Handbook of UK Urban Tree Allometric Equations and Size Characteristics (Version 1.4)

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Handbook of UK Urban Tree Allometric Equations and Size Characteristics

Version 1.4, December 2024

Joe Fennell and Luke Fay

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Data Contributors

The following organisations contributed data that was used in this study:

- Treework Environmental Practice
- Arbor-eco consultancy
- Bartlett Tree Experts
- Barton Hyett Associates
- Forest Research
- Oxfordshire County Council
- Sharon Hosegood Associates
- TMA Environmental Consultants
- Tree Frontiers
- Wharton Natural Infrastructure

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Contents

Summary

Estimates for the maximum sizes of amenity (and other, non-forestry) trees are important for urban planning and tree management. This report presents the findings of an applied research study to generate current best estimates for UK tree typical sizes and allometric equations.

This report contains typical mature sizes for 46 species and 29 genera of trees commonly found in the UK's towns, cities and land outside of woodland. While the data come from sites across the UK in both urban and rural areas, the data were all collected as part of professional tree surveys and so are likely to be representative of amenity trees. Trees grown in woodland conditions are not likely to be well represented by the models presented here.

This report also contains allometric model formulae for up to 23 species (depending on the relationship), allowing tree characteristics such as diameter at breast height to be predicted by other measured parameters. The formulae can be used in Excel (or other software) for prediction.

What does the document contain?

1. Summary of methods used to generate the values and equations
2. Typical and large (95th percentile) crown radius, height, diameter at breast height and root protection radius for UK amenity tree species and genera
3. Plots to show these values
4. Coefficients for single-parameter allometric equations

Data sources, cleaning and assumptions

Data came from 10 data providers (anonymised in the dataset). The data were largely collected as part of formal tree surveys (e.g. for planning applications, risk management etc.). A data contributor was included if the following fields were present and identifiable in their dataset: (1) crown spread; (2) diameter at breast height; (3) tree height; (4) tree species, (5) genus, latin name or common name; (6) physiological condition and (7) life stage. Records were not included if they did not meet these requirements.

Categorical variables were standardised and grouped into ordered classes:

1. Age class: [young < semi-mature < early-mature < mature < late_mature < ancient]
2. Physiological condition: [dead < poor < fair < good]

Field Names were standardised to the Individual Tree Data Standard[1] names where possible. Latin Names and/or common names were mapped to missing values for the from a standardised mapping where possible. For example, where the dataset contained a record with the common name 'English Oak', the latin name 'quercus robur' was generated from a lookup. The genus would be 'quercus' and the species 'robur'. If the record contained only 'Oak', the latin name would be 'quercus sp.', the genus 'quercus' and the species 'sp.'.

The combined stem diameter was calculated as:

$$D = 2\sqrt{\frac{\sum_{i=1}^{n} A_i}{\pi}}$$

where D is the combined stem diameter and Ai is the stem area of the ith stem. Multi-stemmed trees were included and the stem diameter refers to the combined stem diameter, as described above.

Stem diameters were measured between 1.3 m and 1.5 m although different assessment procedures may have been used by some data suppliers.

Records were removed if any of the following applied:

1. The height was greater than 50 m or less than 3 m
2. The combined stem diameter was greater than 400 cm or less than 10 cm
3. The crown radius was greater than 25 m or less than 1 m
4. There was no common or latin name supplied
5. The combined stem diameter was not present or less than or equal to 0 cm

The table below shows the field name in the dataset and the description or definition used.

Field	Description
n_stems	Number of stems present

[1] https://www.forestresearch.gov.uk/research/quantification-and-valuation-of-benefits-provided-by-urban-trees/individual-tree-data-standard/

Field	Description
stem_diameter_1_cm	Diameter of stem 1 in cm
stem_diameter_2_cm	Diameter of stem 2 in cm
stem_diameter_3_cm	Diameter of stem 3 in cm
stem_diameter_4_cm	Diameter of stem 4 in cm
stem_diameter_5_cm	Diameter of stem 5 in cm
height_m	Max height of tree in metres
latin_name	Original recorded latin name or value inferred from common_name
common_name	Original recorded common name or value inferred from latin_name
latin_name_clean	Cleaned latin name with just genus and species
common_name_clean	Cleaned common name with only the species-level naming (no variety)
physiological_condition	Good/Fair/Poor/Dead tree condition classification
county	County or authority where tree is located
classification	urban/suburban/rural location classification
life_stage	ancient/late_mature/mature/early_mature/ semi_mature/young age classification
crown_radius_n_m	Crown radius north in metres
crown_radius_s_m	Crown radius south in metres
crown_radius_e_m	Crown radius east in metres
crown_radius_w_m	Crown radius west in metres
crown_radius_ne_m	Crown radius north-east in metres
crown_radius_nw_m	Crown radius north-west in metres
crown_radius_se_m	Crown radius south-eastin metres
crown_radius_sw_m	Crown radius south-west in metres
crown_radius_minimum_bounding_circle	The radius of the expected minimum bounding circle of the crown
crown_radius_maximum	The maximum radial value recorded for the tree
data_contributor_id	Dataset-unique identifier for the data contributor
genus	The genus derived from the latin_name
species	The species derived from the latin_name
combined_stem_diameter_cm	The stem_diameter equivalent for a trunk with combined basal area of all stems
is_multistem	If True, more than one stem_diameter record indicated

Section 1: Mature Tree Characteristics

Mature tree characteristics were calculated for each tree species or genus that had more than 20 records of mature, post-mature, late-mature or ancient/veteran.

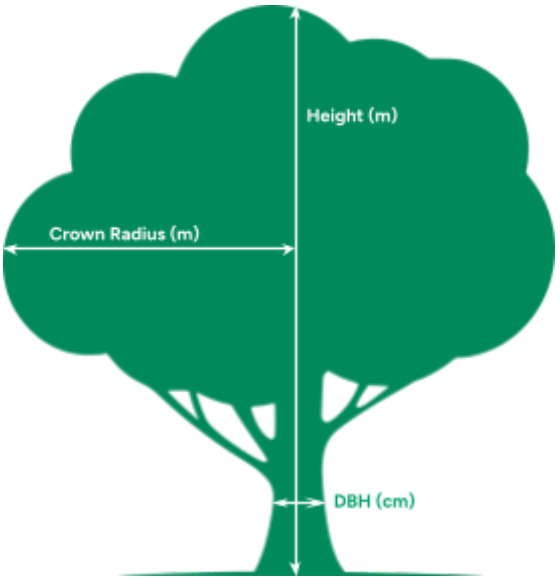
The typical (median) and upper 95th percentile was calculated for each species or for each genus for the following characteristics:

1. Crown Radius (metres)
2. Height (metres)
3. Diameter at Breast Height (centimetres)

The following section contains the data tables for species and genus with plots for Crown Radius, Height and DBH. The typical value is the median or most likely value for a tree of that species or genus, given the values surveyed for this dataset. The 95th percentile is given to indicate relatively unusual trees (by definition, only 5% of the surveyed mature trees had values greater than the 95th percentile value). While this is not an upper limit for the characteristic, trees above the 95th percentile are relatively unusual.

