

Weighing trees with lasers: new insights from tropical forests to urban churchyards

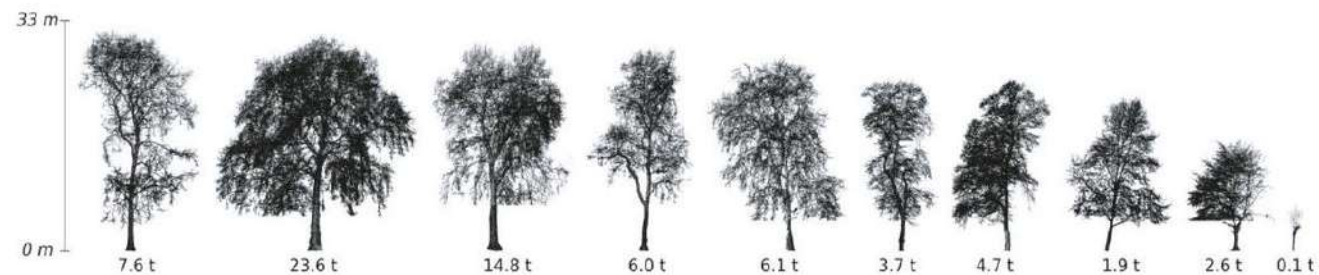


Prof Mat Disney, UCL and NCEO

What is a tree?



(a)



(b)



(c)

A voyage on the good ship Phyton

Gymnosperms and Forests

329

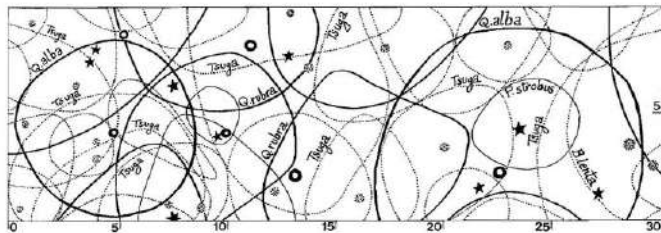


Fig. 93. Profile of a forest plot 10 × 30 m at Harvard Pond, Harvard Forest, Petersham, Massachusetts, USA, prepared by the methods described in this book. Trees of the present (in outline) dicotyledons; trees of the future (densely stippled) mainly *Tsuga canadensis*, most understorey dicotyledons are being smothered. Compare this figure to Figure 85 in order to understand slow, steady growth of gymnosperms. Further explanation in the text

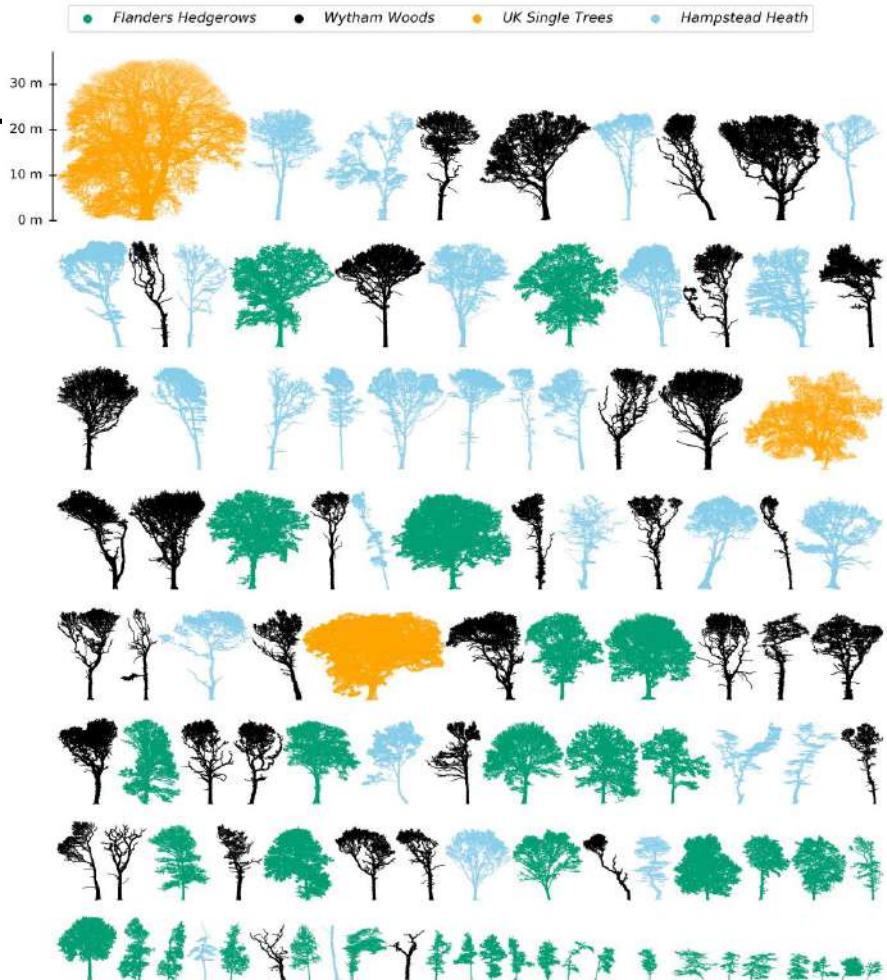


1970s ++ Renewed interest in why forests look like they do

And how to measure them

What do we want to know

- How much carbon is there in a tree? How can we weigh it? Or a forest?
- What is the 'treeness' of a tree – why does an oak in one place look wildly different to one elsewhere?
- How do we value trees and can we do it better?
- Seeing trees differently



