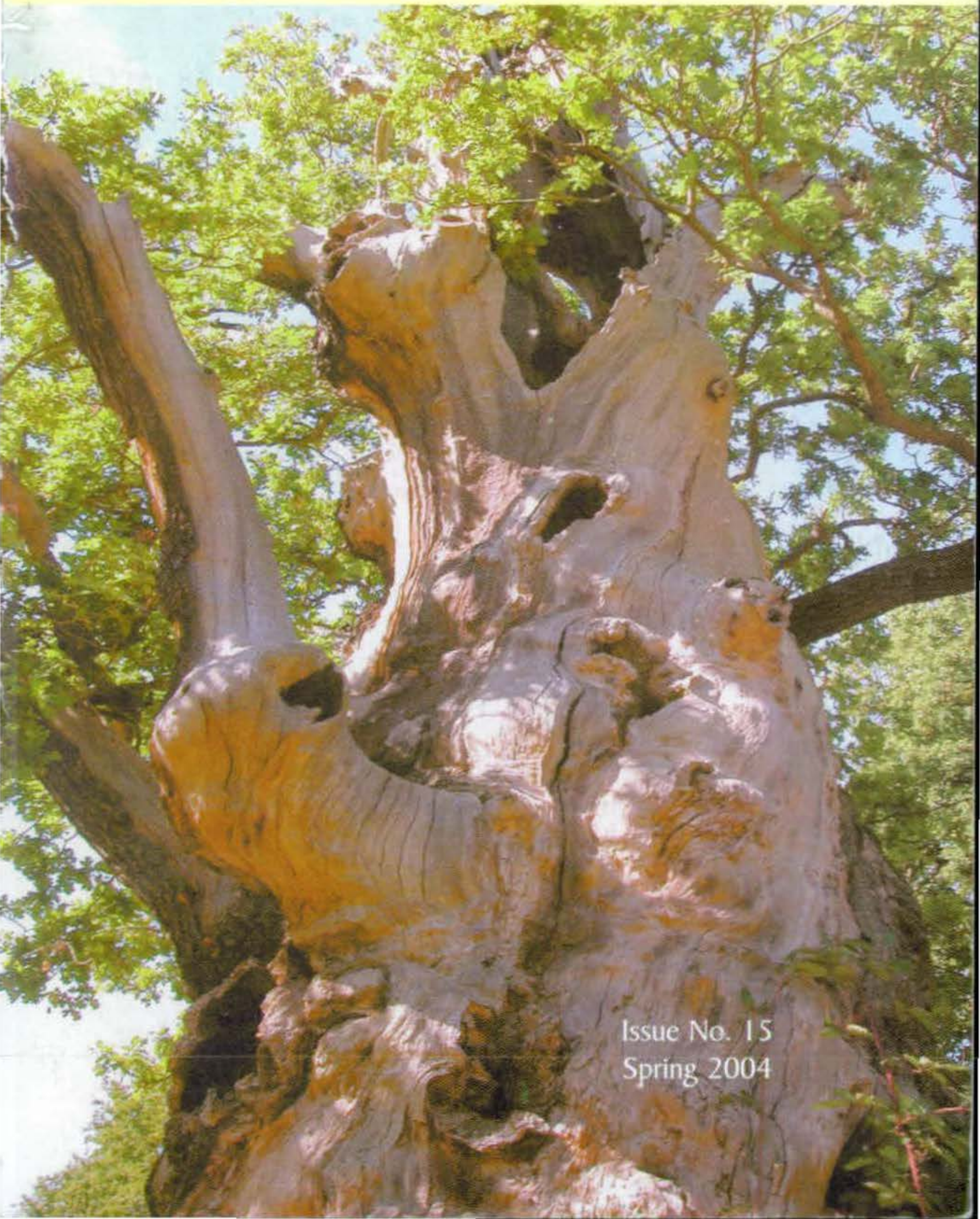
PROCEEDINGS

Fourth International Oak Conference

Fall 2003

Winchester, England



Issue No. 15
Spring 2004

The International Oak Society Fourth Triennial Conference, 2003.
Taken under the oaks just prior to the general members' meeting
at Sir Harold Hillier Arboretum.

Photo by Guy Sternberg

2003

Proceedings

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Anyone interested in joining the International Oak Society or ordering information should contact the membership office. Membership dues are U.S. $25 per year, and benefits include *International Oaks* and *Oak News and Notes* publications, conference discounts, and exchanges of seeds and information among members from approximately 35 nations on six continents.

International Oak Society Website:
http://www.saintmarys.edu/~rjensen/ios.html

Cover Photo:
The William the Conquerer Oak (*Quercus robur*),
said to date from the 10th Century, at Windsor Great Park
(photo © Guy Sternberg)

Edited by Doug McCreary, Ron Lance, and Guy Sternberg

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EDITOR'S NOTE

It is with pleasure from all of us involved with journal publication that this issue of *International Oaks* is now in the hands of the membership. This is the largest journal issue ever produced by your Society, but I'm sure you will agree that bigger is better, since so much information, news, and data concerning oaks are contained in these pages. This proceedings issue represents the efforts of many professional individuals delivering fascinating presentations and posters at the Fourth International Conference. The 2003 International Oak Conference in Winchester, England was orchestrated this past September, in a grand and expert style. For those of you that missed it, I hope by reading through these pages you will gain sufficient insight into the rewards of our conferences that you will make every effort to physically attend the next one! Thanks are extended to Doug McCreary, Chief Editor for this journal issue, from the rest of the Editorial Committee and Society members working in compilation of this edition.

The 2003 Conference Committee consisted of Ron & Dorothy Holley, Allen Coombes, Piers Trehane, Richard & Jo Earle, Phil Morton, James Harris, Eike Jablonski, and a host of other assistants unnamed here. To these individuals gratitude from the Society is extended, for their accomplishment of such a successful conference. Over 100 members participated in this conference, from 18 countries. A pre-conference tour to the Netherlands and Belgium and a post-conference tour in the United Kingdom were filled to maximum capacity, both exemplary experiences.

This was the first International Oak Conference to be physically held out of the United States, a landmark accomplishment itself, for this Society. Owing to the international scope of the presentations, and grammatical style of the host country and presenters, US readers may notice variances in customary spelling of certain words throughout these proceedings. For example, mould vs. mold, hybridisation vs. hybridization, vigour vs. vigor; these are merely different cultural yet accurate spelling variances, not mistakes. Beginning with introductory words by Professor Julian Evans, readers of these proceedings may also note occasional inferences to images that were displayed at the conference through slides, powerpoint, or other format which are not reproduced in this publication. Of course, this is only one example of the advantage of physical attendance.

Finally, on a personal note, as I have bid farewell to the Presidency of the International Oak Society, I leave the post with much gratitude for having had this opportunity for 3 years. It has been a pleasure to serve, and to turn over this role to Eike Jablonski, while at the Winchester Conference. I hope you will join me in support of our Society these next 3 years, under your new Board of Directors.

Ron Lance
IOS Secretary and
Journal Editorial Committee member
February, 2004

INTERNATIONAL OAK CONFERENCE – WINCHESTER 2003

SPEAKERS LIST

Introduction

Prof. Julian Evans OBE, Imperial College, London

Session 1; Oaks of the World

Prof. Peter Schmidt, Dresden University of Technology, Tharandt, Germany

Dr. David Gvianidze, Director, Batumi Gardens, Georgia *presentation not available for publication*

Roy Lancaster OBE VMH, U.K. *presentation summarized for publication*

Dr. Francisco Vazquez-Pardo, Dept. of Forest Production, Badajoz, Spain

Session 2; Oaks in History

Roy Vickery, Natural History Museum, London, U.K.

Dr. Brent Elliot, The Lindley Library, London, U.K.

Dr. Mary Forrest, University College Dublin, Ireland

Dr. Adrian Newton, International Tree Foundation, U.K. *presentation not available for publication*

Peter Savill, University of Oxford, U.K.

Session 3; Oaks in Cultivation

Prof. Eike Jablonski, Curator, Ettelbruck Arboretum, Luxemburg

Piers Trehane FLS, Oak Registrar, U.K.

Doug McCreary, US Integrated Hardwood Range Program, USA

Andrew Poore, Forest Manager, Ilchester Estates *presentation not available for publication*

Dr. Paul Kormanik, USDA Forest Service, Athens, GA, USA

Thierry Lamant, National Forest Office, France

Session 4; Oaks and Their Uses

Prof. Jeffrey Burley, Oxford Forestry Institute, U.K.

Dr. John Box FLS, Ecologist, U.K.

Enrique Balbuena Guitierrez, Forest Engineer, Junta de Extramadura, Spain

Paul Whitehead, Landscape Consultant, Worcestershire, England

Summary and Close

Prof. Julian Evans OBE, Imperial College

Note: two previously scheduled speakers failed to reach the conference location due to unfortunate travel difficulties; Prof. Zhou Zhekun of Institute of Botany, Kumming, China, and Simon Stephens of the National Maritime Museum, England.

AN OVERVIEW OF OAKS

Professor Julian Evans OBE
Professor of Tropical Forestry
Imperial College, London

I am deeply honoured to open this conference. And, as the Forestry Commission's former Chief Research Officer (South), may I welcome overseas delegates to the UK. My particular interest within UK is the silviculture of broadleaved species of which our two native oaks have centre stage. To set the scene for our two-day conference, I shall lightly touch on three of our four principal themes and weave in the fourth, oaks across the world, as we go.

Oaks in history

In the UK we are besotted with oaks! We find engravings of eighteenth century oaks in *Evelyn's Silva* (Hunters Edition of 1802), including the Greendale Oak at Welbeck, measuring 33 ft in circumference at 1 ft above ground. Oaks are also commonly noted on early maps of England, such as this tree in my own wood of Northdown Plantation in Hampshire. Oaks are also deeply imbedded in the national psyche, as evidenced by this decoration on a mug! Finally there are numerous references to oaks in the Bible, such as the great oaks of Mamre. Here and elsewhere this genus is singled out more than any other among the world's trees owing to its size and great longevity

Oaks in cultivation

In England there is a long tradition of pollarding oaks. An example is this oak in my own wood, dedicated to my wife, that graces the cover of my new book *'What Happened to Our Wood'* (Patula Books, 2002). This practice of pollarding was exported, as evidenced by this pollarded English oak outside a post office in Swaziland. However, while English oaks were planted far and wide as landscape trees, they were rarely used for afforestation purposes.

Here is another example of a special form of pollarding called shredding, a practice common in the Mediterranean and Middle East. This example is from the mountains of Iraq where it is used on *Q. aegilops*, *Q. libani* and *Q. infectoria*.

In the UK, oaks are often grown in mixtures with conifers which act as nursery crops. The success of planting efforts has been enhanced recently by using plastic 'tree shelters' which greatly aid survival and early growth. But there are still problems. The American grey squirrel is an increasingly important pest to oaks and other hardwoods in the UK.

Oaks and their uses

The practice of oak shredding shown above produces branches for roofing and bedding. Oak has also been used to make furniture. Today, antique oak furniture is cherished for its beauty and durability, and the figure and character of oak wood is much sought after by wood workers. Brown oak, resulting from timber that is stained from infection by beefsteak fungus, is especially valuable.

Oaks have also been used in construction and there are many uses for its timber. But equally important is the great beauty of the trees themselves and their remarkably rich value for wildlife. Oaks are truly sentinels of history: I give you two days of glorying in oaks. Thank you.

OAKS AND OAK FORESTS IN CAUCASIA

Peter A. Schmidt
Professer, Dresden University of Technology
Department of Forest Sciences, Institute of General Ecology and Environment Management D-01737 Tharandt, Germany

Introduction to the Caucasus Region

When regarding the "Caucasus," some authors refer only to the high mountains of the Great Caucasus. Here the term "Caucasia" will be used to refer to the entire area located between the Black Sea and the Caspian Sea of the Caucasus Region. Besides the Great Caucasus, the North Caucasian Plain belonging to the Russian Federation, as well as the depressions and lowlands, mountain ranges and the highland south of the Great Caucasus up to the southern border of the states Armenia, Aserbaijan, Georgia (South Caucasia, often called "Transcaucasia"), are also included.

The Great Caucasus extends between the Black Sea and Caspian Sea over a distance of 1500 km and a breadth of 30-180 km. It consists of several parallel mountain ranges. The main ridge is preceded towards the north by a second ridge (here the Elbrus, the highest peak 5633 m, and the Kasbek, the highest peak 5044 m), as well as the rocky ridge (chain of limestone massifs). These high mountains form an important climate and water divide between East Europe and Southwest Asia, and thus between two continents. Geological development, as well as the unique orographic and climatic situation, gives rise to a unique natural setting and biological diversity of Caucasia. The cultural diversity characteristic of mountainous regions is not less unique. Likewise, the cultural history and land use dating back for millennia have influenced the landscapes and habitats.

Characteristic orobiomes rich in relics and endemics (from near-shore montane forests up to the alpine grasslands) meet within a small geographic area with submediterranean and warm-humid biomes, as well as continental semiarid biomes (cf. BfN 2000, Zazanashvili et al. 2000, Krever et al. 2001, Schmidt 2002). In the north Caucasian Plain steppe and woodland steppe areas, and in the east, Caspian semideserts closely approach the Caucasus. The steep southern sloping of the Great Caucasus contains very different ecotopes and different phytogeographic provinces of southern Caucasia:

- In the west with its humid climate, it transforms into the coastal area of the Black Sea and the Lowland of Colkheti,
- East of the Suram Mountains, it forms a bridge to Minor Caucasus towards the Kura Lowland, extending in the east to the arid Kura-Arax Lowland at the Caspian Sea.

To the south ascend the mountainous system of Minor Caucasus characterised by its diverse, but human-influenced, montane vegetation. The Minor Caucasus forms the margin of the Armenian Highland. It is poor in forests, being covered over large tracts with xerophytic vegetation, including open woodland up to montane steppes and Oriental thorn-cushion formations. Two landscapes stand out here, distinguished by summer-warm and winter-mild climate, abundant rainfall, and high air humidity. They represent refuges of Tertiary deciduous broad-leaved trees, which otherwise in Western Eurasia are extinct, as well as habitats of endemic oak species (relicts): Colkheti at the Black Sea and Lenkoran at the Caspian Sea. The Colkhic and Hyrcanian deciduous broad-leaved forests are rich in evergreen woody species in the undergrowth, with plenty of lianas and epiphytes, and are characteristic of a warm-humid climate of submeridional latitudes (not subtropical vegetation, as often referred to in Caucasian and Russian literature).

Species concepts – seventeen versus eight oak species

Depending on the taxonomic conception of the authors, the data about the number of *Quercus* species occurring in the Caucasus Region vary considerably (8 to more than 17 species). The "splitter" concept of species according to the KOMAROV school (e.g. Czerepanov 1995), and accepted by most of the authors of the Caucasus states (e.g. *Flora Kavkaza*/ Grossheim 1945, *Flora Azerbajd?ana*/ Bandin 1952, *Dendroflora Kavkaza*/ Matika?vili 1961, *Flora* Gruzii 1975, Artjunjan & Artjunjan 1985, and other floras and dendrological handbooks, or Krever et al. 2001), contrasts with the "lumper" concept (e.g. Govaerts & Frodin 1998) which is also referred to by the monograph of the East European, Caucasian and Asian oaks, by Menitsky (1968-2002). If, however, his subspecies are taken into consideration, the number of the taxa regarded as essential deviate from each other to a lesser extent (see **Table 1**).

Up to now most of the Caucasian authors differentiate between 17 oak species, with deviations of single authors being possible, partly due to recognizing additional species (e.g. *Q. hypochrysa*) or lesser species (e.g. of the species complex *Q. infectoria*). Semagina (1999), for instance, refers to 7 species alone from the limited area in the western Great Caucasus (Caucasus State Nature Reserve). Kolakovski (1982) considers Caucasia as one of the centres of speciation in the genus *Quercus* and of conservation of relics in Eurasia.

The species concept followed here largely corresponds to that of Menitsky (1968-2002). Similar are also the species interpretation in the *Flora of Turkey* (Hedge & Yaltirik 1982) and in the *World Checklist* by Govaerts & Frodin (1998), even though the number of subspecies accepted by these authors is lower and the delimitations of which (and thus data of distribution) may differ. Hence, in Caucasia with regard to broader interpretation of *Q. robur*, *Q. petraea* and *Q. infectoria*, 8 species and 11-14 taxa, respectively, occur, being accepted as species, or at least in the rank of subspecies.

In southwest Asia hybridisation seems to essentially contribute to the formation of taxa and to the blurring of species limits, respectively (cf. Menitsky 1968-1984, Kasapligil 1981). According to Kolakovski (1982) e.g. in the overlapping area of the respective closely related taxa of *Q. robur* sensu lato and *Q. petraea* sensu lato, a great number of hybrid forms occur in Caucasia, but he accepts the Caucasian taxa each as independent endemic species (*Q. imeretina*, *Q. iberica*). Concerning the European species, hybridisation has been verified based on crossing experiments and genetic analyses. Numerous combinations identified as hybrids, or those assumed as such, were given binary names, which also applies to the three occurring between the three far-spread European-West Asian species likewise stocking in Caucasia: *Q. petraea* x *Q. pubescens* (*Q.* x *streimii* Heuff. or *Q.* x *calvescens* Vuk.), *Q. petraea* x *Q. robur* (*Q.* x *rosacea* Bechst.), *Q. pubescens* x *Q. robur* (*Q.* x *kerneri* Simonk.). If the three species are seen in a narrow taxonomic context and several species designated each, the

Table 1. Survey of the oaks of Caucasia according to various authors

CZEREPANOV (1995), floras of the Caucasus Region	MENITSKY (1984, 2002)	GOVAERTS & FRODIN (1998)
Q. castaneifolia	***Q. castaneifolia***	*Q. castaneifolia*
Q. hartwissiana	***Q. hartwissiana***	*Q. hartwissiana*
Q. macranthera	***Q. macra0nthera***	*Q. macranthera*
Q. pontica	**Q. *pontica***	Q. pontica
Q. pubescens	***Q. pubescens***	*Q. pubescens*, but not mentioned for Caucasia
	***Q. infectoria* sensu lato**	
Q. araxina	*Q. infectoria* ssp. *boissieri*	*Q. infectoria* ssp. *veneris*
Q. boissieri	*Q. infectoria* ssp. *boissieri*	*Q. infectoria* ssp. *veneris*
Q. infectoria	*Q. infectoria* ssp. *infectoria* not in Caucasia	*Q. infectoria* ssp. *infectoria* not in Caucasia
	***Q. petraea* sensu lato**	
Q. dalechampii	*Q. petraea* ssp. *medwediewii*	ssp. *medwediewii* = ssp. *iberica* *Q. dalechampii* not in Caucasia
Q. dshorochensis	*Q. petraea* ssp. *dshorochensis*	*Q. petraea* ssp. *iberica*
Q. gagriana	*Q. petraea* ssp. *iberica*	*Q. iberica*
Q. petraea ssp. *iberica*	*Q. petraea* ssp. *iberica*	*Q. petraea*
Q. petraea ssp. *petraea*	*Q. petraea* ssp. *petraea*	
Q. pinnatiloba	*Q. petraea* ssp. *pinnatiloba*	*Q. petraea* ssp. *pinnatiloba* (not mentioned for Caucasia)
	***Q. robur* sensu lato**	
Q. imeretina	*Q. robur* ssp. *imeretina*, 2002: = ssp. *robur*	*Q. robur* ssp. *imeretina*
Q. pedunculiflora	*Q. robur* ssp. *pedunculiflora*	*Q. robur* ssp. *pedunculiflora*
Q. robur	*Q. robur* ssp. *robur*	*Q. robur* ssp. *robur*
17 species	8 species, one with 2, another with 5 subspecies (13 taxa)	8 species, one of them not mentioned for Caucasia, less subspecies (10 taxa)

number of the respective hybrids increases (cf. 10 nothospecies alone for the Czech flora, Hejny & Slavík 1990) and thus, the probability of wrong interpretations. Certainly Menitsky (e.g. 1984) points to the hybrids known from Europe and indicates such ones having Caucasian species (e.g. *Q. hartwissiana* x *Q. petraea*, *Q. hartwissiana* x *Q. robur*), but he renounces binary names. He attaches high significance to the introgressive hybridisation and indicates, given joint occurrences of the species, the presence of respective populations regarding almost all Caucasian species (exceptions *Q. castaneifolia* and *Q. pontica* being also morphologically quite stabile). He interprets several taxa as products of introgressive hybridisation, so e.g. *Q. petraea* ssp. *medwediewii* (*Q. petraea/Q. pubescens*) and *Q. pubescens* ssp. *anatolica* (*Q. pubescens/Q. infectoria*). Between *Q. petraea* ssp. *iberica* and *Q. infectoria* ssp. *veneris* in the Armenian Highland, all transitional forms occur. Govaerts & Frodin (1998) refer to a hybrid between both taxa (*Q.* x *mannifera* Lindl.) for eastern Turkey to northern Iran, allocating to it numerous species described by authors of older publications (e.g. *Q. longifolia* K. Koch, *Q. komarowii* A. Camus).

In dendrological literature reference has been made repeatedly to cultivated plants, which were identified as hybrids between species occurring in Caucasia, e.g. *Q. pontica* x *Q. robur* (Rehder 1940), *Q. castaneifolia* x *Q. macranthera* and *Q. macranthera* x *Q. robur* (Hillier 1998).

Classification of the Caucasian oaks into the system of the genus *Quercus*

The Caucasian oaks belong to the subgenus *Quercus* (Syn. *Lepidobalanus*). The majority of species is allocated to the section *Quercus* (Syn. *Robur*), one species (*Q. castaneifolia*) to the section *Cerris*, and another one (*Q. infectoria*) to the group of the *Galliferae* that is sometimes regarded as an independent section and sometimes as part of the section *Quercus*. In particular, concerning *Q. pubescens*, the conceptions differ. Menitsky (1968, 1984, 2002), by whom the following taxonomic survey is oriented, allocates the species at the beginning to subsection *Robur* (1968). Later on, however, he doubted the usual allocations into the groups of relationship of *Q. robur/Q. petraea* or of *Q. macranthera*, and interpreted it as another representative of the *Galliferae* (1984, 2002).

Quercus

Subgenus *Quercus* (Subgen. *Lepidobalanus* [Endl.] Oerst.)

I. Sect. *Quercus* (Sect. *Robur* Loud., Sect. *Eulepidobalanus* Oerst.)

1. **Subsect. *Ponticae*** (Stef.) A. Camus
   Q. pontica
2. **Subsect. *Quercus*** (Subsect. *Robur* [Endl.] Guerke)
   Q. hartwissiana, Q. petraea sensu lato (incl. *Q. dshorochensis, Q. iberica, Q. petraea, Q. pinnatiloba, Q. polycarpa*), *Qu. robur* sensu lato (incl. *Q. haas, Q. imeretina, Q. longipes, Q. pedunculiflora, Q. robur*)
3. **Subsect. *Macrantherae*** (Stef.) A. Camus
   Q. macranthera
4. **Subsect. *Galliferae*** (Spach) Guerke
   Q. infectoria sensu lato (incl. *Q. araxina, Q. boissieri*), *Q. pubescens* sensu lato (incl. *Q. anatolica, Q. crispata*)

II. Sect. Cerris Dumort.

1. **Subsect. Cerris** (Dumort.) Guerke
   Q. castaneifolia

Distribution types of Caucasian oaks

According to Krever et al. (2001), 14 out of 17 species occurring in Caucasia are said to be "endemic to the Caucasus Region," with 11 being included as "Rare and endangered species listed in the Red Books of the Caucasian countries" (Tab. 2). Even if all taxa – whether as species or as subspecies – were accepted, most of them would go beyond the boundaries drawn by the authors of the reference Caucasus Region (southern boundary regarded as coinciding with the southern borders of the countries Armenia, Azerbaijan, and Georgia). Hence, the number of Caucasian endemics that has been assumed is clearly too great. Partly endemic taxa of the Submediterranean or Oriental Region are referred to here (via Anatolia up to the Balkan Peninsula or into Iran) or such ones of the Euxinian or Hyrcanian Province (also in north Anatolia or in northwest Iran). Nakhutsrishvili (1999) designated *Q. pedunculiflora* as an endemic species of "Transcaucasia;" however this taxon (*Q. robur* ssp. *pedunculiflora*) is not only distributed in South Caucasia, but extends via the Isle of Krim and Turkey up to the Balkan Peninsula. Contrary to this, *Q. imeretina* is an "endemic species" of west Georgia, certainly only known from western Caucasus region. The designation as species, however, has been significantly overestimated, even as subspecies (*Q. robur* ssp. *imeretina*), and today is no longer accepted by the monographer of oaks of Caucasia (Menitsky 2002).

It is true that the number of Caucasian endemics among the oaks is considerable, in terms of the biogeographical entity Caucasia, but even then it is not as great as mentioned in Krever et al. (2001), as is obvious from an analysis of distribution types:

Submediterranean/montane-Middle European: ***Q. robur* with 3 subspecies** (geographical races)

- Submediterranean/montane-Atlantic-Sarmatic: **ssp. *robur*** (in Caucasia mainly north of the Great Caucasus)
- East Submediterranean: **ssp. *pedunculiflora*** (in Caucasia chiefly south of the Great Caucasus)
- Colkhic: **ssp. *imeretina*** (only lowland and adjacent uplands of Colkheti)

Submediterranean/montane-Middle European: ***Q. petraea* including several subspecies** disputed as to their delimitation (geographical and/ or ecological races):

- Submediterranean/montane-Atlantic-Central European: **ssp. *petraea*** (in Caucasia primarily north of the Great Caucasus)
- East Mediterranean/montane-Oriental: **ssp. *pinnatiloba*** (by the Armenian-Northwest Iranian part of distribution area extending as far as the southern fringe of Caucasia)
- South Caucasian (incl. Colkhic and Hyrcanian Provinces): **ssp. *iberica*** (in Caucasia mainly south of Great Caucasus; however according to Govaerts & Frodin 1998 with the inclusion of the following subspecies not limited to Caucasia, but East Submediterranean)
- East Submediterranean: **ssp. *medwediewii*** (in Caucasia mainly north of the Great Caucasus)
- Northeast Anatolian (subeuxinian)**: ssp. *dshorochensis*** (only in the utmost southwest of Caucasia)

Mediterranean/montane-Submediterranean-Pannonic-South Subatlantic: ***Q. pubescens*** (in Caucasia chiefly north of the Great Caucasus)

Eastern Mediterranean-Oriental: ***Q. infectoria***, with the eastern (to Armenian-Iranian) subspecies **ssp. *veneris*** extending as far as to the southern fringe of Caucasia

North Anatolian-Caucasian-Hyrcanian: ***Q. macranthera***

Euxinian: ***Q. hartwissiana***

Colkhic: ***Q. pontica***

Hyrcanian: ***Q. castaneifolia***.

Three polymorphic and polytypic species (*Q. robur* sensu lato, *Q. petraea* sensu lato , *Q. pubescens*) occur in nemoral deciduous broad-leaved forest areas of Europe and southwest Asia (Asia Minor and Middle East), and also in Caucasia. Among the taxa designated as subspecies (referred to as a species by most of the Caucasian authors), two occur exclusively or almost exclusively in Caucasia, and two just touching upon Caucasia. One species being likewise very variable, which is distributed in the Eastern Mediterranean Region, Asia Minor and the Middle East, has but few occurrences in the southernmost south Caucasia (*Q. infectoria*). Four well-characterized and less variable species have their main distribution in the Caucasian countries, but are not confined to them. They are very characteristic elements of the Caucasian flora and vegetation. Two species are found in the Black Sea region (Euxinian or Colkhic), one species in the uplands near the southern Caspian Sea (Hyrcanian), and one in the Great and the Minor Caucasus. Among these two species are typical elements of the hygro-thermophytic, deciduous, broad-leaved mixed forests (*Q. hartwissiana* and *Q. castaneifolia*); two species thrive in the upper montane and subalpine belts (montane forests up to the timberline: *Q. macranthera*, krummholz: *Q. pontica*).

Oak forests

The Caucasian oak forests are extraordinarily diverse and belong to the most structured and species-abundant forests of Caucasia. This biodiversity (numerous ecosystem types and species) is enhanced by the great variety of landscapes and by the special evolutional history (refuges of Arcto-Tertiary deciduous broad-leaved forest vegetation, oaks as relics and endemic taxa). However, the distribution area of oak forests has been much reduced by logging and land use. The fertile soils of the lowlands up to the lower uplands have been used for agriculture for centuries (arable farming, viticulture, fruit growing). Oak forests were mostly pushed back to poor sites not suitable for agriculture, to steep slopes or to remote gorges. Also the oak forests that were preserved were subject to changes as well. Wood utilization, lopping systems (twigs and foliage for animal feeding), woodland pasture, and overgrazing led to the degradation of sites. Poor natural regeneration of oaks, changes in the spectrum of species and stand structure resulting from thinnings and stump sprouting (coppice-managed woodland), caused the formation of secondary dry woodlands up to anthropo-zoogenic open land formations devoid of forest (steppe formation of former oak forest tracts). The currently complicated economic situation in the Caucasian States has led to an extension and intensification of utilization of natural resources. This does not even stop at protected areas, which, among others, had been established to protect close-to-nature oak forests and populations of rare or endangered oak species. (See **Table 2**) This also raises landscape ecological problems, because the oak forests fulfil an important function against soil erosion.

Table 2. Rare and endangered species listed in the Red Books of the Caucasian countries according to Krever et al. (2001)

	Armenia	Azerbaijan	Georgia
Q. castaneifolia		x	
Q. hartwissiana			x
***Q. infectoria* sensu lato**:			
- *Q. araxina*	x		
- *Q. boissieri*	x	x	
- *Q. infectoria*	x		
Q. macranthera			x
***Q. petraea* sensu lato**:			
- Q. dshorochensis			x
Q. pontica			x
***Q. robur* sensu lato**:			
- *Q. imeretina*			x
- *Q. pedunculiflora*	x		x
- *Q. robur*	x		
	5	2	6

IUCN Red List 2000, The World List of Threatened Trees (Oldfield et al. 1998):
Q. robur* ssp. *imeretina (Colkheti) - category **Vulnerable**

Numerous publications are available, taking the Caucasian types of vegetation of the oak forests into consideration (e.g. Bandin 1954, Mahatadze 1957, Gulisa_vili et al. 1975, Alentev 1976, Nakhutsrishvili 1999, BfN 2000, Zazanashvili et al. 2000, Kvachakidze 2001) or data of the single oak species are given, and which forest associations they occur in (e.g. Sokolov et al. 1977, Menitsky 1984). Since the major number of oak taxa is also distributed in Anatolia, a comparison with the forest vegetation of the Euxinian region and the woodland steppe vegetation of Turkey (e.g. Mayer & Aksoy 1986) is of interest. The description of the vegetation of the oak forests follows various geobotanical schools, which results in completely different classifications. In general, the methods of the Russian forest typology are applied, only very seldom the west-European Braun-Blanquet school (few syntaxa with *Quercus* species as characteristic and differential species in Korotkov et al. 1991), partly also mixed forms. Since different methods are applied and homonymous terms (e.g. formations, associations) are defined differently, a comparison of the oak forest vegetation types of the single authors is more difficult. In Georgia alone, of the 23 "formations" and 280 "associations" of the forests designated by Kvachakidze (2001), 5 "formations" and 45 "associations" belong to the "Quercetea:"

- 27 to *Q. petraea* sensu lato (25 ssp. *iberica-*, 2 ssp. *dschorochensis-*) forest associations;
- 10 to *Q. robur* sensu lato (6 ssp. *pedunculiflora-*, 4 ssp. *imeretina-*) forest associations;
- 8 to *Q. macranthera* forest associations.

Corresponding to their ecological norm of reaction, oaks are characterized by a wide variety of sites. They occur as stand-forming entities or as mixtures of tree species from the lowland (alluvial and lowland forests, e. g. *Q. robur* subsp. *imeretina* et subsp. *pedunculiflora*) up to the timberline and the subalpine belt (*Q. macranthera*, *Q. pontica*). The main distribution is found in forest belts of lower and medium elevations (e.g. *Q. petraea* along with its subspecies being widely distributed as main and mixtures of tree species ranging from sea level up to 1200 m or the Hyrcanian *Q. castaneifolia* in Lenkoran up to 1800 m). As light-demanding tree species, the oaks are absent from forests where shade-bearing trees are predominant (beech forests, spruce-fir forests). (See **Table 3**) The west Caucasian *Q. hartwissiana* is slightly more shade-tolerant and requires higher humidity. In contrast to this, species like *Q. infectoria* and *Q. pubescens* still thrive in xerophytic open woodlands with low rainfall, frequently with shrubby habit encouraged by coppicing.

Table 3. *Quercus* species and subspecies in common with other trees in Georgian forests. The figures give the number of common occurrences according to the diagnostic tree-species groups of forest associations of Kvachakidze (2001)

	Quercus petraea ssp.		*Quercus robur* ssp.		*Quercus macranthera*
	iberica	*dshorochensis*	*pedunculiflora*	*imeretina*	
Carpinus betulus (C. caucasicus)	35	1	5	2	11
Fraxinus excelsior	26	-	7	1	3
Fagus orientalis	9	-	-	-	10
Acer cappadocicum (A. laetum)	11	-	-	-	1
Pinus sylvestris ssp. *hamata (P. sosnowskyi, P. kochiana)*	8	1	-	-	3
Sorbus torminalis	15	-	-	-	-
Tilia begoniifolia (T. caucasica)	18	-	5	-	1
Acer campestre	5	-	3	-	-
Pyrus caucasica	2	1	2	-	-
Zelkova carpinifolia	4	-	-	1	-
Carpinus orientalis	5	-	-	-	-
Castanea sativa	4	-	-	-	-
Ulmus glabra (U. elliptica)	3	-	-	-	-
Corylus colurna (C. iberica)	2	-	-	-	-
Ostrya carpinifolia	-	1	-	-	-
Pinus brutia ssp. *pityusa*	1	-	-		-
Juniperus foetidissima	1	-	-	-	-
Juniperus excelsa ssp. *polycarpos*	1	-	-	-	-
Ulmus minor (U. foliacea)	-	-	7	-	-
Prunus cerasifera ssp. *divaricata*	-	-	2	-	-
Salix alba sensu lato. *(S. excelsa)*	-	-	1	-	-
Quercus hartwissiana	-	-	-	2	-
Alnus glutinosa ssp. *barbata*	-	-	-	1	-
Betula litwinowii	-	-	-	-	7
Acer trautvetteri	-	-	-	-	5
Picea orientalis	3	-	-	-	1
Populus tremula	1	-	-	-	2
Sorbus aucuparia (S.caucasigena)	-	-	-	-	2
Salix caprea	1	-	-	-	1
Acer platanoides	1	-	-	-	1
Acer hyrcanum	-	-	-	-	1
Quercus petraea ssp. *iberica*	-	-	-	-	1

The following listing gives orientation as to the vegetation types in which Caucasian oaks can be found. The most important forest types of the oak forests and the oak mixed forests formed by the individual oak species are given in the *Survey of oaks of Caucasia* (see chap. 6), each under the respective taxa.

Forest formations and main forest vegetation types including oaks as dominant or characteristic tree species

Alluvial and wet lowland forests of large river valleys

- Alder and hardwood alluvial forests and wet lowland forests: *Q. robur* ssp. *imeretina*
- Poplar-willow and hardwood alluvial forests: *Q. robur* ssp. *pedunculiflora*, ssp. *robur*

Hygro-thermophilous mixed deciduous broad-leaved forests

- Lowland to submontane, partly to montane oak and mixed broad-leaved forests: *Q. castaneifolia, Q. hartwissiana, Q. robur* ssp. *imeretina*

Thermophilous mixed deciduous broad-leaved forests

- Colline Oak and Oriental hornbeam (*Carpinus orientalis*-)-oak forests: *Q. pubescens*

Xerophytic open woodland and forests

- Submediterranean pine (*Pinus brutia* ssp. *pityusa*-) forests: *Q. petraea* ssp. *iberica*
- Open juniper (*Juniperus excelsa* ssp. *polycarpos*-, *J. foetidissima*-) woodland: *Q. petraea* ssp. *iberica*
- Submontane-montane oak forests and open woodland: *Q. infectoria* ssp. *veneris*

Mesophytic mixed deciduous broad-leaved forests

- Colline-submontane to montane oak and mixed hornbeam-oak forests
  - oak forests and hornbeam (*Carpinus betulus*-)-oak forests: *Q. petraea* ssp. *petraea* and ssp. *iberica, Q. robur* ssp. *robur* and ssp. *pedunculiflora*
  - hygrophilous types of oak, hornbeam-oak and hornbeam-chestnut-beech forests with evergreen understory: *Q. petraea* ssp. *iberica*
  - Oriental hornbeam (*Carpinus orientalis*-)-oak forests: *Q. petraea* ssp. *iberica*
- Submontane to montane hornbeam (*Carpinus betulus*-)-beech forests: *Q. petraea* ssp. *iberica*
- Montane beech (*Fagus orientalis*-) forests, partly with evergreen understory: *Q. castaneifolia, Q. petraea* ssp. *iberica*
- Altimontane oak forests: *Q. macranthera*

Montane to subalpine coniferous forests

- Montane pine (*Pinus sylvestris* ssp. *hamata*-) forests: *Q. petraea* ssp. *iberica*
- Montane to subalpine pine forests: *Q. macranthera*

Subalpine open woodlands, krummholz, scrub: *Q. macranthera, Q. pontica*

Survey of oak species and their subspecies

The species and their subspecies are given below in alphabetical order and their synonyms and distribution are explained. Taxonomically difficult species complexes are also discussed. The forest vegetation types coined by them are outlined.

Quercus castaneifolia C. A. Mey. – Chestnut-leaved oak

The species is unmistakable by virtue of its leaves, the small triangular mucronate teeth (7-14 pairs), the cup with subulate, spreading or reflexed scales, and the persistent stipules of the buds. It is a typical Hyrcanian species, occurring exclusively in the east of South Caucasia (Aserbaijan; Red book species of the country) and in the Elburs Mountains (northern Iran). In Lenkoran it is one of the most important forest-forming trees, 40-45 (occasionally up to over 50) m in height, 100-150 cm stem diameter and growing for 300 years or more. *Quercus castaneifolia* forests occur in the lowland as coastal vegetation of the Caspian Sea up to the mountain regions (up to 1800 m, Talysh Mts.). As lowland and mountainous oak forests they represent the Hyrcanian type of the hygro-thermophilous deciduous broad-leaved forests, and thus residual stock of the Arcto-Tertiary deciduous broad-leaved forests in Caucasia abounding in relics and endemics. Among others, *Parrotia persica, Zelkova carpinifolia, Acer velutium,* and *Gleditsia caspica* occur as mixtures of tree species in the Hyrcanian colline to montane oak forests. Mixed deciduous broad-leaved forests with *Q. castaneifolia* are also found in the Talysh Mountains, and in the beech forest belt, where *Fagus orientalis* forests with evergreen lianas and shrubs (e.g. *Hedera pastuchowii, Ilex hyrcana, Danae racemosa*) are predominant.

Quercus hartwissiana Steven – Hartwiss' oak
Syn.: *Q. armeniaca* Kotschy - *Q. stranjensis* Turrill

This species is similar to *Q. petraea* (leaves very similar to the ssp. *iberica*), its fruits however are long pedunculate (3-4.5 cm). This Euxinian species is distributed in western Caucasia (mainly south of the Great Caucasus) and extends via north Anatolia along the Black Sea up to eastern Bulgaria. According to Kolakovski (1982), this is a Tertiary relic that used to be widely distributed. This shade-tolerant tree (among the Caucasian oaks it is the most shade-tolerant species) grows to 34-36 m in height, does not form stands, but merely occurs as with other species. For instance in the Colkhic deciduous broad-leaved mixed forests (in particular the hygro-thermophilous broad-leaved forests of warm-humid climate), it occurs on eutrophic, fresh-to-wet soils from the lowland up to the mountain region (up to 1200-1500 m). The German name Armenian oak for the species in Bärtels (2001) is misleading, as it does not occur in Armenia. Moreover in the English literature (Hillier 1998) – not appropriate either - *Q. pontica* is referred to as Armenian Oak. According to Krüssmann (1978), *Q. hartwissiana* as a cultivated plant is often confused with *Q. pubescens*.

Quercus infectoria Oliv. – Aleppo oak

This species is variable, with sclerophyllous, partly semi-evergreen leaves, pubescent beneath at the first, the shape of which undergoes conspicuous change along the annual shoots (basal ones mostly entire, and the subsequent ones with acute teeth). The large distribution range extends from the southern Balkan Peninsula via Asia Minor up to the Middle East. The small (up to 8 m in height), small-leaved and small-fruited (leaves with 5-7 paired teeth, cup up to 1 cm in diameter) type taxon ssp. *infectoria* is missing in the Caucasus countries; its easternmost north-Anatolian occurrences are at Artvin, not extending as far as Georgia. However, this species is represented in Caucasia, even though very limited, since the following East Mediterranean-Oriental subspecies has isolated occurances in the southern South Caucasia (Karabakh, Megri):

- **ssp. *veneris*** (A.Kern.) Meikle – Boissier's oak, Araxes oak

Syn.: *Q. boissieri* Reut. - *Q. infectoria* ssp. *boissieri* (Reut.) O. Schwarz - *Q. araxina* (Trautv.) Grossh.

The subspecies (in Caucasia treated as separate species) can grow as tall as 8-16 (-20) m, and general has a shrubby habit due to coppicing. The leaves have 8-12 pairs of leaf-teeth, and the cupules are up to 2 cm in width. In the south Caucasian area, all morphological transitions between *Q. infectoria* and *Q. petraea* ssp. *iberica* can be found (Gulisa_vili et al. 1975, Menitsky 1984). This oak tolerates drought (annual mean precipitation is only 300-350 mm) and hot summers (average July temperature 26-27° C). It is a characteristic element of the xerophytic open woodland of dry mountainous areas (up to 1000-1300 m) in southernmost Armenia and Azerbaijan. The rare *Quercus infectoria* ssp. *veneris* forests (i.e. with *Fraxinus oxycarpa, Celtis glabrata, Acer monspessulanum* ssp. *ibericum*) generally occur on the slopes of the Arax valley (see *Q. araxina* for this taxon). In lower tracts they transition into the arid *Pistacia mutica* open woodland (adjacent to semi-deserts), at elevations from 900-1000 m, to *Q. petraea* ssp. *iberica* forests. Intact stands are rare. There are no longer high forests and regeneration takes place via stump sprouting. The stands have been greatly reduced and are endangered (likewise those of *Pistacia mutica*, cf. Schmidt 2003), because of fuel wood extraction, missing natural regeneration (feeding on acorns by grazing animals, woodland pasture), utilization of the foliage for winter-feeding, and high incidences of mistletoe infestations. For its rarity and endangerment this oak was included in the Red Books of the two south Caucasian countries (in Krever et al. 2001 under several species names: *Q. infectoria*, *Q. boissieri* and *Q. araxina*). In Armenia, a total ban of felling was imposed (Red Data Book 1988).

Quercus macranthera Fisch. et C. A. Mey. ex Hohen. – Persian oak, Highland oak

This is a readily identifiable species with tomentose shoots, persistent stipules at the buds, and rather large (7-15cm in length) leaves, grey to yellowish tomentose beneath. In Caucasia the Caucasian-Hyrcanian type-taxon ssp. *macranthera* occurs. No occurrences are known for the northern Anatolic subspecies ssp. *syspirensis* (K. Koch) Menitsky, from the Caucasus countries. This oak can grow as old as 300 years, achieve 20-(35) m in height, as well as 80 cm in stem diameter. It is highly light-demanding, but can tolerate both drought and frost. In Great Caucasus (here in the East also extending as far as north Caucasia) as in Minor Caucasus, its significance as a stand-forming forest tree increases towards the east. Forests consisting of, or including, *Q. macranthera* are, above all, rather spread out in South Caucasia. They occur from middle montane belts up to the timberline in the subalpine belt (1450-2400, occasionally up to 2700 m), with the most favourable conditions between 1450-1600 m. But even here the stands have almost totally become opened up due to overgrazing and timber utilization, or they are characterized by crookedness of boles and insufficient natural regeneration. In the dry, only sparsely forest-covered highland of South Caucasia (S Armenia, S Azerbaijan), *Q. macranthera* is the only forest-forming oak in the uppermost forest belt. It occurs as monospecies stands, mainly on south-facing slopes, on skeletal soils. In the subalpine krummholz and open woodland of Caucasia, *Acer trautvetteri, Betula litwinowii* and *Sorbus aucuparia* s.l.(*S. caucasigena*) are often concomitant, while in open woodlands in southeast South Caucasia, *Acer hyrcanum* and *Pyrus zangezura* are accompanying species.

Quercus petraea L. ex Liebl. sensu lato– Sessile oak
Incl. *Q. calcarea* Troitsky non Gand. - *Q. dshorochensis* K. Koch - *Q. gagriana* Rossinsky - *Q. iberica* Steven - *Q. pinnatiloba* K. Koch - *Q. polycarpa* Schur

Of the *Q. petraea* group, numerous species have been described from Caucasia, and even today, up to 7 species are designated (in addition to those given in Tab. 1, others such as *Q. hypochrysa*, e.g. Artjunjan & Artjunjan 1985). Likewise in Europe, *Q. petraea* was, and partly still is, seen in the narrower sense (separation of *Q. polycarpa*, *Q. dalechampii*), also in dendrological handbooks (e.g. Rehder 1940 after Krüssmann 1978) *Q. iberica* and *Q. polycarpa* are named as separate species. On the other hand, *Q. petraea* has recently been classified merely as a subspecies of *Q. robur* by some authors (Roloff & Bärtels 1996). The classification of *Q. petraea* sensu lato in Menitsky (1968-2002) for Caucasia and southwest Asia deviates from that in the *Flora of Turkey* (Hedge & Yaltirik 1982) and the *World Checklist* (Govaerts & Frodin 1998). The latter regard *Q. dalechampii*, which Menitsky allocates to its ssp. *medwediewii*, as another species not occurring in Caucasia, and differentiate between 3 subspecies of *Q. petraea*. In this context ssp. *iberica* is understood in the broader sense with the inclusion of the subspecies ssp. *dshorochensis* and ssp. *medwediewii* designated by Menitsky. The named authors agree as to the classification of *Q. polycarpa* in *Q. petraea*, although in European floras it is often accepted as a separate species (e.g. Hejny & Slavik 1999). However, it is allocated to different subspecies, so to ssp. *iberica* by Govaerts & Frodin (1998), to ssp. *medwediewii* by Menitsky initially (1968), and later on to ssp. *petraea*. The latter (Menitsky 1984) emphasised that a designation of *Q. polycarpa*, irrespective of whether as species or subspecies, would presuppose the description of a whole series likewise of such "small " taxa, being virtually indistinguishable (ecotypes).

Q. petraea sensu lato, like *Q. robur* sensu lato, belongs to the Submediterranean/montane-Middle European species, but contrary to the latter, it is absent in the East-European deciduous boad-leaved and mixed forest region (*Fagus sylvatica* type of distribution areas according to Meusel & Jäger 1992). Being widely distributed in Europe, the range of which extends from the eastern Mediterranean region via Asia Minor to Middle East, it is an important forest tree of Caucasia (20-40 m in height and >1 m in stem diameter). It occurs in various forest ecosystems on dry and fresh sites from the lowland up to 1200 m, predominantly in the lower forest belt, but at higher elevations (1100-1800 m), in semiarid areas. *Quercus petraea* forests (incl. hornbeam-oak mixed forests) are the most widespread oak forests of Caucasia, mainly represented by ssp. *iberica* south of, and by ssp. *petraea* north of, the Great Caucasus. Korotkov et al. (1991) refer to *Q. petraea* as characteristic species or as differential species of various forest communities of Caucasian beech and hornbeam-beech forests, as well as hornbeam-oak forests, without differentiating between the subspecies:

- suballiance Orobo-Fagenion (ordo Rhododendro pontici-Fagetalia orientalis; Central Caucasus, southern slope),

- alliances Crataego-Carpinion (Central Georgia) and Carpino-Quercion petraeae (i.a. along with association Rhododenro lutei-Quercetum; northwest part of Great Caucasus range) of the ordo Lathyro-Carpinetalia caucasicae.

- **ssp. *dshorochensis*** (K. Koch) Menitsky – Chorokhi oak

Syn.: *Q. dshorochensis* K. Koch

This taxon was classified by Russian (e.g. Czerepanov 1995) and Georgian (e.g. Dmitrieva 1990) authors as a separate species, but other authors do not accept it as an independent taxon, and is therefore controversial. It occurs on sunny, rocky dry slopes of river valleys of the uplands in the southeast of the Black Sea (southeast subeuxinian). This small area extends from southwest Ajara into the east of the North Anatolian Province. Nowadays, *Q. petraea* ssp. *dshorochensis* forests are reduced to residual occurrences on the slopes of the Ajarisckali and Chorokhi River valleys in southwest Ajara (therefore belonging to the rare and endangered species of Georgia; Papunidze et al. 1978, Krever et al. 2001) and adjoining Turkey. However, in the *Flora of Turkey* such a taxon is not designated; rather is it incorporated – like in Govaerts & Frodin (1998) – into ssp. *iberica*. It is true that Menitsky (1968, 1984) accepted the similarity with this subspecies (xeromorphic descendant of the ssp. *iberica* with transitional forms to this one), but he believed that the small and oblong leaves (5-8[10] cm in length, 3-4 cm in breadth) justified a designation of a separate race. However, the leaves of the stands occurring in Ajara are described by Dmitrieva (1990) as oblong-elliptical, 8-12 cm in length, and 3-6 cm in width. According to my own observations, the plants differ greatly from the ssp. *iberica* in where they grow, being distributed in Georgia, but a xerophytic population on very dry slopes of shallow soil might have to be referred to. However, other factors may play a role. Unfortunately, few normally developed trees exist, because the stands are used for fuel wood extraction (coppicing) and animal feed (pollarding), thus being more liable to a shrubby habit. According to Menitsky (1984), in western Turkey tree forms appear, pointing to an introgressive hybridisation of ssp. *dshorochensis* with *Q. infectoria*. The occurrence of such transitional forms supposedly explains why the species described by authors of older publications such as *Q. woronowii* Maleev or *Q. komarowii* A. Camus are regarded as synonyms on the one hand of ssp. *dshorochensis* (Menitsky 1984, Czerepanov 1995), or on the other hand of *Q. infectoria* or their hybrid with *Q. petraea* (*Q.* x *mannifera*, Govaerts & Frodin 1998).

- **ssp. *iberica*** (Steven) Krassiln. – Georgian oak

Syn: *Q. gagriana* Rossinsky - *Q. grossheimii* Sachok. - *Q. hypochrysa* Steven - *Q. iberica* Steven - *Q. kozlowskyi* Woronow ex Grossh. - *Q. szowitzii* Wenz.

The subspecies, in general designated as separate species by Caucasian authors, differs from ssp. *petraea* by larger, thicker (more leathery), and slightly more pubescent undersides of leaves, the lobes (at least 1-2 additional pairs) of which are shorter (not exceeding 1/3 of the width of half the lamina). According to Menitsky (1984), it represents the most primordial taxon of the relationship of *Q. petraea* sensu lato. This oak is a characteristic forest tree of the lower and middle mountainous belts of South Caucasia (0-1800 m), which towards the north, hardly extends past the Great Caucasus (only Daghestan, Chechnya, Ingushetia); in the south, it extends up to Karadag Mountains;in the east up to the

Elburs Mountains (Iran); and in the west up to the Black Sea coast (here in the Gagra populations with tendency to winter-green foliage it is described as *Q. gagriana*). In *the Flora of Turkey* and Govaerts & Frodin (1998) this subspecies is referred to in greatly broader terms, and the distribution range thus extending with the inclusion of ssp. *dshorochensis* and ssp. *medwediewii*, as well as *Q. polycarpa* via Anatolia and the Krim up to the Balkan Peninsula and into the Pannonian Region (up to Slovakia). *Q. petraea* ssp. *iberica* forests among the oak and hornbeam-oak forests in South-Caucasia are distinguished by the widest geographical distribution, from the coastal region of the Black Sea extending as far as the uplands (occasionally up to 1800 m) and into semiarid regions. Nowadays, they are often found bordering on xerophytic woody vegetation and steppes, which partly occupy their former sites. Frequent associated tree species are *Carpinus betulus* (*C. caucasica*), *C. orientalis, Acer laetum, Sorbus torminalis,* and *Zelkova carpinifolia*. Overexploitation of oak, site degradation, erosion etc. lead to the establishment of monospecies of *Carpinus betulus* forests, of *C. orientalis* shibliak or *Bothriochloa* grassland.

Dolukhanov 1992 (according to Nakhutsrishvili 1999) differentiates between the following types (sub-formations) of the *Q. petraea* ssp. *iberica* forests:

- monodominant forests (hemi-xerophytic and xero-mesophytic series),
- *Carpinus orientalis-Q. iberica* forests (in arid regions at elevations of 600-1000 m, in humid locations 350-800 m; in lower belts on north slopes and on south slopes in higher belts),
- *Carpinus betulus-Q. iberica* forests (in the transition zone to beech forests). Kvachakidze (2001) indicates 25 Quercetea/*Q. iberica* forest associations for Georgia, among which those being rich in shrubs (e.g. *Quercetum azaleosum, cornosum, cotinosum*), those rich in dwarf shrubs (*Quercetum ericosum, ruscosum*), and those rich in herbs (e.g. *Quercetum epimediosum, trachystemosum*), as well as those rich in grasses (e.g. *Quercetum festucosum, poosum*).

- **ssp. *medwediewii*** (A. Camus) Menitsky – Medvedevs oak

Syn.: *Q. lanuginosa* Lam. ssp. *medwediewii* A. Camus - *Q. calcarea* Troitsky non Gand.

As compared to the other subspecies, this one is distinguished by a stronger pubescence and (with the exception of ssp. *pinnatiloba*) by deeper divided leaves (lobes extend as far as 1/3-3/4 of the width of half the lamina). Initially young shoots, petioles and the lower sides of leaves are very pubescent (discernible also with the naked eye); they become glabrescent, however, in the course of the vegetation period. The pubescence is maintained at the base of the lamina and the lateral veins. According to Menitsky (1968-1984), introgressive hybridisation with *Q. pubescens*, linked with an ecological differentiation, is decisive for the formation of this taxon. This "ecological race" that grows mainly on limestone in the northern Great Caucasus, as well as in its northern and western piedmont (at the Black Sea coast to the south up to Soczi; 0-1600m), takes a transitional position in view of the sites it occupies (less xerophytic than *Q. pubescens*, more thermophytic and calciphytic than *Q. petraea*).

According to Menitsky (1968-84), ssp. *medwediewii* does not only occur in the Caucasus region, but is likewise distributed in the Mediterranean/montane and Submediterranean Europe (from East France up to the Krim), as well as in Anatolia. In this regard, he incorporates ***Q. dalechampii*** Ten. (as synonym). This is the reason why this taxon known as a south to southeast European species of the relationship of *Q. petraea* by authors who do not follow the "subspecies concept" of Menitsky is designated as a species also for Caucasia (e.g. Czerepanov 1995, Semagina 1999). Govaerts & Frodin (1998) accept *Q. dalechampii* as a separate species, however, not occuring in Caucasia, while they designate ssp. *medwediewii* as a synonym of ssp. *iberica*. This situation is confusing due to the contrary conceptions, and the structure of the taxon and nomenclature need to be clarified. Obviously, the transitional forms or hybridogenous populations between *Q. petraea* and *Q. pubescens*, as they often occur in the joint geographic range of both species, occupy a greater area in northern Caucasia, in which *Q. pubescens* no longer occurs. Hence, it seems conceivable that an independent taxon has formed. Although the morphological characteristics mediate between both species, and respective plants could be allocated to this (cf. *Q. lanuginosa* [= *pubescens*] *ssp. medwediewii*) or that (*Q. petraea* ssp. *medwediewii*) species, the failure of *Q. pubescens* and the continued existence of the contact with *Q. petraea* gives good reason for Menitsky's procedure (1968-2002). Finally, it would also be conceivable to designate nothosubspecies of a hybrid *Q. petraea* x *Q. pubescens*, because the wide distribution area of the subspecies in Menitsky, which apparently includes hybrids from the overlapping geographic ranges of both species.

- **ssp. *petraea*** - Durmast oak

Syn.: *Q. petraea* L. ex Liebl. sensu stricto

This subspecies is distributed in the western, middle and south European deciduous broad-leaved forest areas, being more mesophytic as compared to the more southern ssp. *iberica*. It occurs exclusively in the North Caucasian Plain, as well as the adjoining Great Caucasus (60-1800 m). In South Caucasia it is replaced by the ssp. *iberica*.

