

<b>Institution:</b> Edinburgh Napier University		
<b>Unit of Assessment:</b> Unit of Assessment 12 - Engineering		
<b>Title of case study:</b> Improving Timber Utilisation: better outcomes for growers, processors, manufactures, engineering structures and new international standards		
<b>Period when the underpinning research was undertaken:</b> 1 April 2003 - 31 December 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Dan Ridley-Ellis	PI, Head of Research Centre (CWST, Centre for Wood Science & Technology)	2003 - ongoing
Ivor Davies	PI, Researcher	2003 - 2020
Steven Adams	Researcher	2014 - ongoing
Stefan Lehneke	Research technician	2006 - ongoing
<b>Period when the claimed impact occurred:</b> 1 August 2013 - 31 July 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> N		
<p><b>1. Summary of the impact</b> (indicative maximum 100 words)</p> <p>Wood is a vital material for sustainable manufacturing and construction, but it must be used efficiently. Though renewable, it is a limited resource. This award winning, industry-funded research <b>advanced knowledge of key properties of UK and Irish-grown timber, and the factors that influence them.</b></p> <p>Research led to <b>improved standards and practices for the production of timber engineering construction products across Europe.</b> It directly benefitted UK and Irish growers and processors through <b>reduced wastage in manufacturing and trade, and by providing access to higher value markets.</b> Specifically, it supported new and improved grading, improved European standards for grading, increased knowledge of species for forest diversification, and improved quality control for the wood packaging industry, that has become even more relevant in preparation for Brexit.</p>		
<p><b>2. Underpinning research</b> (indicative maximum 500 words)</p> <p>Trees are high on the current political agenda for afforestation, and as the most important source of renewable biotic materials. Wood is a vital material for sustainable manufacturing and construction and is core to important goals such as green growth, zero carbon and affordable homes, as well as satisfying many basic daily needs. Demand has caused timber prices to rise by unprecedented levels in 2020, but this is not a temporary situation. Increasing, competing, demands on land, and conflicting priorities need interdisciplinary research to find solutions to meet the technical, economic, social, cultural, and environmental aspects of a material flow that literally shapes the landscape in which we live. Even forest-rich European countries import wood due to limited availability of certain varieties, while global demand for wood continues to rise.</p> <p>The ways forward are by no means clear. Perspectives differ on how forests should be created and managed, what role they play as a source for raw materials, and how they can be used to respond to the climate and ecological challenges we face. Research by the Centre for Wood Science and Technology (CWST) at Edinburgh Napier University (ENU) provides key information for decision makers to prepare the paths for the current and next generation of forestry and timber, linking forest planning and management to wood properties and end uses.</p>		

CWST's core work is about quantifying and assessing wood properties. Although the Centre also covers other aspects of the industry, the research described here concerns construction timber and wooden pallets (which each account for approximately one third of the UK's home-grown sawn timber usage). This research work involves collection of large amounts of new data from fieldwork, often in close collaboration with Forest Research (government agency). The work on construction timber can be divided into two types, structural timber (e.g. for timber frame, cross-laminated timber etc) and non-structural timber (e.g. external cladding and tiling battens).

For structural timber the focus has been on improving mechanical performance and safe construction within the *European Construction Products Regulations* (and UK equivalent going forward). In 2003 the Scottish Funding Council funded the creation of the *Strategic Integrated Research in Timber* (SIRT) project, which is still ongoing [P1]. This work sought to understand fundamental properties of UK and Irish wood, including tree growth and non-destructive assessment (of key wood properties without damage). Research has been heavily influenced by knowledge exchange activity, and crucially, included British and European product testing and production standards committee work underpinned by this research. This is led by Ridley-Ellis, and supported by Adams and Lehneke. Since 2017, a collaboration "WoodProps for Ireland" [P3] has complemented this research with a similar approach for Ireland. The National University of Ireland, Galway, was funded to work in partnership with ENU to co-investigate wood properties in both countries. The ENU role was particularly focused on grading and standards expertise, and fundamental wood properties. How this research is core to European standardisation work for structural timber is summarised in O1, which was written prior to a major change in those standards. O2 is an example of how this research connects to decisions being made on new planting and forest policy. New approaches to make improvements for home grown timber are illustrated in O3, and O4 is a summary of what is involved for one species. The body of the grading work is much larger, and summarised in O5, as it was in 2018.

