



**Performance of sixty two half sib families at eight breeding seedling orchards
in the United Kingdom and Ireland: twelve year results**

Research Report December 2015

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Acknowledgements

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Introduction

In spring 2003, the oak group of Future Trees Trust (then BIHIP) established eight breeding seedling orchards (BSOs) across Britain and Ireland, to investigate the performance of 62 half-sib families of oak, comprising both *Quercus petraea* (28 families) and *Quercus robur* (34 families). The main objective is to provide seed to the forest industry that is well adapted to Britain and Ireland, to improve the form and vigour of oak with the aim of increasing the amount of recoverable timber (Oak Group Business Plan 2016). A further objective is to breed trees less prone to shake, which is thought to be under relatively strong genetic control (Kanowski *et al.* 1991). Figure 1 shows the location of the trees included in the trials.

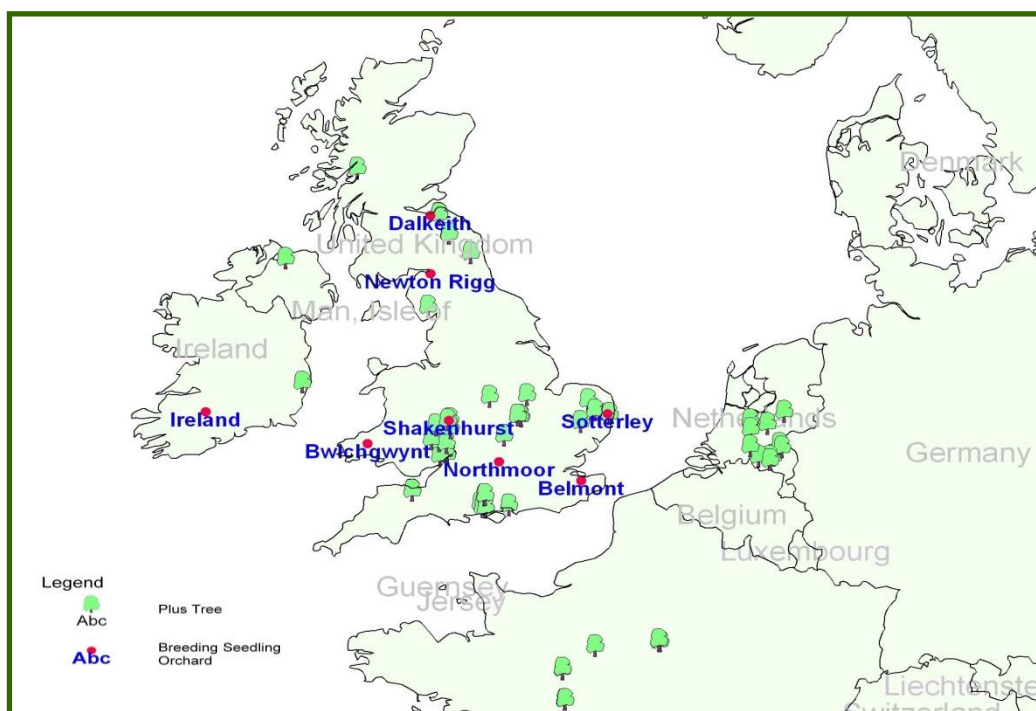


Figure 1. Map showing the location of selected plus trees (green trees) included in the eight trials (red dots).

The trials are mostly planted at 2 x 2 m spacing as single tree plots within a complete randomised plot design, with various numbers of families (66 are being tested) and replicates per site (Table 1). Twenty one families are common to all sites. The objective is to test the progeny over a 15–20 year period, and then rogue poorer performing families to allow for conversion to tested seed orchards.

The orchards occur on various site types and were assessed in 2007 at four years of age. At this time, severe damage by voles at Newton Rigg, Cumbria, resulted in high mortality at this site, and the trial was condensed from 63 to 45 reps by moving trees. In 2011, the trial at Dalkeith was reported to have problems and apical growth of the trees had ceased, with the result that most trees had many tops and appeared almost spherical. The trial was stumped winter 2012, and trees were singled winter 2016. Therefore, this trial was excluded from assessment during winter 2014.

Table 1. Site details for eight breeding seedling orchards for oak, displayed by latitude.

Site	Lat (°N)	Long (°W)	Alt (masl)	Families per site	Reps per site	Total trees
Dalkeith, Mid-Lothian	55.54	3.00	112	32	85	2,635
Newton Rigg, Cumbria	54.40	2.46	150	40	45	2,520
Sotterley, Suffolk	52.25	-1.34	20	61	50	3,050
Shakenhurst, Worcestershire	52.21	2.27	112	21	100	2,100
Rathluirc, Co. Cork	52.19	8.38	120	46	48	2,208
Little Wittenham, Oxfordshire	51.63	1.17	55	56	39	2,184
Bwlchgwynt, Carmarthenshire	51.52	4.30	170	44	52	2,288
Belmont, Kent	51.16	0.49	88	34	70	2,380

Table 2. Number of families per species at each site.

Site	Families per site	<i>robur</i>	<i>petraea</i>
Dalkeith, Mid-Lothian	32	18	14
Newton Rigg, Cumbria	40	22	18
Sotterley, Suffolk	61	33	28
Shakenhurst, Worcestershire	21	12	9
Rathluirc, Co. Cork	46	25	21
Little Wittenham, Oxfordshire	56	32	24
Bwlchgwynt, Carmarthenshire	44	24	20
Belmont, Kent	34	19	15

Methods

Data in the report are presented as accession numbers, and in some tables family ID also, which identifies the county or country of origin. An accession number comprises three elements: a species code, the UK seed zone or country ID, and then the tree identifier. Thus qpe108001 identifies the first sessile oak tree selected in seed zone 108. The seed zone code also identifies the region of provenance. 108 indicates the eighth seed zone in Region of Provenance 10. The regions of provenance are:

Region 10: north and west Scotland

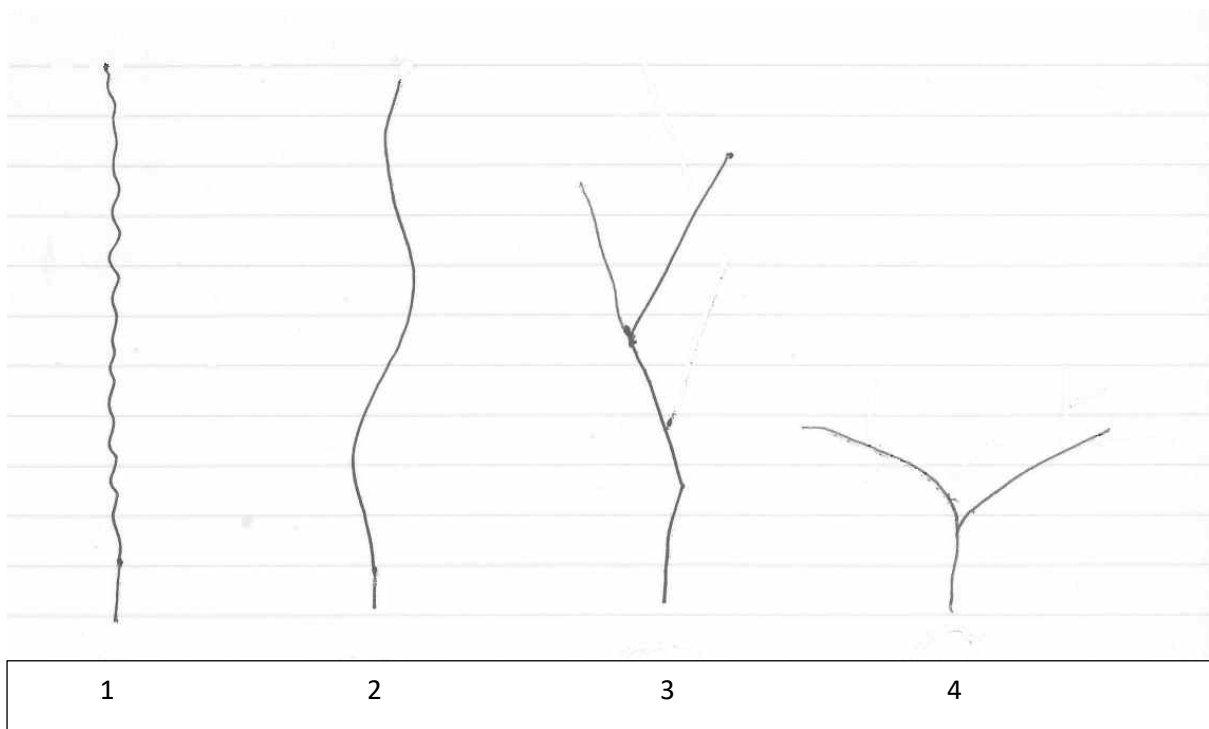
Region 20: north and east Scotland including Northumberland

Region 30: Wales and south west England

Region 40: England (excluding the south west).

There are two exceptions: the 'family' Fontainbleu comprises seed from two mother trees, qpeFRA018 and 019. The 'family' Alice Holt is a bulked seed collection from trees around Alice Holt, Farnham, Hampshire and has been incorporated as a control at all sites except Shakenhurst.

All trees at each site (except Dalkeith) were assessed during winter 2014 to spring 2015. Height was measured to the nearest centimetre using a telescoping measuring pole. Diameter at breast height was measured to the nearest millimetre using digital callipers. Apical dominance was subjectively assessed using a 1 – 4 score where 1 is perfect (the leader persists throughout, and is clear. 1 is still scored where there are two leaders within the last year alone); 2 is good (apical dominance is clearly evident, but has been lost at some point); 3 is acceptable with some corrective pruning (the tree has lost apical dominance, but is still growing upwards and it is possible to select a leader) 4 is poor (no apical dominance, and multiple tops). A form factor was also scored, 1 - 4 where 1 is very good, and 4 is very poor following a scoring provided by Harmer (pers comm) to assess form in young oak (figure 2). Finally, the number of equal forks was counted up the main axis to a maximum number of 5.