- **ssp. *pinnatiloba*** (K. Koch) Menitsky

Syn.: *Q. pinnatiloba* K. Koch

This is easily distinguished by the more xerophytic leaves, finely pubescent beneath and deeply lobed (1/2 and more of the width of half of the lamina). Certainly this taxon occupies an extended area that is disjunct due to the restriction to mountains (1000-2700 m) in the eastern Mediterranean and western Oriental-Turanic Regions. One of the partial areas of distribution extends up to the farthest south of Caucasia (only very occasional occurrences in the Armenian highland: Zangezur, Megri).

Quercus pontica K. Koch - Armenian oak

This species is unmistakable by its undivided, sharply serrate leaves, 12-30 cm in length, the 20-30 paired teeth being mucronate. The English name Armenian Oak (Hillier 1998) is not so appropriate, since this species does not occur in Armenia (cf. also the German name Armenian oak in Bärtels 2001 as for *Q. hartwissiana*).

The distribution of *Q. pontica*, an ancient relict of the Colkhic flora (next relatives in the Himalayas and East Asia), is restricted to the western part of

South Caucasia: Colkhic Province from Bzyb river valley of the Great Caucasus (Abkhazeti) and the southwest Georgian part of Minor Caucasus up to Lazistan (northeast Turkey). Because of its limited geographical range in Georgia, it belongs to the rare and endangered plants of Georgia (Papunidze et al. 1978, Krever et al. 2001). According to Kolakovski (1982), the increased air humidity and soil moisture that continued to exist in Colkheti almost invariably facilitated the survival of this Tertiary relict. The species occurs in the uplands in locations with high amounts of rainfall and high air humidity (1200-1800 up to 2300 m, in near-shore gorges also at lower elevations), thriving exclusively on acid subsoil. In the subalpine vegetation *Q. pontica* occurs as a component of the shrub layer in open woodlands (*Betula litwinowii, Fagus orientalis, Acer trautvetteri*) with *Betula medwediewii* sensu lato (incl. *B. megrelica*), *Rhododendron caucasicum, Prunus laurocerasus* etc. Moreover, this oak grows either alone or together with other species (e.g. *Rhododendron ponticum, Prunus laurocerasus, Vaccinium arctostaphylos*) a dense, hardly pervious, krummholz. The procumbent-ascendant stems (30-40cm in diameter) grow as tall as 12 m, attaining however only 6-7 m in height. Under extreme conditions the plants can remain shrubby, growing only 1.5-2 m in height. At timberline the fruits rarely come to fruition–being compensated by vegetative propagation. The procumbent branches, being partly covered with soil, may initiate roots, thus giving rise to the formation of clonal scrub stands.

Quercus pubescens Willd. – Downy oak
Syn.: *Q. crispata* Steven - *Q. lanuginosa* Lam. ssp. *crispata* (Stev.) A. Camus - *Q. pubescens* ssp. *crispata* (Steven) Greuter et Burdet - *Q. pubescens* subsp. *anatolica* O. Schwarz - *Q. anatolica* (O. Schwarz) Sosn. ex Bandin

The Submediterranean area of distribution extends from the Balkan Peninsula via the Krim to Caucasia, whereas from Anatolia it extends as far as South Caucasia. In the Caucasus region this species appears to have two isolated partial ranges, one in the utmost northwest in the area of the Russian Black Sea coast, and one in the far east on the slope of Great Caucasus towards the Caspian Sea (Dagestan, northeast Aserbaijan). The trees are generally only 8-10 m in height (often shrubby) and, like *Q. macranthera,* tolerate drought, being however less frost-hardy. Therefore this species occurs in the influential zone of the inland seas (coastal slopes up to 500 m), above all in thermophilous, deciduous, broad-leaved forests or open woodlands. In the western part of its distribution, it forms together with Submediterranean species *Carpinus orientalis-Q. pubescens* forests (i.e. with *Pistacia mutica, Rhus coriaria, Juniperus oxycedrus, J. excelsa*), while in the eastern part the Dagestanian *Q. pubescens* forests (i.e. including *Pyrus salicifolia, Rhamnus pallasii*). Korotkov et al. (1991) assigns *Q. pubescens* to the groups of the characteristic and differential species of the alliance Carpinion orientalis (order Quercetalia pubescentis), for which they indicate, referring to West Caucasia, the associations *Pistacio muticae-Juniperetum excelsae* (Black Sea coast) and *Querco pubescentis-Carpinetum orientalis* (slopes with cinnamomic soils or rendzina on limestone).

Regarding pubescence, leaf-size and leaf-form, *Q. pubescens* has a great amount of variability, encouraged by hybridisation and introgression (e.g. with *Q. petraea, Q. robur, Q. infectoria*), hence the delimitation to other species and the intraspecific classification becoming more complicated. Several taxa were designated as separate species by authors of older publications, so also in Azerbaijan two other species were separated from *Q. pubescens* (Bandin 1952): *Q. crispata*, *Q. anatolica*. Until now, both names have been differently interpreted, thus causing confusion. Govaerts & Frodin (1998), who surprisingly do not name *Q. pubescens* sensu lato at all regarding the Caucasus countries, assign its occurrences in the eastern part of the distribution area (E Balkan Peninsula, Krym, Turkey) to ssp. *crispata*. Contrary to this, according to the outline map in Menitsky (1984), the Turkey area contains the ssp. *anatolica*, which he regards as a product of introgressive hybridisation of ssp. *pubescens* with *Q. infectoria*. All Caucasian occurrences, among them also *Q. crispata* (according verification of Steven's type material), are designated by him (Menitsky 1968-2002) to ssp. *pubescens*.

Quercus robur L. sensu lato – Pedunculate oak

In Caucasia generally three species of *Q. robur* relatives have been distinguished until now: *Q. robur* (s.str.) in the north, *Q. pedunculiflora* (often as *Q. longipes*) in the east, and *Q. imeretina* in the western lowlands and river valleys of South Caucasia. According to Menitsky (1968-84) three subspecies are referred to here, although he eventually (2002) reduced this number to two (ssp. *robur*, ssp. *pedunculiflora*).

Like *Q. petraea*, this species belongs to the Submediterranen/montane-Middle European species of the nemoral European deciduous broad-leaved forests. However it occupies a greater range of distribution (*Tilia cordata* type according to Meusel & Jäger 1992). Hence, the most widely distributed oak species of Europe is referred to here, its range extending further from the Balkan Peninsula via Asia Minor up to the Middle East. Likewise, it is an important forest tree in Caucasia, where it often colonizes moister sites (also water-logged sites as compared to *Q. petraea*, not achieving the tree heights of the latter). Forests comprising and including taxa of *Q. robur* sensu lato mainly occur in the lowland, riverine, and flood-plain forests.

- **ssp. *imeretina*** (Woronow) Menitsky – Imeretian oak

Syn.: *Q. imeretina* Steven ex Woronow

This subspecies differs from ssp. *robur* by the extremely short petioles (1-4 mm, smaller than 10 mm), which are almost completely covered by the auricles of the leaf lamina base, and by the less deeply lobed leaves (only up to 1/3, not up to _ of the width of half the lamina). In 1984 Menitsky emphasised the small morphological differences, considering a designation as subspecies (ssp. *imeretina* as pronounced Colkhic race) as justified for phytogeographical reasons. Later on (Menitsky 2002) no longer attached any taxonomic rank to this population, i.e. in contrast to Govaerts & Frodin (1998), and allocated it to the type subspecies (synonym of ssp. *robur*). Contrary to this, Kolakovski (1982) regarded the geographical isolation as an essential argument for recognizing it as separate species (*Q. imeretina*).

This taxon, which only occurs in the western part of South Caucasia (west Georgia with small part extending into Russia along the Black Sea coast), particularly in the Rioni lowland, in flood-plain forests and on river terraces (0-400 m), is endemic to the Colkhic Province.

Q. robur ssp. *imeretina* forests used to be largely distributed in west

Georgia from the lowland up to the lower mountain region, both on moist and dry sites, both in monodominant stands and in mixed forests, so in flood-plains and river valleys with *Carpinus betulus*, *Fraxinus excelsior*, *Alnus glutinosa* ssp. *barbata* and *Pterocarya pterocarpa* or in dry locations with *Zelkova carpinifolia* and *Carpinus orientalis*. In the hygro-thermophilous Colkhic mixed oak forests with evergreen understory (e.g. *Rhododendron ponticum*, *Prunus laurocerasus*), the subspecies may occur together with other oaks (*Q. hartwissiana*, *Q. petraea* ssp. *iberica*), but also *Zelkova carpinifolia*, *Carpinus betulus* or *Castanea sativa*. Because of the very restricted area and the depletion of the stands due to clear-cutting and agriculture (e.g. only occurrence in Ajara extinct, nowadays a tea plantation; Dmitrieva 1990), it was not only classified as rare and endangered species of Georgia (Papunidze et al. 1978, Krever et al. 2001), but was put on the IUCN Red List (Hilton-Taylor 2000) and the World List of Threatened Trees (Oldfield et al. 1998; Category Vulnerable).

- **ssp. *pedunculiflora*** (K. Koch) Menitsky – Long-stalked oak

Syn.: *Q. erucifolia* Steven - *Q. haas* Kotschy - *Q. kurdica* Wenz. - *Q. longipes* Steven - *Q. pedunculiflora* K. Koch - *Q. pedunculiflora* var. *erucifolia* (Steven) Gagnidze

This subspecies adapted to dry-warm climatic conditions is extraordinary heterogeneous, but as such, fairly well characterised. It is distinguished by more leathery leaves, as compared with other taxa of *Q. robur* s.l., which are more deeply divided (lobes longer than _ of the width of half the lamina); the leaves are often pubescent beneath and the cup is thicker-walled. The distribution area of the east Submediterranean taxon extends from the Balkan Peninsula via the Isle of Krim and Asia Minor up to Caucasia (mainly in central and eastern South Caucasia, in East Caucasia also in the northern Caucasus piedmont) and in the adjacent northwest Iran. In the Caucasian countries the taxon has been regarded as a separate, even endemic, species, either as *Q. longipes* (e.g. Kvachakidze 2002) or as *Q. pedunculiflora* (e.g. Nakhutsrishvili 1999, Krever et al. 2001). Likewise, in the European Floras (e.g. Hejny & Slavik 1990) and in the standard dendrological works like Krüssmann (1978) or Hillier (1998), it is often designated as a separate species. *Q. robur* ssp. *pedunculiflora* occurs as a predominant or admixture tree in oak and hornbeam-oak forests (i.a. with *Carpinus betulus* and *Ulmus minor*) from the lowland up to the lower uplands (up to 1000-1100 m). In this context, it is also found in hornbeam-oak forests on drier sites, according to Papunidze et al. (1978), even together with *Pistacia mutica* on slightly saline dry soils. This oak is a characteristic element of the hardwood alluvial forests, which occur in combination with poplar (*Populus alba*, *P. canescens*, *P. nigra*) and willow (*Salix alba* sensu lato: *S. excelsa*) alluvial forests in the river valleys of South Caucasia, especially upon the Kura and its tributaries (noticeable residual stands e.g. in Iori- and Alazan valleys, E Georgia). In Armenia the area has markedly shrunk due to overexploitation of timber, so that only single individuals survive, thus having been included in the Red Data Book of Armenia (1988).

- **subsp. *robur*** – Common oak, English oak

Syn.: *Q. medwedewii* Sosn. - *Q. robur* L. sensu stricto

This thin-leaved, more mesophytic subspecies, as compared with ssp.

pedunculiflora, represents the species in the middle European area of deciduous broad-leaved forest, in the east up to the Urals and northern Caucasia. It occurs in the North Caucasian Plain and on the foothills (300-1400 m). From the northern slopes of the Great Caucasus (Teberda River Valley) a microphyllous alpine ecotype was described as a separate species under *Q. medwedewii* (not to be confused with *Q. petraea* ssp. *medwediewii*! likewise occurring in northern Caucasia). *Q. robur* ssp. *robur* is found in colline-submontane north Caucasian oak and hornbeam-oak forests (i.a. with *Carpinus betulus* and *Ulmus minor*), as well as in the hardwood alluvial forests of river valleys. Small open oak woodlands (i.e. with *Caragana frutex*, *Prunus tenella*) occur as residual trees of the steppe woodland, also on riparian slopes in the North Caucasian Plain.

Acknowledgement

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TRAVELS IN CHINA

Roy Lancaster, OBE VMH

Roy Lancaster is a well-known freelance writer, lecturer, broadcaster and author of at least eight books. He has travelled extensively in China and his beautifully illustrated talk, *"Plants of China"*, was, without doubt, one of the highlights of the Conference, once again demonstrating both his comprehensive knowledge of the subject and the many benefits of his work as a collector over the years.

One of his most breathtaking slides was that of the *Quercus monimotricha*, flowering in his own garden just as it does on the scree outside Jermyn's House, with an explosion of soft golden yellow catkins in June. Roy introduced this oak in 1986, having collected it above Lijiang in the north western province of Yunnan. In October 1981, Roy collected the evergreen *Quercus longispica* from the Pi Valley, a river in Western Sichuan. Like the former, this is an evergreen.

On the Monday following the Conference Roy helped conduct a group of delegates around some of the national collection of oaks in the Sir Harold Hillier Gardens and Arboretum, including the champion *Q. rysophylla* introduced by Sir Harold Hillier from Mexico in 1978, at which time Roy had already been the Curator for some eight years. Also seen were more recent introductions from Mexico collected by Allen Coombes.

As Roy reached *Quercus balloot*, he asked who had collected it, and Shaun Haddock was on hand to own up!

There could have been no better illustration of the generosity with which Roy always shares with those around him, both his love of plants and the credit for ensuring that they are conserved for all of us to enjoy.

DIVERSITY OF IBERIAN OAKS

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Abstract

In this paper we examine the diversity of Iberian oaks on different levels. The main factor discussed is the difficult species concept in *Quercus* L. Our study addressed 11 species and their infra-specific diversity (subspecies, varieties and forms) and includes an in-depth treatment of hybrid diversity, with nearly 40 different hybrids identified. All species and subspecies are included, with information about their main characteristics, their distribution, and their ecological preferences. The final result is a complete guide to the oaks of the Iberian Peninsula, with a detailed discussion of specific and infra-specific diversity.

In order to bring the nomenclature of Iberian oaks up-to-date, the following new combinations are listed here:

***Q.* x *coutinhoi* nssp. *ferreirae* (A. Camus) F.M. Vázquez, S. Ramos & S. García, comb. et stat. nov.** (Bas.:*Q.* x *ferreirae* A. Camus, Les Chenes, 2: 406, 1938-1939.) (*Q. faginea* x *Q. robur* subsp. *estremadurensis*).
***Q.* x *coutinhoi* nssp. *subalpestris* (A.Camus) F.M. Vázquez, S. Ramos & S. García, comb. et stat. nov.** (Bas.: *Q.* x *subalpestris* A. Camus, Les Chenes 2: 412, 792, 1938-1939) (*Q. faginea* subsp. *alpestris* x *Q. robur* subsp. *estremadurensis*)
***Q. lusitanica* var. *subinclusa* (Coutinho) F.M. Vázquez, S. Ramos & S. García, comb. nov**., (Bas.: *Q. fruticosa* subvar. *subinclusa* Coutinho in Bol. Soc. Brot 6: 79, 1888).
***Q. pubescens* var. *microcarpa* (Guss.) F.M. Vázquez, S. Ramos & S. García, comb. nov.,** (Bas.: *Q. microcarpa* Guss. Fl. Sic. Syn. Ed. 2, 2: 607, 1844).
***Q. rotundifolia* var. *avellaniformis* (Colmeiro & Boutelou) F.M. Vázquez, S. Ramos & S. García, comb. nov.** (Bas.: *Q. avellaniformis* Colmeiro & Boutelo, Examen Encinas 9, 1854)
***Q. rotundifolia* var. *brevicupulata* (Laguna) F.M. Vázquez, S. Ramos & S. García, comb. et stat. nov.** (Bas.: *Q. ilex* f. *brevicupulata* Laguna in Fl. Fr. Española 1: 256, 1883).
***Q. rotundifolia* var. *macrocarpa* (Coutinho) F.M. Vázquez, S. Ramos & S. García, comb. nov.** (Bas.: *Q. ilex* var. *ballota* f. *macrocarpa* Coutinho, Bol. Soc. Brot. 6: 95, 1888)
***Q. rotundifolia* var. *pilosella* (F.M. Vázquez) F.M. Vázquez, S. Ramos & S. García, stat. nov.** (Bas.: *Q. rotundifolia* for. *pilosella* F.M. Vázquez in Semillas Quercus, 84, 1998)
***Q.* x *villariana* nssp. *clementei* (C. Vicioso) F.M. Vázquez, S. Ramos & S. García, comb. et stat. nov.** (Bas. *Q.* x *clementei* C. Vicioso, Rev. Gen. Quercus España 140-141, 1950) (*Q. faginea* subsp. *alpestris* x *Q. faginea* subsp. *broteroi*)

Key words: Distribution, Ecology, Hybrid, Infraspecific, Portugal, *Quercus*, Spain, Taxonomy.

Introduction

The Iberian Peninsula is the most western portion of the European continent, and has wide variability in climate, soils and forest types. We find pine forest in the northern and southern territory, and oak forests are widely distributed in the southern, northern, central, eastern or western parts. Species of genera such as *Tilia*, *Fraxinus*, *Ulmus*, *Celtis*, *Juglans*, *Alnus* and *Abies* are lesser components of the oak forests.

The most representative forests of the Iberian Peninsula are the oak forests, which comprise over 10 million hectares and include eleven different oak species. The habitats, diversity of landscapes, vegetation types, flora, fauna and soils are the most interesting parts of the oak forests' ecosystems.

The origin of diversity in the oak forests is associated with the wide range of oak species in these forests. We can find three or four different types of oaks within a single hectare of oak forest. We can also find within the same habitat evergreen and deciduous oaks, hybrids between oaks, shrub oaks and oak trees, and oak species that have different physiological cycles. For instance, the holm oak (*Quercus ilex*) has annual phenological cycles and two vegetative cycles, while the cork oak (*Q. suber*) has annual and biennial phenological cycles and up to three annual vegetative cycles.

The diversity of flora in these forests produces a great diversity of animals and fungi. There are more than 3000 different fungi, close to 45,000 insect species, and approximately 500 bird species in the Iberian Peninsula. But the biggest diversity is within the oak species themselves. Iberian oaks have adapted physiologically, phenologically, and reproductively, and for these reasons, oaks have developed great tolerance to environmental stress. These adaptations are the source of diversity and the basis of the origin of new varieties, subspecies, and numerous hybrids.

The objective of this paper is to show the diversity of oak taxa: species, subspecies, varieties, forms and hybrids, found in the oak forests of the Iberian Peninsula. Also, the origin of the diversity and the problems linked to some of the complex oak species, such as the *Q. pubescens* group and the *Q. faginea* group, will be discussed.

This study was based on information compiled from of the following works: Amaral, J. (1990), Battandier, J. A. & L. C. Trabut (1890), Camus, A. (1936-39), Carvahlo, J. & J. Amaral (1954), Coutinho, A. X. (1888), Llamas, F., et al. (1995), Rivas Martínez, S. & C. Saenz (1991), Vázquez, F. M. (1995), Vázquez, F. M. et al. (2000), Vázquez, F.M. et al. (2002), Vázquez, F.M. et al. (2003) and Vicioso, C. (1950); and the specific data from Forest Production Department.

Oak Species

The diversity of the oak flora of the Iberian Peninsula came about in different ways. The deciduous oaks originated during the last glaciation, when large parts of northern and central Europe were covered by ice. The recession of the ice provided an opportunity for colonization of subspecies of the common oaks, whose origins are associated with the glaciation. These include *Quercus canariensis* Willd. And *Q. robur* subsp. *estremadurensis* (O.Schwarz) A.Camus.

Other species are more typical of the Mediterranean climate, and these species are associated with the higher temperatures of the present interglacial period. They grow in warm environments, such as *Q. coccifera* L. and *Q. rotundifolia* Lam. These species are associated with the dry territories of the central, northern and southern parts of the Iberian Peninsula. Oceanic conditions are the typical habitat for species like *Q. ilex* L. The holm oak occupies areas without frost, with high environmental humidity, and with sandy soils.

The rest of the species of the Peninsula originated by combinations of different causes. The *Q. pubescens* group is a combination of microspecies that live in different conditions of the northern and central Iberian Peninsula with an unknown origin, though they are likely associated with glacial oak species which later adapted to Mediterranean conditions. As a result, the populations close to the glacial oak species are different from populations better adapted to Mediterranean conditions. This last case is similar to the origin of the *Q. faginea* group.

The species currently growing in the Iberian Peninsula are the following:

- ***Q. canariensis*** Willd.

Tree of up to 35 m, with deciduous and glabrous, large- to medium-sized leaves at maturity, with long and abundant hairs on the young leaves; laminae with lobules on their margins, and long petioles. Annual fruit with short cupules and medium-sized bitter acorns with 1 to 5 fruits per raceme, on short peduncles.

<u>Distribution and habitat:</u> Associated with the humid zones of the Mediterranean coast of Andalucia and Cataluña. This species also grows inland in the Monchique (Portugal), Sierra Morena, and Toledo Mountains. It is a species that grows in the Iberian Peninsula, Morocco and Algeria.

- ***Q. cerris*** L.

Tree of up to 22 m, with medium- to small-sized deciduous pubescent leaves, the laminae with dentate to lobuled margins and acute apexes. Biennial fruits of medium size in cupules with free bracts and bitter acorns in groups of 2-4 per raceme, with short peduncles.

<u>Distribution and habitat</u>: This species originated in central Europe, and was introduced in the XVII century close to Madrid, where it grows today in the Prado oak forest with cork oak.

- ***Q. coccifera*** L.

Shrub of up to 4 m, with populations in Arrabida (Portugal), Malaga (Spain) and the Odemira (Portugal) coast, with large specimens of up to 15 m. Evergreen species with small, glabrous leaves and laminae with prickles on the margins. Biennial fruits with large to small cupules and medium-sized acorns, normally 1 fruit per raceme, with short peduncles.

<u>Distribution and habitat</u>: This species grows in harsh conditions, with high contrasts of humidity and temperature in open areas. It is common in all areas where there is a Mediterranean influence, from the Near East to the Iberian Peninsula, but it prefers calcareous soils and a southerly exposure.

- ***Q. faginea*** Lam.

Tree of up to 27 m, with medium- to small-sized pubescent deciduous leaves, and laminae with obtuse to acute apexes of the lobules. Small to medium sized, annual fruits with short cupules and 1 to 7 fruits per raceme, on long or short peduncles.

Q. cerris L., an introduced species to the Iberian Peninsula. (© Guy Sternberg)

Distribution and habitat: *Q. faginea* grows in many different habitats where other oaks also grow. We can see *Q. faginea* in the typical habitats of *Q. pyrenaica* Willd, *Q. suber* L., *Q. rotundifolia* Lam., or *Q. lusitanica* Lam. For this reason, it is difficult to define an exclusive ecosystem for *Q. faginea*. It grows in the western Mediterranean area, in Morocco, Tunisia, Algeria, France and throughout the Iberian Peninsula.

• ***Q. ilex*** L.

Tree of up to 37 m, with medium-sized evergreen pubescent leaves and lanceolate, acute laminae with entire margins. Annual fruits with medium-sized cupules and medium-sized bitter acorns, normally with 2 to 6 fruits per raceme, with short peduncles.

Distribution and habitat: This species is found in large parts of southern Europe, in regions influenced by the Mediterranean Sea. The populations of this species prefer a temperate climate with high humidity and frost-free areas. In the Iberian Peninsula we can see it in the northern territory and the eastern coast close to the Mediterranean Sea, from Murcia to Cataluña regions.

• ***Q. petraea*** (Matt.) Liebl.

Tree of up to 30 m, with medium to large-sized, deciduous, glabrous leaves and round, obtuse apex, the laminae with lobuled margins and medium-sized petioles. Annual fruits with small- to medium-sized cupules and small- to medium-sized acorns, with 1 to 4 fruit per raceme, with long peduncles.

Distribution and habitat: *Q. petraea* grows in the northern part of the Iberian Peninsula, and is common in the Pyrenean, Cantabrian and Basque Mountains. It also grows in the central part of the Peninsula in deep valleys with constant humidity.

• ***Q. pubescens*** Willd. *nom. cons.*

Tree of up to 20 m, with medium- to small-sized, deciduous, pubescent leaves and oblong lanceolate to obovate laminae, with acute to obtuse apexes and small to incisive lobules on the margins. Annual fruits with medium- to small-sized cupules and small- to medium-sized bitter acorns, with 1 to 4 fruits per raceme, with short peduncles.

Distribution and habitat: The optimum environment for this species are the Pyrenean conditions and the protected valleys of the interior Iberian Peninsula. The main distribution areas are Cataluña, Navarra and Aragon, but we can find this species in the central and northeastern regions also.

• ***Q. pyrenaica*** Willd.

Tree of up to 28 m, with medium- to large-sized, deciduous, pubescent leaves and oblong to round obtuse laminae, with lobed to pinnate margins. Annual fruits on medium-, small- to large-sized cupules and small, medium or large, bitter acorns, with 1 to 4 fruits per raceme, with short peduncles.

Distribution and habitat: This species grows in southern France, the Iberian Peninsula, and northwest Africa, associated with small mountain areas with medium humidity and fertile soils. In the Iberian Peninsula it is frequent in the central territory associated with the Central Mountains.

• ***Q. robur*** L.

Tree of up to 37 m, with small- to medium-sized deciduous, glabrous leaves, with rounded apexes, the laminae with lobuled margins. Fruits annual with medium- to small-sized, bitter acorns, with 1 to 4 fruits per raceme, medium-sized cupules and long peduncles.

Distribution and habitat: This common oak grows in northern areas of the Iberian Peninsula, but populations can also be found in the central territory and there is an endemic subspecies confined to the southwest part of the region.

• ***Q. rotundifolia*** Lam.

Tree of up to 25 m, with medium- to small-sized evergreen, pubescent leaves, the oblong to round, obtuse laminae with entire margins. Annual fruits with a medium to large cupule and small, medium or large, sweet acorns, with 1 to 7 fruits per raceme, on short peduncles.

Distribution and habitat: This species grows in southern France, the Iberian Peninsula, and northwest Africa, associated with temperature and precipitation contrasts and indifferent to soil type. In the Iberian Peninsula, it is found in all regions and is the most common oak species there.

• ***Q. suber*** L.

Tree of up to 27 m, with medium- to small-sized evergreen leaves, glabrous to pubescent beneath, the laminae with obtuse apexes and dentate margins. Annual to biennial fruits with medium- to large-sized cupules and small, medium or large, bitter acorns, with 1 to 9 fruits per raceme, with short peduncles.

Distribution and habitat: The cork oak grows in southern France, the Iberian Peninsula and northwest Africa, associated with acid soils and moderate rainfall. In the Iberian Peninsula, it is most commonly found in the southwest.

Infraspecific Variations

Variations within species fall into two distinct categories: the subspecies concept, and the variant and form concepts. The subspecies concept is a term used to differentiate between forms of the same species resulting from populations growing in two different habitats. Typical examples are subspecies growing in coastal and continental habitats, respectively.

The variant and form types originated as a result of mutation and a plastic genotype. The oak species have many small variations in habitats (edaphic, climatic, geological).

The variations of the subspecies concept are constant characteristics, whereas the characteristics of variant and form are variable. The largest diversity is in taxa variants and forms, creating great problems with nomenclatue and taxonomy.

Iberian Oak Subspecies

The Iberian oaks that have subspecies are listed below:

• ***Q. coccifera*** L.

This species has two subspecies: *Q. coccifera* subsp. *coccifera* and *Q. coccifera* subsp. *calliprinos* (Webb) Holmboe. We can segregate these two subspecies by means of leaf characteristics. *Q. coccifera* subsp. *coccifera* is a shrub of up to 4 m and has glabrous leaves and petioles, whereas *Q. coccifera* subsp. *calliprinos* is a tree of up to 15 m, and the petioles and leaf bases have hairs. *Q. coccifera* subsp. *coccifera* lives in areas with widely varying temperature and frost conditions, while *Q. coccifera* subsp. *calliprinos* lives in frost-free areas and in valleys near the coast.

- ***Q. faginea*** Lam.

In *Q. faginea* we can see three different subspecies differing in leaf morphology. The three subspecies are *Q. faginea* subsp. *faginea*, *Q. faginea* subsp. *broteroi* (Coutinho) A. Camus and *Q. faginea* subsp. *alpestris* (Boiss.) A. Camus. The differences between the subspecies are the following: *Q. faginea* subsp. *faginea* is characterised by the presence of subglabrous leaves and short laminae with obtuse apexes. *Q. faginea* subsp. *broteroi* has medium to large sized, pubescent leaves with obtuse apexes; whereas *Q. faginea* subsp. *alpestris* has medium-sized pubescent leaves with acute apexes of the laminae.

Q. faginea subsp. *faginea* grows throughout the Iberian Peninsula; *Q. faginea* subsp. *broteroi* grows in the southern and central Iberian Peninsula; and *Q. faginea* subsp. *alpestris* is distributed in southern Iberia.

Q. faginea, a native oak of the Iberian Peninsula. (© Guy Sternberg)

- ***Q. petraea*** (Matt.) Liebl.

The subspecies of *Q. petraea* are *Q. petraea* subsp. *petraea* and *Q. petraea* subsp. *huguetiana* Franco & G. López. These two subspecies have different leaf characteristics. *Q. petraea* subsp. *petraea* has short leaves with 2-5 pairs of lobules and medium-sized leaves up to 20-cm long, whereas *Q. petraea* subsp. *huguetiana* has leaves up to 30-cm long with 4-9 pairs of lobules.

The typical habitat of *Q. petraea* subsp. *petraea* are the valleys of the northern and central regions of the Iberian Peninsula, while *Q. petraea* subsp. *huguetiana* grows in the deep valleys of the northeastern regions of the Iberian Peninsula.

• ***Q. pubescens*** Willd.

In the Iberian Peninsula we find see three different taxa of the *Q. pubescens* group: *Q. cerrioides* Willk. & Costa, *Q. subpyrenaica* Huguet del Villar, and *Q. lanuginosa* (Lam.) Thuill. The nomenclature and taxonomic considerations are complex in this group and we can regard the taxa as species, subspecies, or variants of *Q. pubescens* Willd.

It is difficult to distinguish between the three taxa because they frequently form hybrids and differentiation is possible only in pure populations. *Q. cerrioides* has small, short-pubescent leaves with obtuse lobules; *Q. lanuginosa* has medium sized, long-pubescent leaves with obtuse lobules; and *Q. subpyrenaica* has large to medium sized, glabrous to pubescent leaves with acute lobules. The *Q. pubescens* group grows in the northern Iberian Peninsula; there is also a small population in central Iberia.

• ***Q. robur*** L.

There are three different subspecies of *Q. robur*: *Q. robur* subsp. *robur*, *Q. robur* subsp. *broteroana* O. Schwarz, and *Q. robur* subsp. *estremadurensis* (O. Schwarz) A. Camus. The three subspecies can be distinguished by their leaves. The leaves of the typical subspecies (*Q. robur* subsp. *robur*) are short with 2-5 pairs of obtuse lobules which are glabrous. *Q. robur* subsp. *broteroana* has leaves with 3-7 pairs of obtuse lobules and with dispersed hairs on the abaxial surface. *Q. robur* subsp. *estremadurensis* has leaves with 3-7 pairs of acute lobules and the abaxial and adaxial surfaces have hairs.

The habitat of *Q. robur* subsp. *robur* is the Eurosiberian region of the northern Iberian Peninsula. *Q. robur* subsp. *broteroana* grows in the northern and central regions of the Peninsula, and *Q. robur* subsp. *estremadurensis* grows in the southwestern part of Peninsula, in deep valleys with constant humidity and temperature.

Varieties and Forms of Iberian Oaks

The greatest taxonomic difficulty is differentiating between variety and form in *Quercus* L. We prefer to associate the term "variety" with variations associated with consistent characteristics such as size or form of the fruits, whereas inconsistent characteristics are referred to as "form category" and include the size or morphology of the leaves.

When the acorns are small, taxa often bear the epithet "microcarpa" or "microbalanus", like *Q. pubescens* var. *microcarpa* (Guss.) F.M. Vázquez, S. Ramos & S. García or *Q. robur* var. *microbalanos* (Heuff.) Schur. At other times we can see large acorns and the epithets used for these taxa are often "macrocarpa" or "macrobalanus", such as *Q. rotundifolia* var. *macrocarpa* (Coutinho) F.M. Vázquez, S. Ramos & S. García, or *Q. faginea* var. *macrobalanus* A. Camus.

When acorns have small cupules, the taxa are often given epithet "brevicupulata", such as: *Q. coccifera* var. *brevicupulata* Batt. & Trabut or *Q. rotundifolia* var. *brevicupulata* (Laguna) F.M. Vázquez, S. Ramos & S. García. Another situation is when the acorns are included inside the cupules. In these instances, the taxa often carry epithets "subinclusa" or "avellaniformis" such as: *Q. lusitanica* var. *subinclusa* (Coutinho) F.M. Vázquez, S. Ramos & S. García or *Q. rotundifolia* var. *avellaniformis* (Colmeiro & Boutelou) F.M. Vázquez, S. Ramos & S. García.

Inflorescences often differ between the individuals within the same population, and the character is constant. In these cases we can see different groupings of the fruits in the tree associated with the female inflorescence. The epithet applied to these taxa is often "racemosa", such as *Q. suber* var. *racemosa* Borzi. And finally, we sometimes see pubescent acorns. In this case the epithet can be "pilosa", such as *Q. rotundifolia* var. *pilosella* (F.M. Vázquez) F.M. Vázquez, S. Ramos & S. García.

Variations associated with leaf morphology are often given the rank of forma. Within the group of the these forms we can see species with pinnate leaves receiving the epithet "pinnatifida", such as *Q. pyrenaica* f. *pinnatifida* O. Schwarz or *Q. pyrenaica* f. *pinnatipartita* (Sennen) C. Vicioso. Others may have large leaves such as *Q. suber* f. *macrophylla* (Coutinho) F.M. Vázquez, S. Ramos & S. García.

Apart from variations associated with leaves, flowers and acorns, we can find variations in other organs such as the branches or the wood. Specimens exist with pendulous branches such as *Q. rotundifolia* f. *pendula* (Batt. & Trabut) Luebbert (Bas.: *Q. ilex* var. *pendula* Batt. & Trab., Fl. Algerie 825, 1888-1890). On other occasions, it is possible to find specimens with cork in the wood such as *Q. faginea* f. *subsuberosa* (Coutinho) Luebbert (Bas.: *Q. lusitanica* f. *subsuberosa* Coutinho, Bol. Soc. Brot. 6: 68,1988).

Hybrid Diversity

The most important source of diversity in the Iberian oaks results from combinations between different species. The ease with which different species, subspecies or varieties hybridize causes the greatest problems in identification and characterization of taxa within *Quercus*.

Along with hybridization, it is necessary to include the combinations between hybrids and their parents. The final result is a large group of combinations with intermediate characteristics between the hybrids and their parents. This creates a large problem with little possibility of finding a solution.

In this paper we offer information on the diversity of Iberian oak hybrids that are listed below under their parent species:

Hybrids of ***Q. canariensis*** Willd.

Q. x *carrisoana* A. Camus (*Q. canariensis* x *Q. robur* subsp. *estremadurensis*)
Q. x *fontqueri* O. Schwarz (*Q. canariensis* x *Q. pyrenaica*)
Q. x *jahandiezii* A.Camus (*Q. canariensis* x *Q. faginea* subsp. *alpestris*)
Q. x *jahandiezii* nssp. *viciosoi* Rivas Martínez & Sáenz (*Q. canariensis* var. *mirbeckii* x *Q. faginea*)
Q. x *lagunai* Luebbert (*Q. canariensis* x *Q. lusitanica*)
Q. x *marianica* C. Vicioso (*Q. canariensis* x *Q. faginea* subsp. *broteroi*)
Q. x *paui* C. Vicioso (*Q. canariensis* x *Q. pubescens* x *Q. pyrenaica*)
Q. x *subglaucescens* A. Camus (*Q. canariensis* x *Q. pubescens* subsp. *subpyrenaica*)

Q. x *viveri* Sennen (*Q. canariensis* x *Q. petraea* subsp. *huguetiana*)

Hybrids of ***Q. cerris*** L.
Q. x *hispanica* Lam. (*Q. cerris* x *Q. suber*)

Hybrids of ***Q. coccifera*** L.
Q. x *airensis* Franco & Vasc. (*Q. coccifera* x *Q. rotundifolia*)
Q. x *auzandrii* Gren & Godr. (*Q. coccifera* x *Q. ilex*)
Q. x *battandieri* Trabut (*Q. coccifera* x *Q. faginea* subsp. *broteroi*)

Hybrids of ***Q. ilex*** L.
Q. x *albescens* Rouy (*Q. ilex* x *Q. pubescens*)
Q. x *autumnalis* Vázquez, F.M., S. Ramos & E. Doncel (*Q. ilex* x *Q. rotundifolia*)
Q. x *auzandrii* Gren & Godr. (*Q. coccifera* x *Q. ilex*)
Q. x *morisii* Borzi (*Q. ilex* x *Q. suber*)
Q. x *turneri* Willd. (*Q. ilex* x *Q. robur*)

Hybrids of ***Q. faginea*** Lam.
Q. x *allorgeana* A. Camus (*Q. faginea* x *Q. pubescens* subsp. *subpyrenaica*)
Q. x *battandieri* Trabut (*Q. coccifera* x *Q. faginea* subsp. *broteroi*)
Q. x *coutinhoi* nssp. *duriensis* Vasc. & Franco (*Q. faginea* var. *salicifolia* x *Q. robur*)
Q. x *coutinhoi* nssp. *ferreirae* (A. Camus) F.M. Vázquez, S. Ramos & S. García (*Q. faginea* x *Q. robur* subsp. *estremadurensis*)
Q. x *coutinhoi* nssp. *subalpestris* (A.Camus) F.M. Vázquez, S. Ramos & S. García (*Q. faginea* subsp. *alpestris* x *Q. robur* subsp. *estremadurensis*)
Q. x *coutinhoi* Samp. (*Q. faginea* x *Q. robur*)
Q. x *jahandiezii* A.Camus (*Q. canariensis* x *Q. faginea* subsp. *alpestris*)
Q. x *jahandiezii* nssp. *viciosoi* Rivas Martínez & Sáenz (*Q. canariensis* var. *mirbeckii* x *Q. faginea*)
Q. x *marianica* C. Vicioso (*Q. canariensis* x *Q. faginea* subsp. *broteroi*)
Q. x *numantina* (*Q. faginea* x *Q. pyrenaica*)
Q. x *numantina* nssp. *neomairei* (Coutinho) Luebbert (*Q. faginea* subsp. *broteroi* x *Q. pyrenaica*)
Q. x *numantina* nssp. *transmontana* (Coutinho) Luebbert (*Q. faginea* subsp. *alpestris* x *Q. pyrenaica*)
Q. x *pacensis* F.M. Vázquez (*Q. faginea* subsp. *broteroi* x *Q. suber*)
Q. x *salcedoi* C. Vicioso (*Q. faginea* x *Q. petraea* subsp. *huguetiana*)
Q. x *senneniana* A. Camus (*Q. faginea* x *Q. rotundifolia*)
Q. x *senneniana* nssp. *tentudaicus* F.M. Vázquez (*Q. faginea* subsp. *broteroi* x *Q. rotundifolia*)
Q. x *tingitana* A. Camus (*Q. faginea* subsp. *alpestris* x *Q. lusitanica*)
Q. x *villariana* A. Camus (*Q. faginea* subsp. *faginea* x *Q. faginea* subsp. *alpestris*)
Q. x *villariana* nssp. *clementei* (C. Vicioso) F.M. Vázquez, S. Ramos & S. García (*Q. faginea* subsp. *alpestris* x *Q. faginea* subsp. *broteroi*)

Hybrids of ***Q. lusitanica*** Lam.
Q. x *celtica* Vázquez, F.M., A.J. Coombes, M. Rodríguez, S. Ramos & E. Doncel (*Q. lusitanica* x *Q. suber*)
Q. x gallaeica Penas, Llama s & A. Acedo (*Q. lusitanica* x *Q. robur*)

Q. x *lagunai* Luebbert (*Q. canariensis* x *Q. lusitanica*)
Q. x *tingitana* A. Camus (*Q. faginea* subsp. *alpestris* x *Q. lusitanica*)

Hybrid of ***Q. petraea*** (Matt.) Liebl.
Q. x *cantabrica* Vicioso (*Q. petraea* x *Q. pyrenaica* x *Q. robur* subsp. *broteroana*)
Q. x *rosacea* nssp. *secalliana* (C. Vicioso) Rivas Martínez & Sánez (*Q. petraea* x *Q. robur* subsp. *broteroana*)
Q. x *rosacea* O. Schwarz (*Q. petraea* x *Q. robur*)
Q. x *salcedoi* C. Vicioso (*Q. faginea* x *Q. petraea* subsp. *huguetiana*)
Q. x *streimii* Hueffel (*Q. petraea* x *Q. pubescens*)
Q. x *streimii* nssp. *costae* (C. Vicioso) Luebbert (*Q. cerrioides* x *Q. petraea* subsp. *huguetiana*)
Q. x *subglaucescens* A. Camus (*Q. canariensis* x *Q. pubescens* subsp. *subpyrenaica*)
Q. x *trabutii* Hy (*Q. petraea* x *Q. pyrenaica*)
Q. x *trabutii* nssp. *legionensis* (O. Schwarz) Sáenz (*Q. petraea* subsp. *huguetiana* x *Q. pyrenaica*)
Q. x *viveri* Sennen (*Q. canariensis* x *Q. petraea* subsp. *huguetiana*)

Hybris of ***Q. pubescens*** Willd.
Q. x *albescens* Rouy (*Q. ilex* x *Q. pubescens*)
Q. x *allorgeana* A. Camus (*Q. faginea* x *Q. pubescens* subsp. *subpyrenaica*)
Q. x *firmurensis* Hy (*Q. pubescens* subsp. *lanuginosa* x *Q. pyrenaica*)
Q. x *kerneri* nssp. *montserratii* (C.Vicioso) Rivas Martinez & Saenz (*Q. pubescens* subsp. *subpyrenaica* x *Q. robur*)
Q. x *paui* C.Vicioso (*Q. canariensis* x *Q. pubescens* x *Q. pyrenaica*)
Q. x *streimii* nssp. *costae* (C. Vicioso) Luebbert (*Q. cerrioides* x *Q. petraea* subsp. *huguetiana*)
Q. x *subglaucescens* A. Camus (*Q. canariensis* x *Q. pubescens* subsp. *subpyrenaica*)

Hybrid of ***Q. pyrenaica*** Willd.
Q. x *andegavensis* Hy (*Q. pyrenaica* x *Q. robur*)
Q. x *andegavensis* nssp. *henriquensii* (Franco & Vasc.)Rivas Martínez & Sáenz (*Q. pyrenaica* x *Q. robur* subsp. *broteroana*)
Q. x *cantabrica* Vicioso (*Q. petraea* x *Q. pyrenaica* x *Q. robur* subsp. *broteroana*)
Q. x *diosdadoi* Vázquez F.M., A.J. Coombes, M. Rodríguez, S. Ramos & E. Doncel (*Q. pyrenaica* x *Q. rotundifolia*)
Q. x *firmurensis* Hy (*Q. pubescens* subsp. *lanuginosa* x *Q. pyrenaica*)
Q. x *fontqueri* O. Schwarz (*Q. canariensis* x *Q. pyrenaica*)
Q. x *numantina* nssp. *neomairei* (Coutinho) Luebbert (*Q. faginea* subsp. *broteroi* x *Q. pyrenaica*)
Q. x *numantina* nssp. *transmontana* (Coutinho) Luebbert (*Q. faginea* subsp. *alpestris* x *Q. pyrenaica*)
Q. x *paui* C.Vicioso (*Q. canariensis* x *Q. pubescens* x *Q. pyrenaica*)
Q. x *streimii* Hueffel (*Q. petraea* x *Q. pyrenaica*)
Q. x *trabutii* Hy (*Q. petraea* x *Q. pyrenaica*)
Q. x *trabutii* nssp. *legionensis* (O. Schwarz) Sáenz (*Q. petraea* subsp. *huguetiana* x *Q. pyrenaica*)

Hybrids of ***Q. robur*** L.
Q. x *andegavensis* Hy (*Q. pyrenaica* x *Q. robur*)
Q. x *andegavensis* nssp. *henriquensii* (Franco & Vasc.) Rivas Martínez & Sáenz (*Q. pyrenaica* x *Q. robur* subsp. *broteroana*)
Q. x *cantabrica* Vicioso (*Q. petraea* x *Q. pyrenaica* x *Q. robur* subsp. *broteroana*)
Q. x *carrisoana* A. Camus (*Q. canariensis* x *Q. robur* subsp. *estremadurensis*)
Q. x *coutinhoi* nssp. *duriensis* Vasc. & Franco (*Q. faginea* var. *salicifolia* x *Q. robur*)
Q. x *coutinhoi* nssp. *ferreirae* (A. Camus) F.M. Vázquez, S. Ramos & S. García (*Q. faginea* x *Q. robur* subsp. *estremadurensis*)
Q. x *coutinhoi* nssp. *subalpestris* (A.Camus) F.M. Vázquez, S. Ramos & S. García (*Q. faginea* subsp. *alpestris* x *Q. robur* subsp. *estremadurensis*)
Q. x *coutinhoi* Samp. (*Q. faginea* x *Q. robur*)
Q. x gallaeica Penas, Llama s & A. Acedo (*Q. lusitanica* x *Q. robur*)
Q. x *kerneri* nssp. *montserratii* (C.Vicioso) Rivas Martinez & Saenz (*Q. pubescens* subsp. *subpyrenaica* x *Q. robur*)
Q. x *rosacea* nssp. *secalliana* (C. Vicioso) Rivas Martínez & Sáenz (*Q. petraea* x *Q. robur* subsp. *broteroana*)
Q. x *rosacea* O. Schwarz (*Q. petraea* x *Q. robur*)
Q. x *turneri* Willd. (*Q. ilex* x *Q. robur*)

Hybrids of ***Q. rotundifolia*** Lam.
Q. x *airensis* Franco & Vasc. (*Q. coccifera* x *Q. rotundifolia*)
Q. x *autumnalis* Vázquez, F.M., S. Ramos & E. Doncel (*Q. ilex* x *Q. rotundifolia*)
Q. x *diosdadoi* Vázquez, F.M., A.J. Coombes, M. Rodríguez, S. Ramos & E. Doncel (*Q. pyrenaica* x *Q. rotundifolia*)
Q. x *mixta* Villalobos (*Q. rotundifolia* x *Q. suber*)
Q. x *senneniana* A. Camus (*Q. faginea* x *Q. rotundifolia*)
Q. x *senneniana* nssp. *tentudaica* F.M. Vázquez (*Q. faginea* subsp. *broteroi* x *Q. rotundifolia*)

Hybrids of ***Q. suber*** L.
Q. x *celtica* Vázquez F.M., A.J. Coombes, M. Rodríguez, S. Ramos & E. Doncel (*Q. lusitanica* x *Q. suber*)
Q. x *hispanica* Lam. (*Q. cerris* x *Q. suber*)
Q. x *mixta* Villalobos (*Q. rotundifolia* x *Q. suber*)
Q. x *morisii* Borzi (*Q. ilex* x *Q. suber*)
Q. x *pacensis* Vázquez F.M. (*Q. faginea* subsp. *broteroi* x *Q. suber*)

The greatest diversity of oak hybrids is in deciduous species, with the most significant number of hybrids for *Q. faginea*, probably resulting from the wide range of habitats occupied by this species and the great diversity of subspecies. There is also a great amount of hybridization for *Q. robur*, *Q. petraea* and *Q. pubescens* in northern Iberia. On the other hand, the evergreen species have the most specific habitats and reproductive success is more specific in time and space.

Conclusions

In conclusion, the diversity of oaks in the Iberian Peninsula can be reduced to two levels associated to adaptation models for taxa. Within this concept we can introduce the diversity of species, subspecies, varieties and forms, with more than 50 different Iberian oak taxa. In the second level, associated with the competition between species for habitats, we introduced the concept of hybrid diversity of Iberian oaks, with close to 40 hybrids. The most significant conclusion is that there is great diversity of oaks in the Iberian Penninsula, with close to 100 different oak taxa.

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HISTORICAL INFORMATION AND THE STATE OF OAK COLLECTIONS IN FRANCE

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Introduction

As in a good number of European countries, the oak has played, and continues to play, an important role in both historic and cultural realms. It is interesting to note that it is also one of the ubiquitous elements in the landscapes of this continent, both in the Temperate and Mediterranean zones. Apart from their presence in forests—an indispensable resource for multiple uses—oaks have been present for centuries in the gardens and botanical collections of Europe, both public and private.

The 19th century was the "Golden Age" of Botany; this treatise will evoke the place of the genus *Quercus* in the collections of a single country, France, which has also mobilized its scientists and dedicated amateurs for the development of Botany and the enrichment of its collections.

Historical public and private collections

Segrez

More than all other collections, the first to offer so many taxa—some still rare in arboreta and botanic gardens—was that of Segrez, in the village of Saint Sulpice de Favières, in the Department of Essonne. This site is actually the former arboretum of Alphonse Lavallée, the great dendrologist and French collector. He was a relative of the de Vilmorin family, which we shall refer to in the lines that follow. The arboretum is still a private holding and belongs today to the Picard family, which descends from Alphonse Lavallée.

The garden is situated on alluvial terrain well supplied with water on a west-facing slope.

This collection, first begun in 1856, was in its day one of the richest in the world; before its almost total destruction in World War II, it comprised nearly 6,800 taxa. Even if this number must be reduced to conform with the latest taxonomic revisions, it still compares favorably with the count of 2700 at the National Arboretum of Barres.

Many first introductions for France were made at Segrez, especially for Mexican species, some of which are still not under cultivation elsewhere in France, for example *Quercus xalapensis* and *Q. skinneri.* During the past 20 years a major enrichment effort has been carried out at Segrez, especially in oaks, including the Mexican species *Q. rysophylla* introduced in 1997; the specimen is already 8-m tall. Still to be found in the arboretum are several historical items such as a superb ancient specimen of *Q. robur fastigiata,* with a notable columnar habit, which is not particularly the case with older subjects. Also present at Segrez are hybrids more than a 100 years old, as well as other unidentified oaks of the same age.

The Jardin des Plantes of the Museum d'Histoire Naturelle de Paris

This botanic garden contains specimens which are at once ancient, and also of both botanic and historical value. Of note are the following 4 species:

Fig. 1. Stephane Brame with *Q. haas* at the Museum d'Histoire Naturelle de Paris (© Thierry Lamant)

Q. haas. Brought from Turkey in 1855 by Balansa, it is the first representative of its species planted in France. It is 121 cm in diameter. It is located near the buildings belonging to the gardening services and can be visited with permission. According to taxonomists, this taxon is associated with *Q. robur* ssp. *robur*. (Figure 1).

Q. infectoria. This is the oldest specimen of this taxon in France, planted in 1850. It is located on a lawn belonging to a private apartment building, behind a grill facing the previously cited *Q. haas*. It appears to be in decline, judging from its rather sparse crown.

Q. ithaburensis ssp. *macrolepis*. This tree was planted by Desfontaines in 1814. In its time, the acorn cups of this species were used for the production of tannin that was formerly used in England and Italy for tanning goat skins ("de luxe leather"). It can be seen in the part of the garden not open to the public north of the Botany School and its systematic garden. Its health is very good. Its spectacular acorns are frequently devoured by crows, often well before they can be observed.

Q. macrocarpa. This tree was planted in 1811 from acorns sent from the United States by Francois-André Michaux. It is a very large individual that exceeds a meter in diameter, with a wide crown (not measured, so no comment is possible). It produces acorns rarely, only when the spring and summer are hot. It is located at the foot of the labyrinth and appears to be healthy.

The arboreta of the de Vilmorin family: Verrières and Les Barres.

Located in the Department of Essonne, in the city of Verrières le Buisson, this garden is one of three arboreta created by the Vilmorin family, famous as grain merchants, botanists, and foresters. Created by Philippe-André de Vilmorin in 1815, it comprises 2.85 hectares; the soil appears to consist of a clay alluvium.

One immediately encounters here a *Q. wislizeni* that is 7.5-m tall; this individual was heavily shaded at some time, and as a consequence, it exhibits lopsided growth. Its diameter is 30 cm. Not far from this tree is a *Q. agrifolia*, also a native of California; it measures approximately 15 m in height and 43 cm in diameter. Until the spring of 2003, this tree was labeled as *Quercus* x *turneri*.

Opposite these trees and situated near the buildings of the family quarters is found a remarkable *Q. calliprinos* (labeled *Q. coccifera*, the species with which the former is associated today); the tree is in fine shape and measures 14 m in height and 38 cm in diameter. It is clearly an arborescent form, corresponding to the eastern populations of the kermes shrub oak of our *garrigues* (coastal scrub).

This arboretum is still the property of the de Vilmorin family. The most famous site of the de Vilmorin family is of course the present day Arboretum National des Barres, located in the village of Nogent sur Vernisson, in the eastern part of the Department of Loiret. It is directed by the ENGREF (Ecole Nationale du Génie Rural des Eaux et des Forêts). A property of approximately 280 hectares acquired in 1821 by Philippe-André de Vilmorin, about 40 hectares are dedicated here to the botanical collection. The first arboretum specimens were planted in 1870. Prior to that, P. A. de Vilmorin had planted different species of pines and oaks (notably *Q. rubra*), with the intention of testing the performance on varying substrates of individuals of a single species from various geographic origins. (The diversity of the soils of this property, from acid sands to the calcareous soils of Beauce was one the principal motivations for the choice of the site.) He was thus the first in the world to feature the notion of forest provenance, a fundamental principle today in reforestation. One can safely assert that P. A. de Vilmorin is the father of modern forest genetics. Numerous oaks are present on the site (83 botanical taxa and 18 cultivars and hybrids), of which the most outstanding are detailed below:

In the *Fruticetum Vilmorinianum* created in 1894 by Maurice-Lévêque de Vilmorin, are found the majority of the great botanical riches of Les Barres. Dedicated to shrubs, few trees are present. One of the exceptions is an oak, and not the least noteworthy, since it is the first living specimen of *Quercus* x *vilmoriniana*, the result of the artificial hybridization of *Q. dentata* with *Q. petraea*. This specimen dates from 1894. Two other trees, younger and relatively stressed by competition, are present in the section called the "Champ des Vignes" ("The Vineyard"), a continuation of the systematic collection called "Les Nouvelles Pelouses" ("The New Greens"). This hybrid, formerly vigorous but now suffering from a setback in February of 2003, has never been impacted by a neighboring tree. The tips of its crown, showing severe die back (the tree is under attack by *Collybia fusipes*, a root rot), are somewhat reduced. Its ultimate dimensions were 10 m in height, 89 cm in diameter, with a crown of 14 m. It still fruits fairly regularly, but the seed are usually hybrid, the result of pollen from large *Q. petraea* trees not far away.

Turning toward the west, one passes a geological transition on a break in the slope, reaching a collection of rather old oaks. Here is found one of the jewels of the site, also in decline, the one and only *Q. gracilis* outside of China. The history of this tree is particularly interesting and moving. It comes from a lot of acorns collected by Father Paul Farges himself, at Heoupin, near Chenkou in eastern Sichuan (western China), at 1400-m altitude. The acorns were received March 3, 1901. This oak belongs to the subgenus *Cyclobalanopsis*, which is to say, to the oaks of the Far East with lanceolate, evergreen leaves and cupules adorned with concentric circles.

Its identification was long a subject of controversy: designated at first as *Q. vibrayeana* (which is in effect a synonym of *Q. glauca*), until August, 1998, it was called *Q. oxyodon*, a tree otherwise known in England, even though the appearance of its leaves, still more dentate, was rather different. It wasn't until the visit of professor Zhekun Zhou of the botanical garden of Kunming that the name *Q. oxyodon* was dropped; this change was confirmed the same day by Allen Coombes, a specialist in the *Fagaceae* from Hillier Gardens in Great Britain, who was also present at the time. It turned out to be *Q. liboensis*, known only from a natural reserve in Kweichow. All would have been well, except that after the appearance of the new flora of China in 2001, *Q. liboensis* has *Q. gracilis* as a synonym and valid name! The tree has almost never fruited since its planting in 1903, except for some acorns harvested in 1944 and probably at other times before 1950, but it did fruit three times between 1995 and 2001. This graceful oak has survived every winter, even the harshest. Today it measures 10 m in height and 23 cm in diameter, with 10 m of breadth. (Figure 2).

The other great rarity from the genus *Quercus* present at Les Barres is a species that is common in central China: *Q. baronii*, a tree with semi-evergreen leaves similar to *Q. cerris*. This is, however, the only tree of this species present in any European collection. It originated from acorns furnished by the de Vilmorin family to the family arboretum of Verrières. Planted between 1922 and 1924 near more vigorous species, it is overshadowed, but in good health; its trunk is short and its crown lopsided (27 cm in diameter by 7-m wide, its height affected by the presence of nearby trees). It began to fruit in 1998, but the two acorns that were observed dropped during the season when they were first set.