For non-structural timber, the focus is more varied, covering factors such as durability, appearance, and proper work execution, as well as some mechanical performance requirements. As part of this work, Davies led projects relating to his specialist expertise in durability, timber facades and wood packaging material, with a particularly impactful project in 2013-2014, the first research study into kilning of green pallets ever conducted [P2]. In 2018 CWST conducted the largest ever testing programme concerning the performance of tiling battens, funded by industry [P4]. This developed the sampling design, arranged for machine grading, conducted visual grading measurements, carried out strength testing and devised new rules for grading based on the analysis [O6].

### 3. References to the research (indicative maximum of six references)

O1 O2 and O4 have been published following rigorous peer review. O3 has been presented at a prestigious international event. O5 and O6 summarise reports evaluated by European experts, that have directly influenced industry practice.

- [O1] Ridley-Ellis, D., Stapel, P. & Baño, V. (2016). Strength grading of sawn timber in Europe: an explanation for engineers and researchers. *European Journal of Wood and Wood Products*. 74(3), 291-306. <https://doi.org/10.1007/s00107-016-1034-1>. ISSN 0018-3768
- [O2] Gil-Moreno, D., Ridley-Ellis, D. & McLean, P. (2016). Timber properties of noble fir, Norway spruce, western red cedar and western hemlock grown in Great Britain. Great Britain: Forest Research. Research Note. <https://www.forestresearch.gov.uk/research/timber-properties-of-noble-fir-norway-spruce-western-red-cedar-and-western-hemlock-grown-in-great-britain/>
- [O3] Ridley-Ellis, D., Adams, S., & Lehneke, S. (2018). Some thresholds for grading British grown spruce to optimised strength classes using longitudinal resonance, Proceedings of the 2018 World Conference on Timber Engineering, (WCTE 2018), Seoul, Republic of Korea. <http://researchrepository.napier.ac.uk/output/1291789>.
- [O4] Gil-Moreno, D., Ridley-Ellis, D., & Harte, A. (2019). Timber grading potential of Douglas fir in the Republic of Ireland and the UK. *International Wood Products Journal*, 10(2), 64-69. <https://doi.org/10.1080/20426445.2019.1617984>

- **[O5] Ridley-Ellis, D.** (2018) Strength grading of timber in the UK in 2018, presented at the Timber 2018 conference of the Wood Technology Society of IOM3. Can be supplied by HEI on request.
- **[O6] Ridley-Ellis, D.** Confidential summary report for Coillte “Project to establish data for a new grading framework for tiling and cladding battens” (31 March 2019). Can be supplied by HEI on request.
- **[P1] Strategic Integrated Research in Timber**  
 September 2020 - August 2021 (WP1&2), £165k, Forestry Commission Scotland & Industry, PI Dan Ridley-Ellis.  
 September 2019 - August 2020 (WP1&2), £96k, Forestry Commission Scotland, PI Dan Ridley-Ellis.  
 August 2018 - July 2019 (WP1&2), £99k, Forestry Commission Scotland, PI Dan Ridley-Ellis.  
 August 2017 - July 2018 (WP1), £107k Forestry Commission Scotland & Industry, PI Dan Ridley-Ellis .  
 August 2017 - July 2018 (WP2), £42k Forestry Commission Scotland & Industry, PI Dan Ridley-Ellis.  
 March 2014 - 31 July 2018, £290k Forestry Commission Scotland & Industry, PI Dan Ridley-Ellis  
 January 2011 - September 2015 as part of Wood Products Innovation Gateway, £1075k, European Regional Development Fund, Scottish Government, PI Peter Wilson.
- **[P2] TIMCON Dried Pallet Study**, March 2013 – June 2014, £20k TIMCON (Industry).  
 PI Ivor Davies
- **[P3] WoodProps for Ireland**, September 2017 - August 2020, ENU part £41k (Irish Department for Agriculture, Fisheries and the Marine, DAFM), PI Dan Ridley-Ellis, CI Stefan Lehneke.
- **[P4] Project to establish data for a new grading framework for tiling and cladding battens**, February 2018 - March 2019, £43k Coillte (Industry), PI Dan Ridley-Ellis, CI Steven Adams and Ivor Davies.