1. Well defined main central axis with only small kinks and no large forks
2. Obvious main central axis, some large kinks but no large forks (e.g. co-dominants)
3. Ill-defined main axis with large kinks and forks but tree growing more or less upwards. Overall crown shape relatively taller than broad.
4. No clearly defined main axis growing upwards, crown spreading and generally broader than tall, flat topped, dish/cup/bush shaped.

Figure 2. Pictorial representation of form assessment used in the oak trials, reproduced courtesy of R. Harmer, Forest Research.

The following questions will be addressed:

Q1. Which are the best performing families across all 7 sites for robur and petraea in terms of a) vigour and b) form

Q2. Which are the best performing families at each site for robur and petraea in terms of a) vigour and b) form

Q3. Is there are juvenile/ mature correlation (year 4 vs year 11)

Q4. Is there any correlation between form and flushing data? ie do early flushing families have poorer form?

Q5. Can we correlate poor form with any environmental variables (exposed, using ESC for climatic factors).

Analyses

Dead trees and those that had been beaten up were removed from the analyses. Seedling survival was analysed for each year as the percentage survival of all seedlings that was present at the start of each assessment period.

An overall form score for each tree was calculated by adding the scores for apical dominance, form and number of forks to give a maximum poor form score of 13 (4 for apical dominance, 4 for form and 5 for forks).

Family performance was analysed first across all sites, and then on a site by site basis. Statistical analyses of the significance of site and provenance on growth were carried out using Genstat v16 (VSN international) using generalised linear models (GLM).

Results

1. Survival

Since the last assessment seven years previously, survival had decreased at most sites by 2.3% on average (Table 3). At Little Wittenham, there was a slight increase in survival (0.2%) due to 4 trees resprouting from the base, recorded as dead in 2007.

Table 3. Percentage survival of *Quercus petraea* and *Quercus robur* at seven breeding seedling orchards in Great Britain and Ireland, over four assessment years.

Trial Site	2003	2004	2007	2014
Newton Rigg	98.0	73.0	58.2	54.6
Sotterley	73.7	79.5	77.4	75.5
Shakenhurst	97.0	97.7	94.2	88.8
Rathluirc	99.1	98.0	95.0	94.3
Little Wittenham	93.3	94.1	89.2	89.4
Bwlchgwynt	90.0	87.9	87.2	85.5
Belmont	74.3	74.1	64.5	61.2

2. Species performance across sites

Species performance in terms of height growth across sites was not significantly different with *Quercus petraea* being 0.6 cm taller on average across all sites ($p = 0.816$). Diameter at breast height was not significantly different between species, with *Quercus petraea* having a

mean dbh of 47.1 mm and *Quercus robur* of 46.1 mm. Overall form was significantly different between species ($p < 0.001$) with *Quercus petraea* having a mean form score of 5.68 and *Quercus robur* of 6.12.

Table 4. Site mean performance and performance of each species of oak at seven breeding seedling orchards in Great Britain and Ireland assessed in 2014. P values for significant difference between the species is given for each value. The orchard with the best (in green) and worst (in red) overall values for each trait are highlighted.

Site	Height (cm)	dbh (mm)	Apical Dominance	form	Forks	OVERALL FORM
Newton Rigg	323.0	41.7	2.33	2.75	0.99	6.07
<i>robur</i>	341.1	44.0	2.48	2.82	1.10	6.40
<i>petraea</i>	300.9	39.4	2.14	2.66	0.86	5.67
P value	<0.001	0.015	<0.001	<0.001	<0.001	<0.001
Sotterley	292.5	35.2	2.14	2.50	0.59	5.23
<i>robur</i>	292.8	34.2	2.26	2.62	0.64	5.52
<i>petraea</i>	296.0	36.4	2.01	2.36	0.53	4.90
P value	0.468	0.008	<0.001	<0.001	<0.001	<0.001
Shakenhurst	588.6	84.6	2.22	2.49	1.34	6.05
<i>robur</i>	575.7	80.4	2.26	2.52	1.34	6.13
<i>petraea</i>	605.8	90.1	2.16	2.44	1.33	5.94
P value	<0.001	<0.001	0.06	0.165	0.597	0.134
Rathluirc	349.3	39.9	2.27	2.71	0.55	5.53
<i>robur</i>	339.0	38.8	2.36	2.79	0.64	5.79
<i>petraea</i>	361.6	41.2	2.17	2.62	0.44	5.23
P value	<0.001	0.003	<0.001	<0.001	<0.001	<0.001
Little Wittenham	294.0	33.6	2.21	2.62	0.34	5.18
<i>robur</i>	308.2	35.5	2.24	2.63	0.38	5.25
<i>petraea</i>	275.0	31.1	2.17	2.61	0.29	5.07
P value	<0.001	<0.001	0.175	0.617	<0.001	0.077
Bwlchgwynt	330.0	40.7	2.61	3.14	1.30	7.05
<i>robur</i>	335.5	43.1	2.85	3.27	1.50	7.63
<i>petraea</i>	323.4	37.7	2.32	2.99	1.05	6.36
P value	0.028	<0.001	<0.001	<0.001	<0.001	<0.001
Belmont	358.5	48.8	2.26	2.64	0.65	5.55
<i>robur</i>	343.4	45.1	2.39	2.75	0.64	5.77
<i>petraea</i>	377.6	53.5	2.22	2.49	0.66	5.35
P value	0.003	<0.001	0.016	<0.001	0.498	0.004

Apical dominance and form are scored 1 (good) to 4 (poor).

Forks is the mean number of forks counted up the main stem.

The overall form column is the sum of the three form scores (AD, form, forks) to give an overview for each orchard.

Overall species performance tends to vary little within a site, but is much greater across sites. *Quercus robur* families tend to exhibit much greater variation within a site than do *Quercus petraea* families. For example, the range in height for *Q. robur* at Rathluirc is 268 – 440 cm (range of 170cm) whereas for *Q. petraea* this is much reduced: 324 – 407 cm, a range of 80 cm. This pattern is repeated for all parameters assessed at all sites (Table 4). This table also shows best and worst performing family, by site and by species.

3. Family performance across sites – common 21 families

Twenty one families are common to all sites; nine *petraea* and 12 *robur*. Both family and site are highly significant sources of variation ($p < 0.001$, Table 5). Mean height for *Quercus petraea* was 405.4 cm, and *Quercus robur* was 398.2 cm although this difference was not significant. Mean diameter however was significantly different between the 21 common families ($p = 0.02$), with *Q. robur* having a mean diameter of 52.4mm, and *Q. petraea* having a mean diameter of 55.0 mm. However, these differences are relatively small, and only height growth is looked at in detail in this report. In terms of height growth, the four best performing families were all from the mainland continent, three from the Netherlands, and one from France (Table 6).

Table 5. Results of analysis of variance of height for 21 families common to seven breeding seedling orchards in Great Britain and Ireland in 2014.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Family	20	7964913	398246	40.53	<.001
Site	6	94058165	15676361	1595.47	<.001
Family x Site	120	4789335	39911	4.06	<.001
Residual	6703	65860583	9826		
Total	6849	172672996			

In terms of growth, trees performed outstandingly well at Shakenhurst compared to other sites, with a site mean of 225 cm greater than the next best performing site of Belmont. Indeed, growth was over twice that of the poorest site of Sotterley. Within sites, family performance varied with qroNLD015 performing in the top four families at each site. In fact, this family was the best performer at each site with the only exception of qpeFRA007 which grew on average 1.7 cm greater than the Dutch family at Belmont only. The other family to note for good growth was qpeFRA023, which ranked in the top 4 families at five sites, and qroNLD002 and qroNLD021 ranking in the top 4 families at each of 3 sites. It is interesting to note that the only British trees to rank in the top 4 at any site were two Scottish families, qpe108001 (at Rathluirc and Bwlchgwynt) and qpe204001 (at Shakenhurst).

Table 6. Mean height (cm) in 2014 and parental plus tree vessel size (um) at seven breeding seedling orchards in Great Britain and Ireland of 21 families common to each site. The four tallest (in green) and shortest (in red) families at each orchard are highlighted. Families are ranked by vessel size (um), and those with vessels over 160 um are highlighted red as more likely to be prone to shake.

accession	N. Rigg	Sotterley	Shake.	Rathluirc	LWT	Bwlch.	Belmont	Mean	Vessel
qpeFRA023	270.9	346.3	650.6	403.3	334.5	318.0	420.9	392.1	118.0
qpe305002	255.8	289.9	588.3	327.0	214.5	302.4	344.1	331.7	123.6
qpeFRA027	273.3	312.5	558.5	373.5	245.7	279.3	336.9	340.0	124.2
qro404003	321.9	280.4	577.1	331.9	286.4	358.9	304.0	351.5	130.5
qroIRE006	299.9	285.6	545.2	327.7	306.0	323.6	315.8	343.4	132.2
qpeFRA007	301.7	314.4	639.4	361.4	215.4	284.9	426.9	363.4	132.6
qro203007	313.5	303.8	624.2	367.8	293.8	281.8	381.1	366.6	136.1
qpeFRA021	275.2	317.9	606.0	343.1	284.4	302.0	409.0	362.5	137.4
qroNLD012	352.2	299.7	599.1	353.6	310.9	368.2	350.6	376.3	149.7
qro404004	322.5	260.4	519.6	303.8	246.1	330.6	300.8	326.3	151.5
qpe404002	329.7	278.7	600.8	362.1	248.2	344.3	352.7	359.5	152.9
qpe204001	320.3	268.8	627.4	349.0	263.8	337.7	364.0	361.6	153.6
qroNLD001	362.7	317.2	549.8	308.0	308.9	282.9	395.5	360.7	156.6
qro403009	301.1	230.6	502.7	268.7	259.1	262.5	282.2	301.0	157.0
qroNLD015	453.0	385.1	683.9	439.8	429.7	406.6	425.2	460.5	157.9
qpe108001	325.0	317.6	609.1	388.4	256.2	365.4	407.1	381.3	161.5
qpe403026	309.2	280.3	571.7	324.5	270.0	324.6	324.7	343.6	164.4
qro406007	380.4	256.7	557.3	330.6	322.8	334.0	346.2	361.1	165.3
qroNLD002	383.7	358.0	609.6	364.1	378.7	349.3	408.3	407.4	171.6
qroNLD021	386.0	312.3	585.2	371.5	344.9	360.3	365.5	389.4	180.0
qroNLD008	347.2	297.0	555.0	297.5	313.7	330.7	367.0	358.3	203.5
Site Mean	327.9	300.6	588.6	347.5	292.1	326.1	363.3		