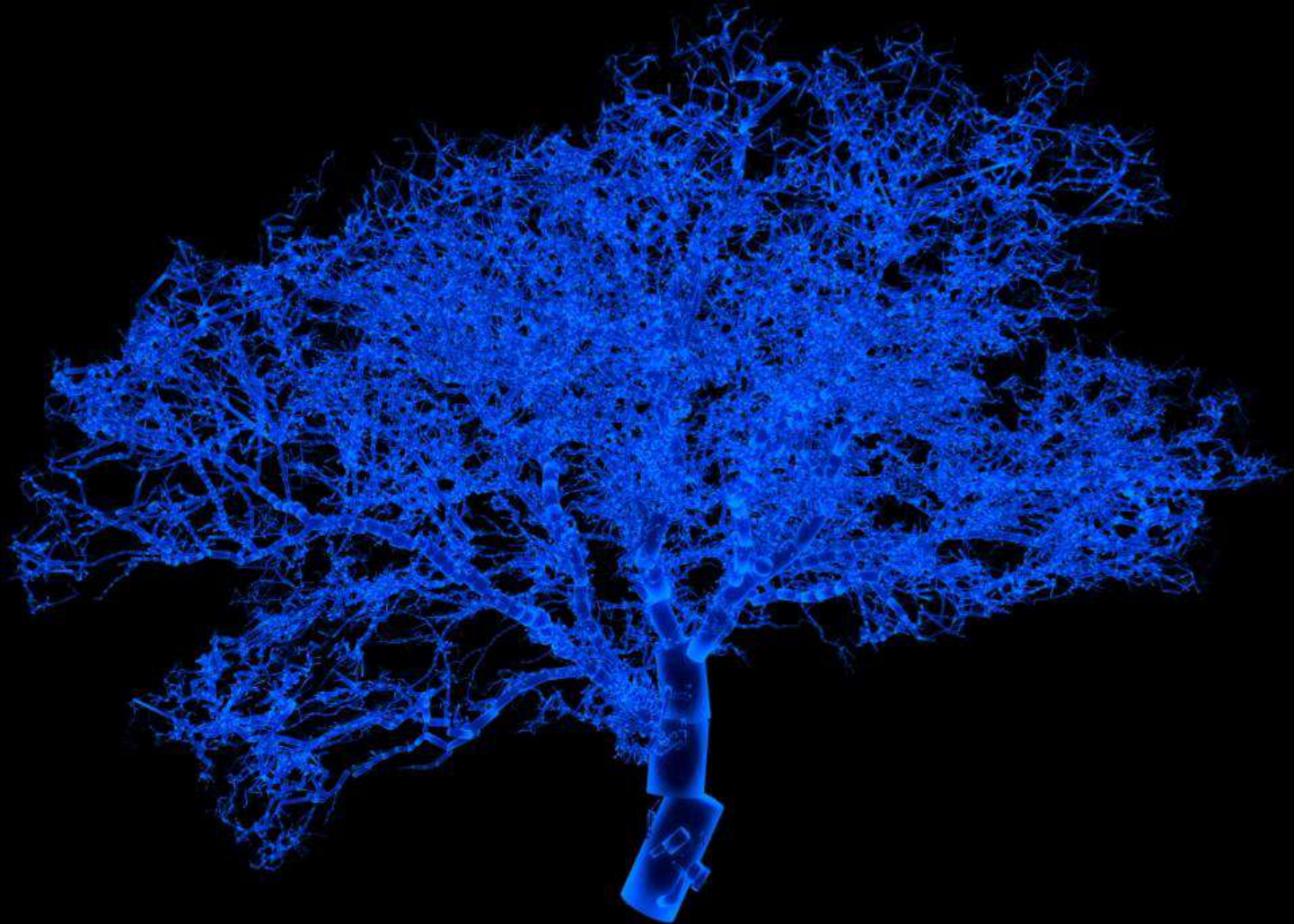
Rogue's gallery of oaks

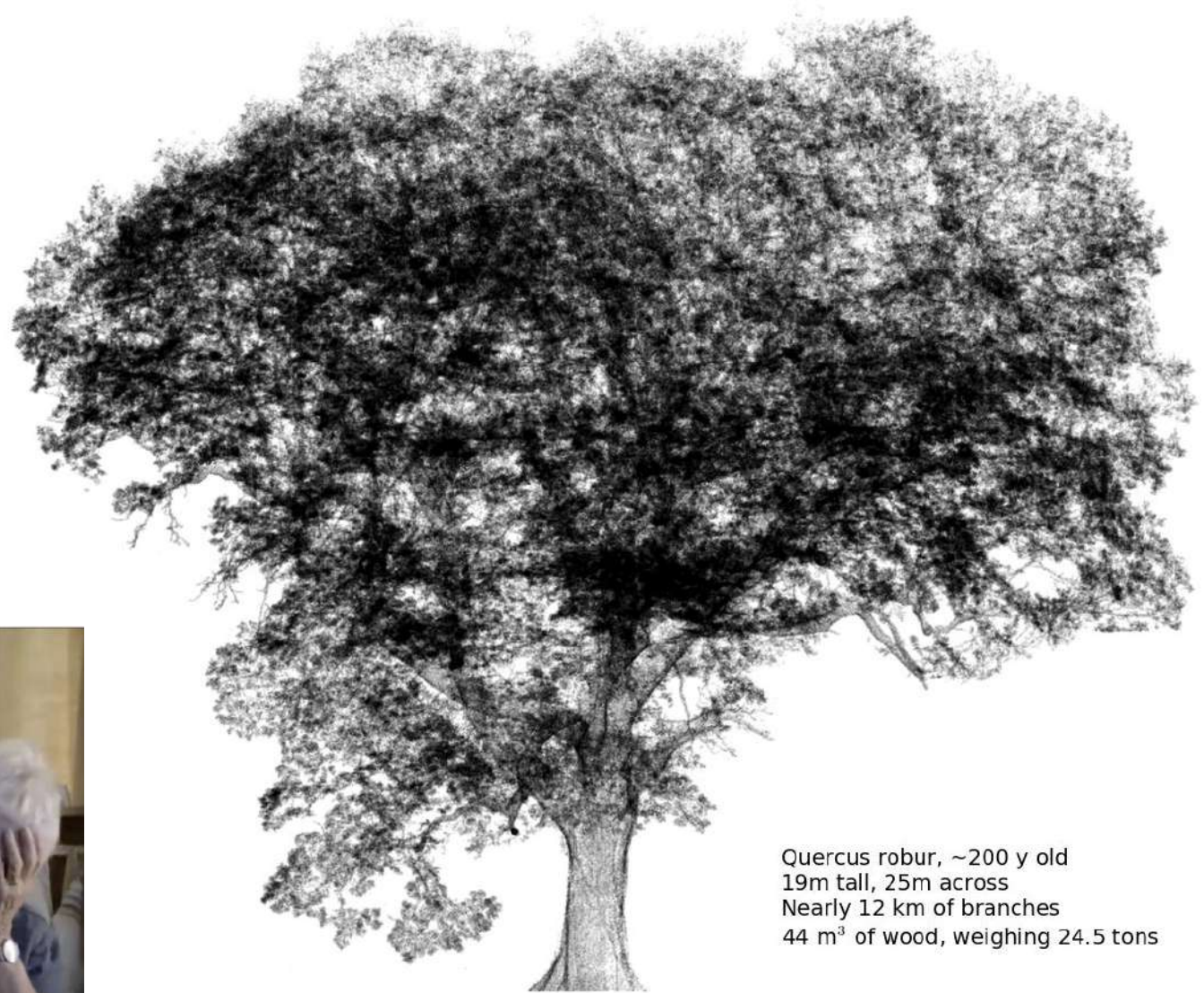


Capturing TLS data



Turning points into trees





Quercus robur, ~200 y old
19m tall, 25m across
Nearly 12 km of branches
44 m³ of wood, weighing 24.5 tons



It's riveting!

