual production of 20,000 m^3 of sawlogs must be available within an economic radius, requiring total plantation areas to be between 5,000 to 10,000 ha. Below these levels, production with fluctuating quantities would be expected, making long term planning problematical. Analysis, of the potential for these alternative species, must also consider plantations outside of the political boundaries of Wales and giving the necessary due consideration to economic, logistic and geographical factors (something outside of the remit of this scoping study). Local supply chains mean just that and are not to be restricted by political considerations.

There is a need to build upon the limited knowledge of the structural properties of the timber of UK-grown alternative softwoods. In the absence of grading machines, which are used in large high throughput mills, the most practical option is to use visual grading, as used for joinery. For structural timber, visual grading tends to underestimate the mechanical performance of the material. For this reason, there is increasing interest in the use of acoustic tools for grading. Much work has been undertaken at Edinburgh Napier University in the use of acoustic tools for grading, but within Wales no research capability exists. Hand-held grading tools have considerable potential for use in small processing facilities, but they first need to be calibrated with a meaningfully large number of samples. For joinery applications, it is likely that visual grading will continue to be the method of choice to select for value.

It is now recognised that it is quite possible to achieve C22 structural grades without economically unsustainable reject rates with larch, Scots pine and Douglas fir. Although it should be noted that C16 structural grade timber is perfectly suitable for many purposes in construction. Upgrading of lower structural grades to make higher performing glulam beams is also a very attractive proposition.

Apart from mechanical properties, it is also important to develop knowledge on the dimensional stability and distortion of the wood. BS 5268 Part 3 (2006) giving the code of practice for trussed rafter roofs states that bow should be no greater than 10mm over 2m, spring no more than 4mm over 2m and twist not greater than 1mm per 25mm over 2m. Wood with spiral grain, high proportions of juvenile wood and/or compression wood is inherently susceptible to distortion. It is possible to use scanning technologies and modified cutting patterns to reduce these undesirable features in the wood. But such technologies are confined to the larger scale production mills, which are not configured to producing small batches of alternative softwood species.

The stiffer and stronger material is located in the outer regions of the stem, away from the juvenile wood of the core. If there are not excessive amounts of compression wood, this more recently laid down wood is also less prone to distortion. This is often the wood that is produced as falling boards in the mill, which tend to go into lower value markets, such as pallets. There is considerable potential for obtaining more value from this material if it is laminated.

Unfortunately the UK is not in a very strong position when it comes to wood science research. There is an urgent and pressing need to develop expertise in this subject area in Wales. One possible way of recovering this lost knowledge is through ‘partenering’ programmes in Horizon 2020, European Regional Development Fund, INTERREG, etc. Without strategic investment, it is extremely unlikely that these potentially valuable feedstocks will see much use in higher value products.

5. Conclusions and recommendations

There is evidence indicating that both larch and Douglas fir have very good structural properties, but their use in engineering applications is relatively limited at present. Given the current state of knowledge with respect to other lesser softwood timbers in Wales, it is highly unlikely that there will be any significant commercial development of these species. Whether the potential for these softwood species will be realised depends upon the willingness of the commercial sector to invest in the necessary infrastructure for the processing of the timber and the development of markets for high quality locally sourced timber. Investment decisions involve analysis of risk and if there is no guarantee of supply into the future an industry based on alternative softwood species will not develop.

It needs to be shown that Welsh-grown softwood can deliver quality and this can only happen through properly targeted research and development and by setting up supply chain based demonstration projects. The public sector has a role to play in developing such projects in partnership with industry. This could be used to leverage European funding via Horizon 2020, INTERREG, ERDF, whilst partnering with other regions of Europe which already have similar issues to address. Apart from determining the physical properties of the solid timber, research also needs to be directed into lamination and wood modification technologies. It is essential that this research is part of an integrated project to demonstrate the use and the benefits of using alternative Welsh softwoods. These benefits need to include, social, environmental and economic considerations. Other regions of Europe (e.g. SITCOB in Brittany) have much greater success in growing and using local grown timber (Goossens and Mahé, 2011). These are models which need to be examined and adopted if they are appropriate to a Welsh context.