One of the trees that towers over it is a *Q. petraea* "Mespilifolia" (16-m high, 70 cm in diameter, 16-m wide), a grafted plant donated in 1930 by the Hillier Arboretum. In the same meadow can be admired a beautiful *Q. aliena* var. *aliena*, 15-m high, 48 cm in diameter, 16-m wide. This tree, planted in 1929, comes from acorns collected and provided by the Belgian botanist Hers (seed registered under the number 2785). Not far away is a large *Q. kelloggii*, dying but nevertheless imposing (80 cm in diameter against 20-m high). It comes from acorns sent by the U.S. Forest Service in 1926.

Still farther west, in the area known as the "Champ des Vignes" ("The Vineyard"), is an old *Q. trojana* (16-m tall, 28 cm in diameter and 7-m wide), in competition with other trees for almost its entire life. A little bit farther on is a *Quercus* x *libanerris* (an artificial hybrid between *Q. cerris* and *Q. libani*), planted in 1935, originally from Nancy in eastern France. It stands among other sexually mature specimens that it has now surpassed (it is 19 m in height, 54 cm in diameter and 10-m wide).

Figure 2. *Q. liboensis* in Arboretum National des Barres (© Thierry Lamant)

Let us now leave systematic collections to go on to geographic collections. The Asiatic arboretum, dedicated to its founder Leon Pardé, was established between 1919 and 1934. In a section surrounded by the buildings of the forestry school is the first known specimen of *Quercus* x *hickelii* (a hybrid between *Q. petraea* and *Q. pontica*). It was planted in 1922 and is presently 12-m high with a breadth of 9 m. It consists of three trunks separating fairly close to the ground. On instructions from Raymond Durand, who was responsible for the collections during the 80's and 90's, its root system was protected during the construction of the buildings that surround it. In fact, the other trees and bushes of this sector were moved to other locations.

The two other trees belong to a species from North Africa: *Q. afares*, mistakenly affiliated with *Q. castaneifolia*, which is actually from Iran. One was planted in 1929 and the other two years later; these two trees show almost equivalent growth since they measure 18 and 20 m in height, respectively, and 86 and 79 cm in diameter, while each is 20-m wide. Along with the specimen in Angers, these are probably the most beautiful specimens in Europe.

This is not the end of the evergreen oaks, since we can observe a *Q. phillyreoides*, with widely extended branches, in the shade of a *Q. macranthera*. This shrub was planted in 1932 and its growth has always been slow, due, no doubt, to too much shade, since it measures today only 9 m in height with an equal breadth; it has several trunks of which the largest measures 16 cm in diameter. This oak shows much more vigorous growth in full light and turns out to be perfectly hardy, having survived the cold of the winters of 1985 and 1986 with temperatures of –20 C. It could serve as an excellent alternative to cypress hedges, since in Japan it is in fact often cultivated as a pruned hedge.

A few dozen meters from it are two very old individuals of *Q. myrsinifolia*, planted in 1931 (10 m in height against 25 cm in diameter), struggling as best they can against the omnipresent *Collybia fusipes*.

Let us stay in the exclusively Asiatic subgenus *Cyclobalanopsis* by going to the Arboretum Gouet, established in 1870, and which offers for the most part American and circum Mediterranean species. In fact, in the shade of the largest tree in the arboretum, a *Sequoia sempervirens* at least 46 m in height, we spy a beautiful *Q. glauca*, in good condition and planted in 1936 from acorns sent from Tokyo. Its dimensions (11-m high, 25 cm in diameter and 9 m breadth) are commendable for a tree that has grown up in a climate that is very different from that of the subtropical region of which it is native. Its recent history is surprising, since it fruited for the first time in 1997 and has done so regularly since. Why did this happen? Is its entry into relatively good light after the disappearance of a population of centenarian *Pinus nigra* ssp. *laricio* that shaded it responsible for its late fertility? No one can say.

In the park of the château, a building constructed in 1894, is found a grove of *Q. frainetto*, one of which is branched rather low, forming a vast, round, spreading, crown; it measures 20-m high, 140 cm in diameter and 26-m wide. This oak of east-central Europe has become one of the preferred species in the new urban spaces of France. The trees planted today are nevertheless genetically almost identical because they derive from grafts.

Finally, we cannot leave Les Barres without reference to an exceptional population of *Q. ilicifolia*, a shrub red oak native to the North East of the United States. At the time of his visit in 1996, Guy Sternberg, at that time President of the International Oak Society, was astonished at the size of some of the specimens not pruned or trimmed regularly. The most beautiful of them measures 6.5 m in height, 22 cm in diameter, and 5-m wide. This population of one half hectare was established in 1828. It is still in existence, in good health, and fairly regular in producing important quantities of acorns much appreciated by the local wildlife.

The National Arboretum of Les Barres very nearly disappeared during World War II, as was the case with most of the trees in the Segrez Arboretum. It was the appeal of Jean Pourtet, a colleague of the director of the arboretum in 1940 (Marcel Paillie), to the president of the German Dendrological Society, through his adjunct von Magdeburg, who saved the trees at the beginning of the assault on them. In effect, a cavalry unit had taken over the chateau built by M. L. de Vilmorin. Von Magdeburg had visited Les Barres in 1937 and at that time he edited an article in a special revue. Considering the appeal legitimate, he transmitted it to the person in charge of this dendrological society, who was none other than Herman Goering, a key figure in the Third Reich. Goering issued an order to the soldiers to clear out of the area, which was done the sixth of December 1940.

The National Arboretum of Les Barres is unquestionably one of the richest historical collections of the genus *Quercus* in France. As we have seen, a certain number of these historical trees are very frail today. However, a major renewal effort initiated in 1985 and reinforced in 1994 has made this arboretum an official collection specializing in the genus *Quercus*. It is the responsibility of the Comité des Collections Végétales Spécialisées (D.C.V.S) (Committee for Special Plant Collections); it was visited notably during the World Forestry Congress and the Symposium on Oaks in 1991.

The Arboretum Gaston Allard (called De La Maulévrie) at Angers

This municipal arboretum includes several attractive features with respect to the genus that interests us presently. It was created by Gaston Allard in 1863 in the town of Angers. The first part visited is that reserved for botanists and plant professionals. To be found there is a collection of various cultivars of *Q. ilex*, including *Q. ilex* "Microphylla". This form obviously has very small leaves (mostly 1 to 1.5 cm in length against 0.6-0.9 cm in width), the blade with an entire edge finely endowed with teeth at its distal end. Its growth rate is slower than other members of the species.

In a sheltered part of the arboretum, in the company of a superb *Arbutus andrachne*, is found a *Q. suber*, remarkable for this region, whose foliage shades the sidewalk at the other side of the arboretum fence. This tree is very remarkable from the point of view of its geographic situation. Despite the renowned climate of "mild Anjou," Gaston Allard planted this tree on the west side in order to avoid exposure to the lowest temperatures, which eliminated other specimens of this species during the cold winters of 1956 and especially, 1985/1986. Its dimensions are completely respectable (80 cm in diameter and 15 m breadth).

Not far from there is found the crown jewel of the oaks in the arboretum: a giant *Quercus* x *schochiana* (a natural hybrid between *Q. palustris* and *Q. phellos*). This tree has required crown reduction, performed by qualified professional tree trimmers, because its circular crown also overspreads the nearby sidewalk and the street that parallels it, as is the case with the *Q. suber* referred to above. The dimensions of this mighty hybrid (fruiting at Angers) speak for themselves: 35 m in height, 143 cm in diameter, with a spread of 30 m.

Bordering this part of the arboretum, open to the public with special authorization, are other specimens of *Q. ilex*, among which reigns an enormous sexually mature *Q. phellos* (25-m high, 120 cm in diameter, 30-m breadth). It is to be noted that for many of the trees here, even the gymnosperms, the trees were planted high, not being fully inserted into the soil, so that the upper part of the root system is exposed. This technique is a sort of "trademark" of Gaston Allard.

In this same sector is a very handsome *Q. haas*, associated taxonomically today with *Q. robur* (the acorns are much larger in circumference in its natural state), as well as a *Q. castaneifolia* 115 cm in diameter. Many of the trees in this part of the arboretum show serious signs of decline connected with their great age as collection specimens. Among the younger specimens is found a *Q. mongolica* with a light exfoliating bark. In this country this species is often of mediocre appearance.

There has existed here since 1875 a remarkable row of *Q. frainetto* alternating with *Q. palustris*. The most impressive *Q. frainetto* has the following measurements: 25 m in height against 110 cm in diameter. The crown, constrained by the other trees in the row, was not measured due to its small size. In the same row, other taxa are found at the ends, one of which, a *Q. afares,* is particularly impressive (140 cm in diameter).

Several Remarkable Ancient Specimens Located in Different Gardens

The Arboretum of the Vallée aux Loups is located in the city of Châtenay-Malabry. An old garden in the English style of the l8th century, it was created in 1890 by the nurseryman Gustave Croux with the aid of landscape architects Deny and Marcel. It comprises 13 hectares with soil varying in pH between 6.8 and 7; the soil is alluvial with a phreatic layer very close to ground level. It is the responsibility of the Conseil Général des Hauts de Seine. It is by no means an arboretum dominated by *Quercus,* but one tree by itself justifies a visit to this wooded place. At issue is an exceptional example of *Q. myrsinifolia*, the largest in France. It is consists of six trunks separating very low, measuring respectively 24, 28, 30, 33, 50, and 59 cm in diameter. Its height is 17 m and its spread an imposing 14 m! It was supposedly planted in 1895. The tree was unfortunately subjected to a bout of very questionable pruning while its health was still satisfactory. Although it showed some signs of recovery, it is now in decline. A rise in the water table, perhaps aggravated the stress caused by the questionable elimination of a portion of its superstructure, which strongly illuminated a crown that was initially very dark. (Figure 3).

Older specimens belonging to the subgenus *Cyclobalanopsis* are rare in France and often of inferior dimensions, with the exception of the sumptuous *Q. glauca* of the town of Anduze. In the private garden of Gard, well known for its collection of bamboos, are three beautiful fruiting specimens (there are seedlings at the foot of the tree!): the first measures 18 m in height, 70 cm in diameter, and 10 m in breadth, a second which hardly differs in breadth (12 m) and a third which has reached 20.5 m in height, 0.85 meter in diameter and 15 m of breadth! They were very probably planted between 1860 and 1870.

Also worthy of mention is the magnificent Himalayan *Q. leucotricophora* in The Jardin des Serres de la Madone in the town of Menton, Department of Alpes Maritimes; planted between 1930 and 1940, it measures today 16 m in height, 45 cm in diameter and 8 m in breadth; the latter is due to the fact that it is wedged between two trees. Also in this sumptuous garden created by Major

Figure 3. *Q. myrsinifolia* in the Arbortum of the Vallée aux Loups
(© Thierry Lamant)

Lawrence Johnston, a Briton who had previously created the Hidcote gardens in England, are two specimens of *Q. canariensis,* known in North Africa as "chene zeen" ("zeen oak"). This garden was begun in 1924.

Present day public and private collections

Old sites previously mentioned continue today to grow richer in *Quercus*. This is true of the Arboretum National des Barres, but also of the other national arboretum, that of Chèvreloup. It is also the case for the arboretum of Villa Thuret in the city of Antibes in the Department of Alpes-Maritimes.

In the last mentioned garden, best known for its conifers (an exhaustive collection of the genus *Cupressus*) and its palms, have been planted species of

Mexican oaks beginning in the 1990's. The oldest specimen is a *Q. sartorii* planted in 1970; it measures 3.2 m in height. The largest are *Q. polymorpha* planted in 1994, and *Q. mexicana*, both measuring 4.8 m in height. Also to be found here are two other specimens of *Q. polymorpha* (respectively 4 and 4.2 m in height), as well as *Q. acutifolia* (3.5 m) and *Q. affinis* (4 m), both planted in 1995 (although the second during the spring), *Q. laeta* (2.8 m) and the inevitable *Q. rysophylla*, planted in 1994, measuring 3 m in height in the summer of 2003. This site is administered by I.N.R.A (Institut National pour la Recherche Agronomique—The National Institute for Agricultural Research).

The increase in knowledge about Mexico, and the possibilities for plant exploration in that vast country, the richest in the world for the genus *Quercus* (between 125 and 160 taxa), have permitted these oaks to be planted in numerous collections, both public and private. Thus it is that at Les Barres three specimens of *Q. sartorii* have been planted, a very vigorous Mexican species, which have easily survived the winters since they were planted in 1997. These plants come from acorns collected in 1995 in the state of Puebla, in southeastern Mexico, at 1805 m of altitude; they were collected by the Coombes, Coggeshall, Nixon & Sternberg expedition.

Figure 4. Shaun Haddock and his *Q. eugeniifolia* in his Arboretum of La Beryerette (© Thierry Lamant)

Since 1983 the collection of Les Barres, known as the Champ des Vignes (the Vineyard), initially constituted as plantings in forest style (*Thuja plicata, Abies grandis)* has been regularly replaced every year down to the present with young oaks of various origins, with American species dominating. Found here are *Q. buckleyi* (planted in 1996), *Q. berberidifolia* (planted in 1999), and *Q. georgiana*, among others.

The National Arboretum of Chèvreloup, directed by the Museum National d'Histoire Naturelle de Paris (National Museum of Natural History of Paris), borders the Chateau of Versailles. It has an area of 200 hectares. The soil is light, alluvial, and deep; the pH is between 6.5 and 8. It possesses several old specimens (*Q. variabilis* and *Q. shumardii* in particular, planted between 1924 and 1940), but among the most recent introductions are the most important national specimens of *Q. myrtifolia* and above all, of the very rare *Q. hinckleyi*, planted in 1977. This accession is native to several small, very hot, dry, calcareous sites in southwestern Texas and northeastern Mexico.

Q. rugosa, the most widespread species in Mexico, is also present in the Southwest of the United States, and occurs as far south as the mountains of Guatemala. On the subject of this species, it is interesting to note that two specimens are in the park of the university campus of Saint Martin d'Hères, in the Grenoble outskirts in the Department of Isère. One of these is of fruiting age. The largest one measures 9-m high, 34 cm in diameter and 8-m wide. As for the second, it measures 5 m in height, 18 cm in diameter, and 4 m- wide.

Before going through the new private collections, I should conclude the public arboreta with that of the Centre hélio-marin (Solar-Marine Center) of the city of Vallauris in the Department of Alpes-Maritimes. This small arboretum was created in 1991 and consists of two hectares, to be extended by four hectares. Created by Yves Chalamel, an employee of the Center, and directed by a non-profit society, this hilly site possesses the largest contemporary collection of xerophilic oaks in France, lodged in a *Quercetum* inaugurated in November 2002. In 2003 the collection counted 160 taxa, with numerous oaks from California, Texas, New Mexico and in particular of course, Mexico itself.

Largely since the 1980's, numerous private collections have been established or expanded; these frequently belong to members of the APBF (Association des Parcs Botaniques de France (Association of French Botanical Parks) and even to the International Oak Society. The collections that follow are examples of these.

The arboretum "Chocha" in the Basque village of Ustaritz

This is a private collection located in Department of Pyrénées Atlantiques. The exceptional climate of the Basque Country with its moderate winter temperatures and mild weather the rest of the year, combined with an unbelievable moisture regime (1800 mm per annum!), has permitted the establishment of rare species native to the Far East, but also to Central America (Mexico, Costa Rica). The proprietor, Michel Duhart, made his first plantings on a hilly site of 3.5 hectares in 1975. The soil consists of schists, more or less covered by a clay mantle, with an acid pH (around 6). At the present time it includes 130 species of the genus *Quercus* alone.

The first oak that we encounter here is a *Q. bicolor*. This species is not rare but it is frequently puny in this country. This tree requires a moist soil as well as precipitation. In this garden the clay retains the water; since dry periods are rare, the species looks very good indeed. Beside it is a fine example of the California oak *Q. agrifolia,* from an acorn received from Kew Gardens in 1981, planted in 1982. It has a height of 9 m, a diameter of 40.1 cm, and a spread of 10 m. But the best example of growth is, without doubt, a sexually mature *Q. texana* planted in 1987. Its dimensions are 18 m in height, a spread of 10 m, and a diameter of ...35 cm!

This garden also harbors numerous Mexican species, including a sexually mature *Q. rysophylla*! The growth of this tree is particularly strong. Planted in 1992, it is today 12-m tall by 6-m wide, with a diameter of 22 cm. Also here is a young and vigorous *Q. sartorii*. Unfortunately it was impossible to observe the acorns of this tree, which do not mature and drop before having attained their optimal size.

The other oaks of this part of the world are recent plantings. *Q. pilarius* died from the effects of the past winter, but we were able to see the following oaks with the greatest of interest and even surprise: *Q. peduncularis, Q. acutifolia, Q. planipocula, Q. affinis, Q. lancifolia,* and *Q. oleoides,* as well as other species reputed to be more fragile, for the moment in containers and destined to pass several winters in a cold greenhouse. Examples of these are *Q. strombocarpa* and the remarkable *Q. insignis*, whose acorns—the largest in the genus—can measure 7 cm in diameter.

Figure 5. *Q. obtusata*, Arboretum la Bergerette (© Thierry Lamant)

Asiatic oaks are not neglected either. There are two very vigorous specimens of *Q. gilva* that show the remarkable golden tomentum on their young shoots. To be seen also are a young *Q. schottkyana*, as well as a *Q. franchetii* (with the reverse of the leaves a pure white), *Q. acuta* (3-m high) with lush, dark foliage, *Q. monimotricha* (with a base at least a meter wide when adult), and *Q. sessilifolia* and *Q. leucotricophora*. A specimen collected in Yunnan belonging, as does *Q. gilva*, to the sub-genus *Cyclobalanopsis*, could well be *Q. oxyodon*. However, it needs to grow some more in order to confirm this determination.

The Arboretum of La Bergerette in the village of Saint Sardos

This other great oak collection is also situated in the southwest of France, more precisely near the village of Saint Sardos to the southwest of the city of Montauban, in the Department of Tarn et Garonne. This arboretum belongs to Shaun Haddock, a British subject. This passionate amateur is an airline pilot and it is in connection with his professional activity around the world that he has been able to discover numerous species of oaks and to devote himself particularly to them.

The arboretum is composed of three distinct parts. To begin with, one flat sector is composed of a charming garden with different mass plantings of shrubs (*Cistus* sp.), conifers (several beautiful examples of *Pinus coulteri* and of *Pinus muricata)*, as well as some xerophilic shrub oaks. The soil in this part of the garden is more or less dry and sandy on the surface. Here are some beautiful examples of *Q. pacifica*, which he collected on the island of Santa Cruz off shore from Los Angeles in 1997 at the time of the Second International Oak Conference. Next are the first bushes of *Q. baloot* from a wild Afghan source, as well as a very beautiful bush *Q. berberidifolia.* The specimens of *Q. durata* are not doing well and have only the leaves of the present season. It is possible that the pH, which is rather acid here, may be the cause of this.

Next comes the oak collection properly speaking; it is situated on a slope with a northeast exposure. Thick alluvial soil characterizes this planting. The oaks are arranged geographically and we will begin our visit with the Mexican oaks. Very rare in collections and poorly known in Europe, they are presently objects of an infatuation that is very justified in view of their important diversity. (Figure 4)

The most remarkable specimens are the following: *Q. eugeniifolia*, a tropical oak which has never undergone winter or spring frosts, *Q. microphylla*, a shrubby species from semi-arid places, *Q. affinis* and *Q. acutifolia*, both especially vigorous with very lush foliage, as well as *Q. acherdophylla* and *Q. crassipes,* both of whose growth yields little to the preceding species. *Q. laeta, Q. rugosa, Q. polymorpha* are also thriving; two specimens of *Q. obtusata* are particularly arresting because of the white color of the tomentum on the new leaves, which reinforces their beauty. (Figure 5)

Here also is a very beautiful *Q. rysophylla*, situated at the bottom of the slope, showing how promising this oak is for European collections and gardens. Finally, as in the case of *Q. eugeniifolia*, a young *Q. laurina* represents a first introduction into France.

All in all, the growth of these oaks, almost all planted in 1996, is staggering. The heat, the fertility of the soils, and the water supply (a stream flows through the middle of the site), have all made it possible to achieve these results. Only *Q. liebmannii* shows poor adaptation to local conditions with its only modest attainment. Among the species that have perished because of winter cold are *Q. lancifolia, Q. planipocula, Q. salicifolia* and rather curiously, *Q. uxoris* and *Q. sartorii* (during the winter of 2002-2003).

Also found at this site is a collection of European, American, and Asiatic oaks. The later group includes the first *Q. hondae* introduced in France; it suffered during the scortching heat of 2003. Here too is a promising *Q. dolicholepis. Q. schottkyana* and, above all, *Q. franchetii* are also to be noted. The later measures 3.5 m in height and is believed to be the largest specimen now growing in France.

This garden also possesses the most beautiful specimen presently in this country of *Q. floribunda*, a native of the Himalayas planted the first of May 1995. It is 4-m tall. Introductions in the future of Turkish and American (Texas, New Mexico) species will enrich this garden in the next few years.

The Arboretum of Les Coulées in the village of Trélazé (Department of Maine et Loire)

This collection is the work of Michel Angeard, now retired, who divides his time between his trees and his numerous artistic endeavors (painting, sculpture). The first plantings were done in 1977. Today there are 200 oak taxa, of which the majority of pure species are American; there are also a number of cultivars, mostly European. The garden includes 20 hectares and the soil is acid (pH 5.5). Among the noteworthy taxa are *Q. rugosa, Q. graciliformis, Q.*

rysophylla and a very unusual *Q. macranthera* "fastigiata" planted in 1987. Its dimensions are as follows: 14 m in height, 25 cm in diameter, and 6 m spread.

The oak collections of Stéphane Brame

The oak plantations of this founding member of the IOS are situated in three different places in France. A recently acquired parcel in the Department of Lot, with chalky soil, is destined for future plantings of xerophilic taxa able to tolerate elevated pH levels. Another is located in the Paris region, in the Department of Seine et Marne in the village of Villeneuve le Comte. This is in fact essentially a nursery intended to supply the two provincial collections. Nevertheless it contains a beautiful specimen of *Q. tomentella*, a rare oak endemic to the Channel Islands of California, famous for its lack of hardiness.

The third and main collection of Stéphane Brame is found in the village of Latronche, in the Department of Corrèze. The climate there is harsh (we are not far from the Plateau of Millevaches), well watered (1300 to 1500 mm annual precipitation), and located on an acid, porous substrate of granitic origin. It is very interesting to note here the hardiness of the Texas oak *Q. graciliformis* (4-m high), *Q. durifolia*, native to northern Mexico, and even *Q. agrifolia* (also 4-m tall)!

A collection of shrubby oaks in the Paris region

The collection of Olivier Colin is in a small garden in the eastern outskirts of Paris, in the city of Villemomble, Department of Seine Saint Denis. Here one encounters a young collection of shrubby oaks such as the American species *Q. pacifica* (with the same origin as mentioned earlier), the Mexican species *Q. glabrescens and Q. microphylla*, and the Asian species *Q. senescens, Q. rehderiana,* and *Q. spinosa*, all rare in collections.

The two nicest specimens in this garden are a *Q. acuta* (the only taxon in this garden which by its nature is destined to become rather big), in very good health, measuring 5 m in height and on the way to fruiting in 2003. Here also is what should be the most beautiful specimen in France of *Q. alnifolia*, 1.8-m tall. This oak, endemic to Cyprus, is characterized by the golden yellow reverse of its leaves.

Speaking for myself, I have planted in the southwest of the Department of Cantal and in the Department of Loiret, several different species of oaks of which certain ones have shown a perfectly respectable performance, both in growth and hardiness; examples are the Texas oaks *Q. gravesii* (5-m tall in 5 years) and *Q. graciliformis* (4 m in height in 5 years); both of these are in the Loiret. In Cantal, at 600 m of altitude, I have a California oak, *Q. john-tuckeri*, that has survived negative temperatures on several occasions (-7.3 degrees C, the lowest average temperature for three consecutive weeks). In Loiret, an individual of this species has even endured—without batting an eye, so to speak— -6 and -7 degrees C the same week in April 2003, even though the buds had begun to open two weeks earlier. Its bluish semi-evergreen foliage makes it an interesting shrub for small gardens.

Conclusions

We need to take note of the generation gap between the oaks of French arboreta and gardens planted before the Second World War (often even before the

First World War) and after the 1980's. That decade marks a renewal of botanical collections in France, or at least a renewed interest in plant collections. That is fortunate for future generations because the majority of the old oak specimens are showing major health problems and will soon pass away. At the present time many plant collections, including oaks, are being planted, especially after the hurricanes at the end of the last century. The popularity of oaks is again topical today, coinciding with numerous taxonomic studies and the improvement of ecological knowledge.

Moreover, because of the great diversity within the genus, from both morphological and ecological points of view, oaks constitute a unique genus among temperate woody plants; for this reason they offer characteristics that make them indispensable for ornamental use.

At the present time North American species are very much in vogue, thanks to very wide commercial distribution and to good knowledge of their behavior under cultivation. On the same continent, the Mexican species offer today an immense potential that is only now beginning to be studied. Turkey and southwest China also harbor very attractive taxa, but they are less known and more difficult to acquire from nurserymen specializing in collecting. This is especially true of the Asiatic oaks. In this connection, dendrological associations (in particular the International Oak Society and closer to us, the Association des Parcs Botaniques de France) are playing a major role in the renewal of arboreta and the variety of taxa planted and particularly at the level of the diffusion of knowledge through publications depending heavily on field observations.

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Note: The following reference was used in the preparation of this manuscript:

1993 Delmas-Trolliet, M. Les arbres historiques du Jardin des Plantes. Paris: Publications of the Museum.

Also, all measurements were taken at the end of autumn, 2002 or the beginning of spring, 2003.

OAKS IN BRITISH AND IRISH FOLKLORE

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Introduction

My interest in plant folklore is primarily concerned with recent material. I'm more concerned about what people do or believe today, than vague records in ancient manuscripts. Rather than speculating about and trying to understand the works of long-dead authors, I prefer to collect from people who are still alive.

The British Isles have only two native species of oak, sessile oak (*Quercus petraea*) and pedunculate oak (*Q. robur*). Obviously the English names for these species are invented "book" names, rather than names which are in everyday use by non-botanists. This suggests, quite rightly, that most people do not distinguish between the two species, both of which are known simply as "oak." So when we consider oak folklore, we can treat both *Q. petraea* and *Q. robur* as one species.

Although the oak tree is an unofficial emblem of England (for example, it appears as a "national" plant, equivalent to flax, leek, and thistle on Pound coins), and was adopted in 1990 as the national tree of the Republic of Ireland, it is not the focus of a great deal of folklore. Even the selection of pedunculate oak as Ireland's national tree seems to have been a bit haphazard. Apparently the Irish had a stand at a horticultural show in Osaka, Japan, for which they needed a national tree, so they hurriedly adopted the oak (Nelson, 1993). Oak lore concentrates around five themes: weather, the wearing of oak on Oak Apple Day (29 May), legends concerning individual trees, the commemoration of victims of road accidents, and folk medicine.

Oaks and Weather

Versions of the weather-rhyme, by which the emergence of oak and ash (*Fraxinus excelsior* in the UK) leaves foretell weather conditions, are widespread, but their interpretation can cause confusion. In the early 1960s an elderly estate worker who used to visit my parents' farm in west Dorset would recite: "If the oak is out before the ash, we shall surely have a splash." Then he would scratch his head and remark, "but there's another way of saying that: if the ash is out before the oak, we shall surely have a soak." He believed that both rhymes implied wet summers. However, it seems to be generally agreed that if ash produces leaves before oak, the summer will be wet.

According to a correspondent from Ballycastle, County Antrim, Northern Ireland: "If the oak before the ash, then we'll only have a splash; if the ash before the oak, then we'll surely have a soak" (personal communication, 1991). Similarly, in a letter from Enmore, Somerset, published in *The Times* of 20 March 1990, it was recorded that in that part of England it was said: "Oak before ash – splash; Ash before oak – soak.." Finally, in the *Daily Telegraph* of 27 June 1987, a correspondent from Marnull, Dorset, wrote: "If oak and ash leaves show together, us may fear some awful weather; this be a sight but seldom seen, that could remind we what has been."

(Editor's note: The common traditional wording in North America is: "If oak is out before the ash, 'twill be a summer of wet and splash; if ash is out before the oak, 'twill be a summer of fire and smoke.")

Many popular publications on plant folklore mention that oak was used to protect homes against lightning. Usually it is claimed that the bobbins on old-fashioned window blinds were turned in this shape to protect the home from lightning. I've never found this convincing, but Margaret Baker, who was born in 1926, records in her *Discovering the Folklore of Plants* (1996): "In a Sussex cottage, where the writer stayed as a child, oak twigs and oak apples and acorns stood in a spill jar on the mantelpiece, summer and winter, against lightning."

29 May was known as Oak Apple Day, or Royal Oak Apple Day, and commemorated the restoration of the monarchy in 1660, when King Charles II triumphantly entered London. Charles II is probably best remembered for the way in which he evaded capture after the battle of Worcester by hiding in an oak tree at Boscobel. At one time Charles II considered setting up a new order of chivalry, the Knights of the Royal Oak, but the project was abandoned, being thought likely "to keep awake animosities which it was part of wisdom to lull to sleep" (Yallop, 1984).

In the 1760s the Oak Boys, a group of Protestant agrarian rioters active in Ulster, wore oak sprigs in their hats, presumably to demonstrate their loyalty to the British monarchy (Nelson, 1993). On a journey through the Black Country on 29 May 1883, Charlotte Burne, an indefatigable collector of folklore, noted that railway engines, sheds, and signal boxes were decorated with oak boughs.

Well into the 2Oth Century oak leaves and, if possible, oak apples, were worn on 29 May. In areas where oaks were scarce, field maple (*Acer campestre*) was used as a substitute. Writing of Devon, where oaks are plentiful, in the late 19th Century, Hilderic Friend (1882) recorded: "I have been astonished to find how constantly the maple is called oak. On Whit-Monday, which this year was Oak-Apple Day as well (May - 29th), I took an early walk into Bradley Woods. Here I met a number of children decorated with maple, and asked them what it was for. "It's Oak-Apple Day sir; and if you ain't got a piece of oak-apple they'll pinch you, or sting you." " Will they?" I replied, "Then I must get a piece." "Here's a piece, sir" said a bright lad. It was a sprig of maple, as were all the rest they had. I said, "This is not oak, is it?" to which they replied, "It's oak-apple, sir." I could give illustrations from conversations with grown people showing the same error.

However, in most areas, oak twigs were worn. Thus, a correspondent writing from Church Gresley, Staffordshire to the *Daily Mirror* of 1 November 1973 recalled: "When I went to school, 60-odd years ago, there was one day we used to call 'Oak Ball Day'. We were supposed to wear an oak leaf or oak ball on our coats and if we didn't, the other kids used to attack us with stinging nettles."

Other examples from my own experience include:

During my childhood in East Cowes, Isle of Wight, in the 1920s and 30s on Oak Apple Day (29 May), we would wear a sprig for luck. An oak apple made you even luckier.

My grandmother, born in Adlington, Cheshire, in 1873, sent me to school wearing oak leaves on 29 May on at least one occasion in about 1946.

My mother, now 83, lived in Hinton St George, Somerset as a child. On Oak Apple Day she remembers the children all had a day off school, and went round singing "It's Oak Apple Day, Oak Apple Day, if you don't give us a holiday, we'll all run away" (pers. comm., 1990).

Local names for Oak Apple Day included Shick-Shack Day in Dorset, Gloucestershire, Oxfordshire and Surrey; Yak Bob day in High Furness, Cumbria; and Oak-and-Nettle Day in Northamptonshire.

In their *Lore & Language of Schoolchildren* (1959), Iona & Peter Opie recorded: "Although the number of places where the day is remembered is dwindling, in parts of the north country, especially in Cumberland, Westmorland, Furness, and the North Riding, and also quite commonly in the north Midlands in a broad belt stretching from Shrewsbury to the Walsh, children continue to commemorate old loyalty.

I have been unable to find any records of oak leaves being used spontaneously by children, or anyone else, on Oak Apple Day. Charles' escapade seems to be best remembered by the large number of "Royal Oak" pubs which are still scattered around the country.

The oak apples worn on Oak Apple Day were not the hard globular "marble" galls which are often known as oak apples today, but the larger, less regular, spongy galls which rapidly develop on oak trees in May and mature in June or July. The wasp responsible for the smaller, marble-sized galls were deliberately introduced from the Middle East to Devon in about 1830, so that its galls could be used as a source of tannic acid for use in dyeing cloth and making ink (Darlington and Hirons, 1975).

In some places the use of oak sprigs on Oak Apple Day has become more formalized. At the Royal Hospital, Chelsea, oak sprigs are worn by the pensioners and their guests on Founder's Day, which is held on, or near, 29 May each year. As the grounds of the Royal Hospital host the annual Chelsea Flower Show, which takes place in late May, the Founder's Parade has to fit in around the Show, so it is now usually held on the first Thursday in June, rather than on 29 May. The Royal Hospital was founded by Charles II in 1682 as a home for old soldiers, and the Founder's Day parade, at which a member of the Royal Family or a high-ranking army officer takes the salute, is often said to have been held without break since 1692. However, according to other sources, the Parade was first held in 1817. In addition to oak being worn by participants, the Grinling Gibbons statue of Charles II in the Hospital's Figure Court is decked with oak branches (Brentnall, 1975). According to a report in the *Sunday Times* of 29 May 1949, the pensioners were also provided with "extra rations, including Christmas pudding, decked (with) sprigs of oak instead of holly."

No doubt the Founder's Day celebrations have changed over the years, and it is not known when oak was first used on Founder's Day. The Curator of the Royal Hospital's Museum claims to have no archives relating to the history of the event. However, in a photograph of the 1921 event (anon, no date), the statue is shown concealed in oak, but the marching pensioners do not appear to be wearing oak sprigs; so, presumably, the wearing of oak is a 20th Century innovation. (Figure 1)

Throughout the 20th Century the statue was completely covered in oak branches, but in 2002 the statue's gilding was renewed to commemorate the Golden Jubilee of Queen Elizabeth II, and recent photographs of Founder's Day show the statue naked with oak branches placed around its plinth. Other places decorated with oak on 29 June include Worcester Guildhall and a statue of King Charles in Northampton (Hole, 1976).

Elsewhere, oak branches are hoisted to the top of church towers on Oak Apple Day. At Castleton, in the Derbyshire Peak District, a garland ceremony

MARCH PAST, FOUNDER'S DAY, 1921.

Figure 1. The Founder's Day March past Royal Hospital, Chelsea, 1921, showing to left, statue of King Charles II covered in oak boughs, from anon., The Royal Hospital, n.d.

takes place on 29 May. For this, the church tower is" decorated with branches of greenery (usually oak), and sometimes the children dance back through the village (from the church) and all the parents who have ever taken part in the ceremony dance behind wearing oak sprays" (Lester, 1972).

In Cornwall, an oak branch is still placed on the top of the tower of the parish church of St. Neot on Oak Apple Day. St. Neot was a royalist parish during the Civil War. The oak bough is always supplied by Lampen Farm. The bough is hoisted up the outside of the tower. When in place, the vicar says prayers for the Royal Family and for the government of the day, and closes with the Lord's Prayer and a blessing. In addition, the St. Neot Women's Institute holds an Oak Apple Day fair (Vickery, 1995).

In the early 1990s the environmental organization Common Ground actively promoted Oak Apple Day with a card: "Revive an ancient festival – wear the oak on the 29th of May."

A strange custom, not directly associated with the Restoration, takes place at Great Wishford, in Wiltshire, on 29 May. This event is connected with the maintenance of wood-gathering rights in Groveley Forest and reenacts the requirements of a 1603 charter. Early in the morning (at 3 a.m.) local young men pass through the village making "rough music" and go to the forest to cut the oak branches needed for later in the day. Some of these branches are used to decorate houses in the village, and one large branch, known as the Marriage Bough, is decorated with ribbons and hauled to the top of the church tower, where it is said to ensure good luck for all those who are married in the church during the following year. Later in the morning, villagers go to Salisbury Cathedral where, in a ceremony revived in 1951, four village women dressed in early-Twentieth Century clothes and carrying small oak branches dance in the nave. On completion of the dance they and other villagers stand in front of the altar and shout "Groveley, Groveley, Groveley, and all Groveley." On leaving the Cathedral, the dance is performed again outside for the benefit of tourists before the villagers return home for a procession around the village and a ceremonial lunch (Frampton, 1992).

Significant Individual Oaks

Oaks are relatively long-lived trees and can attain (by British standards) a massive size. So it is, perhaps, inevitable that some individual trees have become the focus of legends. Gospel Oaks still exist is some localities, or more usually are remembered as place names. Most of these trees are said to mark spots where the Gospel was read during beating-the-bounds ceremonies, during which the boundaries of a parish were walked on Rogation Day – the Sunday before Ascension Day.

Other Gospel Oaks commemorate the preaching of a particular missionary, the most famous of these probably being a tree which stood near the church at Polstead, Essex. According to Laurence Harley (1988): "Tradition gives the Gospel Oak an age of over 1300 years, attributing its earliest use to the Saxon missionaries led by Bishop Cedd in the mid-Seventh Century." However, what was supposed to be the original tree collapsed in 1953, but it has been replaced by a young tree "which may presumed self-sown from the now dead tree." Since 1910, or possibly earlier, an annual service – the Gospel Oak Service – has been held beside the oak tree on the first Sunday in August. Music is provided by the local Salvation Army band, and there is a guest preacher. In the 1990s a congregation of 70 or more was expected. According to a 1958 press report the Service was at that time held beneath a sycamore tree which did duty while "a sapling grown from an acorn of the ancient tree is slowly growing to maturity."

An oak tree at High Ercall, in Shropshire, is said to be the only Gospel Oak in the county. This tree was used as a preaching site for Methodists from early in the 19th Century until about 1855. The local landowner forbade Methodists to hold services in their homes, and there was no land available for them to build their chapel, so they held open-air services under an oak tree (Morton, 1986).

In areas of Wales where Nonconformists were strong, Gospel Oaks were known as Preaching Oaks. Thus, in Cardiganshire: "Two of the best remaining Preaching Oaks are sessiles (*Quercus petraea*), one at Tanyralltuchaf near Tregaron, 432 cm in girth, under which William Williams of Pantycelyn preached in about 1744, and the other at Llywynrhydowen, 495 cm in girth, under which David Davies of Castell Hywel is said to have been ordained in 1733 (pers. comm., 2003).

The Major Oak in Sherwood Forest (see Palmer, 2003) got its name from a local antiquary – Major Hayman Rooke – who described the tree in 1790. It is popularly associated with the outlaw Robin Hood and his merry men, who are said to have hatched their projects for the distribution of wealth beneath its branches. According to J.C. Holt in his *Robin Hood*, published in 1982, the age of this tree is difficult to estimate, but it is not thought to be older than the Sixteenth

Century. Today Robin Hood is usually considered to be a totally fictional character, but the earliest rhymes which mention him date from the 1370s, well before the tree apparently existed.

Although the Major Oak is now one of the centres of Robin Hood tourist commerce, according to Holt it is part of Sherwood Forest "which owes its prominence and all its supposed detailed associations with legend to romantic interest in Robin Hood which developed in the 19th Century." Despite the Major Oak's rather weak links with the outlaw, its current decrepitude is causing concern. In The *Times* of 8 August 1989 it was reported that: "Leaning wearily on a stockade of pit-props, clasped by an iron collar, scorched by vandals' attempts to bum it down, and bound together with makeshift braces and stays, the 800-year-old tree is so decrepit that Nottingham County is seriously concerned about its possible disappearance."

On 30 August 1990 *The Times* reported that the Major Oak was "being drenched daily in thousands of gallons of water because of fears that during the hot, dry weather it could be destroyed by fire or drought." Later, on 4 January 2001, it was reported that "the rotting wooden struts on the hollow tree are being replaced by steel supports, thanks to £25,000 from the Global Environmental Community Trust." In the meantime, Nottingham County Council paid Micropropagation Services of East Leake to produce clones of the tree, expecting them to produce up to 100 a year, to be sold at £300 each.

The oak tree in which King Charles is said to have hidden after the Battles of Worcester in 1651 can still be seen in the grounds of Boscobel House in Shropshire. However, there is some doubt whether this is the original tree or a younger one that has replaced it. According to Weaver (1987): "Immediately the

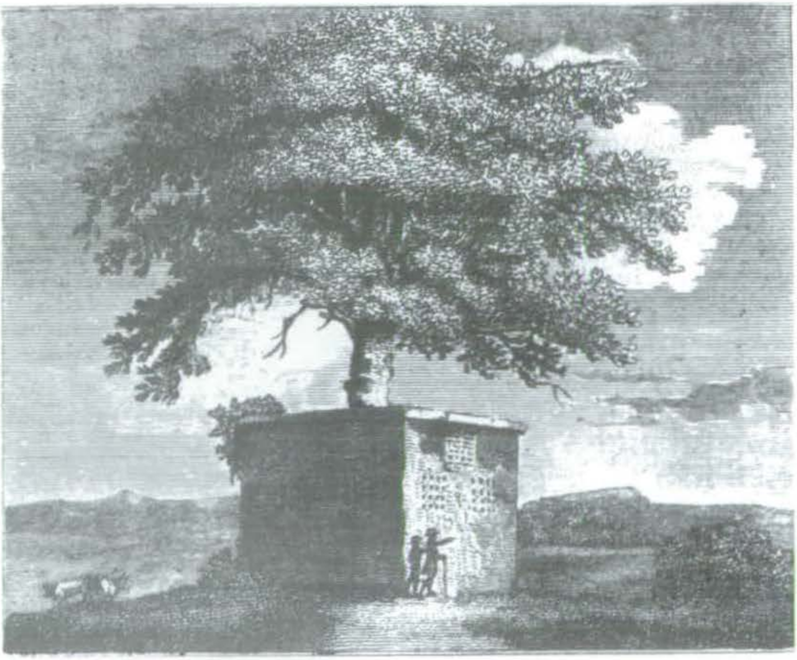

Figure 2. Engraving of the Boscobel Oak, from the Gentleman's Magazine (1809).

story of Boscobel became known people flocked to see the house and the oak, and almost at once the tree was injured by souvenir hunters removing its young boughs. The damage was so great that before 1680 the owners of Boscobel ... were forced to crop part of the tree and protect it with a high brick wall (Figure 2). In 1706 John Evelyn wrote that he had heard that the "Famous Oak near White Ladies" had been killed by people hacking the boughs and bark, and six years later William Stukeley described the tree as "almost cut away by travelers." He also remarked that "a young thriving plant from one of its acorns" was growing close by the side.

It appears that the custom of growing acorns from the Boscobel tree was popular and persistent.. At one time there were two oak trees in St James's Park, London, which were reputed to have been grown from Boscobel acorns and planted by King Charles himself (Weaver, 1987). In November 1982 the environmentalist David Bellamy planted an oak which has supposedly grown from a Boscobel acorn in the grounds of the Natural History Museum in South Kensington, London, to celebrate National Tree Week.

A cork oak (*Quercus suber*) tree which grows at Combe-in-Teignhead in south Devon is said to be over 350 years old and, it is claimed, has "surrounded itself with a strange power to bring good luck to those observing certain rituals" dating back to the time of the Great Plague of London in 1665. At that time, people came from all parts of the country to walk around the tree three times and, as they walked, to make a wish. As its powers became more widely known, many

Figure 3. Combe-in-Teignhead 'wishing' cork oak greetings card, as sold in 1988

people suffering from ill health and unable to make the journey to south Devon wrote asking for a piece of the lucky cork in order that they might walk round it three times in their own home. Today greetings cards which contain fragments of cork from the tree are available, should anyone want them (Figure 3).

In 1962 an oak stump at a road junction in the town of Carmarthen caused concern. This tree was associated with the legendary prophet Merlin, first mentioned in 1136 in Geoffrey of Monmouth's *History of the Kings of Britain.* It was said that Merlin had prophesied that when this "oak shall tumble down, then will fall Carmarthen town." But the Ministry of Transport considered it to be a dangerous obstruction *(The Times,* 16 August 1962). The stump was removed and is now preserved in a local museum.

Oaks Commemorating Victims

In 1992, when the charity RoadPeace was formed, the clergy of Coventry Cathedral became aware of the need to help people bereaved and disabled through road crashes and created a service to meet their situation. They invited all affected by road accidents to put forward names to be read out during the service as an act of remembrance. The names were written on oak leaves (not on real leaves, but on paper leaves about twice the size of real leaves) and upon leaving the cathedral people were given acorns as symbols of continuing life.

According to RoadPeace, oak was chosen for the service because it was "a symbol of strength and permanence." In recent years, European Day of Remembrance for Road Traffic Victims is held on the third Sunday in November, and in 2003 RoadPeace expected about 30 services to be held.

Oaks and Folk Medicine

Oak was occasionally used in folk medicine. For example, in the collections of the Irish Folklore Commission's Schools Survey, conducted in 1937 and 1938, it was recorded from County Offaly, that for ringworm one should get six leaves from an oak tree, boil them, and drink the water in which they were boiled. In County Donegal, oak bark was commonly used as a cure for sore shoulders in horses. The bark was boiled and the sores washed in the water. In Suffolk in the 1920s Mark Taylor recorded that a cure for diarrhea was to grate an acorn into warm milk and give it to the patient (Vickery, 1995).

Although oaks feature in British and Irish folklore less than one might expect, they touch a wide range of beliefs and customs.

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Editor's Note: Roy Vickery continues to collect plant folklore, and would be pleased to receive any oak lore (or other plant lore) which readers may remember.

OAKS IN BOTANICAL LITERATURE

Brent Elliott
The Lindley Library

The taxonomy of oaks has advanced considerably from the early days when what we would now regard as from four to six different species constituted the range familiar to European botanists. Recent estimates of the number of species range from 400 to 600 – unless, of course, something startling is announced at this conference.

The history of the botanical study of oaks can be conveniently divided into three periods: those of European oaks, American oaks, and Asiatic oaks, in roughly chronological sequence. In this paper I will take you through these periods and look at the ways in which oaks have been regarded, and portrayed, in each.

The age of European oaks

The botanical literature on oaks effectively begins with Fuchs, in 1542. Those who are accustomed to thinking of Brunfels (*Herbarum vivae icones*, 1530) as the starting point of modern botany may be surprised to find him passed over; but Brunfels' book is important for its illustrations, not its text. The little section on trees at the end of the work is not illustrated, and Brunfels' page-long discussion of *Quercus* is little more than a rehash of recycled mediaeval gossip. No, it is in Fuchs' *De historia stirpium* of 1542 that the first treatment of oaks with some botanical merit will be found – as well as the first botanical illustration of an oak drawn from life.

Let us look first at the illustrations, for without illustrations descriptive botany would never have got off the ground; and let us begin with a glance at woodblock printing and its characteristics. It is always useful to be reminded of the limitations of printing technology in any given period, to help us to judge the artists' accomplishment properly. Fuchs' herbal contains a non-botanical plate that makes the matter clearer: a group portrait of the artists he employed. Albrecht Meyer drew the plants; Heinrich Füllmaurer copied Meyer's drawings onto the woodblocks; Veit Rudolf Speckle carved the blocks. (This is the first time that the artists received their due in a botanical publication – and the last for a few centuries.) So, the important point to remember is that botanical illustrations in the 16th century were made by whittling a block of wood, so that a certain number of lines stood up above the rest of the surface; these projecting lines of wood received the ink and were pressed against the paper. The advantage is that the illustration can fit on the same page as the text, since woodblocks operate on the same principle as pieces of type; the disadvantage is that there is a distinct upper limit to the amount of detail you can whittle out of a wooden block.

This is very apparent in Fuchs' illustration. This version comes not from the 1542 Latin edition, but from the abridged German translation that appeared the following year (because the Lindley Library's copy is coloured). The lines in a Fuchs illustration were largely confined to outlines; there was little internal detail, no shading, little modeling; and this was deliberate, because the owners of copies were expected to have them coloured, and Fuchs did not want to fill the illustrations with detailed lines that were likely to be effaced by the colourists.

Fuchs' work was later reissued in a handy octavo format, and, the popularity of the genre thus established, publishers vied with each other for a share in the market for herbals. Competition, business deals, copying and outright piracy governed the botanical market just as they have governed other markets since. All these aspects of the publishing business can be demonstrated using illustrations of oaks.

First, copying and piracy: This we can see in the case of William Turner, the author of the first respected British herbal, in the 1560s. Turner's illustrations are copied from those of Fuchs, and exhibit a characteristic reversal. The copyist would open Fuchs to the right picture, and copy it onto the woodblock; when the woodblock was carved and placed in the printing form, it came out reversed left-to-right.

The two editions of Gerard's *Herball* present a much more complicated problem. The *Herball* was very much a publisher-led book. The proposal came from the Queen's printer, John Norton, who wanted to publish a good English-language herbal. His original plan was to commission a new translation of Dodoens' herbal (already translated in 1578), and accompany it with the best of recent plant portraiture. At the Frankfurt Book Fair, he saw the *Eicones plantarum* of Tabernaemontanus, published in 1590 by Nicolas Bassaeus; He arranged to rent the woodblocks for his proposed book, and a comparison between Gerard and Tabernaemontanus reveals that the illustrations were printed from the same blocks: Not only is there no right-to-left reversal, but when photocopied onto transparent acetate and overlaid, the two images correspond exactly. Any discrepancies are due to woodblock erosion or to rouching of the paper during printing.

What about the text? For the translation Norton hired a London physician named Robert Priest. Priest died leaving the work unfinished; Norton found a replacement author in the barber-surgeon John Gerard. Gerard claimed never to have seen Priest's work, but to have begun the whole project anew; Agnes Arber, in her history of herbals, said that this statement 'can only have been a deliberate lie' (Arber 1986: 129). Gerard based his work on Mathieu de L'Obel's herbal, instead of Dodoens'; L'Obel was asked to make corrections, when the publishers expressed concern that some of the illustrations were being wrongly identified; but according to L'Obel himself, not all his corrections were accepted, and the work rushed into print before being fully amended. L'Obel retaliated by accusing Gerard of plagiarism.

Gerard has been defended on the grounds that the accusations of plagiarism were either anonymous or made by interested parties (Henrey 1975 I 145-7; Louis 1980: 269-74), and it is undeniable that there is much more in the *Herball* than can be found in Dodoens' original: locations at which plants have been found in England, observations made in Gerard's garden and those of his friends, and reports from correspondents. On the other hand, the fact that the text was fitted to a series of illustrations made on the continent helps to explain why the Turkey oak and cork oak appear in Gerard even though he acknowledged that they were not to be found in England.

In the early 1630s, a new edition of Gerard's *Herball* was commissioned – again a publisher-led enterprise, conceived in order to cut out a competitor: John Parkinson, whose *Paradisus terrestris* of 1629 had been a great success, and who was reported to be working on a new herbal to replace Gerard's. Norton's widow and her colleagues commissioned Thomas Johnson, an apothecary who had published descriptions of his plant collecting in the environs of London, to revise the text; his enlarged and improved edition was published in 1633, with a further reissue in 1636. Botanists are uniform in praising Thomas Johnson's revision as more accurate and less credulous than its predecessor. But what of the illustrations?

It is generally claimed in the literature that, as Bassaeus' woodblocks had been rented for the first edition; blocks from Christopher Plantin of Antwerp were rented for the revision. Johnson claimed in his Preface to have 'made use of those wherewith the Workes of Dodonaeus, Lobel, and Clusius were formerly printed', and at the end, apologising for some out-of-sequence addenda, 'This worke was begun to be printed before such time as we received all the figures from beyond the Seas' (Gerard 1633: 1630). However, the Plantin-Moretus Museum has no record of such a loan of woodblocks taking place – and the fact that the book was reissued within three years would have required either a most extended loan period or a second loan, an event one would not expect to have been lost sight of. And a comparison of superimposed acetate copies reveals that the Gerard illustrations are all slightly smaller than the Plantin versions; they were not printed from the same blocks, but were copied. The fact that the majority of the illustrations show no right-to-left reversal indicates that the copying was a technically sophisticated process. I suspect that the Plantin illustrations were copied onto paper which was then treated with turpentine or an equivalent in order to make it transparent, so that the paper could be turned over for re-copying onto the blocks; and that the paper shrank slightly in the process, thus accounting for the discrepancy in size. No single volume issued by Plantin contained all the illustrations copied; fully 1800 of them can be found in L'Obel's *Plantarum seu stirpium icones* of 1581, but over 400 came from Clusius' *Rariorum plantarum historia* (1601), a further 150 from Dodoens' *Stirpium historiae pemptades sex* (1583), and a smattering from other sources – including over 100 copied from the first edition of Gerard, but this time more cavalierly, with frequent right-to-left reversal.

During the course of the 17th century, woodblock printing was progressively superseded by copper-plate engraving as the preferred medium for high-quality plant illustrations, but the larger botanical encyclopaedias also continued to use woodcuts until the early 18th century, for reasons of space and cost. Probably the most important of 17th-century encyclopaedias was Jean Bauhin's *Historia plantarum universalis,* published posthumously in 1650-51, as edited by Dominique Chabrey. Here, the sheer quantity of plants dealt with encouraged economy of presentation: the work was laid out in double columns, and woodcuts used to depict the plants regardless of scale. There are indications that Bauhin's work was published in some haste. Its pagination is complicated, and it teems with pagination errors. There are evident gaps in the illustrations: some articles are unillustrated, and in one case there is a blank space accompanying the text entry. Bauhin's illustrations were cribbed from a variety of sources: Plantin, Tabernaemontanus, and Fuchs.

Fifteen years after Bauhin's work was completed, an abridged version was published by Chabrey under the title *Stirpium icones et sciagraphia* (1666). Chabrey's work is not as well known as Bauhin's original, and when it is known is not as highly regarded, for fairly obvious reasons. The text is brief, providing only thumbnail accounts of standard length for each plant, so as to cram the entire scope of Bauhin's three volumes into a single one. Also, as a piece of book production, Chabrey's work is disconcertingly poor: although it was published under prestigious auspices, the printers seem to have eked out a meager paper supply by using a variety of papers of different thicknesses and qualities. (Eleven years later, a 'second edition' appeared, made up entirely of unsold stock from 1666 with a new title page.) Nonetheless, anyone interested in Bauhin cannot afford to ignore Chabrey. The illustrations in the *Sciagraphia* were printed from the same blocks used in Bauhin, and while sometimes they were printed upside down, and occasionally used for a different plant from the one assigned in Bauhin, they also include reworkings and additions that indicate that Chabrey was completing an unfinished process of editing. Previously unillustrated articles are fitted with images; where Bauhin has a blank space, the omission is repaired. One such addition is found among the oaks, where Bauhin supplied no illustration for *Cerrus*, and the woodcut duly appears in Chabrey.

Such was the world of botanical publishing in which our earliest treatises appeared. By this time certain peculiarities of the pictures of oaks you have seen may have struck you. Most of the plants in Fuchs were depicted at life-size: but while a large quarto or folio volume allows most herbaceous plants to fit on the page at natural size, things are different when it comes to trees. (It is probably this consideration that led to the omission of pictures for the trees in Brunfels.) In order to depict a tree in a small compass, one could portray the tree as a whole – but a study of its habit would lack the anatomical details necessary for identification; or one could depict a fragment of the tree only, such as a portion of stem with characteristic foliage – but the reader would then get little idea of the tree as a whole, for identification at a distance. The first option was followed by nobody in the sixteenth century. The second option was taken up by Adam Lonitzer (a hack compiler, but possibly the most reprinted of all Renaissance authors on botany); Mattioli; Parkinson– this is the work whose rumoured progress sparked the revision of Gerard's *Herball*, and which finally appeared in 1640 as *Theatrum botanicum* – and by the botanists working with Plantin. But some works, beginning with Fuchs, compromised by presenting a stylised outline of a tree, a portion of which is expanded into the detailed fragment. The results are exceedingly un-lifelike, and could only have been understood by convention. Johannes Jonston's *Dendrographias* (1662), like Bauhin and Chabrey cribbing merrily from all the earlier sources available, gives a handy anthology of all the conventions in a single page; the illustration taken from Fuchs appears without right-to-left reversal, so it was presumably copied from Turner or some other intervening source who had reversed it in the interim.

Virtually all the illustrations discussed so far have a decidedly rectangular format. When one is carving standardised blocks of wood, it is difficult not to adapt the carving to the shape of the blocks, and produce illustrations in which the images themselves becomes rectangular. This tendency carried over into the larger blocks used for large quartos and folios as well; There was no particular reason for the illustrations in Mattioli's commentary on Dioscorides to cover the page with such repetitive elaboration that serves no additional diagnostic purpose.

