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Hardwoods in the United Kingdom – Considerations When Looking to Future Planting and Future Value Chains

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ABSTRACT

Reasons for increasing the diversity of the tree species providing wood for the value chain include: improving forest resilience to climate change; mitigating the risks of pests and pathogens; and improving other important functions of forests such as biodiversity, landscape protection and social benefits. This paper presents a summary of collated data on the broadleaves identified as having potential as future productive species in the United Kingdom, and that are currently being examined to create a shortlist for focusing resources on tree improvement work and silviculture. The data covers mechanical and physical properties, working qualities, natural durability, drying knowledge, and the potential for existing and emerging markets. Much of the data relating to UK-grown hardwoods is old, and not easy to find or interpret. The paper draws on information from the records of the former Forest Products Research Laboratory, as well as recent research data and industrial experience. The paper also summarises the work necessary to bring underutilised species into construction timber markets under the current standards framework. It outlines some of the knowledge that is missing in the current standards for hardwoods generally, and what needs to be done to make it easier for less mainstream hardwoods to be assigned structural design values. The aim of the paper is to inform researchers in countries facing similar challenges, in the hope that a more coordinated research strategy for wood value chain species diversification can emerge across Europe.

1. INTRODUCTION

The processing of the United Kingdom's home-grown timber has focused mostly on softwoods. The current hardwood harvest is less than 10% of the total, and around 85% of this hardwood is used only for wood fuel (Forest Research 2023). The existing broadleaf forest certainly has potential to help satisfy more of the country's needs for wood-based products in the coming years, but there is also a more long-term need to look at species choice for planting and restocking. Reasons include: improving forest resilience to climate change; mitigating the risks of pests and pathogens; and to improve other important functions of forests including biodiversity, landscape protection, social and cultural benefits. There is particular political and public focus on native broadleaves, but there inevitably also needs to be serious consideration of near-native and exotic species. This paper summarises collated data on the broadleaves that have been identified as having potential as future productive species in the UK, and that are currently being examined to create a shortlist for focusing resources on tree improvement work and silviculture. It aims to highlight the key information for researchers in the UK, and to inform researchers in countries that face similar challenges, in the hope that a more coordinated research strategy for wood value chain species diversification can emerge across Europe.

About 50% of the UK's forest area is broadleaf, of which 90% is in private ownership (Forest Research 2023). This means there is considerable variation in approaches and priorities to growing broadleaves, and much less standardisation than in the state and large company-managed conifer forests (Savill 2002), with consequent effects on wood properties. This is especially the case for England, where the forest area is about 75% broadleaf. The market for UK-grown hardwoods struggles to compete with imports, with challenging constraints including: the UK's very long tradition of importing hardwoods; higher profitability of UK-grown softwood; higher cost of land needed for hardwoods compared to conifers; costly establishment and management; lack of training in broadleaf silviculture; marketing difficulties due to the scale, consistency and relative poor quality of the existing resource; and the damage caused by grey squirrel and deer. Accessing markets when the industry is small is a challenge for growers even when

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they have good timber (Seminara 2023). There have also been issues with obtaining improved hardwood planting stock (Clark and Hemery 2009). The issues are long standing (Thurkettle 1997), perhaps for more than a century, but potentially now also facing reduction in wood fuel markets due to clean air legislation, and other renewable energy.

Nevertheless, there are many reasons other than timber markets to consider improving the forest management and resilience of the UK's broadleaves. Since the requirements for managing high forest for public access are similar to those for wood production, it should at least be possible to satisfy some element of the UK's timber demand, and raise some income to support the forest upkeep. Guides for hardwood production from forestry (Kerr and Evans 1993), farms (Brazier 1990), urban areas (Cooper 2012), and ancient woodland (Forestry Commission England 2010) cover the most common species, and the Future Trees Trust (www.futuretrees.org) is actively researching tree breeding and forest management. The SilviFuture network (www.silvifuture.org.uk) is sharing knowledge about the growth of the less common species, and several detailed species profiles for potential new introductions have also been published by the Royal Forestry Society. These consider timber production with future climate resilience, covering eucalyptus (Purse and Leslie, 2016a, 2016b), maples, planes, hickories, wingnuts, hop hornbeams, sweetgum, tulip tree (Wilson et al. 2017), southern beeches (Mason et al. 2018), oaks (Wilson et al. 2018a) and alders (Wilson et al. 2018b).