The Welsh Government should seriously consider the planting of alternative softwood species in some of the intended extra 100,000 ha that it is committed to plant between now and 2030. The carbon benefits of the sequestration of atmospheric carbon dioxide by this new planting will be enhanced by the sustainable harvesting of timber and use thereof in long-life products, thereby extending the storage benefits. Extra benefit arises through substitution of timber products for higher embodied energy materials. The built environment is the ideal sector to realise these benefits.

In order to create the local supply chains to capitalise on the potential for using Welsh alternative softwoods there needs to be demonstration of properties and commitment to guarantee supply.

Swot Analysis

STRENGTHS	WEAKNESSES
• Some species (e.g. larch, Douglas fir) have superior mechanical properties • Good processing properties, some species have historically been used for high quality joinery • Potential for increasing diversity of forest structure and composition • Suitable climate for conifer plantations and land area available for forest expansion	• Lack of infrastructure in the value chain • Lack of knowledge of properties and potential yields • Lack of knowledge regarding existing value chains • Lack of a strategic approach
OPPORTUNITIES	**THREATS**
• New markets for home grown timber • Potential to add value • Economic boost to rural communities • Environmental benefits (carbon storage, ecosystem services) • Potential for development of low carbon supply chains • Potential for upgrading of properties through use of lamination technologies (glulam, crosslam)	• Pathogens • No strategic view on restocking with alternative conifer species • Possible competition for biomass from energy sector

APPENDIX 1:
Softwood grades calculated from data of lavers

Species	Botanical name	Grade based on MoR	Grade based on MoE	Corrected grade[1]
Cypress, Lawson	*Chamaecyparis lawsonia*	C40	-	-
Cedar - Western Red	*Thuja plicata*	C40	C14	-
Cypress, Leyland	*Cupressocyparis leylandii*	C60	-	-
Fir, Douglas	*Pseudotsuga menziesii*	C50	C22	C20
Fir, Grand	*Abies grandis*	C30	C14	n/a
Fir, Noble	*Abies procera*	C40	C16	n/a
Fir, Silver	*Abies alba*	C50	C20	C18
Hemlock, Western	*Tsuga heterophylla*	C40	C16	C14
Larch, Hybrid	*Larix eurolepis*	C50	C16	C16
Larch, European	*Larix decidua*	C60	C20	C18
Larch, Japanese	*Larix kaempferi*	C50	C16	n/a
Pine, Corsican	*Pinus nigra* subsp. *laricio*	C50	C18	n/a
Pine, Lodgepole	*Pinus contorta*	C40	C16	n/a
Pine, Maritime	*Pinus pinaster*	C60	C16	C16
Pine, Scots	*Pinus sylvestris*	C50	C22	C18
Pine, Yellow	*Pinus strobus*	C30	-	n/a
Spruce, Norway	*Picea abies*	C40	C16	C16
Spruce, Sitka	*Picea sitchensis*	C40	C16	n/a

Notes:
[1]The data in Lavers was almost all on small clears, the corrected grade was modelled by Dr Dan Ridley Ellis of Edinburgh Napier University based upon experience with Sitka spruce. The corrected grade takes account of the effects of defects, such as knots. Where the data was not modelled, this is shown as n/a.

The data shows that the timber is always stiffness (MoE) limited.

APPENDIX 2:
The properties of different softwood species in the UK

Much of the information about the different softwood species comes from US or Canadian sources. The applicability of this information to the Welsh-grown equivalents is uncertain and there is less information available on UK-grown softwood species, other than Sitka spruce. What limited information is available has been sourced and reviewed.