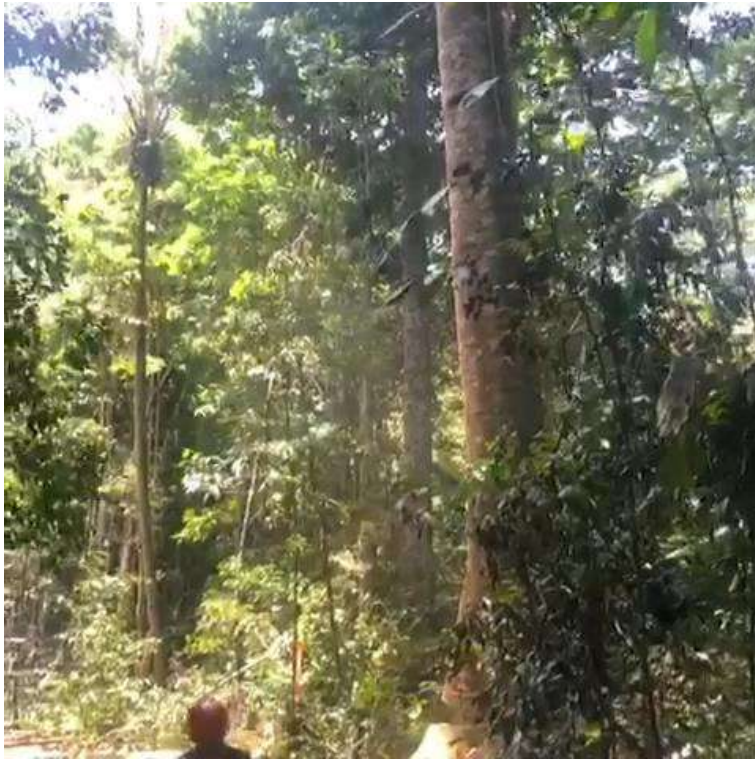
(Judi Dench My Passion for Trees:
<https://www.youtube.com/watch?v=48tHOY-TvLE>

Weighing individual trees – why??

- ALL estimates of forest C stocks (biomass) based on a small number of harvest measurements, and then simple (allometric) models that predict mass from diameter & / or height
- Eg for ~1.4 tn trees in the tropics, our best estimates of C stocks come from a few 1000s of harvested trees
- Satellite estimates of C stocks are (mostly) based on models relating height to diameter to mass
- But there are 40-50k tree species in the tropics alone, 3 tn trees globally

Weighing a tree: the hard way & the easy way

- Use TLS to measure many more trees and forests, and many more LARGE trees
- BUT you still need to harvest some

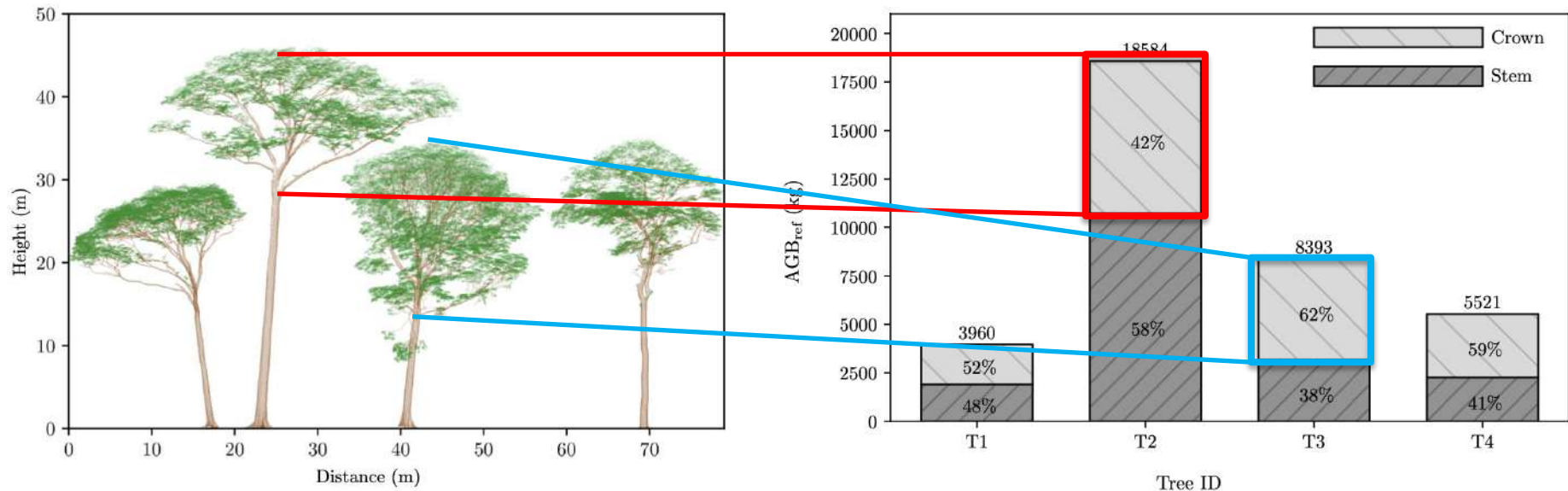


UCL & Brazilian team, Caxuiaña, Brazil: Burt et al. (2021)

<https://doi.org/10.1098/rsos.201458>.

When we DO weigh large trees AND do TLS

Harvest: The one TRUE measurement of biomass!