Overall form scores are a combination of apical dominance, form and forking. A higher score corresponds to a tree with poorer form. The sites with the overall best form are Little Wittenham and Sotterley, and it should be noted that these are the two sites where the trees are smallest. Bwlchgwynt scored particularly high for form. Shakenhurst and Belmont, the orchards with the tallest trees, are intermediate for form. Some families have particularly good form, most notably qro203007 whose form is good at every site. qpe108001 also scores well for form, ranking in the top 4 at every site except Little Wittenham, and is a family that also ranked highly for growth. Two French families, qpeFRA021 and 027 rank in the top 4 at three sites each, as does qroNLD015 (the top ranking family for growth). Only qpe108001 has a good form score, but fail on vessel size (but only marginally at 161.5 um).

Table 6. Family mean overall form score in 2014 and parental plus tree vessel size (um) at seven breeding seedling orchards in Great Britain and Ireland of 21 families common to each site. The best (in green) and worst (in red) families at each orchard are highlighted. Families are ranked by vessel size (um), and those with vessels over 160 um are highlighted red as more likely to be prone to shake.

accession	N. Rigg	Sotterley	Shake.	Rathluirc	LWT	Bwlch.	Belmont	Mean	Vessel
qpeFRA023	5.6	5.0	6.8	5.2	5.0	6.4	5.4	5.63	118.0
qpe305002	6.3	4.9	5.3	6.1	6.3	6.0	5.2	5.73	123.6
qpeFRA027	5.4	4.1	5.4	5.5	5.3	6.3	5.2	5.31	124.2
qro404003	6.9	5.7	6.7	7.2	5.9	8.9	6.9	6.89	130.5
qroIRE006	6.4	6.2	6.4	6.1	5.5	8.1	6.8	6.50	132.2
qpeFRA007	5.1	6.0	6.3	5.4	5.1	6.4	6.3	5.80	132.6
qro203007	5.3	4.3	4.5	4.7	4.5	6.2	4.8	4.90	136.1
qpeFRA021	5.6	5.0	5.8	4.9	4.5	6.2	5.0	5.29	137.4
qroNLD012	6.4	5.4	6.1	5.6	5.4	8.3	6.1	6.19	149.7
qro404004	7.3	5.4	6.0	6.0	5.8	8.6	6.3	6.49	151.5
qpe404002	6.5	4.7	6.2	5.1	5.3	6.8	6.1	5.81	152.9
qpe204001	5.8	6.2	6.0	5.7	6.1	7.0	5.7	6.07	153.6
qroNLD001	5.6	5.9	5.5	5.7	4.5	6.1	5.5	5.54	156.6
qro403009	7.1	7.0	6.6	7.1	6.0	8.9	6.0	6.96	157.0
qroNLD015	6.5	4.4	7.2	4.6	4.0	7.8	5.5	5.71	157.9
qpe108001	5.5	3.9	5.1	4.3	5.0	5.7	5.2	4.96	161.5
qpe403026	5.5	5.9	6.5	5.9	5.4	7.2	5.6	6.00	164.4
qro406007	5.8	5.5	5.8	5.5	5.3	7.7	6.2	5.97	165.3
qroNLD002	5.8	4.7	5.6	5.5	3.7	7.4	5.2	5.41	171.6
qroNLD021	6.2	4.8	5.9	5.6	4.8	7.5	4.1	5.56	180.0
qroNLD008	7.6	6.8	7.2	6.3	5.5	8.5	6.6	6.93	203.5
Site Mean	6.1	5.3	6.0	5.6	5.2	7.2	5.7		

There is some similarity between ranking of family performance for growth and form. Family qro403009 ranks last for both these factors and qroIRE006 ranks highly also, 17th for growth and 18th for form. These families would be candidates for rogueing at time of trial conversion to seed orchard

Table xxx

accession number	Mean Growth	Growth Rank	Mean Form	Form Rank	Mean Flush	Flush Rank	Vessel	Vessel Rank
qroNLD015	460.5	1	5.7	9	3.0	17	157.9	15
qroNLD002	407.4	2	5.4	5	2.8	18	171.6	19
qpeFRA023	392.1	3	5.6	8	4.1	3	118.0	1
qroNLD021	389.4	4	5.6	7	2.2	21	180.0	20
qpe108001	381.3	5	5.0	2	4.4	2	161.5	16
qroNLD012	376.3	6	6.2	16	3.7	8	149.7	9
qro203007	366.6	7	4.9	1	3.1	16	136.1	7
qpeFRA007	363.4	8	5.8	11	4.0	4	132.6	6
qpeFRA021	362.5	9	5.3	3	4.4	1	137.4	8
qpe204001	361.6	10	6.1	15	3.8	5	153.6	12
qro406007	361.1	11	6.0	13	3.1	15	165.3	18
qroNLD001	360.7	12	5.5	6	3.3	14	156.6	13
qpe404002	359.5	13	5.8	12	3.7	6	152.9	11
qroNLD008	358.3	14	6.9	20	2.7	19	203.5	21
qro404003	351.5	15	6.9	19	2.6	20	130.5	4
qpe403026	343.6	16	6.0	14	3.6	10	164.4	17
qroIRE006	343.4	17	6.5	18	3.7	9	132.2	5
qpeFRA027	340.0	18	5.3	4	3.4	12	124.2	3
qpe305002	331.7	19	5.7	10	3.7	7	123.6	2
qro404004	326.3	20	6.5	17	3.5	11	151.5	10
qro403009	301.0	21	7.0	21	3.4	13	157.0	14

Family performance at each site, and by species

Across all families and all sites, species performance is not significantly different with *Quercus petraea* being 0.6cm taller than *Quercus robur* at 362.2 cm versus 361.6 cm. However, on a site by site basis, species performance (based on height) is significantly different at all sites except Sotterley (Table xxx) with *Quercus petraea* being taller than *Q. robur* at Belmont, Rathluirc and Shakenhurst, and *Quercus robur* being tallest at Little Wittenham, Bwlchgwynt and Newton Rigg. Mean family data for each site are given in Appendix 1 with site notes.

Interpretation of results – what are we likely to do with each orahcrd

Newton Rigg

At Newton Rigg, overall mean height growth was 323 cm, with *Quercus robur* (341.1 cm) being significantly greater than *Quercus petraea* (300.9 cm; $p = <0.001$), as was diameter growth (Table xxx). However, in term of form performance *Quercus petraea* was significantly superior to that of *Q. robur* ($p = <0.001$).

Sotterley

Shakenhurst

Correlation with 2007 data

Look at correlation between 2007 and 2014.

Correlation between ht 2007 and ht 2014 = 0.76

Across species: 15% of all petraea scored 4+4, and 22.8% of all robur scored 4+4

Correlation of performance with vessel size.

Correlation of performance with flushing data.

Use overall form score of adding together AD, from and forks. Thus lowest score = best. **CUT THIS - REPITITION**

	Newton Rigg	Sotterley	Shakenhurst	Rathluirc	L. Wittenham	Bwlchgwynt	Belmont
Orchard							
Tallest	qroNLD015	qroNLD015	qroNLD015	qroNLD015			
Shortest	qpe403012	qro406009	qro403009				
Best form	qpe403012	qpe301002	qroNLD001				
Worst from	qro204001	qro403009	qroNLD008				
robur							
Tallest	qroNLD015	qroNLD015	qroNLD015	qroNLD015			
Shortest	qro406004	qro406009	qro403009				
Range (cm)	(280-453) = 173	203-385 = 182	503-683 = 180				
Best form	qro106001		qroNLD001				
Worst from	qro204001		qroNLD008				
Range (Score)	1.95-3.00 = 1.05		1.97-2.98 = 1.01				
petraea							
Tallest	qpe404010		qpeFRA023				
Shortest	qpe403012		qpeFRA027				
Range (cm)	242-364 = 122		558-651 = 93				
Best form	qpe403012		qpe305002				
Worst from	qpeFRA006		qpeFRA023				
Range (score)	1.82-2.80 = 0.98						

2004 includes beat ups with correct family (hence higher trial survival). Any beat ups after 2004 are fillers. Increase survival due to resprouted from base tree

Belmont site survival = 70.6%

Sotterley – 36 trees alive that were dead in 2007. Slight increase in survival. Look likely to be resprouts (weeds were very bad in 2007, so possibly didn't find very tiny trees).

Shakenhurst – 68 trees felled between 2007 – 2014 so survival should be 92.1% Also, survival IS 92% as 63 non test replants alive

Discussion

In 2015, analysis of four oak provenance trials growing in Ireland was undertaken to assess to what extent juvenile mature correlations exist in oak aged xxxx (Kennedy 2015). Correlations were very weak (XXXXXXX).