The following limitations should be considered when using these summary statistics:

1. The amount/extent of any pruning was often not recorded and is not taken into account for the maximum extent. The summaries were calculated over trees that may have a range of different pruning extents.
2. Ancient and Veteran trees were included in the mature tree class. Although these may have different characteristics (smaller crown radius) compared to mature crowns, these are a small percentage of the trees in the dataset (< 10%).



Mature tree dimensions at species level (data table)

Latin Name	Number of Trees	Crown Radius (metres) Typical (95th)	Height (metres) Typical (95th)	Combined DBH (cm) Typical (95th)
Acer Campestre	167	5.0 (8.7)	9.0 (17.0)	38.7 (75.7)
Acer Platanoides	208	6.0 (9.0)	13.0 (19.0)	44.5 (80.0)
Acer Pseudoplatanus	438	6.5 (10.0)	15.0 (21.0)	55.6 (99.1)
Acer Saccharinum	21	7.0 (9.0)	17.0 (20.0)	70.0 (107.0)
Aesculus Hippocastanum	266	6.0 (10.0)	15.0 (25.0)	67.0 (114.8)
Alnus Cordata	25	5.5 (8.0)	17.0 (20.0)	51.0 (63.8)
Alnus Glutinosa	56	5.0 (9.0)	12.0 (18.8)	43.4 (82.6)
Betula Pendula	231	5.0 (7.8)	13.0 (20.0)	35.0 (62.5)
Carpinus Betulus	51	6.0 (10.2)	14.0 (19.0)	42.0 (72.1)
Castanea Sativa	46	8.0 (10.9)	15.0 (23.0)	108.2 (190.8)
Cedrus Atlantica	22	8.5 (13.4)	20.0 (27.0)	88.0 (162.5)
Cerasus Avium	79	5.0 (8.0)	10.0 (16.0)	36.0 (74.1)
Chamaecyparis Lawsoniana	43	3.0 (6.4)	12.0 (19.8)	30.0 (85.3)
Corylus Avellana	37	3.0 (6.0)	6.0 (8.4)	10.0 (41.2)
Crataegus Monogyna	240	3.0 (5.8)	5.0 (10.0)	23.0 (48.1)
Cupressus Macrocarpa	20	5.0 (8.0)	17.0 (20.2)	61.1 (135.9)
Fagus Sylvatica	149	8.0 (12.5)	16.0 (24.0)	76.0 (123.0)
Fraxinus Excelsior	610	6.0 (10.0)	14.0 (20.8)	54.0 (100.0)
Ilex Aquifolium	42	3.0 (5.9)	6.8 (9.9)	30.5 (54.8)
Malus Sylvestris	23	4.0 (5.9)	6.0 (9.0)	32.0 (59.1)
Picea Abies	27	4.5 (6.0)	19.0 (19.0)	47.0 (58.3)
Pinus Nigra	35	6.0 (10.3)	18.0 (24.2)	62.0 (106.5)
Pinus Sylvestris	146	5.0 (8.0)	14.0 (19.0)	48.5 (80.8)
Platanus X Hispanica	207	10.0 (15.0)	18.0 (32.0)	74.0 (114.7)
Populus Alba	44	7.0 (10.7)	18.0 (22.8)	52.0 (89.0)
Populus Nigra	31	7.0 (9.0)	22.0 (32.0)	75.0 (127.5)
Populus X Canadensis	38	8.0 (11.1)	23.0 (25.2)	93.5 (128.3)
Prunus Avium	152	5.0 (7.0)	8.0 (15.4)	40.0 (61.4)
Prunus Cerasifera	45	4.0 (7.7)	7.0 (12.8)	35.0 (56.8)
Pseudotsuga Menziesii	20	6.0 (7.6)	16.5 (30.0)	65.0 (100.2)
Quercus Cerris	28	9.2 (14.3)	19.0 (28.9)	75.0 (119.7)
Quercus Ilex	23	5.0 (10.0)	11.0 (16.9)	55.0 (119.7)
Quercus Robur	1008	8.5 (12.0)	17.0 (22.0)	83.0 (141.0)

Quercus Rubra	24	7.5 (10.8)	16.0 (19.0)	53.0 (94.2)
Robinia Pseudoacacia	39	6.6 (9.0)	14.0 (19.1)	49.0 (90.1)
Salix Alba	57	7.0 (12.2)	17.0 (30.0)	66.0 (145.0)
Salix Caprea	88	5.8 (8.0)	10.0 (14.6)	42.8 (84.6)
Salix Fragilis	238	6.2 (12.0)	12.0 (21.0)	80.0 (210.0)
Sambucus Nigra	54	2.2 (4.1)	5.0 (7.0)	15.0 (40.0)
Sorbus Aria	33	4.0 (7.0)	8.0 (12.0)	37.0 (54.2)
Sorbus Aucuparia	41	3.5 (5.0)	6.0 (12.0)	28.0 (40.0)
Sorbus Intermedia	30	4.0 (5.0)	7.0 (10.0)	47.0 (61.0)
Taxus Baccata	21	6.0 (9.0)	10.0 (16.0)	60.0 (100.0)
Tilia Cordata	46	6.0 (8.4)	16.5 (29.5)	50.0 (120.0)
Tilia X Europaea	191	6.0 (9.0)	16.0 (25.0)	67.0 (88.0)
Tilia X Vulgaris	69	5.0 (7.8)	13.0 (26.2)	68.0 (100.0)

Mature tree dimensions at species level (crown radius plot)

