# THE FUTURE OF BLACK WALNUT IN BRITAIN

Black walnut (*Juglans nigra*) is economically one of the more productive broadleaved timber species in Britain. However, it is also one of the least planted and known about species, with little or no improved material available. **Jo Clark, Gabriel Hemery, Karen Russell** and **Hugh Williams** describe the international research programme aimed at addressing these issues.

**B** lack walnut (*Juglans nigra* L.) was introduced to Britain from North America in the early 17th century (Bean, 1981) and was widely planted for its valuable timber. It is capable of producing high quality timber on a relatively short rotation of about 60 years and is in great demand by end-users. During 2001 alone, British imports of this timber rose by 51% (Buckley, 2002). Currently, the species is often disregarded by British foresters because it is seen as a species that is site-demanding, usually of poor form and vulnerable to frost. Until now, no research has effectively addressed these problems in Britain.

The Forestry Commission established a series of black walnut provenance experiments between 1986 and 1987 to test a limited range of material from four provenances (Wisconsin, Southern Illinois, Ohio and Vermont) (Kerr, 1993). Insufficient seed was available for testing all material across four low-quality British trial sites. Therefore, a new and more comprehensive collection of material, selecting desirable, straight-stemmed and lightly-branched trees suitable to the climatic conditions of the British Isles should encourage renewed interest in the species.

A collaborative research programme was initiated, resulting in the collection of seeds across black walnut's native range in the United States (McGranahan and Leslie, 1991) and its introduced European range between 2002 and 2003 (Mitchell and Wilkinson, 2001). This material is being tested in a long-term combined provenance and progeny research programme. Field trials containing European and US seedlots were planted in two establishment phases during 2003 and 2004 with the aim of identifying superior black walnut trees as seed trees or those to be cloned for timber production. A clonal collection of superior plus trees has been established at East Malling Research in Kent (Russell and Hemery, 2004). This article summarises the background to this work, presents some early results and outlines expected outcomes from the long-term research programme.

#### Methods

Within the programme, provenance is defined as a seed collection unit composed of a community of potentially interbreeding trees in an area subject to uniform environmental conditions (adapted from Turnbull and Griffin, 1986). Collections made from scattered individual trees within a country are termed a population. Progeny refers to half-sib families where the female parent is known, but the pollen male is unknown. Details concerning provenance selection and seed collection and handling are detailed by Russell and Hemery (2004) and summarised in the Table 1. The distribution of the provenances sampled is illustrated in Figure 1 (ascross Europe) and Figure 2 (across USA). Seed was collected from between 10 and 25 individual trees for each provenance. Trees were established over two years: Phase I in 2003 and Phase II in 2004.



Figure 1. Distribution of black walnut provenances sampled across Europe.



Figure 2. Distribution of black walnut provenances sampled across the USA.

# Table 1. Summary of provenances and progeny included in bothphases of the provenance and progeny trials.

Collections	Planting year	Provenances	Progeny	Populations
		n	n	n
European				
Austria	2003	2	15	
Czech Republic	2003	1	15	
France	2004	1	*	
Great Britain	2003 + 2004	*	8	1
Italy	2004	*	1	
Serbia & Montene	egro 2004	*	1	
Slovak Republic	2003	1	3	
		5	43	1
US				
Alabama	2004	1	*	
Illinois	2004	2	*	
Indiana	2004	3	*	
lowa	2004	1	*	
Kentucky	2004	2	*	
Maryland	2004	2	*	
Minnesota	2004	1	*	
Missouri	2004	1	*	
North Carolina	2004	1	*	
Ohio	2004	1	*	
Pennsylvania	2004	1	*	
Tennessee	2004	1	*	
Wisconsin	2004	3	*	
		20	0	

# Experimental design

The main purpose of the field trials is to assess the suitability of provenances for timber production under British conditions, with particular emphasis on selection for good form, vigour and late flushing. The trials will also provide а resource for genetic studies. diversity The trees were planted out in combined provenance/progeny experiments at two sites in central and England southern (Table 2) during 2003 and 2004 in collaboration with the National Forest Company and the Forestry Commission. Trees

Table 2. Site details for the black walnut provenance/progeny trials.					
	Lat/long	Soil (pH)	Soil Type	Altitude (m asl)	Rainfall (mm)
Lount Wood, The National Forest, Derbyshire	52° 36' N/1° 25 W	7.0	Heavy clay loam	120	600
Paradise Wood, Northmoor Trust, Oxfordshire	51° 38' N/1° 12' W	6.2 to 7.7	Sandy clay loam	50	570

were spaced at 2 x 2m (2500 trees ha<sup>-1</sup>) and protected by 0.75m treeshelters. The use of two sites will permit the assessment of genotype x site interaction.

#### Phase I

The experimental design combines both provenance and progeny assessments in a single experiment. Progenies are distributed as singletree plots (only one tree per replicate) within a randomised complete block 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 seeds from individual trees, these progeny contribute towards provenance assessment only. 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 progeny included in the trials (Table 1).

Provenances were distributed in noncontiguous, multiple-tree plots within 10 replicates across two sites. The number of trees representing a provenance differed for each of the five provenances. Tree positions were assigned randomly at planting time and recorded. Each replicate contains 49 trees, one of which is a British control, planted in spring 2005 at the same time as the Phase II material in a neighbouring trial.