Savill (1986) found that trees with large vessel diameters are particularly predisposed to shake. Because of this correlation, at the time of plus tree selection, 5 mm increment cores were taken from the base of selected plus trees using a Pressler borer and vessel size (the radius of the first two vessels of each of 20 consecutive annual rings) was measured using a microscope. Trees with vessel sizes greater than 160 μm radius were deemed to be more likely to be prone to shake (Savill 1986) and some trees with larger than average vessels were therefore excluded from the breeding programme (Hubert and Savill 1999). Vessel size of selected plus trees range from 116.6 to 210 μm , (a tree growing in Lincolnshire, suspected of being a hybrid), and one outlier, qpe404012, growing in the Forest of Dean, Gloucestershire, which has a vessel size of 232 μm . Within the BSOs, vessel radii range from 116.6 μm (tree qro406004) to 203.5 μm (tree qroNLD008). Furthermore, Savill and Mather (1990) report that oak trees with larger vessel sizes (i.e. those trees more likely to be predisposed to shake) are associated with late flushing.

The oak group's breeding strategy acknowledges that tolerance to late spring frosts is of particular interest given the predominance of late spring frosts in the British/Irish climate (Boshier 2010) and that frost damage to particular organs is dependent upon flushing stage at the time of exposure to frost.

Issues to address.

Results show very clearly that some families perform best in term of growth, and others perform best in terms of form. Some families perform well for both these criteria.

Appendix 1. Site visit notes, and mean family values for each assessed trait. Height and increment 2007 – 2014 are in centimetres and diameter at breast height in mm. Apical dominance and form assessments are subjective, scored 1 – 4 with 1 being a perfect tree, and 4 being very poor. Forks is the number of forks (up to a maximum of 5) at the main axis. FORM is the sum of the form factors for an overall comparison. The four best and worst performing families are highlighted in green and red for each species for each trait, and the overall FORM highlights only the best and worst family. Results of the analysis of variance are given for all families, and then by species; Probability >F for within site analysis: n.s. = not significant $P > 0.05$; * significant at $P \leq 0.05$; ** significant at $P \leq 0.005$; *** significant at $P \leq 0.001$.

Rathluirc, County Cork, Ireland: 20-23rd Oct 2014

The site is very well laid out. A few marker posts are missing (reps 3, 39, 40, 41, 46, 47 and 48).

This BSO is variable in size of trees and vegetation. In places there is much willow regen, which in many cases is swamping the oak and pushing them away from vertical. In the middle a few reps had dense bramble, and in 28, most of the rep is impenetrable, so only half this rep was assessed. Each rep is surrounded by a wide path (makes ease of access, but unequal competition – trees around the edge are more bushy). There is also some ash regen, which is not a problem at present but is obviously growing well. Although only 2-3 years old, some ash are already 1.5m tall. The bottom of the site is more wet with lots of *Juncus*, and willow, but the oak are doing well.

In the last few reps, there is a small area covered in marsh thistle, and the oak very stunted here and more mortality than elsewhere on site – presumably a wet spot.

No tubes present, and the oak are very branchy low down. 324 trees forked at base and several have two perfect stems, so that if one were removed, the tree would look very good. Many more trees like this than normal.

Accession #	Height	dbh	inc 07-14	AD	Form	Forks	FORM
qpe108001	388.4	42.8	269.6	1.86	2.07	0.35	4.3
qpe403012	344.4	33.2	238.0	1.74	2.19	0.40	4.3
qpe403015	407.0	45.4	276.3	1.92	2.35	0.42	4.7
qpe203002	350.8	37.8	234.6	2.06	2.40	0.27	4.7
qpe301002	396.2	50.0	269.3	1.98	2.45	0.34	4.8
qpeFRA021	343.1	37.8	246.5	1.92	2.50	0.44	4.9
qpe305001	352.0	38.0	247.4	2.04	2.68	0.32	5.0
qpe404003	340.7	37.5	230.3	2.20	2.52	0.39	5.1
qpe404002	362.1	44.8	251.9	2.23	2.57	0.32	5.1
qpe404001	335.4	37.0	229.4	2.13	2.57	0.51	5.2
qpeFRA023	403.3	53.4	264.2	2.20	2.70	0.35	5.2

qpeFRA007	361.4	40.3	236.4	2.34	2.68	0.40	5.4
qpe404017	378.0	42.3	241.9	2.22	2.72	0.54	5.5
qpeFRA027	373.5	47.8	238.8	2.40	2.71	0.38	5.5
qpeIRE008	325.1	33.8	218.0	2.27	2.73	0.49	5.5
qpe403009	382.4	44.6	242.7	2.35	2.72	0.48	5.5
qpeFRA006	353.9	38.8	244.0	2.28	2.89	0.38	5.6
qpe204001	349.0	37.0	243.0	2.35	3.02	0.30	5.7
qpe404010	394.5	47.1	249.0	2.26	2.53	0.91	5.7
qpe403026	324.5	34.0	216.1	2.37	2.91	0.65	5.9
qpe305002	327.0	42.6	222.2	2.51	3.00	0.60	6.1
<i>petraea</i>	361.6	41.2	243.31	2.17	2.62	0.44	5.23
qroNLD015	439.8	52.6	295.6	1.85	2.26	0.49	4.6
qroNLD018	379.6	42.1	247.9	1.85	2.23	0.54	4.6
qro203007	367.8	42.3	237.4	1.89	2.39	0.37	4.7
qroNLD009	338.1	37.2	217.4	2.11	2.60	0.60	5.3
qroNLD017	312.7	32.0	218.4	2.11	2.49	0.71	5.3
qro106001	333.1	36.1	229.0	2.13	2.60	0.64	5.4
qroNLD002	364.1	41.6	235.8	2.17	2.59	0.74	5.5
qro406007	330.6	41.4	200.1	2.39	2.78	0.33	5.5
qroNLD012	353.6	39.9	243.1	2.27	2.63	0.71	5.6
qroNLD021	371.5	45.2	248.8	2.28	2.60	0.74	5.6
qroNLD001	308.0	33.2	195.0	2.21	2.85	0.60	5.7
qro402001	362.4	43.7	227.5	2.38	2.72	0.57	5.7
qro109001	408.2	52.8	248.7	2.36	2.66	0.70	5.7
qro406004	301.6	31.5	188.0	2.40	2.85	0.55	5.8
qro405	299.6	33.5	189.7	2.48	2.95	0.39	5.8
qro404004	303.8	30.7	190.9	2.35	2.98	0.67	6.0
qro403008	325.8	38.0	213.5	2.52	2.93	0.54	6.0
qro406008	349.7	38.1	222.8	2.46	2.92	0.67	6.0
qroIRE006	327.7	36.4	203.9	2.38	2.87	0.84	6.1
qro204001	314.1	32.9	194.4	2.43	3.06	0.70	6.2
qro404009	391.1	46.0	245.7	2.43	2.89	0.93	6.3
qroNLD008	297.5	29.4	191.3	2.56	3.10	0.63	6.3
qro406009	293.5	36.0	181.4	2.89	3.17	0.76	6.8
qro403009	268.8	35.8	162.3	2.98	3.27	0.89	7.1
qro404003	331.9	42.3	201.4	3.02	3.45	0.77	7.2
<i>robur</i>	339.0	38.8	217.20	2.36	2.79	0.64	5.79
orchard mean	349.3	39.9	229.12	2.27	2.71	0.55	5.53
<i>p</i> values							
species	n.s	n.s	***	***	***	***	***
All families	***	***	***	***	***	***	***
<i>robur</i>	***	***	***	***	***	n.s	***
<i>petraea</i>	***	***	***	**	***	*	***

Bwlchgwynt, Carmarthenshire, Wales. 24-25th Oct 2014

A pheasant pen has been erected in the gate entrance, so no access. Access is now via the bottom of trial, through a hole in the fence.

Trees are still in tubes. There is quite a bit of willow regen in some areas. The trees at the top of the slope are very poor with excessive amounts of forking in the crown and complete lose of apical dominance with many trees being extremely bushy. There is a lot of variation in size and now the bigger trees are impacting smaller trees making them lean or outcompeting them entirely. This is also due to willow regen which is dominant in some areas.

The site is on a gradual slope. Trees at the top are of substantially poorer form than those lower down. There is a wet patch in the middle that was planted with ash and birch instead of oak. The ash have grown very well, and where they are adjacent to the oak, have provided shelter, and there is noticeable improved form and vigour in the oak here. Further down the slope, the form improves quite a bit.

It would appear to be a pronounced site effect except that: 1. The landowner says it is an extremely mild site. It is about ten miles from the sea, and he says this does not affect the site. There is ancient woodland above the site, and the site is south facing across the valley. The site did appear to be quite sheltered. However, am convinced it is a site effect that we are seeing with frost damage to the upper half of the site. Extremely exposed and windy during visit.