The potential for future markets for UK-grown hardwoods was examined by Law et al. (2016). According to Davies (2016) the main current construction markets for sawn UK-grown hardwood are for oak, as structural timber, external cladding and decking. Sweet chestnut is used for these to a lesser extent, and both have some minor use for making window frames and internal joinery. Ash, beech, and sycamore also have some minor use in internal joinery, although the devastating effects of chalara (ash dieback), means ash has very limited prospect for the future. There are some notable commercial examples: Vastern Timber produce thermally modified “Brimstone” cladding from ash, sycamore and poplar, and Buckland timber manufacture ash glulam. There are also recent experiments in using UK-grown hardwoods, including projects supported by Grown in Britain (www.growninbritain.org, e.g. split sweet chestnut coppice, Fereday et al. 2023), but in general core wood properties data is very under-researched in the UK.

2. Use in Construction – Current and Previous Possibilities for Strength Grading

The UK uses the European normative framework for visual and machine strength grading of sawn timber (Ridley-Ellis et al. 2022). Machine strength grading of UK-grown hardwoods is not yet possible, although of course non-destructive assessment methods can be used to inform their use in one-off construction and manufacture of laminated products. There is a visual grading standard, BS5756, with four grades for temperate hardwoods: TH1, TH2, THA and THB (the latter two being for large cross-section). There have never been any assignments for visually graded UK-grown hardwoods in EN1912, but grading to an EN338 strength class is possible for oak and sweet chestnut via the national non-contradictory complementary information (NCCI) document PD6693-1. While PD6693-1 is specific about sweet chestnut referring to Castanea sativa, the entry for oak is written only as Quercus spp. It should probably be assumed that this is intended to refer to the most familiar and commercially relevant “European oak” combination of Quercus petraea and Q. robur. The basis for these assignments is not explained, but, in 2006, when new EN338 strength classes for temperate hardwoods were being discussed, a short committee discussion paper provided a table of data (Fewell, 2006). There is little explanation in this very brief paper, but figures also given for beech and oak from Germany and eucalyptus from Spain match the results in detailed grading reports that are available to read, suggesting these do represent characteristic values, adjusted to 12% moisture content, calculated in a similar way to current standards. For some not explained reason the given values for characteristic strength of UK-grown oak and sweet chestnut are much lower than the PD6693-1 assignments. This is plausibly due to the calculation basis and its adjustment factors. At the time, EN384 imposed a ks factor that reduced strength based on the number of geographical sub-samples and the number of test pieces in them. Previous practice in the UK seems to have been a calculation based on three parameter Weibull with all sub-samples combined. Regardless of the explanation, what is given in PD6693-1 reflects what had been in the most recent versions the timber design code, BS5268-2, which the Eurocodes superseded. Comparing the design values in the older permissible stress code to the limit states Eurocode equivalent is rather complex (Fewell 1984a, 1984b), but BS5268-2 and PD6693-1 are consistent.

These assignments were based on relatively recent test data. An initiative by the timber trade, Forestry Commission and South East England Local Authorities had funded a research project at the Building Research Establishment to develop grading and structural standards for the use of chestnut for construction. Sawn timber samples, sourced from Southern England and the Forest of Dean, were tested to determine the strength properties in bending (Branden and Russell, 2001). A detailed testing report has yet to be located, but the results are summarised in a grading update report (Building Research Establishment 2000). This contains the information that the sampling attempted to capture the normal variation in the quality of the material, and that three cross-section sizes were tested. 50x100mm2, 100x200mm2 and 150x150mm2. It is reported that the bulk of the sweet chestnut tested conformed to the TH1 visual grade. Unlike modern practice, the timber was tested in bending green (above fibre saturation). Information about how the values of strength and stiffness were corrected to a reference 12% moisture content are not given in this summary. This study result in sweet chestnut's addition in BS5268-2:2002.