## Phase II

This phase contained only provenance data. Provenances were distributed in non-contiguous multiple-tree plots within 12 replicates at Paradise Wood and 16 replicates at Lount Wood. Twenty provenances from the States, one French provenance, one British population (the control), and two progenies, one from Italy and the other from Serbia and Montenegro were incorporated. Tree positions were assigned randomly at planting time and recorded. Table 3 summarises the planting details of both phases.

Given the high value of this untested genetic material, all spare trees were planted within the two guard rows surrounding each trial, and their positions mapped.

During winter 2004, height and survival were recorded for Phase I and height baseline data for Phase II at both sites.

Data were analysed with Genstat using plot

Table 3. Material planted at each site in number of replicates.					
	No. of Reps	Trees per Rep	Provenances per Rep	Families per Rep	Total no. of trees in trial
Lount Wood Phase I	10	49	5	49	490
Paradise Wood Phase I	10	49	5	49	490
Lount Wood Phase II	16	80	21	-	1280
Paradise Wood Phase II	12	80	21	-	960

Table 4. Summary results for tree growth and survival					
for Phase 1 (P03).					
	Lount Wood	Paradise Wood	Both sites		
Tree height (2003)					
mean (cm)	50.3	49.8	50.1		
s.e.	1.3	1.5	1.0		
Tree height (2004)					
mean (cm)	56.5	55.3	55.9		
s.e.	0.9	0.9	0.7		
Height increment					
(2003-04)					
mean (cm)	6.1	5.6	5.8		
s.e.	0.5	0.7	0.4		
Survival					
(%)	99.5	99.7	99.6		
no. dead	2	1	3		

means. The model of the variance of analysis used was:

*site* + *replicate within site* + *site* **x** *provenance*.

# Results

Germination of seed lots varied considerably from zero to 60%. Seedlots that germinated poorly were resown winter 2004 with the intention of establishing a further combined progeny/provenance trial if sufficient seedlings are obtained.

#### Phase 1

Tree survival one year after establishment remained excellent at 99.6%, with only 3 trees

Table 5. Analysis of variance for first year tree height increment between planting in 2003 and 2004 in the Phase I black walnut provenance trials, based on plot means.

Source of variation	d.f.	m.s.	<i>v.r</i> .	p
Site	1	7.955	0.96	0.330
Site/Replicate	18	9.930	1.20	0.286
Provenance	4	240.766	29.05	<0.001
Site x Provenance	4	22.054	2.66	0.039
Residual	72	8.287		
Total	99			

lost from the 980 planted across both Trees only grew 6cm on sites. average across both sites (Table 4), although statistical analyses indicated significant (p=0.039) genotype x site interaction for height increment (Table 5). There were highly significant (p=0.001) differences for tree height at the end of the first growing season (2004) between provenances (Figure 3). Height increment was greatest for the Serbian and UK provenances, although these remained significantly smaller in height (p < 0.05) than the Croatian Austrian and two provenances (Table 6).

## Conclusions

The provenance/progeny trials will be assessed for survival, flushing, vigour (height and diameter), form and occurrence of anthracnose. Data will be analysed and superior progenies and individuals will be selected to form the basis of the next stage of the improvement programme after ten years. It is anticipated that clonal trials of plus trees and/or of seedling selections will be established in the future, subject to propagation techniques being readily available. In addition, it will also be desirable to establish grafted seed orchards comprising the best performing trees. It is also hoped that a collaborative research programme on the genetic diversity of these

> collections can be initiated with the Hardwood Tree Improvement Regeneration Center (HTIRC), Indiana, USA, with the objectives of assessing the extent of diversity in black walnut represented in the programme and potentially providing information on the origin of the European material.

> A study using molecular markers of the genetic diversity of genotypes within the trials is planned early in the life of the programme to minimise genetic

loss due to thinning.

The average rotation for hardwood timber species in the UK, based on expected rotation ages for oak (150 years), cherry (55 years) and ash (70 years) is 90 years (Savill, 1991) and guality can be highly variable which threatens the sustainability of timber production. The improvement programme for walnut potentially offers substantial reductions in rotation (to 50 years) and higher proportions of veneer grade and higher class timber. Sustainable woodland strategies are built upon three recognised and balanced principles pertaining to social.

environmental and economic functions. Walnut has the potential to produce high quality, valuable and greatly desired timber over a comparatively short rotation. As such, it could increase the production of home grown timber, contribute to a reduction in imports and stimulate woodland related employment. The production of high quality timber that results in positive cash flows to the woodland owner can only assist in the management of diverse, attractive and wellused woodland. Research into the production of quality timbers, such as walnut at Lount Wood and Paradise Wood, is an exemplary initiative whose results and information could demonstrate how woodlands could be considered as truly socially, environmentally and economically sustainable.

Ultimately, it is hoped that this programme of

work will identify good quality timber trees, well adapted to growing in UK conditions. This will enable the recommendation of suitable provenances and potentially the development of seed orchards. The challenges facing foresters striving to achieve profitable, and



Figure 3. Mean tree height increment for provenances in Phase I across both sites in 2004.

therefore, sustainable forests are considerable but the benefits from tree breeding programmes and research will help support and progress forestry through the 21st century.

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Table 6. Mean heights of trees for the five European provenances
in Phase I in 2003 and 2004, and height increment (2003-04).

	Mean Height 2003 (cm)	Mean Height 2004 (cm)	Mean increment 2003-2004 (cm)
Austria (Altenworth)	58	61	3
Austria (Seebarn)	56	60	4
Croatia	57	60	3
Serbia	44	53	9
UK	35	46	11

graftwood, and to Alba Trees plc for raising the seedlings.

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