Accession #	Height	dbh	inc 07-14	AD	Form	Forks	FORM
qpe403012	294.3	24.8	202.6	1.61	2.52	0.82	4.94
qpe203002	277.9	28.5	171.0	2.12	2.80	0.63	5.56
qpe108001	365.4	44.8	258.6	1.98	2.63	1.08	5.68
qpe301002	411.8	60.3	274.6	2.04	2.61	1.16	5.82
qpe404001	326.5	43.1	197.3	2.39	2.75	0.77	5.91
qpe305002	302.4	33.5	210.4	2.15	2.94	0.88	5.97
qpe403015	368.4	47.9	224.9	2.13	2.87	1.02	6.02
qpeIRE008	302.3	29.9	209.8	2.21	2.88	1.00	6.09
qpeFRA021	302.0	33.4	195.9	2.13	2.97	1.13	6.23
qpeFRA027	279.3	26.0	178.3	2.36	2.92	0.97	6.25
qpeFRA007	284.9	26.3	170.8	2.24	3.05	1.10	6.39
qpeFRA023	318.0	34.1	217.7	2.33	3.05	1.03	6.41
qpe305001	347.7	46.0	219.6	2.52	2.98	0.98	6.48
qpe404003	345.2	50.0	227.0	2.39	3.07	1.34	6.80
qpe404002	344.3	44.1	218.1	2.53	3.35	0.94	6.82
qpe404010	369.6	46.7	220.0	2.49	3.02	1.41	6.92
qpe403009	318.1	32.8	195.4	2.46	3.24	1.30	7.00
qpe204001	337.7	36.8	218.5	2.56	3.20	1.29	7.04
qpe403026	324.6	40.1	199.5	2.64	3.30	1.25	7.18
qpeFRA006	247.2	23.9	142.2	3.04	3.60	0.98	7.63

<i>petraea</i>	323.4	37.7	207.6	2.32	2.99	1.05	6.36
qroNLD001	282.9	27.4	177.2	2.11	2.91	1.09	6.11
qro203007	281.8	26.9	163.1	2.71	2.73	0.75	6.19
qroNLD009	308.4	30.7	190.1	2.31	2.93	1.07	6.31
qro402001	340.9	42.1	235.7	2.40	3.03	1.11	6.54
qro106001	345.8	39.4	234.1	2.57	3.03	1.10	6.70
qroNLD018	375.0	45.4	238.5	2.52	2.93	1.43	6.89
qro403008	360.4	51.5	228.6	2.60	3.14	1.32	7.06
qro204001	350.2	42.1	222.6	2.70	3.30	1.35	7.35
qroNLD002	349.3	46.0	222.9	2.66	3.11	1.62	7.38
qroNLD021	360.3	46.9	224.1	2.60	3.21	1.65	7.47
qro406009	305.5	40.6	200.8	2.77	3.27	1.59	7.64
qro406007	334.0	46.5	216.4	2.91	3.33	1.45	7.69
qroNLD015	406.6	52.9	252.3	2.81	3.15	1.83	7.79
qro406004	277.1	32.6	165.4	2.98	3.40	1.51	7.89
qro406008	341.0	44.8	223.0	2.86	3.40	1.65	7.91
qroNLD017	325.9	40.7	209.5	3.14	3.27	1.61	8.02
qroIRE006	323.6	45.3	200.6	3.04	3.50	1.56	8.10
qro404009	375.3	50.2	234.4	3.06	3.39	1.78	8.22
qroNLD012	368.2	46.8	233.5	3.17	3.39	1.74	8.30
qroNLD008	330.7	43.6	200.7	3.23	3.58	1.67	8.48
qro404004	330.6	40.8	206.9	3.18	3.56	1.84	8.58
qro405	356.4	54.3	224.9	3.22	3.57	2.00	8.78
qro404003	358.9	64.1	218.6	3.45	3.70	1.72	8.87
qro403009	262.5	33.9	150.8	3.50	3.76	1.64	8.90
<i>robur</i>	335.5	43.1	211.4	2.85	3.27	1.50	7.63
orchard mean	330.0	40.7	209.7	2.61	3.14	1.30	7.05
<i>p</i> values							
species	***	***	***	***	***	***	***
all families	*	***	n.s	***	***	***	***
<i>robur</i>	***	***	***	***	***	***	***
<i>petraea</i>	***	***	***	***	***	*	***

Little Wittenham, Oxfordshire. October 2014

This orchard is on a completely flat site, and is very well laid out. Trees are noticeably smaller to other BSOs but the form appears to be better. There was severe flooding in winter 2013/14 but there is no visible negative impact in 2014 in terms of mortality. The site underwater for several weeks and is waterlogged most winters. This is possibly having an effect on growth rates with perhaps fine roots dying in the winter. No other problems. All rep markers are present.

Accession #	Height	dbh	inc 07-14	AD	Form	Forks	FORM
qpe301002	335.6	38.9	206.5	1.74	2.00	0.26	4.00
qpe404003	281.8	30.1	170.7	1.91	2.21	0.26	4.38
qpeFRA021	284.4	31.9	183.1	1.86	2.39	0.26	4.51
qpe403012	235.1	23.4	141.6	1.91	2.43	0.17	4.51
qpe403015	309.3	36.2	194.0	1.88	2.41	0.26	4.56
qpe404010	356.8	42.8	228.5	1.95	2.13	0.53	4.61
qpe403007	343.3	41.9	214.3	1.94	2.33	0.39	4.67
qpe203002	295.0	33.1	174.3	2.11	2.43	0.23	4.77
qpe404001	293.6	33.4	176.1	2.14	2.54	0.22	4.89
qpe404017	287.3	28.3	167.2	2.09	2.52	0.30	4.91
qpeFRA023	334.5	37.5	223.9	1.95	2.59	0.43	4.97
qpe108001	256.2	26.5	148.4	2.14	2.56	0.31	5.00
qpe404021	267.6	31.1	170.7	2.14	2.61	0.28	5.03
qpeFRA007	215.4	22.3	120.3	2.30	2.70	0.09	5.09
qpeIRE008	214.0	24.1	112.9	2.27	2.64	0.21	5.12
qpe305001	223.1	28.2	131.4	2.39	2.85	0.09	5.33
qpe404002	248.2	27.4	142.4	2.29	2.75	0.29	5.33
qpeFRA027	245.7	26.2	143.5	2.39	2.72	0.23	5.34
qpe403009	346.8	39.5	217.0	2.09	2.70	0.61	5.39
qpe403026	270.0	35.0	155.3	2.34	2.84	0.25	5.44
qpe403001	211.1	22.4	125.7	2.41	3.00	0.28	5.69
qpeFRA006	266.8	28.1	155.0	2.42	2.92	0.47	5.81
qpe204001	263.8	30.3	157.2	2.61	3.22	0.28	6.11
qpe305002	214.5	28.9	109.5	2.76	3.21	0.33	6.30
<i>petraea</i>	275.0	31.1	165.40	2.17	2.61	0.29	5.07
qroNLD002	378.7	40.9	246.0	1.58	1.87	0.26	3.71
qroNLD018	350.0	39.2	209.9	1.63	1.89	0.20	3.71
qroNLD015	429.7	48.5	282.1	1.57	1.94	0.49	4.00
qroNLD009	307.2	30.9	188.4	1.69	2.11	0.39	4.19
qro404007	347.9	43.5	225.2	1.88	2.27	0.21	4.36
qro203007	293.8	31.1	178.0	1.81	2.50	0.19	4.50
qroNLD001	308.9	32.4	191.8	1.92	2.27	0.34	4.53
qro402002	366.2	46.8	219.4	1.82	2.41	0.41	4.65
qroNLD021	344.9	40.4	209.5	2.00	2.27	0.51	4.78
qro402009	293.7	32.5	175.6	2.11	2.38	0.49	4.97
qro402003	302.2	31.5	178.4	2.14	2.67	0.31	5.11
qro406008	311.7	34.4	186.8	2.22	2.57	0.38	5.16
qro406007	322.8	37.9	195.8	2.08	2.70	0.54	5.33
qroNLD019	317.9	35.4	180.6	2.21	2.70	0.52	5.42
qroNLD012	310.9	34.0	181.7	2.33	2.77	0.33	5.44
qroNLD017	266.2	28.5	147.1	2.41	2.71	0.32	5.44
qro106001	248.5	24.9	153.8	2.43	2.90	0.13	5.47
qro406004	263.0	29.4	151.5	2.50	2.71	0.26	5.47

qroIRE006	306.0	38.6	178.3	2.35	2.70	0.43	5.49
qroNLD008	313.7	39.6	190.6	2.45	2.70	0.39	5.55
qro403008	308.0	39.2	172.8	2.38	2.79	0.44	5.62
qro402001	317.8	36.8	184.5	2.39	2.86	0.42	5.67
qro404009	325.6	40.6	190.3	2.41	2.85	0.46	5.72
qro406003	290.6	30.8	169.7	2.43	2.89	0.46	5.78
qro204001	274.1	32.4	148.8	2.53	2.94	0.35	5.82
qro404004	246.1	26.9	135.9	2.57	3.00	0.26	5.83
qro109001	372.7	45.6	214.7	2.38	2.73	0.73	5.84
qro404003	286.4	32.5	164.8	2.53	2.97	0.42	5.92
qro405	282.8	35.3	170.6	2.68	2.86	0.39	5.93
qro403009	259.1	35.8	133.1	2.62	3.03	0.35	6.00
qro406009	227.4	26.7	117.1	2.71	3.11	0.32	6.13
qro404002	288.9	32.3	162.5	2.85	3.15	0.53	6.53
<i>robur</i>	308.2	35.5	182.36	2.24	2.23	0.38	4.85
Orchard mean	294.0	33.6	175.1	2.21	2.62	0.34	5.17
<i>p</i> values							
Species	***	***	***	n.s	n.s	***	n.s
All families	***	***	***	***	***	*	***
<i>petraea</i>	***	***	***	**	***	***	***
<i>robur</i>	***	***	***	***	***	n.s	***

Newton Rigg, Cumbria 27th – 29th Oct 2014

Originally planted as 63 reps, the BSO was consolidated to 45 reps in 2006 due to severe vole damage. The 2007 assessment recorded an additional 450 dead tree, many likely due to transplanting. However, many of the tree labels were wrong, and this was also noted in 2007. A tree by tree ID will be carried out in 2015. Some additional oak mortality was recorded in 2014, due to dense vegetation (mostly willowherb) where trees were small in 2007. The site is completely covered in head high nettles, and some areas of dense willowherb which is likely responsible for further tree mortality.

Some rep posts and tags are missing (no post: reps 1, 12, 19, 24. Post but no tag: 3, 7, 30. Rotten post on ground 43, 25). The site is flat, and very well laid out, so it was easy to walk off in a diagonal. It would be very helpful to have these missing rep makers and posts replaced.

