Institution: Edinburgh Napier University

Unit of Assessment: 13 – Electrical and Electronic Engineering, Metallurgy and Materials

Title of case study: Mechanical properties of UK grown timber – improving quality and reducing waste

1. Summary of the impact

As a result of Edinburgh Napier University's contribution to the 'Strategic Integrated Research in Timber' network, the UK forest industries (from tree breeders to timber engineers) and policy makers are much better informed about the key characteristics of UK-grown timber (particularly the principal commercial species, Sitka spruce) and how these characteristics are influenced by tree growth, silviculture and processing decisions.

Information has been provided to support: improved grading of timber; segregation of logs and trees for optimal conversion; refocusing the UK tree breeding programme for future wood quality; improvement of European Standards for timber grading; and improved perception of UK-grown timber for construction use. These combine to produce impact through reduced wastage (material and energy) and creation of wider markets for UK-grown timber.

2. Underpinning research

The UK forest and timber industries (excluding furniture) have an annual turnover of £8.5billion. Conifers account for half of the UK woodland, of which half is Sitka spruce, the main commercial species (72% of which is in Scotland). Softwood accounts for ~95% of timber harvested, of which 1/3 goes to construction markets. However, the UK imports ~60% of the (£1.3billion value) sawn softwood it consumes and the construction industry (notably timber frame house building) has used mostly imported timber. The aim of the research in this case study has been to improve the profitability of UK forestry and sawmilling by increasing the use of UK timber in construction by improving the quality of graded timber and reducing wastage in the value chain.

The Strategic Intergraded Research in Timber (SIRT) network is a collaboration between Edinburgh Napier University (sawn timber level), The University of Glasgow (wood anatomy level) and Forest Research (tree level) which has been running since 2003 – initially with funding from the Scottish Funding Council and later with funding (at Napier) from industry, Forestry Commission, Scottish Enterprise, Scottish Forestry Trust, and the European Regional Development Fund. Impact (priority for these funders) was built into the research from the outset.

This case study is for the research undertaken at Edinburgh Napier University (by full time research staff) into the quality of UK-grown timber for construction – principally Sitka spruce but also Douglas-fir and larch (currently extending into other species). The research covers the extent of between-forest, between-tree, within-tree and within-timber variation of wood properties and links those properties to tree growth, silviculture and processing decisions in order that the suitability of UK timber for construction can be improved in the short term (via processing and segregation) and the longer term (through silviculture and tree breeding). The research involved bending tests, non-destructive testing, tree measurement and statistical modelling. The key findings of the research that produced impact are:

F1) That UK-grown spruce is limited in strength grading by stiffness, rather than strength or density (as previously believed), with statistical distributions of properties quantified and correlated with commonly used grading indicators.

F2) That small changes in the resource stiffness would have a major impact on future machine grading settings (and production yield), and that current European Standards for strength grading exacerbate this unnecessarily (in the way characteristic values are calculated from test data).

F3) The realisation that tree breeding programmes need to consider stiffness (in addition to existing focus on improved stem form, growth and density) with some evidence of selection having reduced stiffness.

F4) That within-tree and within-forest variation exceeds between-UK-forest variation, with influence of spacing, latitude, and tree age quantified.

F5) That the juvenile core wood currently governs quality of structural timber due, largely, to high

microfibril angle (orientation of cellulose crystals with the wood cell wall) which results in low stiffness and drying distortion.

F6) Understanding of the application of acoustic tools for quality assessment of trees and logs, and their limitations has been improved (previously it was believed these tools do not work for UK spruce due to its knottiness).

F7) That it is not possible to segregate logs to reduce drying distortion of sawn timber, but that cutting patterns could be used to reduce distortion

Key researchers (Napier):

Dan Ridley-Ellis, Principal Research Fellow (April 2003 – present)
Stefan Lehneke, Research Technician (April 2006 – present)
John Moore, Principal Research Fellow (January 2006 – February 2011)
Paul McLean, Senior Research Fellow (November 2011 – June 2013)

3. References to the research

Researchers who have been employed by, registered as PhD students at, or seconded to Edinburgh Napier University are underlined. Researchers named above in bold.

McLean, J., Evans, R., **Moore**, J. R.. (2010). Predicting the longitudinal modulus of elasticity of Sitka spruce from cellulose orientation and abundance. Holzforschung 64:495-500.

