



# **FOREST RESEARCH REPORT 2003**

## **WALNUT TRIALS AT LOUNT, NATIONAL FOREST**

*Contract report submitted in fulfilment of  
the Annual Management Agreement  
between the National Forest Company and  
the Northmoor Trust.*

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## **Introduction**

This report summarises results within the walnut research trials established at Lount, and progress with research programmes planned for completion by 2005. The silviculture trials were established in 2001 and background information on these provided within the 2002 research report (Hemery and Russell 2003). New information is provided on black walnut provenance and progeny trials initiated in 2002, culminating in the establishment of field trials spring 2003.

This report is submitted in fulfilment of the Annual Management Agreement between the Northmoor Trust and the National Forest Company.

## **Aims**

- 1.** To investigate planting mixtures that promote the growth of walnut species and hybrids in terms of stem quality and vigour, leading to a reduction in rotation time.
- 2.** To evaluate planting mixtures which create, in line with aim one, additional financial and environmental incentives to landowners.
- 3.** To test a wide-range collection of black walnut (*Juglans nigra* L.) material for their suitability to produce timber in the UK.

## **Silviculture trials**

### *Method and results*

Walnut tree heights and survival were measured to the nearest centimetre during March 2004. The data, representing 2003 growth and survival, permitted the calculation of height increment (growth between 2002 and 2003). Data were analysed in Genstat with analysis of variance using plot means (mean of 6 individuals per plot) by G. Hemery.

Of the walnuts assessed in the experiment, overall survival remained high at 92 %, although since the assessment at the end of the last growing season (6 trees dead; Hemery and Russell 2003), an additional 58 trees have died. Mortality was significantly higher ( $p < 0.001$ ) at the southern block in 12 %, compared to the northern block at 3 %.

Overall, across the whole site and all treatments, mean walnut height at the end of the second growing season (2003) was 81.7 cm. Mean tree height at the end of 2003 was significantly greater (14.1 cm;  $p < 0.001$ ) at the northern block compared to the southern block.

Mean tree height was significantly different ( $p < 0.001$ ) between walnut species (Table 1), explained by the small size of the *Juglans nigra* trees, as height differences between the remaining three species were non significant. Mean height increment was significantly different ( $p = 0.38$ ) between walnut species (Table 1), attributable to *J. regia* growing

significantly more during 2003 than *J. nigra* and MJ209. There were no significant differences for other factors in the tested model.

Table 1 Summary survival, height and height increment for walnut species within the silviculture trials, based on plot means. Standard error = *s.e.*

Species	Survival	mean height		mean height increment	
	2003 %	2003 <i>cm</i>	<i>s.e.</i>	2002-03 <i>cm</i>	<i>s.e.</i>
<i>J. nigra</i>	79	66.6	3.0	10.5	1.5
<i>J. regia</i>	99	89.5	2.2	17.6	2.1
MJ209	95	79.9	2.8	11.9	1.6
NG23	95	91.1	2.9	12.7	1.6
overall	92	81.7	1.6	13.2	1.5

## **Black walnut combined provenance/progeny trials**

### *Background*

The aims of the black walnut research programme are to:

- identify superior individual and stands of black walnut trees in the UK and overseas;
- collect and raise seedlings from these trees;
- demonstrate through field trials, those best suited for timber production in UK conditions, and;
- initiate a collaborative research programme to assess patterns of genetic variation across the introduced and natural ranges of the species.

### *Material*

Individual trees and groups of trees have been identified in regions from which tree material was considered suitable for growing in the UK. Seeds were sought from both the natural range in North America and the introduced range in Europe. Due to the difficulties experienced in gathering sufficient seeds within a short time scale, the collection was phased across two collection years, 2002 and 2003.

### Phase 1

European seed material was collected during autumn 2002 and raised in root trainers by a commercial tree nursery<sup>1</sup>. The resulting one-year-old seedlings were planted at two sites during spring 2004.

<sup>1</sup> Alba Trees PLC., Lower Winton, Gladsmuir, East Lothian EH33 2AL.