That work followed on from earlier testing by BRE that had established the grading for oak, apparently also of similar cross-section to the sweet chestnut (Building Research Establishment 2000). This is the data that supported the entry for oak in BS5268-2:1996 via an amendment in 1997; that being the year that the British visual grading standard for hardwoods, BS5756, was extended to cover temperate hardwood (the grades TH1, TH2, and THA and THB). BRE continued to do some research on oak, including oak from small diameter stems (Cooper and Chase 2004).

It is also known that, in 1991, BRE was undertaking research on Populus x canadensis cv. 'Robusta' for grading work, at that time for machine grading with bending type machines. It is not known what came of this study, but it did not lead to any strength grading possibility. What full size test data has been located seems broadly similar in stiffness to Lavers (1983). Possibly there is information in Mundy and Maun (1997), which has not yet been located.

Prior to oak and sweet chestnut being added to BS5268-2, engineers who needed to design hardwoods continued to use CP112-2, which had been superseded by BS5268 in 1984. Indeed, at least for traditional green oak construction this continued to be the case afterwards as well (Ross et al. 2007). CP112-2:1971 (and the 1967 non-metric version) had a different basis for timber strength grading; that of small-clear testing (Booth and Reece 1967). It contained design values for UK-grown ash, beech and oak as well as visual grading rules as alternative to BS4978. Slightly later BS4978 covered temperate hardwoods, but the grading possibility for this does not ever seem to have been used and in the transition to BS5268 (see Ozelton and Baird 1982), it became BS4978 for softwood and BS5756 for hardwood.

3. Historical Data

Knowledge about the properties and other characteristics of UK-grown hardwoods goes back many years, although not all of this knowledge is based on the standard of evidence we would expect today. Information is often repeated without links to the original sources, giving the impression that there is more data than there is in reality. A non-specialist reader might easily be misled by the various ways of expressing data about properties such as density and strength, and the ways in which results can be influenced by sampling and testing methods. On the other hand, information that is based on good quality science might be thought to be to have been based on educated guesswork from long-standing practice, because the original reports are hard to find or unknown. A significant inspiration for writing this paper was the discovery that documents about the testing of UK-grown timber, previously thought to have been lost to history, had been placed in the National Archives (and other repositories).

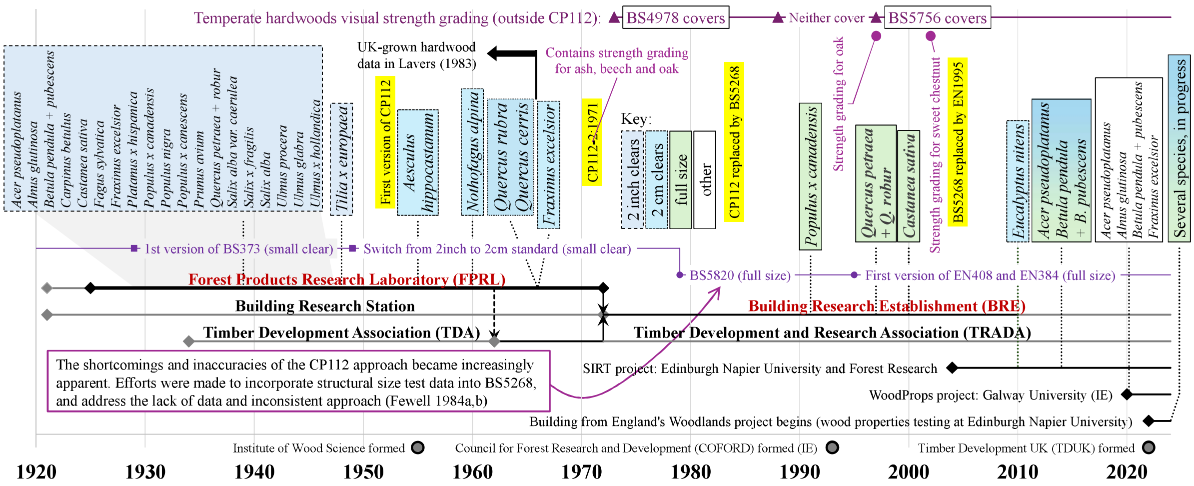

Figure 1: Timeline of mechanical properties research and standards for UK hardwoods (including some information from Ireland)

Table 1: Main broadleaf species being considered, their T-E-K scores, nativeness (N) and key references