How many species of oaks did the authors of this early period recognise? For the earliest writers, the nomenclature of oaks was derived from Pliny, Theophrastus, and Dioscorides, and the Greek and Latin names were treated as primary; so in addition to *Quercus*, *Ilex*, *Cerrus* and *Suber*, we find *Glans, Phellodrys, Hemeris, Aesculus,* and *Galla*. Not that this dependence did not bring its own problems, for it has been argued that Pliny misunderstood Dioscorides and confused the holm oak and the yew (Riddle 1985: 16).

The earliest of our authors, from Brunfels to Mattioli, limit their discussions to a generic level, and speak simply of *Quercus* or *Ilex*. But with the rise of the Clusius, L'Obel, and Dodoens, attempts began to be made to distinguish species or varieties within those larger categories. By the 1620s, names in use for taxa had become so numerous that the first dictionary of synonyms appeared: Gaspar Bauhin's *Pinax*; the problem was that Bauhin's names eventually became one more set of synonyms to remember. There was as yet no agreed terminology for classification, no rationale for distinguishing genera and species, certainly no higher-order groupings. Nonetheless, it is noteworthy how many of these early authors keep the oaks grouped together even though there is no common Latin vocabulary to govern them. The trees may be named *Quercus, Cerrus, Ilex, Phellodrys,* and *Suber*, but they still cluster together in the text. In most cases *Castanea* and *Fagus* will be found nearby – indeed, in Mattioli and others, *Fagus* is interposed between *Quercus* and the other oaks. Those who favour Scott Atran's recent claims for the intuitive nature of most plant groupings will no doubt be reinforced by these suggestions that the concept of Fagaceae was simmering just below the level of consciousness. (Atran 1990).

Continental and Mediterranean oaks began to be introduced into Britain in the 16th century. The holm oak was the first to arrive; Clusius reported seeing one growing at Whitehall in 1581, and Gerard confirmed that there were other scattered specimens by 1597 (Clusius 1601: 23; Gerard 1597: 1161). The Kernes oak probably arrived in the 1680s; the cork oak and evergreen oak (probably the holm oak, for the Turkey oak may not have reached Britain until the 18th century) were being offered by William Lucas as early as 1677 (Harvey 1972: 23). Other Mediterranean species trickled in throughout the 18th and early 19th centuries, especially Iberian oaks, which the discouragement of travel in pre-Napoleonic Spain kept from view.

A note on galls and mistletoe

It is not only beeches and chestnuts that accompany the oaks in the early herbals. Galls and mistletoe form part of the same clusters of entries, partly one supposes on practical and economic grounds – the target audience for herbals was after all the medical profession – but also on quasi-taxonomic ones. The types of galls were treated as more useful diagnostic signs than sessile or pedunculate fruits, and as the 16th century progressed, the itemisation of different types of galls proceeded much more rapidly than the discrimination of oak varieties. William Turner, incidentally, made an astonishing statement in his *Herbal*: 'I have not sene any galles in England growing upon oak leves. But I have sene them not only in Italy, but also in great plenty in East Freseland.' Canon Raven thought that this passage indicated the limits of Turner's intellectual powers (Raven 1947: 90), but it has been suggested that Turner was thinking specifically of the galls used to make ink, for he goes on to suggest that 'it were wel done, to fetch som from Freseland and to plant them in some hote sunnye place in England' (Turner 1568 ii 109; Robbins 1993). The diagnostic use of galls fell away after the late 17th century, after Malpighi demonstrated that galls were caused by insects; though English publications did not note this fact before Withering in the 1770s.

The inclusion of mistletoe is harder to justify on any terms other than those of received tradition. Pliny had told of the Druids, and their religious use of branches of mistletoe harvested from oak trees; he was under the impression that mistletoe grew commonly on oak. But by the late sixteenth century, commentators, especially English ones, were expressing polite skepticism about the frequency of this occurrence, though this did not stop them from treating Mistletoe immediately after Oak, instead of near trees it frequented more.

Ethnographers eventually concluded that the Druids' enthusiasm for oak-grown mistletoe was a consequence of its rarity, but before that time there was frequent debate over whether mistletoe could grow on oaks at all. The conclusive demonstration was made by the redoubtable Donald Beaton, at the time head gardener at Haffield House in Herefordshire, when he exhibited a mistletoe growing on an oak branch at the Horticultural Society in 1837 (Beaton 1837). The Woolhope Club, that curious natural history organisation devoted to the cider districts of the west country, undertook a survey in 1870, and concluded that only nine oaks were known to bear mistletoe, though others had done so until their recent felling. Once the capacity of (some) oaks to bear mistletoe had been demonstrated, it was not long before attempts were made to cultivate it deliberately. Francis D. Horner, better known for his work with florists' flowers, began growing mistletoe in the 1860s, and forty years later reported that he had only once got it to grow on oak (Mosley 1910: 84-93).

The age of American oaks

Leonard Plukenet was able to illustrate American – or as he called them Virginian – oaks in the 1690s, but the first American oak whose introduction into Britain can be well dated was *Quercus coccinea*, which arrived about 1690. It was followed by *Quercus nigra* and *Q. marilandica* by the 1720s; *Quercus alba* was introduced about the same time, but has never done well in this country and has been re-introduced or re-attempted at various intervals since. The 1730s saw *Quercus phellos*, and others followed in the later 18th century. Joseph Allerton's nursery at Knightsbridge was one of the first to make a specialty of importing American oaks, in the 1730s. In the last quarter of the century the action shifted to Leytonstone, where at least three nurserymen played a prominent role: James Fraser, who was offering *Quercus imbricaria* by 1786; James Hill, who built up a collection of red oaks which was still admired in Loudon's time half a century later; and Spencer Turner, though he is best remembered for raising one of the first commercial hybrids, *Quercus* x *turneri*. By the 1770s, there was a flourishing trade, as we can tell from a statement made in 1776 by William Speechly, the head gardener at Welbeck in Nottinghamshire: 'I have several times made trial of twelve or fourteen kinds of American oaks sent over to his Grace in great quantities' (Evelyn 1776: 97).

In 1730 the *Catalogus plantarum* of the Society of Gardeners recognised ten species of oaks, six of them American; in 1753, Linnaeus recognised 14 species, only five of them American (*Q. phellos*, *prinus*, *nigra*, *rubra*, and *alba*). Since the *Catalogus* gave two different white oaks, they may have been varieties only.

Linnaeus' treatment was not without its problems. As was his wont, he adopted some of the traditional Greco-Latin names as specific epithets, so that the ilex became *Quercus ilex*; but he then felt free to use *Ilex* as the generic name for the hollies, reducing their traditional name, *Aquifolium*, to the status of a specific epithet. Another traditional name, *Aegilops*, was similarly turned into *Quercus aegilops*, but to describe the result I can do no better than quote the latest edition of Bean: 'Linnaeus' account of this species is so confused that most botanists have rejected the name as of uncertain application, though there can be little doubt that it was intended for *Q. macrolepis* or one of its allies. Mme Camus adopts the name and under it distinguishes seven subspecies, but she did not venture to suggest which of these was *Q. aegilops sens. strict.*' (Bean 1976: 495).

Linnaeus' description of *Quercus robur* is too vague to allow it to be distinguished from *Quercus petraea*, though eventually, in the second edition of his *Flora Suecica*, he treated the sessile oak as variety b of *Quercus robur*. William Hudson popularised this treatment of the two oaks in his *Flora Anglica* (Hudson 1762: 359), but Philip Miller sowed further confusion when he adopted the Linnaean nomenclature in the eighth edition of his *Gardener's dictionary*; he used *Quercus robur* for the sessile oak, and renamed the pedunculate oak *Quercus foemina*. In this he was followed on the continent for several decades, e.g. by Willdenow, but fortunately not much in England. But thanks to the efforts of Miller, Martyn, Smith, Salisbury, and others, both the trees now identified as *Quercus robur* and *Quercus petraea* have been referred to as *Quercus pedunculata* in the earlier literature. (Gardiner 1974: 14).

But the major drawback to Linnaeus' treatment lies in the higher-order classification. The late 17th and early 18th centuries had seen the first significant efforts to produce systematic classifications of the plant kingdom, and Linnaeus', first propounded in the 1730s and solidified by the achievement of the *Species plantarum* in 1753, was the most widely adopted throughout Europe. Its taxonomy has not survived as well as its nomenclature, however. Acting on the principle that it was the sexual organs that ought to be the basis of classification, Linnaeus grouped plants according to the numbering, relative position, and separation of the stamens. Plants whose flowers bore a single stamen were grouped into Monandria, those with three stamens into Triandria, and so on. This system was adopted internationally with great speed, and especially in Britain lingered for generations, precisely because it was so simple to learn and remember; much of the history of early 19th-century taxonomy is the story of rebellions against Linnaeus, and his eventual supersession. Oaks, in Linnaean classification, formed part of the natural order Monoecia polyandria - along with *Fagus*, it is true, and *Juglans*, but also *Poterium*, *Sagittaria*, *Platanus*, and *Liquidambar*.

By the time of Willdenow's revision of the *Species plantarum* at the end of the century, the number of recognised species had grown from Linnaeus' 14 to 76, and Willdenow thought it was time to introduce some sub-generic divisions. But here he was handicapped by his master's principles: after the sexual organs, leaves tended to come next as criteria for classification, so Willdenow arranged the known oaks in five groups according to their leaf shapes: entire, toothed, lobed, sinuate with mucronate lobes, and sinuate without mucronate lobes (Linnaeus 1797-1830: IV 423-54). This classification was widely adopted, by James Edward Smith and the 'Nouveau Duhamel' among others. But by the 1830s John Claudius Loudon could remark: 'We do not mean to say that this arrangement is without its use; but we think it decidedly inferior to one in which the species are thrown into groups according to a totality of characters' (Loudon 1838: 1729). There speaks the 19th century, with its goal of replacing Linnaeus' artificial system with a natural classification that would take all parts of the plant into consideration. But as, for reasons shortly to become apparent, that totality of characters was not yet botanically available, Loudon in his own work adopted a handy division into deciduous and evergreen species.

Part of the problem with Willdenow's attempt was the variability of foliage; in the more modern classifications, similar leaves can occur in widely different sections. But of more immediate impact was the problem of the American species. Once again, let us listen to Loudon: 'Till the oaks of America began to attract the notice of botanists, the European species occasioned comparatively little difficulty. The American sorts, however, vary so exceedingly in their leaves at different seasons of the year, in different stages of their growth, and in different localities, that it is next to impossible to fix on a specific character, taken from them, which shall remain constant. The descriptions of the American oaks which have been published are, consequently, of very little use, without figures; and even the figures differ exceedingly in different authors… not to speak of … works published on American oaks by botanists who have not been in America' (Loudon 1838: 1729).

The botanist who brought this problem to general awareness was André Michaux, whose *Histoire des chênes de l'Amérique* was published in 1801, with 32 uncoloured engravings by Pierre Joseph Redouté, and four by his brother Henri Joseph. In his preface, Michaux explained that 'the greater part of those which grow in America appear under such diversified forms when they are young, that we cannot be certain what they are until they have arrived at maturer age, or have got their full growth' (Michaux 1801: page; translation care of Savage 1986: 184). Michaux was still in thrall to Linnaeus, and so it is primarily the leaves that are illustrated, a fact which somewhat limits the work's usefulness to the botanist; but to show the depth of the problem, Michaux provided two plates for most of his oaks, one showing the mature foliage, and one the juvenile.

Michaux's book was well received, and an incomplete German translation appeared in 1802-4, which I have not seen, but is cited by Stafleu as having coloured plates, though the publisher announced the availability of uncoloured copies. (Stafleu 5957) Michaux's son François followed his father by producing a larger treatment of eastern American forest trees. This, the first classic of American forestry, was published in three volumes in Paris in 1810-13, as *Histoire des arbres forestiers de l'Amérique septentrionale*. The portion dealing with oaks was separately published in 1811, and translated into German in 1842. The entire work was translated into English as *The North American sylva* in 1817-19, with two immediate re-issues, and three posthumous editions edited with annotations by Thomas Nuttall and others. As a result of the works of the Michaux, it became apparent to botanists that America was full of 'dwarf, stoloniferous, or creeping oaks' (Loudon 1838: 1718), which corresponded to nothing familiar in Europe, and presented taxonomic difficulties.

Again, François Michaux's book has illustrations by Redouté, found in both coloured and uncoloured copies. Redouté was the greatest master of engraved texture that botanical art has seen, and even in a commercial production like Michaux, over which Redouté could exert little artistic control, the quality of his treatment of leaves is apparent. Engraving continued throughout the 19th century, but increasingly the various forms of lithography, which allowed a uniform texture instead of a multiplication of dots or lines to provide modeling, superseded it. The zinc lithographs in Loudon's *Arboretum et fruticetum Britannicum* are a representative example of British work in uncoloured lithography, with image standards heavily derived from the preceding tradition of engraving. Probably the most beautifully illustrated of all works on oaks was Karl Kotschy's *Eichen*, published in eight folio parts between 1858 and 1862, and containing 40 chromolithographed plates by Joseph Seboth and J. Oberer. Although it is confined to the European and Mediterranean species, no better oak portraits have been published: detailed dissections complement specimen branches whose foliage is portrayed in all its complexity. Chromolithography is generally not as highly regarded as hand-coloured engraving as a means of presenting subtlety in colouring, but with a sufficient number of stones good results could be obtained, and the superiority of the Kotschy plates over the Redouté plates for Michaux in terms of taxonomic value will readily be seen.

New American species continued to arrive in England throughout the 19th century. David Douglas sent *Quercus garryana* at the beginning of the 1830s; at the end of that decade, another Horticultural Society collector, Theodor Hartweg, sent *Quercus crassipes*, *Q. reticulata*, and others that lasted less well (e.g. *Q. agrifolia*) from Mexico. John Jeffrey, working for the Oregon Association, sent *Q. sadleriana* at the beginning of the 1850s, though it was not described until 1871. More Californian species arrived at Kew in the 1870s: *Q. kelloggii*, *Q. lobata*, and *Q. wislizeni*. By this time the Americans themselves were beginning to produce respectable surveys of their native flora; Albert Kellogg's collections were published by Edward L. Greene under the title *Illustrations of American oaks* in 1889, and two years later Charles Sprague Sargent launched his massive *Sylva of North America*, whose treatment of American oaks was the most substantial survey until the 20th century. Sargent's illustrator was Charles Edward Faxon, highly praised for the softness of his line, balanced against his botanical accuracy. But comparable work in line was also being undertaken in England, for example in Miss E. Goldring's illustrations for the early editions of Bean's *Trees and shrubs hardy in the British Isles*.

The age of Asiatic oaks

The establishment of the Calcutta Botanic Garden, and the Buitenzorg Botanic Garden in the Dutch East Indies, created the conditions from which the abundance of Asiatic oaks could impinge on the European botanical horizon. Wallich and Royle found twelve species in India, and Blume sixteen in Java, which their various writings made known to the West during the first quarter of the 19th century. By 1838, Loudon was calculating that there must be 150 species, 100 of which remained to be introduced into Britain by that time; he expected that they 'would probably all live in the open air in the climate of London' (Loudon 1838: 1722). The first species to arrive in Europe had been *Quercus glauca*, sent from Nepal in 1804, and re-introduced 60 years later via Kew. In the 1850s and 1860s, Robert Fortune brought *Quercus myrsinifolia* and *Q. variabilis*; Charles Maries collected *Quercus acuta* for the Veitch nurseries in 1878, and their later collector E.H. Wilson brought several Chinese species at the end of the century.

The arrival of the Asiatic oaks stimulated new efforts in classification. De Candolle, in his *Prodromus* (De Candolle 1864), divided the 281 species of oaks he recognised into six sections, one of which (Lithocarpus) has generally been treated as a distinct genus since. The other sections were Lepidobalanus, Cyclobalanus, Androgyne, Pasania, and Chlamydobalanus, the last two entirely consisting of Asian species; the divisions were based on a variety of fruit and flower characters ranging from the form of the style to the pattern of scales on the acorn cups. Since then, botanists like Trelease and Oscar Schwarz have tackled the oaks of different geographical areas, each making alterations to the system based on their local populations. Despite the fact that Schwarz's classification was adopted in *Flora Europaea*, I think it is safe to say that the two most widely used systems today are those of Prantl and Camus – because they were adopted, with minor amendments, by Krüssmann and Bean in their respective surveys of trees in cultivation (Krüssmann 1986; Bean 1976).

Prantl's survey cannot be called monographic, and covers only a few pages; it formed part of the massive collaborative work he co-edited with Adolf Engler, *Die natürlichen Pflanzenfamilien*, and appeared in 1887. Prantl abandoned three of De Candolle's groups, and divided the oaks into three sections of equal status: Cyclobalanus, the evergreen species in which the scales on the acorn cups are arranged in concentric rings; Erythrobalanus, the American red oaks and willow oaks; and Lepidobalanus for all the rest (Prantl 1887).

Aimée Camus wrote monographs on *Salix* and *Castanea*, and had a particular expertise in the east Asiatic flora; in the 1930s she treated several families for Lecomte's *Flore Indochine*. But her magnum opus was *Les chênes: monographie du genre Quercus*, published as part of Paul Lechevalier's *Encyclopédie economique de sylviculture*. The initial publication date is often given as 1936, but the first part of the illustrations appeared in 1934. Over a twenty-year period, the work grew into three fat octavo volumes (including a treatment of *Lithocarpus*), with three accompanying portfolios of illustrations. Camus, like Prantl, made the presence or absence of concentric rings of scales on the acorn cups the major distinction between divisions. Both make Cyclobalanus (or Cyclobalanopsis), a separate division. Prantl distinguished two sections among the remaining oaks: Erythrobalanus and Lepidobalanus; Camus subsumed both into a subgenus Euquercus, giving Erythrobalanus equal status to groups that Prantl had made into subsections. And thereafter there are frequent differences between their groupings of species into small taxa.

The illustrations in Camus were drawn by her sister Blanche, an artist of considerable talent, and reproduced by photolithography, a medium very handy for publishers but in those early days less rewarding for the botanical artist. The variety of oak species had now become so great (430), and so many of them were not known in cultivation but from herbarium specimens alone, that many appear only as part of composite plates, the leaf frequently being the major diagnostic character depicted. But for the long-established and long-cultivated species, several plates are devoted to exhibiting ranges of morphological variation: in leaves, in acorns, not to mention juvenile forms. Composite plates have since the 19th century become one of the major forms of botanical illustration, as the handy one-volume identification guide has flourished as a genre; to bring us more or less up to date, let me single out Ian Garrard's illustrations for the late Herbert Edlin's *Tree key*, as splendid examples of how to convey a large amount of necessary information in a small compass.

Oaks as specimens, individuals, ecosystems

Loudon, in his *Arboretum*, had depicted some particular named specimens as well as typical forms of the species. The emergence, toward the end of the 19th century, of photography as a means of book illustration augmented the tendency to depict individuals: after all, individuals are all one can photograph. Books such as Elwes and Henry's *Trees of Great Britain and Ireland* (1906-13) and, more profusely, Max Lange's *Unsere deutschen Eichen* (1937), with sixty trees each photographed in winter and summer, offered splendid ranges of photographs of individual trees, and no doubt helped to focus attention on the issue of variation. However, Lange's book, tastefully dedicated to Field Marshall Goering, was offered not so much as a contribution to botany as a celebration of 'the German national tree, the folk-tree'. And while in England the oak may not have had quite such a layer of nationalistic ferfor hung from it, its cultural importance nonetheless intruded into botanical and horticultural treatments of it.

In England as well as Germany, various individual oaks had become celebrated as historic and veteran trees: King Charles' Oak at Boscobel, in which the fleeing king had hidden; the Abbot's Oak at Woburn, (on which the abbot had been hanged; gospel and parliament oaks in various parts of the country. From the 1770s to the 1790s, the enthusiastic amateur Hayman Rooke measured and drew striking oaks on the Welbeck estate, publishing a book on the subject in 1790. One of the most striking was 'a view of the famous green dale oak, thought to be above seven hundred years old' – somewhat truncated by the time Rooke was observing it. Other books in the early 19th century devoted attention to historic oaks, notably H.W. Burgess's *Eidodendron* in 1827, and Mary Roberts' *Ruins and old trees* in the 1840s (Burgess 1827; Roberts n.d.).

All this emphasis on what might be called the cultural importance of oaks may have affected perceptions of its ecological status. Even Loudon begins his discussion of *Quercus* in his *Arboretum* by a comparison of the oak and the lion as the kings of their respective kingdoms (Loudon 1838: 1717). So as the discipline of ecology slowly developed in the late 19th and early 20th centuries, and the idea of succession was formulated and widely adopted, oak forest was seen as the culmination of ecological development in England. Tansley, the most important authority on British ecology in the first half of the 20th century, gave detailed consideration to other types of woodland, but still regarded oakwood as the final phase to which all previous ones tended (Tansley 1939, 1949).

Twenty years ago I was on the advisory committee for a park which will remain nameless; when it was reported that the swamp cypress was dying and needed replacement, the chairman, remarking that it was an ugly tree and shouldn't be replaced, capped his argument by saying, 'What we want is native English trees: oak climax woodland!' Such was the state of popular ecology at the beginning of the 1980s. Then, within a very few years, the idea of a single, uniform ecological succession was superseded by the idea of ancient woodland, as the studies of Oliver Rackham in particular accustomed the public to the fact that the dominance of oak in British woodlands was a cultural, rather than a natural, phenomenon: human beings favoured the oak because of its utility for building, coppice, and other purposes (Rackham 1974). Oak has now been reduced from the king of trees to a more democratic role as merely one of the most frequent locally dominant trees, in a patchwork of plant communities in which lime, alder, birch, beech, and others dominate their respective areas.

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* Note on Bauhin: the title pages of 1650-51 give the place of publication as Yverdon, but do not supply the publisher's name. The Lindley Library copy has an additional title page dated 1661, and giving the publisher as Samuel Chouet of Geneva. This could indicate a re-issue by a different publisher; but, in view of the confused and complicated printing of the work, it could be that Chouet was involved from the beginning.

THE INTRODUCTION OF OAK SPECIES INTO BRITAIN AND IRELAND

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Introduction

While sessile oak (*Quercus petraea*) and English or pedunculate oak (*Quercus robur*) are native in Britain and Ireland and have made an important contribution to the development of parks and estates, so too have some of the introduced oak species. This paper examines firstly, the introduction of oak species from temperate regions of the Northern Hemisphere, and secondly, their use by plant enthusiasts and botanists to develop collections of oak and their role in the broader landscape development of estates.

The main sources for this review were *Arboretum et Fruticetum Brittanicum* (Loudon 1835-1838), Trees of Great Britain and Ireland (Elwes and Henry 1906–1913), and Trees and Shrubs Hardy in the British Isles (Bean 1976–1988).

Introduction of Oak from the Mediterranean Region and Western Asia

From the 16th century to the 19th century deciduous and evergreen oak species were introduced to Britain from the Mediterranean and western Asia (see Table 1).

- *Quercus ilex* is native to the Mediterranean region. The Flemish botanist Clusius (L'Écluse) in 1581 knew of two trees growing near London. It is common in cultivation.
- *Q. suber*, or cork oak, was introduced in 1677 from the Mediterranean area. It is infrequent in cultivation.
- *Q. coccifera* was introduced in 1683 and is native to the western Mediterranean region. It is used as a symbol of one of the London Livery companies, the Dyers Company.
- *Q. macrolepis* was introduced in the early 18th century. It is native to Greece, Albania, and Turkey.
- *Q. cerris*, Turkey oak, is native to southern to eastern Europe. At Royal Botanic Gardens (R.B.G) Kew, a specimen more than 200 years old was blown down in 1987 (Desmond, 1995). It is common in cultivation.
- *Q. calliprinos* — the date of introduction is uncertain. It is considered to an eastern Mediterranean sub species of *Q. coccifera*.
- *Q. pyrenaica* was introduced in 1822. It was recommended by Loudon 'for the beauty of its spring foliage'.
- *Q. fruticosa* was introduced before 1827 from the Iberian peninsula. A specimen was planted in the Milford Nurseries in 1827 (Loudon 1835).
- *Q. canariensis* 1835 (*Q. mirbeckii* 1844) is native to Algeria, Spain, and Portugal. It was introduced from Gibraltar to gardens of the Royal Horticultural Society. A specimen planted in the R.B.G. Kew was

supplied by Booth of Hamburg,, Germany.

- *Q. castaneifolia* is native to the Caspian Sea. The specimen at R.B.G. Kew was raised from seed imported in 1843 and planted in 1846. It is now the largest tree in terms of volume in the Gardens. (Desmond, 1995). It is rare in cultivation.
- *Q. faginea* was introduced in 1835 from Spain and Portugal.
- *Q. frainetto* was introduced in 1837/1838 from Hungary. A specimen was planted in R.B.G. Kew in 1840. It is infrequent in cultivation.
- *Q. libani* was introduced in 1855. It is native to Syria, Asia Minor, and Kurdistan and is rare in cultivation.
- *Q. macranthera* was introduced in 1873 from the Caucasus and Transcaucasus and northern Iran. It is uncommon in cultivation.
- *Q. alnifolia* , the golden oak of Cyprus, was introduced in 1885.
- *Q. pontica* , or the Armenian oak, was introduced in 1885. It is native to Anatolia, Caucasus, and Transcaucasus. It was introduced by Dr. Dieck to the nursery company Zoeschen.
- *Q. trojana* was introduced in 1890 and is native to southwest Italy and the Balkans. There is a specimen at R.B.G. Kew.
- *Q. pubescens* is native to a broad region from Spain to the Caucasus and was introduced long ago. It is rare in cultivation.

Foliage of *Q. coccifera* photo © Guy Sternberg

Table 1. Introduction of Oak from Mediterranean and Western Asia

Genus	*Common Name*	*Date of Introduction*	*Occurrence* *
Q. ilex	Evergreen Oak	pre 1581	Common
Q. suber	Cork Oak	1677	Infrequent
Q. coccifera	Kermes Oak	1683	
Q. macrolepis		1731	
Q. cerris	Turkey Oak	pre 1735	Common
Q. pyrenaica		1822	
Q. fruticosa		pre 1827	
Q. faginea		1835	
Q. canariensis	Algerian Oak	1835	Infrequent
Q. frainetto	Hungarian Oak	1837	Infrequent
Q. calliprinos	Sindian Oak	pre 1838	
Q. castaneifolia		pre 1846	Rare
Q. libani	Lebanon Oak	1855	Rare
Q. macranthera		1873	Uncommon
Q. alnifolia	Golden Oak of Cyprus	1885	
Q. pontica	Armenian Oak	1885	Rare
Q. trojana		1890	
Q. pubescens		long introduced	Rare

* From *Trees of Great Britain and Northern Europe* (Mitchell 1974)

Introduction of Oak from North America

With the increasing trade links between Britain and eastern North America in the 17th century, and the interest shown in trees and shrubs from this region, many oaks were introduced into Britain in the 17th and 18th century (see Table 2).

- *Quercus coccinea,* the scarlet oak, was introduced in 1691 (Mitchell 1974). It is native to eastern North America. A specimen grew in Bishop Compton's Garden at Fulham in London. It is frequent in cultivation.
- *Q. phellos,* the willow oak, was introduced in 1723. It is native to eastern North America and westward to Texas. It is rare in cultivation. There is a specimen at R.B.G. Kew.
- *Q. alba* was introduced in 1724. It is native to eastern North America from Florida to Canada. It is rare in cultivation. There is a specimen at R.B.G. Kew.
- *Q. marilandica* is native to the eastern United States and was introduced in 1724.

- *Q. rubra* was introduced in 1724. A tree planted about 1746 at R.B.G. Kew was blown down in 1916 (Desmond 1995). It is common in cultivation.
- *Q. nigra* is native to the southern United States. It was in cultivation in 1723 but is now considered rare.
- *Q. muehlenbergii* was introduced in 1737. It is very rare in cultivation.
- *Q. falcata* was introduced by 1763 by Murdoch Murchison (Elwes and Henry 1906).
- *Q. palustris* was introduced before 1770. It is native to the eastern United States.
- *Q. imbricaria* was introduced in 1786 by John Fraser (1750–1811) It is infrequent in cultivation. There are specimens at R.B.G. Kew and Syon House, London. John Fraser was a native of Invernesshire. He went on 12 expeditions to America and also went to Russia. He established a nursery in London, which was later run by his son John (fl 1790's – 1860's) (Desmond 1994). According to Loudon (1838), between 1781 and 1790 John Fraser introduced *Q. lyrata*, *Q. imbricaria* and *Q. rotundifolia* and between 1791-1800. Messrs Fraser introduced *Q. triloba*, *Q. tinctoria*, *Q. palustris* and *Q. Americana* into cultivation.
- *Q. lyrata*, the overcup oak, was introduced by John Fraser in 1786. It is rare in cultivation.
- *Q. bicolor* is native to eastern North America and was introduced in 1800. It is rare in cultivation.
- *Q. ilicifolia* is native to eastern North America and was introduced in 1800 by Messrs Fraser.
- *Q. prinus*, or chestnut oak, was introduced between 1721 and 1730. It is native to eastern North America.
- *Q. stellata* is widespread in the United States but is uncommon in cultivation. It was introduced in 1800.
- *Q. velutina* is native to the eastern United States in 1800. It is infrequent in cultivation.
- *Q. macrocarpa* is native to eastern North America. It was introduced in 1811, but is rare in cultivation.
- *Q. laevis* was introduced in 1823. It is native to the south eastern United States.
- *Q. prinoides* is native to the eastern and central United States. It was introduced in 1828, but being a suckering shrub with little ornamental value, is rare in cultivation.

Table 2. Introduction of Oak from Eastern North America

Genus	Common Name	Date of Introduction	Collector	Occurrence *
Q. coccinea	Scarlet Oak	1691		Frequent
Q. phellos	Willow Oak	1723		Infrequent
Q. alba	White Oak	1724		Rare
Q. marilandica	Black Jack Oak	e. 18th C		
Q. rubra	Red Oak	1724		Common
Q. nigra	Water Oak	1723		Very rare
Q. muehlenbergii		1737		Very rare
Q. falcata	Spanish Oak	1763		
Q. palustris	Pin Oak	1721-1730		Uncommon
Q. imbricaria	Shingle Oak	1786	John Fraser	Infrequent
Q. lyrata	Overcup Oak	1786	John Fraser	Rare
Q. bicolor	Swamp White Oak	1800		Rare
Q. ilicifolia	Bear Oak	1800	Messrs Fraser	
Q. prinus	Chestnut Oak	1721-1730		
Q. stellata	Post Oak	1800		
Q. velutina	Black Oak	1800		Infrequent
Q. macrocarpa	Burr oak	1811		Rare
Q. laevis		1823		
Q. prinoides	Chinquapin Oak	1828		

* From *Trees of Great Britain and Northern Europe* (Mitchell 1974)

In the early- to mid-19th century, plant collectors, at the behest of horticultural societies, explored western North and South America. Several oaks were found in western North America and introduced into cultivation (see Table 3).

- *Quercus crassipes* and *Q. glabrescens* were introduced from Mexico in 1839 by Hartweg. K.T. Hartweg (1812–1871) was a native of Carlsruhe in Germany. He collected in Mexico for the Royal Horticultural Society, where he introduced *Pinus montezumae* and *P. ayacahuite*. In 1846–47 he went on a plant expedition to California. There he collected *Q. agrifolia*, a native of California and Mexico, and introduced it in 1849 for the Horticultural Society. It is very rare in cultivation.
- *Q. sadleriana* was discovered in 1851-1852 by Jeffrey. John Jeffrey, a native of Fifeshire, was sent by a Scottish organisation called the Oregon Association, which had an interest in developing commercial links with western North America, to collect *Pinus jeffreyi*.
- . *Quercus lobata* and *Q. wislizeni* from California were collected in 1874 by H.N. Bolander and introduced to R.B.G. Kew.
- *Q. chrysolepis* was introduced by Sargent in 1877. Charles Sprague Sargent was born in 1841. He was Director of the newly formed Arnold Arboretum from 1872 until his death in 1927. He collected in North America and Japan. He sent E.H. Wilson to China to collect for the Arnold Arboretum. Under his directorship many genera, including oak, were distributed to gardens worldwide.
- *Q. crassifolia* is native to central Mexico. An American botanist, G.B. Hinton, sent seed to Caerhays in Cornwall in 1939.

Table 3. Introduction of Oak from Western North America

Genus	*Common Name*	*Date of Introduction*	*Collector*	*Occurrence **
Q. crassipes		1839	Hartweg	
Q. glabrescens		1839		
Q. agrifolia	Encina	1849	Hartweg	Rare
Q. sadleriana	Deer Oak	1851	Jeffrey	
Q. lobata	Valley Oak	1874	Bolander	
Q. wislizeni		1874	Bolander	
Q. chrysolepis	Maul Oak	1877	Sargent	
Q. crassifolia		1939	Hinton	

* From *Trees of Great Britain and Northern Europe* (Mitchell 1974)

Introduction of Asiatic Oak

From the early 19th century oak were introduced from Asia (see Table 4).

- *Quercus lamellosa* was introduced in 1802 by Buchanan Hamilton, Director of the Calcutta Botanic Garden. It is native from the Himalayas to China. It was later introduced by George Forrest (1873- 1932), who made six plant-hunting expeditions to China and Burma.
- *Q. glauca* has a broad distribution from Nepal to Japan. Originally introduced in 1804 from Nepal, it was later introduced from Japan in 1861 by Richard Oldham. Richard Oldham (1837–1864) was a gardener at R.B.G. Kew in 1859 and collected in eastern China in 1861 and in the Khasia Hills, India in 1861–1862. He died in China in 1864 (Desmond 1994). *Q. glauca* was later collected by E.H. Wilson (1876-1930). Wilson collected in Japan and China for the nursery company Veitch, and later for the Arnold Arboretum, Boston, United States.
- *Q. dentata* was introduced in 1830, probably by the Swedish botanist von Siebold. It is native to Japan and northeast Asia and is infrequent in cultivation.
- *Q. myrsinifolia* was introduced by Robert Fortune in 1854. It is native to southern China, Laos, and Japan. Robert Fortune (1812 – 1880) was a native of Berwickshire. From 1843-1846 he visited China, collecting plants for the Horticultural Society. He made further expeditions on behalf of the East India Company, collecting tea plants. It is rare in cultivation.
- *Q. phillyraeoides* was introduced in 1861 by Richard Oldham. It is native to China and Japan.
- *Q. variabilis*, another Fortune introduction of 1861, is native to China, Japan, and Korea. It is rare in cultivation.
- *Q. acutissima* was introduced in 1862 by Richard Oldham. It is native to China, Japan, and the Himalayas. It is rare in cultivation
- *Q. serrata* was introduced in the years 1861-1864 by Richard Oldham.
- *Q. acuta* was introduced from Japan in 1878 by Maries. C. Maries (c 1851–1902) collected on behalf of Messrs. Veitch, the nurserymen. It is rare in cultivation.
- *Q. glandulifera* was introduced in 1893 by Sargent. It is native to China, Korea, and Japan. Trees from Japanese seed are in cultivation in the oak collection in R.B.G. Kew.

- *Q. mongolica* var. *grosserrata* is native to Japan. It was introduced into cultivation by Sargent in 1893.
- *Q. baronii* was discovered by the Italian collector Giraldi in 1895. Giussepe Giraldi (1848–1901) was an Italian missionary in China (Stearn 1994). It is native to western China and was later introduced by the Dutch-born F.N. Meyer (1875-1918) who collected on behalf of the United States Department of Agriculture (USDA) and by E.H. Wilson.
- *Q. engleriana* was introduced by E.H. Wilson in 1900. It is native to Hubei and Sichuan in China.
- *Q. aliena* was introduced to R.B.G. Kew in 1908. It is native to Japan, Korea, and China.

Table 4. Introduction of Asiatic Oak

Genus	Common Name	Date of Introduction	Collector	Occurrence *
Q. lamellosa		1802	Buchanan Hamilton	
Q. glauca		1804		
Q. dentata	Daimio Oak	1830	Siebold	Infrequent
Q. myrsinifolia		1854	Fortune	Rare
Q. phillyraeoides		1861	Oldham	
Q. variabilis		1861	Fortune	Rare
Q. acutissima		1862	Oldham	Rare
Q. acuta		c 1878		Rare
Q. glandulifera		1893	Sargent	
Q. mongolica var grosserrata		1893	Sargent	
Q. baronii		1895	Giraldi	
Q. engleriana		1900	Wilson	
Q. aliena		1908		

* From *Trees of Great Britain and Northern Europe* (Mitchell 1974)

Some general points can be made about the introduction of oak species into Britain and Ireland. The pattern of introduction over 400 years echoes the main trends in the introduction of exotic species. In general, species were introduced more or less in sequence from temperate regions as follows: Europe; eastern North America; western Asia; Japan and Himalayas; western North America and finally, China and Japan. While Charles Sprague Sargent introduced some oak species, the well-known collectors E.H. Wilson and George Forrest collected few oaks. In comparison with genera such as *Rhododendron*, little seed of known wild origin was introduced. However, in recent years Allen Coombes of the Sir Harold Hillier Gardens and Arboretum, Winchester, and Martin Gardner of the Royal Botanic Garden, Edinburgh, among others, have been introducing species from the wild.

The Distribution of Oak Species and Development of Cultivars and Hybrids

Nurserymen selected cultivars of oak and also raised some hybrids. Nurseries played a significant role in the distribution of oak. Conrad Loddiges, a German, started a nursery business in Hackey in 1771 which continued until the mid 19th century. Loudon (1835) commented that oak was first grafted by such nurseryman as Loddiges 70–80 years ago, but by the 1830's, oaks were grown from seed. *Quercus stellata* was introduced to the trade by Messrs Loddiges in 1819 and *Q. tauzin*, in 1822. According to Loudon (1835), Leyton Nursery near

Stratford, Essex had a great variety of American oak in 1836.

Oak Cultivars

Many cultivars of *Quercus robur* in particular have been selected by nurserymen and introduced into the trade; three are mentioned here.

1. *Q. robur* f. *fastigiata* was found in a forest near Frankfurt-am-Main and propagated by grafting from 1783. It is now widely used in present-day landscape schemes.
2. *Q.* 'Fennessii' is an Irish cultivar. It came from seed grown by a nurseryman John Fennessey and his son of Waterford about 1820. In 1836 the parent tree was 15ft high (5m). (Loudon 1838) The name was later corrupted to 'Trinessii'. Some young specimens have been planted in Kilmacurragh, Co. Wicklow, and the National Botanic Gardens, Dublin and John F. Kennedy Arboretum, Co. Wexford.
3. *Q. coccinea* 'Splendens' was selected by the Knaphill nursery at the end of 19th century. It was given an Award of Garden Merit in 1927.

Oak Hybrids

With the ever-expanding range of oaks in cultivation from the 18th century onwards, nurserymen began to raise seedlings, some of which gave rise to valuable hybrids. *Q. lucombeana*, a seedling of *Q. cerris* x *Q. suber*, was raised about 1763 by William Lucombe. William Lucombe (c. 1696–1794) of Exeter was described as an ingenious gardener. He later founded a nursery named Lucombe, Pince and Co. Old trees at Carclew, the garden of Sir Charles Lemon in Cornwall, and one at Kilmacurragh, in Co. Wicklow, Ireland are said to be original. *Q. lucombeana*. It is now called *Q.* x *hispanica* and the particular hybrid, *Q.* 'Lucombeana'.

About this time another nurseryman, Spencer Turner of the Leyton nursery mentioned above, raised two forms of hybrid oak derived from *Quercus ilex* and *Q. robur*. One was known as *Q.* x *turneri*, recently named *Q.* 'Spencer Turner' by Wiltshire and Coombes (2001), and the second, known as *Q.* x *turneri* 'Pseudoturneri'.

Oak Collections

In the 18th century an interest in the cultivation of introduced species developed among the horticultural fraternity and has continued since. Many plant enthusiasts acquired the newly introduced plants from nurseries and contacts in trade.

John Foster of Oriel Temple, Collon, Co. Louth, one of those who established the Botanic Gardens in Glasnevin, wrote to John Ellis, the London agent of the Linen Board, requesting him to purchase seed from his American contacts of 'such forest trees and shrubs as will thrive here, particularly various species of Oak, Pines, Firrs (*sic*) and cedars' (Nelson and Mc Cracken 1987). *Quercus palustris* was planted at Collon in 1788. Loudon (1838) records this tree, as well as *'Q. aegilops, Q. lucombeana,, Q. fastigiata*, and *Q. exoniensis'*.

Hobhouse (1992) describes planting of North American species. At Thorndon Hall, Essex, in a planting undertaken by Lord Petre in 1740–1742, more than 60,000 trees were planted, including 10,000 'Americans', among them 230 Carolina oak. In 1756, *Q. phellos* was growing well at Painshill, the garden of Charles Hamilton. Loudon (1838) noted American oaks, cork trees (*Quercus* *suber*) and 'Ilices' (*Q. ilex*) there. In 1995 a venerable old specimen of *Q. suber* was photographed in Painshill by the author (see Figure 1).

Charles Lennox, the 2nd Duke of Richmond, had 30 different kinds of oak and 400 different American trees and shrubs at Goodwood, Sussex, in 1750 (Jacques 1983). From 1789 American and other exotic oak were planted in the 'Forest Lawn' at Fonthill for William Beckford in his picturesque landscape (Jacques 1983). From 1804–1817, William Spencer, Marquis of Blandford, spent a lot of money on his estate at Whiteknights, but was later forced to sell (Jacques, 1983). *Quercus cerris* from this date remain in what are now the grounds of the University of Reading. A specimen of *Q.* x *turneri* dating from this time is extant (Wiltshire and Coombes 2001). A specimen of *Q. robur* f. *fastigiata*' was planted about 1800. Elwes and Henry mention the oak collection formed by the Earl of Ducie at Tortworth and give many examples of these trees in their work, '*The Trees of Great Britain and Ireland*'.

Oak Collections in Botanic Gardens

Collections of oak also developed in Botanic Gardens. The most complete collection, according to Elwes and Henry (1906), was at R.B.G. Kew. A comprehensive collection was planted at the Botanic Gardens, Glasnevin. The National Botanic Gardens, Glasnevin, Dublin was established by the Royal Dublin Society in 1795 on a site of 27 acres (11.25 ha), later extended to 50 acres (20.8ha). Maps from 1800 and 1818 illustrate an Arboretum at Fruticetum. From 1800 an oak class was planted and remains to the present time. In 1809 Walter Wade, Professor of Botany at the Gardens, wrote *Quercus or oaks from the French of Michaux*, with notes and an appendix. He lists twenty one species or sub species of American oak as present, and a further ten Mediterranean species in the collection in the Botanic Gardens. Many of the species listed by Wade were later sunk (???) by botanists. The sources for the collection included nurseries such as Messrs. J. Veitch of London, Simon Louis Freres of Metz, France, Baumaschulen Zoschen b Merseburg, Germany, Vicary Gibbs of Aldenham, and the nursery company Späth. Plants were also received from other Botanic Gardens such as R.B.G. Kew, the Arnold Arboretum, Jardin des Plantes, Paris, and in recent years from the Morton Arboretum, United States, R.B.G. Edinburgh, and the Sir Harold Hillier Gardens and Arboretum. There was also some plant exchange among Irish garden owners. For example, Sir John Ross of Bladensburg, who had an important collection at Rostrevor, Co. Down, donated *Quercus agrifolia* to Glasnevin in 1906 and to Mount Usher, Co. Wicklow in 1908. Records from Birr Castle, Co. Offaly, indicate that in the 1930's the Earl of Rosse received oak from Glasnevin.

'Estate Embellishment'

Quercus ilex and *Q. suber*, according to Evelyn in his *Sylva*, could be used for general use (Hobhouse 1992). History has shown that this was true for *Q. ilex*, but not for *Q. suber*. Evergreen oak was widely planted. Two and a half hogshead (600 litres) of acorns of evergreen oak were sent from Minorca to Stowe, Buckinghamshire, in 1723 (Hobhouse 1992). In 1718 Thomas Ball F.R. S. planted *Q. ilex* in large quantities at Mamhead near Exeter, south Devon according to Hadfield (1979), probably the first to do so. Wade (1809) quotes a Mr. Bradley: "Robert Balle Esq. raised some thousands of these trees from acorns at Mamhead in Devonshire (*sic*) some of which in 30 years have grown to a considerable size and that within the compass of six years many millions of them have been raised in England from acorns brought from Italy and Virginia (*sic*) as well as great numbers of cork trees. The latter were killed by frost; but what is become of the millions of Ilexes ? " An answer is given presently.

Q. cerris was common in the south of England by the latter half of the 18th century. The largest trees were at Mamhead Park near Exeter, where three specimens measuring 100ft, 90 ft, and 80 ft. were mentioned by Elwes and Henry (1906). Oak was part of the palette of trees used by a major designer of the English Landscape Style, Lancelot Capability Brown. In the years 1768–1774, Brown planted 'large ilex and cork trees' for Lord Clive at Claremont, Esher. Brown also planted *Quercus ilex*, along with beech, sweet chestnut, and Scots pine at Cadland on the Solent shore near Southampton for his banker Robert Drummond (Hedley and Rance 1987).

ShelterBelts

There were great numbers of *Quercus ilex* at Tregothnan, Cornwall, shading a drive by the shore of the harbour. *Q. ilex* was described by Arnold Foster (2000) as a mainstay of shelter planting in Devon and Cornwall where it will withstand wind and salt spray. It is also used as a hedge.

Avenues and woodland

A grove of *Q. ilex* at Holkham Hall was, according to Elwes and Henry (1906), pre-eminent in numbers and size. This species was used extensively at St. Annes in Dublin, the estate of Benjamin Lee Guinness, later Lord Ardilaun. From 1870 the estate was planted with many evergreen oaks, *Pinus nigra*, Austrian, pine and *Pinus radiata*. Monterey pine was used to create a formal mile line entrance avenue. It was also used to line walks within the park and shelter belts on the periphery of the property. Today St. Annes is a large public park.

In 1903 Lord Ardilaun donated 600 6ft (3m) tall evergreen oak trees to the Phoenix Park in Dublin. (John Mc Cullen pers.comm 2003). One hundred years later, they are a magnificent sight in the forming blocks of woodland and shelter belts in the Park.

At Buscot Park, Farringdon, Gloucestershire, *Quercus robur* 'Fastigiata' is used to create one of the many fine formal avenues in the park.

Planting of Introduced Oak for Timber

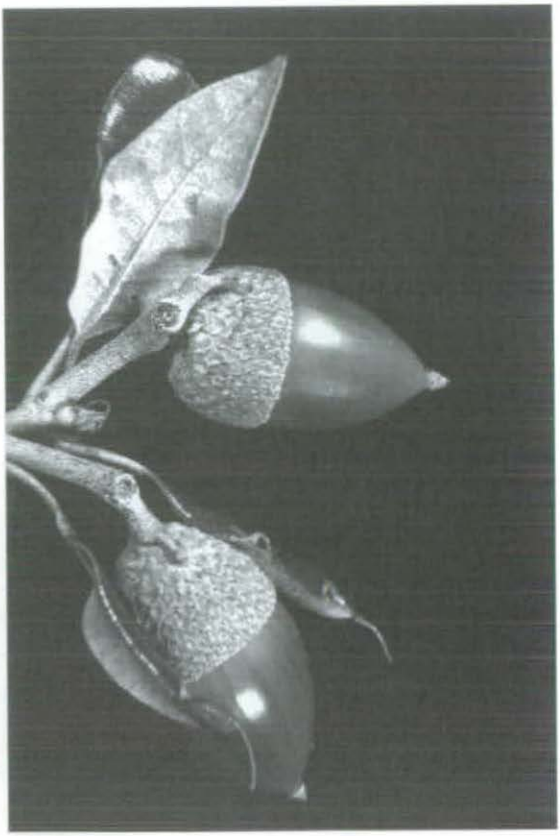
The Society of Arts encouraged the planting of oak, which was required by the Navy for the construction of ships. Details of species, numbers, and areas were recorded and the Society awarded medals to landowners (Jacques, 1983). In Ireland an Act of 1698 stated that tenants with leases of over 31 years from 1703 were to plant ten 4-year-old trees annually. Under an Act of 1765 it was necessary to register trees planted with a Justice of the Peace. A ledger remains for Londonderry with names of tenants, dates of registration, and numbers of trees and species given. Oak was the most widely planted species in county Londonderry, with 500 plants each of what were considered minor hardwoods, Lucombe, turkey and holm oak, *Q.* x *hispanica*, *Q. cerris* and *Q. ilex*, respectively. For those with an interest in place names, word 'Derry' is derived from the Gaelic word 'dair' oak wood.

From Ireland to England

Over the years there has been speculation, which Nelson (1993) considers unfounded, that Irish oak was used in the construction of the roof of Westminster Hall, the Chapel of Kings College, Cambridge, and Salisbury Cathedral. A news item in the *Church Times* in March 2003 sheds new light on the use of Irish oak in the construction of at least one of these buildings. In 1222, the warden of the nearby Clarendon Forest, had a disagreement with the chief carpenter Godarus over the supply of 40 trees for use in the construction of the roof of Salisbury Cathedral. William of Dublin then supplied timber from medieval oak forests south of Dublin (Anon, 2003).

Conclusions

Through the work of plant collectors, many oak species have been introduced into Britain and Ireland. Nurserymen propagated these introductions, selected cultivars, and raised oak hybrids. They, in turn, were grown by plant enthusiasts in their estates and by botanists in botanic gardens. One species in particular, *Quercus ilex*, became an important tree in the development of avenues and shelter belts. One can speculate why many introduced species grow well in these islands; climate, soil, and cultivation techniques all play a part. These introduced species have become 'honoured guests' among 'distinguished natives'.



Q. ilex photo © Guy Sternberg

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IMPROVING OAK: THE FIRST STEPS TOWARDS A BREEDING PROGRAMME

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Summary

An oak genetic improvement programme (of *Quercus robur* and *Q. petraea*) based on the selection of 110 'elite' trees has been started. Mother trees were chosen to maximise recoverable timber volume and quality, with an emphasis on improving form and reducing shake. The 246 trees selected were reduced to 110 using the criterion of early wood vessel size. The larger vessel sizes were in Dutch oak, so planting it could increase the predisposition to shake. A poor acorn crop in 1998 meant that seed collection had to be repeated in 1999 and 2000. Shoots were collected in early 1999 for grafting and propagation, in collaboration with Horticulture Research International. In 2003, eight replicated Breeding Seedling Orchards were established in Great Britain and Ireland, involving 19,500 trees.

Introduction

The long-term nature of the temperate broadleaved tree improvement, coupled with the highly variable timber quality of many native British hardwoods, has led to a reluctance to fund improvement projects that have a projected lifetime of over 40 years. Hence, our understanding of the genetics of these species is limited and attempts have only recently started under the umbrella of the British and Irish Hardwoods Improvement Programme (BIHIP) (Savill, 1998). In the Netherlands, improvement in oak has been achieved by selection but with no real trials. In the Great Britain the Forestry Commission is running oak progeny and provenance trials, but has not selected elite trees with a view to a breeding programme. This project is unique in that it is the only program for oak which combines all the elements of selection, trial, and breeding.

Oak presents a problem due to the length of time until sexual maturity and the low quantities of seed produced per hectare; hence the need to combine breeding and vegetative propagation. Horticulture Research International (HRI) has extensive experience in the breeding, improvement, and propagation of fruit trees and has been collaborating with the Oxford Forestry Institute (OFI) in the oak project.

The method used is to collect seeds from selected 'elite' mother trees and use them to establish breeding seedling orchards (BSOs). This concept combines a trial and a seed orchard (Barnes 1986, 1995). The trial element will help to establish the genotypic contribution towards the observed elite phenotypes. Trees that do not perform well will be removed, leaving only the best for propagation, which could be by sexual or vegetative methods. Micropropagation alone relies solely on phenotypic selection and removes the possibility for further gains, but can rapidly provide good planting stock. It is for these reasons that we have decided to follow the slower route of breeding, but probably in conjunction with micro-propagation. In this way the superior material selected in the trials can be made available to growers in a shorter time than by breeding alone. In addition, due to the low seed output of oak per hectare, some form of scaling up is likely to be necessary to disseminate the improved material and, when improved seed is available, large-scale methods of vegetative propagation will be needed.

Objectives

The two principal objectives of this project are:

- to increase the recoverable timber production of oak per unit area by genetic means, and;
- to increase the quality of the timber produced.

If successful, then secondary environmental and amenity benefits could be expected to accrue, linked to an increase in the area of lowland broadleaved tree cover.

More immediate objectives from the collaboration with HRI are that the elite trees identified at the start of the project would be conserved *ex-situ,* for possible vegetative propagation of superior clones and future genetic improvement programmes. They could eventually be compared to their progeny for inheritance studies, including the use of molecular markers for genetic mapping and for breeding commercially valuable selections.

Outline of Methods

Savill (1998) has outlined the BSO methodology adopted. It has shown itself to be cheaper than more complex breeding methods, but still capable of producing large genetic gains in the improved material (Kanowski 1993). One big advantage for Great Britain, where land prices are so high, is that it combines the trial and the seed orchard into one site.

Selection

The first step is the selection of the best possible mother trees whose progeny will make up the initial breeding population. Great Britain, Ireland, northern France and The Netherlands were chosen as the range for selection since they encompass the climatic and geographic conditions encountered in Great Britain and Ireland. One concern is the potential for hybridisation between *Quercus robur* and *Q. petraea.* There is still debate as to the exact taxonomic status of these species and some authors treat both as one complex (Kleinschmit *et al.* 1995; Aas 1993). Since the main objective of this project is timber production and the timber from either is indistinguishable, we have identified the selected trees, but chosen to treat both as one species for the purpose of selection and the trials.

The basis for selection in the field was phenotypic; the trees had to fulfil the criteria outlined below. Savill and Kanowski (1993) have discussed these characteristics in detail for oak. A minimum of around 50 trees is necessary to establish a sufficiently broad genetic base. Our aim was to select 200 suitable trees with the intention of eliminating 100 and testing the remaining 100 in trials. The basis of elimination was on wood properties and is discussed later.

The selection criteria can be grouped into three broad categories:

1. Form
   - Straight stem: the first 6 m of each tree was ranked for straightness using the method of Barnes and Gibson (1986). In addition, the length of first grade timber, total height, canopy length, and the length of straight stem, regardless of branches (apical dominance), were measured.
   - Absence of fluting.
   - Absence of spiral grain.
   - Absence of basal sweep: This was not at all common in the stands visited, one exception being the Forêt Domaniale de Vouille, Poitiers, in France where there is a high proportion of oak of coppice origin.
   - Epicormics: The coverage of epicormics, where they occurred, was estimated as a percentage surface area on the worst affected side of the tree. Greater than 5% could be rejected by eye, and trees were selected with no epicormics or <1%. This criterion proved to be the most contentious due to the role of silviculture. However, even in stands with a high prevalence of epicormic shoots, some oaks do not produce them, indicating a genetic contribution to the production of epicormics. Research at Oxford University has shown that epicormic production is heritable (0.38, narrow sense), indicating that it is possible to breed against epicormic production (Savill and Kanowski 1993: Jensen *et al.* 1997).
2. Health and Vigour
   - Frost cracks: Trees with frost cracks were rejected.
   - Pests and diseases: Healthy trees with well developed crowns were selected; but occasionally trees that showed signs of die-back were also included, since this may be a function of recent droughts, or age, rather than a pathogen.
   - Dominant trees: Forest grown trees were preferred over parkland trees, often on the basis of form, but also because the competitive environment in a forest stand has meant a higher selection intensity over the lifetime of the tree.
3. Wood Properties
   - The final selection of 100 trees was made on the basis of the criteria outlined above, coupled with an examination of the number of sapwood rings (low numbers of sapwood rings), and reduced susceptibility to 'shake' (a separation of the wood along the grain which makes the wood almost worthless), which is linked to average early wood vessel diameters. Work by Savill (1986) has shown that oaks with large early wood vessels (>160 µm radius) appear to have a much greater predisposition to shake than trees with smaller vessels (<145 µm radius). Subsequent work indicated that both vessel size (Savill and Mather 1990; Kanowski *et al.* 1991; Savill *et al.* 1993b) and the number of sapwood rings (Savill *et al.* 1993a) are highly heritable. Both were measured from 5 mm diameter increment cores taken from near the bases of the trees.

Application of criteria

Selection proceeded in two stages with the criteria being applied in the order given above. Form and health were overriding; an eye-catching straight stem was often the first step towards the tree being selected. A total of 246 trees were selected and were reduced to 110 by rejecting those with above average early wood vessel diameters, combined with a review of all other characters. The aim was to have good-quality trees and a geographical spread to capture diversity; for this reason no more than one tree was selected from any stand.

Finding the Trees

One of the problems of any selection programme is the time and expense of locating plus trees. For a tree as common as oak this problem is particularly difficult and a complete survey would be impossible and unnecessary. The selections can not, therefore, be said to be the 100 best trees in the four countries visited since not all trees were seen. However, those chosen represent a good proportion of the best-quality oaks that exist in Great Britain and Ireland. In France and the Netherlands selection was less intense, but guided by the local State Forestry organisations to find the best material for planting in Great Britain and Ireland.