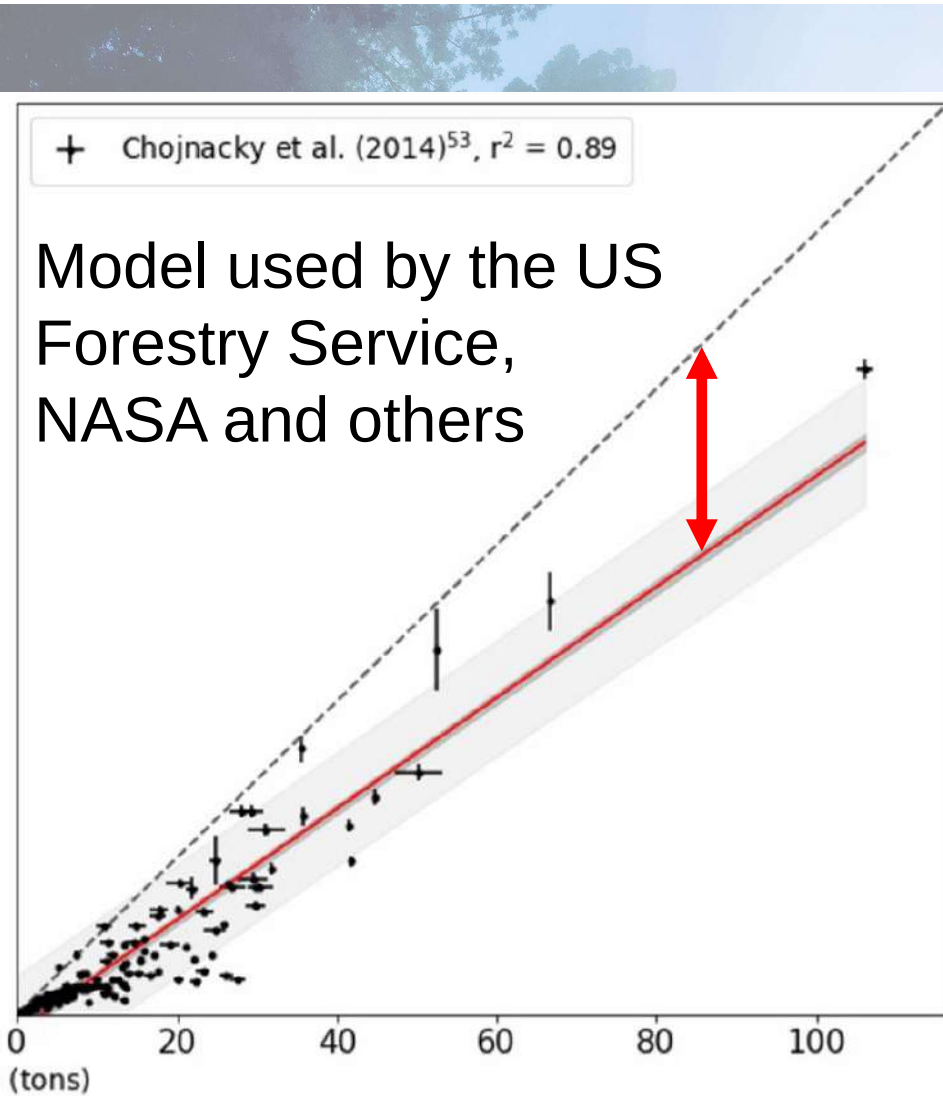


- TLS & harvest agrees to within a few % BUT 40-60% mass in the crown, and very variable. This is not what models assume!
- Mass - size relationship is very variable, particularly for large trees

