SIRT

Strategic Integrated Research in Timber

Edinburgh Napier UNIVERSITY

timber properties of minor conifer species in Britain and future marketing opportunities

Dan Ridley-Ellis

Centre for Wood Science and Technology

National Forestry Conference

"Minor Conifers in Ireland"

The Queen's Anniversary Prizes
For Higher and Further Education
2015

What is wood quality?

- Wood quality depends on the application
- Most important thing is to have knowledge

Before we begin…

1) Focus on density (alone) is misleading
2) Species is not everything
   (to some it does not matter *at all*)

Density
– not always a good thing

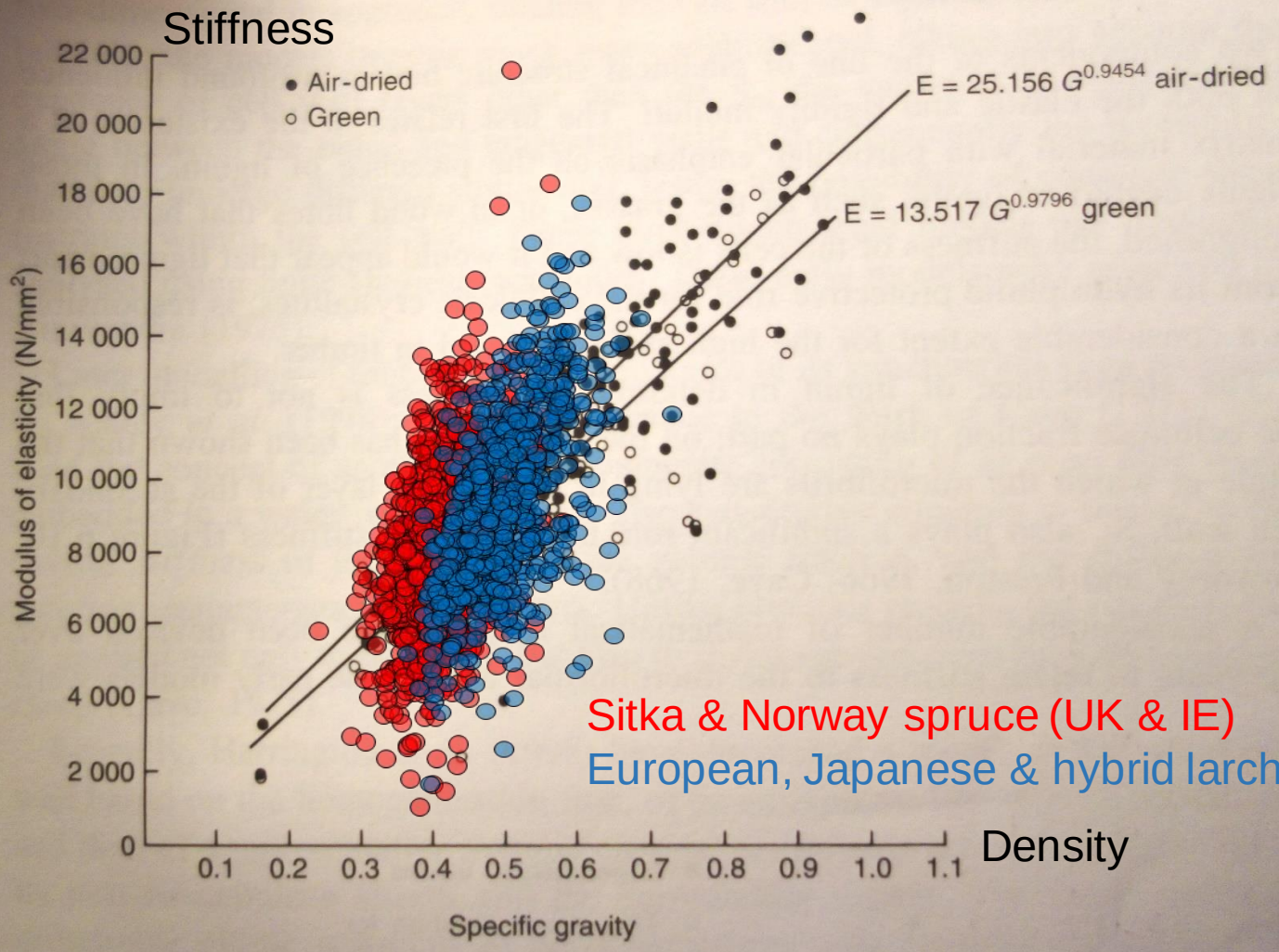


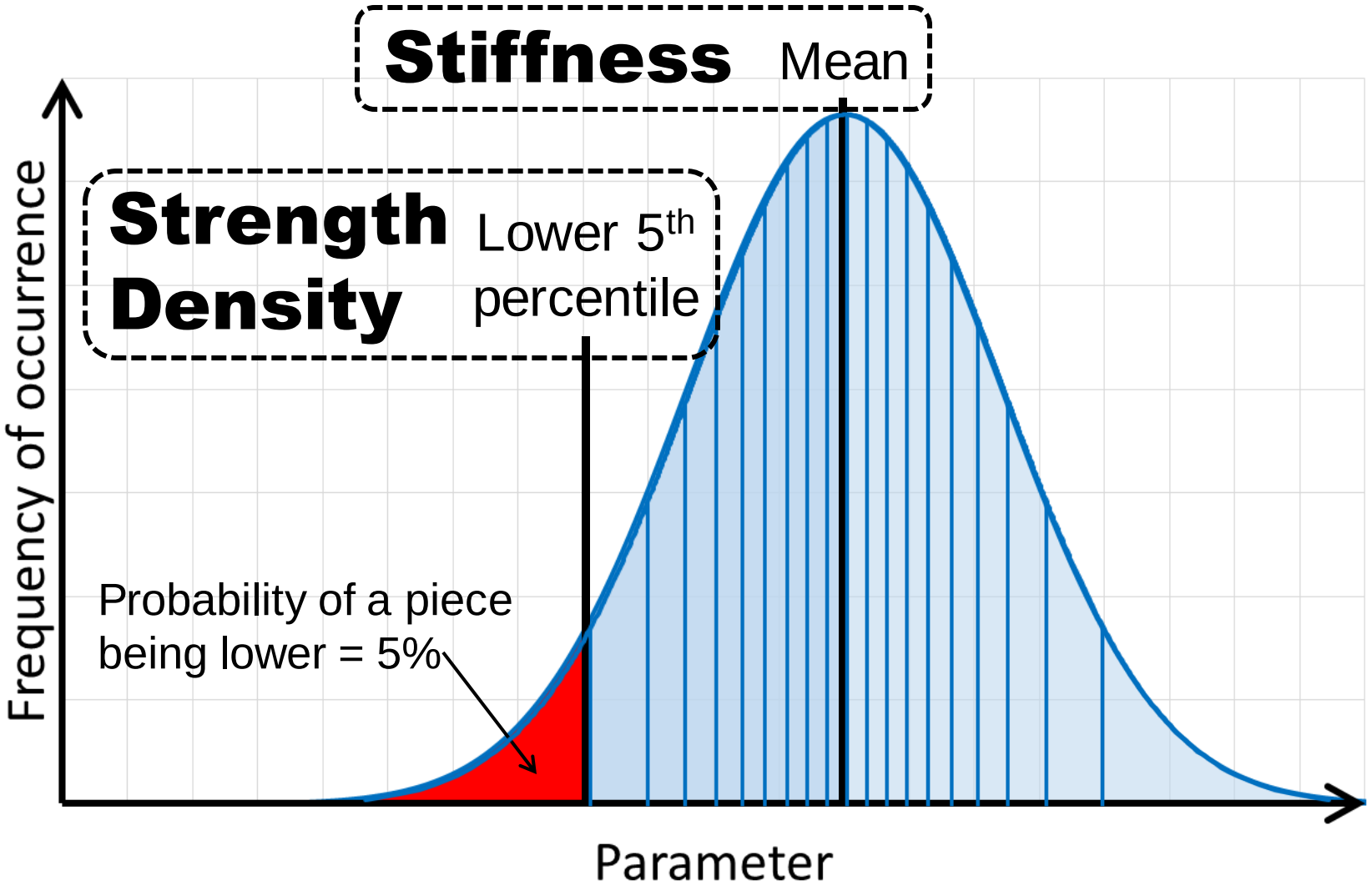
Figure 6.9 Effect of specific gravity on the longitudinal modulus of elasticity for over