Order	Family	Species	Common name	T	E	K	N	①	②	Other references
Fagales	Betulaceae	*Alnus cordata*	Italian alder	2	1	0	☆			
		Alnus glutinosa	Common alder	5	3	2	★	①	②	Llana et al. (2020)
		Alnus incana	Grey alder	3	1	1	★			
		Alnus rubra	Red alder	6	2	1	☆		②	
		Betula pendula	Silver birch 'Birch'	6	4	3	★	①	②	Price et al. (2022) ③④
		Betula pubescens	Downy birch							
		Carpinus betulus	Hornbeam	3	1	1	★	①	②	
		Corylus avellana	Hazel	3	2	1	★			
	Fagaceae	*Castanea sativa*	Sweet chestnut	7	4	4	★	①	②	BRE ~ 2002 ?
		Fagus sylvatica	Beech	6	4	4	★	①	②	Ridley-Ellis (2019)
		Quercus petraea	Sessile oak 'Oak'	7	5	5	★	①	②	BRE ~ 1997 ?
		Quercus robur	Pedunculate oak							
		Quercus rubra	Red oak	7	3	3	☆	①	②	
		Juglans nigra	Black walnut	4	2	1	☆		②	
		Juglans regia	Walnut	5	2	1	★		②	
		Nothofagus alpina	Rauli	5	2	1	☆	①	②	
		Nothofagus obliqua	Roble	4	1	1	☆		②	Mason et al. (2018)
		Nothofagus pumilio	Lenga	6	2	1	☆			
		Fraxinus excelsior	Ash	6	4	4	★	①	②	FPRL (1966) ④
		Paulownia tomentosa	Foxglove-tree	3	2	1	☆			
		Liriodendron tulipifera	Tulip-tree	6	2	1	☆		②	
Malpighiales		*Populus nigra*	Black poplar	6	3	2	★		②	
		Populus x canadensis	Hybrid poplar	4	2	2	☆	①	②	BRE ~ 1991 ?
		Populus tremula	Aspen	4	2	2	★		②	
		Salix alba	White willow	4	3	1	★	①	②	
		Salix caprea	Goat willow	3	3	1	★		②	
		Salix fragilis	Crack willow	4	3	1	★	①	②	
		Salix viminalis	Osier	4	3	1	★		②	
		Tilia cordata	Small-leaved lime	4	3	2	★		②	
		Eucalyptus glaucescens	Tingiringi gum	0	0	0	☆			
		Eucalyptus gunnii	Cider gum	2	0	1	☆			
		Eucalyptus nitens	Shining gum	6	2	1	☆			Moore (2010)
Rosales	('Sorbus')	*Aria edulis*	Common whitebeam	0	0	0	★			
		Cormus domestica	Service-tree	2	0	0	★			
		Sorbus aucuparia	Rowan	1	0	0	★			
		Torminalis glaberrima	Wild service-tree	2	0	1	★			
		Prunus avium	Wild cherry (gean)	5	2	2	★	①	②	
		Acer campestre	Field maple	5	2	1	★			
		Acer macrophyllum	Oregon maple	5	2	1	☆			
		Acer platanoides	Norway maple	4	2	1	☆		②	
		Acer pseudoplatanus	Sycamore	6	3	3	☆	①	②	Price et al. (2022) ③④
		Acer saccharinum	Silver maple	5	2	1	☆		②	

T, E & K = Technical, Economic & Knowledge scores (0 to 7 higher is better), N = Nativeness (darker is more native)
References: ① = Lavers (1983), ② = Pratt et al. (1997), ③ = also Price et al. (in press), ④ = also Llana et al. (2020)

Figure 1 shows a timeline of mechanical properties research for UK-grown hardwoods, together with the normative framework of the time and the main research providers. It includes some information from Ireland since timber from both countries is considered comparable thanks to similar forest management and climate. The aim of collating this data was similar to that of Huber at al. (2023), but considering alternatives to Sitka spruce in UK rather than Norway spruce in Europe. This paper is focused particularly on the main broadleaf alternatives (Table 1).