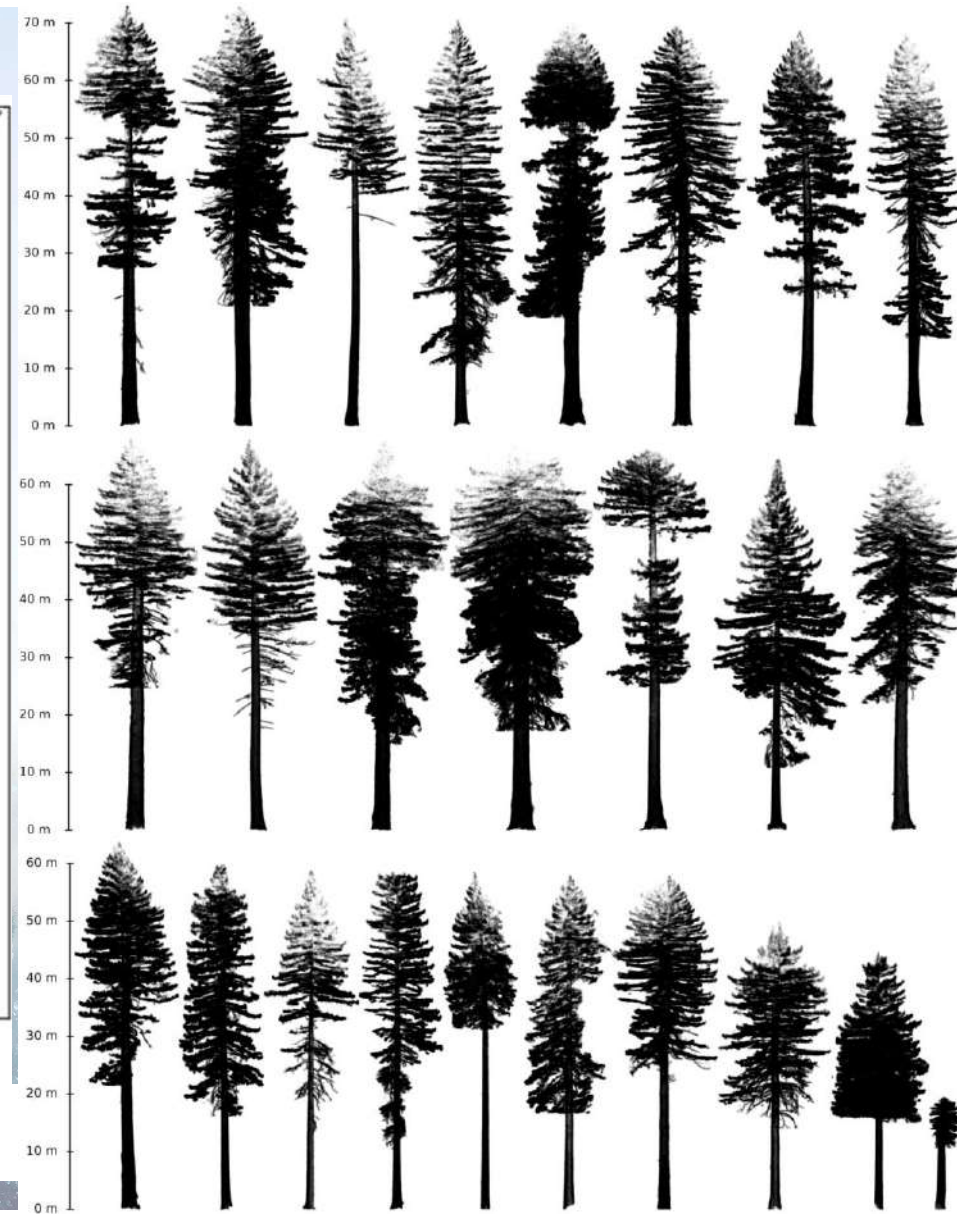
Coastal redwoods in the NW US

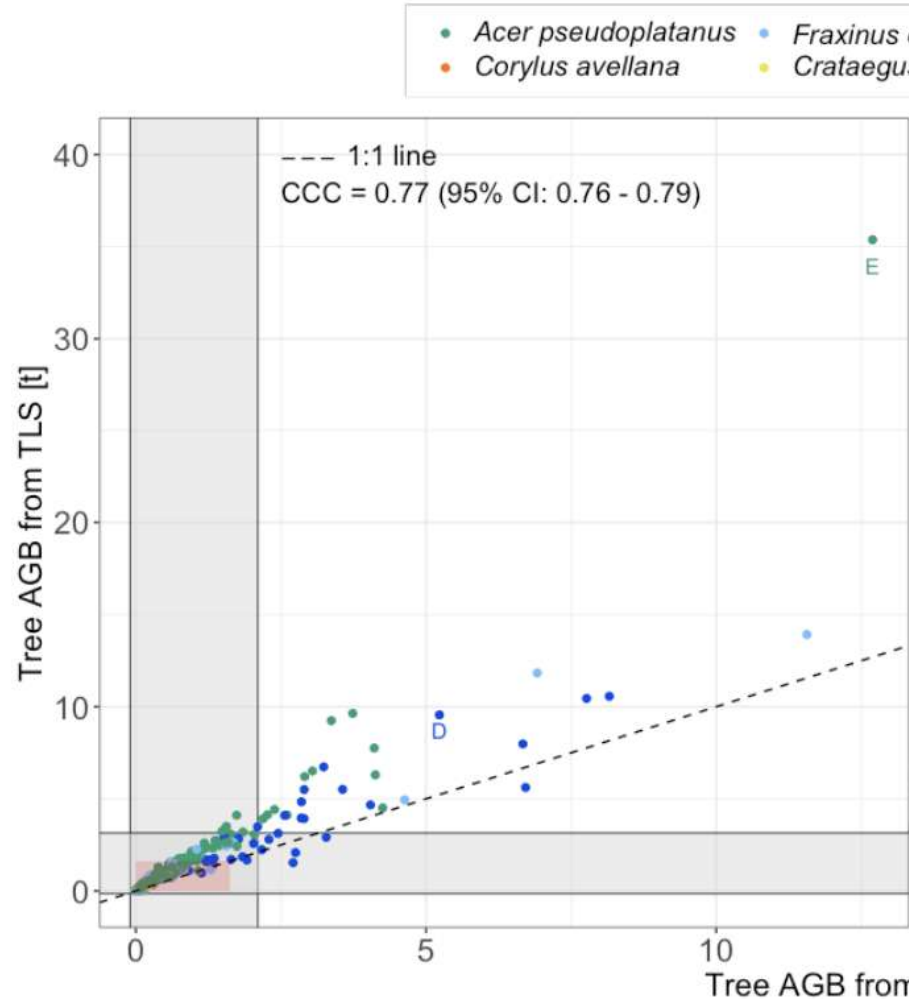
+ Chojnacky et al. (2014)⁵³, $r^2 = 0.89$

Model used by the US
Forestry Service,
NASA and others



TLS biomass (tons) v allometric

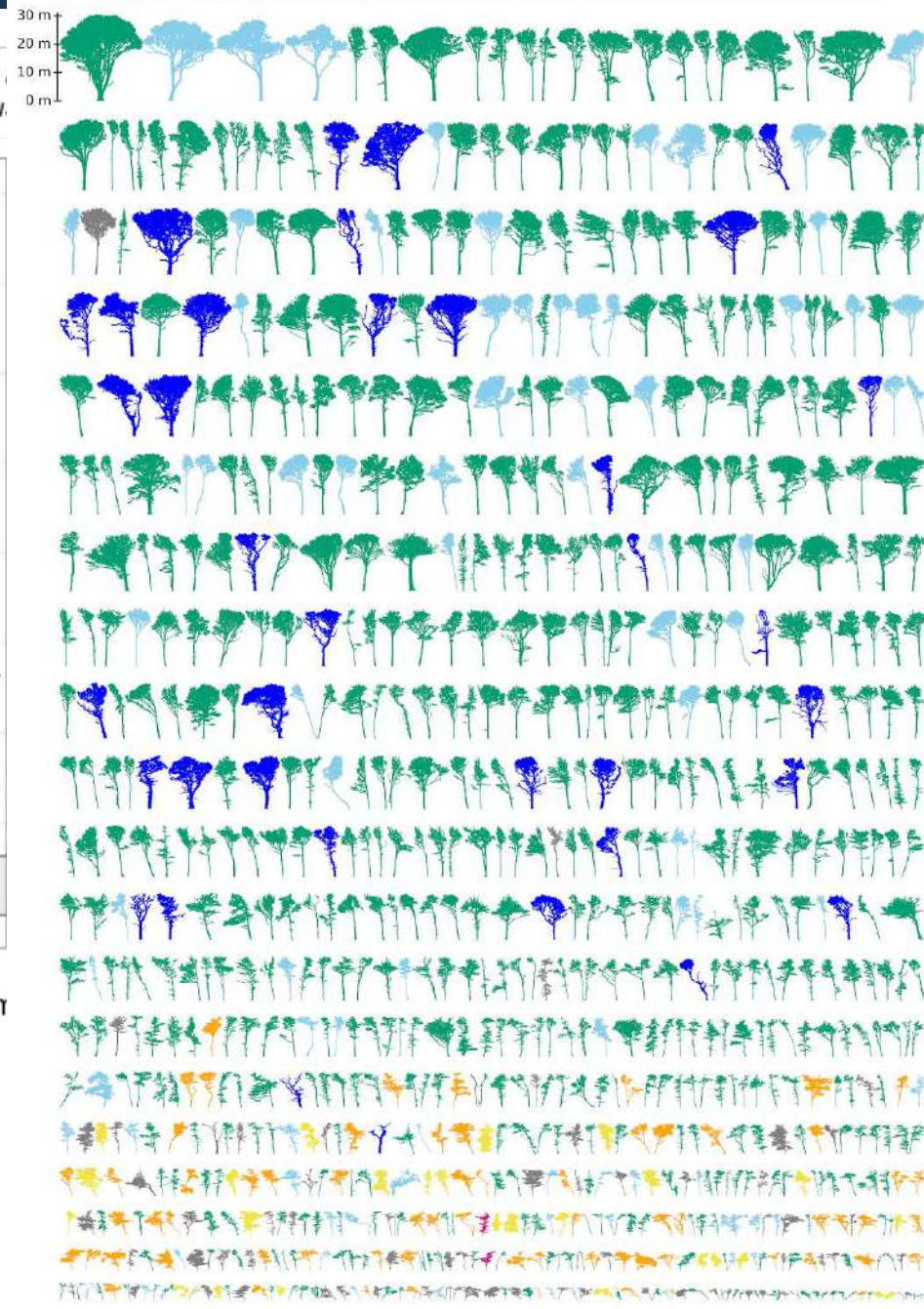




The Trees of Wytham Woods

Legend:

- *Acer pseudoplatanus*
- *Fraxinus excelsior*
- *Quercus robur*
- Unknown
- *Corylus avellana*
- *Crataegus monogyna*
- *Acer campestre*



Calders, Disney et al. 2022
<https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12197>

Allometry: to good to be true?

Despite Bob's 1968 warning his model has been used multiple times. Why??

Destructive harvest is really hard + allometry seems to work 'well enough' to avoid redoing, particularly for large trees.