Structural engineering design

- About buildings
  - Staying safe
  - Staying fit for use
- Dealing with uncertainty
  - Of material
  - Of the actions on a structure
  - Of analysis and construction
- True irrespective of the material

  (There is always some uncertainty)

Characteristic values

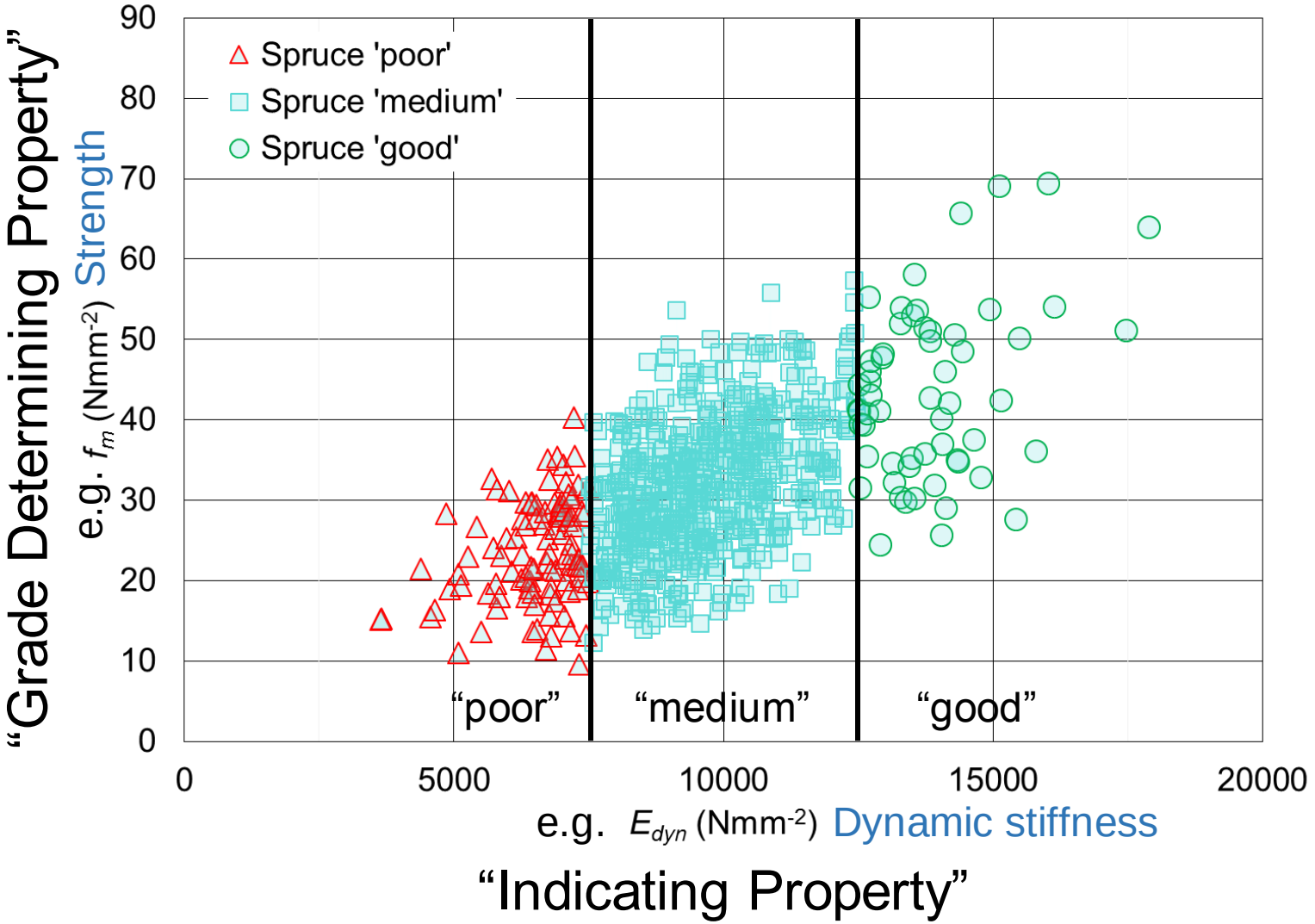


Current methods in Europe

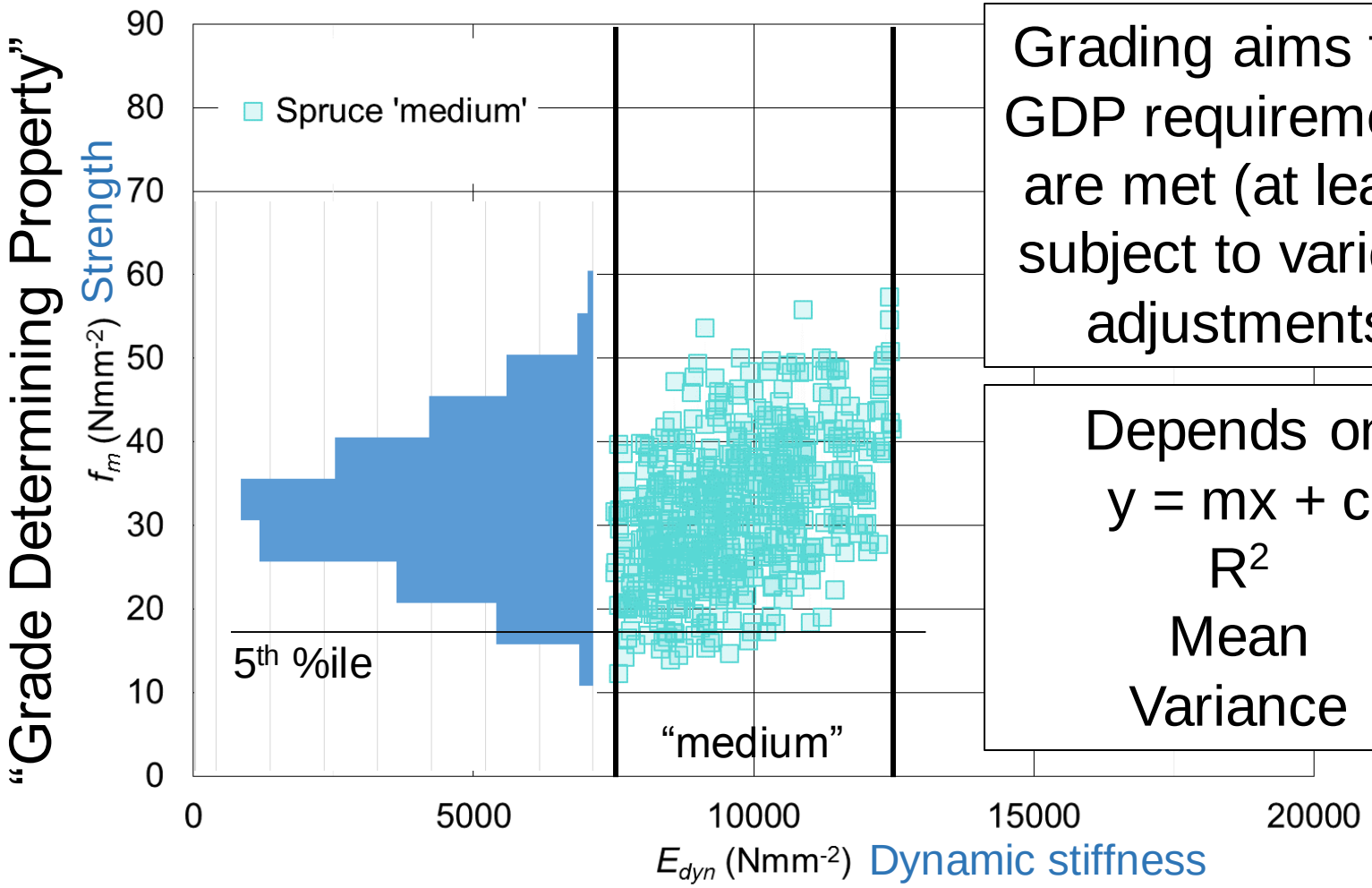
- Visual grading
  - Visually grade – then assign to strength class
- Machine grading
  - Machine control (large initial testing, fixed settings)
  - Output control (regular testing, settings can change)

- Slightly different basis
- …but same fundamentals