Scots pine

Scots pine (also known as European redwood) is native to the UK and is the second most abundant confer species after Sitka spruce. The timber is of commercial importance and finds use in construction, joinery and fencing. The wood dries well and is stable in use. The wood is easy to work with hand and machine tools and it finishes well. The heartwood is rated as moderately durable to non-durable and the sapwood is relatively easy to treat with preservative. The knots are usually grouped in the stem, making the timber suitable for finger jointing combined with defect removal, although the economics of this depends strongly on the distance between whorls. Defect cutting is used to produce glulam in New Zealand from radiata pine (*Pinus radiata*), where the distance between knot clusters is 100 to 150 cm, in Scots pine the distance is much less (20 to 40 cm). Scots pine exhibits far higher values of strength and stiffness compared with UK grown Sitka spruce, with the mature wood being much stronger and stiffer than the juvenile wood. BRE conducted a study of the potential for using the falling boards of UK grown Scots pine (Holland and Cooper, 2006; Cooper et al. 2008). A trial grading exercise showed that the falling boards met the requirements of C22 and could produce acceptable yields of higher strength classes. Twin lamination of GS visually graded boards (C14) produced C27/TR26 grade laminated beams, while SS grade (C22) produced the equivalent of C35. A study conducted by the Centre for Timber Engineering at Napier University found that the timber met the requirements for the C20 strength class. By segregating out logs using acoustic tools it was possible to achieve the requirements for C22 and C24, with only 12.5% of logs having to be segregated out to achieve C22, but 65% removal required for C24 (Moore et al., 2008). By making twin laminated boards from the visually graded material (general structural - GS according to BS EN 1912:2007). The tree can have a variable stem form with heavy branching, with dead knots frequently encountered in sawn timber. Older trees tend to have a lower proportion of dead knots (Davies, 2008). The timber is also prone to the rapid development of blue stain. Much of the sawn timber is used for fencing (Macdonald, undated). Barriers to exploitation include a perceived inferior quality compared to imported timber and the inability to obtain a consistent supply at a competitive price. The timber is suitable for use in massive wood construction and stress laminated timber bridges. There has been a study where the potential for using acoustic tools to identify quality as soon as possible in the value chain. Log assessment gives a good indication of sawn timber mechanical properties. A market survey of Scots pine from Northern Scotland was undertaken by Ivor Davies of Edinburgh Napier University (Davies, 2008). The timber is suitable for use in post and beam construction, provided it is free of blue stain.

Corsican pine

In its native range, Corsican pine can reach heights of 49 metres and grow for 500 years. It withstands summer drought well and is ideally planted on sandy soils. With the effects of climate change, it was expected that there would be increased production of Corsican pine, but this is now in doubt with the advent of red band needle blight. Timber properties are similar to Scots pine, with selected material being suitable for joinery. French et al. (2010) found that wood from red band needle blight infected trees exhibits slightly improved strength and stiffness properties, due to a reduced growth rate, when tested according to EN408 (CEN, 2003). It was found that the timber met a minimum machine graded strength class of C16. One of the greatest influences on strength properties, is the size and frequency of the knot whorls in the tree.

Larch

In terms of total area, the UK has one of the largest larch resources in Europe outside of Russia (Bergstedt and Lyck, 2003). In the UK, larch timber is mainly used for external cladding; however, much of this material is Siberian larch (*Larix siberica*) which comes from old-growth stands, has narrow annual rings and a large mature heartwood zone. While there is increasing use of home-grown larch for external cladding, it is still an undervalued commercial species in the UK in terms of potential timber utilisation. The majority of UK-grown larch timber is used for pallet production, which is a comparatively low value market. In other parts of Europe and North America, larch timber is used in applications where a combination of high strength, durability, or hardness are required; for example bridges and heavy structures. It is also used in indoor applications where aesthetics are important, e.g., ceilings, walls, exposed roof structures, stairs and floors, and as exterior cladding due to its relatively good natural durability, which often eliminates the need for preservative treatment. In the UK, larch has been grown for 200 years, where it has traditionally been used in place of oak in construction and boatbuilding. European (*Larix decidua*) and hybrid (*Larix × marschlinsii*) larch are preferred over Japanese (*Larix kaempferi*) larch which has a lower market value. Larch cladding is being marketed under the trade-name Scotlarch by Russwood of Newtonmore and smaller diameter material has been used in gridshell structures, such as the Savill building in Windsor. The UK resource is under considerable threat from *Phytophthora ramorum* with more than two million infected trees felled since 2009. Since *Phytophthora ramorum* was first identified in Wales in 2010, more than 6000 hectares of woodland have become infected (roughly 6 million trees). More than two million trees have so far been felled. The spread of this disease is greatly facilitated by wet summers and there are indications that there was reduced infection of trees in 2014. Work is on-going to replant with more varied native species as well as more 'marketable' timber like spruce. BSW at Newbridge-on-Wye has recently signed a contract to process 600,000 m^3 of larch from the Welsh Government's forest estates over the next ten years. This mill currently produces a structural grade of larch at C16. There is certainly considerable scope for using this timber in both cladding and structural applications in the built environment. Woodknowledge Wales undertook a survey of the quality of the larch resource in Wales in 2013. The survey sampled 55 sites in Wales. Standing trees were visually assessed for potential use as construction timber, fencing, short sawlogs, bars and chips. It was concluded that the Welsh larch resource could supply 1.375 million m^3 of timber suitable for construction. However, it was warned that much of this timber could be used for lower value applications unless urgent action was taken. WKW released an information sheet on Japanese larch in February 2014 (Japanese larch and its innovative applications in construction). In this and a previous WKW publication (Welsh softwoods in construction) it was concluded that larch had potential for use in several mainstream timber construction systems. The latest information regarding larch, is that it can be graded C20 with no loss, but higher grades are possible with an acceptable reject rate. This is very encouraging.