#### 4. Details of the impact (indicative maximum 750 words)

This research **advanced knowledge of key properties of UK and Irish-grown timber. It improved standards for production of timber engineering construction products across Europe**, and directly benefitted UK and Irish growers and processors through **reduced wastage in manufacturing and by providing access to higher value markets**.

The UK and Irish industries have similar growth conditions and forest management and industry practices, and both operate under the European standards (CEN) framework on international trade. In the UK alone, the forest and timber industries have a gross value added of ~GBP13 billion, and directly employ 175,000 people (Office for National Statistics 2019). Approximately 90% of the sawn construction timber produced in the UK is graded based on this research (~0.8 million m<sup>3</sup> per year). The value of this work was recognised by industry organisation Grown in Britain who awarded Ridley-Ellis “*Woodland Hero*” for 2016. It also contributed to recognition in the award of the Queens Anniversary Prize in 2015. A production director of a major UK sawmill said “*I would like to just say how invaluable this research is to shaping the future of our industry. We have a valuable timber resource in the UK and your work is hugely instrumental in ensuring we collectively maximise its value...This is essential research underpinning the successful future of our industry.*” **[C1]**

#### Influencing European, British and Irish Standards and their Use

Research has improved knowledge of the key properties of UK and Irish-grown timber and their drivers. This has also resulted in improved standards for production and use of sustainable timber construction products across Europe (from light timber frame to tall cross laminated timber). This helps to ensure the future of economically, environmentally and socially sustainable forestry and timber, while reinforcing the safety of timber construction for all. The research has also been described by an Irish forest industry representative as “*essential, and in many cases acts as a catalyst for industry to make subsequent investments in new capacity or new product development.*” **[C2]**.

Research has supported new ways of grading structural timber (a form of non-destructive strength assessment) [e.g. O3, O4, O5], and non-structural timber in work with tiling battens [O6]. It has also directly responded to the need to improve European standards [O1], and sought to improve knowledge of species to inform forest diversification and associated policy [e.g. O2]. It has also supported the wood packaging industry in satisfying customer needs [P2].

ENU is named in the Scottish industry action plan “*Roots for further growth*” (by the Scottish Forest and Timber Technologies Industry Leadership Group, and launched by the Scottish Cabinet Secretary for the Rural Economy in our laboratories in November 2018). The University is cited as a supporting institution in their ambition for the forest and timber sector to double its economic contribution to Scotland’s economy by 2030 through innovation and investment (to GBP2 billion per annum). This is based on research-informed expertise in the knowledge of key properties of UK and Irish-grown timber, which has resulted in new and improved possibilities for production and use of sustainable timber construction products. However, the impact is certainly not limited to Scotland.

Work on British and European standards has led to the development of British standards for timber facades, and improvement of the harmonized European Standard (and supporting standards) for structural timber [P1] (to improve safety and yields, and avoid unnecessary costs and processes).

This standardisation work goes beyond routine maintenance and improvement. At European level, the most important committees are CEN TC124 WG2 and its task group TG1, which examines and approves new grading settings for structural timber sold in the European market. Ridley-Ellis has led this expert group since 2018, selected by other members (country’s grading specialists, researchers and conformity assessors, nominated by the national standards bodies of, most actively, Sweden, France, Germany, Netherlands, Italy, Finland, Slovenia, Austria, Norway, Ireland, Spain and UK, but covering all CEN members, including Turkey). As an Italian timber industry representative explains “*This standardization work is only possible at this high level based on the research work performed by the CWST.*” [C3]

This work on standards and grading has allowed access to new markets, and increased efficiency and safety (reduced rejects, increased yields and improved processes) [C4, C5]. This also has upstream benefits for growers and downstream benefits for secondary processors and ultimately the public, via better environmental impact from construction, strengthened economic sustainability of forestry, and forest practices more aligned to public expectations of forestry. Improved standards also improve building quality and reduce problems for construction companies and building owners, especially the case for the cladding standard BS 8605-1:2014. Details include research justified changes to European standards that improve the safety of those standards and also improve grading efficiency of UK and Irish grown timber (which can affect production yields of 10% and more). The Chair of the UK Timber Grading Committee (and a sawmill General Manager) said “*The work on standardisation, underpinned by this research, is critically important in ensuring that standards are fit for purpose; allowing timber to be safely specified and enabling growers and producers to make informed long-term investment decisions as they look to expand the use of home grown timber and bring their products to market. This body of research has been a key element of ensuring changes to the standards have been appropriate for our industry, and avoided some potentially costly problems*” [C4]