Grading – IP boundaries



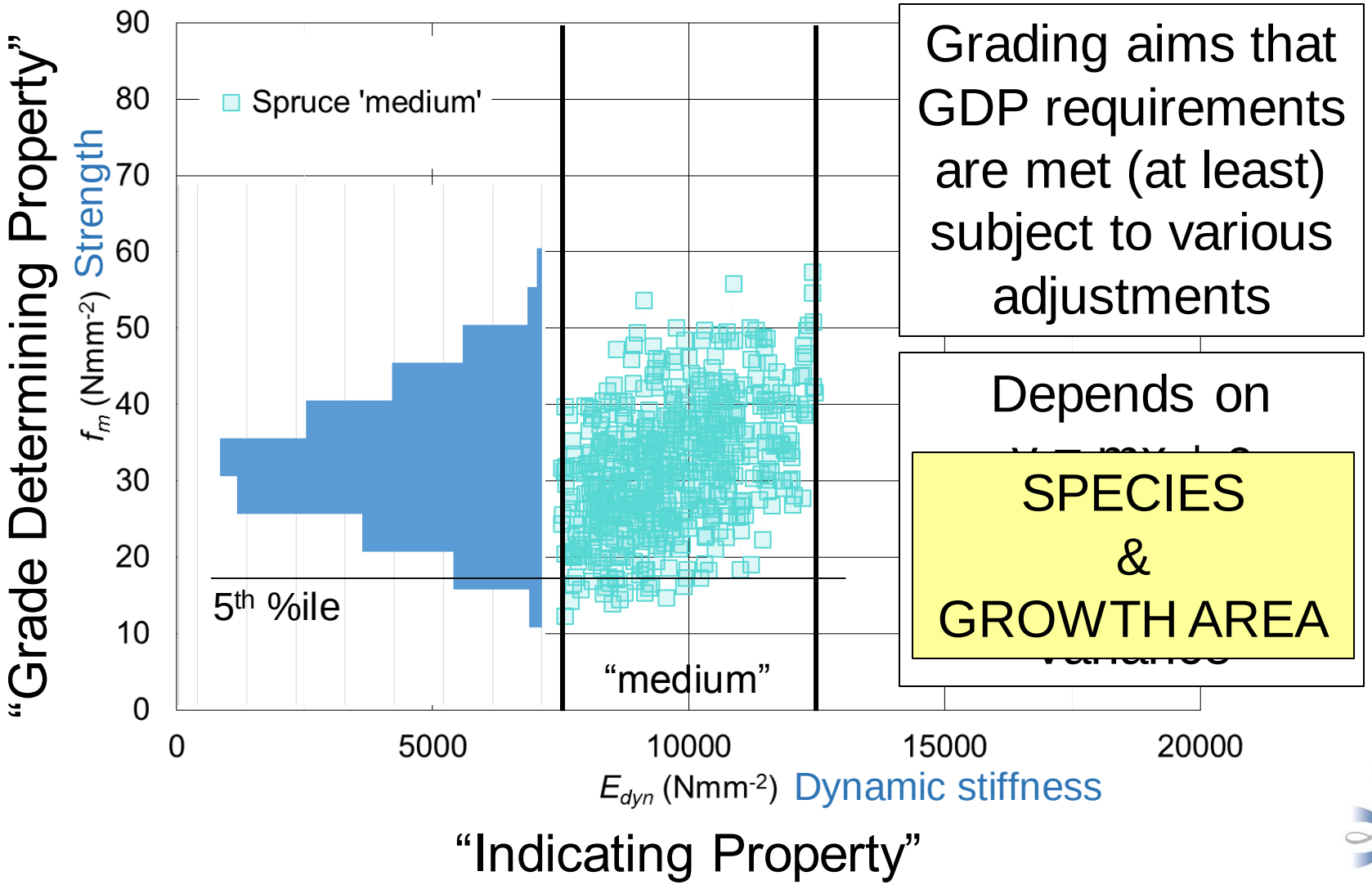
Grading – IP boundaries



Grading aims that GDP requirements are met (at least) subject to various adjustments

Depends on
$y = mx + c$
R^2
Mean
Variance

Grading – IP boundaries



Grading aims that GDP requirements are met (at least) subject to various adjustments

Depends on

SPECIES
&
GROWTH AREA

Means that…

- Grading not about properties of individual pieces – it is about collective properties
- Often only one of the GDPs is limiting
  - Strength
  - Stiffness
  - Density
- …indeed sometimes none of them are


Based on testing
EN 408
EN 384
EN 14358

What other challenges?