Moore, J.R., Achim, A., Lyon, A, Mochan, S. and Gardiner, B. 2009. Effects of early re-spacing on the physical and mechanical properties of Sitka spruce structural timber. Forest Ecology and Management, 258: 1174-1180.

Moore, J.R., Mochan, S., Brüchert, F., Hapca, A.I., **Ridley-Ellis**, D.J., Gardiner, B.A., and Lee, S.J. (2009). A comparison of four different Sitka spruce genotypes growing in the United Kingdom. Bending strength and stiffness of structural timber. Forestry, DOI:10.1093/forestry/cpp018

Moore, J.R, Gardiner, B., **Ridley-Ellis**, D., Jarvis, M., Mochan, S. & Macdonald, E. (2009) "Getting the most out of the United Kingdom's timber resource". Scottish Forestry, Volume 63, number 3, pp 3-8

Moore, J. R., Lyon, A. J., Searles, G. J., **Lehneke**, S. A., **Ridley-Ellis**, D. J. (2013) Within- and between-stand variation in selected properties of Sitka spruce sawn timber in the United Kingdom: implications for segregation and grade recovery. Annals of Forest Science. Volume 70, Issue 4, pp 403-415. DOI 10.1007/s13595-013-0275-y

Moore, J.R. (2011) Wood properties and uses of Sitka spruce in Britain. Forestry Commission Research Report. Forestry Commission, Edinburgh. ISBN 978-0-85538-825-6
http://www.forestry.gov.uk/pdf/FCRP015.pdf/$file/FCRP015.pdf

Funding for research at Edinburgh Napier University has come largely from donations for the overarching research programme, but with some grants associated with specific PhD projects. e.g. "Sitka Spruce Segregation and Cutting" from the Scottish Forestry Trust, 2008-2012, £10k, PI: John Moore. The student, Greg Searles was awarded the Scottish Woodlands Student Excellence Award for 2012-13 due to the industrial relevance of the work.

4. Details of the impact

Overview

Impact has been achieved in four areas: economic impact for industry; policy at UK and Scottish Government level; improvement of European Standards; and raising awareness and understanding of timber-related issues among the public. The economic impact comes with environmental impact as profitability for UK forest industries means more forest planting, substitution of non-renewable construction materials and reduced timber miles.

Primary beneficiaries and routes to impact

The primary beneficiaries are UK timber growers and sawmillers. The research has been directed by their needs from the establishment of SIRT in 2003. An industry sponsor board meets quarterly

to discuss the research work and the network has conferences for sponsors (at least annually) and industry generally (also at least annually) for knowledge transfer and set the research agenda to real industry problems. Sponsor organisations include the largest UK sawmilling and forestry companies as well as the Confederation of Forest Industries. Projects have, to varying degrees, been co-funded by industry, in many cases, involving industry providing substantial in-kind support through donation of material, facilities and staff time for discussion; the primary route for knowledge transfer and impact. Knowledge transfer also takes place though events for specific projects (at least annually) and industry magazines.

Economic and policy impacts

It is not possible to provide a precise value of impact because timber markets are sensitive to international exchange rates and trends in the construction sector meaning that the economic differential between graded timber and rejects (which go to other markets) is volatile. Production costs are commercially sensitive, but in 2010, during the construction recession, it was estimated by industry that the cost of 1% reject (construction timber sawmilling across the UK) was approximately £300-500k. A figure of £400k per percent rejects has been used for the following value assessments.

The project underpinned development of settings for the latest generation of X-ray and acoustic grading machines, which has enabled UK (and Irish) sawmills to use these machines. These settings have resulted in reduced reject rates for British spruce. These settings were approved for industrial use by the CEN (European Standards) committee in Spring 2011 and used data collected in the preceding 18 months. Estimated worth across UK sawmillers: £400-£800k per annum [from **F1**].

UK sawmilling industry now producing higher grades from UK spruce with no increase in reject due to these improved machine settings (above). Industry is only now (summer 2013) putting the combined grading into practice (it requires changing production lines). It is too early to estimate worth, but this is already challenging the misconception (held by sawmills, merchants and end users) that UK timber cannot achieve such grades - improving perception as a construction material [from **F1**].

Dan Ridley-Ellis is now playing an active role in timber grading committees at UK (since 2009) and CEN level (since 2011), improving standards and representing the interests of the UK. The value of this lies in preventing problems in standards impacting on UK sawmilling which could easily cost millions of pounds per year. For example, arguing against a mandatory adjustment on measured stiffness (in standard EN384) (that was shown, thanks to research undertaken, not to work) has saved future grading settings moving from the currently low proportion of machine rejects (~2%) up to an unviable 20-30% [from **F2**].