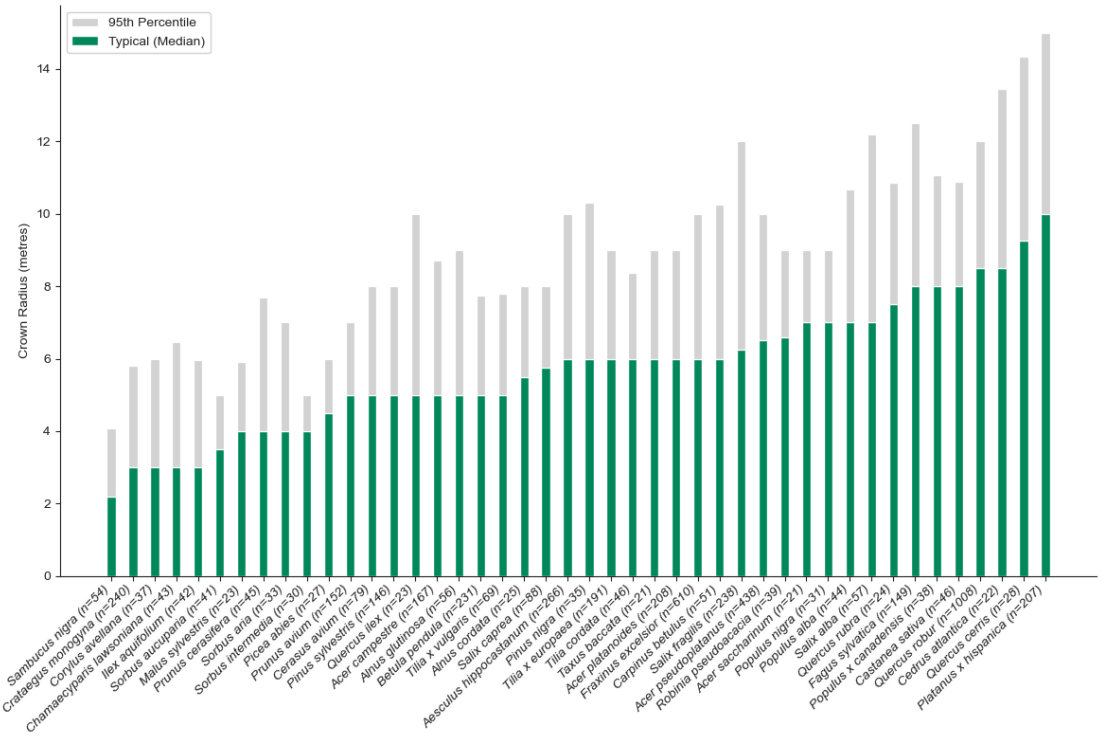


Figure 1: Typical and upper 95th percentile maximum crown radii for all trees classified as Mature, Post-Mature or Ancient. Only trees with a full species classification were included.

Mature tree dimensions at species level (height plot)

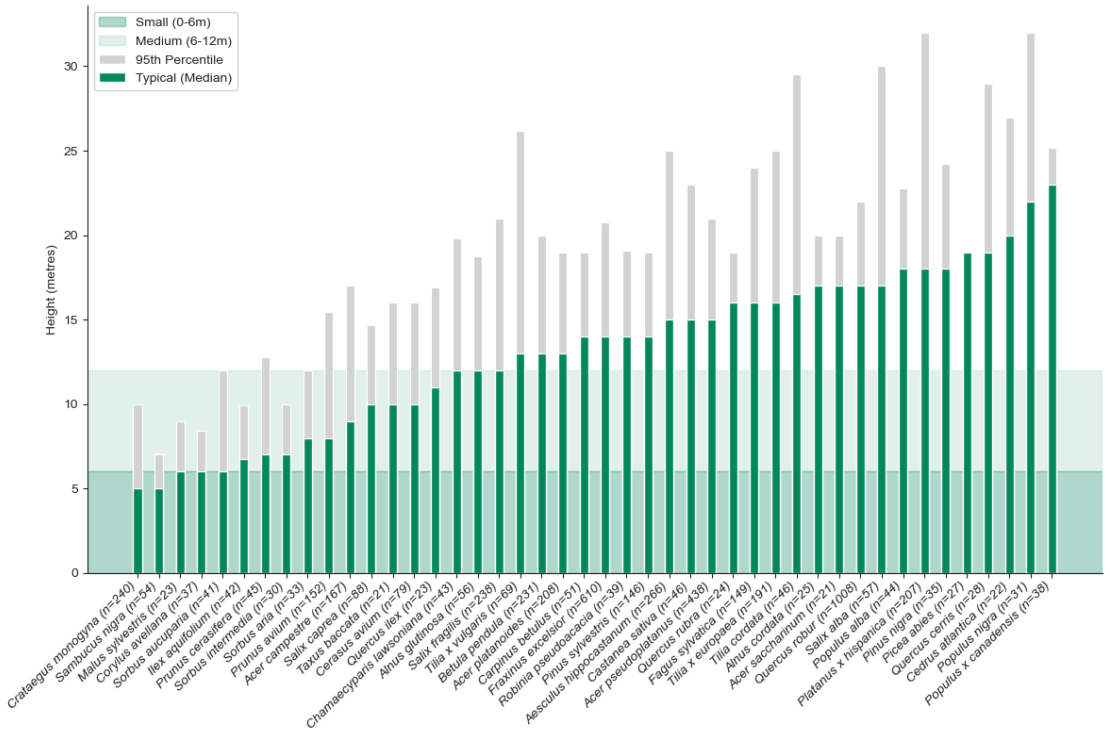


Figure 2: The typical and upper 95th percentile height for all trees classified as Mature, Post-Mature or Ancient. Only trees with a full species classification were included.

Mature tree dimensions at species level (DBH plot)

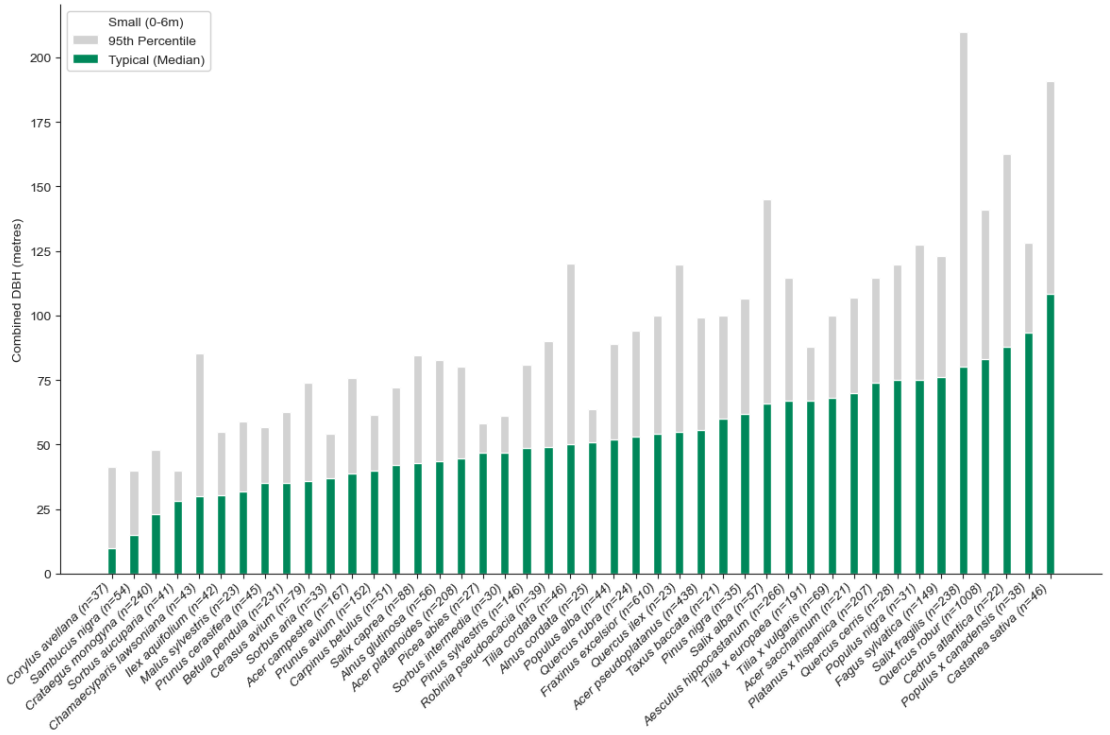


Figure 3: The typical and upper 95th percentile Diameter at Breast Height (DBH) for all trees classified as Mature, Post-Mature or Ancient. Only trees with a full species classification were included.