- Perhaps the biggest challenge is overcoming what people think is possible with home-grown wood

- Perhaps the biggest problem is junk and/or unverified knowledge
(both negative and positive)

What matters about properties?

- Properties and performance
  - Knowledge / predictability of
  - Variation in
  - Consistency of

  - Generic market categories (e.g. C16)

Some properties that matter

- Strength (bending, tension, shear, perp to grain, fracture etc…)
- Stiffness
- Density (fasteners, charring rate, self-weight, calorific value…)
- Dimensional stability / distortion
- Durability
- Colour and colour change
- Creep
- Finishing, gluing, painting etc

What might not be the same as same species grown elsewhere

- Density
- Strength
- Stiffness
- Knottiness (and appearance)
- Durability
- Drying distortion
- Reaction wood, splitting
- Log sizes and form

“Sitka”

- **“British spruce” WPCS** Species combination code EN14081

Species code EN13556

- Sitka spruce (*Picea sitchensis*) (PCST)
- Norway spruce (*Picea abies*) (PCAB)
- Typically graded C16/reject
  - But does contain potential for higher grades

- Maybe other species can be added?
  (doesn’t need to be spruce, just needs to be similar enough)

“Pine”

- **“British pine” WPNN**

- Scots pine (*Pinus sylvestris*) (PNSY)
  - Blue stain
  - Dead knots

- Austrian pine (*Pinus nigra*) (PNNN)
- Corsican pine (*Pinus nigra laricio*) (PNNL)?

“Larch”

- **“Larch” WLAD**
- Hybrid larch (*Larix x eurolepis*) (LAER)
- Japanese larch (*Larix kaempferi*) (LAKM)
- European larch (*Larix decidua*) (LADC)

- Durability
- But heavy
- Reputation for distortion, splitting

Douglas-fir

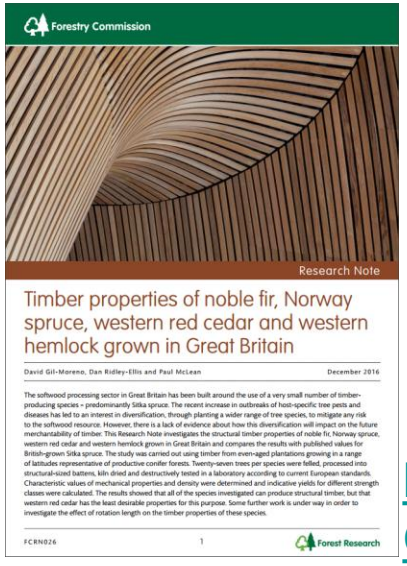
- Douglas-fir (*Pseudotsuga menziesii*) (PSMN)

- Has visual grading assignments
- Grading settings coming…

- Used as imported construction timber, in combination with Western larch (*Larix occidentalis*) (WPSM)

Up coming…

- Noble fir (*Abies procera*) (ABPR)
- Western hemlock (*Tsuga heterophylla*) (TSHT)
- Western red cedar (*Thuja plicata*) (THPL)


Forestry Commission

Research Note

Timber properties of noble fir, Norway spruce, western red cedar and western hemlock grown in Great Britain

David Gil-Moreno, Dan Ridley-Ellis and Paul McLean December 2016

The softwood processing sector in Great Britain has been built around the use of a very small number of timber-producing species – predominantly Sitka spruce. The recent increase in outbreaks of host-specific tree pests and diseases has led to an interest in diversification, through planting a wider range of tree species, to mitigate any risk to the softwood resource. However, there is a lack of evidence about how this diversification will impact on the future merchantability of timber. This Research Note investigates the structural timber properties of noble fir, Norway spruce, western red cedar and western hemlock grown in Great Britain and compares the results with published values for British-grown Sitka spruce. The study was carried out using timber from even-aged plantations growing in a range of latitudes representative of productive conifer forests. Twenty-seven trees per species were felled, processed into structural-sized battens, kiln dried and destructively tested in a laboratory according to current European standards. Characteristic values of mechanical properties and density were determined and indicative yields for different strength classes were calculated. The results showed that all of the species investigated can produce structural timber, but that western red cedar has the least desirable properties for this purpose. Some further work is under way in order to investigate the effect of rotation length on the timber properties of these species.

FCRN026 1 Forest Research

Noble fir and western hemlock are included in the “Hem-fir” combination (WABA)

https://www.forestry.gov.uk/pdf/FCRN026.pdf/$file/FCRN026.pdf

On the list

- European silver fir (*Abies alba*) (ABAL)
  - in European spruce and fir whitewood (WPCA)
- Pacific silver fir (aka amabilis fir) (*Abies amabilis*) (ABAM)
- Grand fir (*Abies grandis*) (ABGR)
  - Also in “Hem-fir” mix (WABA)

On the list

- Japanese incense cedar (aka sugi / Japanese red cedar) (*Cryptomeria Japonica*) (CYJP)

- Serbian spruce (*Picea omorika*)

Not forgetting hardwoods

- Sycamore (*Acer pseudoplatanus*) (ACPS)
- Birch (*Betula pendula/pubescens*) (BTXX)

EN338 now allows hardwoods to be graded to the C-classes (the “softwood” grades)
…particularly useful for the less dense species

Declaration of performance usually via

Strength classes (or "grades")

e.g. EN 338:2016

	Class	C14	C16	C18	C20	C22	C24	C27	
Strength properties in N/mm²									
Bending	$f_{m,,k}$	14	**16**	**18**	20	22	**24**	27	
Tension parallel	$f_{t,0,k}$	7,2	**8,5**	**10**	11,5	13	**14,5**	16,5	
Tension perpendicular	$f_{t,90,k}$	0,4	**0,4**	**0,4**	0,4	0,4	**0,4**	0,4	**0**
Compression parallel	$f_{c,0,k}$	16	**17**	**18**	19	20	**21**	22	**24**
Compression perpendicular	$f_{c,90,k}$	2,0	**2,2**	**2,2**	2,3	2,4	**2,5**	2,5	**2,7**
Shear	$f_{v,k}$	3,0	**3,2**	**3,4**	3,6	3,8	**4,0**	4,0	**4,(**
Stiffness properties in kN/mm²									
Mean modulus of elasticity parallel bending	$E_{m,0,mean}$	7,0	**8,0**	**9,0**	9,5	10,0	**11,0**	11,5	**1**
5 percentile modulus of elasticity parallel bending	$E_{m,0,k}$	4,7	**5,4**	**6,0**	6,4	6,7	**7,4**	7,7	
Mean modulus of elasticity perpendicular	$E_{m,90,mean}$	0,23	**0,27**	**0,30**	0,32	0,33	**0,37**	0,38	
Mean shear modulus	G_{mean}	0,44	**0,50**	**0,56**	0,59	0,63	**0,69**	0,72	
Density in kg/m³									
5 percentile density	ρ_k	290	**310**	**320**	330	340	**350**	36	
Mean density	ρ_{mean}	350	**370**	**380**	400	410	**420**	4.	