## *Phase 2*

Collection of additional material was made during autumn 2003 from the USA and Europe. Material was collected within 13 states in the USA, representing 20 counties (Table 2). The US collection therefore represents 20 provenances and 269 progenies. Five additional provenances were collected from Europe and six sampled within the UK (Table 2), adding to those already sampled from the UK in phase 1.

Table 2 Summary of black walnut material collected from the USA and Europe during autumn 2003 (phase 2).

Code	US State	County	No Trees	Number of seed supplied
US01	Alabama	*	15	*
US02	Illinois	Vermillion	15	998
US03	Illinois	Sangamon	11	641
US04	Indiana	Tippecanoe	25	1,652
US05	Indiana	Sullivan	15	785
US06	Indiana	Marshall	18	1,881
US07	Iowa	Boone	10	581
US08	Kentucky	Fayette	15	941
US09	Kentucky	Hardin	15	964
US10a	Maryland	Howard	15	815
US10b	Maryland	Washington	10	873
US11	Minnesota	Olmsted	10	619
US12	North Carolina	Burke	11	591
US13	Ohio	Franklin	10	*
US14	Pennsylvania	Mifflin	15	725
US15	Tennessee	Greene	15	721
US16	Wisconsin	Grant	14	902
US17	Wisconsin	La Crosse	15	991
US18	Wisconsin	Rock	15	979
US19	Missouri	Howard	15	790
total			269	16,449
Code	Country	Region		
FR01		Lambert	11	*
IT01	Italy	Piedmont	10	*
IT02	Italy	Arezzo	*	*
SM01	Serbia & Montenegro	Belgrade	1	*
SM02	Serbia & Montenegro	Cacak	6	*
UK**	United Kingdom	England	6	*
total			34 +	*

## *Experimental design*

Where possible the identity of seedlots with individual mother trees has been maintained, thereby allowing progeny testing. Where this was not possible, or where there were insufficient number of seeds from individual trees, these progeny contribute towards provenance assessment only. The experimental design permits the assessment of provenance and progeny in a combined research experiment.

**Figure 1** Site plan of the black walnut (*Juglans nigra*) combined provenance/progeny trial sited at Lount, National Forest. Numbers outside the grid indicate replicate numbers (10) and each cell represents a tree position. Provenance codes: AU Austria, CR Czech Republic, SR Slovak Republic and UK United Kingdom.