Investigations into the properties, uses, and future potential of home-grown wood go back a long way in the UK (e.g. Evelyn 1664, Selby 1842), including work relating to the construction of wooden ships. Thomas Laslett was timber inspector for the Admiralty and his book (Laslett and Ward 1894) contains much interesting information, including data he gathered from testing of UK oak, ash, elm and hornbeam in bending, tension and compression (as well as many imported timbers). Laslett was interested in seeking out new species with potential to satisfy growing need in the face of declining supply; a parallel to our contemporary situation perhaps, but the data, albeit based on quite large-dimensioned specimens, is from a small number of test samples per species. The focus of study later transferred to wood and wood products in aircraft, for which Jenkin (1920) provides a lot of data. Almost all of this is about imported timber, but there is a very detailed discussion of mechanical testing methods that is still relevant today.

Strategic research into the properties of home-grown and overseas timbers really began with the foundation of the Forest Products Research Laboratory (FPRL) in 1925, working initially with the Royal Aircraft Establishment at Farnborough, but soon opening its own facilities at Princes Risborough in 1927. FPRL was part of a wider UK Government response to the strategic importance of timber following the First World War. Being a timber importing country, much of the work was about timber from overseas, but there was also an objective to increase the production and utilisation of home-grown timber. Rendle (1976) provides a history outlining the main activities and events up until the point that Government funding ended, and the site was transferred in 1972 into the Building Research Station, becoming the Building Research Establishment (BRE). A few years earlier, some more industry focused work had passed to the Timber Development Association (becoming TRADA). Work still continued on home-grown timbers in cooperation with Forestry Commission, even after 1988 when work transferred to BRE's site in Watford.

Different lines of investigation were followed in several research projects that all yielded large amounts of data on a wide variety of species. Much of these data, mostly generated between 1926 and the Second World War, form the basis of our understanding of timber properties of many of the UK-grown hardwood species even now.

One of the most important lines of work in the early years of FPRL was the characterisation of physical and mechanical properties, stating as "project 1". The project began with testing small clear specimens of 2inch cross section in three-point bending, impact bending, compression parallel to grain, tension perpendicular to grain, shear, cleavage and Janka hardness. Specimens were cut from logs in pairs for testing in green and air-dry condition, which allowed to quantify the moisture-dependency of mechanical properties. Most testing on home-grown hardwoods appears to have been finished when the second edition of "The handbook of home-grown timbers" was published (FPRL 1939). Project reports provide a lot of background information to this data. For example, for oak it can be seen in FPRL (1936) that the trees came from Bedgebury (Kent), Oakenhill (Forest of Dean), Brandon (Suffolk) and Walcot Park (Shropshire). There were no large differences in wood from the different localities.

Nowadays the best-known summary of mechanical properties in the UK is probably Lavers (1983), although most of the UK-grown hardwood data had been in earlier versions by F.H. Armstrong. Of note is that FPRL switched from using 2inch small clears to 2cm small clears in 1949. There is some discussion in Lavers about the conversion, but more information can be found in Armstrong (1955). Of some note is that FPRL were using a method that supported the 2cm bending specimens in rotating trunnions rather than on curved bearings.

Additional data on mechanical and physical properties was also generated in "project 18". At the beginning of the project, the general anatomy of different species and the influence of wood structure on timber properties was investigated, but later the focus shifted more towards tension wood in temperate hardwoods, as this seems to be most influential. Data on compression strength, toughness and tensile strength are published in various reports, although average properties are often not explicitly stated, and reports focus rather on the comparison of normal and tension wood. Some reports also determine longitudinal shrinkage in tension and normal wood and report on observations during machining. The findings are summarised by Clarke (1939), but the property data, even of normal wood, collected within project 18, is not included in summaries like "The handbook of home-grown timbers".

Another highly important line of investigations from the earliest days of FPRL was the establishment of effective and efficient air- and kiln-drying methods, with "Project 5" starting lab-scale trials in 1926 and quickly advancing to full-scale kiln tests to support industry. Reports on kiln-seasoning properties within project 5 contain descriptions of the tree stands, the history of the logs, information on defects visible in logs and sawn timber, as well as data on specific gravity in the green and dried state and shrinkage in radial and tangential direction. It is this work that supports the majority of the entries in BRE's "Timber Drying Manual" (Pratt et al. 1997).