UK-grown timber

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C14 C16 C18 C20 C22 C24 C27

confident

Actual resource

Spruce (Sitka & Norway)

Larch (European, hybrid & Japanese)

Scots pine (estimate based on existing settings)

indications from limited datasets

Indications of ~45 year rotation crop

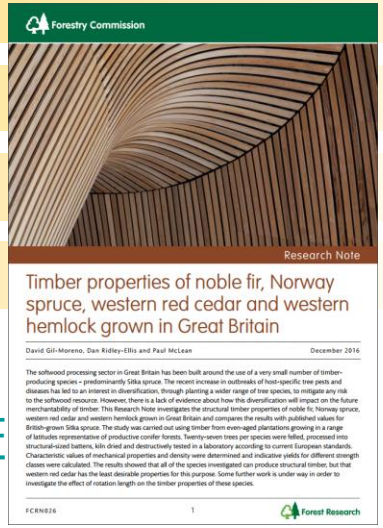
Douglas-fir

Norway spruce (alone)

Western hemlock

Noble fir

Western red cedar



https://www.forestry.gov.uk/pdf/FCRN026.pdf/$file/FCRN026.pdf

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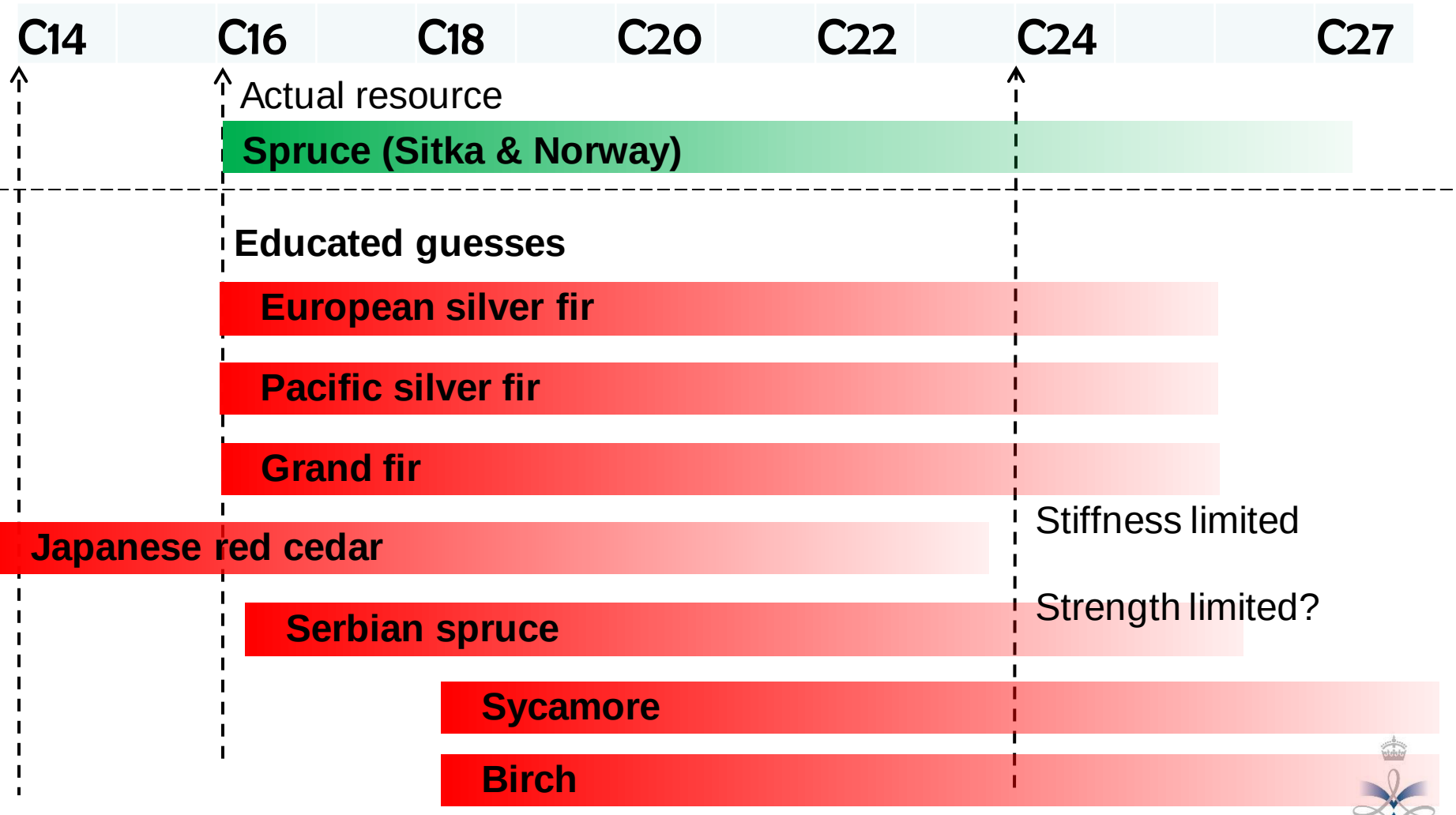
UK-grown timber



Routes for structural timber

- Routes for CE marking
  - Visual grading
    - No minimum requirement, but need some 200-400 pieces
  - Machine grading (machine control)
    - If machine already used, requires 450 pieces (ideally 1000)
  - Machine grading (output control)
    - Requires continuous testing, not suited to small volumes
- Expensive…requires lots of timber