The trees were pruned by Newton Rigg students in 2007. This has helped improved the form of the trees a great deal and has also made it much the easiest trial to move around in as trees had high and formative pruning. However, this will unfortunately give erroneous form measurements.

Some gaps have been beaten up with beech. We recorded 77, although this number is likely to be higher, as we didn't start off noting these. We will make a full count when we checked label IDs in

2015. Although small, most seem to be doing really well, except in a few cases where the nettles and willowherb are too dense.

Accession #	Height	dbh	inc 07-14	AD	Form	Forks	FORM
qpe203002	325.2	38.9	232.5	1.89	2.34	0.55	4.79
qpe403012	242.0	24.4	177.7	1.88	2.35	0.76	5.00
qpeFRA007	301.7	30.0	217.4	1.95	2.53	0.58	5.05
qpe404010	364.0	46.6	242.2	1.82	2.45	0.94	5.20
qpeFRA027	273.3	28.0	194.0	2.11	2.52	0.81	5.44
qpe404003	324.3	40.9	222.1	2.00	2.52	0.94	5.45
qpe108001	325.0	37.5	244.6	1.96	2.61	0.93	5.50
qpe403026	309.2	40.3	211.8	2.15	2.62	0.76	5.53
qpe404001	286.4	36.8	193.6	2.15	2.71	0.68	5.53
qpe301002	347.3	66.8	229.8	2.10	2.62	0.88	5.60
qpeFRA023	270.9	36.2	179.5	2.19	2.81	0.63	5.63
qpeFRA021	275.2	28.6	194.4	2.15	2.67	0.82	5.64
qpe204001	320.3	37.0	232.2	2.09	2.91	0.81	5.81
qpe403015	340.5	47.9	232.9	2.20	2.59	1.05	5.84
qpe305001	255.2	29.6	172.2	2.31	2.69	1.15	6.15
qpe305002	255.8	27.3	175.2	2.35	2.87	1.04	6.26
qpe404002	329.7	43.2	228.7	2.44	2.94	1.09	6.47
qpeFRA006	271.2	26.7	186.2	2.80	3.23	1.07	7.10
<i>petraea</i> mean	300.9	37.0	209.3	2.14	2.66	0.86	5.67
qro106001	309.8	33.5	243.7	1.95	2.41	0.64	5.00
qroNLD009	327.3	34.5	244.3	2.03	2.27	0.70	5.00
qro203007	313.5	36.8	219.9	2.06	2.50	0.69	5.25
qroNLD001	362.7	45.3	262.4	2.07	2.47	1.07	5.60
qro406007	380.4	53.3	268.0	2.34	2.61	0.85	5.80
qroNLD002	383.7	50.4	279.0	2.38	2.50	0.94	5.81
qro406009	284.7	32.2	198.9	2.24	2.70	0.91	5.85
qroNLD021	386.0	54.3	275.2	2.21	2.67	1.31	6.19
qro406008	359.7	44.1	261.7	2.39	2.78	1.12	6.29
qroIRE006	299.9	34.4	206.4	2.42	2.86	1.14	6.42
qroNLD012	352.2	43.4	243.2	2.38	2.89	1.16	6.42
qroNLD015	453.0	67.7	322.3	2.49	2.73	1.31	6.53
qro405	329.7	45.6	230.6	2.56	2.79	1.23	6.59
qroNLD017	341.6	40.5	236.4	2.49	2.92	1.35	6.76
qro403008	392.3	58.5	260.5	2.60	2.98	1.23	6.81
qro404003	321.9	38.2	229.6	2.67	3.06	1.15	6.88
qro406004	280.7	33.9	179.0	2.80	3.13	1.00	6.93
qro403009	301.1	38.1	198.8	2.87	3.21	1.03	7.11
qro204001	314.8	41.7	198.7	3.00	3.24	1.02	7.27
qro404004	322.5	39.0	215.7	2.94	3.13	1.23	7.29

qro402001	339.9	39.6	249.7	2.74	3.09	1.52	7.35
qroNLD008	347.2	42.3	249.9	2.94	3.17	1.50	7.61
<i>robur</i> mean	341.1	43.1	239.7	2.48	2.82	1.10	6.40
orchard mean	323.0	40.3	226.0	2.33	2.75	0.99	6.07
<i>p</i> values							
species	***	*	***	***	***	***	***
All families	***	***	***	***	***	***	***
<i>robur</i>	***	***	***	***	***	**	***
<i>petraea</i>	***	*	***	n.s	*	n.s	n.s

Sotterley, Suffolk. 14-16th Feb 2015

Sotterley BSO is in very good shape. The site has been inter-row mown, so discrete bramble patches were present around the base of some trees, but this was not impacting the trees. Some rep markers are rotten, and a few missing, and nearly all rep tags missing. The trial is very well laid out, on a south facing slope, surrounded by a double guard row, and then hedges. Some mature oak are in the immediate vicinity. The site is quite exposed. Form seems to be better than average with many trees exhibiting good apical dominance. Many trees were stumped very early on (year 2 or 3) but only just singled this winter for the most part, with one stem being removed at base. (290 clearly singled (probably more) and 15 clearly not singled (probably more)).

These appear to have better than average form, and there is no evidence of any pruning. Rep 1 is at the bottom of slope, and nearest to the gate, in the south west corner. There is a bad patch in the middle of the site, where mortality is much higher. Very few (less than 10) additionally dead trees from 2007 in total, with quite a few resurrections but these are mostly very small. The site has been beaten up with hornbeam.

A tenant farmer runs a pheasant shoot, so couldn't get in until after 1st Feb. Doesn't seem to have done any damage to the trees, and probably is keeping access maintained.

An oak clonal hedge is at bottom of trial (very southern end of field) after a few rows of hornbeam, and then some very decent chestnut coppice. This has been maintained in excellent order, cut back hard each year, planted at close spacing. It will be possible to get excellent scion material from these for clonal seed orchards. NB. Need to check have planting order list.

Accession #	Height	dbh	inc 07-14	AD	Form	Forks	FORM
qpe301002	337.9	45.1	229.23	1.41	1.90	0.41	3.72
qpe108001	317.6	35.4	234.98	1.63	1.85	0.41	3.90
qpeFRA027	312.5	37.3	216.53	1.82	2.03	0.29	4.13
qpe203002	307.9	36.7	208.39	1.75	2.07	0.32	4.14
qpe404010	340.3	40.9	217.34	1.81	2.05	0.45	4.31
qpeIRE008	254.0	24.2	187.69	1.78	2.11	0.47	4.36
qpe403015	319.0	40.8	217.50	1.75	2.23	0.39	4.36

qpe403012	257.4	30.8	184.00	1.72	2.26	0.46	4.44
qpe404002	278.7	29.9	200.05	1.91	2.32	0.45	4.68
qpe403002	252.3	26.5	184.11	1.89	2.34	0.45	4.68
qpeFRA	263.9	33.0	196.75	2.03	2.29	0.47	4.79
qpe404021	299.1	37.9	205.70	1.86	2.32	0.64	4.82
qpe404003	278.1	32.7	195.07	2.04	2.26	0.52	4.83
qpe403007	328.5	43.1	223.93	2.02	2.28	0.54	4.85
qpeFRA006	282.3	36.0	201.80	2.00	2.39	0.47	4.86
qpe305002	289.9	35.8	192.97	2.17	2.36	0.42	4.94
qpeFRA023	346.3	42.9	233.61	1.98	2.34	0.66	4.98
qpeFRA021	317.9	41.6	229.49	2.13	2.34	0.53	5.00
qpe305001	263.5	32.8	166.22	2.03	2.49	0.49	5.00
qpe403009	328.9	40.3	211.63	2.06	2.43	0.69	5.17
qpe404001	269.0	33.5	175.83	2.26	2.50	0.43	5.19
qpe403001	281.0	31.5	215.54	2.27	2.46	0.59	5.32
qpeIRE011	280.2	36.4	183.15	1.95	2.71	0.78	5.44
qpe404017	297.4	41.4	196.20	2.30	2.61	0.70	5.61
qpe403003	295.2	41.3	207.76	2.21	2.68	0.76	5.66
qpe403026	280.3	37.7	181.00	2.49	2.77	0.63	5.89
qpeFRA007	314.4	45.3	228.36	2.39	2.61	0.95	5.95
qpe204001	268.8	28.9	186.72	2.64	2.94	0.58	6.17
petraea	295.1	36.4	204.0	2.01	2.36	0.53	4.90
qroNLD018	293.6	35.1	209.91	1.50	1.97	0.25	3.72
qroNLD009	262.9	25.3	183.83	1.70	2.09	0.48	4.26
qro203007	303.8	37.4	216.52	1.85	2.12	0.30	4.27
qroNLD015	385.1	48.2	260.37	1.69	2.08	0.65	4.41
qro404007	309.1	35.8	219.10	1.88	2.17	0.37	4.41
qroNLD003	320.5	34.1	231.17	1.92	2.08	0.54	4.54
qroNLD002	358.0	43.8	246.59	1.80	2.23	0.68	4.70
qroNLD021	312.3	38.7	207.98	1.94	2.32	0.53	4.79
qro406004	303.0	37.7	193.41	1.93	2.39	0.52	4.85
qroNLD017	270.7	34.5	202.71	2.05	2.46	0.54	5.05
qro406008	314.1	37.1	214.89	2.00	2.60	0.58	5.18
qro109001	318.3	39.1	185.62	2.07	2.57	0.57	5.21
qro106001	213.9	18.3	168.75	2.35	2.61	0.35	5.30
qro404004	260.4	29.8	182.50	2.21	2.58	0.58	5.37
qroNLD012	299.7	32.6	200.50	2.23	2.40	0.79	5.42
qro402001	253.8	25.8	173.13	2.24	2.61	0.66	5.50
qro406007	256.7	29.6	164.36	2.48	2.67	0.37	5.52
qro204001	297.9	34.1	181.43	2.26	2.63	0.66	5.54
qroNLD019	302.6	35.1	207.68	2.21	2.57	0.81	5.60
qro402003	293.6	32.7	196.00	2.33	2.73	0.60	5.67
qro404003	280.4	33.8	174.70	2.43	2.77	0.51	5.70
qro402009	318.4	36.4	219.42	2.42	2.51	0.88	5.81
qro406003	282.7	31.8	196.95	2.39	2.66	0.77	5.82
qroNLD001	317.2	37.4	211.74	2.23	2.63	1.05	5.91