4. Informing Future Species Choice – and the T-E-K Scoring Approach

Decisions already need to be made about the broadleaf species for new planting, and where to target effort for tree nurseries and silvicultural research. The relevant factors are much wider than wood products, but this is still a necessary component since industry, markets and standards also need time to adapt. There is a view that 'if there is potentially useful wood the industry will find a way to use it', but experience suggests otherwise for broadleaves with, for example, stands of high quality UK-grown beech having to be sold for firewood as the only accessible market.

Financial resources, land and time are limited, and it is becoming increasingly vital to make wise decisions quickly. Forestry is, of course, well experienced with taking the very long view, but it also needs to apply the "fail fast" approach more commonly seen in the technology sector. The UK's state forestry bodies are beginning to look at this; gathering data and setting criteria with input from the industry and researchers. A recent study has already been published for conifers (Peters et al. 2021), but this kind of exercise is also now underway for broadleaves as well.

The most important criteria are related to site suitability; the prospect of healthy growth in different parts of the country, on land available for forestry. Given the growth rate and longevity of many broadleaves this means looking at climate scenarios to at least 2080. Considerations include drought and frost resistance, wind and fire risk; droughtiness being a particular problem for Southern England with consequences for the existing broadleaf forests there. Another key consideration is the pests and pathogens risk profile; not just for the species in consideration, but also the risks it might present for important native and established commercial species. Other factors include: current silvicultural knowledge for management; compatibility with existing commercial species for mixed stands; potential for tree improvement (wood quality, productivity, resistance); the plant and seed supply; the economics of establishment and productivity; carbon sequestration; and contribution to ecology and other forest functions. Relevant to this paper is the consideration of wood properties, uses and compatibility with the UK's wood value chain. Preliminary findings suggest that native birch seems to be scoring well overall. It has been known for a long time that the UK challenge for this is stem form, but work is underway to improve that for future establishment. Sycamore also scores well, but timber production faces significant challenge from damage by grey squirrels. Sycamore is naturalised, but disliked by some for its invasiveness; particularly for its impact on ancient native broadleaf woodlands.

To inform species choice on the main broadleaf species being considered for the UK (Table 1) data has been collected, and summarised by a three-dimensional scoring system:

- Technical (T) - This score expresses the potential inherent in the wood, based on its properties and other characteristics. Some aspects of this score can be improved through tree breeding and silviculture. The score is weighted towards construction use, but recognises that timber is needed for multiple markets, and that there needs to be a range of product types for different components of the log breakdown. It covers: strength, stiffness, density, natural durability, workability and reported usages relevant to the modern world. When the K score is low, a low T score does not necessarily mean lack of technical potential, only lack of data to evaluate it.
- Economic (E) - This score expresses the compatibility with the current timber industry in the UK. It describes the economic challenge to bring the resource to market. A high E score represents a species that can be adapted into the current wood value chain without major changes. A low score represents a species that would need significant changes for primary processing, manufacturing and end use. The E score is particular to the UK context and species would score totally differently in other countries. It covers workability, drying, market familiarity, similarity to used species, amount of work needed to develop a strength grading possibility, and documented use in markets that are not particularly demanding on species or properties.
- Knowledge (K) - This score expresses the confidence in the T and E scores. It describes the research challenge to bring the resource to market, and the level of risk that reality will be different from expectations. A high K score represents a species about which we can be confident thanks to research and/or experience. A low K score represents a lack of information, or having only information that may not be transferable to the UK context. It covers the amount of data, its relevance to UK-grown timber, the current level of research interest in the UK and Europe, and the familiarity on the European market.

The ratings, which run from 0 (low) to 7 (high) were calculated via algorithms; quantitative where possible, informed by expert judgement, but unavoidably subjective in many regards. For that reason, they should only be considered as a rough guide to a complicated topic.