In Great Britain three methods were used to sample both private and state-owned woodlands:

- Relocating the "plus" trees selected by the Forestry Commission in the 1950s; 18 trees were selected from the 31 located.
- Visiting the registered seed stands of oak; all but 3 of the 63 stands contained in the 1997 Great Britain list of stands were visited.
- Letters were placed in several journals (e.g. Barne 1998) which forestry professionals and landowners read. Replies to these proved to be very useful and preferred to a more general article in a national newspaper.

In Ireland, visits were undertaken to plus trees already identified for Coillte Teoranta (the Irish Forestry Board). In addition, several stands which had shown good results in trials of native material were also visited. Efforts were made to sample across the whole country, but the quality of the oak declined toward the west. The majority of stands visited were state- owned. All three of the registered stands of oak in Northern Ireland were visited, as were trees on three private estates.

Registered seed stands of French oak were recommended by the Centre National du Machinisme Agricole, du Génie Rural, des Eaux et des Forêts (CEMAGREF) for planting in Great Britain, located predominately in NW France. In addition, two stands were included that d represented the southern (Poitiers) and the continental eastern limit (Fontainebleau) for oak that would be expected to perform well in Britain and Ireland. All the stands visited were owned and managed by the Office National des Forêts.

In The Netherlands, the top 15 registered and tested seed stands of oak recommended by the Instituut voor Bos- en Natuuronderzoek (IBN-DLO) were visited. All these seed stands were roadside avenues owned by different state and private owners.

Selection Intensity

To give an idea of the level of selection it is useful to provide an approximate estimate of the selection intensity. The average size of the wood/compartment visited was estimated at 5 ha, and the assumed stocking density was 70-100 trees/ha. In total 235 woods/compartments were visited and 110 trees selected for trial, giving an estimated selection intensity of 0.14-0.09%, or approximately 1 tree selected in 1000.

Distribution and range of the selected trees

The distribution of selected plus trees by country and species is given in Table 1. The proportions of *Quercus robur* and *Q. petraea* are governed by the geographical extent of the search, with predominately more *Q. robur* in the east, and more *Q. petraea* in the west. The fact that the proportions of each species in the initial selection are roughly equal to the proportions of each in the final selection indicates that there was no correlation between vessel size and species for *Q. robur* and *Q. petraea*; this was borne out by statistical analysis.

The geographical spread is a N-S range of approximately 1,200 km and an E-W range of 960 km. This encompasses the variation of climatic and soil conditions that oaks are likely to encounter in Great Britain and Ireland.

Table 1: Distribution of Selected Oak Plus Trees by Species and Country. Initial selections are bracketed, the final selections are not.

Country	Q. robur	Q. petraea	Unknown/hybrids	Total
Great Britain	(93) 44	(55) 22	(12) 4	(160) 70
France	(5) 3	(37) 14	(0) 0	(42) 17
Ireland	(8) 4	(11) 7	(1) 1	(20) 12
Netherlands	(24) 11	(0) 0	(0) 0	(24) 11
Total	(130) 62	(103) 43	(13) 5	(246) 110

Wood Property Results

A summary of the wood property data is given in Table 2. The two selection criteria, mean vessel size and the number of sapwood rings, were very weakly correlated (Pearson Correlation coefficient = -0.232) and therefore selection for both criteria would have required a much larger initial sample than was available. Since shake is a more serious problem than the proportion of sapwood, the mean vessel size was used as the main selection criterion and where possible, sapwood rings were included. Only for the British oaks was there a statistically significant difference (at $p<0.05$) between the mean vessel size of the finally selected trees and the initially selected trees. The small sample size elsewhere may explain the lack of a statistically significant difference.

Table 2: Mean vessel size, number of sapwood rings, average age, and radial growth for the last 10 years for the initial and final selections.

	Great Britain Mean (SD)		France Mean (SD)		Netherlands Mean (SD)		Ireland Mean (SD)	
	Initial	**Final**	**Initial**	**Final**	**Initial**	**Final**	**Initial**	**Final**
number†	246	110	42	17	24	11	20	12
Mean vessel radius /μm*	159.6^{a} (19.96)	149.9^{c} (13.94)	145.6^{bc} (20.15)	132.0^{b} (10.25)	179.4^{d} (16.64)	168.8^{ad} (10.10)	141.4^{bc} (16.34)	131.9^{b} (10.52)
No. of sapwood rings*	23.1^{a} (6.36)	23.9^{a} (6.95)	25.0^{a} (6.15)	24.0^{a} (5.75)	16.0^{b} (4.59)	15.7^{b} (4.56)	23.6^{a} (4.84)	22.6^{ab} (4.50)
Average age /yr*	151^{a} (59.6)	152^{a} (64.8)	202^{b} (59.7)	216^{b} (75.0)	102^{c} (36.4)	101^{ac} (39.5)	104^{c} (51.2)	103^{ac} (54.7)
10-yr radial growth /mm*	26.0^{b} (10.7)	23.9^{ab} (9.79)	20.3^{ab} (9.98)	16.5^{a} (6.58)	44.7^{c} (17.27)	44.4^{c} (16.98)	25.3^{a} (13.3)	23.5^{ab} (7.27)

† Number of trees in the sample. Note: wood samples were not available for all the selected trees.
* For each character, values with the same letter are not significantly different by Tukey's Pairwise comparison at $p<0.05$.

Table 2 shows that on a country basis the French and Irish selections have significantly smaller mean vessel sizes than the British or Dutch oaks. The Dutch oaks have the largest mean vessel sizes, significantly larger than the British selections. This could have important consequences for British forestry since Dutch oak is commonly planted in Britain. The larger vessel sizes indicate an increased propensity to shake. Work by Savill and Mather (1990) has shown that vessel size is not only related to shake, but also flushing date. Therefore the country variation may be due to the milder climates of Ireland and western France favouring early flushing dates, and hence smaller vessel sizes, whereas the more continental climate of the Netherlands, with the possibility of late frosts, favours later flushing and hence larger vessel size.

Radial growth in the last ten years was recorded to test whether it is correlated with any other observed traits. Correlations were generally poor with Pearson correlation coefficients greater than 0.4 only being found between radial growth and age (R=-0.404), mean vessel size (R=0.416), and sapwood rings (R=-0.581). The negative correlation observed between growth and age is to be expected since mature trees grow more slowly in diameter than younger trees. The fact that the correlation is so poor indicates the large influence of silviculture and environment on growth. The correlation with vessel size is counter intuitive since mean vessel size within a tree is constant and unaffected by speed of growth. However, when the data are examined on a country by country basis, the fact that the fastest growing trees are in the Netherlands, where they are open-grown, and the slowest in France, where the trees were grown at high stocking densities, indicates that the correlation is fortuitous and due to differing silvicultural systems and the country differences outlined above for vessel size. When the correlation coefficient is recalculated using only samples from Great Britain it drops to 0.25, indicating that this is the case. For sapwood there was a relatively large negative correlation (R=-0.581) between the number of sapwood rings and diameter growth. The reason for this is unclear but could be linked to the physiology of heartwood formation.

Collection of seed

Having identified the trees, it was then necessary to collect seed. Unfortunately, this proved to be difficult. In 1998 there was a very poor acorn crop everywhere except in the Netherlands. In the Netherlands there was a mast year and collections were obtained for all the selected trees. In addition a handful of collections were successful in Great Britain. Collections were repeated in both 1999 and 2000. In none of these years was masting widespread and plentiful. An additional problem also arose in that all the selected trees in Fontainbleu (France) were blown over in the gales that hit that country so badly in the winter of 1999/2000. Eventually, acorns from 60 of the 110 selected trees were collected in sufficient numbers for the establishment of trials.

Acorns were sown in the Forest Research Agency's nursery in Roslin near Edinburgh. Because they had to be sown quickly after collection, and are impossible to store the plants that were eventually available for use in the BSOs differed in age by up to three years.

Collection of clonal material from mother trees

In collaboration with HRI a collection of vegetative material from all of the selected mother trees was undertaken in 1999. These were grafted onto root stocks to provide a collection of genetic material, allowing the possibility of future genetic analysis. Unfortunately, not all of the grafts were successful, and collections from about one third of the trees will have to be repeated. Grafting has been used by HRI to assess the performance and growth form of fruit trees for many years (Howard 1987, 1995) and has been achieved for oak propagated from mature trees at East Malling (Marks and Simpson 1993). This technique also allows the rapid propagation of material for screening; one potential application is screening for oak mildew resistance.

The clonal propagation of oak is difficult both by conventional vegetative cuttings and by micropropagation. However, HRI propose to investigate the feasibility of vegetatively propagating 20 elite trees on their own root systems both by micropropagation and vegetative cuttings, with the aim of answering the question; can mature oak be reliably micropropagated?

Establishment of trials

During March and April of 2003, eight trial sites were planted, either by the site owners or by contractors. In total 19,499 trees, excluding the two surrounding guard rows per site, were established (Table 3). The breeding seedling orchard design adopted was common to all sites, but there was variation between sites both for number of families and replicates. All families within a trial were represented as single-tree plots in each block (replicate) and distributed randomly within the block at planting time. The total number of families available with sufficient trees and the area presented at each site dictated the number of blocks within a trial.

At the planning stage, each trial was balanced in that all families within a trial were represented in each block by one tree. Owing to some inevitable incorrect sorting by the nursery there were either duplicates or missing families within several blocks. This factor combined with mortality and, in all probability insufficient replacement numbers available in 2004, will make the experiments slightly unbalanced. However, the large within-site replication at many sites may allow consolidation within sites to keep these site-balanced.

All trials have adequate protection from pests, either in the form of fencing, treeshelters, or spiral guards. The sites have been mapped.

At Little Wittenham, seven replicates were removed from the experiment and the constituent 392 (7 x 56) trees lined out by family in a *demonstration plot* adjoining the BSO.

Table 3

The eight P2003 BIHIP oak breeding seedling orchard experiments.

SITE	Families per site	Replications per site	Trees per site	Area per site(ha)
Little Wittenham, Oxfordshire	56	40	2240	0.96
Shakenhurst Worcestershire	21	100	2100	0.84
Belmont Kent	34	71	2414	0.97
Sotterley Suffolk	61	50	3050	1.22
Newton Rigg Cumbria	40	63	2520	1.01
Dalkeith Midlothian	31	85	2635	1.05
Bwlchgwynt Carmarthenshire	44	53	2332	0.93
Co. Cork Ireland	46	48	2208	0.88

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[2] Northmoor Trust.

EUROPEAN OAK CULTIVARS, COLLECTIONS AND COLLECTORS

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Key words: *Quercus, Oak Cultivars, Oak Collections, Oak Collectors*

Abstract: *Oak cultivars are part of the horticultural heritage in Europe. Among the recorded named cultivars, only a third of them are still in cultivation. An overview is given to show the differences among the cultivars. Historical and present oak cultivars and oak collections are described. The future development of oak cultivars, their biological diversity, and the importance of oak collections are discussed.*

Introduction

Some 600 oak species are known to science (Govaerts & Frodin, 1998). From this huge number of oak species, about 240 cultivars of oak have been named (Petzold & Kirchner, 1864; Schneider, 1916; Boom, 1949; 2000; Rehder, 1949; Krüssmann, 1976; McArdle & Santamour, 1985; 1987a&b; Jablonski et al., 2001; Lübbert, 2001a&b). Although the number of oak species is large, cultivars stem mainly from just a handful of species. About three quarters of all known oak cultivars come from just three European species: *Quercus robur, Quercus petraea* and *Quercus cerris* (Figure 1).

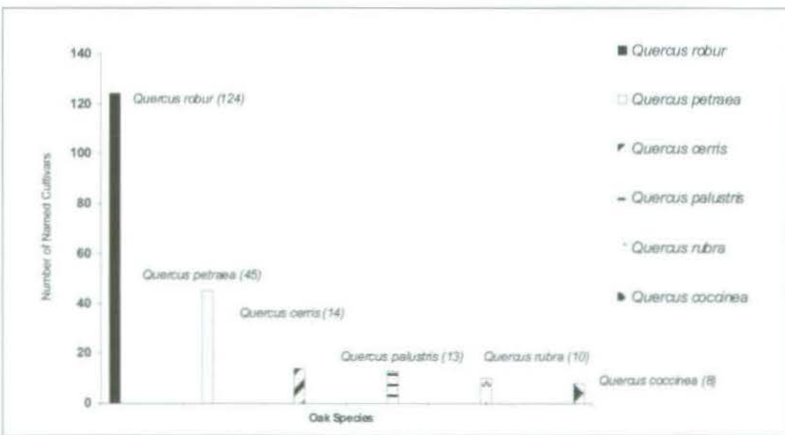


Figure 1: Named cultivars of *Quercus robur*, *Q. petraea*, *Q. cerris* and some American oaks.

Around 40 cultivars also come from American Oaks, e.g. *Quercus rubra, Quercus palustris, Quercus coccinea,* and *Quercus virginiana.* Interesting enough, the only widely grown oak cultivar in the United States is a cultivar of the English Oak, *Quercus robur* 'Fastigiata'.

Cultivars from several Japanese species are recorded, but most are poorly known outside of East Asia. About ten of them are still in cultivation (KATOH, 2002). Only one of them is well known in Europe, the beautiful *Quercus dentata* 'Pinnatifida'.

Since the 18th century, different forms of European Oaks, such as *Quercus robur* and *Quercus petraea*, have been documented. Only three oak cultivars were described before 1800: *Quercus robur* 'Fastigiata', 'Pendula' and 'Variegata'. At the time, these selections were not called cultivars in today's sense; they were regarded merely as varieties or forms of a normal tree. From a total of 124 described cultivars of *Quercus robur* known today, 57 were introduced in the second half of the 19th century. This was the epoch of the great plant collectors, who collected not only worldwide, but also in their home forests. They took all that was strange and different, even if the differences were so small that they were difficult to discern! Many of the described cultivars from that time are lost from cultivation today. After the turn of the 20th century, just a few new oak cultivars have been selected, but from 1950 until today, some 40 new *Quercus robur* cultivars have been introduced, some of them with outstanding characteristics (Figure 2).

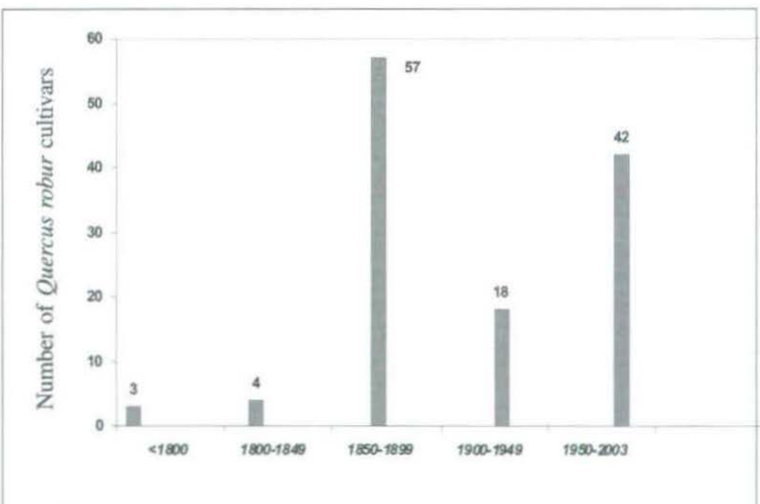


Figure 2: Timetable of the introduction of *Quercus robur* cultivars

The First Cultivars

Forms of the common (English) oak, *Quercus robur*, were probably the first cultivars, in those days treated as varieties or forms, as has already been noted. The first documented oak that differed in form from the norm was an upright form of the English Oak: *Quercus robur* 'Fastigiata'. It was already known in the middle of the 18th century. First descriptions date from 1781 (Anonymous, 1781), and again from 1821 (Bechstein, 1821), but the story starts long before that date.

A fastigiate form of *Quercus robur*, growing at the edge of the famous Spessart forest near the small village of Harreshausen, close to Darmstadt in Hesse, has long been known as an unusual form of oak. It was given the name of "The Beauty Oak of Harreshausen". The history of this specific oak started around 1450, when it was a seedling in a dense forest. As a mature and already a vigorous tree, a secondary trunk that was growing out of the crown distinguished it. Around 1700, Duke Reinhard II of Hanau ordered this trunk to be shot (???), which was done by his head forester (Caspary, 1873). According to the

"The Beauty Oak of Harreshausen"with author standing at the trunk. photo © Guy Sternberg

French army officer stationed there during the occupation following the Seven Years War collected masses of acorns from this tree around 1759. The fastigiate oaks found in France today may have originated from this oak (Schenck, 1916). Years later, when Napoleon's army invaded Hesse and occupied Darmstadt in 1806, the French General in charge placed an armed guard around the tree to protect it from felling, just as it was done some 50 years before by another French Army officer. For decades, this oak also was a landmark on a pilgrimage path, and pilgrims stripped off a piece of the bark and carried a piece of it as a sign of good luck (but not for tree certainly).
Around 1821, the surrounding forest was cut down, but this remarkable oak was spared (Caspary, 1873). The original height was described in 1781 as some 28 meters (Anonymus, 1781). Lightning struck the oak in 1871, and in 1928 a second bolt struck it, shattering more than half of the crown.

This oak is still growing today, in the midst of vegetable fields, still showing the unusual beauty. Although surgical work has recently been done on the tree, it is to be hoped that this exceptional oak will live many more decades.

At the end of the 18th century, unusual plants were a part of the parks and gardens of the nobility. It is known that grafts were made from the "Beauty Oak of Harreshausen", and as early as 1795 Elector Wilhelm I of Hesse-Kassel had planted a grafted tree in the famous park of Wilhelmshoehe at Kassel (Jablonski, 1998). This tree is still growing in its original location. Rare or unusual plants were also exchanged among the nobility, and thus it is believed that at that early stage fastigiated oaks from Kassel were distributed all over Europe, and later to America. Seedlings from the two fastigiate oaks at Harreshausen and Kassel were also distributed. Loudon (1841) shows a drawing of a fastigiate oak in his "*Arboretum et Fruticetum Britannicum*". The fastigiate character is dominant, and the trait of upright growth is passed to progeny: two of three seedlings are always more or less fastigiate, if the mother tree is a fastigiate oak (Oppermann, 1932; in McArdle & Santamour, 1985).

A variegated oak is also known from this early period. The epithet "variegata" does not clearly distinguish among variegated selections, but it is known that one variegated oak was found around 1770, and a pendulous oak was known as well. As the techniques of grafting were known at that time, it was possible to propagate and distribute such forms.

With the change of garden style, which emanated from Britain around 1800, the parks changed from formal baroque gardens to gardens with more natural landscapes. Parks with this new style were planted with trees such as oaks that did not need to be pruned. At first, the native oaks from the woodlands were planted in the new parks. Later, after more and more exotic plants were introduced (first from North America, and later from Asia), it became increasingly fashionable to collect rare and unusual trees, both exotics from abroad, and unusual forms of native trees. Nurseries also collected more and more unusual forms, which they gathered from foresters and farmers, and plant collectors. The height of the interest in unusual plants was in the middle of the 19th century. Trees that differed even slightly from the norm were selected and propagated. Between 1850 and 1899 nearly 60 new cultivars of the common English Oak *Quercus robur* alone were named, and a large number of forms of *Quercus petraea* and *Quercus cerris* as well. Most of these forms were selected in Germany.

Differences Among Oak Cultivars

Although there are many different oak cultivars, it is possible to put the oak cultivars into groups with certain common attributes. The cultivars differ from the parent species in certain features, such as growth habit (fastigiated, pendulous, creeping, tortuose, horizontal, dwarf, single leader); leaf color (red, yellow, variegated colors), leaf form (laciniate, cucullate, crinkled, bullate, unlobed), or leaf size (smaller, larger), and also certain aspects of autumn coloring. Combinations of the different attributes do also occur, and these attributes are normally easy to recognize. Other important attributes, which are only recognizable after a long-term observation, are such things as tolerance of, or resistance to, pests and diseases, or environmental influences (e.g. nonsusceptibility to powdery mildew; drought resistance, tolerance of high pH).

Some of these groups include a number of different oak cultivars, all with an attribute in common. The fastigiate oaks, for example, form a group of some 30 different and named clones. They share the trait of fastigiate growth, but differ in their habit (from an extreme narrow growth to a broad upright form), or show different abnormal leaf characteristics. Some are resistant to powdery mildew, while others are not.

Historical Cultivars, Collections and Collectors of Oaks

Wilhelmshöhe and Karlsaue, Kassel (Central Germany):

Not only grafts but also a large number of seedlings from the fastigiate oaks in Harreshausen and Kassel were distributed, with the result that many forms of fastigiate oaks were named. Today, there exist some good forms of the fastigiate *Quercus robur*, one of them found in Kassel "Karlsaue Park", and distributed under the name 'Kassel' by the Döring Nursery, Ahnatal. From 1822 to1864, Wilhelm Hentze was the Garden Director in Kassel. Hentze was very keen on oaks and presided over one of the richest oak collections of that time, with more than 50 different oaks, many of them cultivars (Jablonski, 1999). One of his selections was a slow growing *Quercus robur* with narrow, warped leaves. This selection is still in culture: *Quercus robur* 'Hentzei'. The old oak collections in Kassel include some very rare oak cultivars grown: one is *Quercus robur* 'Macrophylla' with luxuriant foliage; another is *Quercus macranthera* 'Kasseler Gold', an old and until recently little known selection, which was listed in an old handwritten compilation as *Quercus macranthera* 'Aurea' (which is actually an invalid name because it lacks a description). The leaves of this oak show a pure yellow flush in spring, becoming light green in summer. In autumn, a warm golden color distinguishes this cultivar (Jablonski, 2000).

Muskau Park, Muskau (Eastern Germany/Poland)

In Muskau, Eastern Germany, 1815 the landscaping Prince Pückler began to create the largest classical 19th century landscape park ever devised. Since 1945, however, the German-Polish border has run through the middle of the park, and now only 200 hectares (494 acres) remain in Germany; the remaining 350 hectares (865 acres) lies in Poland. Pückler had to sell the park in 1845 to Prince Frederick of the Netherlands, who improved the park, with the constant help of Eduard Petzold and Georg Kirchner. In 1864 these men wrote an account of all trees under cultivation in the Arboretum, which is still an important source for early cultivar descriptions (PETZOLD & KIRCHNER, 1864). Altogether the arboretum housed a collection of some 150 different oaks, many of them forms of *Quercus robur* and *Quercus petraea*. Muskau is one of the first places where oaks were collected systematically, and where all new forms and varieties were brought together. From here, and from the associated nursery, many of the new oak forms or cultivars found their way to other nurseries and parks all over Europe.

Some of the following oak cultivars from Muskau were first described in 1864 by PETZOLD and KIRCHNER:

- *Quercus cerris* 'Argenteo-variegata', a beautiful variegated Turkey Oak;
- *Quercus petraea* 'Cochleata', with blistered, leaves, which appear to be infested;
- *Quercus robur* 'Argenteo-marginta', leaves with an irregular, but sharply defined white border. Sometimes the acorns show also a variagation.
- *Quercus robur* 'Pulverulenta', leaves with abundant yellowish-white striations and flecks.
- *Quercus robur* 'Argenteo-picta', with green leaves in spring, but second growth with almost completely white or with white marbled leaves.
- *Quercus robur* 'Atropurpurea', with dark brown foliage. Unfortunately this selection is susceptible to powdery mildew;
- *Quercus robur* 'Crispa', with crinkled dark green foliage and curled margins;
- *Quercus robur* 'Pectinata', with deeply cut leaf lobes, similar to 'Filicifolia';

The yellow English Oak, *Quercus robur* 'Concordia', was also first described by PETZOLD and KIRCHNER (1864). It originated, however, about 1843 at the VAN GEERTS nursery in Ghent, Belgium.

A *Quercus petraea* selection with an unusual, only slightly lobed leaf, still in cultivation, was later named *Q. petraea* 'Muscaviensis'.

Späth Nursery, Berlin, (Eastern Germany)

After the liquidation of the Muskau park nursery, the Späth Nursery, which was the largest nursery in the world around 1900, bought the complete oak collection of Muskau, together with many other woody plants. The Späth nursery introduced a large number of oaks, and many new cultivars, such as the *Quercus petraea* 'Giesleri', one of the cultivars of the sessile oak with narrow, almost unlobed leaves (SPÄTH, 1912; 1930). Another oak cultivar introduced by Späth is:

Quercus robur 'Fürst Schwarzenberg', with normal leaves in spring, but the second growth of shoots with white spots and pink leaves at the top of the second shoot. Unfortunately, this beautiful cultivar is very susceptible to powdery mildew. The Späth nursery still exists today. Several interesting oaks are present in their arboretum, but none of the famous cultivars is still there.

Hesse Nursery, Weener (Northern Germany)

In northern Germany, the Hesse nursery was nearly as large as the Späth Nursery in Berlin. With their huge assortment of tree varieties, this nursery was known worldwide. Unfortunately, the nursery had to close in 1992 because of fiscal difficulties. Around 1925, the nursery cultivated some 100 different oaks. One well-known oak cultivar introduced by Hesse, and still in cultivation, is:

Quercus petraea 'Laciniata Crispa', a wonderful tree with very unusual foliage; the first shoot is nearly normal, followed by a second growth with more or less irregular lobed and incised leaves, often extremely narrow and drawn out in length. This beautiful cultivar occurs quite frequently in European collections.

Q. x *rosacea* 'Columna' photo © Guy Sternberg

Hesse also introduced the interesting hybrid *Quercus* x *rosacea* 'Columna', with *Quercus petraea* 'Muscaviense' and *Quercus robur* 'Fastigiata' as parents. The fastigiate growth, combined with the large, oblong, narrow leaves, makes this an excellent cultivar. It is far more resistant to powdery mildew than most fastigiate English oak cultivars.

Arboretum Malonya (Mlynany), Austria-Hungary (Slovak Republic)

In 1892, the Hungarian Duke ISTVAN AMBROZY-MIGGAZZI founded an Arboretum at Malonyana, a small town in the northern part of the Hungarian Plain. His aim was to create a park mainly with evergreen woody plants, and he started to collect and to plant every evergreen plant he could find. His motto "Semper Vireo" is still to be seen at the entrance of his castle amidst the park. Together with his excellent head gardener, JOSEF MISAK, he tested the plants brought from all over the world, mainly for winter hardiness. His main object was to collect *Rhododendron* and *Prunus laurocerasus*, but he also assembled a number of evergreen or wintergreen oaks (MISAK, 1925; TABOR & PAVLACKA, 1992). Of the many oaks he tried and selected, two cultivars were named after him:

Quercus x *hspanica* 'Ambrozyana'(by some still recognized as a variety of *Quercus cerris*), a nearly evergreen form, and *Quercus pubescens* 'Miggazziana', a semi-evergreen form. Both of them are still in cultivation and available in the trade. Contemporary cultivars, collections, and collectors of oaks

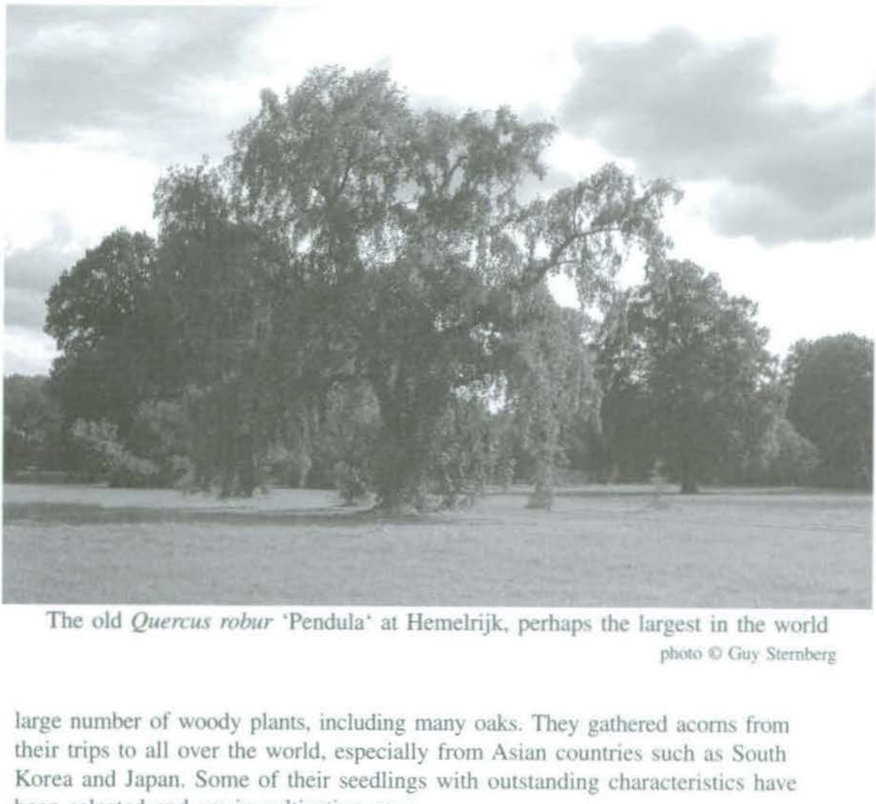
At the present time, a few important oak collections are based in continental Europe, and several nurseries specialize in oaks. Also, some new oak cultivars have been established recently at Arboretum Trompenburg, Rotterdam (The Netherlands). The finest present-day European collection of oaks is at the Arboretum Trompenburg in Rotterdam, The Netherlands. J.R.P. VAN HOEY SMITH, former owner of the Arboretum Trompenburg (which is now a foundation), has a keen passion for oaks. He bought his first oaks in 1939 from the Hesse Nursery in Germany. These oaks are still growing in Trompenburg, together with some 260 others, all different, of which more than 100 are cultivars (HOEY SMITH, 1992; 2001). Many of the older cultivars are growing there, but VAN HOEY SMITH has always sought and introduced new oaks, many of them commercially available. Some of his introductions are:

- *Quercus castaneifolia* 'Zuiderpark', a beautiful form of the *Quercus castaneifolia*, with unusually deeply incised leaves. Originally found at Zuiderpark in Den Haag, this tree is now in cultivation.
- *Quercus cerris* 'Marmor Star', a stable yellow variegated *Quercus cerris*.
- *Quercus* x *libanerris* 'Rotterdam', a hybrid of *Quercus cerris* x *Quercus libani*, which has a central leader, making it suitable for street planting. The leaves are like those of *Quercus libani*, the growth like *Quercus cerris*: thus uniting the best characteristics of the two parents.
- *Quercus ilicifolia* 'Tromp Ball', a dwarf selection of *Quercus ilicifolia*, a 40-year-old shrub of distinctly slow and compact growth; it reaches 1.8 meters in height.
- *Quercus montana* 'Laciniata', with deeper lobes, originally from a tree cultivated at the Arnold Arboretum in Boston, Massachusetts, U.S.A.
- *Quercus robur* 'Salfast', an interesting upright oak, with entire leaves of the old cultivar 'Salicifolia' and fastigiate growth. This is a seedling of *Quercus robur* 'Fastigiata' and *Quercus robur* 'Salicifolia'.
- *Quercus robur* 'Strypemonde', a selection made already by van Hoey SMITH's father from a tree growing at their estate Rockanje; it has incised and curled leaves, similar to the old cultivars 'Fennessii', 'Hentzei' and 'Heterophylla Cucullata'.

- *Quercus robur* 'Tromp Dwarf' is a promising slow growing selection of a seedling from *Quercus robur* 'Cristata', forming a globular little shrub. After 25 years, it has reached just about one meter in height.
- *Quercus* x *rosacea* 'Eastcolumn' and 'Westcolumn', two fastigiate selections with compact growth, originating from seedlings of *Quercus* x *rosacea* 'Columna'. They are planted together and named for their respective positions in the Arboretum.
- *Quercus* 'Pondaim', a hybrid of *Quercus dentata* and *Quercus pontica* now 50 years old, with good healthy foliage and vigorous growth, suitable for large gardens and parks.
- *Quercus* 'Macon', also a hybrid, the parents are *Quercus frainetto* x *Quercus macranthera*. This cultivar, now 50 years old, shows vigorous growth as well as very healthy foliage.

Arboretum Hemelrijk, Essen (Belgium)

In Northern Belgium, Baroness Jelena and Baron Robert de Belder, co-founders of the International Dendrology Society, created the Arboretum Hemelrijk from 1960 onwards. Some old oak cultivars were already planted, such as a huge *Quercus robur* 'Pendula'. As keen plant people, they have collected a



The old *Quercus robur* 'Pendula' at Hemelrijk, perhaps the largest in the world
photo © Guy Sternberg

large number of woody plants, including many oaks. They gathered acorns from their trips to all over the world, especially from Asian countries such as South Korea and Japan. Some of their seedlings with outstanding characteristics have been selected and are in cultivation now:

- *Quercus dentata* 'Carl Ferris Miller' is a selection of the Daimyo Oak from South Korea. This cultivar shows a vigorous growth, a good hardiness, and has healthy, leathery foliage.
- *Quercus dentata* 'Sir Harold Hillier', another selection of the Daimyo Oak with good hardiness and a rich orange to golden autumn color. Both Daimyo Oaks originated from seedlings. The acorns were gathered on a tour to South Korea, which the de Belder's made together with Mrs. And Mr. Harold Hillier from England.
- *Quercus ithaburensis* subsp. *macrolepis* 'Hemelrijk Silver' is a hardy selection of this Mediterranean oak, with luxuriant foliage. New shoots and leaves are remarkably silvery because of their dense indumentum.
- *Quercus ellipsoidalis* 'Hemelrijk'; this selection shows exceptional dark red autumn color.

Waasland Arboretum, Nieuwkerken (Belgium)

Michel Decalut, a former sailor with an interest in plants, founded the Waasland Arboretum in 1972. He started to collect all woody plants he could find in nurseries and collections, and planted them around his house. Nowadays the Arboretum Waasland and nursery lists some 3500 different plants, including some 150 different oaks. Some of them are their own selections. These include:

- *Quercus x hispanica* 'Waasland Select', a seedling of *Quercus cerris* x *Quercus suber*, the cork oak, with small incised leaves, which persist on the tree in winter, and good hardiness.
- *Quercus cerris* 'Waasland Compact', a compact and slow growing form of *Quercus cerris*, which reaches 5 m height in 25 years. It is a suitable selection for the smaller garden.
- *Quercus trojana* 'Fragno', with curled leaves, a seedling from acorns gathered at Kew Gardens.

Poznan Botanical Garden, Poznan (Poland)

In Poland, nurserymen and the Polish Institute of Dendrology have produced a few oak cultivars. In the Botanical Garden of Poznan, the following polish cultivars can be found:

- *Quercus* 'Monument', a newly introduced cultivar is a hybrid with upright growth. The parents are thought to be *Quercus macranthera* and *Quercus robur* 'Fastigiata'. Leaf characters are intermediate between *Quercus macranthera* and *Quercus robur*, dark green, thick and not susceptible to powdery mildew (Jerzak & Zielinski, 2002).
- *Quercus robur* 'Jan Zamoyski', a beautiful variegated English Oak, unknown in cultivation in Western Europe, but already known in 1903 at the Podzamcze Nurseries in central Poland.

Bömer Nursery, Zundert (The Netherlands)

Jo and Maarten Bömer founded the M.M.Bömer Nursery in 1966 in Zundert, Southern Holland. They began specializing in Chestnuts, Ginkgos and other Conifers, but became more and more interested in Beeches (*Fagus*) and Oaks. Because of their close contacts with collectors all over Europe, they have gathered a huge collection of oaks, including many rare and unusual forms, and introduced numerous new cultivars. Some of these are the following:

- *Quercus robur* 'Irtha', with curled and incised leaves, similar to those of 'Strypemonde'
- *Quercus robur* 'Miki', with deeply incised leaves, of uncertain origin. In fact, this oak so different from the normal form of English Oak that the cultivar was for some time treated as a red oak cultivar. This selection is originally from Hungary.
- *Quercus robur* 'Gyor', a slow and very narrow-growing fastigiate selection, found in Hungary in the city of Gyor.
- *Quercus robur* 'Hof ter Saksen', found by Maarten Bömer at the Belgian Park at Hofter Saksen. It is a selection with an outstanding and regular crop of fruits, the acorns larger than normal. It is a selection for fruit production, and therefore, as Maarten says, "good for the pig farmer".
- *Quercus cerris* 'Curly Head' is a slow growing selection of the Turkey Oak, with curled, small, deep green foliage. This is a promising new cultivar as it is suitable also for the small garden. Grafted on a rootstock or on a standard, it makes a beautiful addition to the oak assortment. It was found by M. Bömer as a chance seedling.
- *Quercus cerris* 'Summer Vale' is another outstanding selection of the Turkey Oak, with deeply lobed and incised leaves, better than many existing forms. This oak is also a chance seedling, found by M. Bömer.
- *Quercus rubra* 'Vana' shows an extraordinary leaf variation that is very stable. This is one of the American oak cultivars raised in Europe; this one originated in Belgium.
- *Quercus rubra* 'Haaren' is a dwarf selection of the American Red Oak. It was found as a witches broom in the city of Haaren, The Netherlands.

Plate 2. Foliage of *Q. Cerris* 'Summer Vale' photo © Guy Sternberg

Döring Nursery, Ahnatal/Kassel, Germany

In 1957, the DÖRING nursery was founded in Ahnatal, a small village close to Kassel in Central Germany. Now maintained by the third generation, all of the DÖRINGS collected and propagated rare and unusual plants. Since 1981, oaks are one of the specialties there. Today the oaks in cultivation number about 160 different ones. Close to Kassel, Dieter Döring is propagating many of the old cultivars from Kassel and Muskau. Anyhow, he also introduced a number of his own selections, such as:

- *Quercus rubra* 'Boltes Gold' is a seedling of the Golden Red Oak, *Quercus rubra* 'Aurea'. The leaves are thick and leathery, and this oak can thus be planted in full sun without risk of burn on the leaves. This one was introduced by M.M. Bömer as well.
- *Quercus petraea* 'Lanze' is a seedling of *Quercus petraea* 'Mespilifolia'. It shows slower growth and smaller foliage than 'Mespilifolia' or the old cultivar 'Muscaviense'.

Oak Cultivars for the Future

What can be expected regarding oak cultivars in the future? Is there any reason to seek new forms of oaks? It must be admitted that nurserymen and collectors are always eager to find something new. If it is better than an existing plant, it will be taken into culture, and will become available in the trade. A new cultivar with outstanding characteristics can also be of economical interest for the producer. According to HATCH (1998), there are multiple reasons to find new ornamental plants, such as unusual or new combinations of certain attributes, or better propagation possibilities for the producer. In addition to new forms of oaks with unusual foliage or growth habit, resistance to pests, diseases and environmental changes would be very desirable. Today, there is a demand for several particular characters in oaks:

- **Leaf characteristics**: yellow leaves which do not burn in the sun (e.g. *Quercus rubra* 'Boltes Gold'); red leaves not fading to green during the summer (*Quercus robur* 'Timuki', an oak with red foliage not fading out, introduced by Bömer), remarkable variation (*Quercus rubra* 'Vana' or new *Quercus palustris* seedlings); remarkable incised leaves (*Quercus robur* 'Miki'; *Quercus cerris* 'Summer Vale'); but also exeptional autumn color, which is shown by the cultivars *Quercus ellipsoidalis* 'Hemelrijk' (from de Belder), *Q. coccinea* 'Splendens' and Q. rubra 'Magic Fire' (introduced by Bömer).

Q. x *reifii* var. *warei* 'Windcandle'
photo © Guy Sternberg

- **Growth habit**: smaller gardens need smaller plants: *Quercus robur* 'Gyor'; *Quercus robur* 'Tromp Dwarf' and *Quercus cerris* 'Curly Head' (this three already mentioned); or *Quercus palustris* 'Swamp Pygmy' and 'Green Dwarf', two dwarf selections of the Pin Oak by Bömers. Other promising selections are made at Bömer's nursery, such as dwarf growing seedlings of *Quercus cerris*, *Quercus palustris* or *Quercus robur* 'Fastigiata', all without a cultivar name yet.
- **Resistance to stress, pests and diseases**: *Quercus* x *reifii* var. *warei* 'Windcandle' (a selection made by Guy Sternberg, Illinois, for upright growth and good resistance to powdery mildew. It is a hybrid of *Quercus bicolor* and *Quercus robur* 'Fastigiata'); *Quercus* 'Monument'
- **Suitability for street planting (i.e. showing a central leader and/or vigorous growth)**: *Quercus robur* 'Alpha' and 'Beta', *Quercus frainetto* 'Trump', all three Dutch selections that show a good central leader (Grootendorst, 1980).

The Importance of Oak Cultivar Collections

Oak cultivars belong to the European horticultural heritage. Despite the vast number of oak cultivars, which have been named, only a third are still in cultivation and commercially available from specialized nurseries (Figure 3). For example, 124 clones of *Quercus robur* are named (from which about 25 named clones are not commercially available and only a mother plant in the nursery is existing). Only about 40 of them are still growing in living collections, and 33 of them are still available in the trade. In the regular nursery trade, both in Europe and the United States, only one oak cultivar plays a major role: the fastigiate English Oak.

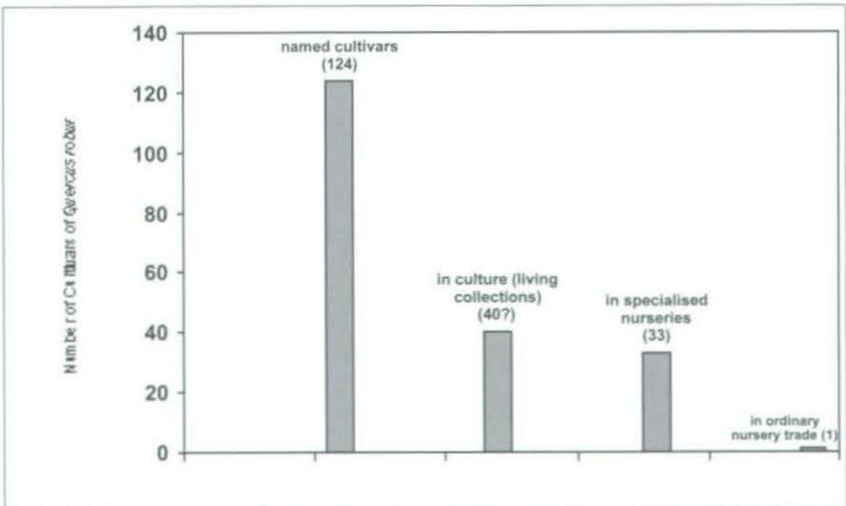


Figure 3: Cultivars of Quercus robur (named, in collections, and in nurseries)

Oaks are not longer a part of the modern European garden inventory. They are simply too large for small European gardens. Where space is available, in public parks or Botanical Gardens, the policy is different: in public parks today the planting of indigenous trees is favored. The preference for indigenous trees, the lack of money for trees from specialized nurseries, and perhaps a lack of sophistication on the part of landscape architects, make it highly unlikely that selected oak cultivars will be planted in today's public plantations.

Botanical Gardens in general have the policy of planting only wild collected material or material of known wild origin, an understandable policy when the purpose is scientific. These taxa are normally pure species, not cultivars. According to Menzel (2001) and Schwarz (2001), it is important for the future to conserve collections of ornamental plants such as of oaks and their cultivars, but also to watch for potential new collections. There are several reasons for this. These include: *horticultural history; horticultural tastes; breeding catalogs and other information on propagation; information about tolerance and resistance to environmental stress, pests and diseases;* and *comparison of similar cultivars*. Reference collections for oak cultivars should be planted in at least two or three different locations and countries, with different ecological, edaphic, and climatic characteristics. Data from such controlled plantings will be of immense value in the future as mankind adapts nature to his ongoing practical and aesthetic needs.

Summary

Already since the end of the 18th century, unusual forms of oaks have been collected. Today some 240 cultivars of oaks are known, many of them no longer in cultivation. The height of the interest for oak cultivars was around 1850, when forms with even a little difference were selected. Oak cultivars may be put together in groups or sections with certain attributes in common, as it is done with the fastigiate forms of *Quercus robur*. Anyhow, single clones with exceptional characteristics should be carefully separated. Today's new cultivars have to have striking attributes, or they have to be resistant or tolerant to stress, pests and diseases, if they shall be of economical interest for nurserymen. Presently, oak cultivars are not widely planted, for several reasons. Although there is concern about the future of oak collections, enthusiastic private collectors play an important role in the conservation of oaks.

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GROWING, SELECTING, AND ESTABLISHING 1-0 *QUERCUS RUBRA* AND *Q. ALBA* SEEDLINGS FOR RAPID GROWTH AND EARLY ACORN PRODUCTION ON FORESTED LANDS IN THE SOUTHEASTERN UNITED STATES

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Introduction

Northern red oak (*Quercus rubra* L., NRO) and white oak (*Q. alba* L., WO) are among the most valuable oak species in the eastern United States and throughout the eastern provinces of Canada. They have a broad geographic distribution; yet no single regeneration mechanism can explain their presence in current stands. Both species are declining in numbers and importance on high quality mesic sites throughout their range. Many scientists feel NRO may become threatened or endangered on these sites unless new regeneration techniques are developed (Kellison 1993). The status of WO is not as critical because it can develop on poorer sites than NRO. Nevertheless, its competitive position on high quality sites is precarious.

These two species often coexist in natural stands in the US. Many oak-dominated stands originated because of human activity or biological catastrophes such as the chestnut blight caused by *Cryphonectria parasitica* ((Murr.) Barr). This disease resulted in the decimation of American chestnut (*Castanea dentata* (Marsh.) Borth.). Also, past land use, harvesting practices, and fires have enabled these oaks to occupy broad geographic and physiographic ranges (Abrams and Norwacki 1992). Currently, whether NRO stands are harvested, or whether the trees have succumbed to other disturbances such as gypsy moth (*Lymantria dispar* L.), new stands are not becoming established. However, a method used for regenerating these oaks on low quality sites (Site Index$_{50} \leq 20$ m, height of dominant and co-dominant trees at age 50) reliably produces new stands composed of stump sprouts and individuals of seedling origin (Sander 1972). The procedure consists of thinning the mature stands to specific densities, then allowing oak seedlings to regenerate under the canopies. Once the desired seedling densities and sizes are obtained, the overstory canopy is removed. This shelterwood technique popularized the term "advanced oak regeneration" and specified the widely accepted minimum seedling stem height of 1 m in the eastern and central US. Others tried to modify Sander's low-quality site shelterwood prescription for use on high quality mesic sites. The results showed that shade tolerant species, as well as yellow poplar (*Liriodendron tulipifera* L.), responded well to these shelterwood modifications, but oaks did not (Loftis 1983).

Sander's (1972) system proved effective on the low-quality sites, especially with WO, because faster growing competitors to the oaks were absent or at minimal levels on these sites. A disadvantage was that at least 10-20 years might be needed to build up the necessary advanced oak regeneration. To shorten this regeneration cycle, attempts were made to incorporate artificial regeneration on the low-quality upland sites, as well as on high-quality mesic sites (Johnson 1993). On high-quality sites, however, severe competition from faster growing and/or more shade tolerant species (Barton and Gleeson 1996; Crunkilton et al. 1992) and the absence of high quality oak planting stock prevented artificial regeneration from being a practical endeavor. As needs of diversified management options gained in importance, the declining numbers of these two important species became of considerable concern among forest managers. This situation has lead to a resurgence of interest in oak management throughout the US.

Our goal in this oak research was to develop a reliable regeneration technology for establishing several species of oak on high-quality mesic sites in the southeastern US National Forest lands. The goal of this management technology placed equal consideration to timber values and to mast production needed for wildlife management efforts. As was amply demonstrated during the 2003 International Oak Society meeting, there are countless other landscape uses of oak that can employ other specific morphological attributes. These other attributes are not necessarily suitable for successful forest regeneration where vegetation competition can be severe.

Initial research with northern red oak

In the early 1980's, concern grew about the failure of NRO and WO to regenerate on high quality mesic sites through their ranges in North America. One of the questions asked was whether ectomycorrhizal fungi could improve establishment of these oaks as much as has been repeatedly demonstrated with various coniferous species (Marx 1991). From the beginning, research clearly demonstrated that various ectomycorrhizal fungi would readily colonize oaks under controlled, sterile conditions. However, the 1-0 stock produced did not attain the size desired for artificial regeneration use. For several years, countless oak seedlings were grown at the experimental nursery maintained by the Institute of Tree Root Biology of the US Forest Service under different nursery protocols. As seedling quality gradually improved, it became evident that a better method of evaluating seedling quality would have to be developed. The traditional mycorrhizal index used so successfully in conifer studies (Marx 1991) was inadequate for oak seedling quality evaluation. What was readily apparent was that seedlings could have comparable mycorrhizal indices, but be significantly different in seedling development and outplanting performance. Gradually, it became clear that while the percentage of feeder roots colonized by ectomycorrhizal fungi was important to seedling development, the number of first-order lateral roots (FOLR) was the essential factor in determining seedling field performance. Simply stated, higher FOLR numbers resulted in more mycorrhizal short roots for absorbing soil moisture and nutrients. However, in spite of nursery soils being artificially inoculated with specific ectomycorrhizal fungi, the nursery protocols used then rarely produced 1-0 oak seedlings with the necessary minimum root collar diameters (8 mm) and heights (0.8 m) for outplanting.

Development of a nursery base-line fertility protocol

During the initial phase of working with oaks, we found that few seedlings had more than three growth flushes the first year in the nursery beds. Tight terminal buds were usually present by late July. Over a period of three to four years we developed a nursery baseline fertility protocol that characteristically produced many 1-0 seedlings with five to seven flushes. Final heights and root collar diameters could exceed 1.0 to 1.25 m and 12 mm, respectively. With slight modifications, this protocol is effective for most hardwood species and has been used on 17 other species of oaks. Briefly, the extractable soil nutrient concentrations are adjusted to maintain Ca at 500, K at 130, P at 100, Mg at 75, Cu at 0.3-3, Zn at 3-8, and B at 0.4-1.2 ppm. From 900 to 1350 kg/ha of NH_4NO_3 is top-dressed in increasing increments over the growing season. From 50 to 170 kg N/ha is applied at 10-14 day intervals until 6 to 7 weeks before the first frost is expected (Kormanik et al. 1994).

With this baseline fertility procedure, approximately 30 to 35 days are required for the sequence of bud set, bud swelling, bud break, stem elongation, leaf expansion, leaf maturation, and bud set in various oak species in our area (Sung et al. 2002, 2004). Irrigation is provided throughout the growing season when rainfall is less than 2.5 cm per week and is reduced after mid-October. Irrigation is stopped when the leaf abscission zone develops after several frosts.

Initial attempts on up-scaling seedling production to larger commercial forest seedling nurseries proved difficult because nursery managers who had successfully grown conifers for many years were reluctant to modify their nursery procedures to accommodate the biological requirements of oaks. Currently commercial up-scaling of this nursery protocol has been successfully used in three different forest tree nurseries.

Biological considerations in oak seedling production

Perhaps the most common cause of nursery failures in producing seedlings meeting the standard for outplantng is mishandling of the acorns. Only sound, weevil-free acorns which have not been desiccated should be used for seedling production. Acorns are recalcitrant and when permitted to desiccate, they will either not germinate or, if they do germinate, will produce inferior grade seedlings. This is especially true for WO which rapidly desiccates upon radicle protrusion. This rapid radicle elongation is, of course, most pronounced with WO since no stratification period is required for germination. Furthermore, radicles that protrude and elongate in storage are readily broken, a circumstance that can result in multiple taproots. Seedlings exhibiting this condition frequently develop poorly, both in the nursery and after outplanting for at least six years (PP Kormanik, personal observation).

A major consideration in producing quality oak seedlings in our geographical area is to maintain the 30 to 35 days bud-to-bud cycle in the nursery bed until the main seedling canopy is 0.75 to 1.0 m. Buds should not be permitted to become dormant until the desirable height is obtained. If either the irrigation or nitrogen top dressing schedules are ignored, the buds can become dormant, and then it can be extremely difficult to stimulate bud break again. In fact, permitting premature bud set and sowing acorns which may have been desiccated are the major causes of substandard seedling sizes. The development of WO is significantly slower than that of NRO and seedlings frequently need more seasonal top dressing and irrigation than NRO seedlings to obtain sizes desirable for artificial regeneration.

Maintenance of soil moisture has proven to be essential even long after fall leaf coloration occurs. In early December, even though the green chlorophyll coloration appears diminished, photosynthesis in NRO and WO continues at 30 to 60% of the summer activity until 4 to 6 weeks after the first frost, when abscission layers finally develop (SS Sung, personal observation). During this period, growth has stopped and starch is being stored in taproots and stems. If soil moisture is not effectively managed, the leaves may wilt and the accumulation of starch reserves needed in the spring is seriously impacted.

Development of a biologically based seedling grading system

When consistent seedling production meeting the desired standards was achieved, a biologically-based seedling grading system was developed using FOLR numbers similar to that used earlier for loblolly pine (*Pinus taeda* L.) (Kormanik et al. 1990) and sweetgum (*Liqudambar styraciflua* L.) (Kormanik 1986). Heritability estimates for FOLR numbers were as high as 0.898 and 0.918, with standard errors as low as 0.153 and 0.073 for NRO and WO, respectively (Kormanik et al. 1999). Seedlings with more FOLRs usually grow more in height and root-collar diameter than those with few or no FOLRs. Thus, we developed a minimum acceptable seedling morphological grading standard for outplanting in a forest situation. For both NRO and WO the standard is 6 FOLR, 8 mm root-collar diameter, and 0.75 m height. There is a significant difference in morphological development between the best 20% and the poorest 20% of the seedlings, even from among the best half –sibling (half-sib) progeny groups as shown in Figure 1. Usually about 40 to 60% of seedlings from most properly handled seedlots meet the specifications.

Figure 1. 1-0 *Quercus alba* seedlings grown with a nursery baseline fertility protocol in the southeastern US. Seedlings on the left of the meter stick were selected from the best 20% of a half-sib family, GFC-30. Seedlings on the right of the meter stick were selected from the poorest 50% of the same family.

Outplanting of northern red oak and white oak

One of the most frequent causes of poor growth and development of NRO and WO seedlings is maintaining too dense an overhead canopy. There has long been a misconception that, even though stem development is poor in understory conditions, seedling root systems are rapidly expanding and will be of benefit when the seedlings are eventually released. We have found this not to be the case. We have examined countless oak seedlings outplanted under different light conditions and excavated them to examine root development after several years. One of the studies is shown in Figure 2 where one-year-old (1-0) NRO seedlings were planted either under a hardwood canopy with a 7 m^2 basal area or in a clearcut site. The FOLRs of the underplanted seedlings began to atrophy and within a few years only the taproot remained (Figure 2A). At this point, canopy removal may afford little benefit to the deteriorating seedling, and recently developing competing vegetation will dominate the site after release. In contrast, seedlings planted in a clearcut site have grown immense root systems (Figure 2B).

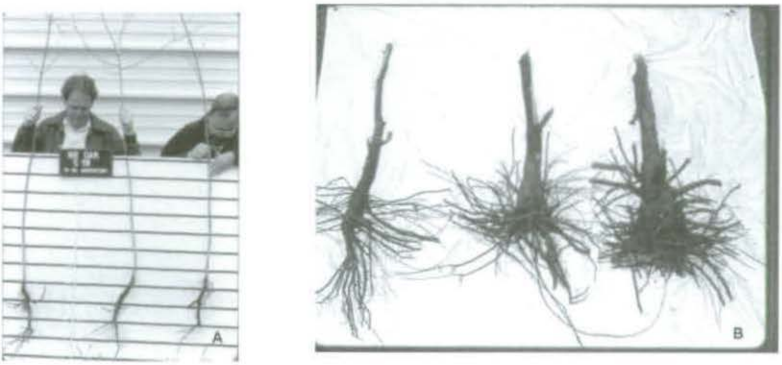

Figure 2. (A) Plants of *Quercus rubra* underplanted in a stand with a 7 m^2 basal area after five years; (B) Roots of *Q. rubra* planted in a clearcut site after five years. All individuals were of comparable size as 1-0 planting stock.

In another experiment, NRO and WO seedlings grown in full sun for two years allocated much more biomass, in absolute amounts and in percentages of total biomass, to lateral roots and to leaves than did seedlings grown under 70% shade cloth (Sung et al. 1998). In natural stands, young seedling cohorts growing in the understory seldom survive more than just a few years. Examination of their root systems typically shows the same root atrophy we observed in our understory planting studies.

On high quality mesic sites, mixtures of NRO and WO dominate the site if overhead competition is eliminated during the first three years after planting (Table 1). Depending on the site, if the woody sprout competition is controlled for three years, annual vegetation may need only minimal control because the tree crowns will rapidly close when seedlings are planted at 3.5 x 3.5 m spacing.

Table 1. Fourth year performance of a mixed *Quercus rubra* (NRO) and *Quercus alba* (WO) stand in Brasstown Ranger District of the Chattahoochee National Forest, Blairsville, Georgia, USA. The stand was established with 1-0 seedling stock in March 1999.