Douglas fir

Douglas fir is not a fir, but is the only member of its own genus. It is a native species of NW America, although a closely related species (now extinct) grew in Europe before the last ice age. Douglas fir is a widely used construction timber in the USA and Canada. The wood of Douglas fir is harder than most other softwoods and exhibits good dimensional stability. The wood dries well without checking or distortion. The sapwood is yellowish to reddish white and the fresh heartwood is yellowish-brown to reddish yellow, darkening upon exposure to the air. Workability is described as excellent, although fine grained wood is easier to work than broad grained and the wood has a moderate blunting effect on cutters. The wood is moderately durable. It accepts stains and glues and finishes well. It holds nails and screws well. Because of its good gluing characteristics, Douglas fir is often used for the manufacture of glulam elements. It does corrode ferrous fastenings and also stains when in contact with ferrous metals. There are a number of specialist mills processing Douglas fir to produce large section solid beams, including Somerscales and JB Timber on Humberside, Gilmour and Aitken on Clydeside and East Brothers near Salisbury. In Wales, processors of Douglas fir include S and G Barrett in Monmouthshire, Dickmans and Orielton Mill Partnership in Pembrokeshire and Yswyth Valley sawmill in Ceredigion. Although some stands of Douglas fir are being managed in the UK under a CCF regime, others have been felled and re-stocked with Sitka spruce, or with native hardwoods. New planting with Douglas fir is at a reduced level. This is limiting the potential future supply of this timber and encouraging processers to seek French, German and North American sourced timber. The mechanical properties of this, in common with most of the other alternative softwood species were investigated by Gwendoline Lavers of the then Forest Products Research Laboratory at Princes Risborough in the late 1960's. There have been some recent studies of the mechanical properties of Douglas fir by the BRE, Bath University and Edinburgh Napier University. As with all previous studies, the structural properties of the timber were found to be stiffness limited. The timber has been used in many post and beam timber structures in the UK with great success.

Firs

There are no true fir species native to the British Isles; the first to be introduced was silver fir (*Abies alba*) in the 1600's, which was planted until the late 1800's when it became vulnerable to an insect pest. Thereafter, planting of grand (*Abies grandis*) and noble (*Abies procera*) firs became prevalent. As of 2010, there were about 8000 ha of *Abies* species in Britain, comprising less than 1% of the forested area. The shade tolerant nature of the firs makes them suitable for continuous cover forestry systems. In addition, silver fir species from southern Europe have been identified as potential candidates to improve the resilience of forests against the impacts of climate change. The firs dry easily and well and non-tainting when dry. They are mostly low in strength, tending to be brittle, but are easy to work. They are not resistant to fungi and are difficult to preserve effectively. As they are soft, tools must be kept sharp to give a good finish. As sawn wood, the firs are used in building for joinery and for packaging. Firs are an important source of pulpwood in N. America. Aldhous and Low noted that grand fir was generally found to convert well, although where drought cracks were present, slabs and boards tended to split on the saw side, losses of production due to this were found to be small. The wood was found to dry well (PRL Kiln Schedule L) with some tendency to collapse, very slight checking and end splitting. Spring and bow varied between consignments, but was generally slight. Meanwhile, cupping could be marked, especially in wood from young trees, with the degree of twist varying between samples. Shrinkage on drying was rated as moderate, although movement of the dried timber on changes with relative humidity was small. The timber planed well, especially with a reduced sharpness angle on the cutters, although tearing occurred near knots and where spiral grain was present. Poor results were obtained with moulding machines. The timber is not suitable for structural uses and is classed as non-durable. Impregnation with preservative was rated as slightly better than Sitka spruce. Noble fir was also found to be converted using standard sawmilling equipment without difficulty, although logs with drought cracks produced weakened boards. The appearance of drought cracks was stated to be more serious than with grand fir. Conversion rates were also lower because of a higher degree of log taper compared with other species. Kiln drying using PRL Kiln Schedule L was reasonably satisfactory, although there was a higher degree of bowing compared to grand fir. Machining properties were similar to grand fir. The timber is rated non-durable and has impregnation properties similar to grand fir. In Western North America, the timber is regarded as relatively high grade and used for joinery and construction work.