5. Work Necessary to Bring Underutilised Species into Construction Timber Markets

There are significant commercial challenges in bringing unfamiliar species to the market, especially when the scale of the resource is much smaller than for mainstream species. However, with other drivers towards diversification it becomes necessary to make such routes for the future possible, and to do so in a way that does not make the commercial challenge harder still. The work that needs to be done has been discussed by Cramer (2023), but includes:

- Revising the European strength class system (or alternative ways of declaring properties), to better fit the actual properties of the resource; especially less dense temperate hardwoods. This has been understood since even the beginning of the development of European strength classes (Fewell and Sunley 1983), and the existing system already has flexibility not yet well used for local markets (Ridley-Ellis et al. 2016a).
- Research to support the safe calculation of secondary properties (Ridley-Ellis et al. 2016b), the various adjustment equations (e.g. for moisture content, specimen size, and other test factors), and the required limitations for assigning hardwoods into softwood strength classes.
- Routes that require less testing in exchange for more conservative results or restricted uses. Current standards require a lot of testing; even more so for less familiar species for those for which a variety of forest management styles make them more variable than mainstream timber species. The testing requirement can be entirely out of proportion to the size of the resource and its economic value, and ways need to be found to adapt it better to the context. This could perhaps include looking at ways to return to testing based on small-clear samples.
- Examine the ways that test standards influence the results, in order to better understand historical data.
- Development of new grading technologies to address the problem that the currently used grading indicators are often less well correlated with grade determining properties for hardwoods. That said, grading approaches need to be easy and cost effective even for small processors. Initial work is perhaps more usefully aimed at grading one-off timber batches, for specific projects, with focus more on high grading yield and simplicity, than achieving high design values for the graded timber.

Some of these challenges are being addressed within the "Building from England's woodlands" project and "An easier route to strength grading hardwoods" project. Eight UK-grown hardwood species are currently undergoing testing, and four more are being processed for future testing. Limited material is available for full-size bending tests according to EN408, but small clear testing is being done to supplement the data. Small clear bending tests are being done to both the 2inch and 2centimeter standards, in order to get a better understanding of historical test data and how timbers grown now compare to in the past. Non-destructive measurements are being performed on all bending specimens, mainly dynamic stiffness measurements using longitudinal vibration and/or ultrasound, as well as measurement of visual defects. Secondary properties are being characterised on small clear and full size specimens including: hardness; compression strength parallel and perpendicular to grain; shear modulus and shear strength; and fastener withdrawal strength. The species currently being tested are: common alder, ash, beech, birch, sweet chestnut, European oak, poplar and sycamore. The species being processed for future testing are: American red oak, aspen, wild cherry and lime.

6. Summary

In the UK, and across Europe, there is increasing need to consider the potential for broadleaves to provide timber for construction and other products. This is not just limited to under-utilised existing broadleaf forests, farm woodland and urban trees, but also to trees not yet growing, and species that are not currently common. Given the limited time and resources, there is need to focus and coordinate efforts for research, and share data to inform new planting and forest management. Historical data can help, but it can be difficult to locate, and challenging to translate into a form comparable with data obtained by testing to modern standards; there is potential for a non-expert reader to be misled. When data is very old, there is also a possibility that changed growth conditions since that time mean properties of the current resource are different. For this reason, it is also necessary to confirm the information that we think we know. That said, there is much valuable information in old reports about test effects, secondary properties and adjustments.

ACKNOWLEDGEMENTS

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BRITISH AND EUROPEAN STANDARDS

The most recent version is listed here. The text above refers to some specific earlier versions. All European Standards (EN) of the European Committee for Standardization (CEN) are published as British Standards (BS EN) by the British Standards Institution (BSI).

BS373:1957 Methods of testing small clear specimens of timber. BSI

BS4978:2007+A2:2017 Visual strength grading of softwood. Specification. BSI

BS5268-2:2002 Structural use of timber. Code of practice for permissible stress design, materials and workmanship. BSI

BS5756:2007+A2:2017 Visual strength grading of temperate hardwood. Specification. BSI

BS5820:1979 Methods of test for determination of certain physical and mechanical properties of timber in structural sizes. BSI

CP112-2:1971 The structural use of timber. Metric units. BSI

EN1912:2024 Structural Timber. Strength classes. Assignment of visual grades and species. CEN

EN338: 2016 Structural timber. Strength classes. CEN

EN384:2016+A2:2022 Structural timber. Determination of characteristic values of mechanical properties and density. CEN

EN408:2010+A1:2012 Timber structures. Structural timber and glued laminated timber. Determination of some physical and mechanical properties. CEN

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