Mature tree dimensions at genus level (data table)

Latin Name	Number of Trees	Crown Radius (metres) Typical (95th %)	Height (metres) Typical (95th %)	Combined DBH (cm) Typical (95th %)
Acer	869	6.0 (9.5)	13.5 (20.0)	49.0 (93.0)
Aesculus	285	6.0 (10.0)	15.0 (25.0)	67.0 (113.6)
Alnus	101	5.0 (9.0)	14.0 (20.0)	47.0 (80.6)
Betula	252	4.9 (7.7)	13.0 (20.0)	35.0 (62.0)
Carpinus	53	6.0 (10.2)	14.0 (18.8)	43.0 (76.5)
Castanea	46	8.0 (10.9)	15.0 (23.0)	108.2 (190.8)
Cedrus	54	11.2 (16.3)	20.0 (26.0)	121.0 (206.7)
Cerasus	89	5.0 (8.0)	10.0 (15.6)	36.0 (73.6)
Chamaecyparis	57	3.0 (6.1)	12.0 (18.4)	30.0 (73.4)
Corylus	37	3.0 (6.0)	6.0 (8.4)	10.0 (41.2)
Crataegus	300	3.0 (5.0)	5.0 (10.0)	24.0 (47.5)
Cupressus	37	4.0 (8.1)	15.0 (20.0)	48.0 (120.0)
Fagus	150	8.0 (12.5)	16.0 (24.0)	76.0 (123.0)
Fraxinus	660	6.0 (10.0)	14.0 (21.5)	54.0 (100.0)
Ilex	43	3.0 (5.9)	7.0 (9.9)	30.0 (54.6)
Malus	137	3.5 (6.0)	6.0 (11.2)	27.0 (54.4)
Picea	34	4.5 (6.3)	18.0 (19.3)	47.0 (63.0)
Pinus	224	5.0 (9.0)	15.0 (21.0)	52.0 (96.4)
Platanus	215	10.0 (15.0)	18.0 (32.0)	72.0 (115.3)
Populus	173	7.0 (11.0)	20.0 (27.0)	73.0 (128.5)
Prunus	333	4.5 (7.0)	7.0 (15.0)	37.0 (61.0)
Pseudotsuga	20	6.0 (7.6)	16.5 (30.0)	65.0 (100.2)
Quercus	1103	8.5 (12.0)	17.0 (22.0)	81.0 (139.9)
Robinia	40	6.6 (9.0)	14.0 (19.0)	49.5 (90.0)
Salix	525	6.0 (12.0)	12.0 (23.0)	67.0 (159.2)
Sambucus	60	2.0 (4.0)	5.0 (7.0)	15.5 (40.4)
Sorbus	130	4.0 (6.0)	7.0 (12.0)	33.0 (53.0)
Taxus	24	5.4 (8.9)	10.0 (15.8)	58.0 (98.5)
Tilia	525	5.5 (8.0)	14.5 (24.0)	58.0 (93.6)

Mature tree dimensions at genus level (crown radius plot)

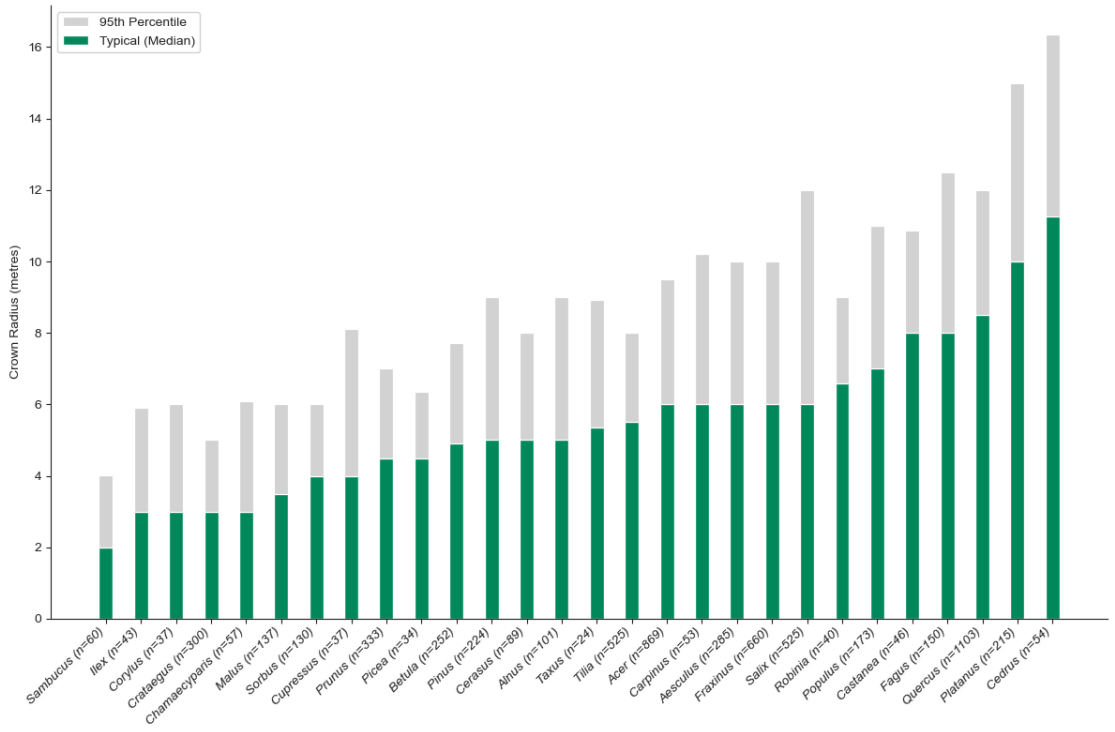


Figure 4: The typical and upper 95th percentile crown radius for all trees classified as Mature, Post-Mature or Ancient.