qroIRE006	285.6	34.9	182.92	2.53	2.89	0.79	6.21
qro406009	203.4	26.0	120.56	2.57	3.07	0.59	6.23
qro404009	313.1	35.6	210.95	2.50	2.93	0.82	6.25
qro403008	251.1	29.3	156.60	2.55	3.10	0.70	6.35
qro405001	322.2	42.0	193.20	2.63	2.88	1.05	6.55
qroNLD008	297.0	36.9	196.56	2.78	3.04	0.96	6.78
qro405	276.8	32.4	175.21	2.86	3.29	0.68	6.82
qro403009	230.6	34.0	132.13	3.00	3.40	0.60	7.00
qro404002	270.9	33.4	166.30	2.98	3.30	1.05	7.33
<i>robur</i>	290.3	34.2	193.4	2.26	2.62	0.64	5.52
orchard mean	292.5	35.2	198.28	2.14	2.50	0.59	5.23
<i>p</i> values							
Species	0.468	0.008	>0.001	>0.001	>0.001	>0.001	>0.001
All families	>0.001	>0.001	>0.001	>0.001	>0.001	>0.001	>0.001
<i>robur</i> families	>0.001	>0.001	>0.001	>0.001	>0.001	0.042	>0.001
<i>petraea</i> families	>0.001	>0.001	>0.001	>0.001	>0.001	>0.001	>0.001

Belmont, Kent. 16-18th February 2015

The trial is well laid out and surrounded by a double guard row to the west, north and east but no guard row to the south. Survival was recorded by NMT in 2004, and again by the estate in 2006. The site is quite wet (lots of marsh thistle), and experienced fairly high mortality during establishment and 580 trees beaten up with oak by the estate in 2006. Of these, 213 were alive in 2014, and have been excluded from the analysis. Four reps: 43, 44, 57 and 58 were not assessed by the estate, so excluded from the analysis as cannot be sure which trees were beaten up.

Reps in the south east corner were extremely poor, with very high mortality, and trees mostly very small and not growing. Dense, very high thistles would indicate this to be the wettest part of the site. (standing water in hollows in ground). Most reps markers present, although a few were missing (rotten) and several were missing tags. Double guard row appears to be growing best, adjacent to arable fields and presumably benefitting from applied nitrogen. There are some small patches of thin bramble which are not a problem. Form is pretty good, especially apical dominance. Forking appears lighter than elsewhere. The site has had no intervention at all. In some trees (at least 24 noted) 24 trees, the tube was completely filled with ants nests which had likely killed a few of the smaller trees.

Where trees are very big and bushy, they are beginning to push some smaller trees that are of good form. **Need to decide what to do about this. Trees would not normally just be left.** Estate managed by a private Trust. Steve Hicks is the forester.

New posts and tags required at reps 40, 42, 51, 52, 63, 69 and 70.

New tags required for: 7, 8, 9, 10, 11, 12, 17, 18, 19, 20, 29, 29, 30, 37.

Accession #	Height	dbh	inc 07-14	AD	Form	Forks	FORM
qpe403012	388.6	46.8	277.5	1.34	1.82	0.45	3.61
qpeFRA021	409.0	60.3	279.5	1.86	2.39	0.70	4.95
qpe108001	407.1	61.1	279.0	2.05	2.31	0.81	5.17
qpe305002	344.1	47.2	235.1	2.13	2.38	0.67	5.18
qpe403015	378.2	54.3	262.8	2.02	2.31	0.88	5.21
qpeFRA027	336.9	40.1	232.8	2.14	2.46	0.63	5.23
qpe404003	335.7	61.0	222.3	2.07	2.50	0.77	5.34
qpeFRA023	550.9	59.4	421.4	2.23	2.48	0.65	5.35
qpe404001	340.5	44.9	238.5	2.19	2.52	0.67	5.38
qpe305001	327.1	42.4	227.3	2.15	2.69	0.70	5.54
qpe403026	324.7	45.6	209.8	2.32	2.71	0.53	5.55
qpe204001	364.0	45.1	261.1	2.43	2.78	0.43	5.65
qpe203002	377.3	54.9	258.5	3.00	2.36	0.61	5.96
qpe404002	352.7	79.3	242.0	2.77	2.92	0.42	6.12
qpeFRA007	426.9	60.7	292.3	2.56	2.75	1.03	6.33
<i>petraea</i>	377.6	53.5	262.6	2.22	2.49	0.66	5.37
qroNLD021	365.5	46.5	242.8	1.57	2.02	0.47	4.06
qroNLD009	342.3	37.5	238.8	1.93	2.28	0.59	4.80
qro203007	381.1	50.1	257.3	1.84	2.37	0.61	4.82
qro402001	322.5	42.0	208.1	2.10	2.60	0.48	5.18
qroNLD002	408.3	57.4	271.4	1.94	2.37	0.89	5.20
qro406008	358.3	49.5	242.9	2.33	2.63	0.52	5.48
qroNLD001	395.5	54.7	268.9	2.24	2.48	0.78	5.50
qroNLD015	425.2	56.5	297.4	2.14	2.45	0.93	5.52
qro406004	354.8	48.7	233.2	2.41	2.87	0.50	5.78
qro405	338.4	46.2	221.3	2.45	2.84	0.74	6.03
qro403009	282.2	37.8	162.8	2.68	2.97	0.38	6.03
qroNLD012	350.6	47.5	228.6	2.63	2.77	0.67	6.08
qro406007	346.2	46.5	220.9	2.62	3.02	0.58	6.21
qro403008	280.1	36.1	167.6	2.71	3.05	0.47	6.24
qro404004	300.8	33.1	188.0	2.85	2.96	0.50	6.31
qro406009	286.1	36.5	170.6	2.74	3.03	0.65	6.41
qroNLD008	367.0	47.8	243.1	2.55	3.08	0.95	6.58
qroIRE006	315.8	40.4	196.1	2.91	3.13	0.80	6.84
qro404003	304.0	41.8	191.1	2.87	3.34	0.74	6.95
<i>robur</i>	343.4	45.1	223.7	2.39	2.75	0.64	5.79
orchard mean	358.5	48.8	240.9	2.32	2.64	0.65	5.61
<i>p</i> values							
species	0.003	<0.001	<0.001	0.016	<0.001	0.498	0.004
all families	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001
<i>robur</i>	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<0.001
<i>petraea</i>	<0.001	0.058	0.004	0.067	0.002	0.087	0.019

Shakenhurst, Worcestershire. DATES TO ADD

Shakenhurst BSO is mostly in very good state with all posts clearly visible, and only a few tags missing, but no problem. As trees have grown so well here, there is canopy closure, and almost no ground vegetation. There are a few mature oak around the edges. One row of trees has previously been felled about two thirds the way up slope. Some reps, especially towards the top of the slope have had a few trees cut out in groups – presumably for pheasants. This was done at least 3 years ago and some trees around there gaps have been pruned with various degrees of skill. Competition is becoming a problem and some intervention is now needed. Several good stems are being pushed from vertical due to adjacent big shaggy poor trees.

There are 39 additional dead trees in 2014, due to no light. 62 trees have been felled and 49 trees are clearly being pushed away from vertical due to bushy neighbours.

Accession #	Height (cm)	dbh (mm)	inc 07-14 (cm)	AD	Form	Forks	FORM
qpe108001	609.1	89.5	426.8	1.86	2.12	1.10	5.08
qpe305002	588.3	76.3	435.6	1.86	2.22	1.21	5.29
qpeFRA027	558.5	73.0	392.9	1.99	2.21	1.18	5.38
qpeFRA021	606.0	90.5	432.2	2.08	2.38	1.36	5.82
qpe204001	627.4	91.3	437.5	2.14	2.55	1.35	6.05
qpe404002	600.8	93.0	414.2	2.39	2.76	1.10	6.25
qpeFRA007	639.4	104.4	436.2	2.32	2.48	1.47	6.28
qpe403026	571.7	86.7	391.0	2.34	2.64	1.53	6.50
qpeFRA023	650.6	106.5	442.4	2.50	2.63	1.67	6.80
<i>petraea</i> mean	605.8	90.1	423.2	2.16	2.44	1.33	5.94
qro203007	624.2	89.8	433.4	1.70	1.89	0.88	4.48
qroNLD001	549.8	70.6	380.5	1.97	2.24	1.25	5.46
qroNLD002	609.6	92.5	393.0	2.09	2.28	1.25	5.63
qro406007	557.3	76.2	378.6	2.18	2.42	1.20	5.81
qroNLD021	585.2	76.3	398.3	2.04	2.52	1.37	5.93
qro404004	519.6	64.2	362.6	2.15	2.62	1.21	5.98
qroNLD012	599.1	83.0	401.0	2.28	2.47	1.38	6.13
qroIRE006	545.2	74.7	363.0	2.44	2.63	1.30	6.37
qro403009	502.7	67.2	337.7	2.55	2.87	1.21	6.63
qro404003	577.1	82.4	385.7	2.43	2.83	1.45	6.71
qroNLD015	683.9	111.0	446.1	2.66	2.61	1.92	7.19
qroNLD008	555.0	77.0	369.3	2.68	2.83	1.70	7.22
<i>robur</i> mean	575.7	80.4	387.4	2.26	2.52	1.34	6.13
orchard mean	588.6	84.6	402.8	2.22	2.49	1.34	6.05
<i>p</i> values							
Species	***	***	***	0.060	0.165	0.597	0.134
All families	***	***	***	***	***	***	***
<i>robur</i>	***	***	***	***	***	***	***
<i>petraea</i>	***	***	***	***	***	***	***

Questions to answer as a group

1. Should we single double stems at Rathluirc
2. Should we bother trying to check IDs at Newton Rigg
3. Should we stump several reps at Wales
4. What to do about pruning? Especially at Belmont, several good trees are being deformed by adjacent very big and bushy trees which would normally be removed by now.