Reference	Geographic region	Species to which models were applied	Remarks
Riikonen et al. (2017) ⁵	Finland	TC	Urban trees
Schmidt et al. (2015) ⁶	Germany	TC, TP	
Strobbach et al. (2012a) ⁷	Germany	AC, APL, APS, B ₁₀₀ , CB, C ₁₀₀ , FE, QP, QR, T ₁₀₀	Urban trees
Strobbach et al. (2012b) ⁸	Germany	CB, QR, TC	Urban trees
Jacob et al. (2010) ⁹	Germany	TC, APS, FE	
Wellock et al. (2014) ¹⁰	Ireland	FE	
Russo et al. (2014) ¹¹	Italy	B ₁₀₀ , C ₁₀₀	Urban trees
Björkregren et al. (2018) ¹²	UK (London)	APS, Q ₁₀₀ , TC, FE	Urban trees
Badelley et al. (2017) ¹³	UK (Scotland)	APS	
Ningthoujam et al. (2016) ¹⁴	UK (Wytham Woods & Saverne Forest)	APS, Q ₁₀₀ , FE	
Beckert et al. (2016) ¹⁵	UK (Scotland)	APS	
Fenn et al. (2015) ¹⁶	UK (Wytham Woods)	QR, APS, FE	
Butt et al. (2013) ¹⁷	UK (Wytham Woods)	QR, APS, FE	
Tanentzap et al. (2013) ¹⁸	UK (Scotland)	B ₁₀₀	
Abdul-Hamid et al. (2008) ¹⁹	UK (Scotland)	APS, FE	
Poulton et al. (2003) ²⁰	UK (Rothamsted Experimental Farm)	QR, FE, APS, CM	
Martin et al. (1982) ²¹	UK (Hay Wood & Midger Wood)	QR, C ₁₀₀	
Aston et al. (1978) ²²	UK (Wales)	FE, Q ₁₀₀	
Zianis et al. (2015) ²³	Review paper	APS, B ₁₀₀ , FE, TC, Q ₁₀₀	



Bob Bunce
1940 - 2022

Bob Bunce obituary

Landscape ecologist who developed the Countryside Survey to monitor changes to Britain's natural environment



Bob Bunce developed a statistical technique to sample Britain's countryside that would allow him to draw conclusions at a national scale.

News stories about change in the countryside often make their point by presenting stark totals – 28,000km of hedgerow lost in the six years from 1979, followed by even more (42,000km) lost between 1984 and 1990, for instance. These and other significant statistics for countryside change over the last half century resulted from the work of the research ecologist Bob Bunce, who developed Britain's **Countryside Survey**. He has died at the age of 81.

Old models never die

Bob Bunce's original
regression models

See my BES blog on this:

<https://appliedecologistsblog.com/2022/12/20/research-stories-how-to-almost-double-woodland-carbon-overnight/>

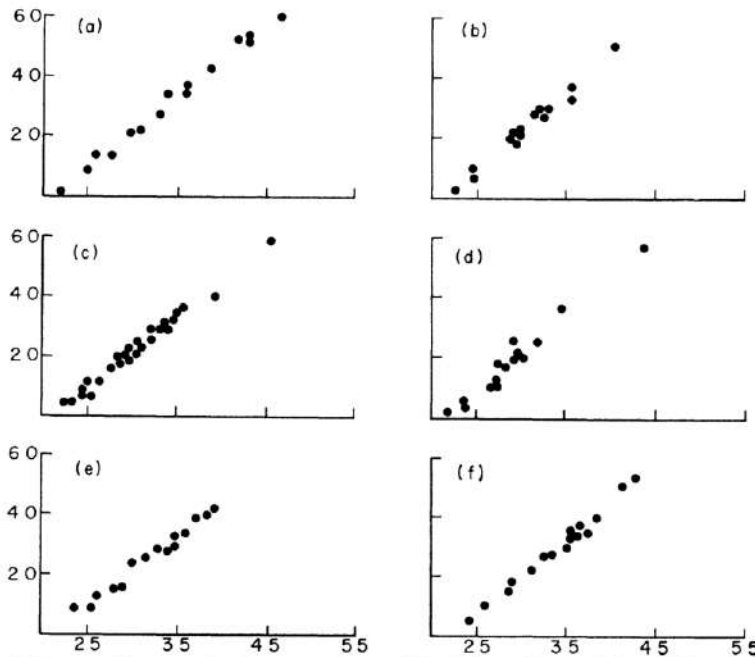


FIG. 1. Scatter diagrams for $\log_e$ tree dry weight (kg) and $\log_e$ girth at 1.3 m (cm). (a) Meathop ash; (b) Roudsea ash; (c) Meathop birch; (d) Roudsea birch; (e) Force Forge birch; (f) Coniston birch.

Most of the time it's easier to use an existing model than re-calibrate, particularly if it's really (REALLY) hard work AND there is some (apparent) theoretical / physical meaning to the model

CAVEAT EMPTOR! (always check the small print)

Closer to home: urban forests, health and wealth



Urban trees are increasingly important, but how best to value manage, preserve them? We use what we know about woodland trees BUT urban trees lead very different lives: “London has not suppressed nature, but rather provoked it to odd improvisations” (R. Jefferies 1883, in Macfarlane, Landmarks, 2015)