<b>1</b>	UK07	AU18	AU07	CR14	CR09	AU13	AU05	CR18	CR05	AU11	UK07	AU05	UK15	AU03	<b>6</b>
	UK13	CR17	CR01	AU10	CR05	CR16	SR06	CR19	CR04	CR02	UK08	AU14	SR06	UK04	
	AU01	SR10	CR13	UK02	CR11	CR19	AU15	SR01	AU19	UK03	CR14	UK22	AU02	CR13	
	CR07	AU08	SR05	CR02	AU11	UK22	AU16	CR17	CR15	AU16	CR09	UK13	UK02	AU07	
	AU03	UK04	CR08	SR03	AU02	AU06	AU12	AU12	CR01	CR03	CR12	AU08	SR08	AU06	
	UK08	CR20	AU09	SR01	CR04	UK03	AU04	CR20	AU04	AU20	AU01	AU15	CR16	SR05	
	UK15	CR03	CR18	AU14	SR07	CR15	control	CR11	AU17	CR08	SR10	SR09	AU18	control	
<b>2</b>	AU12	CR03	CR13	UK13	AU15	SR06	AU08	UK08	CR16	AU13	SR07	CR03	CR04	UK15	<b>7</b>
	CR09	SR10	AU11	AU18	CR17	AU06	AU14	AU14	CR19	CR05	AU19	UK13	CR15	CR13	
	UK02	CR16	CR12	CR14	AU04	UK12	CR21	UK03	UK04	AU04	CR21	AU18	AU11	AU02	
	AU17	AU05	SR08	CR19	SR05	AU03	SR01	SR10	AU01	AU15	CR14	UK22	CR07	CR17	
	CR04	CR15	SR09	AU02	CR05	CR11	AU07	CR01	UK07	AU12	SR06	CR02	AU03	AU08	
	AU19	CR18	UK07	UK03	CR02	CR20	UK08	CR18	AU16	SR01	CR09	AU05	CR11	SR08	
	AU20	AU16	UK22	AU01	CR01	UK15	control	CR20	SR05	AU17	UK02	AU20	AU06	control	
<b>3</b>	CR19	AU09	CR20	AU14	AU08	SR10	CR13	AU08	UK04	UK22	AU02	AU19	CR13	AU01	<b>8</b>
	AU01	CR07	SR07	UK08	AU12	SR05	UK15	CR20	CR18	CR03	UK03	SR10	CR12	CR15	
	SR03	AU16	CR14	AU13	CR01	AU17	SR06	CR05	AU10	AU15	CR17	AU14	AU20	UK08	
	CR03	UK02	CR16	CR09	UK22	CR05	AU04	AU11	CR09	CR01	SR07	UK13	CR14	CR11	
	CR17	AU02	UK13	CR18	AU11	UK14	SR08	SR01	CR16	UK02	AU17	SR06	CR19	SR09	
	CR15	CR11	AU10	AU05	CR02	CR04	AU19	UK15	CR02	AU06	CR04	CR08	AU05	AU18	
	AU18	AU15	AU06	UK03	UK07	CR08	control	AU16	AU04	AU13	UK07	AU12	SR05	control	
<b>4</b>	AU02	AU08	AU19	UK15	UK22	SR06	CR11	AU10	CR17	CR09	CR02	AU18	AU12	AU09	<b>9</b>
	CR20	CR12	CR09	SR01	AU14	UK03	CR15	UK04	UK08	CR04	SR07	SR09	CR19	UK03	
	SR09	AU15	CR13	SR05	CR04	AU07	CR17	CR20	AU15	UK02	CR01	SR10	UK13	CR15	
	AU18	CR14	AU20	CR21	AU03	SR10	CR18	SR05	UK22	AU20	CR13	AU08	UK15	CR21	
	UK04	AU06	CR01	AU12	AU04	SR03	UK08	CR18	CR03	AU14	CR11	CR05	SR06	AU05	
	CR19	AU05	AU01	CR03	UK02	CR05	AU16	AU17	AU19	CR14	UK07	AU16	AU11	CR07	
	AU17	CR16	AU11	UK07	UK13	CR02	control	AU02	AU06	SR01	AU01	CR16	AU04	control	
<b>5</b>	SR01	AU12	CR21	CR03	SR03	CR14	AU18	UK15	CR14	UK13	AU11	AU18	UK04	AU01	<b>10</b>
	AU01	UK22	AU05	AU09	SR05	CR15	CR19	CR09	CR01	CR03	UK03	AU12	AU10	SR07	
	AU19	CR09	CR16	CR07	CR11	AU13	UK14	CR16	CR18	AU02	CR17	AU09	AU13	AU05	
	CR17	AU02	UK07	AU20	UK15	AU10	UK13	CR19	SR06	CR20	UK08	CR05	CR15	SR09	
	UK03	AU16	SR06	AU11	CR05	CR01	UK08	AU04	AU16	SR01	AU06	CR02	AU15	SR05	
	CR13	AU15	CR20	UK02	AU06	SR07	CR18	AU01	CR08	CR13	UK07	SR10	CR04	AU14	
	SR10	AU04	CR02	AU14	AU08	CR04	control	AU08	UK22	CR11	UK02	CR12	AU20	control	

The material will be tested at two sites; Paradise Wood in Oxfordshire owned by the Northmoor Trust, and Lount in Leicestershire in collaboration with the National Forest Company. The use of two sites will permit the assessment of genotype × site interaction.

The phase 1 trial at each of the two sites is a randomised complete block design at the provenance level. Provenances were distributed as non-contiguous and multiple-tree plots within 10 replicates (Figure 1). The number of trees representing a provenance differs for each of the five provenances (Table 3). Tree positions were assigned randomly at planting time and recorded. Each replicate contains 49 trees, one of which is a control (UK10) to be planted in spring 2005, at the same time as the phase 2 material in a neighbouring trial.