Appendix – mean height for each family at each site - CUT this – replace with one for each site with all parameters

Ranked by accession number. In wrong order.

Family	accession	N. Rigg	Sotterley	Shake.	Rathluirc	LWT	Bwlch.	Belmont
D&G003	qpe108001	325	317.6	609.1	388.4	256.2	365.4	407.1
ELT004	qpe203002	325.2	307.9	*	350.8	295	277.9	377.3
BOR002	qpe204001	320.3	268.8	627.4	349	263.8	337.7	364
CUM001	qpe301002	347.3	337.9	*	396.2	335.6	411.8	*
SOM003	qpe305001	255.2	263.5	*	352	223.1	347.7	327.1
SOM002	qpe305002	255.8	289.9	588.3	327	214.5	302.4	344.1
HRF008	qpe403001	*	281	*	*	211.1	*	*
SHP005	qpe403002	*	252.3	*	*	*	*	*
WOR003	qpe403003	*	295.2	*	*	*	*	*
HRF004	qpe403007	*	328.5	*	*	343.3	*	*
HRF006	qpe403009	*	328.9	*	382.4	346.8	318.1	*
HRF013	qpe403012	242	257.4	*	344.4	235.1	294.3	388.6
HRF017	qpe403015	340.5	319	*	407	309.3	368.4	378.2
WOR007	qpe403026	309.2	280.3	571.7	324.5	270	324.6	324.7
GLS025	qpe404001	286.4	269	*	335.4	293.6	326.5	340.5
HAM004	qpe404002	329.7	278.7	600.8	362.1	248.2	344.3	352.7
HAM012	qpe404003	324.3	278.1	*	340.7	281.8	345.2	335.7
GLS022	qpe404010	364	340.3	*	394.5	356.8	369.6	*
GLS012	qpe404017	*	297.4	*	378	287.3	*	*
HAM007	qpe404021	*	299.1	*	*	267.6	*	*
BRC001	qpeFRA006	271.2	282.2	*	353.9	266.8	247.2	*
BRC002	qpeFRA007	301.7	314.4	639.4	361.4	215.4	284.9	426.9
Fontainbleu	qpeFRA018/019	*	263.9	*	*	*	*	*
REN001	qpeFRA021	275.2	317.9	606	343.1	284.4	302	409
REN003	qpeFRA023	270.9	346.3	650.6	403.3	334.5	318	420.9
SEN002	qpeFRA027	273.3	312.5	558.5	373.5	245.7	279.3	336.9
WIK003	qpeIRE008	*	254	*	325.1	214	302.3	*
LND003	qpeIRE011	*	280.2	*	*	*	*	*
HGH001	qro106001	309.8	213.9	*	333.1	248.5	345.8	*
NMB001	qro109001	*	318.3	*	408.2	372.7	*	*
ELT005	qro203007	313.5	303.8	624.2	367.8	293.8	281.8	381.1
BOR001	qro204001	314.8	297.9	*	314.1	274.1	350.2	*
NHP002	qro402001	339.9	253.8	*	362.4	317.8	340.9	322.5
LNC001	qro402003	*	293.6	*	*	302.2	*	*
NHP006	qro402009	*	318.4	*	*	293.7	*	*

LEI001	qro403008	392.3	251.1	*	325.8	308	360.4	280.1
NHP009	qro403009	301.1	230.6	502.7	268.7	259.1	262.5	282.2
NHP008	qro402002	*	*	*	*	366.2	*	*
HAM006	qro404002	*	270.9	*	*	288.9	*	*
HAM013	qro404003	321.9	280.4	577.1	331.9	286.4	358.9	304
HAM014	qro404004	322.5	260.4	519.6	303.8	246.1	330.6	300.8
GLS014	qro404007	*	309.1	*	*	347.9	*	*
GLS016	qro404009	*	313.1	*	391.1	325.6	375.3	*
Alice Holt	qro405***	329.7	276.8	*	299.6	282.8	356.4	338.4
HAM011	qro405001	*	322.2	*	*	*	*	*
NOR007	qro406003	*	282.7	*	*	290.6	*	*
SUF004	qro406004	280.7	303	*	301.6	263	277.1	354.8
NOR005	qro406007	380.4	256.7	557.3	330.6	322.8	334	346.2
SUF001	qro406008	359.7	314.1	*	349.7	311.7	341	358.3
SUF003	qro406009	284.7	203.4	*	293.5	227.4	305.5	286.1
OFL002	qroIRE006	299.9	285.6	545.2	327.7	306	323.6	315.8
ZE11-1	qroNLD001	362.7	317.2	549.8	308	308.9	282.9	395.5
ZE142-1	qroNLD002	383.7	358	609.6	364.1	378.7	349.3	408.3
ZE23-2	qroNLD008	347.2	297	555	297.5	313.7	330.7	367
ZE15 -1	qroNLD003	*	320.5	*	*	*	*	*
ZE34-1	qroNLD009	327.3	262.9	*	338.1	307.2	308.4	342.3
ZE46-1	qroNLD012	352.2	299.7	599.1	353.6	310.9	368.2	350.6
ZE47-2	qroNLD015	453	385.1	683.9	439.8	429.7	406.6	425.2
ZE58-2	qroNLD017	341.6	270.7	*	312.7	266.2	325.9	*
ZE64 -1	qroNLD018	*	293.6	*	379.6	350	375	*
ZE80 -1	qroNLD019	*	302.6	*	*	317.9	*	*
ZE82-1	qroNLD021	386	312.3	585.2	371.5	344.9	360.3	365.5

Newton Rigg

Accession #	Ht 07	Ht 14	dbh 14	Inc 07-14	AD 14	Form 14	Forks
qpe403012	64.3	242.0	24.4	177.7	1.88	2.35	0.76
qpe305001	83.0	255.2	29.6	172.2	2.31	2.69	1.15
qpe305002	80.6	255.8	27.3	175.2	2.35	2.87	1.04
qpeFRA023	91.4	270.9	36.2	179.5	2.19	2.81	0.63
qpeFRA006	84.9	271.2	26.7	186.2	2.80	3.23	1.07
qpeFRA027	82.0	273.3	28.0	194.0	2.11	2.52	0.81
qpeFRA021	80.9	275.2	28.6	194.4	2.15	2.67	0.82
qpe404001	92.8	286.4	36.8	193.6	2.15	2.71	0.68
qpeFRA007	84.3	301.7	30.0	217.4	1.95	2.53	0.58

qpe403026	97.4	309.2	40.3	211.8	2.15	2.62	0.76
qpe204001	88.1	320.3	37.0	232.2	2.09	2.91	0.81
qpe404003	102.2	324.3	40.9	222.1	2.00	2.52	0.94
qpe108001	80.4	325.0	37.5	244.6	1.96	2.61	0.93
qpe203002	92.7	325.2	38.9	232.5	1.89	2.34	0.55
qpe404002	106.4	329.7	43.2	228.7	2.44	2.94	1.09
qpe403015	107.6	340.5	47.9	232.9	2.20	2.59	1.05
qpe301002	117.5	347.3	66.8	229.8	2.10	2.62	0.88
qpe404010	121.7	364.0	46.6	242.2	1.82	2.45	0.94
qro406004	105.3	280.7	33.9	179.0	2.80	3.13	1.00
qro406009	85.8	284.7	32.2	198.9	2.24	2.70	0.91
qroIRE006	93.5	299.9	34.4	206.4	2.42	2.86	1.14
qro403009	102.3	301.1	38.1	198.8	2.87	3.21	1.03
qro106001	81.4	309.8	33.5	243.7	1.95	2.41	0.64
qro203007	93.7	313.5	36.8	219.9	2.06	2.50	0.69
qro204001	119.9	314.8	41.7	198.7	3.00	3.24	1.02
qro404003	92.3	321.9	38.2	229.6	2.67	3.06	1.15
qro404004	106.7	322.5	39.0	215.7	2.94	3.13	1.23
qroNLD009	83.1	327.3	34.5	244.3	2.03	2.27	0.70
qro405	100.5	329.7	45.6	230.6	2.56	2.79	1.23
qro402001	90.2	339.9	39.6	249.7	2.74	3.09	1.52
qroNLD017	105.2	341.6	40.5	236.4	2.49	2.92	1.35
qroNLD008	99.6	347.2	42.3	249.9	2.94	3.17	1.50
qroNLD012	109.0	352.2	43.4	243.2	2.38	2.89	1.16
qro406008	98.1	359.7	44.1	261.7	2.39	2.78	1.12
qroNLD001	100.3	362.7	45.3	262.4	2.07	2.47	1.07
qro406007	112.3	380.4	53.3	268.0	2.34	2.61	0.85
qroNLD002	104.7	383.7	50.4	279.0	2.38	2.50	0.94
qroNLD021	110.8	386.0	54.3	275.2	2.21	2.67	1.31
qro403008	131.8	392.3	58.5	260.5	2.60	2.98	1.23
qroNLD015	133.7	453.0	67.7	322.3	2.49	2.73	1.31
Mean	101.0	330.5	42.2	230.4	2.35	2.76	1.01