Species	Survival, %	Height, cm			Diameter at breast height, mm		
		Mean	Max	Min	Mean	Max	Min
Quercus rubra	99	293	440	45	23	44	0
Quercus alba	95	246	410	10	15	39	0

The advantage of these rapidly growing oak seedlings is that their exceptional early vigor may activate genes that control flowering response (Zimmerman and Brown 1971). Thus, by selecting the largest individuals with the largest root system, we have been able to develop individual seedlings that begin acorn production at a very early age. However, not all individuals with large FOLR numbers are precocious acorn producers. We have established a second generation NRO seed orchard from an existing 20-year-old planting that contains a number of individuals that are consistent acorn producers. Approximately one third of the half-sib progeny from this second generation planting have produced multiple acorn crops between year 6 and their current age of 11. Furthermore, good acorn production has been achieved from a second generation WO planting. Some WO seedlings have been consistent acorn producers since age 6. Half-sib progeny from some of these early acorn producers are now well established in a third generation seed orchard and are being monitored for precocious acorn production. Most importantly, from a forest management perspective in the US, trees that have the best form and are fastest growing appear to produce acorns at an early age. Early acorn production is very critical for the management of NRO and WO on even small woodlands in the US. While oak timber has great economic value, much emphasis is now placed on hard mast production for wildlife management considerations.

Conclusions

Selecting oak seedlings possessing the best root systems and the most desirable stem characteristics for outplanting in natural forested areas can also lead to acorn production in less than 10 years. Major problems in obtaining large, vigorous seedlings are acorn desiccation prior to sowing and allowing early bud set in the nursery. The latter is caused by inconsistent top dressing and irrigation practices following seed germination. Our results indicate that NRO and WO thrive best in the absence of competing vegetation and in full sunlight. The commonly held belief that young NRO and WO seedlings thrive in the understory prior to overstory removal may not be scientifically accurate and should be evaluated worldwide. Although more defining research is needed to fully understand oak carbon metabolism under varying overhead canopy densities, current research indicates that root atrophy occurs under sub-optimal light conditions.

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NAMING OAK CULTIVARS: INTRODUCING THE CULTIVAR NAME REGISTRATION FORM

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Abstract

While the names of oak species are named under the provisions of the *International Code of Botanical Nomenclature*, the additional categories, cultivar and Group, are named according to the *International Code of Nomenclature for Cultivated Plants*, a new edition of which is due in early 2004. This presentation describes what the terms "cultivar" and "Group" mean and outlines the provisions for creating and registering new names. The newly-released Registration Form for names of oak cultivars is described and the establishment of the Advisory Committee for Oak Registration and Nomenclature (ACORN) announced.

Introductions

What is an ICRA?

There are currently about 70 International Cultivar Registration Authorities (ICRAs) appointed by the Commission for Nomenclature and Cultivar Registration of the International Society for Horticultural Science (I.S.H.S.) and the International Oak Society was appointed as ICRA for the genus *Quercus* by this body in 1998. The ICRA system aims to promote stability in the naming of cultivated plants by promoting lists of authenticated names in a number of important groups of plants which are commonly cultivated.

While the *International Code of Botanical Nomenclature* (I.C.B.N.) (Greuter et el., 2000) deals with the rules for forming the Latin names of plants, the *International Code of Nomenclature for Cultivated Plants* (I.C.N.C.P.) (Brickell et al., 2004) deals only with the naming of two categories, the cultivar and the Group – i.e., those categories of plants that arise and are maintained by mankind.

The primary functions of an ICRA are (a) to register cultivar and Group names in the denomination class for which they have accepted responsibility and to ensure their establishment, (b) to publish full lists of cultivar and Group names in that denomination class, and (c) to maintain records, in as great a detail as is practical, of the origin, characteristics, and history of each cultivar and Group in that denomination class. All ICRAs are contracted to operate within the provisions of the current I.C.N.C.P. (Trehane et al., 1995).

The "denomination class" is that taxonomic unit in which names (technically, epithets) may not be repeated. In our case, *Quercus* L. is taken to include other genera such as *Cyclobalanopsis* Oerst. and *Cyclobalanus* (Endl.) Oerst. which are accepted as separate genera in some parts of the world.

"Establishment" under the I.C.N.C.P. is roughly equivalent to "valid publication" in the terminology of the I.C.B.N., i.e., the provision of a correctly formed new name in a printed and dated publication. Establishment cannot be achieved solely by placing the name on labels or via the internet or in some undated and ephemeral publication. If a cultivar or Group name has not already been established when it is registered by an ICRA, the ICRA itself will organize its establishment by writing up the details and publishing them in a proper way: for oaks, it is hoped that newly registered names will appear in the Journal of the International Oak Society so the information will reach the widest group of oak enthusiasts.

It is not the function of an ICRA to (a) conduct trials, (b) judge if one cultivar or Group is more meritorious or useful than another or (c), to judge distinctness of cultivars or Groups (Trehane et al., 1995). ICRAs record cultivar and Group names, not the cultivars or Groups themselves, so one does not register a new cultivar with an ICRA, one registers their names. Further information on ICRAs may be found at: *http://www.ishs.org/icra/index.htm*

What is a Cultivar?

It should be remembered that a plant is not, in itself, a cultivar. A cultivar is a taxonomic unit made up of a number of plants with the same set of characteristics and is defined in the I.C.N.C.P. thus:

> *Art. 2.2: "A cultivar is an assemblage of plants that has been selected for a particular attribute or combination of attributes and that is clearly distinct, uniform, and stable in these characteristics and that when propagated by appropriate means retains those characteristics."*

So a cultivar name cannot be established unless the original plant on which the name is based has been propagated to the point where a number of identical plants exist that together meet the criteria above.

What is a group?

The other taxonomic unit whose nomenclature is governed by the I.C.N.C.P. is the Group, a formal category that is defined and provided for under these two Articles:

> *Art. 3.1: "A Group is a formal category for assembling cultivars, individual plants or assemblages of plants on the basis of defined similarity...".*
>
> *Art. 3.2: "A taxonomic unit at or below the rank of species that is no longer recognized as having taxonomic value in botany yet which continues to have utility in agricultural, horticultural or silvicultural classification, may be designated as a Group."*

For woody plants, this category is often used for bundling together cultivars and individual plants with predefined characters in common so that they may be labelled. An example used in Fig. 1 below is *Q. robur* Fastigiata Group, a name originally published for a species by Lamarck in 1785, but which is now subsumed under *Q. robur* by most taxonomists. Nonetheless it is useful for horticulture to have a label under which all fastigiate forms of that species may be assembled so, by using the Group system, an easy-to-use and comprehend name is provided that does not have to rely on the I.C.B.N. in its questionable use of ranking systems such as the use of *varietas* or *forma* and the infinite number of ranks below these taxa.

How do I recognize a cultivar or group name?

In order for the status of both these to be recognized, the I.C.N.C.P. defines how the epithets in the names of these categories be written:

> *Art. 13.1: " Cultivar status is to be indicated by enclosing the cultivar epithet within single quotation marks. Double quotation marks, and the abbreviations cv. and var. are not to be used within a name to distinguish cultivar epithets: such use is to be corrected.*
>
> *Note 1. Single quotation marks are generally effected typographically either by using (') at the beginning and (') at the end of an epithet as used throughout this Code, or alternatively by use of the apostrophe (') or other demarcation device such as (?) on each side of the epithet."*
>
> *Art. 14.1: "Formal Group status is indicated by use of the word Group or its equivalent in other languages as the first or final word in the Group epithet."*

The sample page of the proposed Register (Fig. 1) uses these conventions in listing epithets so that the status of each name may be discerned with ease. In the sample page, accepted names are in bold, synonyms not in bold, scientific names in italics, common names in plain Roman. There is another category of names illustrated, that for "trade designations", also called commercial synonyms. The I.C.N.P. defines these:

> *Art. 12.1: A trade designation is not a name but is a device that is usually used for marketing a cultivar or Group in place of its accepted name when the accepted name is not considered suitable for marketing purposes.*

Trade designations are not widely used for oaks, but some nurseries use either registered or common-law trademarks with which they market plants. Although these are not names as such (Trehane, 2001), a record is kept of these so as to reduce confusion. Note that they are presented in Fig. 1 using a different typeface.

Fig. 1. Sample entries for proposed ICRA Register of names in the genus *Quercus* L.

PROPOSED ICRA REGISTER FOR NAMES IN THE GENUS *QUERCUS* L.

SAMPLE ENTRIES

Black Jack Oak	Common name in USA for ***Q. marilandica*** (L.) Münchh.
clavata	*Q. suber* var. *clavata* Cout., Fl. Portugal 165 (1913). A supposed variant of the species, not generally recognized as being distinct.
farnetto	*Q. farnetto* Ten., Cat. Hort. Neopol. 1813, App. 1, ed. alt. 65 (1819). An orthographical variant of ***Q. frainetto*** Ten. (1813). It seems that Tenore attempted to correct the spelling of his original epithet to that of the local common name of this species: although this would be permissible under Art. 60.1 of the ICBN, the corrected spelling has not been widely taken up and in the interests of stability, it is not recommended that this be done.
Fastigiata Group	***Q. robur*** **Fastigiata Group.** "*Q. fastigiata*" hort. ex Lam., Encycl. Méth. Bot. 1. 725 (1785). Name to cover the various tall, upright-growing cultivars and plants of the species.
'Fordii'	***Q. ilex*** **'Fordii'.** "*Q. ilex* var. *Fordi*" Loud., Gard. Mag. (London) 19: 35 (1843). Raised in Lucombe and Pince's Nursery, Exeter, UK, pre-1843.
FOREST GREEN	Not an epithet but a US registered trademark used by J. Frank Schmidt & Son Co., Oregon, USA to market ***Q. frainetto*** **'Schmidt'.**
harbisonii	***Q. xharbisonii*** Sarg., Bot. Gaz. 65: 458 (1918). Name for hybrids between *Q. stellata* and *Q. virginiana*. Occurs naturally in Florida, USA.
'Rubrifolia'	***Q. velutina*** **'Rubrifolia'** hort. ex Bean, New Flora and Sylva 2: 152 (1939) "*Q. velutina* var. *rubrifolia*". Large-leaved form originating at the firm of Lee, Isleworth, UK in mid 1800s.
serrata	***Q. serrata*** Thunb., Fl. Jap. 1. 176 (1784). Eastern Himalaya, China, Taiwan, Korea, Japan.
Shingle Oak	Common name in USA for ***Q. imbricaria*** Michx.
SKYROCKET	Not an epithet but a US registered trademark used by J. Frank Schmidt & Son Co., Oregon, USA to market their plants of ***Q. robur*** **Fastigiata Group.**
'Spencer Turner'	***Q. xturneri*** **'Spencer Turner'** E. Wiltshire & A. J. Coombes, Lond. Nat. 80: 25 (2001). Name for plants of the original clone, a seedling resulting from the cross between *Q. ilex* and *Q. robur* grown and propagated by grafting at Turner's Nursery, Leyton, Essex, UK c.1760. Named for the nursery owner. Nomenclatural standard: Harold Hillier Arboretum.
turneri	***Q. xturneri*** Willd., Hort. Berol. 975 (1809). Name for any plants resulting from a cross between *Q. ilex* and *Q. robur*.

Forming a cultivar or group name

This is not the place to go into details of forming names but the I.C.N.C.P. rules are designed to prevent names which might be confusing. Details will be found in Articles 19 and 20 of the I.C.N.C.P. and a summary of the basic rules is provided on the ICRA webpages at: *http://www.ishs.org/sci/icraname.htm*. The Registrar will be pleased to offer advice on any matter of nomenclature and anyone planning to publish a new name would wise to make contact with the Registrar, even if just to make sure that a proposed name has not had prior use or is likely to confuse.

Advisory committee for registration

To assist the Registrar, an informal committee has been set up called the Advisory Committee for Oak Registration and Nomenclature (ACORN). This is made up of I.O.S. members with a special interest in cultivars and helps to collect and verify information for the Registrar. If anyone has an interest in this sort of participation, please contact Allen Coombes or myself.

Provision of information

There are roughly 530 species of oak with many times more synonyms including orthographical variants (Govaerts and Frodin, 1998). Many of the epithets of published names actually relate to what we would now term cultivars or Groups. Each of these names has to be researched to establish the status of the names concerned. Operating within the taxonomic framework provided in the World Checklist and Bibliography of Fagales (Govaerts and Frodin, 1998), a comprehensive listing of all the epithets ever used is being compiled in a database so that a report may be generated as demonstrated in Fig. 1. This tool will be invaluable to help ensure that duplication of names in the future will be minimized. It is hoped that the data will be made available over the internet as well as by hard copy. It is envisaged that an initial Checklist will be released which hopefully will attract comment and further observation before a full printed Register is produced.

The Registration Form

The Registration Form is reproduced here in Appendix I and may be freely downloaded and saved by anyone from the International Oak Society web pages (*http://www.saintmarys.edu/~rjensen/ios.html*). The following notes are to be made available with the form and are designed to be helpful for those not familiar with what is required in filling in the form. If extra papers are to be included with the form, they should be attached together, each separate sheet being labelled with the proposed name of the cultivar so they cannot get misplaced.

It would be extremely helpful if at least one photograph be included when returning the Registration Form. Such a photograph should show the characteristics whereby the cultivar differs from other known cultivars of the same species. Photographs of a mature plant would also be helpful, especially if it is the original plant from which the cultivar was derived.

Registrants are also encouraged to send a piece of the plant showing the essential characteristics so that it may be prepared as a herbarium specimen and kept in a safe place. Such a specimen might become designated as the "nomenclatural standard" to which the name will be permanently attached.

For any further assistance or advice, the Registrar, Piers Trehane, should be contacted at the address above or on the top of the Registration form. Alternatively, he may be e-mailed at: *oaktrehane@indhort.demon.co.uk.*

PART 1: THE NAME OF THE CULTIVAR

Try to fill in this section as much as possible.

Q.1 If you know to which species or other taxon your cultivar belongs, write it here. Example: *Q. ILEX* or *Q. RUBRA*. Alternatively, give the common name if you are sure this is unambiguous. Example: SHINGLE OAK which equates to *Q. imbricaria*.

Q.2 Due to wind pollination, many garden seedlings are hybrids: indicate if you think your cultivar may be such a hybrid.

Q.3. If you can, indicate the pollen and seed parents of the hybrid. If you are uncertain of one or both parents, put a question mark beside the name or names in question.

Q.4 Write your proposed name (technically, the epithet) of your cultivar. Example: 'Moonlight Parade'. Use a mixture of capital and lower case letters and include any diacritical signs such as the e acute (é) or umlaut (ü) if these signs form part of your proposed name. Be careful where you insert any apostrophes and do not include any words banned by the I.C.N.C.P. If your proposed name is in a script other than Roman, such as Japanese, Cyrillic or Hebrew, add the Romanized transliteration according to the standards laid down in the I.C.N.C.P.

Q.5 The originator is the person who recognizes that a new cultivar has particular merit that is of value; that person may or may not be the finder (Q.24) or the raiser (Q.27) or the initial propagator (Q.30). Please give his/her full address, and for the date originated, please state as exactly as possible when the worth of the cultivar was recognized by the originator. The year will suffice.

Q.6 The nominant is that person who first suggests or coins a new name for the plant, even if it is not formally named as such. If the nominant is not the originator, give his/her name - if it is the same person, simple write AS ORIGINATOR.

Q.7 Very often, new cultivars are not introduced into circulation by the originator but by a nurseryman or other enthusiast who may be termed the introducer. Please supply details of that person and when the cultivar was introduced or distributed. This may be several years after origination.

Q.8 This is where you, the registrant filling in this form, give your contact details. Please fill in all your personal address details etc., which will not be published (apart from your mailing address) but which are essential if the Registrar needs to ask further questions from you about registering your proposed name.

Q.9 If you are registering a name on behalf of an employer or other organization, fill this in so that their details will be recorded in the Register.

Q.10 We ask this question to be certain that the originator has no objections to the proposed name (if the originator objects, the name may have to become rejected): this also acts as a prompt to see if the originator has knowledge of other names being used for the same cultivar.

Q.11 The Registrar needs to know if the name has appeared in some other publication previous to your application since this helps determine the author and date of a cultivar name. If the name has appeared in a printed work such as a dated nursery catalogue, the author will be that person credited with writing the catalogue. If the name has not been previously published, the author will be you, the Registrant, as long as the name is not published in a work which is not accredited to you between the time of dating the Registration Form and formal publication of your name by the Registrar.

Q.12 It is asked that if you know that the name has been established in another printed work, you send either a copy or a photocopy of the relevant pages for the Registrar so that he can be certain that the name has been properly established. Please, when copying the pages, include the title page of the printed work and the page upon which its author and publication date appears.

Q.13 If a cultivar has been awarded a patent or plant breeders' rights under some legal process such as provided for under various national and international statutory provisions, the name (often called the "variety denomination" by these agencies) as provided by the originator (breeder) or his agent and as approved by the agency for the purposes of such rights is always to be taken as the cultivar name. These names are fixed by statutory provision and an ICRA is not in a position to alter these names in any way whatsoever. The Registrar must be advised of these special cases.

Q.14 Only the first statutory authority needs to be cited here; by international treaty, the same cultivar being granted similar rights in other countries will normally carry the same "variety denomination".

Q.15 In some parts of the world, a nurseryman or other trader will attempt to change a name if he/she finds that the proper cultivar name is unsuitable for marketing reasons. Please indicate if you know of such "names" being used for the cultivar so that the Registrar may record these to avoid potential confusion in the future.

Q.16 It would be useful if as much information as possible can be provided for the Registrar to record. Sometimes, different trade designations are used in different countries and sometimes the same cultivar is sold by different traders in the same country under their own trade designation.

Q.17 Trademarks are sometimes used instead of the full name of a plant for marketing purposes. Trademarks which have been formally registered by a national trademark authority are usually so indicated by using the international sign ®.

Q.18 Trademarks which have not been formally registered, yet which are self-claimed by a person or organization, are common-law marks are generally so indicated by using the sign ™.

Q.19 Please list both registered and common-law trademarks if you know these have been applied to the cultivar whose name you are registering. If you can, state the authority and grant number for registered marks as this will enable the Registrar to check their status.

Q.20 Some people - especially famous people - see their names as part of their personal property and need to be asked if they mind a plant being named after them. Before publishing such a name for the first time, a Registrar may need to check that such an act does not offend, so that the Registrar's office would not be subject to complaint or even litigation by any such aggrieved parties.

Q.21 If your name is based on some strange word(s) or deliberately misspelled word(s), an explanation here will save rectifying spelling or punctuation errors later.

Q.22 It is becoming common practice to supply a plant or piece of a plant of the cultivar which may be turned into the herbarium specimen that acts as the nomenclatural standard to which your name is permanently attached. Please indicate if you have done so.

Q.23 So that a record may be made of the whereabouts of nomenclatural standards and any duplicate specimens, please indicate which herbarium these will be found in. If you are sending material with this application, fill in the answer box with the word ENCLOSED.

PART 2: HISTORY OF THE CULTIVAR

This section is designed to provide information on the origin of the cultivar.

Q.24 If the plant was found in the wild, it is helpful to indicate as exactly as possible where it was found so as to avoid duplication if two people find the same plant at different times, each person coining a different name.

Q.25 Sometimes, a plant stands out in a batch of acorn seedlings, is selected and grown on: such a plant may turn out to be permanently distinct and propagated to give rise to a new cultivar.

Q.26 Only if you are certain should you state pollen and seed parent. Usually these are the same. If there is some doubt, add a question mark next to the name (see also Q.2).

Q.27 The raiser/hybridizer may be quite a different person from the originator (Q.5), who may only recognize a cultivar's value many years after seed was sown, perhaps long after the raiser has retired or even died.

Q.28 Indicate if the cultivar originated as a sport on another plant. This often happens, especially with variegated, pendulous or fastigiate sports.

Q.29 State the name of the parent plant, especially if it is another named cultivar. If the parent plant is unnamed, write UNNAMED.

Q.30 The initial propagator is very often the originator (the person who first recognized the potential cultivar) in which case write AS ORIGINATOR, but it may be an employee or someone else. We need to know the year that cuttings where successfully taken.

Q.31 Since many new plants do not develop worthwhile properties until years after being planted, it may be several years before an unnamed seedling can be judged to have particular worth. We need to know from who and where such plants came. If not known, enter UNKNOWN, but give any information you can.

Q.32 List any known awards, including provisional ones, given to the cultivar even though, in some cases, the cultivar may not have been formally named at the time. Do not include awards of intellectual property rights here (see Q.12-13).

PART 3: DESCRIPTION OF THE CULTIVAR

Try to complete this section as accurately as you can, but do not worry about supplying a full botanical description unless you want to.

Q.33 Try to summarize the distinctive characters.

Q.34 Name the most similar cultivar of the same species known to you.

Q.35 You must be able to note at least one consistently stable character by which your cultivar may be distinguished from that in Q.34.

Q.36 Any extra descriptive information would be helpful.

Q.37 Do not forget to state if you are using metric or imperial measurements etc.

Q.38 Comment here on any special attributes such as disease resistance or drought tolerance, etc.

Q.39 Comment on any other feature which may be of interest and that you would like the Registrar to publish, such as brightly-coloured acorns, seasonal leaf colour, special means of propagation etc.

Q.40 Don't forget to sign and date the form!

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International Oak Society	# APPLICATION TO REGISTER A CULTIVAR NAME FOR AN OAK
Appointed in 1998 as The International Cultivar Registration Authority (ICRA) for the genus ***Quercus***	Address for correspondence **The Registrar for Oaks, c/o The Sir Harold Hillier Gardens, Jermys Lane, Ampfield, Romsey, Hampshire SO51 0QA, United Kingdom** Copies of this form together with notes to help with filling in this form are available from the address above or from the International Oak Society webpage http://www.saintmarys.edu/~rjensen/ios.html

PART 1: THE NAME OF THE CULTIVAR

1	State the species or other taxon to which the cultivar belongs (if known)	
2	Do you believe the cultivar to be a hybrid?	Circle: YES NO
3	If the answer to 2 above is "Yes", please state name of parents if known	
	Pollen (male) parent	
	Seed (female) parent	
4	Write here your proposed cultivar name (epithet)	

5	Name and address of Originator Date originated	
6	Name and address of Nominant if different from above Date named	
7	Name and address of Introducer if different from above Date introduced	
8	Name and address of Registrant if different from above	
	Contact telephone number	
	Contact fax number	
	Contact e-mail address	

9	If the cultivar name is being registered on behalf of an organization, give name and address of that organization	
10	Has the Originator given permission for the cultivar to be registered under the proposed name?	Circle: YES NO
11	As far as you know, has the name already been published in a dated publication together with a description?	Circle: YES NO
12	If the answer to 11 above is "Yes", please give details of the earliest publication and enclose a copy or a photocopy of the relevant pages (including evidence of date of publication) with your application	
13	As far as you know, has the cultivar ever been subject to application for, or grant of, a Patent or Plant Breeders' Rights?	Circle: YES NO
14	If the answer to 13 above is "Yes", please give details of the first such issuing National Authority and any grant number(s) issued	
	Grant Number	
	Issued by	
15	As far as you know, is the cultivar being sold under a trade designation ("selling name") instead of the cultivar name?	Circle: YES NO
16	If the answer to 15 above is "Yes", please list any such trade designations together with any other information you may have	
17	Is the cultivar marketed under a trademark which has been formally been registered by a trademark authority (and entitled to bear the sign ®)?	Circle: YES NO
18	Is the cultivar marketed under a common-law trademark denoted by the sign ™?	Circle: YES NO
19	If the answer to 17 or 18 above is "Yes", please give name and address of the trademark owner (or his assignee) and for registered trademarks, please state the issuing authority together with any grant number (if known)	
	Grant Number	
	Issued by	
20	If the cultivar is named after someone living or dead, have you had permission from that person (or his/her legal representative) to Register the name?	Circle: YES NO
21	If it is not obvious, please state derivation (meaning) of your proposed name	

22	Has a nomenclatural standard been deposited in a recognized herbarium?	Circle: YES NO
23	If the answer to 22 above is "Yes", please list the herbarium and any others maintaining duplicates	

PART 2: HISTORY OF THE CULTIVAR

24	If the original plant of the cultivar was found growing in the wild, please give location where it was found, who found it, and when it was found	

25	Was the original plant of the cultivar selected from a batch of cultivated seedlings?	Circle: YES NO
26	If the answer to 25 above is "Yes", please state name of parents if known	
	Pollen (male) parent	
	Seed (female) parent	
27	Name and address of Raiser or Hybridizer	
	Year of raising / hybridizing	

28	Was the original plant of the cultivar derived from a sport of another plant?	Circle: YES NO
29	If the answer to 28 above is "Yes", please state name of parent plant	
30	Name and address of initial Propagator	
	Year of initial propagation	

31	If the original plant of the cultivar was received as an unnamed seedling, from whom and where did it come?	

32	If the cultivar has received any awards, please list them here

PART 3: DESCRIPTION OF THE CULTIVAR

33	What are the distinctive characteristics of the new cultivar?	
34	What existing cultivar does the new cultivar most resemble?	
35	In what way is the new cultivar distinct from that in 34 above?	
36	Please give here any other descriptive information you think may be relevant	

37	Please indicate the height and width of a specimen of the cultivar (state if in metres/cms or feet/inches etc)			
	Height	Width	After how many years	Estimated growth rate

38 If you consider that the cultivar has special merits for a particular purpose, please explain below

39 Please write here any other comments or information you would like the Registrar to publish

40	Signature of Registrant	
	Dated	

This section for Registrar's use only				Cultivar Epithet:		
Taxon:				Author & bibl. citation:		
Appl. Received	Receipt	Approved	Standard	Photographs	Entered in Reg.	Date of Name

SUDDEN OAK DEATH IN CALIFORNIA, AN OVERVIEW

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Background

In 1995 a new type of oak mortality was observed in the coastal forests north of San Francisco, California. At first it appeared to only affect tanoak (*Lithocarpus densiflorus*) trees, a species more closely related to chestnuts than true oaks. Within several years, however, both coast live oak (*Quercus agrifolia*) and California black oak (*Quercus kelloggii*) were also observed to be dying . No one had ever seen anything quite like this before. First, the new shoots of tanoak would wilt and droop. Typical symptoms of infected oaks and tanoaks also included seeping of dark brown viscous sap from lower portions of the main stem, dead discolored patches beneath the bark, extensive tunneling by small insects (ambrosia and oak bark beetles), and the appearance of dark, knob-like fruiting bodies of *Hypoxylon* fungi on the bole. Eventually, the foliage of attacked trees would turn yellow, and then completely brown. Dr. Pavel Svihra, a University of California Environmental Horticulture Advisor who was among the first to observe this problem, called this new mortality complex "Sudden Oak Death", or SOD. While the name Sudden Oak Death implies that trees are killed rapidly, it now appears that it can take months, or even a year or two, from the time of the initial infection for death to occur. Also, many more species than oaks are affected by SOD, and many of these other hosts aren't killed by it.

For several years it remained a mystery what was causing this new oak mortality. Some scientists originally felt that the insects observed on the sickened trees were the fundamental cause of mortality, while others suspected that *Hypoxylon* fungi played a primary role. This question remained unanswered until the summer of 2000 when plant pathologists at the University of California, Dr. David Rizzo and Dr. Matteo Garbelotto, isolated a new, unidentified species of *Phytophthora* from the cankers of trees exhibiting the symptoms. They were able to determine that this was the primary agent responsible for SOD through a series of inoculation tests and the establishment of field plots that were designed to track the development of the pathogen (Rizzo et. al 2002).

Phytophthoras are fungus-like water molds, the most famous of which is *Phytophthora infestans*, the agent responsible for the Irish potato blight in the middle of the 19th century (Sinclair et al. 1987). Previous efforts to identify this new pathogen in California had failed because plant samples were not tested rapidly enough after collection. Now it is widely accepted that this new *Phytophthora* is the primary cause of tree mortality, and that the boring insects and *Hypoxylon* fungi play a secondary role, attacking trees that have already been weakened, thus hastening their demise.

A serendipitous visit to California by a British scientist further helped shed light on this mysterious new disease. Dr. Clive Brasier, a pathologist from the

British Forestry Commission, happened to be visiting California about the same time that this *Phytophthora* was identified as the underlying cause of Sudden Oak Death. Dr. Brasier is a world expert on *Phytophthoras* in wildland forests and looked at the organism under a microscope and in the field. Several months later, when a German colleague showed him a *Phytophthora* that had been causing leaf spots and twig dieback on ornamental Rhododendrons in Germany and the Netherlands since 1993, he thought it looked very similar to the organism he had seen in California. It turned out to be nearly identical and by 2001, this new species was named *Phytophthora ramorum* by the European researchers, which translates to "affinity for branches" (Werres et al. 2001).

By the summer of 2003, this organism had been positively confirmed in 12 coastal counties in California, ranging along a 400 km stretch from the Big Sur area in Mendocino County in the south, to Humboldt County in the north. It was also found further north in the southernmost county in Oregon. This new *Phytophthora* appeared to be genetically distant to most of the other 60 species within the genus *Phytophthora.* The closest relative seemed to be *P. lateralis*, a virulent pathogen of Port-Orford-cedar (*Chamaecyparis lawsoniana*) known to be present in natural stands in the Pacific Northwest and occasionally on Port-Orford-cedar stock in nurseries in Europe (Hansen et al. 2000). Was *P. ramorum* a new, introduced species, or perhaps one that was already in California, but had remained dormant until environmental conditions became favorable? We do not yet know, but the fact that California has had some rather unusual weather conditions during the past decade – wet 'El Niño' winters, interspersed with unusually dry years – lends support to the latter theory. Or perhaps this new species is a hybrid between two existing *Phytophthoras.* These questions still remain unanswered, though based on genetic population structure, researchers now generally believe that *P. ramorum* is relatively new to both California and Europe, and was likely introduced from a third location, perhaps Asia. Its aggressiveness on tanoaks of all sizes, and its limited geographic range in relation to the distribution of its hosts, suggest that it was probably introduced to California fairly recently (Rizzo and Garbelotto 2003).

How does the pathogen spread?

One of the most critical questions being asked by researchers, quarantine officers, and foresters is how is this pathogen spread? Most *Phytophthoras* attack roots, but this one has so far only been isolated from the aerial portions of plants. While it has been determined that *P. ramorum* can be spread by rain splash and that spores can remain viable both in the soil and in streams that flow through SOD-infected forests, it has not been ruled out whether this particular pathogen could also be transmitted through the air, as is the case for *P. infestans*. It is also possible that it is vectored by the insects that attack infected trees, or birds that come in contact with infected material. However, preliminary studies suggest that these modes of spread are unlikely. Other potential pathways, including movement by deer and humans, are also being investigated. It is critical to find out how the disease spreads as soon as possible so that effective management recommendations, that will hopefully curtail the spread of the disease, can be made.

Disease occurrence and susceptible species

Even though large numbers of trees with similar symptoms have been observed on the California coast, many of the trees that are dying are not infected with *P. ramorum*. Several other, as yet unidentified *Phytophthoras*, have also been recovered from host species displaying similar symptoms to SOD. Fortunately, these *Phytophthoras* appear to be less virulent than *P. ramorum*, and are typically found on isolated trees. Other common oak diseases such as *P. cinnamomi* (crown rot) and *Armillarea mellea* (oak root fungus) can also cause similar symptoms and are probably responsible for many deaths in the zones where SOD has been detected. It is also important to point out that members of the white oak subgenus of *Quercus* (Section Quercus), which includes both blue oak (*Quercus douglasii*) and valley oak (*Quercus lobata*) in California, and English oak (*Quercus robur*) and sessile oak (*Quercus petraea*) in Europe, do not appear to be susceptible. In laboratory pathogenicity trials, however, species of the red oak subgenus (Section Lobatae) from the eastern United States, including northern red oak (*Quercus rubra*) and pin oak (*Quercus palustris*), have been found to be highly susceptible to the pathogen, though none have yet become infected outside of the laboratory. These species are commercially important in the eastern U.S., so there is considerable concern that *P. ramorum* could have enormous economic impacts if it spread eastward and infected these species. The habitat in the eastern forests also has susceptible understory species, further increasing the concern.

To date, this disease has been limited to coastal locations in California. As mentioned above, the pathogen has been found in 12 counties and has not yet been reported further than 80 km inland. It is estimated to have killed tens of thousands of trees. There is certainly concern in California that *P. ramorum* could move inland and attack plants in the Sierra Nevada mountain range, where many of the confirmed hosts grow. But to date, there have been no confirmed infections in this region. It is hoped that the warmer and drier conditions inland will prove inhospitable to the pathogen and prevent it from establishing there.

In May and June 2003, the pathogen was detected in ornamental plant nurseries in four California counties, as well as in nurseries in Oregon, Washington and British Columbia, Canada. Such findings illustrate that the pathogen can move long distances on nursery stock, and reinforce the belief that it is essential to take steps to insure that diseased plants are identified and destroyed before they are shipped to other locations.

The number of confirmed host species in California continues to increase and, as of the preparation of this paper, stands at over 20 species, which are listed in Table 1. The interesting thing about *P. ramorum* is that it causes two distinct types of disease. The affected oaks and tanoak suffer a canker disease that attacks the boles of trees and can eventually kill plants by girdling them. The second type of disease caused by *P. ramorum* is one that only affects foliage and small shoots. This infection does not damage the main stem of plants and rarely kills them. It can kill leaves, but it is common for only a portion of an individual leaf to be affected. These infected leaves can produce prodigious quantities of spores, creating a highly effective mechanism for spreading the pathogen. Since these plants are rarely killed (unlike the true oaks and tanoak), they continue to serve as a source of inoculum and continue to spread the pathogen. And since *P. ramorum* has such a wide host range, and has spread over such a wide geographical area, treatment of infected plants in order to limit natural spread is extremely difficult, if not impossible.

Table 1. List of host species of *P. ramorum* in California (as of July 3, 2003)

Common Name	Scientific Name
Coast live oak	*Quercus agrifolia*
California black oak	*Quercus kelloggii*
Shreve oak	*Quercus parvula* var. *shrevei*
Canyon live oak	*Quercus chrysolepis*
Tanoak	*Lithocarpus densiflorus*
Douglas-fir	*Pseudotsuga menziesii*
Coast redwood	*Sequoia sempervirens*
Madrone	*Arbutus menziesii*
Bay laurel	*Umbellularia californica*
Evergreen huckleberry	*Vaccinium ovatum*
Manzanita	*Arctostaphylos* spp.
Buckeye	*Aesculus californica*
Ornamental and native rhododendron	*Rhododendron* spp.
Honeysuckle	*Lonicera* spp.
Big leaf maple	*Acer macrophyllum*
Coffeeberry	*Rhamnus californica*
Toyon	*Heteromeles arbutifolia*
Arrowwood	*Viburnam* spp.
Pieris	*Pieris*
Western starflower	*Trientalis latifolia*
Cascara	*Rhamnus purshiana*
Camellia	*Camellia* spp.
Associated Species*	
California hazelnut	*Corylus cornuta*
Poison oak	*Toxicodendron diversiloba*
Salmon berry	*Rubus spectabilis*
Grand fir	*Abies grandis*
Victorian box	*Pittosporum undulatum*

Associated Plant Species*
* These plants are associated with *P. ramorum*, but have not been officially confirmed as hosts.

In Europe the occurrence of *P. ramorum* has been widespread, but the number of species serving as hosts has been fairly limited, although it is expanding. To date, arrowwood (*Viburnum* spp.), mountain laurel (*Kalmia latifolia*), rhododendron (*Rhododendron* spp.), strawberry tree (*Arbutus unedo*), camellia (*Camellia* spp.), lilac (*Syringa* spp.), *Pieris*, and European yew (*Taxus baccata*) have been identified as hosts, although there have been extensive surveys to determine if other plants, including oaks, are infected (see web page at end of paper for updated species list for both California and Europe). Most infected plants have been in nurseries and these plants have all been destroyed. Infected plants have been found in Germany, the Netherlands, Spain, Portugal, France, Poland, the United Kingdom, Italy, Sweden, and Belgium.

Impacts of Sudden Oak Death

The potential consequences of high levels of oak tree mortality from *P. ramorum* are severe and far-reaching. Of greatest immediate concern is the safety risk posed by large numbers of dead trees in urban locales and in heavily-used recreation areas. Such mortality requires tree removal, which can be costly, as well as dangerous to the tree workers involved. The visual landscape of California, which has large regions of oak woodland, could be altered dramatically. Oak-covered hillsides are what many think of when they picture the golden state, and oak trees represent values, such as strength, endurance and longevity, which are held dear by the state's residents. The people of California, as in the United Kingdom and elsewhere, value their oaks greatly, and significant losses of this resource would be emotionally devastating to many. Widespread oak mortality would also have significant impacts to the many wildlife species that are so dependent on coastal oak forests for food and shelter. Deer, turkeys, jays, quail, squirrels and acorn woodpeckers are just a few of the many wildlife species that rely heavily on acorns as a food source. And there are numerous other animals that utilize oak woodlands for breeding or as stopover points during migration.

Ecological processes such as nutrient cycling, storage and release of water, and moderation of soil temperatures could also be affected. The loss of large numbers of trees could also result in the invasion of denuded sites by undesirable weed species. Another concern is the increased risk of fire resulting from the addition of large quantities of highly combustible fuels as the trees die and dry out. This risk is of particular concern in many regions where SOD occurs, because these woodlands are at the urban-interface, where homes and businesses are nestled among the trees.

What is being done?

In August 2000, the California Oak Mortality Task Force (COMTF) was established to provide a comprehensive and unified approach to address the Sudden Oak Death problem for California. This Task Force is a non-profit, organization that has six board members representing a wide range of interests and backgrounds. They oversee committees on research, education, fire prevention, management, biomass utilization, monitoring, funding and regulation, and represent the COMTF to agencies and the general public. It was immediately recognized by the Task Force that there was an urgent need for additional funding, and both the state and federal governments, as well as private foundations, have responded with sizeable grants to support research and other activities. They have also provided funds to affected counties to assist private landowners in removing dead trees on their property. To date over $20 million has been invested in Sudden Oak Death research, management and education programs. The COMTF has grown rapidly and today has over 80 member organizations and 1000 members (Goheen and Frankel 2003).

In December 2002, the Task Force co-sponsored the first Sudden Oak Death Science Symposium in Monterey, California. This research symposium brought together the broad array of researchers, regulators, and affected industries from throughout the world addressing this new disease, in order to share information and describe the most recent research advances. It featured 40 formal presentations, as well as over 50 posters, and was attended by 300 people from 13 countries and 26 states. The goal of the Symposium was to provide a scientific overview of the state of knowledge about Sudden Oak Death in forest, woodland, urban forestry, and agricultural settings. This broad overview is expected to foster closer cooperation between people in various disciplines and geographic areas working on this disease, and inform managers and policy makers about the focus of current research efforts. Results presented at the Symposium indicated that Sudden Oak Death is expanding in California, though it is not yet clear whether the rate of spread is increasing or decreasing. Results also suggested that sporulation is related to rainfall, so a recurrence of wet, 'El Niño' conditions could promote an increase in the incidence of the disease. However, it currently appears that within infected areas, some oak trees are less susceptible to the disease, suggesting that this disease will not wipe out almost all plants in a species, as was the case for chestnut blight in the eastern U.S. in the mid 20th century.

Another major activity of the COMTF has been to identify and map locations where SOD has been positively identified and where trees with similar symptoms have been observed. A GIS database of the known distribution of SOD in California is maintained at UC Berkeley and is available for downloading at the CAMFER web site (see address at end of paper). This information will be particularly important in determining how rapidly SOD is spreading, developing regulations, and managing fire prevention and hazard-tree-removal programs. Knowing where SOD is occurring is also important for quantifying economic and ecological impacts, assisting in early detection, and providing a statistically-based estimate of the area impacted by SOD.

There is also a concerted effort to inform oak woodland owners and managers, as well as the state's residents, about this disease and what they can do to help limit its spread. Many educational materials have been produced and distributed by the COMTF including diagnostic guides, brochures, signs, posters, and videos. There have also been numerous lectures, talks and field tours about Sudden Oak Death and its potential consequences. In addition, over 800 professionals have attended COMTF trainings on disease identification, sampling, and quarantine compliance. The COMTF has also established a web site (see address at end of paper) where up-to-date information is available on host plants, confirmed infection locations, best management practices, disease characteristics, current regulations, and research results.

Treatment

Not surprisingly, there has been an intense demand to find some kind of chemical treatment that can cure trees that have already become infected, or protect healthy trees from becoming infected. Many large oak trees in urban settings are highly valued by the landowners, and some would pay almost anything to prevent specimen trees from dying. However, as of this writing, no chemical treatments have been approved and registered for treating SOD, although there have been promising preliminary results with some phosphorous-based products and the registration of a chemical treatment will likely occur very soon. These chemicals have been found to reduce the size of lesions on infected saplings and small trees. Even though research results have been encouraging, it is worth noting that even if these chemicals prove effective in treating individual trees and are approved, it is unlikely they would be used in wildland settings. The areas where the affected species grow are too large, the number of host plants enormous, and the costs of applying chemicals to thousands of acres would be astronomical. In addition, there would be serious environmental concerns about applying such pesticides over vast areas of the landscape.

In the absence of effective chemical treatments, recommendations to landowners in infected regions have focused on maintaining tree health and, hopefully, resistance to the disease. Since native oaks can be adversely affected by summer irrigation, homeowners are encouraged to avoid this practice. They are also encouraged to employ correct pruning practices and to take steps to minimize adverse impacts to tree's roots. Trenching, grading, backfilling, and compacting the area around oak roots are to be avoided. To help reduce the spread of the disease to uninfected areas, it is also recommended that dead trees be left on site and, if possible, burned. Equipment used to cut down or prune infected trees should also be sterilized before being used again. And hikers and other recreationists in infected regions are encouraged to wash shoes, tires and even their pet's paws before leaving the areas, so as to reduce the threat of transporting spores off-site.

Regulation

Both the state of California and the federal government recognize that the artificial spread of this pathogen is a serious concern and threat. They have therefore imposed quarantines governing the movement of host material both within and outside of infected areas. These rules are designed to limit the artificial spread of SOD by curtailing the movement of material that could potentially cause the disease to become established in a new location. The state and federal governments are in the process of "harmonizing" these regulations so that they are consistent and evenly applied and enforced. (see APHIS and CDFA web sites at end of paper)

A number of other countries also have regulations or quarantines regarding the movement of plant parts from species or genera that are confirmed hosts of *P. ramorum*. In addition to the U.S., these include Canada, Germany, the Netherlands, the U.K., Spain, Korea, Australia, and New Zealand. The European Union also has regulations. In some cases, movement of soil that is suspected of being contaminated is also regulated.

Conclusions

While the threat of SOD is very serious and should be of concern to all Californians, it is encouraging to know that there is broad consensus that swift action is necessary and resources need to be allocated to minimize the impacts and slow the spread of this disease. Compared to research on many other plant diseases, the collaborative efforts by federal, state and county governments, universities, private industry, and non-profit groups has led to rapid progress on identifying what is causing Sudden Oak Death, determining where it occurs, and developing effective tests to confirm if a plant is infected. But more work is needed. Hopefully these efforts will succeed and California's majestic oaks, which are such a vital natural resource, will continue to survive and prosper.

For additional information, see the following web sites:

http://www.suddenoakdeath.org - California Oak Mortality Task Force
http://cemarin.ucdavis.edu/ - UCCE Marin County SOD Website
*http://kellylab.berkeley.edu/*SODmonitoring/ - UC CAMFER Monitoring Updates
www.CDFA.ca.gov – California Department of Food and Agriculture
www.aphis.usda.gov/ppq/ismp/sod/ - USDA APHIS Updated host list

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THE BRITISH AND IRISH HARDWOODS IMPROVEMENT PROGRAMME (BIHIP)

Jeffery Burley, Peter Savill, Gabriel Hemery and John Davis
(Chairman, Committee Member, Secretary and Treasurer, BIHIP)

Summary

The British and Irish Hardwoods Improvement Programme (BIHP) is an informal but active collaboration among many organizations and individuals concerned with the evaluation, improvement, and conservation of hardwoods for commercial and ecological purposes. BIHIP has seven Species Groups dealing with the selection and testing of populations and individual trees from throughout their ranges in Britain and Ireland on a range of sites. Comparative trials and breeding seedling orchards have been established.

History of the programme

The British Hardwoods Improvement Programme (BHIP) owes its origin to the Royal Forestry Society's symposium on Tree Breeding and Improvement, held at Edgbaston in 1991 where John Davis, of Woodland Improvement and Conservation, and Peter Kanowski and Peter Savill, of the Oxford Forestry Institute, agreed to initiate some work on improving ash (Savill, 1998). From that beginning BHIP developed into a voluntary association of landowners, nursery managers, professional and technical foresters, researchers, academics and others who are actively attempting to improve the quality and performance of hardwood species of economic importance in Britain and Ireland. It expanded to include members from Ireland and changed its name accordingly.

Administration

As a relatively young and voluntary association BIHIP does not have major financial resources, nor heavy administrative machinery. Members cover the cost of meetings and the Committee seeks support for collaborative research projects from governmental and non-governmental organizations including the Department for Environment, Food and Rural Affairs, the Forestry Commission and the Woodland Heritage charitable trust. Support for the Secretariat is provided by the Northmoor Trust at Little Wittenham, near Oxford. The small number of voluntary Committee members are elected by the full BIHIP membership.

Aims of the programme

The aims of BIHIP are to:

- promote research into provenance testing, selection, and breeding;
- support the establishment of field trials;
- develop technologies to aid the rapid multiplication of improved material;
- promote the use of improved material;
- undertake education, publicity, fund raising and lobbying to further the above aims.

The nature of Species Groups

BIHIP is organized into collaborative Species Groups covering seven major hardwood tree species of economic importance in Britain and Ireland: ash, cherry, oak, silver birch, sweet chestnut, sycamore and walnut. Each of these species presents different opportunities, potential, and problems that the Groups aim to address. Each Species Group is normally made up of a landowner as chairman, a researcher as secretary, and members with the best expertise that can be brought together for the rapid development of an appropriate programme. All Species Groups and other interested people meet together for individual meetings at various times and locations. The entire membership of BIHIP assembles at an Annual General Meeting, usually in November, to hear progress reports on the Groups' work, to visit field experiments, and to discuss opportunities for future collaborative work and financing. BIHIP also collaborates closely with the Royal Forestry Society of England and Wales in organizing collaborative work, meetings, and publications.

Participants

BIHIP includes the following participants representing commerce and research:

- COFORD (Ireland)
- Coillte (Ireland)
- Forestry Commission (Edinburgh, Scotland)
- Horticulture Research International (Maidstone, Kent)
- Imperial College of London (University of London at Wye, Kent)
- Institute of Ecology and Resource Management (Edinburgh University, Scotland)
- National School of Forestry (Central Lancashire University, Newton Rigg, Lancashire)
- Oxford Forestry Institute (Oxford University, Oxford)
- Northern Ireland Forestry Service (Belfast, Northern Ireland)
- Northmoor Trust (Little Wittenham, Oxfordshire)
- Woodland Heritage (Buckinghamshire)
- Woodland Improvement and Conservation Ltd. (Gloucestershire)
- Landowners, nursery managers and professional and technical foresters across Britain and Ireland

Activities of the Species Groups

The following information is extracted from the reports on the Species Groups in the BIHIP web-site: *http://www.bihip.com*

Ash — *Fraxinus excelsior*

Ash was recorded as the third most common broadleaved species in the last Census of Woodlands and Trees, and today it is the second most widely planted broadleaved tree in Britain. The attraction of ash is that it is native, produces valuable timber on short rotations, and grows well on nutrient rich sites over much of lowland Britain. However, those trees planted are often of poorly adapted or from foreign stock. BIHIP hopes to address this problem by providing the forester with superior planting stock of local provenance.

To this end, the Ash Group has the following targets:

1. To select 500 superior individuals on a regional basis across Great Britain and Ireland, to fall in line with guidelines issued by the Forestry Commission.
2. To collect reproductive material from the selected trees in the form of either seed for progeny trials, or scion material for the development of a clone bank for gene conservation.

Ash has a reputation for being site sensitive, requiring base-rich, freely draining soils. It is highly susceptible to forking, partly due to the ash bud moth (*Prays fraxinella*), but increasing evidence points to early flushing and subsequent late frost as being a significant cause of damage. While growth and vigour are important elements of any improvement programme, research into the time of flushing and the degree to which this is genetically controlled are essential to the ash programme.

The Ash Group of the BIHIP started work in 1991 and has six Breeding Seedling Orchards (BSOs) under its management. The orchards have been measured for growth and vigour several times. The Group is currently looking for approximately 500 superior trees to be included in the next stage of progeny testing. Ash is a dioecious species - a complete sexual mix-up. Individuals can be male, female, hermaphrodite, or any set of combinations in between.

Silver birch — *Betula pendula*

Although birch was previously frequently planted for amenity and conservation reasons, there was apparently little thought given to the origin of the plants used or to the potential quality of any timber that might be produced. The Birch Group was founded in 1997 to address these problems and the Group set itself two main objectives:

1. To determine the extent of adaptive genetic variation in silver birch in Britain. A comprehensive series of provenance trials with 25 populations planted in four sites in England, Scotland and Wales will establish 'transfer rules', identify any superior populations, and demonstrate the efficacy of proposed seed collection zones in this species. In addition, basic environmental relationships and the genetic structure of the species could be studied in these collections.
2. To initiate a breeding programme for improving the quality of the species. Based on defined regions within Britain, selected superior phenotypes are installed in polyhouse seed orchards to rapidly provide 'improved' seed for commercial use. The technique, based on Finnish practice, was demonstrated for a collection of 'plus' trees from NW Scotland by Forest Research at Roslin. Particular attention needs to be paid to improving stem quality, as well as growth rates.

Wild cherry — *Prunus avium*

Wild cherry is also known as the Gean or Mazzard tree. It is an attractive native species with a high quality timber, short rotation time, and resistance to squirrel damage. As it is a light-demanding tree, it frequently can be found occurring as single trees or small groups in lowland woodlands, particularly on the woodland edges. Cherry is often reproduced vegetatively by suckering, so clumps of cherry frequently consist of identical trees or a low number of genetically distinct individuals. It is one of the first trees to flower in the spring and the fruits are eaten by many small mammals and birds. Its attractive nature and its ability to grow well in many soil types and pH ranges have made cherry a common species in farm woodlands. Cherry timber is used for cabinet making, furniture, panelling, and decorative joinery. The demand for wild cherry timber is high, though top quality timber can be hard to find and very expensive. As a result, the majority of the cherry used in the UK is actually imported Black Cherry (*Prunus serotina*) from North America.

Currently, the majority of wild cherry seedlings planted in the UK are of continental origin and are of unknown quality and uncertain adaptability. Many have characteristics similar to sweet cherry which have been bred to produce large fruited, heavily cropping trees with a wide, open and strong branching habit for ease of picking. Trees selected and bred for timber production will have quite different characteristics, including light branching and vigorous apical growth. Timber trees also tend to be much less susceptible to bacterial canker, therefore ensuring that trees are of a timber type that is suitable for forestry purposes.

The Cherry Group held its first meeting at Woodland Improvement and Conservation Ltd, Gloucestershire on 17th July 1997. The cherry improvement programme is the most advanced of the BIHIP species groups because since 1989 the Department for Environment, Food and Rural Affairs (DEFRA, formerly MAFF) has funded a genetic improvement programme at Horticulture Research International (HRI). This work is now jointly funded by DEFRA and the Forestry Commission. The group supports HRI's ongoing programme of research by helping in the location and collection of 'plus' trees, the selection of sites for trials and seed orchards, the selection of trees from the breeding programme, and the promotion of cherry as a valuable timber and amenity tree. In addition, the cherry group would like to see research undertaken on the silviculture of cherry and aspects of timber quality.

Oak: Penduculate — *Quercus robur* and Sessile — *Q. petraea*

Oak trees form a crucial feature of our landscapes, provide vital wildlife habitats, and are a potentially valuable timber resource. The commercial forester's goal of better returns on shorter rotations has particular appeal for all growers of broadleaves where the difference in price between firewood and veneer timber can be 100-fold, and the time between seed and harvest makes planting an act of faith. Although silviculture can help, it has long been recognized that improving the quality of the planting stock could hold potentially massive benefits for the countryside.

The Oak Group is working to provide improved planting stock to ensure we leave quality oak trees to help sustain the countryside and the rural economy for our successors; it was formed to initiate and support research into the improvement of oak by selective breeding. The objective was to identify two hundred 'elite' oak trees selected for their excellent phenotypic characters: straight trunks, lighter branching, superior vigour, and timber quality. Work at the Oxford Forestry Institute had also identified a link between large spring vessels sizes in the wood, and the presence of shake. All trees 'selected' were therefore microscopically assessed and of these, 100 trees were rejected as having large vessels. Acorns from the remaining 100 superior mother trees were collected over three years and seedlings were raised at Forest Research's nursery at Roslin. The nursery stock was planted in eight 1-2 hectare breeding seedling orchards across Great Britain and Ireland during the winter of 2002/03.

The orchards will be managed (over 50 years) to exclude any obviously inferior lines and the resulting 'improved' acorns will become available for multiplication and release to the nursery trade. It is hoped that the seed orchards should begin to produce acorns in 20 years. Similar projects using tropical hardwood species have yielded 30% increases in average growth rates. Comparable results can be expected with oak. More details of the work of the Oak Group are given in the second BIHIP presentation to the International Oak Society meeting (Savill, Burley and Hemery, 2003)

Sweet chestnut — *Castanea sativa*

Although originally introduced from southern Europe, sweet chestnut is usually considered an 'honorary native' in southern England where it is still the most important commercial coppice crop. The timber is naturally durable, with little sapwood, and requires no preservatives for outdoor use. Its suitability for furniture and other purposes is similar to that of oak, but in large diameters it can be susceptible to timber defects, especially ring shake and spiral grain.

Climate and management changes, together with biotic factors (such as the fungal diseases *Phytophthora* spp. and *Cryphonectria* spp.), pose potential threats to the species. At the same time, genetic variation in domesticated plant material may have diminished, both through breeding and selection (primarily in orchards for edible nuts) and silvicultural intensification.

The Sweet Chestnut Group was formed in June, 1999 with the objective of developing a programme for the genetic conservation and improvement of sweet chestnut in Britain and Ireland. The Group's overall aim is to set up strategies of integrated conservation and utilization that minimize these risks. Its primary objective is to establish both seedling and clonal orchards of chestnut from superior trees, but in the longer term, to investigate a number of research themes including genetic variation, flowering, ecology, defects, and economics.

Sycamore — *Acer pseudoplatanus*

There are thought to be 66,600 ha of sycamore planted across Great Britain, representing about 3% of the total woodland cover. Sycamore grows on a wide range of sites and has similar ecological requirements as ash, but is more frost hardy and less demanding.

This naturalized exotic has considerable economic potential, being one of the fastest growing broadleaves in the UK and Ireland, and because it produces a desirable white timber with little discernible figure or grain. In addition, some individual trees exhibit wavy grain timber, which is prized for making musical instruments and for producing veneer. This is highly valued, but whether this characteristic is determined by the tree's genetic composition, by environmental factors, or both, is not known.

The time of introduction of sycamore to Britain and Ireland is uncertain. It is thought to have been introduced to Britain some time between the Roman occupation and 1550, although it has become established strongly only over the last 200 years. Recently it has acquired a reputation as being an invasive species, yet it thrives best when there is disturbance and evidence seems to support the view that it cannot dominate woodlands for long periods as it has difficulty regenerating under its own canopy.

Little work has been undertaken in the UK or Ireland towards improving sycamore. In the UK five provenance trials testing local and continental European origins showed that there was little difference in growth between the local and continental origins. This has encouraged selecting superior trees or stands to be focussed on local populations.

In May, 2003 the Sycamore Group held its inaugural meeting in Edinburgh. In order to increase the availability of quality genetic material for those wanting to plant sycamore, the Sycamore Group set out to expand the current number of registered seed stands (in Britain there are currently only two registered seed stands). This will improve the supply of seed from stands of better-than-average quality and give rapid results. In the longer term plus trees will also be selected. These will be used to produce seed orchards using grafted stock. Such orchards could produce seed within 5-6 years and be commercially productive within 10 years. There are no such orchards in the UK, but Coillte has established one in Ireland.

Walnut: Common — *Juglans regia* and Black — *J. nigra*

The common or English walnut (*Juglans regia*) is one of the ancient introductions to Britain, but today there are probably fewer trees than at any time since the late sixteenth or early seventeenth centuries.

Black walnut (*Juglans nigra*) was introduced to Britain from North America in 1656 and planted for its valuable timber. The species is potentially the provider of high quality timber on a relatively short rotation, and is consistently in great demand by end-users. During 2000 alone, UK imports of this valuable timber rose by 51%.

At present both species are often overlooked by British foresters because of their reputation as being site demanding, usually of poor form, and vulnerable to frost. No research has effectively addressed these problems in Britain, and although the UK Forestry Commission in 1986-87 planted a series of black walnut provenance experiments, these tested a limited range of material. Since then walnut-tree breeding in North America and mainland Europe has advanced considerably, making available new and improved stock for testing in Britain. Selecting desirable, straight stemmed and finely branched trees to suit the climatic conditions of the UK should encourage a revival of interest.