Mature tree dimensions at genus level (height plot)

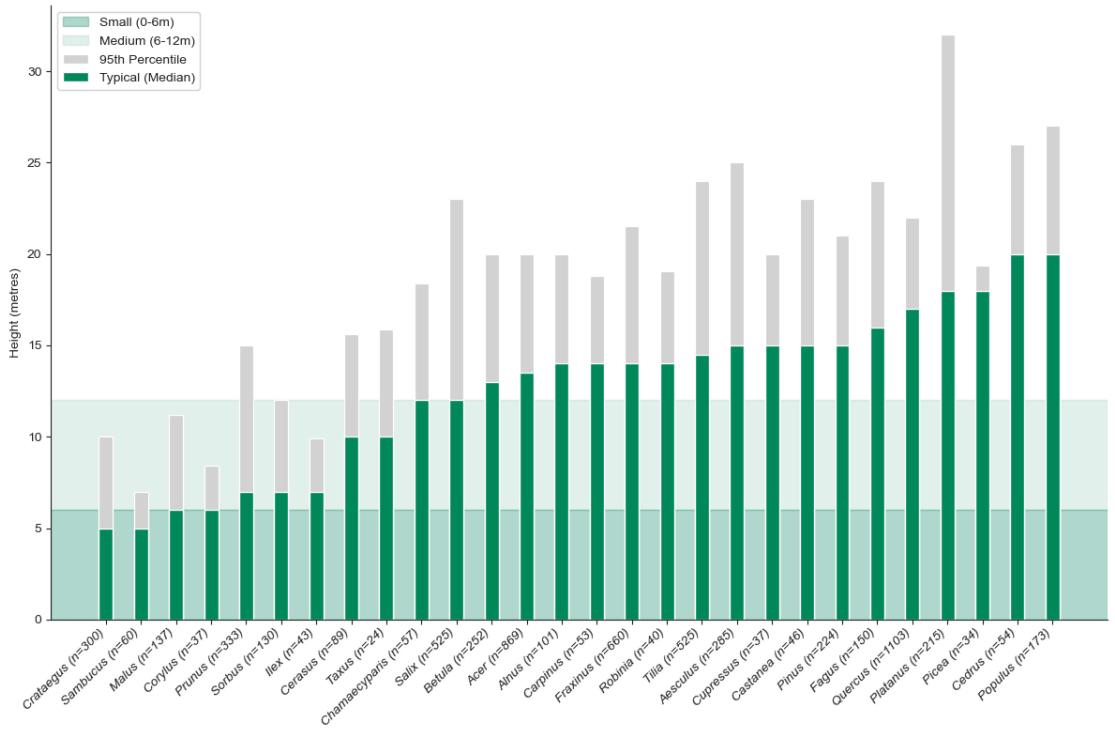


Figure 5: The typical and upper 95th percentile height for all trees classified as Mature, Post-Mature or Ancient.

Mature tree dimensions at genus level (DBH plot)

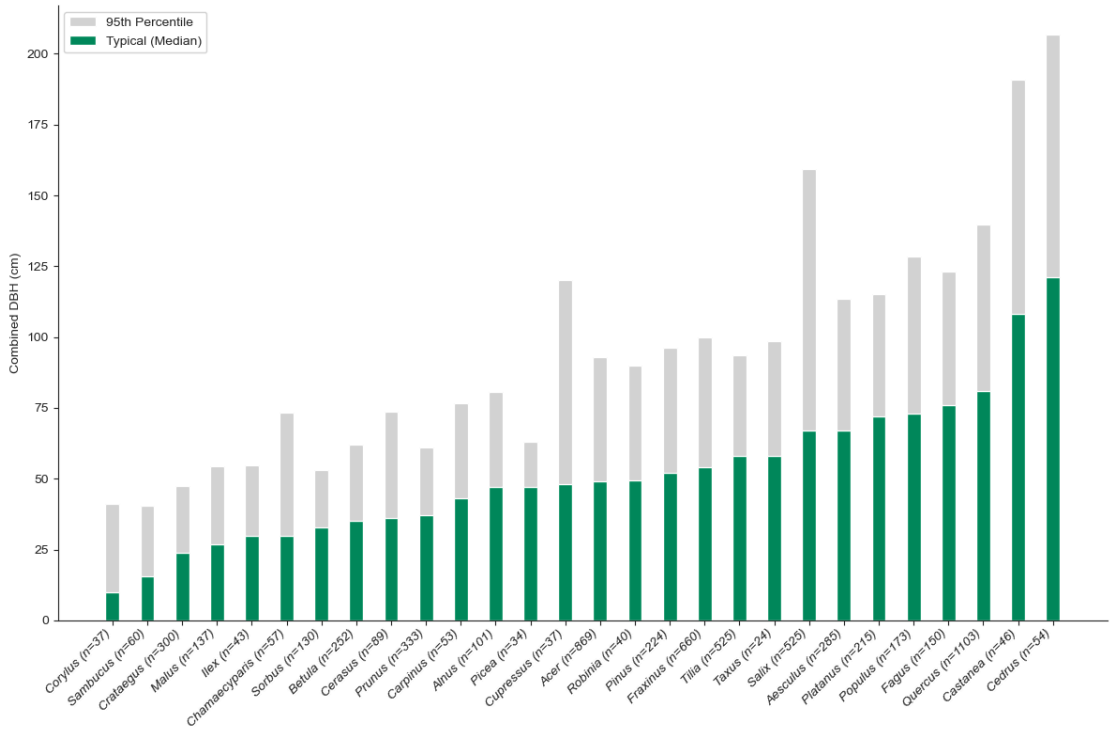


Figure 6: The typical and upper 95th percentile Diameter at Breast Height (DBH) for all trees classified as Mature, Post-Mature or Ancient.

Section 2: Single Species Allometry

Single parameter allometric equations were calculated for each species where there were at least 100 records of the species across all age classes. Each model was fit as a log-log model (log-transformed response and predictor) using established principles[2]. The model R^2 describes the fit of the model, with values closer to 1 indicating a better fit. Models with R^2 less than 0.2 were not included in the results presented here, even if a significant *p*–value was achieved. The Standard Error (SE) is provided for each model as an uncertainty measure. The predictive equations provided include the correction factor (see reference section on Correction Factors for further information).

Worked example for *Quercus robur*:

If we had measured a crown radius of 12m and wanted to estimate the DBH, we need to:

1. Find the relevant Response variable in the "Response" column. In this case it is "DBH_cm".
2. Find the relevant species in the "Species" column. In this case it is "*Quercus robur*"

The Excel formula from the table is :

```
=exp(2.20733)*(Crown_Radius_m^0.97484)*exp(0.0681)
```

Replacing `Crown_Radius_m` with 12 and running in Excel gives a predicted DBH of 110cm.

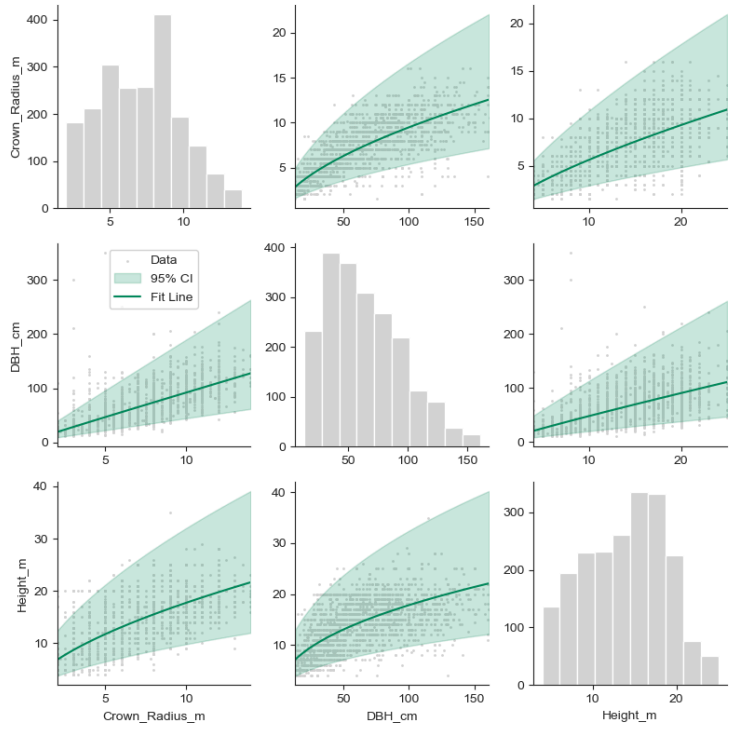


Figure 7: Example allometric equation fits and histograms (diagonal) for every parameter combination for *Quercus robur*

[2] Picard N., Saint-André L., Henry M. 2012. Manual for building tree volume and biomass allometric equations: from field measurement to prediction. Food and Agricultural Organization of the United Nations, Rome, and Centre de Coopération Internationale en Recherche Agronomique pour le Développement, Montpellier, 215 pp.