Western red cedar

Western red cedar has been grown in the UK since the 1800's. It grows well on many different sites and is a useful species for continuous cover forestry (CCF). It is a durable timber that is often used for cladding. It is a fairly easy timber to work and takes staining well. It is corrosive to ferrous metal fastenings. The timber dries well if not cut too thick and exhibits good dimensional stability when in service. The timber is rated as moderately durable (imported timber is rated as durable). Uses of this timber included use for construction of greenhouses and conservatories. There is a requirement for consistent supplies of this species in the 30-50 cm class with a high proportion of heartwood to develop these markets. Although a popular timber for these 'high-end' uses, there is little activity in re-stocking with this species on clear-felled sites. Aldhous and Low (1974) reported no difficulty in sawing logs using standard commercial machines and saws. However, slabs from fluted butt logs were difficult to handle. The fibrous nature of the bark makes it difficult to remove with rotary peelers. Excessive taper of logs in thinnings material led to high conversion losses. The wood was found to dry well (PRL kiln schedule J) with some occurrence of collapse, minimal splitting and checking and occasional severe spring and twist. Shrinkage on drying and subsequent movement with changes in humidity were found to be small. Working properties were found to be good, apart from some tearing in the vicinity of knots. It was found that this species produced a good proportion of 'general structural use' grade timber. The sapwood band is narrow and consequently a high proportion of the timber consists only of heartwood, which is readily identified. Knots are distributed randomly throughout the tree and although frequent, tend to be medium sized and live.

Cedars

There is a long tradition in the British Isles of growing specimen trees of true cedars (*Cedrus* spp.). Japanese cedar (*Cryptomeria japonica*) has been planted on a number of sites throughout the UK, especially in western coastal areas. The timber is highly valued for construction in Japan. The timber is classed as semi-durable and is pleasantly scented. The heartwood has a warm reddish colour and is highly decorative, with contrasting earlywood and latewood bands. The wood is dimensionally stable in service, with a fine texture. It is suitable for panelling, but can be subject to indentation and should not be used in applications requiring hard-wearing timber. It is ideal for exterior cladding provided that the heartwood is used. Atlas cedar is being used to re-forest large areas of Italy. Ramsay and McDonald (2013) reported on good strength properties of this species, but cautioned that this was based on a very narrow sample set. They also noted that this species is used as a major construction timber in Morocco. Cedar wood is easily worked, although sharp cutters are required in order to avoid ridging between the softer earlywood and harder latewood. It takes glue, stain and paints well, although *Cryptomeria* is prone to exude resin.