Walnut is perhaps the finest and most valuable hardwood species, and is seen as a tree that could regain the place it had centuries ago as the provider of high quality timber on relatively short rotations. The wood is used for making quality furniture and producing highly figured veneers, usually from burrs, which are used for cabinet-making and decorative panels. Phenotypes for timber or nut production are generally viewed as incompatible because good phenotypes for timber (*e.g.* long and straight stemmed, finely branched) have deliberately been selected against. Short-boled, spreading and branched trees were sought for high nut productivity and ease of harvesting. Additionally, some phenotypes in Britain may originate from ancient introductions, taken from environments unsuitable for widespread introduction to the British climate.

BIHIP's walnut research is led by Horticulture Research International and the Northmoor Trust. Initially research concentrated on the common walnut, but more recently it has expanded to include black walnut. The walnut trials at the Northmoor Trust's estate in south Oxfordshire include one of the largest collections of walnut (*Juglans regia*) genotypes found worldwide, incorporated in a tree improvement programme and various silvicultural trials. Many of the several trials now underway are planted both with the Northmoor Trust and on independent sites across southern England.

Further information about BIHIP and the work of its individual Species Groups can be found at the website is *http://www.bihip.com* or by communication with the Secretary, *Gabriel.Hemery@northmoortrust.co.uk*

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OAK OPEN FORESTS ("*DEHESA* " OR "*MONTADO* ") OF *QUERCUS ROTUNDIFOLIA* LAM. AND *QUERCUS SUBER* L. IN THE IBERIAN PENINSULA AND THEIR PRODUCTS

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Introduction

"*Dehesa* " ("*Montado* " in Portuguese) is the Spanish word used to name the open forests and woodlands of *Quercus* species (mostly *Quercus rotundifolia* Lam. and *Quercus suber* L.) mixed with pastures, forming a savannah-like landscape, that occur in the south-western Iberian Peninsula. They are manmade ecosystems with high levels of sustainability and stability in terms of ecological products. They are good grazing lands on poor acid soils with scattered trees. Pastures are usually divided into enclosed grazing plots, "*defended*" ("*deffesa*" = latin word for defence) by stone walls or wire fences to permit the management of livestock (SAN MIGUEL, 1994).

The "*Dehesa* " lands have changeable Mediterranean climate and form the largest open forest in Western Europe (around 5,000,000 ha) (GONÇALVEZ, 2000). Lands where the "*Dehesa* " mainly occur are areas of low population

Typical dehesa scene with livestock grazing under oaks. photo © E. Balbuena density and are among the poorest areas in Europe (Objective One EU Regions below 75 per cent of the average performance, as measured by Gross Domestic Product (GDP) per head of population), and the income that comes from the "*Dehesa* " represents more than 50 % GDP (CAMPOS & MUSLERA, 1999) for these regions (mainly Andalucia and Extremadura in Spain, and Alentejo in Portugal).

There are two clearly different layers of vegetation in the "*Dehesa*" — trees and grass.

Grassland has a high turnover rate since annual grasses are alive only during autumn-winter-spring, and survive as seeds during the hot and dry summers. The trees are generally widely spaced with a medium density of 40- 60 trees/ per ha (up to 100 trees/ per ha in pure cork oak forests). They can live for hundreds of years, but today natural replacement is often infrequent. The tree canopy is mainly formed by *Q. rotundifolia* Lam. and *Q. suber* L. (the latter is more abundant in places of oceanic influence), with the occasional presence of *Q. pyrenaica* Willd. (in mountainous areas), *Q. lusitanica* Lam. and *Q. coccifera* L. (as shrubs), and rarely, *Q. faginea* Lam.

In some areas, mainly inside Spain, you can find woodland with only *Q. rotundifolia*, but as you approach the Atlantic Ocean and the soils become more sandy, you will first find areas of mixed forests of *Q. suber* and *Q. rotundifolia*, and then, mainly in Portugal, areas with pure forests of cork oaks appear, in which the cork is so valuable that no grazing is allowed in order to prevent livestock from damaging the trees.

Livestock is both one of the main products of "*Dehesa* " and the tool for stabilising pastureland and controlling the invasion of shrubs (*Cistaceae, Ericaceae, Leguminoseae*, etc.). However, grazing intensity is critical. The rotation, season, and duration of grazing depends of the animal's requirements for food and water and the particular structure of the ranch.

Products derived from oak open forests

("*DEHESA* " OR "*MONTADO* ") in the Iberian Peninsula

Since ancient times trees helped human societies satisfy their feeding and clothing needs. For hundreds of years inhabitants of these lands have been selecting the best trees; the ones with sweetest acorns, good morphological structure, and those that are situated in the best locations. Early on, people understood some of the main advantages of leaving oak trees in these pasturelands: acorns could be used as food both by men and livestock, and cork could be used in many useful ways. These early human societies, consisting mainly by shepherds, found thousands of years ago that by not felling the special oak trees of these regions, you could obtain a wide variety of products.

Indirect products

This productive, multi-purpose, manmade ecosystem, close to natural forest, has a very high biodiversity (at least 8 plants & 139 bird species are currently threatened (GONÇALVEZ, 2000). "*Dehesas*" have important ecological (as a place for carbon sequestration forming the largest open forest in Western Europe) and social values, (as a place for leisure in industrialised Europe), but are difficult to quantify economically.

"*Dehesa*" conserves landscapes of high aesthetic value, low forest fire risk, and well- regulated hydrological cycle, since the trees protect the soils against erosion in areas with changeable Mediterranean climate. The "*Dehesa*" is also the repository of cultural, historical and ethnographical values, since it is the place where ancient, indigenous, local shepherds and cork producers lived and worked.

Direct Products

"*Dehesa*" provides products of great singularity, high quality, and high economic value that are increasing day by day. These products are all produced in a natural, traceable way that is highly valued by today's consumers. Also there are less economic risks for producers and landowners because a large variety of natural products can be obtained in a changeable market. In this descriptive article we will only give a quick look at all the products the "*Dehesa*" and "*Montado*" supply, concentrating a bit more on the two most important economic products which are Iberian black pigs and cork.

Acorns

Acorn production of *Q. rotundifolia* is very variable from one year to another and depends of tree distribution, but averages 500kg-ha/year (SAN MIGUEL, 1994). Acorns today are used mainly for fattening Iberian black pigs in the fall, and other animals such as sheep, goats, deer, will complete their feeding requirements with acorns. This is because acorns of *Q. rotundifolia* are big, sweet, and tasty and contain lots of carbohydrates — around 70% dry weight that are easily transformed into fats when eaten by Iberian black pigs (VAZQUEZ, 1998).

In the past *Q. rotundifolia* acorns were eaten directly by men or were dried and crushed into acorn flour. Nowadays they are mainly used for making traditional products such as liquors, acorn chocolates, and acorn cakes. Acorns of *Q. suber* are not as good for animal feeding, and will be eaten by livestock only when *Q. rotundifolia* acorns are not available or are very scarce. Animals that change from eating *Q. rotundifolia* acorns to *Q. suber* acorns will lose weight.

Acorn liquors photo © E. Balbuena

Iberian black pigs

During the time of acorns, known locally in Spain as "*montanera*" time (Oct.-Feb.), you will find pigs being fattened in a complete natural way all through the "*Dehesa*" at the rate of 0.5-1 animals/ha. Pigs will double their weight in only a few months by eating mostly acorns (carbohydrates) of *Q. rotundifolia* and grasses (proteins) and mushrooms. They increase in size from around 60-80 kg at the start of fattening time (when they are a year old) to around 120-160 kg three to four months later. They are then slaughtered, with a production of nearly 1,000,000 animals/year (APARICIO & VARGUS, 2000), and their meat has a special delicious flavour. This is why pork and other products from the Iberian black pigs such as "*acorn cured ham*" (~500?), and special dried up sausages such as "*chorizos*" (~30?) and "*lomos*" (~100?), are very expensive. These natural, high-quality products, are highly valued by consumers around the world.

Iberian black pigs photo © E. Balbuena

Products of the Dehesa

photo © E. Balbuena

Cattle

Cattle are bred and reared in the cooler and moister areas of the "*Dehesa*" since the animals have great need for water and must be fed supplements during summer. Indigenous breeds such us "retinta", "morucha", "avileña" and "brave Spanish bulls" will graze all year long at the rate of 0.25 animals per hectare, and are bred mainly for beef production (nearly 1,400,000 breeding females in Spanish areas of "*Dehesa*" (ESCRIBANO & PULIDO, 1998) . Today cattle numbers are increasing rapidly and they are more abundant than in the past.

Sheep, goats and horses

Sheep are grazed with goats in big flocks that require a shepherd and are consequently less profitable because of this added cost. Sheep were the main livestock used in "*Dehesa*" pastures in the past. Sheep graze all year long (nearly 200,000 sheep were slaughtered in Extremadura alone during 2001). They are stocked at the rate of 1-3 animals/ha, mainly the "merina" breed, but sometimes are also cross-bred to improve production. They are bred for lamb meat and milk, and for a very high quality cheese.

Goats were more abundant in the past and are stocked at the rate of 1-3 animals/ha and produce meat and milk for cheese (nearly 20,000 animals were slaughtered in Extremadura alone during 2001). Horses are only used for recreation or for managing the Spanish brave bulls, since they are very expensive to maintain.

Products from agriculture

Nowadays "*Dehesa* " lands are only cultivated occasionally to control shrubs and the increased yield is used as supplementary food by livestock or game species during periods of scarce food.

Hunting

"*Dehesa*" lands are also the feeding zones of many wild animals, such as deer, wild boars, hares, etc. , some of which have high economic value because they are highly-sought-after game species.

Mushrooms

Traditionally only small amounts of mushrooms were collected but today they have become very expensive and are starting to be harvested in an organised way.

Honey

The scarce production of honey is only partly commercialised, but it has a very high quality; it was traditionally used for domestic use.

Firewood and Charcoal

Q. rotundifolia produces a very dense firewood which is very good for home heating and for good quality charcoal for barbecues. Firewood is a by-product of the pruning of oaks to enhance acorn production; pruning for obtaining only firewood is strictly forbidden.

Cork harvesting photo © E. Balbuena

Browsing of branches

Thin branches and leaves of oaks will be directly eaten by animals from the trees, or the animals will eat leftovers from pruning during dry winters or hot summers when other food is scarce.

Cork

Cork nowadays has acquired a high commercial value because of the continuously increasing demand for cork products including stoppers The stripping of cork in an industrial way, however, didn't start until the end of the 18th century. The principal cork producing countries are: Portugal (50.5%), Spain (22.7%), Algeria (10.7%), Morocco (5.3%), Italy (4.2%), France (3.7%) and Tunisia (2.7%) (IPROCOR et al., 1998), and more than 70% of the world's cork production comes from the "*Dehesa*" (GONÇALVEZ, 2000). New cork oak forests are being planted to insure the future production of cork in areas of "*Dehesa*".

Today there are strict laws that control the process of cork stripping. The stripping of the tree takes place during summer (June to mid August), because the sap is running more freely through the tree. The first stripping takes place when the tree is about 25-40 years old (70 to 90 cm diameter) and cork from this first stripping is used principally for decorative cork and grain cork after being grinded, as it is useless for stoppers.

With each successive stripping the quality of cork improves, and normally it is not until the third stripping that cork can be used for stoppers. The trees can be stripped again after at least nine years, and up to fourteen years, as the bark is then thick enough for industrial use. Trees can be stripped 12-14 times (until they are 150 years old), without causing the dying-back of the tree.

Two men work at the same tree using special traditional axes and there are more than 10,000 professional cork-strippers in Spain and Portugal (GONÇALVEZ, 2000). They always try to cut up the bark using the same cutting pattern from the previous stripping and they will produce pieces 75-125 cm x 50-

70 cm for easier transport to factories. More than 30,000 people work in Spain and Portugal at cork processing factories and producing companies (GONÇALVEZ, 2000).

The basic process at the factory is as follows (IPROCOR et al., 2000):

CORK TRANSPORTED BY LORRIES TO THE FACTORY;
RAW CORK STORED;
CORK BOILED AND THEN STORED AND DRIED;
CORK CUT INTO REGULAR PIECES;
PIECES SORTED AND PRESSED;
PIECES CLASSIFIED INTO BUNDLES;
DIFFERENT PRODUCTS MADE FROM DIFFERENT GRADES;

- WINE AND CHAMPAGNE CORKS (70% of production by value);
- GRINDING LEFTOVERS FROM MAKING STOPPERS;
- OTHER DIFFERENT PRODUCTS (30% of production by value) - for variable purposes such as products for building industry, car industry, shoes, and many others.

Conclusions

In conclusion, we can only subscribe to the opinion that many ecologists and scientists hold and share nowadays; That is, that the "*Dehesa*" and "*Montado*" ecosystems are very good candidates for listing as a red book of threatened ecologically sustainable landscapes with high biodiversity (RADU & COANDA, 2002).

The Dehesa in Winter — photo © E. Balbuena

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MISTLETOE ON OAKS IN BRITAIN

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Abstract

Oak trees have always been considered to be rare hosts for mistletoe in Britain despite the traditional association between the Druids and mistletoe growing on oaks in the minds of many people. Currently there are eleven confirmed mistletoe-oaks in Britain. Common oak (*Quercus robur*) is the most frequent host; mistletoe is growing on red oak (*Q. rubra*) at three separate sites, as well as on one scarlet oak (*Q. coccinea*). The estimated ages of the existing oak hosts range from 90 to 400 years and they are found in hedges, woodland edges, parks and a churchyard rather than in pure woodland. The existing mistletoe-oaks are concentrated in Herefordshire and the current range is very much more restricted than the historical range. Evidence from past records, reports and general accounts of mistletoe on oak indicates that the rarity of mistletoe-oaks in Britain has not changed since the 17th century. The current results suggest a population of mistletoe-oaks that is apparently fairly stable in number, but with some turnover as losses are compensated by the discovery of new sites and the parasitism of new trees.

Introduction

Mistletoe (*Viscum album*) has a wide range of hosts in Britain (Bull 1864a, 1864b, 1907; Somerville 1914; Nicholson 1932; Perring 1973). The commonest hosts are apple (*Malus sylvestris*), common lime (*Tilia* x *europaea*), common hawthorn (*Crataegus monogyna*) and hybrid black poplars (*Populus* x *canadensis*) (Perring 1973; Briggs 1999). Despite the traditional association between mistletoe, oaks, and Druids in the minds of many people (Frazer 1922; Kanner 1939; Box 1995), oaks have always been considered to be a rare host for mistletoe in Britain (Evelyn 1664; Ray 1670, 1677; Withering 1796; Loudon 1838; Bull 1864a, 1864b, 1907; Nicholson 1932; Tubuef 1923; Perring 1973).

The Botanical Society of the British Isles (BSBI) carried out a survey of mistletoe and its hosts from 1969 to 1972 using both BSBI members and the general public (Perring 1973). Mistletoe was not recorded on sessile oak (*Q. petraea*) and was recorded on common oak (*Q. robur*) in only twelve of the 10-km squares in Britain (2.2% of the 539 10-km squares recorded).

In contrast, the most recent survey of mistletoe carried out from 1994 to 1995 by Plantlife and the BSBI produced some 140 sightings of mistletoe on oak, 1.8% of the 8,000+ sightings of mistletoe sent in by the public and by botanists (Briggs 1995), although there are likely errors due to the misidentification of oak in winter (Perring 1973; Jonathan Briggs, pers. comm.).

An examination of historical records and the confirmation of existing sites of mistletoe-oaks was undertaken in order to provide firm evidence of their current and their historical distribution in Britain.

Methods

BSBI vice-county recorders, the national Biological Records Centre (Centre for Ecology and Hydrology at Monks Wood), and local Biological Record Centres (usually county based) were asked for past and present records.

County floras for England and Wales, from Victorian times to the present, were examined for references to mistletoe on oak, as were local floras for Bristol (Swete 1854; White 1912) and Chepstow (Shoolbred 1920) that are in mistletoe-rich areas.

Given the density of mistletoe records in Herefordshire and surrounding counties (Perring 1973; Briggs 1999), sources of local natural history records were checked: botanical records published by the Caradoc & Severn Valley Field Club (Shropshire) from 1892 to 1970 when the botanical records petered out; the Transactions of the Woolhope Naturalists' Field Society (Herefordshire) from 1851 to the present; the Transactions of the Worcestershire Naturalists' Club (1847 to the present); and the Proceedings of the Somerset Archaeological & Natural History Society (1850 to the present).

Mistletoe-oaks referred to in the published literature were followed up, if there was sufficient information to identify the site, through correspondence with the landowner and, if necessary, by a site visit.

Existing mistletoe-oaks were visited with the permission of the landowner or occupier. The girth of each tree was measured at 1.3 m above ground level (Hamilton 1975) and used to derive the diameter at breast height (dbh). The age of each tree was estimated using the dbh, taking into account the location in which each tree was growing (White 1994); additional estimates of age were derived from published accounts. Mistletoe is dioecious and the mistletoe on each oak was examined to determine if plants were female by examining for berries in December 1996/January 1997 using 12 x 25 binoculars; mistletoes without berries were checked again in November 1998.

Berries of *Viscum album*

photos © John Box

Viscum album

Results and Discussion

The earliest known report of mistletoe on oak in Britain is the poem attributed to the 13th century Scottish poet, Thomas the Rhymer, describing the mistletoe-oak at Errol in Perthshire. Kanner (1939, p.913) reports an old account of mistletoe growing in profusion on a vast old oak in the neighbourhood of Errol, not far from the Falcon stone; the fate of the family of Hay was reputed to be linked to the continued existence of this tree (Gurney 1848, pp. 576-577; Melville 1935, p.156). Kanner (1939) also notes that the 13th century Scottish poet, Thomas Rymour of Ercildowne (Thomas the Rhymer, 1220-1297), is credited with the authorship of the poem that deals with the connection between this mistletoe-oak (aik) and the fate of the Hay family:

While the mistletoe bats on Errol's aik,
And that aik stands fast,
The Hays shall flourish, and their good grey hawk
Shall nocht flinch before the blast.

But when the root of the aik decays
And the mistletoe dwines on its withered breast
The grass shall grow on Errol's hearthstane,
And the corbie roup [raven croak] in the falcon's nest.

There are no further records of mistletoe on oak trees at Errol and the estate was sold by the Hay family in the 1630s to cover the debts of the 10th Earl (pers. comm., Jeremy Duncan, Local Studies Librarian, AK Bell Library, Perth).

The earliest definite published records of mistletoe growing on specific oak trees, rather than general statements about mistletoe on oaks, all date from the 17th century: the mistletoe-oak at Norwood (Surrey) felled in 1657 (Aubrey 1719); mistletoe on oak near Sheffield (Yorkshire) reported by Ray (1670, 1677); and mistletoe growing on oak at Staveley (Derbyshire) in the second half of the 17th century (Arnold 1887; correspondence from the Countess of Danby to Mrs. Colepeper, Folio 46, Harley MS 7005, British Library).

The 2nd Edition of Ray's *Catalogus Plantarum Angliae* (Ray 1677) contains details of mistletoe on an oak at Sheffield that were not in the 1st Edition (Ray 1670). Ray (1677, p.307) has "*Siquis viscum in Quercu crescentem videre desiderat, Sheffeldiam adeat, a qua non procul inveniri eum a D. Fr. Jessop certior factus sum*" [Anyone who wants to see mistletoe growing on an oak should go to Sheffield, not far from where I have been informed by D. Fr. Jessop, it can be found] whereas Ray (1670, p.319) only has "*Siquis viscum in Quercu crescentem videre desiderat*". Francis Jessop (1638-1691) of Broomhall, Sheffield, met John Ray in 1668 and Ray published some of Jessop's plant records (Desmond 1977).

The oak with mistletoe at Staveley was clearly famous in the 17th century for its rarity because Arnold (1887) reports that "*…in one of Colepeper's MSS. at the British Museum, in a curious notice of Sir Peter Freschville's house at Staveley, Derbyshire, is this passage:— 'Heare my Lord Freschville did live, and heare grows the famous Mistletoe tree, the only oake in England that bears Mistletoe.'*" The Sheffield and Staveley records are particularly interesting and may well be of the same tree, as Staveley is only some 14 km from the centre of Sheffield.

The earliest herbarium specimen of mistletoe from an oak is dated 1690 and was obtained at Stafford and is held in the Morisonian collection at Oxford University.

There was considerable interest in mistletoe and its wide variety of host species from the 19th century until the early part of the 20th century and information on mistletoe on oaks is contained in more general accounts (Lees 1842, 1851; Bull 1864a, 1864b; Anon. 1873; Webster 1885; Arnold 1887; Purchas & Ley 1889; Bull 1907; Elwes & Henry 1907; Somerville 1914; Tubuef 1923; Nicholson 1932; Durham 1935). Bull (1864a, 1864b) built on the initial observations of Lees (1842, 1851) and gives details of six records/ authenticated reports of mistletoe-oaks. Footnotes in the later reprint of this paper (Bull 1907) extended the list of records/ authenticated reports to eleven trees. Later lists of mistletoe-oaks appear to be derived from earlier accounts, often combined with additional second-hand reports without any first-hand evidence. Nevertheless, the various lists compiled

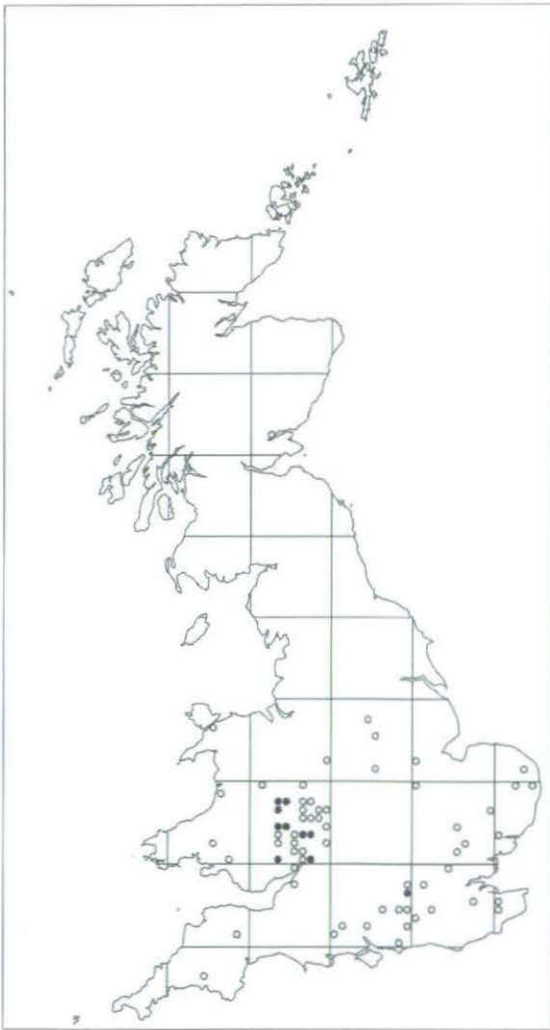

Figure 1. Distribution of records and reports of mistletoe-oaks and existing mistletoe-oaks. Current verifications shown as solid circles.

between the middle of the 19th century and the first part of the 20th century usually describe between ten and twenty mistletoe-oaks.

Currently, eleven oaks with mistletoe growing on them have been located and verified in Britain (Figure 1); nine of the oaks support female mistletoe plants. The mistletoe-oaks are concentrated in Herefordshire, with single examples in Berkshire, Gloucestershire and Gwent, and the records cover ten separate 10-km squares of the Ordnance Survey. This figure is similar to the twelve 10-km squares for which mistletoe-oaks were reported in the 1969 -1972 BSBI survey (Perring 1973).

These results, together with the lists of between ten and twenty mistletoe-oaks in the 19th and early 20th centuries, suggest a population of mistletoe-oaks which is apparently fairly stable in number, but in which there is a considerable turnover as losses are compensated by the discovery of new sites and the parasitism of new trees.

Common oak, *Q. robur*, is the most frequent host amongst the existing mistletoe-oaks. The presence of mistletoe on red oak, *Q. rubra*, at three separate sites, as well as on a scarlet oak, *Q. coccinea*, is notable as the BSBI survey recorded common oak as the only host species of oak (Perring 1973). It is interesting to note that Somerville (1914) includes a report of mistletoe on *Q. rubra* (syn. *Q. borealis*) in Worcestershire, although no details are given. Mistletoe, however, is found on 'red oaks' (*Q. rubra, Q. coccinea, Q. palustris*) in other parts of Europe, particularly in France (Frochot *et al.* 1994). Common oak is also the most frequent species of oak identified in past records/reports of mistletoe-oaks which now either no longer exist or where mistletoe is no longer present on the host tree.

The estimated ages of the existing oak hosts range from 90 to 400 years. These mistletoe-oaks are found in open situations such as woodland edges, hedges, parks and even a churchyard, but not in pure woodland; Frochot *et al.* (1994) report a similar finding with mistletoe on 'red oaks' in France. Records and reports of other oaks with mistletoe confirm the preference for open situations; locations in woodland tend to be on the edge of the woodland, for example "in the corner of a wood", or in "a fringe of ancient woodland" beside the Avon Gorge, or near a stream in the Wyre Forest. This preference for open, un-shaded habitats (gardens, orchards, parks, hedgerows), rather than woodlands, is characteristic of mistletoe in general (Perring 1973; Briggs 1995, 1999).

Hedgeline containing a common oak without leaves but with two bunches of mistletoe. photo © John Box

The pattern of distribution for

Arrow shows a bunch of mistletoe on red oak in churchyard.

photo © John Box

all records and reports of mistletoe-oaks (Figure 1) is similar to the distribution for all mistletoe records given in Perring (1973) and Briggs (1995, 1999). However, the range of existing confirmed mistletoe-oaks (solid circles) is significantly more restricted than the historical range (all circles), but coincides with the concentration of British mistletoe records in Herefordshire and the surrounding counties (Perring 1973; Briggs 1999).

In conclusion, the verification of only eleven existing mistletoe-oaks confirms the rarity of mistletoe growing on oak in Britain. Past records, reports and general accounts suggest that this rarity has not changed significantly since the 17th century when it was commented on by Evelyn (1664) and Ray (1670, 1677). Indeed, mistletoe from the oak at Eastnor was considered sufficiently noteworthy to be exhibited in 1837 at both the Linnean Society and the London Horticultural Society (Anon. 1837; Loudon 1838). Mistletoe growing on native oaks (*Q. robur* and *Q. petraea*) would appear to be a rare association throughout most of western Europe (Tubuef 1923; Grazi & Urech 1983), although surveys over the last twenty years have identified almost 250 native oaks with mistletoe and some 460 'red oaks' with mistletoe in France (Frochot *et al*. 1994; Ramm *et al*. 2000). The present range of mistletoe-oaks in Britain is, however, less than the historical range based on past records and reports. This may be due to the clearance of woods and hedges resulting from the intensification of agriculture and the extension of urban areas over the past 50 years. Within the present range, the existing mistletoe-oaks are concentrated in Herefordshire, which coincides with the core of the present distribution of mistletoe in Britain.

Acknowledgements

The assistance of BSBI recorders throughout Britain is very gratefully acknowledged, as is the help given by the staff of local Biological Record Centres in England and Wales and the staff of various herbaria and libraries (in particular the libraries of the Linnean Society of London and the Royal Society). The owners and occupiers of the sites of mistletoe-oaks, both past and present, have been particularly helpful. Jane Croft and Henry Arnold at the Biological Records Centre of the Centre for Ecology and Hydrology at Monks Wood have computerised the records and reports and generated the distribution map using Alan Morton's DMAP programme. Lastly, much assistance has been given by Franklyn Perring and Jonathan Briggs whose organisation of mistletoe surveys has added significantly to the knowledge of this species. A fuller account of these results is given in *Watsonia* 23: 237-256 (2000).

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OBSERVATIONS ON THE ENTOMOFAUNA OF WEST PALAEARCTIC OAK WITH PARTICULAR REFERENCE TO LONGDON MARSH, WORCESTERSHIRE, ENGLAND

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The tree of life is inextricably linked to the life of the tree...
- P. F. Whitehead

Separating the wood from the trees

In recent years attention has focussed on the role played by mature, senescent and moribund trees as support systems for invertebrates, many of which, by reference to the fossil record exemplifying their changed distributions in space and time (Shotton and Osborne, 1965; Coope, 1990; Buckland and Dinnin, 1993; Elias, 1994), are regarded as being worthy of proactive conservation (Speight, 1989). The invertebrate fauna of such trees (in woodlands or otherwise) provides one reason of many proposed by conservationists to underscore their heritage status as objects of landscape and socio-cultural interest (e.g. Fowles *et al*., 1999; Franc, 1995, 1999; Harding and Rose, 1986; Key, 1996; Read *et al*., 2001; Travé, 2003). Amongst oak-associated invertebrates, the Hermit Beetle *Osmoderma eremita* (Scopoli) is the subject of a European Union Habitat Directive (92/43 CEE), and funding from the European Union Life Project has been employed to safeguard it.

Britain, Europe and the Near East are littered with ancient and veteran trees. British veteran trees have earned a great deal of reverential regard (e.g. Pakenham, 1996), but there are no grounds to suppose that Britain's ancient tree stocks are unique, and many such trees and their sites await description and study throughout the region. One only has to consider the number of veteran Olive (*Olea europaea* Linnaeus) and other trees in Greece (Rackham and Moody, 1996), the entomofauna of which is imperfectly understood. However, there has been a growing awareness that recent social trends may militate against ancient or veteran trees (**Figs 10, 12**). Many specimen trees have been revered and regarded as 'monuments' for hundreds of years; the desire to name veteran trees, e.g. 'Robin Hood's Oak,' 'Hippocrates' Plane,' 'Old Glory' (McCreary, 2003) confirms their place in the minds of people and in human culture. The largest veteran trees are frequently isolated open-grown specimens, or form part of planted or managed anthroposystems.

Such anthroposystems include farmland (**Figs 3,11,12**), farm-orchards and parklands (**Fig. 1**), which in their formal sense extend from early medieval deer parks and pasture-woodlands (**Fig. 2**), to modern post-industrial urban pleasances and individual amenity trees as objects of landscape embellishment. Such open woodlands are frequently composed of trees which are widely spaced (typically 7m apart in the case of English farm-orchards) or essentially equidistant (e.g.

Figure 1. Duncombe Park, East Yorkshire, England. Established in AD1713, with substantial Victorian influence, this parkland is one of the richest sites for arboreal invertebrates in northern England. September 2 1994.

(All photos by author)

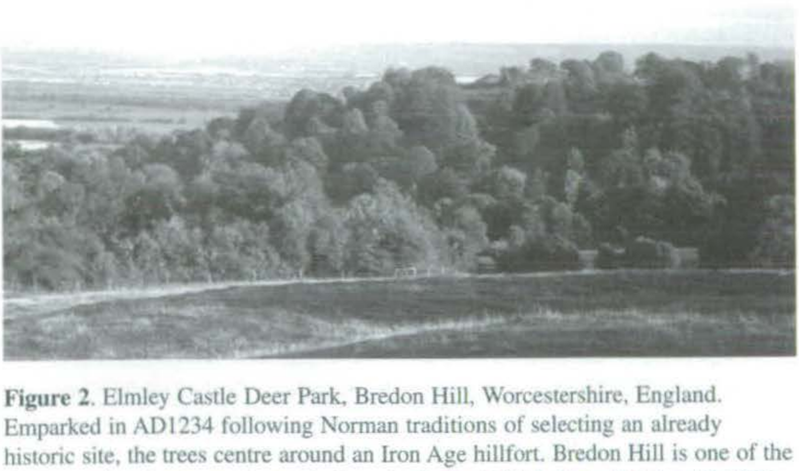

Figure 2. Elmley Castle Deer Park, Bredon Hill, Worcestershire, England. Emparked in AD1234 following Norman traditions of selecting an already historic site, the trees centre around an Iron Age hillfort. Bredon Hill is one of the foremost sites for invertebrate biodiversity in the British Isles. October 29 1995.

Quincunx-defined orchards; managed oak woodlands of Extramadura, Spain; presumed 'acorn-orchards' of central Europe). Their growth, mass and volume may be optimal, bringing benefits to their associated entomofaunas, both in terms of composition and staged succession. In some large-scale managed systems composed of even-aged trees, the matrix may provide a mosaic of dynamically changing conditions developing similarly but asynchronously (but sometimes synchronously, for example in the case of orchards composed of a single cultivar or species). Habitat asynchroneity provides a fluid mosaic and favours biotic continuity over time.

Although these managed systems, some of which have been termed anthropogenic refugia (**Fig. 3**) (Whitehead, 2000), are known to support *Urwaldrelikt* invertebrates (Alexander, 1999; Franc, 1997; Lott *et al.*, 1999; Whitehead, 1999b, 1997, 2002) they are not to be confused with *Urwald* itself, and therein lies an enigma. The complete sylvan ecology of extant *Urwald* is, in most cases, essentially absent from such managed systems; the terricolous invertebrate fauna is frequently composed of somewhat coarsely eurytopic species.

Many of the formally ratified forest reserves of Europe and the Palaearctic support well-expressed biotas with rich faunas of invertebrates (**Fig. 4**), reptiles, amphibians, mammals and birds. Gutowski and Jaroszewicz (2001) list 11564 species of animals from Bialowieza Forest that straddles Poland and Belarus. Where such rich pristine forests are draped across dissected topography and a range of altitudes, combinations of processes may lead to extensive fragmentation of the forest edge. In Turkey, the high Taurus Mountains are dotted in places with extraordinary ancient pollarded and/or coppiced junipers; such trees are either climatic isolates, but more usually anthropo-isolates, and dot the montane plateaux like transfixed spirits of an earlier epoch. In the European alpine forest systems similar isolated trees occur from the canopy edge to above the snowline;

Figure 3. Hisaronü fields, Lycia, Turkey. A biotically rich 'culture-savannah' with oak *Quercus pubescens*. May 23 1997.

Figure 4. Bialowieza Forest, north-east Poland. The *Urwaldrelikt* lucanid beetle *Ceruchus chrysomelinus*, an indicator species of intact well-preserved arboreal systems. September 27 1998.

the deadwood invertebrate fauna of such trees may exceed that of those within the closed forest canopy. In Balkan montane systems, desiccated hulks of cedars litter the hillsides upslope of the forest core; forest edges in these places are diffuse and subject to rapidly vacillating climates, rather than those created by the forest itself. Ragged forest edges may interdigitate with subalpine herb-dominated systems; the sylvan ecology is therefore no more intact than that of the anthroposystems already cited. In south-central Europe oak-dominated forest is broken by xerothermic conditions; in such places the forest floor is penetrated by steppic herbs and xerothermic invertebrates. Jeník (1979) illustrates well the influence of climate on forest structure. What climatically-fragmented forest has in common with arboreal anthroposystems **(Figs 3, 5, 11, 12)** is an ability to sustain populations of many rare invertebrates (Dajoz, 1965, Travé, 2003). One reason for this is that arboreal fungi which prepare living trees for invertebrate colonisation may be able to develop strong populations; spores may perhaps be distributed more effectively, germinate more readily, or develop more aggressively on fragmented, exposed, or stressed trees **(Figs 5, 10)** than on trees growing deep within a forest. Although the mycofauna of dead and fallen trees may be richly speciose in closed canopy forest, and arguments in its favour have frequently been made (e.g. Lamb, 1979), some fastidious invertebrates are clearly indifferent to it as a phytoclimax. Another reason is that many small nectar-providing woody plants occur in broken woodland, and these help to sustain the adult stages of many insect groups.

The stenotopic arboreal aphid genus *Stomaphis* (Hemiptera: Aphididae) includes *S. quercus* Linnaeus on oak and *S. graffii* Cholodkovsky on Field Maple, *Acer campestre* Linnaeus. Until recently *S. graffii* was known only from a single tree in Britain (Whitehead, 1995), and although this is no longer the case, both of these species are most usually found in broken woodland, often in insolated sites

Figure 5. Windsor, Berkshire, England, the prime British site for oak-associated invertebrates. An ancient oak *Quercus robur*, the tanned heartwood weakened and fragmented by basidiomycotine fungi, inducing bole shear. This group of entomologists, including Dr Eva Sprecher, Dr Peter Zach, and inside the bole, Mr P.M. Hammond, recorded the scarce beetles *Procraerus tibialis* (larvae), *Ampedus cardinalis* (larvae), *Dryophthorus corticalis* and *Platypus cylindrus* on June 27 2002.

where their commensals, the ants *Lasius fuliginosus* (Latreille) and *Lasius brunneus* Latreille respectively, proliferate. On the Greek island of Thàsos, open-grown veteran oak trees are uncommon, but large isolated examples of *Quercus calliprinos* Webb sustain key geographical populations of the longhorn beetle *Cerambyx velutinus* Brullé amongst others. The rare, highly specialised *Euryusa sinuata* Erichson (Coleoptera: Staphylinidae), regarded as stenotopic to oak (of the subgenus *Quercus*) where it occurs subcortically and commensally with the ant *Lasius brunneus*, is also known from a single hedegrow hawthorn and a single cultivated apple tree in Britain, in this instance with the ant *Lasius niger* Linnaeus (Whitehead, pers. obs.), as noted by Reitter (1909).

A study on a single exotic Turkey Oak (*Quercus cerris* Linnaeus) (Whitehead, 1996b) planted in pasture in Worcestershire, England, revealed a rich entomofauna with a conservation value quantified as greater than that of the entire Forest of Dean in adjacent Gloucestershire. A cursory study, spanning some 40 minutes, of an open-grown *Quercus pubescens* Willdenow in an ancient agri-system in Lycia, Turkey, during May 1997, revealed two species of beetle and one species of Neuroptera new to science (Whitehead, unpub.). In such extreme cases it may be reasoned that the tree is more important than the forest, although it clearly has to exist in a landscape with sufficient woody plant material to sustain the regional entomofauna which it sustains itself. Great care must therefore be taken to avoid generalities when considering the colonisation success of *Urwaldrelikt* invertebrates in relation to tree density (Ranius, 2003). In the centre of the historic City of Bath, Somerset, a veteran Caucasian Wingnut *Pterocarya fraxinifolia* (Lamb) Spach supports the widespread deadwood *Melanotus villosus* (Fourcroy) (Coleoptera: Elateridae). The situation is no different in the Nearctic Region. In the rambling Disneyworld complex of Orlando, Florida, deadwood elaterid and other beetles survive in isolated trees (J.A. and P.F. Whitehead, pers. obs.). Some European towns and cities, which have been little-modified since their medieval establishment, present few barriers to stenotopic arboreal invertebrates. In 1999 over 10000 exit holes of the subcortical beetle *Gastrallus immarginatus* (Coleoptera: Anobiidae) were observed on a single tree in the then 139-year-old arboretum at Banská Stiavnica, Slovakia (Whitehead, 1999), and in Bratislava, *Urwaldrelikt* insects occur within the connurbation (Vladimir Franc, pers. comm.).

The Kemerton Estate in Worcestershire, England, extends over 250 hectares and is a working rural farmed landscape. A study of its tree resource (Whitehead, 1996a) produced the surprising conclusion that it was, at that time, the seventh most important site for arboreal beetles in Britain; none of the other sites were dominated by commercial agriculture. The incidental importance of this finding was the relative merit of sympathetic agriculture in the formation of a perfect example of an anthropogenic entomo-refugium.

To where are we led? The classic work of Turner and West (1968) determined that the plant succession of interglacials extended through a number of definable zones, of which the post-optimal ones were marked by the opening up and fragmentation of temperate deciduous forest with oak. The arboreal entomofauna of interglacial sites has been studied (Shotton and Osborne, 1965; Coope, 1990; Ponel, 1995). Some of these sites supported substantial populations of herbivorous forest mammals such as elephants, which must have impacted on forest structure just as significantly then as now. All of these combined lines of evidence confirm that well-expressed arboreal entomofaunas do not demand climax forest *per se*, and it is established not only that climatically stressed forests, but also that mature amenity oak trees growing in their own space, are able to sustain exceptionally rich invertebrate faunas.

The invertebrates of oak

Oak is also noted for its great biodiversity; European oaks are thought to be colonised by c6000 species of insect (Dajoz, 2000) and in Slovakia, at least 286 species of parasitic wasps occur on oak (Patocka *et al.*, 1999). Some 225 species of aphids are dependant on the genus *Quercus* (Blackman and Eastop, 1994). Suites of invertebrates characterise the various subfamilies of oak throughout their ranges, although data from the more outlying parts of the Palaearctic Region is often unpublished or scanty. Invertebrates are able to colonise all parts of oak trees, and some gall-forming cynipid wasps alternate between arboreal and terrestrial generations as a means of overcoming seasonal climatic variations. Mites (Acarina) figure very prominently in ancient woodland biocoenoses (Fashing, 1994; Travé, 2003), although the specialist knowledge required has tended to limit interest in the group. Larvae of the stag beetle *Lucanus cervus* Linnaeus (Coleoptera: Lucanidae) feed in the rhizosphere (Sprecher, 2003), their presence often only revealed when the beetles appear. Owen (2000) added significantly to knowledge of the entomofauna of the oak rhizosphere. Invertebrates associated with other parts of the tree may be equally unobtrusive. Some oak mirid bugs may spend up to 11 months as ovae, whilst some adversity-selected deadwood beetles may spend three or four years as larvae, but only three to six weeks as beetles. Adversity-selected species (*sensu* Greenslade, 1983), which may also include mites (Crossley, 1977), are said to be 'K-selected.' Some K-selected beetles form closed populations within the tree, and do not need to leave it to maintain viable populations.

Numerous species of moth larvae feed both internally and externally on oak foliage, although many of these are polyphagous. Patocka *et al.* (1999) cite 249 species of Lepidoptera on Slovakian oaks; this figure rises further south with over 300 species being recorded from Spanish oaks. Morris (1974) reviewed the entomofauna of British oak. In the island groups of the Mediterranean Sea-basin and in Turkey, weevils of the genus *Phyllobius* and *Polydrusus* are especially speciose; these are root feeders as larvae, but along with many other beetles, they swarm in spring on the flowers of *Quercus calliprinos*, *Quercus coccifera* Linnaeus and *Quercus ilex* Linnaeus. Few insects, such as the striking red and black click beetle *Ampedus cardinalis* (Schiödte) (Coleoptera: Elateridae), have evolved an obligate commitment to oak. Amongst moths, *Phyllodesma suberifolia* (Duponchel) (Lepidoptera: Lasiocampidae) of France, Spain and North Africa feeds on oaks of both the subgenera *Quercus* and *Sclerophyllodrys*, but apparently on no other trees. The Oak Hawk Moth *Marumba quercus* (Denis and Schiffermüller) (Lepidoptera: Sphingidae) occurs rarely on other host trees, but *Lasiocampa quercus* (Linnaeus) (Lepidoptera: Lasiocampidae) chooses from at least 20 other genera of woody plants.

Many invertebrates are not known to distinguish between the age and the condition of their host trees. *Dryophilus flavoquadrimaculatus* (De Geer) and *Harpocera thoracica* (Fallén) (Hemiptera: Miridae) occur on oak trees of almost any age, as do many species of gall-forming cynipid wasps. Larvae of the Purple Hairstreak (*Neozephyrus quercus* (Linnaeus)) (Lepidoptera: Lycaenidae) occurs equally readily on both vigorous and veteran oak trees >800 years old; occasionally they also occur on planted *Quercus* subgenus *Sclerophyllodrys* in Britain, although in southern Europe and the Near East, *Sclerophyllodrys* hosts the Ilex Hairstreak (*Nordmannia ilicis* Esper) **(Fig. 6).** The carnivorous bush cricket *Meconema thalassinum*

Figure 6. Hisaronü fields, Lycia, Turkey. Ilex Hairstreak *Nordmannia ilicis*. May 23 1997.

(DeGeer) (Orthoptera: Tettigoniidae) occurs on oaks, especially of the subgenus *Quercus*, in a wide variety of ages and conditions. Case-bearing moth larvae of the genus *Luffia* (Lepidoptera: Psychidae) often prefer isolated veteran oak trees, with their rich flora of lichens; the Zebra Spider *Salticus zebraneus* (C.L. Koch) (Araneae: Salticidae) also has a clear preference (so marked that the author has referred to it as the Veteran Tree Spider) for the deeply corrugated lichen-covered bark of exposed ancient and veteran oak trees with their diversity of microclimates, as do the predatory larvae of *Malachius bipustulatus* (Linnaeus) (Coleoptera: Malachiidae).

Weevils of the genus *Curculio* (Coleoptera: Curculionidae) range widely across oak subgenera; in this genus *C. villosus* Fabricius stands apart as an inquiline in galls of the cynipid *Biorhiza pallida* (Olivier) (Hymenoptera: Cynipidae). Leaf-mining weevils of the genus *Orchestes* (Coleoptera: Curculionidae) have also colonised exotic planted deciduous (Welch, 1994) and evergreen oaks (Thompson, 1994) in parts of their range, although in Greece *Orchestes hirtellus* (Miller) is strongly tied to *Quercus coccifera* (Whitehead, 1999b as *Rhynchaenus*) **(Fig. 7).** Some genera of ground beetles (Carabidae: *Calosoma* spp., *Lebia* spp.) include important predators in Western Palaearctic oakwoods. Arboreal ground beetles of the genus *Dromius* (Coleoptera: Carabidae) are known to breed on ancient Cork Oak (*Quercus suber* Linnaeus) in Britain (Whitehead, pers. obs.). *Antheraea pernyi* (Guérin-Méneville) (Lepidoptera: Saturniidae) provides an interesting example of an originally East Palaearctic species established on Holm Oak *Quercus ilex* in the Balearic Islands. The striking auchenorrhynchan *Ledra aurita* (Linnaeus) (Hemiptera: Ledridae) occurs uncommonly on apple (*Malus* spp.) and maple (*Acer* spp.) trees

Figure 7. Gerakas, Zakynthos, Greece. Coastally-influenced *Quercus coccifera* woodland, supporting a distinctive suite of invertebrates. The house, constructed in Pliocene limey sandstone, once accommodated a family of 12 people. May 19 1999.

(Whitehead, 1991), but more usually on desiccated veteran Pedunculate Oak *Quercus robur* Linnaeus, and in the southern Europe on Holm Oak *Quercus ilex*.

Wood, tree decline, and the entomofauna

What changes most significantly with the age of the oak tree is the condition and structure of bark and wood, and, of course, the conformation of the tree itself. This is reflected in changes in the enotomofauna of wood, particularly when it is degraded by arboreal fungi. As a tree ages, so its energy requirements increase. Annual rings decrease in width with age because of the energy required by a senile tree to lay them down over an increasingly large bole circumference. As oak trees age they expend considerable amounts of energy in filling their redundant vessels with complex aromatic compounds and tannins (Thomas, 2000). Tanned wood is effectively insecticidal, but apart from fungi, some insect larvae, of beetles in particular, have found ways in which to break these complex organic molecules, often by gut-contained cellulolytic enzymes. Larvae of the Goat Moth *Cossus cossus* (Linnaeus) (Lepidoptera: Cossidae), Hermit Beetle *Osmoderma eremita* (Ranius and Hedin, 2001), chafers of the genus *Aleurostictus* (Coleoptera: Scarabaeidae) (Tauzin, 2000, in press; Whitehead, 2003), and longhorn beetles of the genus *Cerambyx* (Coleoptera: Cerambycidae) are all able to exist in the tanned heartwood of oak; the larvae and adults sometimes smell of leather. They are the larger agents of excavation and cultivation of wood and the production from it of wood mould, degraded or recycled tanned heartwood **(Fig. 8)**. Wood mould is a comparatively inert material, frequently the delignified product of fungal activity, which when not desiccated, as for example by fragmentation of the tree, may remain *in situ* for decades.

Figure 8. Llanarth, Monmouthshire, Wales. Queen European hornet *Vespa crabro*, about to construct a winter cell in woodmould beds in fallen oak pollard *Quercus robur*. November 11 2002.

Wood-mould beds support large numbers of invertebrates, many of which are scarce or rare generally. Alexander (2002) estimated that of c1800 invertebrates associated with wood decay processes in Britain, 38% have formal conservation status of one form or another. When an ancient oak tree falls, wood mould contained within it may persist for decades, and providing it does not desiccate, will continue to support rare invertebrates. Some insects, such as the beetle *Oxypoda recondita* Kraatz (Coleoptera: Staphylinidae) have become specialised and some examples may become somewhat depigmented, as a response to continual darkness; populations in stable habitat within a single tree can probably survive indefinitely. Some beetles living in high-volume oak wood mould may also exhibit variations in eye size and somatic pigmentation in relation to examples of the same species occurring in other habitats nearby (Whitehead, pers. obs.).

A rare overlooked habitat is that of wood mould developing externally. This is a phenomenon that occurs on oak trees heavily colonised by fossorial macro-invertebrate larvae. Larvae of *Cerambyx cerdo* Linnaeus (Coleoptera: Cerambycidae) and other beetles in particular, may perforate the tree to such an

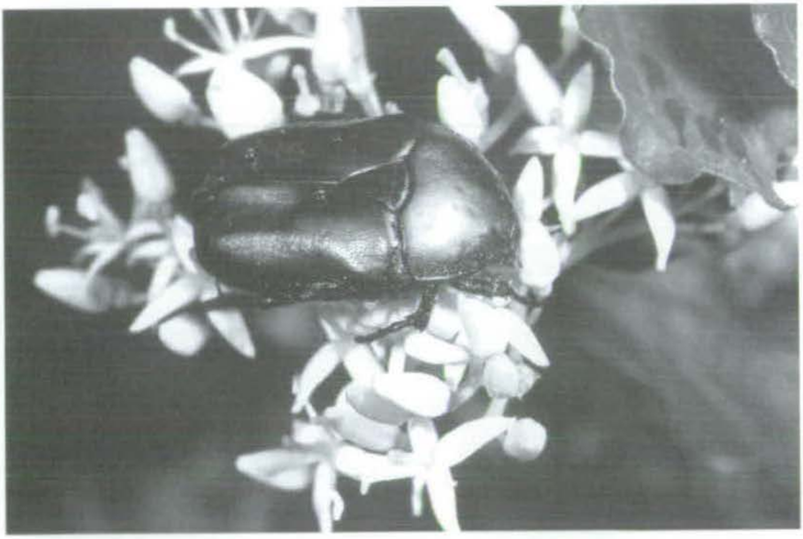

Figure 9. Malcesine, Lago di Garda, Italy. Chafer beetle *Potosia cuprea* at flowers of Dogwood *Cornus sanguinea*. May 7 2000.

extent that frass-beds develop on the ground against the bole. These beds may support an entire fauna of other invertebrates, particularly, in central Europe, larvae of scarabaeid or cetoniid chafers **(Fig. 9).**

Decorticated wood **(Fig. 10)** perforated by the exit holes of anobiid beetles is the special habitat of the rare oak-dwelling *Eucnemis capucina* Ahrens (Coleoptera: Eucnemidae), the larvae of which actively predate anobiid larvae and pupate in their galleries. Larvae of *Megatoma undata* (Linnaeus) (Coleoptera: Dermestidae) also habitually use decorticated wood to enter the galleries of anobiid beetles in their quest for prey. Acts of vandalism may also, in

Figure 10. Longdon Marsh, Worcestershire, England. Open-grown boundary oak tree *Quercus robur* used as living fence post. Decortication following crown fragmentation, noting also loss of sediments and subsequently damaged and decayed root bases. October 11 2000.

a perverse way, enrich the entomofauna of oak trees, in the same way that dramatically sudden mechanical damage, or the instantaneous boiling of sap by lightning strike, can produce distinct faunal facies.

Trees are not 'designed' to be hollow or even cancellous in the sense that bones are, so that their hollowing is an entirely passive process (Mattheck, 1998). The dramatic impact of basidiomycotine fungi on the histological structure of wood has been well illustrated by Mattheck and Kubler (1997, fig. 96). Loss of wood may in at least one sense prove beneficial to the tree; if the annual rings are breached as a result, the tree's overall energy requirement may be reduced to the extent that what remains of the tree may retain vigour. Either way, the invertebrate fauna of dead or decayed wood owes everything to the impact on it of fungi, (Murray, 1974) bacteria, the vagaries of climate and physiological stress. Thomas (2000) implied that the loss of heartwood in veteran trees may result in energy recycling processes that confer benefits. What is clear is that the stored energy made available in the wood of trees is of immense benefit to the synecology of the tree and to its biocoenoses. Wood *per se* could not maintain the diversity of life that we associate with veteran trees today, and this provides another reason why the support role of veteran trees, oak in particular, in biological systems is potentially far greater than that simply of trees in general.

The utilisation of oak trees by invertebrates at Longdon Marsh, Worcestershire, England

During the autumn of 2000 and summer of 2002, a survey was made (Whitehead, 2002) of the invertebrates of Longdon Marsh, Worcestershire, situated at 52°06'N 02°16'W (**Figs 10,11,12**). The site was acquired in the late 1990s by the Worcestershire Wildlife Trust, with the objective of restoring it as a wetland. Longdon Marsh is a fluvial basin near the confluence of the major English midland rivers, the Severn and Avon. It extends over an area of c7km^2, and is floored, as low as 11m O.D., by alluvial silts. The history and development of the Longdon Marsh basin is complex. The Severn Estuary has one of the largest tidal ranges in the world and in the past, particularly prior to river management regimes, tidal influence was felt as far upstream as Longdon. It is believed that Longdon Marsh developed as a natural reservoir at times of both high tides and high river floods, although the cutting of the high-sided basin may have been initiated by fluvial 'catastrophes.' Even so, it is likely to be a comparatively recent feature since the present flow of both the rivers Severn and Avon has been reversed as a result of Pleistocene glaciation and ponding.

In the recent past, following land drainage and intensive watercourse canalisation, Longdon Marsh was converted to semi-intensive mixed agriculture, with improved pasture and some cultivation of maize and other crops (**Figs 11,12**). The 2000 and 2002 surveys (Table 1) confirm the value of the site for hedgerow and open grown oak trees ranging from one to c700 years old, and

Figure 11. Longdon Marsh, Worcestershire, England. Agro-ecosystem with woodland blocks, outgrown hedgerows of willow *Salix alba* and *Salix fragilis* and open grown oak trees *Quercus robur*. Malvern Hills with occluded front in the background. July 20 2002.

provide evidence of a third significant regional site (following Whitehead, 1996a; Lott *et al*., 1999) for invertebrate-rich open-grown trees set in an anthropogenic or 'cultural' land-use matrix (Table 1). These oak-associated invertebrates extend over 17 taxonomic orders, 101 families and at least 231 species. Whitehead (2002) showed that the saproxylic beetle quality index for Longdon Marsh positioned it as the fifth most important site in Britain for such invertebrates, and that it was also of international importance for the same reason.

Figure 12. Longdon Marsh, Worcestershire, England. Mature and post-mature desiccated oak trees *Quercus robur* sustaining fastidious invertebrates in an agricultural land-use matrix (Tables 1 and 2). Suboptimal conditions inhibiting active tree growth. October 6 2000.

Figure 13. Tiddesley Wood, Worcestershire, England. Hygrophilous ground beetle *Carabus granulatus*, a species which may winter gregariously under damp loose bark of oak *Quercus robur*. November 18 2001.