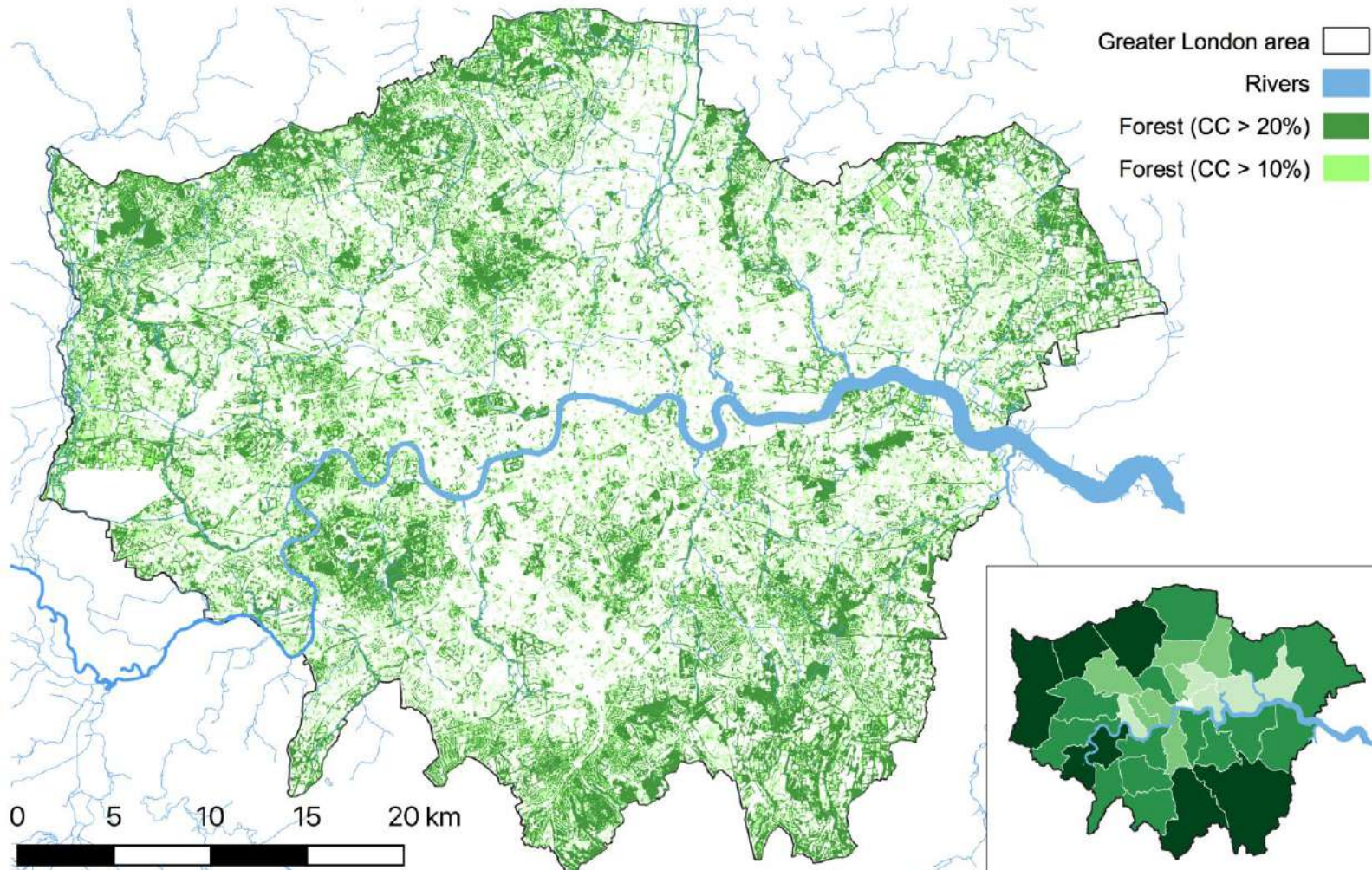
Live fast, die young: Accelerated growth, mortality, and turnover in street trees

Ian A. Smith  , Victoria K. Dearborn , Lucy R. Hutya

Published: May 8, 2019 • <https://doi.org/10.1371/journal.pone.0215846>

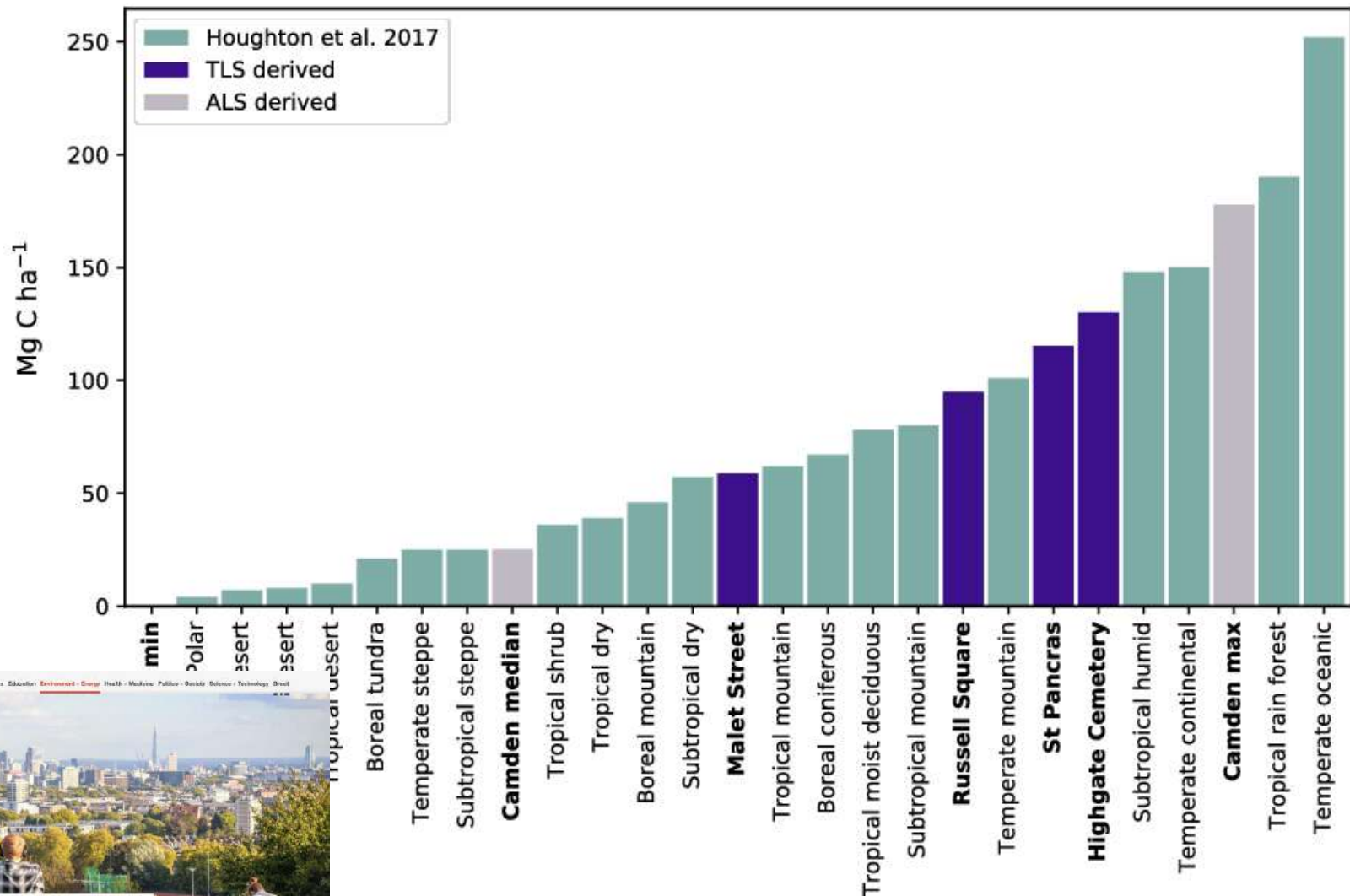
London is a forest

But who has access? Does it matter? How much is it 'worth'?



Carbon in Camden

Wilkes et al. 2018.