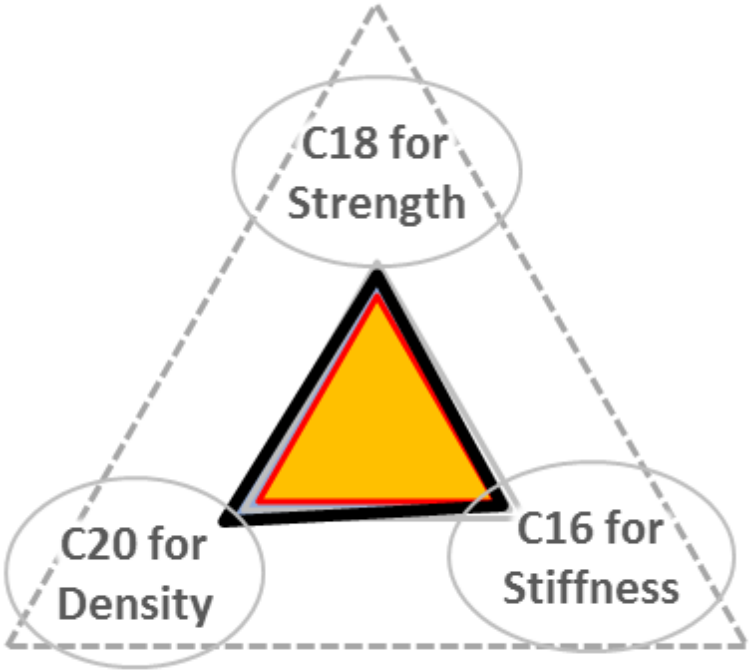
Bypassing CE marking

- One off buildings
- Within a manufacturing process

- …but still need to be safe

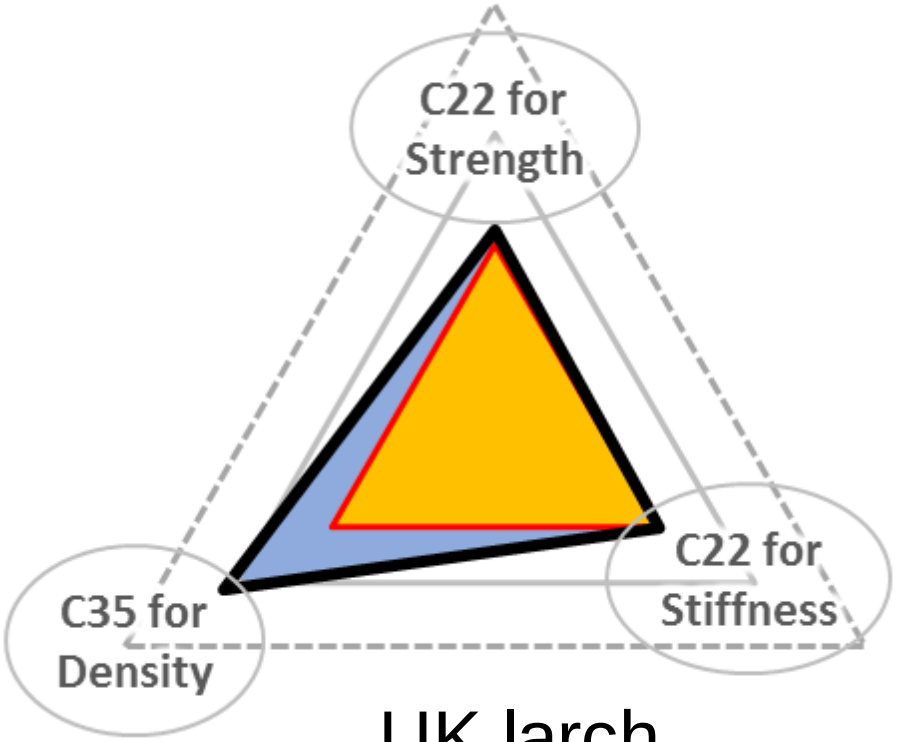
- And convince an engineer

Commodity strength classes



British spruce (WPCS)

“C16+”



UK larch (WLAD)

Example, UK larch with MTG

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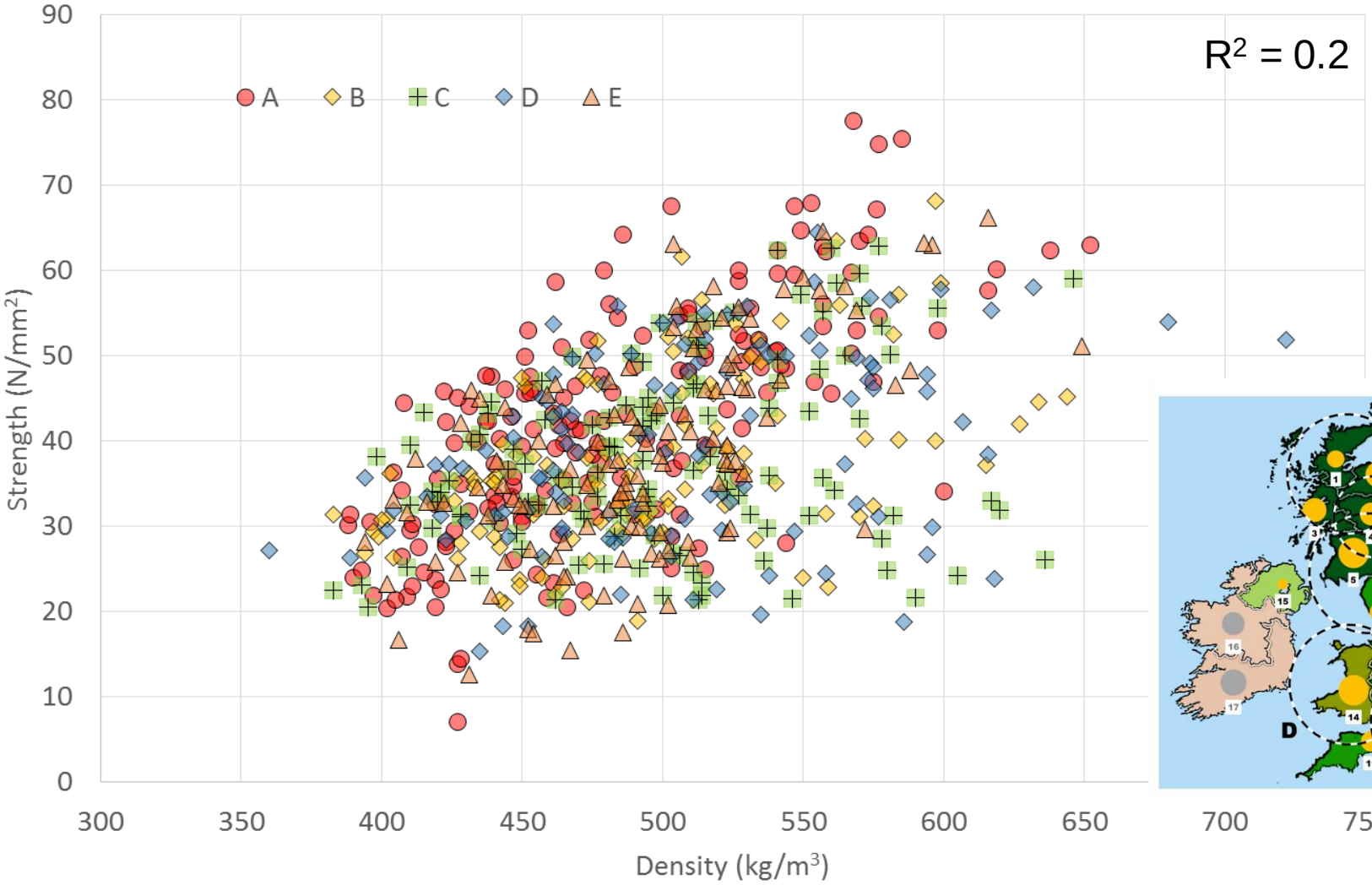
The Brookhuis MTG is a resonance type machine