Response	Excel Formula	R^2	SE	Species
DBH predicted by crown radius (data table)				
DBH_cm	=exp(2.27129)*(Crown_Radius_m^0.83611)*exp(0.05782)	0.46	0.34	*Acer campestre*
DBH_cm	=exp(2.29737)*(Crown_Radius_m^0.82504)*exp(0.04224)	0.53	0.291	*Acer platanoides*
DBH_cm	=exp(2.15605)*(Crown_Radius_m^0.91895)*exp(0.06212)	0.54	0.352	*Acer pseudoplatanus*
DBH_cm	=exp(2.33144)*(Crown_Radius_m^0.98041)*exp(0.06925)	0.52	0.372	*Aesculus hippocastanum*
DBH_cm	=exp(2.41866)*(Crown_Radius_m^0.71601)*exp(0.08117)	0.38	0.403	*Alnus glutinosa*
DBH_cm	=exp(2.35919)*(Crown_Radius_m^0.7158)*exp(0.04892)	0.46	0.313	*Betula pendula*
DBH_cm	=exp(2.24817)*(Crown_Radius_m^0.80861)*exp(0.04952)	0.55	0.315	*Carpinus betulus*
DBH_cm	=exp(1.78312)*(Crown_Radius_m^1.25561)*exp(0.11461)	0.61	0.479	*Castanea sativa*
DBH_cm	=exp(2.38517)*(Crown_Radius_m^0.69208)*exp(0.05292)	0.43	0.325	*Cerasus avium*
DBH_cm	=exp(2.00717)*(Crown_Radius_m^1.04997)*exp(0.0534)	0.65	0.327	*Fagus sylvatica*
DBH_cm	=exp(2.34051)*(Crown_Radius_m^0.80883)*exp(0.07078)	0.5	0.376	*Fraxinus excelsior*
DBH_cm	=exp(2.48209)*(Crown_Radius_m^0.63639)*exp(0.07348)	0.23	0.383	*Ilex aquifolium*
DBH_cm	=exp(2.84563)*(Crown_Radius_m^0.61368)*exp(0.04422)	0.39	0.297	*Pinus sylvestris*
DBH_cm	=exp(1.78705)*(Crown_Radius_m^1.02136)*exp(0.04702)	0.66	0.307	*Platanus x hispanica*
DBH_cm	=exp(2.62285)*(Crown_Radius_m^0.62257)*exp(0.05127)	0.29	0.32	*Prunus avium*
DBH_cm	=exp(2.11932)*(Crown_Radius_m^0.94658)*exp(0.03608)	0.65	0.269	*Quercus petraea*
DBH_cm	=exp(2.20733)*(Crown_Radius_m^0.97484)*exp(0.0681)	0.58	0.369	*Quercus robur*
DBH_cm	=exp(2.31549)*(Crown_Radius_m^0.74238)*exp(0.13063)	0.2	0.511	*Salix caprea*
DBH_cm	=exp(2.88884)*(Crown_Radius_m^0.6976)*exp(0.15262)	0.27	0.552	*Salix fragilis*
DBH_cm	=exp(2.10557)*(Crown_Radius_m^0.80919)*exp(0.04136)	0.44	0.288	*Sorbus aucuparia*

Response	Excel Formula	R^2	SE	Species
DBH_cm	=exp(2.29527)*(Crown_Radius_m^0.96943)*exp(0.05986)	0.53	0.346	*Taxus baccata*
DBH_cm	=exp(1.84549)*(Crown_Radius_m^1.14972)*exp(0.0552)	0.66	0.332	*Tilia cordata*
DBH_cm	=exp(3.15535)*(Crown_Radius_m^0.51882)*exp(0.05566)	0.24	0.334	*Tilia x europaea*
DBH predicted by height (data table)				
DBH_cm	=exp(2.12021)*(Height_m^0.63347)*exp(0.07624)	0.29	0.39	*Acer campestre*
DBH_cm	=exp(1.99982)*(Height_m^0.68087)*exp(0.05789)	0.35	0.34	*Acer platanoides*
DBH_cm	=exp(1.36036)*(Height_m^0.91945)*exp(0.07763)	0.42	0.394	*Acer pseudoplatanus*
DBH_cm	=exp(1.7161)*(Height_m^0.89639)*exp(0.07182)	0.5	0.379	*Aesculus hippocastanum*
DBH_cm	=exp(1.64099)*(Height_m^0.78473)*exp(0.08539)	0.35	0.413	*Alnus glutinosa*
DBH_cm	=exp(1.45866)*(Height_m^0.76676)*exp(0.05237)	0.42	0.324	*Betula pendula*
DBH_cm	=exp(1.71343)*(Height_m^0.7364)*exp(0.06835)	0.38	0.37	*Carpinus betulus*
DBH_cm	=exp(0.82789)*(Height_m^1.31018)*exp(0.13673)	0.53	0.523	*Castanea sativa*
DBH_cm	=exp(1.36669)*(Height_m^1.00453)*exp(0.07088)	0.54	0.377	*Fagus sylvatica*
DBH_cm	=exp(1.90334)*(Height_m^0.69752)*exp(0.1021)	0.28	0.452	*Fraxinus excelsior*
DBH_cm	=exp(1.84685)*(Height_m^0.74367)*exp(0.04986)	0.31	0.316	*Pinus sylvestris*
DBH_cm	=exp(0.92362)*(Height_m^1.05658)*exp(0.05845)	0.58	0.342	*Platanus x hispanica*
DBH_cm	=exp(1.87413)*(Height_m^0.9257)*exp(0.04557)	0.56	0.302	*Quercus petraea*
DBH_cm	=exp(1.68021)*(Height_m^0.91195)*exp(0.09454)	0.41	0.435	*Quercus robur*
DBH_cm	=exp(2.10514)*(Height_m^0.6607)*exp(0.1291)	0.21	0.508	*Salix caprea*
DBH_cm	=exp(1.48839)*(Height_m^0.83843)*exp(0.03786)	0.49	0.275	*Sorbus aucuparia*
DBH_cm	=exp(1.53963)*(Height_m^1.0197)*exp(0.06274)	0.51	0.354	*Taxus baccata*
DBH_cm	=exp(0.97794)*(Height_m^1.07122)*exp(0.03166)	0.8	0.252	*Tilia cordata*
DBH_cm	=exp(2.22726)*(Height_m^0.69124)*exp(0.03965)	0.46	0.282	*Tilia x europaea*