Western hemlock

Western hemlock is an evergreen conifer native to the Pacific coastal area of north-west America. Although it can act as a pioneer species, it is very tolerant of shade and is usually regarded as a climax species. It has the ability to self-prune to produce a tall branch-free trunk. It grows well on most soil types, except those sites where there is poor drainage, or high water tables. It was first introduced to the UK in 1851. In its native range, western hemlock is usually subordinate in stands that include Sitka spruce and Douglas-fir, but it is sometimes the dominant species and can occur in pure stands in coastal areas. The species is an ideal candidate for use in CCF silvicultural systems. The heartwood of western hemlock is a light reddish brown. The sapwood may be a lightly lighter colour but is not readily distinguished from the heartwood. Ring shake is more common in western hemlock than it is in other softwoods. Western hemlock trees frequently contain some wetwood, meaning that parts of the standing tree have unusually high moisture levels. This wetwood is often associated with ring shake. Hemlock dries slowly, but is moderately stable when in use. Its strength is midway between Douglas fir and spruce. It works easily and takes a good finish, but because of the difference between the soft earlywood and hard latewood, sanding can create uneven surfaces. The wood is considered to be attractive with a regular grain pattern that makes it useful for carving. It can be used as an alternative to Douglas fir for structural purposes. External and interior construction applications include joinery, cabinetry, flooring, and ceilings. It also is a popular choice for creating doors, windows, staircases, ladders, flooring, panelling, broom handles, crates, pallets and packing cases. Western hemlock is ranked as intermediate by the USDA in its ability to hold nails and its tendency to split when nailed. The species is not viewed favourably by the British sawmilling industry. However, Aldhous and Low (1974) reported that no special problems were encountered when wood from this species was sawn using standard commercial machines and sawblades, although they did note knots and spiral grain leading to tearing. They also reported that although the wood could be dried with little checking or end splitting, cup and twist could be a problem. The occurrence of twist was attributed to the presence of spiral grain, particularly in the juvenile wood. The wood is classed as non-durable and considered resistant to impregnation by preservatives. These authors also noted that the timber trade in Britain was prejudiced against the use of imported western hemlock because of problems with seasoning and the inclusion of various *Abies* species in shipments, known commercially as ‘hembal’.

APPENDIX 3:
Main diseases currently affecting softwood species in the UK

Dothistroma septasporum affects a number of coniferous hosts, but pine is particularly susceptible, with 86 pine species reported as being prone to the disease worldwide. The disease also has been reported to affect Sitka spruce, Norway spruce, European larch and Douglas fir, but these species are of low susceptibility. In the UK, it is Corsican pine (*Pinus nigra* subsp. *laricio*) and Lodgepole pine (*Pinus contorta*) that have been most affected by this disease, although there are increasingly reports reporting infection of Scots pine. Spread of the disease requires high humidity. First reported in nursery stock in Dorset in 1954, it is only since the late 1990's that the disease has become widespread. Over the UK, it was found in a 2006 survey that 70% of Corsican pine stands were affected. Between 2007 and 2011 the disease was reported in a further 450 stands (lodgepole pine, Corsican pine, Scots pine), with a high rate of mortality in the lodgepole pine stands. The disease has become a significant tree health issue in the UK, causing premature defoliation and in some cases tree death. Methods of control include clear felling or more intense thinning regimes to open up the stand (to about 350 stems per hectare) and thereby reduce humidity in the microclimate.

Phytophora ramorum has been found in over 130 plant hosts worldwide. Originally found in the UK infecting shrub species, such as rhododendron, viburnum and bilberry, in 2009 the disease was found in Japanese larch and a small number of other coniferous species. *Phytophora ramorum* has subsequently been a major cause of dieback in tree mortality in larch, but has also been found to infect some young Douglas fir trees in south-west England and has also been found in some Sitka spruce sites. Larch dieback infection has so far been mainly found on Japanese larch, but has also been confirmed on European and hybrid larch. Although larch acts as the host, other tree species in close proximity to the infected larch trees can be affected. The disease has caused widespread dieback and mortality in larch plantations in south-west England and was first reported in Wales in May 2010. Given the seriousness of the disease, the FC serves statutory plant health notices requiring infected trees to be felled. However, the spread of the disease in Galloway in 2013 was so rapid that sanitation felling was no longer a practical proposition in the Galloway 'red zone'. Wales falls within the high risk zone of the disease, as defined by the FC. There does appear to be some indication that prevalence of the disease was reduced in 2014, associated with the dry summer. The pathogen thrives best in a moist mild climate and the southern and western seaboards of the UK are more likely to be affected.

Report by:
Callum Hill FIMMM
JCH Industrial Ecology Ltd.
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