Strength and density



User defined strength classes for home grown timber (can be graded with Brookhuis MTG960)

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Option 1 – approximately ¼ & ¾

C24	Strength > C24 Stiffness = C24 Density > C27	NapierSA	**British spruce** Sitka spruce (*Picea sitchensis*) Norway spruce (*Picea abies*) GB & IE
C16	Strength = C16 Stiffness = C16 Density = C18	NapierSC	
C30	Strength = C30 Stiffness = C35 Density > C50	NapierLA	**UK larch** European larch (*Larix decidua*) Hybrid larch (*Larix x eurolepsis*) Japanese larch (*Larix kaempferi*) GB
C18	Strength > C20 Stiffness = C18 Density = C40	NapierLC	

Option 2 – approximately ½ & ½

NapierSB	Strength = C22 Stiffness = C22 Density = C27	C22
NapierSD	Strength > C14 Stiffness = C14 Density = C16	C14
NapierLB	Strength > C27 Stiffness = C30 Density > C50	C27
NapierLD	Strength = C20 Stiffness = C16 Density = C35	C16

For information contact Dan Ridley-Ellis, Centre for Wood Science & Technology d.ridleyellis@napier.ac.uk http://blogs.napier.ac.uk/cwst/

What is not going on to help?

- Standardisation demanding more and more test information
- Unfamiliarity of engineers with wood
- Habitual specification of the usual species
- Over specification of grade

WoodProps Ireland

- New joint project (IE with UK)
  - Timber Engineering Research Group at NUI Galway
  - Centre for Wood Science & Technology, Edinburgh Napier University

Funded by the Forestry Division of the Department of Agriculture, Food and the Marine.

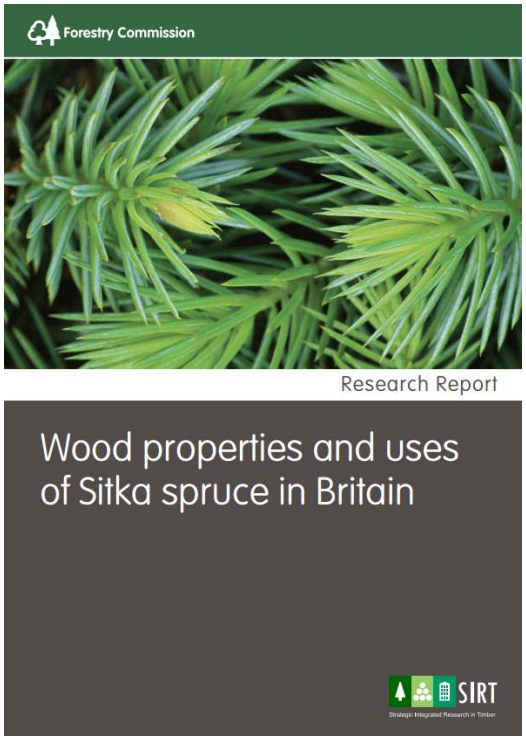
WoodProps Ireland

- Characterisation of Irish-grown timber
- Work at National and European level in standardisation for structural timber quality and production
- Exchange of knowledge related to wood quality, products and standards with forestry and processing industries
- Expert advice to regulatory bodies related to construction of modern timber buildings

WoodProps Ireland

- Sitka / Norway spruce
  - Link to UK work
  - Monitoring, prediction of trends
  - Differences public & private estates?
  - Other sources of degrade

- Other species:
  - Norway spruce
  - Douglas-fir
  - Scots pine & lodgepole pine
  - …broadleaves?



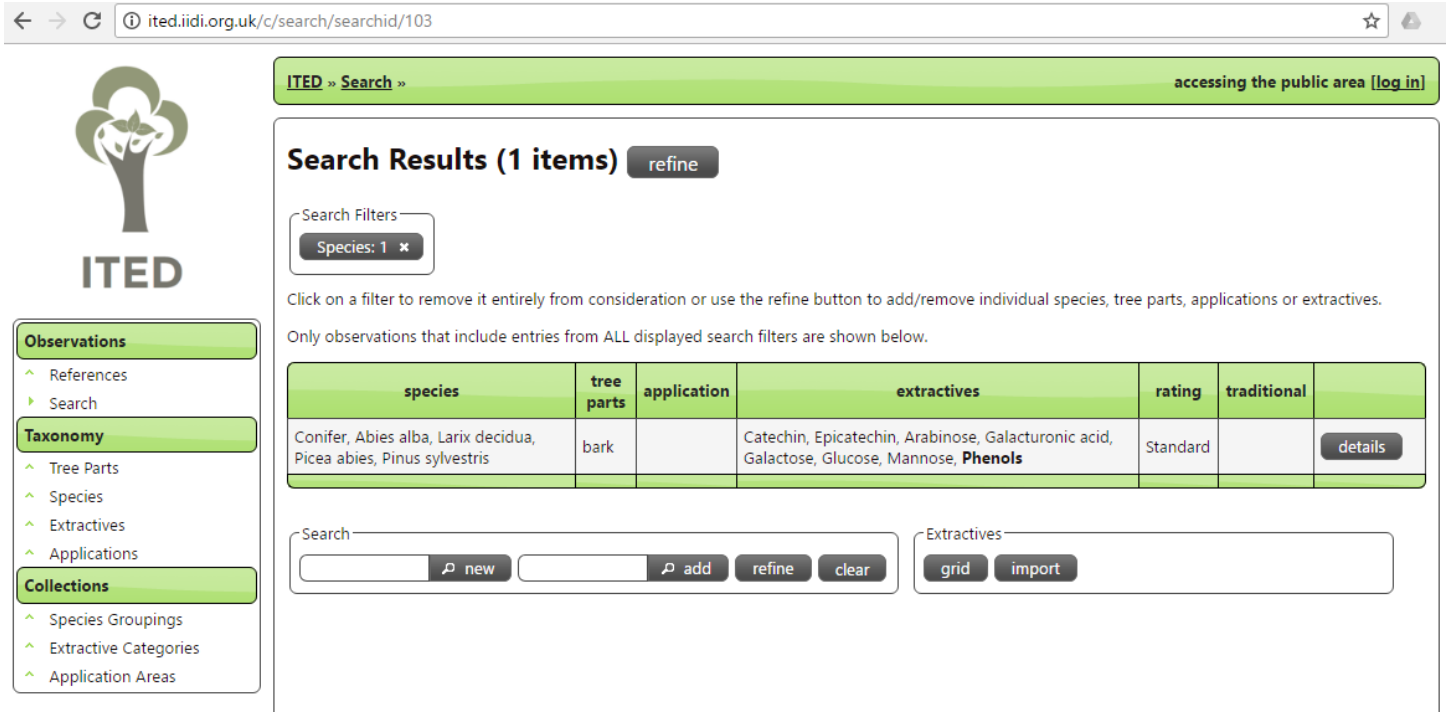
http://www.forestry.gov.uk/pdf/FCRP015.pdf/$FILE/FCRP015.pdf