Table 3 Summary of phase 1 provenance and progeny material planted at Lount.

Provenance	code	number of trees	number of trees per replicate	number of progenies
Austria - Altenworth	A1	88	7	7
Austria - Seebarn	A2	80	10	10
Czech Republic	CR	169	17	15
Slovak Republic	SR	49	6	5
United Kingdom	UK	88	8	8
missing/control	*	16	1	n/a
		474	49	45

At the progeny level trees are distributed in single tree plots (only one tree per replicate) in an incomplete block design, *i.e.* a progeny is not present in every replicate. Where the number of trees within a progeny is less than six, these are excluded from any analysis and contribute only at the provenance level. There are 45 progenies included in the trials (Table 3).

Given the high value of this untested genetic material, all spare material was planted within the two 'guard' rows around the trial and their positions mapped.

Data were analysed with Genstat using plot means. The model for the variance of analysis used was:

$$site + replicate\ within\ site + site \times provenance$$

### Results

At Lount there were no significant differences for tree height between blocks. However, there were significant differences ( $p < 0.001$ ) for tree height between provenances. Least significant differences (at  $p = 0.05$ ) indicated that all provenances, except AU and CR, were significantly different from one another. Height data for provenances at Lount is presented in Table 4.

Analyses of all data, *i.e.* for both sites, indicated significant ( $p = 0.003$ ) genotype  $\times$  site interaction (Tables 4 and 5), although at this stage this pertains only to a random effect from the distribution of planting material between the two sites. Trees were significantly taller, at  $p = 0.05$ , for provenances AU-Altenworth and UK at Lount, and AU-Seebarn at Northmoor Trust. There was no significant genotype  $\times$  site interaction for height between provenances CR and SR.

Table 4 Mean tree heights within provenances in the black walnut provenance trial at Lount.

Provenance	mean height 2003 (cm)	<i>s.e.</i>	<i>N</i> trees
AU Altenworth	59.8	1.3	88
AU Seebarn	54.7	1.9	80
CR	55.8	1.0	169
SR	45.1	1.5	49
UK	37.2	1.3	88
total	51.9	0.7	474

Table 5 Analysis of variance for the phase 1 black walnut provenance trials, based on plot means.

Source of variation	<i>d.f.</i>	<i>s.s.</i>	<i>m.s.</i>	<i>v.r.</i>	<i>p</i>
Site	1	13	13	1.13	0.292
Site/Replicate	18	146.89	8.16	0.71	0.792
Provenance	4	7926.96	1981.74	171.89	<.001
Site $\times$ Provenance	4	208.54	52.13	4.52	0.003
<i>Residual</i>	72	830.11	11.53		
Total	99	9125.5			

## Discussion and conclusions

### *Silviculture trials*

The disappointing survival amongst nurse species in these trials noted by Hemery and Russell (2003) has been addressed by Forest Enterprise, with beating up almost complete when the site was visited during March 2004. The walnut species continue to establish well, with the *Juglans regia* material demonstrating best height increment. However, the increased mortality noted above (page 3) is a concern, particularly when it is so obviously associated with the site conditions within the southern block. This is the area noted by Hemery and Russell (2003) to be most prone to waterlogging and where walnuts were planted over-deep. This effect has been exacerbated recently by the driving of heavy plant machinery across much of the eastern end of this block. This had occurred recently when the site was assessed during March 2004 and many trees, both walnuts and nurses, had been



driven over and severely damaged. It should be noted that there are likely to be knock-on effects from ground compaction, given the conditions in this field. Further such occurrences should be avoided at all cost, not only to ensure the survival of the trees, but the integrity of the research programme.

### *Black walnut trials*

The establishment of phase 1 of the black walnut trials, both at Lount and the site at Northmoor Trust, was extremely successful. Both sites are also prepared to accept the substantial number of trees due for planting within phase 2 during spring 2005, in neighbouring plots. Trees available for planting may number between 6 – 9,000 per site depending on germination rates. The material gathered constitutes one of the largest genotype collections anywhere in the world and is likely to be an extremely important resource for both tree breeders and scientists interested in studies of genetic diversity.

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