### **Increasing Productivity for UK and Irish Timber Manufacturers**

The research [P1] developed grading settings for modern grading machines for UK grown larch in response to the outbreak of the tree pathogen *Phytophthora ramorum*. This allowed the industry to process the timber from large-scale sanitation felling. Later, in collaboration with NUI Galway, this was extended to Irish larch [P3]. Work in collaboration with NUI Galway to produce the first machine grading settings for UK and Irish grown Douglas fir [O4, P1, P3] allowed mills easier access to the construction market. These complement CWST’s work widening the range of grading options for the main commercial species (spruce), especially for smaller sawmills, and



have included creation of a new strength class (“C16+”) with optimised properties for this resource [P1]. This is now available on the market and used in construction. This properties and grading work has been described by the Technical Manager of a major sawmill as being *“critical for us to understand the wood we are processing, its limits and also where the industry can take advantage of strengths as this will help us deliver a better product and reduce wastage and increase yields.”* [C6].

After a particularly bad international problem with stain and mould in 2013, research for proper kiln drying or phytosanitation heat treatment of green pallets enabled UK manufacturers to give 100% guarantees of no stain and mould. This has helped producers of pallets for all sectors, and the President of the Timber Packaging and Pallet Confederation states *“for those manufacturers supplying pharmaceutical, food, drinks, etc customers it has been invaluable”* [C7], avoiding the “disastrous” risk of needing to switch to plastic pallets only. Over the last 5 years, 83 million pallets have been kilned or heat treated in the UK, but this is of increasing importance in light of the COVID-19 pandemic, as the industry has been using heat treated pallets to ship vaccines globally, while also preparing stock for the 1/1/2021 Brexit deadline. This is because ISPM15 heat treatment (to be required for the 60 to 100 million pallet trips between UK and EU) can increase the likelihood of staining and subsequently mould. The industry best practice for pallet drying, developed from this research work has been shared by industry association TIMCON in Europe and the USA [P2].

The largest ever study on tiling battens [O6] (the first ever grading settings for this product under European system), allowed the Irish market to continue to produce tiling battens to their new national code of practice. This presents a very large market, since most buildings have them. This was another rapid response to industry need, enabled by our substantial existing body of research on home grown spruce, and deep understanding of the processes [O6, P4, P1]. A Technical Manager at a major Irish sawmill, explains the value of this as being *“part of our basket of products”* and *“if we didn’t have the battens, we could easily miss out in the region of €1 million in sales per annum”* [C6]. This need also illustrates the importance of standardisation work to avoid such problems before they affect industry.

Gathering of timber properties data for a number of lesser-used species [P1] has informed growers and policy makers of what to plant for enhanced forest resilience (pests, diseases, climate change), and work for sawmills to make it easier for them to process these species and find markets [C8, C9]. As a UK timber industry representative explains our work *“identifying the structural characteristics of a number of alternative species has informed the tree breeding sub sector where to focus their next breeding programmes, which are extremely expensive”*. [C8]

#### Route to impact

CWST’s research achieves impact via knowledge exchange and integration with industry partners working with us on projects, leadership work on standards and industry committees. Wider stakeholders are engaged through articles for magazines, workshops and CPD seminars, and dialogue. Academic conferences and journal papers are an indirect means of impact, via other researchers.

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

- [C1] Testimonial from a production director of a major UK sawmill.
- [C2] Corroborating individual: Irish forest industry representative.
- [C3] Testimonial from an Italian timber industry representative.
- [C4] Corroborating individual: Chair of the UK Timber Grading Committee (and a sawmill General Manager).
- [C5] Corroborating individual: Director at a major UK sawmill.
- [C6] Testimonial from a Technical Manager at a major Irish sawmill.
- [C7] Corroborating individual: President of the Timber Packaging and Pallet Confederation.
- [C8] Testimonial from a UK timber industry representative.
- [C9] Corroborating individual: UK forestry research representative.