Other markets

- Laminated products
- Engineered wood products
- Panel products
- Modified wood
  - Thermal modification
  - Chemical modification
- Bioenergy

Other markets

- Biorefinery
  - Extractives
  - http://ited.iidi.org.uk/



Finally: it's what you do with it

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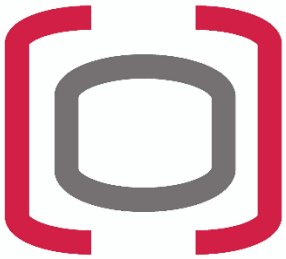

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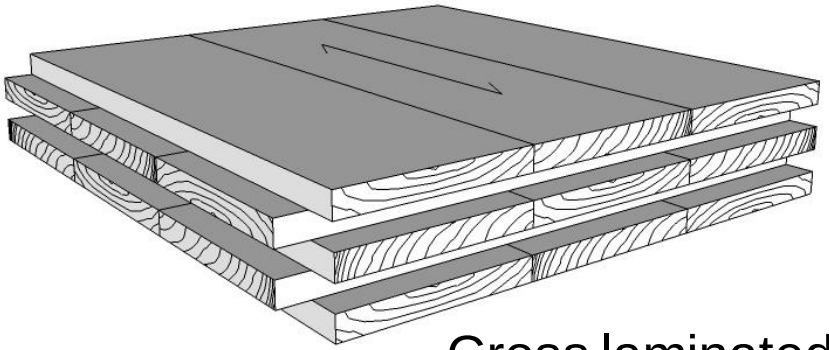
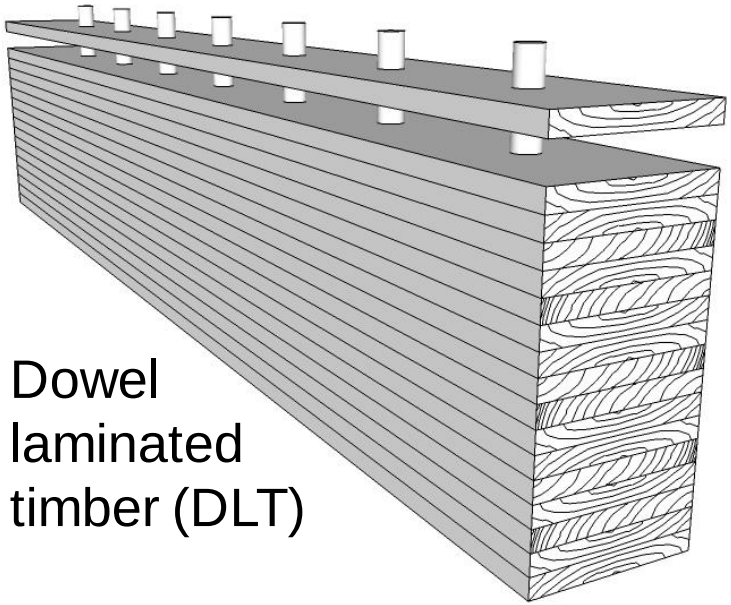
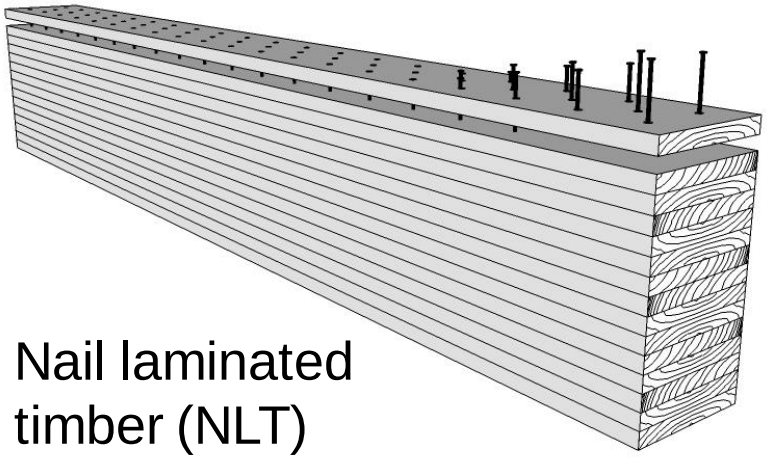
Laminated products



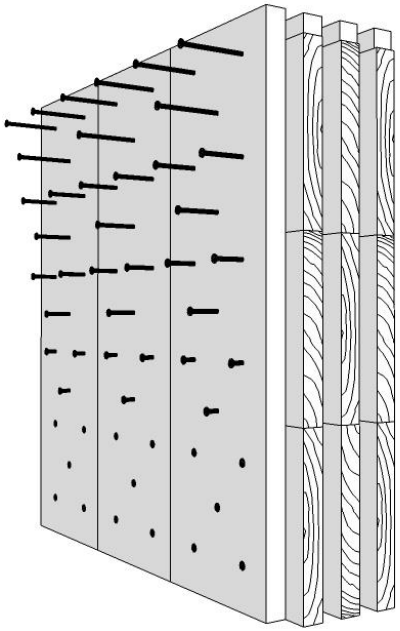
Cross laminated timber (CLT)



Dowel laminated timber (DLT)



Nail laminated timber (NLT)



Nailed cross laminated timber (nCLT)

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Dowel laminated timber (DLT)

Nailed cross laminated timber (nCLT)

Cross laminated timber (CLT)

Journal:

- Crawford, D., Hairstans, R., Smith, S. & Papastavrou, P. (2015) "UK Cross-Laminated Timber (CLT): Market Assessment, Resource Compatibility and Structural Performance" ICE Construction Materials Volume 168, Issue 3.

Conference:

- Crawford, D., Hairstans, R. & Smith, R. (2013) "Feasibility of Cross-Laminated Timber Production from UK Sitka Spruce" COST Action FP1004 Focus Solid Timber Solutions – European Conference on Cross Laminated Timber, 23rd – 24th May, Graz University of Technology