Valuing trees ‘right’ is crucial

Urban forests are valued v conservatively (London iTree report 2018)

London's Urban Forest - Key Statistics			Total
Number of Trees	Inner London	1,587,000	8,421,000
	Outer London	6,834,000	
Tree Cover	Inner London	13%	14%
	Outer London	14%	
Canopy Cover	Inner London	18%	21%
	Outer London	21%	
Replacement Cost (whole value)	Inner London	£1.35 Billion	£6.12 Billion
	Outer London	£4.77 Billion	
Amenity Value (CAVAT) (whole value)	Inner London	£17.6 Billion	£43.3 Billion
	Outer London	£25.7 Billion	
TOTAL ANNUAL BENEFITS	Inner London	£59.54 Million	£132.7 Million
	Outer London	£73.16 Million	

£133M = £16 / tree yr ... full amenity is ~£5K per tree

Measures like canopy cover get baked into policy v quickly as easy to estimate / understand BUT canopy cover ≠ canopy quality ≠ ‘value’

The rush to plant trees

- Easy to get ££ to plant new trees; MUCH harder to get ££ for long-term
- *“Ten thousand oaks of 100 years old are not a substitute for one 500 year-old oak” (Rackham, 1986). Or: you don’t know what you’ve got ‘til it’s gone*



Ryan Senechal [@senechal](#)



Heatwave kills 12,000 trees planted in Gloucester

25 September 2022



The council blamed the summer's drought conditions for the situation

More than 12,000 trees planted across a city have died because they were not watered enough during the summer heatwave.

Gloucester City Council announced in February that it would plant 12,800 saplings across the city as part of its aim to become carbon neutral.

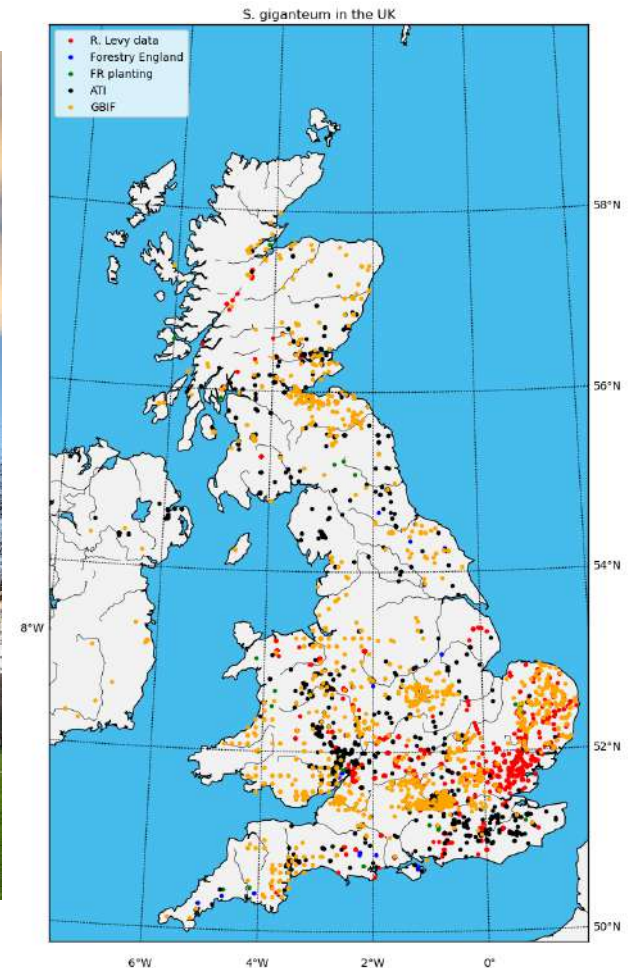


Uncovering the UK redwoods

- Introduced mid-1860s, some of the biggest UK trees, 0.5 M nationally
- Accumulate C rapidly & seem robust to UK climate (& disease)
- Being planted in many urban / peri-urban areas

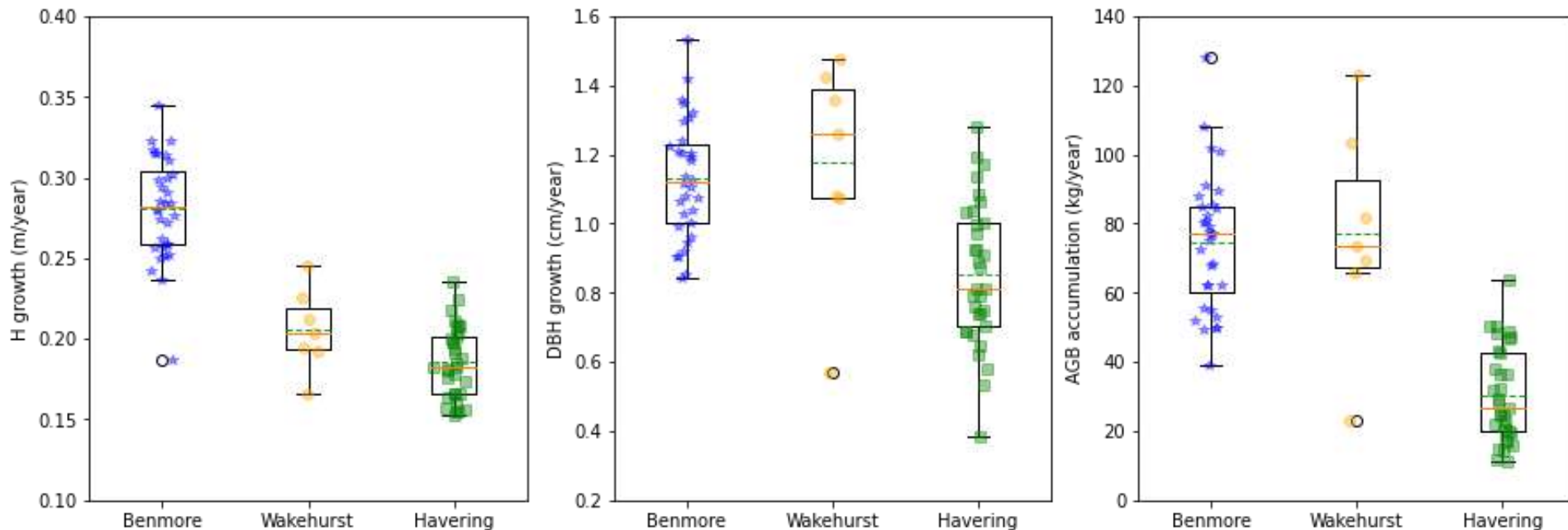


Springfield Park & London Fields



Uncovering the UK redwoods

- We know how old they are (generally) unlike in US
- Can estimate C growth and accumulation rates



- 3 sites across the UK, varying rainfall (& T), C accumulation up to ~80 kg / y / tree (quite close to rates in native CA range)
- 2.5 – 20 x faster than plantation-grown oak & sitka spruce in the UK

Holland et al. (in prep).

Conclusions

- New 3D measurements is giving us a different way to see trees
- Improving estimates of C from ground and space
- Insights into ecological structure and function
- Evaluating how we see and interact with trees.
- Trees and forests operate on long timescales – so we need a long view



YouTube link to a similar lecture by Prof Mat Disney

www.youtube.com/watch?v=itdxfkboZRI