Response	Excel Formula	R^2	SE	Species
Height predicted by crown radius (data table)				
Height_m	=exp(1.11787)*(Crown_Radius_m^0.68329)*exp(0.04399)	0.43	0.297	*Acer campestre*
Height_m	=exp(1.25778)*(Crown_Radius_m^0.6968)*exp(0.03433)	0.49	0.262	*Acer platanoides*
Height_m	=exp(1.55585)*(Crown_Radius_m^0.56895)*exp(0.03907)	0.41	0.28	*Acer pseudoplatanus*
Height_m	=exp(1.23856)*(Crown_Radius_m^0.76249)*exp(0.04493)	0.5	0.3	*Aesculus hippocastanum*
Height_m	=exp(1.67647)*(Crown_Radius_m^0.43529)*exp(0.05498)	0.25	0.332	*Alnus glutinosa*
Height_m	=exp(1.80015)*(Crown_Radius_m^0.46208)*exp(0.0478)	0.27	0.309	*Betula pendula*
Height_m	=exp(1.4969)*(Crown_Radius_m^0.56475)*exp(0.04733)	0.38	0.308	*Carpinus betulus*
Height_m	=exp(1.20863)*(Crown_Radius_m^0.67946)*exp(0.03806)	0.58	0.276	*Castanea sativa*
Height_m	=exp(1.21887)*(Crown_Radius_m^0.44116)*exp(0.03971)	0.2	0.282	*Crataegus monogyna*
Height_m	=exp(1.22129)*(Crown_Radius_m^0.73742)*exp(0.0323)	0.6	0.254	*Fagus sylvatica*
Height_m	=exp(1.75143)*(Crown_Radius_m^0.43757)*exp(0.05958)	0.26	0.345	*Fraxinus excelsior*
Height_m	=exp(1.27294)*(Crown_Radius_m^0.51362)*exp(0.05018)	0.22	0.317	*Ilex aquifolium*
Height_m	=exp(1.25466)*(Crown_Radius_m^0.75079)*exp(0.02234)	0.69	0.211	*Platanus x hispanica*
Height_m	=exp(1.06961)*(Crown_Radius_m^0.62926)*exp(0.05274)	0.29	0.325	*Prunus avium*
Height_m	=exp(0.91441)*(Crown_Radius_m^0.66705)*exp(0.03435)	0.49	0.262	*Quercus petraea*
Height_m	=exp(1.46616)*(Crown_Radius_m^0.59265)*exp(0.04522)	0.43	0.301	*Quercus robur*
Height_m	=exp(1.08995)*(Crown_Radius_m^0.63346)*exp(0.05439)	0.3	0.33	*Salix caprea*
Height_m	=exp(1.58974)*(Crown_Radius_m^0.45608)*exp(0.06133)	0.28	0.35	*Salix fragilis*
Height_m	=exp(1.18461)*(Crown_Radius_m^0.54396)*exp(0.03667)	0.29	0.271	*Sorbus aucuparia*
Height_m	=exp(1.32385)*(Crown_Radius_m^0.60263)*exp(0.03641)	0.42	0.27	*Taxus baccata*
Height_m	=exp(1.00877)*(Crown_Radius_m^0.93801)*exp(0.0425)	0.63	0.292	*Tilia cordata*
Height_m	=exp(1.5031)*(Crown_Radius_m^0.65635)*exp(0.04211)	0.4	0.29	*Tilia x europaea*

Response	Excel Formula	R^2	SE	Species
Height_m	=exp(1.36573)*(Crown_Radius_m^0.7788)*exp(0.02686)	0.44	0.232	*Tilia x vulgaris*
Height predicted by DBH (data table)				
Height_m	=exp(0.5034)*(DBH_cm^0.45482)*exp(0.05474)	0.29	0.331	*Acer campestre*
Height_m	=exp(0.49855)*(DBH_cm^0.51762)*exp(0.04401)	0.35	0.297	*Acer platanoides*
Height_m	=exp(0.80877)*(DBH_cm^0.4572)*exp(0.0386)	0.42	0.278	*Acer pseudoplatanus*
Height_m	=exp(0.28452)*(DBH_cm^0.56106)*exp(0.04496)	0.5	0.3	*Aesculus hippocastanum*
Height_m	=exp(0.78404)*(DBH_cm^0.44028)*exp(0.04791)	0.35	0.31	*Alnus glutinosa*
Height_m	=exp(0.58933)*(DBH_cm^0.55122)*exp(0.03765)	0.42	0.274	*Betula pendula*
Height_m	=exp(0.55571)*(DBH_cm^0.51434)*exp(0.04774)	0.38	0.309	*Carpinus betulus*
Height_m	=exp(0.7846)*(DBH_cm^0.40394)*exp(0.04216)	0.53	0.29	*Castanea sativa*
Height_m	=exp(0.48202)*(DBH_cm^0.53465)*exp(0.03773)	0.54	0.275	*Fagus sylvatica*
Height_m	=exp(1.00629)*(DBH_cm^0.39627)*exp(0.058)	0.28	0.341	*Fraxinus excelsior*
Height_m	=exp(0.92684)*(DBH_cm^0.42296)*exp(0.02836)	0.31	0.238	*Pinus sylvestris*
Height_m	=exp(0.66413)*(DBH_cm^0.5476)*exp(0.03029)	0.58	0.246	*Platanus x hispanica*
Height_m	=exp(-0.20005)*(DBH_cm^0.60622)*exp(0.02984)	0.56	0.244	*Quercus petraea*
Height_m	=exp(0.75628)*(DBH_cm^0.45091)*exp(0.04674)	0.41	0.306	*Quercus robur*
Height_m	=exp(0.98543)*(DBH_cm^0.3162)*exp(0.06179)	0.21	0.352	*Salix caprea*
Height_m	=exp(0.03541)*(DBH_cm^0.58251)*exp(0.0263)	0.49	0.229	*Sorbus aucuparia*
Height_m	=exp(0.37423)*(DBH_cm^0.49985)*exp(0.03075)	0.51	0.248	*Taxus baccata*
Height_m	=exp(-0.26798)*(DBH_cm^0.75112)*exp(0.0222)	0.8	0.211	*Tilia cordata*
Height_m	=exp(-0.05472)*(DBH_cm^0.66247)*exp(0.038)	0.46	0.276	*Tilia x europaea*