Grading standards work and underpinning research has also allowed the University to provide confidence for UK sawmillers in the grading technology they are currently investing in, and advise on how it can be best used (2009-current). "*This should have significant financial impact in the long-term*" (Named Timber Consultant #1) [from **F1, F2**, **F5**, **F6**].

UK tree breeding programmes have refocused to include stiffness (~2011). The impact is to prevent a future increase in rejects (estimated 3-10% or £1-4m/year) [**F1**, **F2**, **F3** and employing **F4**, **F5** and **F6**] The research also allowed advising of policy makers (via Forestry Commission) on future species planting following recent outbreaks of tree diseases.

UK industry now using acoustic tools for log segregation and processing decisions. Estimated worth of 1% reject or £400k/year [from **F6**]

There is added impact in involving industry directly with research (an ongoing process between 2008-now) and encouraging the various growers and sawmillers to come and work together (at least quarterly) on common challenges, and focus their attention on future market opportunities that research enables – which has resulted in ongoing industry funding.

The research underpinning these impacts is the result of our close partnership with Forest Research and Glasgow University – especially linking of forest and tree level research (led by Forest Research) to the wood properties research (led by Edinburgh Napier University). Forest Research is part of the Forestry Commission – a devolved government department in England and

Scotland.

Wider impacts –environmental and social

By supporting the UK forest industries and the use of timber (a sustainable, renewable material) in construction, and reducing wastage of energy and materials, the research provides benefit to the environment and the UK economy – especially in rural areas. This is the reason why the research is funded by Forestry Commission and Scottish Enterprise.

The ultimate beneficiaries of the research are the public who use timber products and benefit from UK forests (the environmental and social benefits of which are well documented). Public engagement with aspects of this research have been enabled through events– producing social impact in raising awareness of wood science and environmental matters. They include:

Wood biomechanics in 3D, Royal Botanic Gardens Edinburgh, 18 July and 21/22 August 2010 (~600 people – general public)

Fantastic Forests, Royal Botanic Gardens Edinburgh, 14/15 April 2011 (~1200 people– general public)

Stand-up comedy by researcher Dan Ridley-Ellis on BBC Radio Scotland (MacAulay and Co 25 May 2012, reach unknown) and Bright Clubs Edinburgh, Glasgow, Dundee, Stirling, Aberdeen and London performing to a total of ~1500 people over 13 shows (general public). (July 2011-Ongoing)

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1) **Named Timber Consultant #1** [All claims – but especially those relating to industry]

5.2) **Named Timber Consultant #2** [All claims – but especially those relating to industry]

5.3) **BSW Timber Ltd (Director)** [All claims – but especially those relating to industry]

5.4) **Forest Research (Research Scientist)** [All claims - but especially those relating to UK breeding programme and timber growers]

5.5) **Forestry Commission Scotland (Timber Development Policy Adviser)** [All claims]

5.6) "**The Scottish Forestry Strategy: Implementation plan (2012-16) and progress report (2012-13)**", Forestry Commission Scotland 2013 http://www.forestry.gov.uk/sfs

[evidence of the research linking into policy development for economic benefit]

5.7) **Timber Development Programme summary reports 2011-12 and 2012-13**, Forestry Commission Scotland. (not currently online but copies available on request)

[evidence of the research linking into policy development for economic benefit]

5.8) **Minutes of the Scottish Forest & Timber Technologies Leadership Group** http://www.forestryscotland.com/about-us/sftt-leadership-group

[evidence of the research linking into policy development for economic benefit]

5.9) Davies, I., "**Sustainable Construction Timber – sourcing and specifying local timber**" (2009) Forestry Commission Scotland. ISBN 978-1-904320-07-4 http://www.forestry.gov.uk/pdf/fcfc152.pdf/$file/fcfc152.pdf

[example of knowledge transfer through Forestry Commission with industry engagement]

5.9) SIRT TIMBER RESEARCH PROJECTS "**A catalogue of projects demonstrating the range of work being conducted within the SIRT and related programmes**" February 2013 http://www.napier.ac.uk/forestproducts/centres/woodstudio/wpig/ResearchNetworks/SIRT/Documents/SIRT%20Abstracts%20booklet.pdf

[As the title describes. This was produced for industry readership]