Response	Excel Formula	R^2	SE	Species
Crown radius predicted by DBH (data table)				
Crown_Radius_m	=exp(-0.50396)*(DBH_cm^0.55026)*exp(0.03806)	0.46	0.276	*Acer campestre*
Crown_Radius_m	=exp(-0.71554)*(DBH_cm^0.6393)*exp(0.03274)	0.53	0.256	*Acer platanoides*
Crown_Radius_m	=exp(-0.51408)*(DBH_cm^0.58347)*exp(0.03944)	0.54	0.281	*Acer pseudoplatanus*
Crown_Radius_m	=exp(-0.43954)*(DBH_cm^0.53115)*exp(0.03752)	0.52	0.274	*Aesculus hippocastanum*
Crown_Radius_m	=exp(-0.38257)*(DBH_cm^0.52772)*exp(0.05982)	0.38	0.346	*Alnus glutinosa*
Crown_Radius_m	=exp(-0.80284)*(DBH_cm^0.64367)*exp(0.04399)	0.46	0.297	*Betula pendula*
Crown_Radius_m	=exp(-0.87842)*(DBH_cm^0.68007)*exp(0.04165)	0.55	0.289	*Carpinus betulus*
Crown_Radius_m	=exp(-0.18116)*(DBH_cm^0.48214)*exp(0.04401)	0.61	0.297	*Castanea sativa*
Crown_Radius_m	=exp(-0.67883)*(DBH_cm^0.62818)*exp(0.04804)	0.43	0.31	*Cerasus avium*
Crown_Radius_m	=exp(-0.58385)*(DBH_cm^0.62032)*exp(0.03154)	0.65	0.251	*Fagus sylvatica*
Crown_Radius_m	=exp(-0.66099)*(DBH_cm^0.61624)*exp(0.05392)	0.5	0.328	*Fraxinus excelsior*
Crown_Radius_m	=exp(-0.01085)*(DBH_cm^0.36319)*exp(0.04194)	0.23	0.29	*Ilex aquifolium*
Crown_Radius_m	=exp(-0.97181)*(DBH_cm^0.63889)*exp(0.04604)	0.39	0.303	*Pinus sylvestris*
Crown_Radius_m	=exp(-0.46949)*(DBH_cm^0.64716)*exp(0.0298)	0.66	0.244	*Platanus x hispanica*
Crown_Radius_m	=exp(-0.2032)*(DBH_cm^0.47252)*exp(0.03891)	0.29	0.279	*Prunus avium*
Crown_Radius_m	=exp(-0.82601)*(DBH_cm^0.68933)*exp(0.02628)	0.65	0.229	*Quercus petraea*
Crown_Radius_m	=exp(-0.513)*(DBH_cm^0.5907)*exp(0.04127)	0.58	0.287	*Quercus robur*
Crown_Radius_m	=exp(0.63746)*(DBH_cm^0.26885)*exp(0.0473)	0.2	0.308	*Salix caprea*
Crown_Radius_m	=exp(0.16541)*(DBH_cm^0.39)*exp(0.08532)	0.27	0.413	*Salix fragilis*
Crown_Radius_m	=exp(-0.55251)*(DBH_cm^0.54508)*exp(0.02786)	0.44	0.236	*Sorbus aucuparia*
Crown_Radius_m	=exp(-0.47663)*(DBH_cm^0.54894)*exp(0.0339)	0.53	0.26	*Taxus baccata*
Crown_Radius_m	=exp(-0.55758)*(DBH_cm^0.57352)*exp(0.02754)	0.66	0.235	*Tilia cordata*

Response	Excel Formula	R^2	SE	Species
Crown_Radius_m	=exp(-0.15803)*(DBH_cm^0.46083)*exp(0.04944)	0.24	0.314	*Tilia x europaea*
Crown radius predicted by height (data table)				
Crown_Radius_m	=exp(0.09007)*(Height_m^0.62631)*exp(0.04032)	0.43	0.284	*Acer campestre*
Crown_Radius_m	=exp(-0.08819)*(Height_m^0.71021)*exp(0.03499)	0.49	0.265	*Acer platanoides*
Crown_Radius_m	=exp(-0.18935)*(Height_m^0.72648)*exp(0.04989)	0.41	0.316	*Acer pseudoplatanus*
Crown_Radius_m	=exp(0.01059)*(Height_m^0.65998)*exp(0.03889)	0.5	0.279	*Aesculus hippocastanum*
Crown_Radius_m	=exp(0.12041)*(Height_m^0.57182)*exp(0.07222)	0.25	0.38	*Alnus glutinosa*
Crown_Radius_m	=exp(-0.06778)*(Height_m^0.578)*exp(0.05978)	0.27	0.346	*Betula pendula*
Crown_Radius_m	=exp(-0.12776)*(Height_m^0.68005)*exp(0.057)	0.38	0.338	*Carpinus betulus*
Crown_Radius_m	=exp(-0.29202)*(Height_m^0.84626)*exp(0.0474)	0.58	0.308	*Castanea sativa*
Crown_Radius_m	=exp(0.32009)*(Height_m^0.46445)*exp(0.0418)	0.2	0.289	*Crataegus monogyna*
Crown_Radius_m	=exp(-0.24804)*(Height_m^0.81856)*exp(0.03586)	0.6	0.268	*Fagus sylvatica*
Crown_Radius_m	=exp(0.12998)*(Height_m^0.58682)*exp(0.0799)	0.26	0.4	*Fraxinus excelsior*
Crown_Radius_m	=exp(0.34802)*(Height_m^0.43382)*exp(0.04239)	0.22	0.291	*Ilex aquifolium*
Crown_Radius_m	=exp(-0.52169)*(Height_m^0.91789)*exp(0.02732)	0.69	0.234	*Platanus x hispanica*
Crown_Radius_m	=exp(0.54057)*(Height_m^0.46525)*exp(0.03899)	0.29	0.279	*Prunus avium*
Crown_Radius_m	=exp(0.24477)*(Height_m^0.74176)*exp(0.03821)	0.49	0.276	*Quercus petraea*
Crown_Radius_m	=exp(-0.00285)*(Height_m^0.72629)*exp(0.05542)	0.43	0.333	*Quercus robur*
Crown_Radius_m	=exp(0.57372)*(Height_m^0.47933)*exp(0.04116)	0.3	0.287	*Salix caprea*
Crown_Radius_m	=exp(0.27855)*(Height_m^0.6237)*exp(0.08387)	0.28	0.41	*Salix fragilis*
Crown_Radius_m	=exp(0.13462)*(Height_m^0.52741)*exp(0.03555)	0.29	0.267	*Sorbus aucuparia*
Crown_Radius_m	=exp(0.05039)*(Height_m^0.69613)*exp(0.04206)	0.42	0.29	*Taxus baccata*
Crown_Radius_m	=exp(-0.12316)*(Height_m^0.66732)*exp(0.03024)	0.63	0.246	*Tilia cordata*

Response	Excel Formula	R^2	SE	Species
Crown_Radius_m	=exp(0.10888)*(Height_m^0.60831)*exp(0.03903)	0.4	0.279	*Tilia x europaea*
Crown_Radius_m	=exp(0.11776)*(Height_m^0.55897)*exp(0.01928)	0.44	0.196	*Tilia x vulgaris*

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