Order	Family	Species	RDB	N	AW	Niche
*Col	Melandryidae	Abdera biflexuosa (Curtis, 1829)		Nb		twigs
Lep	Geometridae	Abraxas grossulariata (L., 1758)				foliage, pupa
Aran	Theridiidae	Achaearanea lunata (Clerck, 1757)				bark
Lep	Noctuidae	Acronicta psi (L., 1758)				bark, larval cocoon
Lep	Noctuidae	Acronicta rumicis (L., 1758)				bark
Col	Coccinellidae	Adalia decempunctata (L., 1758)				bark
**Col	Aderidae	Aderus oculatus (Pk, 1798)		Nb	3	foliage, twigs
**Col	Aderidae	Aderus populneus (Cr. in Pz., 1796)		Nb	3	twigs
**Col	Buprestidae	Agrilus biguttatus F., 1777		Nb	2	exit holes
Col	Elateridae	Agriotes lineatus (L., 1767)				wood mould (bits)
Col	Elateridae	Agriotes obscurus (L., 1758)				wood mould (bits)
Col	Elateridae	Agriotes sputator (L., 1758)				wood mould (bits)
Lep	Noctuidae	Allophyes oxyacanthae (L., 1758)				foliage
Hem	Cicadellidae	Allygus mixtus (F., 1794)				bark
Hem	Cicadellidae	Allygus modestus Scott, 1876				bark
Col	Tenebrionidae	Alphitobius diaperinus (Pz., 1796)				wood mould (bits)
Col	Carabidae	Amara aulica (Pz., 1796)				wood mould (bits)
Aran	Amaurobiidae	Amaurobius fenestralis (Stroem, 1768)				bark, under
Col	Staphylinidae	Amischa analis (Grav., 1802)				foliage
Col	Staphylinidae	Amischa forcipata Muls. & Rey, 1873				wood mould
**Col	Elateridae	Ampedus cardinalis (Schiödte, 1865)	2		1	wood mould (larva); bark
Lep	Noctuidae	Amphipyra pyramidea (L.,1758)				foliage (larvae)
Col	Scraptiidae	Anaspis humeralis (F., 1775)				bole
Col	Scraptiidae	Anaspis regimbarti Schils., 1895				foliage

*Col	Scraptiidae	Anaspis thoracica (L., 1758)	Nb		bark
Col	Carabidae	Anchicera dorsale (Pontopp., 1763)			bark, under
Col	Anobiidae	Anobium punctatum (De Geer, 1774)			wood
Col	Staphylinidae	Anotylus rugosus (F., 1775)			wood, fallen
Hem	Anthocoridae	Anthocoris confusus Reuter, 1884			foliage
Hem	Anthocoridae	Anthocoris nemoralis (F., 1794)			foliage
Col	Dermestidae	Anthrenus fuscus Ol.,1789			bark, under (larvae); bole
Col	Curculionidae	Archarius pyrrhoceras Msh, 1802			foliage
Col	Dermestidae	Anthrenus verbasci (L., 1767)			bark, larvae
Col	Staphylinidae	Astenus immaculatus Ste., 1833	N		wood fallen
Col	Staphylinidae	Astenus lyonessius (Joy, 1908)			wood mould
Col	Staphylinidae	Atrecus affinis (Pk., 1799)			wood mould
Col	Dermestidae	Attagenus pellio (L., 1758)			bark, under
**Col	Staphylinidae	Batrisodes venustus (Reich., 1816)	Nb		wood mould
Col	Carabidae	Bembidion quadrimaculatum (L., 1761)			bark, under
Col	Colydiidae	Bitoma crenata (F., 1775)		3	wood mould (bits)
Col	Bruchidae	Bruchus rufimanus Boh., 1833			bark, under
Col	Byrrhidae	Byrrhus pilula (L., 1758)			wood mould (bits)
Col	Cantharidae	Cantharis cryptica Ashe, 1947			foliage
Col	Cantharidae	Cantharis lateralis L., 1758			foliage
Col	Cantharidae	Cantharis rufa L., 1758			foliage
Col	Carabidae	Carabus granulatus L.,1758			bark, under
Col	Carabidae	Carabus monilis F., 1792	Nb		wood mould (bits)
Col	Carabidae	Carabus violaceus L., 1758			wood mould (bits)
Col	Cholevidae	Catops fuliginosus Er., 1837			wood mould, dead
Col	Cerylonidae	Cerylon ferrugineum Ste., 1830			bark, under

Col	Cerylonidae	Cerylon histeroides (F., 1792)			bark, under
Col	Chrysomelidae	Chaetocnema concinna (Msh, 1802)			foliage
*Pseudo	Chernetidae	Chernes cimicoides (F., 1793)			bark, under
Hym	Chrysididae	Chrysis ignita (L., 1758)			bark, under
Dip	Dolichopodidae	Chrysotus blepharosceles Kowarz			branch
Col	Ciidae	Cis bilamellatus Wood, 1884			bole
Col	Ciidae	Cis nitidus (F., 1792)			fungus, larvae
Col	Ciidae	Cis pygmaeus (Msh, 1802)			bark, under; branch, fallen
Col	Carabidae	Clivina fossor (L., 1758)			wood mould (bits)
Aran	Clubionidae	Clubiona corticalis (Walckenaer, 1802)			bark
Aran	Clubionidae	Clubiona lutescens Westring, 1851			bark, under
Hym	Pteromalidae	Coelopisthia extenta (Walker, 1835)			bark, under
Col	Latridiidae	Corticaria elongata (Gyll.,1827)			twigs
*Col	Latridiidae	Corticaria fagi (Woll.,1854)	I	1	bark, under
Col	Latridiidae	Corticarina fuscula (Gyll.,1827)			foliage
Col	Latridiidae	Cortinicara gibbosa (Hbst, 1793)			foliage
Col	Chrysomelidae	Crepidodera plutus (Latr., 1804)			foliage
Col	Cryptophagidae	Cryptophagus pseudodentatus Bruce, 1934			bark, under
Chil	Cryptopidae	Cryptops hortensis Leach, 1814			wood mould; bark, under
Col	Dermestidae	Ctesias serra (F., 1792)		3	bark
Col	Curculionidae	Curculio glandium Msh, 1802			foliage
Col	Curculionidae	Curculio venosus (Grav., 1807)			foliage
Col	Staphylinidae	Cypha hanseni (Palm, 1949)			foliage
Col	Scirtidae	Cyphon coarctatus Pk., 1799			foliage
Col	Scirtidae	Cyphon palustris Thoms., 1855			foliage
Col	Erotylidae	Dacne bipustulata (Thbg, 1781)			bark, under
Col	Dasytidae	Dasytes aeratus Ste., 1830			bark

*Col	Histeridae	Dendrophilus punctatus (Hbst, 1792)				wood mould
Palpat	Phalangiidae	Dicranopalpus ramosus Simon, 1909				foliage
Dip	Tipulidae	Dictenidia bimaculata (L., 1761)				wood mould (larvae, pupae)
Col	Staphylinidae	Dinaraea angustula (Gyll., 1810)				bark, under
*Hym	Pompilidae	Dipogon subintermedius (Magretti, 1886)				bole
**Col	Anobiidae	Dorcatoma chrysomelina Stm, 1837			2	foliage
*Col	Anobiidae	Dorcatoma dresdensis Hbst, 1792		Na	2	foliage
*Col	Anobiidae	Dorcatoma flavicornis (F., 1792)		Nb	3	foliage
*Col	Lucanidae	Dorcus parallelipipedus (L., 1758)				wood mould (bits)
*Col	Carabidae	Dromius quadrimaculatus (L., 1758)				wood mould (bits)
*Col	Carabidae	Dromius quadrinotatus (Zenk. in Pz., 1800)				bark, under
*Col	Staphylinidae	Dropephylla ioptera (Heer, 1841)				bark, under
*Col	Staphylinidae	Dropephylla vilis (Er., 1840)				bark, under
Col	Curculionidae	Dryocoetes villosus (F., 1792)				bark (bits)
Hem	Miridae	Dryophilocoris flavoquadrimaculatus (DeG., 1773)				bole, foliage
Col	Tenebrionidae	Eledona agricola (Hbst, 1783)				fungus
Psoc	Elipsocidae	Ellipsocus mclachlani Kimmins, 1941				foliage
*Col	Eucnemidae	Epiphanis cornutus Eschsch., 1829		Nb		wood (dead)
*Col	Curculionidae	Euophryum confine (Broun, 1881)				wood, soft
Hem	Cicadellidae	Eurhadina pulchella (Fallén, 1806)				foliage
**Col	Staphylinidae	Euryusa sinuata Er., 1837	I		2	bark, under
Col	Apionidae	Eutrichapion vorax (Hbst, 1797)				wood mould (bits)
Hem	Cicadellidae	Evacanthus acuminatus (F., 1794)				bark
Col	Coccinellidae	Exochomus quadripustulatus (L., 1758)				twigs
Derm	Forficulidae	Forficula auricularia L., 1758				bark, under (nests)
Hym	Ichneumonidae	Gelis bicolor (Villers, 1789)				foliage
Hym	Ichneumonidae	Gelis festinans (F., 1798)				foliage

Dip	Opomyzidae	Geomyza tripunctata (Fallén, 1823)			foliage
*Chil	Geophilidae	Geophilus carpophagus Leach, 1814			bark, under
Col	Geotrupidae	Geotrupes spiniger (Msh., 1802)			wood mould (bits)
Aran	Araneidae	Gibbaranea gibbosa (Walckenaer, 1802)			foliage
**Col	Cerambycidae	Gracilia minuta (F., 1781)	2	?	twigs
Psoc	Stenopsocidae	Graphopsocus cruciatus (L., 1768)			foliage
*Col	Anobiidae	Hadrobregmus denticollis (Cr. in Pz., 1796)	Nb	!	wood
*Hym	Chalcididae	Haltichella rufipes (Ol., 1790)	(Na)		bark
*Col	Staphylinidae	Hapalarea pygmaea (Pk, 1800)			wood mould (bits)
Aran	Dysderidae	Harpactea hornbergi (Scop., 1763)			bark
Col	Carabidae	Harpalus affinis (Schrank, 1781)			wood mould (bits)
Dip	Syrphidae	Helophilus pendulus (L., 1758)			bark
Col	Hydrophilidae	Helophorus aquaticus (L., 1758)			bark, under
Col	Anobiidae	Hemicoelus fulvicornis (Stm., 1837)			twigs
*Col	Elateridae	Hemicrepidius hirtus (Hbst, 1784)			wood mould (bits)
Col	Histeridae	Hister unicolor L., 1758			wood mould (bits)
Col	Curculionidae	Hypera zoilus (Scop., 1763)			wood mould (bits)
Aran	Linyphiidae	Hypomma cornutum (Blackwall, 1833)			foliage
**Hem	Cicadellidae	Iassus lanio (L., 1761)			bark; foliage
Col	Rhynchitidae	Involvulus caeruleus (De G., 1775)			wood mould (bits)
Arthro	Isotomidae	Isotomurus palustris (Müller, 1776)			wood mould
**Col	Cleridae	Korynetes caeruleus (DeGeer, 1775)	Nb	3	bark
Lep	Noctuidae	Lacanobia oleracea (L., 1758)			foliage, larva
Col	Tenebrionidae	Lagria hirta (L., 1758)			foliage
*Hym	Formicidae	Lasius brunneus (Latr., 1798)	Na		bark; wood mould (nest)
Hym	Formicidae	Lasius flavus (F., 1782)			wood mould (nest)
*Hym	Formicidae	Lasius fuliginosus (Latr., 1798)			all parts
Col	Staphylinidae	Lathrobium geminum Kr., 1857			roots
**Col	Cerambycidae	Leiopus nebulosus (L., 1758)			bark, twigs

Col	Carabidae	Leistus spinibarbis (F., 1775)			bark
**Zygen	Lepismatidae	Lepisma saccharina L., 1758			bark, under
Orth	Tettigoniidae	Leptophyes punctatissima (Bosc, 1792)			foliage
Hym	Formicidae	Leptothorax nylanderi (Foerster, 1850)			bark
**Lep	Psychidae	Luffia ferchaultella (Ste., 1850)			bark
*Col	Malachiidae	Malachius bipustulatus (L., 1758)			bark, larvae
Col	Cantharidae	Malthinus frontalis (Msh., 1802)	Nb		bark, pupa
Col	Cantharidae	Malthodes minimus (L., 1758)			foliage
Orth	Tettigoniidae	Meconema thalassinum (De Geer, 1773)			foliage
*Col	Dermestidae	Megatoma undata (L., 1758)	Nb		bark (larvae, pupa)
*Col	Elateridae	Melanotus villosus (Geoff., 1785)			wood mould (larvae); bark
Col	Scirtidae	Microcara testacea (L., 1767)			bark, under
Col	Carabidae	Microlestes maurus (Stm., 1827)			bark, under
Col	Mycetophagidae	Mycetophagus quadripustulatus (L., 1761)			wood fungoid
Col	Carabidae	Nebria brevicollis (F., 1792)			wood mould (bits); bark
Col	Rhynchitidae	Neocoenorrhinus germanicus (Hbst, 1797)			bark, wood mould (bits)
Lep	Lycaenidae	Neozephyrus quercus (L., 1758)			bark
Col	Silphidae	Nicrophorus humator (Gleditsch, 1767)			wood mould (bits)
*Aran	Araneidae	Nuctenea umbratica (Clerck, 1757)			bark, under
Col	Staphylinidae	Ocypus olens Müller, 1764			wood mould (bits)
Hem	Cixiidae	Oliarus panzeri Loew, 1883	Nb		branch
Palpat	Phalangiidae	Oligolophus tridens (C.L.Koch, 1836)			bark
*Col	Cleridae	Opilo mollis (L., 1758)	Nb	3	bark; wood mould (bits)
Col	Curculionidae	Orchestes alni (L., 1758)			bark
Col	Curculionidae	Orchestes pilosus (F., 1781)			foliage
Col	Curculionidae	Orchestes quercus (L., 1758)			bark (bits, dead); foliage
Col	Curculionidae	Orchestes signifer (Creutzer, 1799)			foliage

Hem	Cimicidae	Orius majusculus (Reuter, 1879)				bark, under
**Col	Corylophidae	Orthoperus nigrescens Ste., 1829		Nb		twigs
Col	Chrysomelidae	Oulema obscura (Ste., 1831)				wood mould (bits)
Pulmon	Zonitidae	Oxychilus alliarius (Miller, 1822)				bark, under
Aran	Thomisidae	Ozyptila praticola (C.L.Koch, 1837)				bark
Hym	Vespidae	Paravespula vulgaris (L., 1758)				bark under; wood mld (bits)
Palpat	Phalangiidae	Paroligolophus agrestis (Meade, 1855)				fallen bark
Col	Histeridae	Paromalus flavicornis (Hbst, 1792)			3	bark, under; sporophore
Hem	Pentatomidae	Pentatoma rufipes (L., 1758)				foliage
Col	Chrysomelidae	Phratora vulgatissima (L., 1758)				bark
Col	Curculionidae	Phyllobius maculicornis Germ., 1824				wood mould (bits)
**Col	Cerambycidae	Phymatodes testaceus (L., 1758)			3	bark
Hem	Tingidae	Physatocheila dumetorum (H.-S., 1838)				foliage
Hem	Miridae	Phytocoris tiliae (F., 1776)				bark
Col	Platypodidae	Platypus cylindrus (F., 1792)		Nb		in web
Hym	Eulophidae	Pnigalio pectinicornis (L., 1758)				twigs
Col	Curculionidae	Polydrusus cervinus (L., 1758)				foliage
Col	Curculionidae	Polydrusus pterygomalis Boh., 1840				foliage
*Polyx	Polyxenidae	Polyxenus lagurus (L., 1758)				wood
Iso	Porcellionidae	Porcellio scaber Latr., 1804				bark, dry
*Col	Tenebrionidae	Prionychus ater (F., 1775)		Nb	3	wood mould (bits, larvae)
*Col	Tenebrionidae	Prionychus melanarius (Germ., 1813)	2		1	wood mould (larva); bark
**Col	Elateridae	Procraerus tibialis (Bois. & Lac., 1835)		Na	1	bark; wood; wood mould Diplo
Diplop	Blaniulidae	Proteroiulus fuscus (Am Stein, 1857)				fungal sporophore; bark
Hem	Miridae	Psallus varians (H.-S., 1841)				foliage
Col	Carabidae	Pseudophonus rufipes (De G., 1774)				wood mould (bits)
Col	Carabidae	Pterostichus cupreus (L., 1758)				bark; wood mould (bits)

Col	Carabidae	Pterostichus macer (Msh., 1802)			bark; wood mould (bits)
Col	Carabidae	Pterostichus madidus (F., 1775)			wood mould (bits)
Col	Carabidae	Pterostichus melanarius (Ill., 1798)			wood mould (bits)
Col	Carabidae	Pterostichus niger (Schaller, 1783)			wood mould (bits)
Col	Anobiidae	Ptilinus pectinicornis (L., 1758)			wood
Col	Ptiliidae	Ptinella aptera (G.-M., 1839)			bark, under
**Col	Ptinidae	Ptinus fur (L., 1758)			bark, under
Col	Staphylinidae	Quedius curtipennis Bern., 1908			wood, fallen
Col	Monotomidae	Rhizophagus bipustulatus (F., 1792)			bark, under
Aran	Salticidae	Salticus cingulatus (Panzer, 1797)			bark
Aran	Salticidae	Salticus scenicus (Clerck, 1757)			bark
**Aran	Salticidae	Salticus zebraneus (C.L. Koch, 1837)	Na		bark
*Dip	Scenopinidae	Scenopinus niger (De G.)	Nb		bark, under (pupae)
Col	Curculionidae	Scolytus intricatus (Ratz., 1837)			twigs
Aran	Segestriidae	Segestria senoculata (L., 1758)			bark
Col	Curculionidae	Sitona lineatus (L., 1758)			bark (dead)
Col	Nitidulidae	Soronia grisea (L., 1758)			bark, under
*Aran	Theridiidae	Steatoda bipunctata (L., 1758)			bark, under
*Col	Elateridae	Stenagostus rhombeus (Ol., 1790)		3	bark; wood (larvae)
Col	Scydmaenidae	Stenichnus scutellaris (Müller & Kunze, 1822)			bark, under
Col	Staphylinidae	Stenus clavicornis (Scop., 1763)			wood, fallen
*Col	Curculionidae	Stereocorynes truncorum (Germ., 1824)	Na		1bark, under
**Hem	Aphididae	Stomaphis quercus (L., 1746)	(N)		bark, under
Col	Carabidae	Stomis pumicatus (Pz., 1795)			bole cavity
Chil	Dignathodontidae	Strigamia acuminata (Leach, 1841)			bark, under
Hem	Lygaeidae	Stygnocoris fuligineus (Geoff., 1785)			wood, fallen
Col	Staphylinidae	Sunius propinquus (Bris., 1867)			wood mould

*Col	Staphylinidae	Tasgius ater (Grav., 1802)				wood mould (bits)
Col	Tenebrionidae	Tenebrio molitor L., 1758				wood mould (bits)
Hem	Cimicidae	Tetraphleps bicuspis (H-S., 1835)				foliage
Col	Tetratomidae	Tetratoma fungorum F., 1790			3	wood mould (bits)
*Col	Cleridae	Thanasimus formicarius (L., 1758)			3	wood mould (bits); bark
**Hem	Thelaxidae	Thelaxes dryophila (Schrank, 1801)		?		foliage, twigs
**Dip	Therevidae	Thereva cf. nobilitata (F., 1775)				wood mould (larvae)
Lep	Tortricidae	Tortrix viridana L., 1758				bark (pupae)
Col	Tenebrionidae	Tribolium castaneum (Hbst, 1797)				wood mould (bits)
**Col	Dermestidae	Trinodes hirtus (F., 1781)	3			bark; wood mould (bits)
Col	Throscidae	Trixagus dermestoides (L., 1767)				bark
Hem	Pentatomidae	Troilus luridus (F., 1775)				foliage
Col	Coccinellidae	Tytthaspis sedecimpunctata (L., 1758)				elytron
Lep	Noctuidae	Xestia triangulum (Hufnagel, 1766)				bark (larva)
**Col	Anobiidae	Xestobium rufovillosum (De G., 1774)			3	bark; wood & mould (bits)
Aran	Metidae	Zygiella atrica (C.L. Koch, 1845)				bark, under

Table 1. Longdon Marsh, Worcestershire, England, 2000 and 2002. Utilisation of resources by invertebrates occurring on Pedunculate Oak *Quercus robur* L. **Terminology and abbreviations.** These are in accordance with the following British scheme: RDB - status according to British Red Data Books: RDB 1 endangered; RDB 2 vulnerable; RDB 3 rare; RDB I indeterminate. N - index of national scarcity based on occurrence in numbered 10km map squares, either Na or Nb in declining order of scarcity, or N if data inadequate for assessment; (N) or (Na) parenthesised represent the authors own estimatations of scarcity. AW - species having Ancient Woodland Indicator status (*sensu* Harding and Alexander, 1994). Taxa abbreviations: Aran = spiders; Arthro - Collembola; Chil = centipedes, Col = beetles; Derm = earwigs; Dip = flies; Diplo = millipedes; Hem = true bugs; Hym = bees, wasps and ants; Lep = butterflies and moths; Orth = grasshoppers and allies; Palpat = harvestmen; Polyx = millipede; Pseudo = pseudoscorpions; Psoc = psocids; Pulmon = molluscs; Zygen = silverfish. * = invertebrates frequently characteristic of open grown trees; ** = invertebrates frequently characteristic of open-grown oak trees.

Table 2 illustrates the way in which the varied resources of the tree, **sampled from ground level to a height of 3m above ground only**, were utilised by the invertebrate fauna, including those species which occupy multiple niches. The high crowns of the trees were not sampled, although in studies that have involved insecticidal fogging of tree crowns, many of the scarcer beetles reported were found to be adventitious from elsewhere within the tree (Hammond and Harding, 1991).

It is observed that species recorded from fungi are few. Under no circumstances should this be construed as implying that fungi are of little importance in invertebrate ecology. 73% of all invertebrate occurrences were associated with habitats prepared for them by fungi; only 7.0% of occurrences can be ascribed to purely wood-associated species, and many of the obligate species in that case are anobiid beetles or other species associated with their activity. It is important also to bear in mind that few bio-assessors are able to work uniformly across a variety of taxonomic groups, so that in the present case, information on mites is lacking (Table 1). Nevertheless the entomological usefulness of the interactive systems sustained by oak trees is without question, as is the biological value of wood *per se*. Recent studies (Haase, Topp and Zach, 1998) have suggested that a minimum of $40m^3$ of dead and dieing wood, including fallen wood, should be retained within each hectare of forest to maintain biodiversity, and that as many as 18,000 individual invertebrates may be supported by each cubic metre of dead wood. At Longdon Marsh, in common with other sites dominated by open-grown trees, much of this fauna is absent, and the bulk of the dead wood is contained within the living tree.

	All		**Facultative**		**Obligate**	
Foliage	52	(20.4%)	26	(50%)	26	(50%)
Twigs	15	(5.9%)	7	(47%)	8	(53%)
Bark	110	(43.1%)	54	(49%)	56	(51%)
Wood	18	(7.0%)	6	(33%)	12	(64%)
Wood mould	56	(22.0%)	43	(77%)	13	(23%)
Fungi	4	(1.6%)	2	(50%)	2	(50%)
	255		138	(54%)	117	(46%)

Table 2. Longdon Marsh, Worcestershire, England, 2000 and 2002. The utilisation of resources by 231 species of invertebrate recorded from open-grown Pedunculate Oak *Quercus robur* L.

The relatively large number of facultative occurrences for bark and wood mould result from the use of these resources as shelters by a range of species, or by terrestrial predatory invertebrates. The bark predators include the carabid beetle *Pterostichus macer*; this is a rare finding of a species nearly always subterranean in fissile sediments. Wood-mould predators include the scarce *Carabus monilis*, much declined but associated with old unimproved grasslands and open woodlands. This latter occurs as an intensely green form, noted also in an example of *Carabus granulatus* **(Fig. 13).**

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POSTERS DISPLAYED AT THE FOURTH INTERNATIONAL OAK CONFERENCE,

Winchester, 2003

The 2003 Oak Conference logo shown above was designed by Ron and Dorothy Holley and Alison Lane, and commemorates the history of oak and English shipbuilding, and particularly the strong association of the County of Hampshire with the Royal Navy. The rendition of detail is derived from the 18th century wooden warship HMS Victoria.

BRITISH OAKS

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Introduction

Research is actively underway to collate information on the two native British oaks, the Pedunculate *Quercus robur* and the Sessile *Quercus petraea*. At present with only a few publications available, albeit most out of print, there is no other publication or reference work that includes an overall coverage of the two oaks. The subject areas under research have been outlined below and it is in these categories that information is being sought and collated.

Evolution and Distribution

Geological and archaeological periods will be included to give details of how the two oaks evolved in relation to the changing pattern of the European continent. Data from using pollen counts and radiocarbon dating will be used and methods explained. The latest distribution maps to be included together with details of the pattern of change in the British flora. Reference to ancient semi-fossilised tree trunks formed in bogs, known as 'bog oaks' will be shown as an important source of information on the origin of oaks in Britain.

The geographical distribution and variation in migration patterns since the last ice age together with the ecological succession throughout the British Isles will be covered. The controversial history behind the present day taxonomy of each oak will be explained. The inclusion of the relevance of soil type, climate and altitude and the effects of human activity through several cultures from Neolithic, Bronze Age, Iron Age, Anglo Saxon, Roman, Norman and Medieval periods.

Physiological Characteristics

The biological features of the oaks their structure and function, will be explained, with the use of several diagrams, including life and nutrient cycles. Cytology, genetics and reproduction, in particular hybridization, morphological and genetic traits between the two oaks, will be included with details of experimental methodology.

Variation of morphology and chemical characters of acorns from within and between natural populations and individuals will be discussed. Consideration of studies made on chlorplast DNA variation in oak populations, with the attended influence of postglacial colonisation and human management. Growth patterns will be explored from young oaks to maturity including lateral root systems, crown architecture and the timing of canopy and epicormic shoots. Discussion of the anatomical characters in the wood of oak, which predispose trees to shake and the problems relating thereto with breeding programmes.

Ecology and Natural History

The fascinating ecology of the oaks and their important role in supporting considerable number of fauna and flora will be presented in an interesting clear manner.

Native oaks are known to support a huge diversity of organisms and the major groups will be covered giving a wide picture of the importance of the oak. Reference to be made to studies conducted to ascertain the extent of the level of species established in the native oak and its close environs. Populations of breeding birds and bird communities in oakwoods will be referred to and their influence on the future expansion of woodland and individual growth and survival. Lichen, mosses, fungi, mistletoe and other epiphytes that are found on or close to oaks will be described and their effects on the oak's growth and welfare. Invertebrate play a large part in the 'habitat' of an oak and descriptive notes and roles of butterflies, moths, beetles, bugs and spiders in the life of the oak will be outlined. Mammals, including various species of bat, will also be identified and their roles in the life of the oak explained, especially seed production and food conditions for rodents in oak woodlands. The influence of birds and mammals in the localised distribution of oak and the survival of oak seedlings from naturally planted acorns.

Important national woodlands that support considerable numbers of fauna and flora will be highlighted and reference to studies made of these woodlands.

Illustrations and coloured photographs of some of the many species that frequent the 'habitat' of the oak will be included.

Woodlands

The historical significance of our ancient oak woodlands has become in recent years an important issue to ensure their restoration and long-term survival. It is intended to set out the background to this issue and refer to various management and conservation programmes underway in the Britain. Forestry techniques past and present will also be discussed. Reference to coppicing, pollarding and regeneration of our oak woodlands referring to some of our ancient and interesting oaks and oak woodlands. Former rights and privileges relating to oak woodlands will also be explained.

Present and future plans for oakwoods and their management will be explored and the results of various projects undertaken throughout the Britain will be discussed.

Diseases and Predators

To outline past and present diseases including the fungal pathogens their biology and ecology, particularly those that have been held responsible for a number of diseases affecting our two native oaks. Emphasis will be made on present day diseases and infections causing die back and sudden oak death. Reference will be made to the programme of research in this area. The role and effect of defoliators and galls on the two oaks to be detailed with coloured photographs and illustrations. Tables will be published of mortality rates and the decline of oaks.

Uses of Oak

Few publications devote specific reference to the importance and durability of oak timber in shipbuilding, building construction, medieval woodwork in churches and the manufacture of industrial implements, utensils and furniture. The role of our native oaks in providing timber from the time of early man will be emphasised. Oak and its natural components are still used in various other industries, including the curing of foods, pharmacy and tanning of leather. Examples of these uses, some still operating today, will be made showing how old traditions and crafts are still preserved. Even acorns played an important part in the historical life of oakwoods where the old right of pannage was practised and the sale of acorns a useful income. The use of oak timber in modern times will be outlined.

Pollution and Climate

Climate influence and atmospheric deposition have an effect on the growth and survival of trees and the two oaks are no exception. The effects of global warming, extreme weather conditions on the growth of oaks will be reviewed from recent results of phenological studies. Data will be included to show these effects as well as data on the effect of chemicals, acidification and radiation.

Cultural Heritage

In this chapter, it is intended to collect together folklore, legends and myths that have been published over the years in various publications. Poems, love tokens, 'Oak Apple Days', the 'Green Man' figure and the use of the 'oak' in heraldic designs, naming places and buildings will be explained giving examples and where appropriate locations. Historical events and the many ceremonies and celebrations relating to the native oaks will be explained.

Conservation

Conservation has been referred to in the management of oak woodlands but several projects have been proposed or implemented nationwide to enhance or create new oak woodlands. These have been supplemented with landowner stewardship schemes, tree preservation orders and nursery cultivation. These and other activities to enhance the future of native oaks will be explained. Nature reserves play an important part in the management of oak woodlands, the organisations involved, and their reserves will be highlighted in detail.

The Future

Considerable research is being undertaken especially in respect of genetics and the effects of present day problems with growth and survival. Conservation of individual trees and woodlands is continually being monitored as well as project planting of woodlands and forests. The effects of climate changes will be addressed and education of the public to assure a future for the two native oaks.

SAVERNAKE FOREST OAKS

By Dr. Jack Oliver and Mrs Joan Davies, B.Sc.
High View, Rhyls Lane, Lockeridge, Marlborough, Wiltshire, SN8 4ED. UK
Joan Davies, Ballard's Piece, Forest Hill, Marlborough, Wiltshire, SN8 3HN. UK.

Savernake Forest is in Wiltshire, south east of Marlborough. It is in the North Wessex Downs Area of Outstanding Natural Beauty and most of the present extent of Savernake Forest has been designated as a Site of Special Scientific Interest.

The history of the Forest goes back for a thousand years or more. It became a Royal Forest soon after the Norman Conquest and Richard Esturmy was appointed the first Warden. This Office has continued in the same family and they acquired absolute ownership of the Forest in the 16th century. The present owner is the Earl of Cardigan, who is the 31st hereditary Warden of Savernake Forest.
In 1939, the sylviculture rights of the Forest were leased to the Forestry Commission.

The above aerial photograph was taken in November 1999.

The present extent of Savernake Forest is about 905 hectares. The forest lies on a plateau of Upper Chalk covered by Clay-with-Flints at about 180m above sea level. The area is dissected by dry valleys in which the Chalk is exposed. In addition, in the southern part, there are small deposits of Reading Beds and Bagshot Sands, together with the clay, which gives rise to particularly acid conditions.

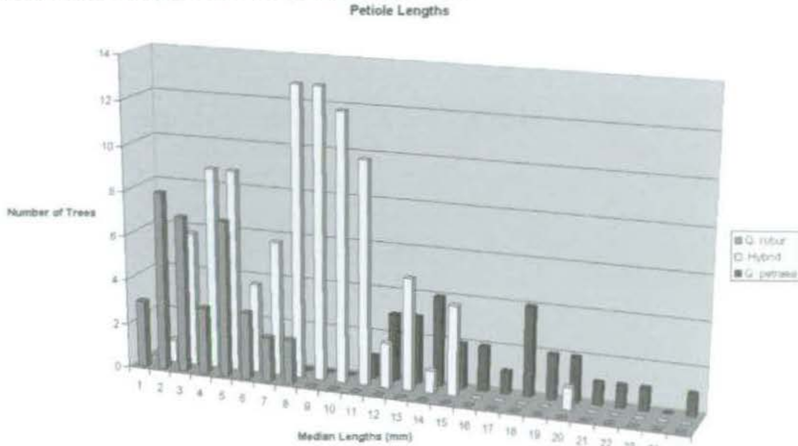
In 1999/2000 Dr Jack Oliver carried out a survey of the oak trees in Savernake Forest. The results were published as 'Savernake Forest Oaks, by Jack Oliver and Joan Davies' in the Wiltshire Archaeological and Natural History Magazine, 2001. We expected to find all or most of the oak trees to be the Pedunculate Oak. Instead, following detailed examination of the leaves, leaf and acorns stalks, we found that the two native oak species were both common and regenerating naturally. The Pedunculate and Sessile Oaks occurred in roughly equal quantities, whether as veterans or as the much more numerous saplings. Neither species was as common as the hybrid between them *Quercus* x *rosacea*. Commonest of all were intermediate trees of all ages which appeared to be introgressed, hybrids back-crossed with either parent.

Identification

The main features scrutinized for each of the oaks were those that discriminate best between the two native oak species: petiole (leaf-stalk) lengths, peduncle (acorn stalk) lengths and pubescence (where available), leaf bases (two features) and pubescence or not on the underside of the leaves (examined by binocular microscope at x30 magnification). Some attention was also given to the number of leaf lobes and the depth and regularity of the leaf-lobing. Based on the preceding, the taxonomic designation was decided for each tree. On any one tree, pubescence and petiole length were much more constant than leaf shapes, leaf bases and peduncle lengths.

Petiole lengths

Specimens were taken from 159 of the largest oaks in Savernake Forest, usually one or more branchlets of average size and appearance for the tree in question, carrying between 5 and 40 leaves. The petioles were measured to find the minimum and maximum lengths for that tree, giving the spread (or range) from which the median value was calculated. There was found to be variation in both the petiole lengths and spread for different oaks. Some oaks (all *Q. robur*) had most leaves with no petioles, and at the other extreme there was a *Q. petraea* whose petioles reached 30mm.



Three Types of Hybrid Intermediacy

1. Indeterminate Features

Petiole and/or peduncle lengths fitting neither *Q. petraea* or *Q. robur,* but between the two, very weakly cordate and auriculate leaf bases, leaf lobing and outline indeterminate, scattered very small 2 or 3-rayed stellate hairs only visible with a 15 or 20x lens on some leaves. Sometimes one character is fairly firm, but counteracted by others pointing to the opposite parent.

2. Discrepant Characteristics

There were 2 great oaks and several small ones with tiny or no petioles and without peduncles. An equal number had petioles over 15mm and peduncles over 30mm. There were some oaks fitting *Q. robur* in all respects except for dense sublaminar brush and stellate pubescence. Others had leaves like *Q. petraea* in outline, with long petioles, but were wholly glabrous.

3. Variable Features

Leaves were found which fitted *Q. robur* and/or *Q. petraea* on a single tree. Lammas leaves aside, seasonal and annual variability could be considerable. Petioles were usually shorter nearer the trunk. Peduncles varied most of all, from 0.1mm to 60-80mm on a single tree or even on one branch, especially when a proportion of acorns were stunted.

The Crockmere Oak, *Quercus petraea,* May 2000

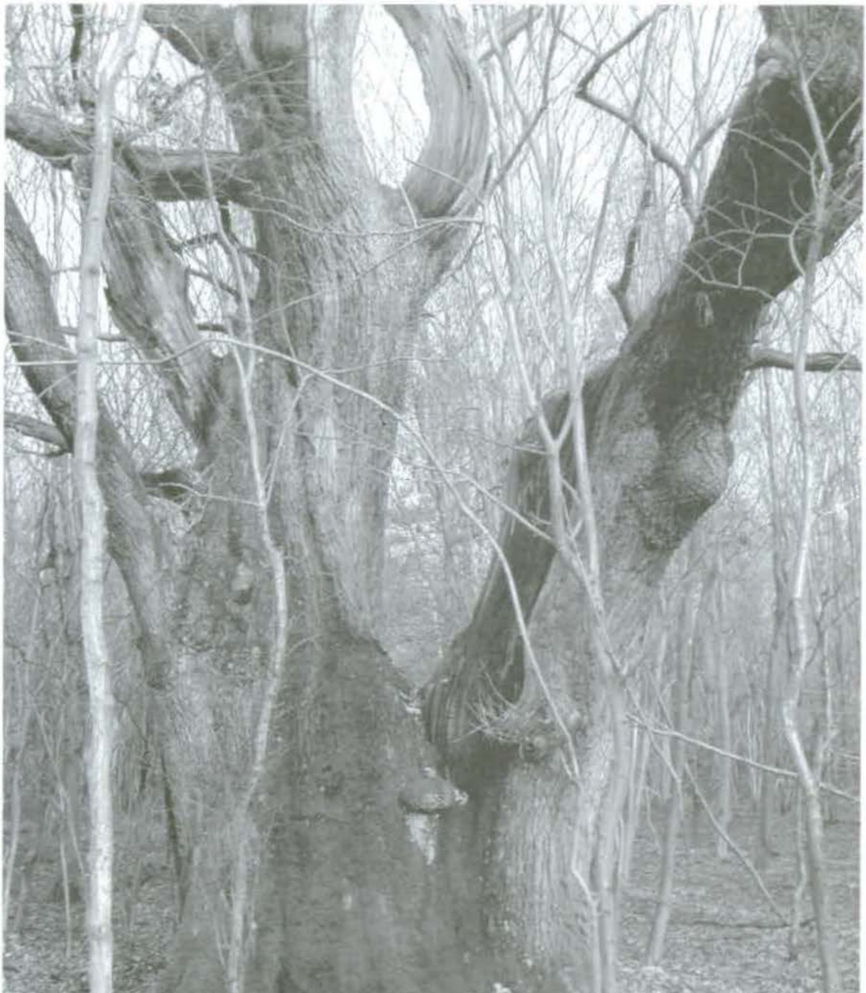
photo © Joan Davies, 2000

The Cathedral Oak, *Quercus robur,* May 2000

photo © Joan Davies, 2000

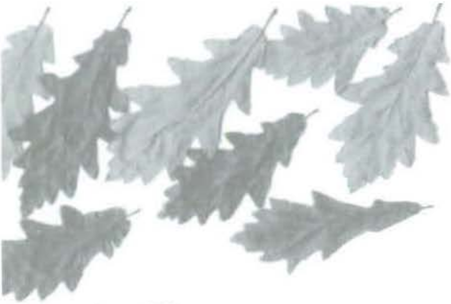
The Big Belly Oak, *Quercus* x *rosacea,* October 1999

photo © Joan Davies, 2000



The Surveyed Oak, *Quercus* x *rosacea*, January 2001

photo © Joan Davies, 2000



THE BIG BELLY OAK

An example of Taxon Identification using mid July sunlit leaves and peduncles from the tree

Q.robur characteristics

Q.petraea characteristics

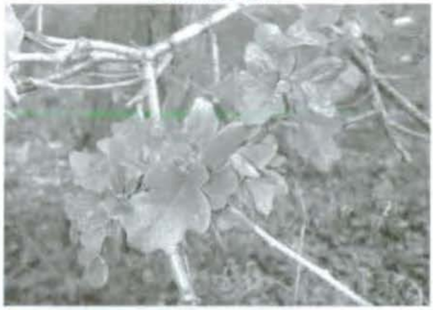
Leaf shape-Outline	Most elliptic, some oblanceolate
Leaf shape-Base	Nearly all cordate or subcordate, most obliquely so (the cuneate one shown in the picture is exceptional)
Leaf auricles	Nearly all leaves auriculate or subauriculate
Intercalary veins	Variable on about half the leaves (but often weak)
Leaf lobing Numbers per side	Average 5.5
Leaf lobing Shape & dissection	Some triangular, most semi-regular, leaves not very deeply incised
Petioles	Very variable. 50% under 10mm, 50% over 10mm, mostly near or just under 10% of leaf length
Leaf pubescence	Laminar surface (underneath); stellate hairs widespread 3-6 rayed. Leaf vein sides & angles; vertical brush hairs, 3-8 rayed & medusoid hairs (tangled & sinuous) 3-7 rayed. Consistent for all leaves
Peduncles	Variable, but few over 20mm. However, mostly little or no pubescence

Overall *Q.x rosacea*, but just on the side of *Q.petraea*

The Original Cluster Oak,

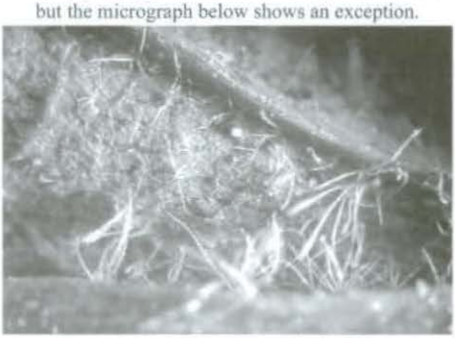
Q. robur var *cristata* (Henry 1917)
Savernake Forest, August 2003

Leaves of the Original Cluster Oak
November 2001



The original Savernake Cluster Oak has completely glabrous leaves.

Most descendants derived by planting acorns from this original tree also have glabrous leaves, but the micrograph below shows an exception.



Hairs on the under surface of a leaf from
one of the six Savernake Arboretum Cluster Oaks
The longest brush hairs are 0.6mm & longest stellate hairs are 0.15mm.
This tree therefore must have *Q. petraea* or *Q.* x *rosacea* (more likely) as the pollen parent.
The photograph was taken by Jack Oliver using a Trinocular High Power Microscope with oblique side lighting

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QUERCUS INSIGNIS MARTENS & GALEOTTI: DISTRIBUTION AND CONSERVATION

Maricela Rodríguez-Coombes[1,2], Allen Coombes[3] and Horacio Morales[1]
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[3] The Sir Harold Hillier Gardens, Hants, U.K.

INTRODUCTION

Quercus insignis is a remarkable oak from tropical regions of southern Mexico and Central America. In Mexico it is found only in the cloud forests of the Gulf and Pacific slopes, particularly in the states of Veracruz and Jalisco. *Quercus insignis* was the second species studied in the Mexican Oaks Conservation Project, funded by Fauna and Flora International (FFI) as part of their Global Trees Campaign.

The project was carried out jointly by staff from the Herbarium and Botanic Garden of the University of Puebla in Mexico and the Sir Harold Hillier Gardens in the U.K., with the collaboration of Xalapa Botanic Garden, Veracruz, and The Institute of Botany in Guadalajara, Jalisco.

In its native habitat, *Quercus insignis* is a large tree with distinctive and very large acorns, making it easily recognizable.

Plant and animal diversity is very important. A single tree can support more than 70 different species of epiphytes, including orchids, bromeliads, and ferns.

METHODOLOGY

The methodology included herbarium and field work, as well as GIS mapping. Information about the distribution of the species was obtained from the National Herbarium at the National University in Mexico, the Institute of Botany at the University of Guadalajara, and the Ecology Institute in Xalapa, Veracruz.

Field work was assisted by local researchers from the herbaria of the Institute of Botany in Guadalajara and Xalapa. GIS mapping was used to determine additional potential localities.

Several field trips were made in the States of Jalisco, Veracruz, Puebla and Oaxaca to visit all the possible locations and determine the current distribution. During these trips local people were informed about the objectives of the project and a good working relationship was established with them.

RESULTS

Ethnobotany

The distinctive acorns make this species well known by local people who collect the acorns for making ornaments. The timber is also used locally in house building, as it is very tolerant of moist ground and lasts for many years.

photo © A. Coombes

Fig 1. *Quercus insignis* in Huatusco, Veracruz

photo © A. Coombes

Fig 2. Local girl in Huatusco, Veracruz with *Q. insignis* acorns.

Conservation

Quercus insignis is threatened in parts of its range by the widespread cultivation of coffee. Regeneration is occurring in some areas, but heavy grazing means that young seedlings can be destroyed by cattle. Seed was collected from several localities and sown in Puebla, Xalapa, and at the Sir Harold Hillier Gardens. The young plants growing in Mexico will be planted in their native habitat.

Distribution

Using satellite images and field data, a very accurate distribution map was prepared of the Huatusco region, from where this species was described. Using GIS it was possible to show the distribution of this species for all Mexico, showing it to be very rare. In the two main centres of distribution, Veracruz and Jalisco, the populations show small morphological differences.

CONCLUSIONS

This study showed the lack of information on the habitat and distribution of *Q. insignis*, one of the most spectacular trees in Mexico. Based on our observations this species needs a warm, humid climate. These conditions are also ideal for coffee and in the area where *Q. insignis* is native, much deforestation has occurred to provide land for coffee plantations. The findings achieved through this project allow us to propose this species as Endangered in Mexico according to the IUCN criteria.

As future work, we are proposing population studies in the regions of distribution, in order to know more about the genetic diversity of this species. Also, more exploration work is needed in the Mexican states of Guerrero and Michoacan, although the populations there, if they exist, are likely to be very small.

Finally, more work is needed with the local communities for replanting and we see the production of educational material to be an invaluable conservation tool.

Collaborators

M. en C. Maite Lascurain, Jardin Botanico,
Francisco Xavier Clavijero, Xalapa, Ver., Mexico

Dr. Jorge Perez de la Rosa, Herbarium, Instituto de
Botanico, Universidad de Guadalajara, Jal., Mexico

The authors would like to thank FFI, their institutions and the collaborating institutions for their support during this project. To assist with their participation in this project, local people in Huatusco, and the Botanic Garden in Xalapa, Veracruz, received financial support from FFI.

REINTRODUCTION OF FOUR *QUERCUS* SPECIES INTO A SEMIDESERT AREA IN MEXICO

Maricela Rodríguez-Coombes[1], Salvador Sánchez-Colón[2] & Ana Mendoza[3]
[1]Benemérita Universidad Autónoma de Puebla, [2]Ecología Vegetal. Escuela Nacional de Ciencias Biológicas, IPN, [3]Instituto de Ecología, Universidad Nacional Autónoma de México.

INTRODUCTION

The response of germinated acorns of four endemic *Quercus* species upon reintroduction into their natural habitat in Valsequillo Valley, Puebla, México, was evaluated.

Besides this response, the emergence, growth and survival of seedlings of two species of white oaks: *Q. microphylla* (Fig. 1) and *Q. glaucoides* (Fig. 2) and two species of red oaks: Q. *acutifolia* (Fig. 3) and *Q. mexicana* (Fig.4) under contrasting planting conditions were also evaluated. The contrasting conditions were: water stress and light levels with and without predator exclusion.

METHODOLOGY

Study area

The study was carried out in Valsequillo Valley, Puebla State, Mexico, located at 18° 56' 10" N, 98° 07' 55" W, and an elevation of 2100 m. The climate is temperate humid, with an annual temperature of 16.7°C and 776 mm of mean annual rainfall.

Vegetation

Vegetation in the area consists mainly of oak woodlands (*Quercus* spp.), xerophytic shrublands with *Rhus standleyi, R. trilobata, Ceanothus coeruleus, Arctostaphylos pungens* and *Amelanchier denticulata*, and induced grasslands. Large areas are devoid of vegetation.

Acorn collection

Acorns from the 4 species were collected between July and November. They were separated from cups, floated in water and the damaged acorns were discarded.

Acorn planting

Nine hundred acorns of each species were chosen randomly. They were sown (50 acorns per tray) in vermiculite, placed in a greenhouse, and watered every other day. Upon germination, acorns were transplanted between August and November into the field sites with different microclimatic conditions: 1) Open site (full sun), 2) Shaded open site, and 3) Woodland site. Data was recorded monthly for 22 months.

RESULTS

Germination

The red oaks showed a delayed radicle appearance followed by slow shoot emergence, while the white oaks showed a very fast radicle appearance. Shoot emergence in the field sites occurred over a 2-6 month period in the case of red oaks, but over 12-14 months for the white oaks. These differences in germination and seedling emergence give an advantage in root growth to the white oaks, because their acorns fall during the rainy season.

Emergence

In general, seedling emergence was lower than 50% with the exception of the red oak *Q. mexicana* at the shaded open site. There is a slight trend for a higher percentage emergence on the control than on the exclusion plots. Emergence is affected by factors such as soil temperature and desiccation of the radicle. For all species, emergence was highest at the shaded open site, intermediate at the open site, and lowest at the woodland site.

Survival

There were differences in seedling survival and growth for all the species studied. At the open shaded site all the species showed similar survival (40-82%), which suggests that the conditions created here were suitable for the establishment of seedlings. At the full exposure site, white oaks showed much better survival than the red oaks. Only 15% of the *Q. acutifolia* seedlings survived to the end of the experiment.

CONCLUSIONS

From the four *Quercus* species studied, the white oaks showed greater survival 22 months after planting. However, the red oaks, in particular *Q. mexicana*, established quickly and grew faster in the first months after planting. The different germination patterns, earlier root development in white oaks, earlier shoot development in red oaks, explain the different biomass allocation patterns and support the hypothesis that white oaks are better adapted to dry areas. The length and thickness of the root in white oaks play a very important role in long-term survival.

ACKNOWLEDGEMENTS

The authors would like to thanks their institutions for support in this project. Special thanks go to Africam Safari for financial support and field-work facilities.

Fig 1. *Q. microphylla* in Valsequillo, Puebla, Mexico

Fig 2. *Quercus glaucoides* growing in El Aquacate, Puebla.

Fig 3. *Quercus acutifolia* growing in Valsequillo, Puebla.

Fig 4. *Q. mexicana* in Valsequillo, Puebla, Mexico

all photos by author

OAKS ON POSTCARDS

Pauline B. Topham
Dundee, United Kingdom

A display of 40 postcards spanning the 20th century illustrates both the development of the postcard itself and the interest taken in individual oak trees. Postcards became important in Britain after 1903 when post office regulations allowed a message alongside the address. Social and economic factors favoured the use of postcards. Special trees, including oaks, were among the wide range of objects of local interest that were featured on the cards. Production techniques changed over time, and where postmarks are illegible, help to date the card and thus, document the tree.

The connection to the trees featured on postcards might be historical, with legendary figures such as Robin Hood pictured, or literary, or even invented for tourism purposes. The largest trees of all in the great English forests were commonly portrayed, including trees in the New Forest, Savernake Forest, and Epping Forest. The Major Oak in Sherwood Forest was featured so often that it is possible to trace ideas of tree conservation from the changes in the images over time.

Postcards of cork oaks from Corsica and Portugal have been used to promote tourism in the Mediterranean area during the last 20 years. Oaks have also been featured on educational postcards produced by museums and national parks.

Information gleaned from postcards may be able to provide additional details about locally significant oaks and inspire people in other countries to investigate if historic postcards can shed light on their oak resources.


THE DUKERIES. ROBIN HOODS LARDER


Gnarled Oak, Pitfour
R.G.J.

SUMMING UP AND CLOSE

Julian Evans OBE
Professor of Tropical Forestry
Imperial College, London
14 September, 2003

It is an immense privilege not only to open your proceedings, but to close them and reflect on all that we have learned and shared. Clearly you won't want me to summarise paper by paper: indeed, this afternoon's panel of speakers have highlighted their main points far more eloquently than I could. But it is fair for me to ask: What did you expect, and are you satisfied? Has your first meeting outside the United States succeeded for you?

So, what have we learned? What are the pointers for the future? Firstly, we have shared new knowledge and gained new insights, and even learned some new words like 'shredding'. But what is clear to me is that there is a continuing imperative to name, classify, and identify at genus, species and cultivar level. We continue our God-given task of taxonomy (Genesis 2:20). However, in this work are we neglecting some modern techniques and specifically, use of DNA and its derivative diagnostic tools? There are issues of parentage, of closeness of species, of identifying resistant forms for which reliance on morphological features of the older taxonomy serve us less well.

Secondly, the need for research remains paramount. We have been forcefully alerted to the devastation and threat of *Phytophthora ramorum* causing 'sudden oak death' or SOD. (Now all the more worrying owing to its discovery on beech trees in UK). The knowledge of cultural practices and their impacts, of how treatments affect tree and stand growth and of the interplay of these with silviculture and the environment remain inadequately understood. We need research; we need research that is properly recorded, and we need research to be systematic and sustained, but I fear I am crying in the wilderness. But if there is one area of research to highlight, it has to be oak genetics and how best to utilise the immense diversity of this supremely important genus.

Thirdly I must touch on politics and related concerns for the 21st century. Deforestation is a largely tropical issue, but what of the tropical oaks in the closely related *Castanopsis* and *Lithocarpus* genera? There is ignorance about trees and forests: how can our understanding of oaks help dispel at least a little of this? How can our love affair with oaks serve the greater good? And, too, there is the present anxiety over climate change, the affect of which may well come to dominate all our thinking in decades to come.

Lastly, what is the thread running through the last two days? For me it has been oaks and heritage. In some senses, cultural values are an even greater reason for working with oaks than their remarkable utility. And, as a Christian, and today being Sunday, can I remind you of the gospel oaks of our land under which great preachers like Wesley, Whitfield and Spurgeon proclaimed the message of Christ.

I hope I have captured the essence of our conference. I trust you will depart more knowledgeable, with friendships made or renewed, and with a zeal to continue because you work with one to our planet's great natural assets – the genus *Quercus*.

Finally, there are many to thank, but I would specially add gratitude to God who has blessed us with fine weather for our days in conference and on field trips.

PHOTO GALLERY OF THE 2003 OAK CONFERENCE

Pre-conference Tour, Netherlands and Belgium

Oak legend Dick van Hoey Smith leads the tour of Trompenburg Arboretum

(© Guy Sternberg)

Incoming President Eike Jablonski presents an oak tree to one of our hosts, Maarten Bomer, at Bomer Nursery (© Mike Tyner)

Michel Decalut leads the rainy tour of his famous Arboretum Waasland

(© Mike Tyner)

PROCEEDINGS CONFERENCE
at Winchester, UK

Our host city, historic Winchester on the Itchen River (© RJ Fehl)

The conference was held at King Alfred College (© Guy Sternberg)

Every meal at KAC was fantastic! (© Guy Sternberg)

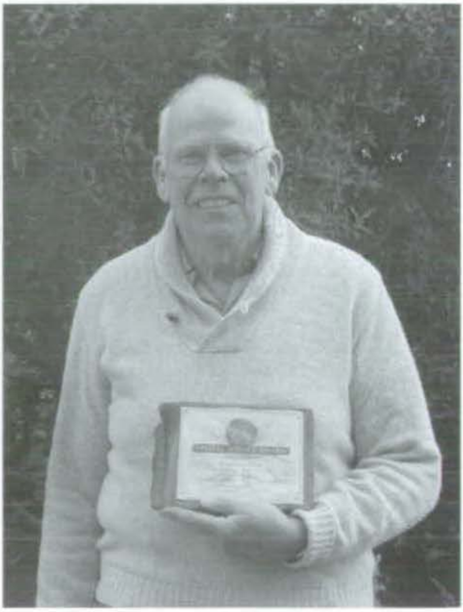
The head table at the banquet with Oak Society Vice-President Allen Coombes, the Mayor of Winchester Mrs. Jean Hammerton, retiring Oak Society President Ron Lance, and Lord Michael Heseltine. (© Guy Sternberg)

Enjoying the meal and the company: Illinois photographer Mike Tyner, founding Oak Society member Stephane Brame of France, Hilliers Arboretum Director Simon Milne, Belgian Dendrology Society President Philippe de Spoelberch, Mrs. Francoise Milne, Conference Committee member James Harris, and retiring Oak Society Vice President Thierry Lamant of France (© Guy Sternberg)

A gift from our Spanish delegation – Licor de Bellota (acorn liquor) for everyone!
(© Mike Tyner)

President Ron Lance prepares to introduce banquet speaker Lord Heseltine
(© Mike Tyner)

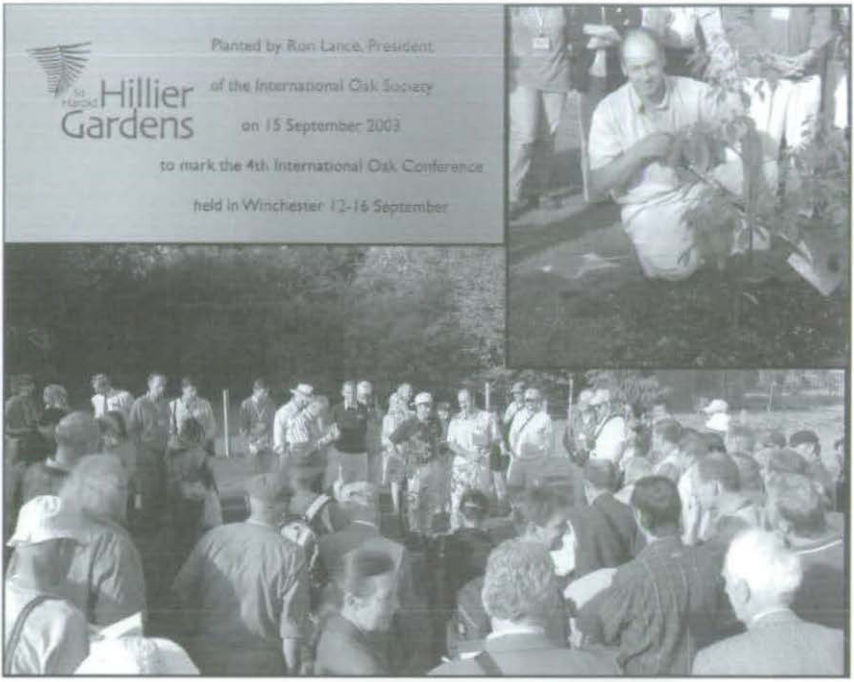
Ron Lance (at right) presents awards to Guy Sternberg (Lifetime Service Award), Diana Gardener (Special Service Award), and Rudy Light (Special Service Award) for their many contributions to the success of the organization. (© Mike Tyner)



Ed Holm, who was unable to attend the conference, proudly holds his Special Service Award under the Holm oak (Quercus ilex) in his yard in Redwood City, California
(photo by Chris Holm)

Your Oak Society Board of Directors from 2000-2003, the business meeting at Sir Harold Hillier Arboretum. (Pictured from left to right) Eike Jablonski, Dorothy Holley, Guy Sternberg, Ron Lance, Maricella Rodriquez-Coombes, Allen Coombes, Thierry Lamant, Doug McCreary. (© Mike Tyner)

The seed exchange was smaller this year due to the early season, but nevertheless another grab-fest! *(© Mike Tyner)*



President Ron Lance planted the ceremonial oak tree at our host facility, the Sir Harold Hillier Arboretum (© Guy Sternberg)

Your new Oak Society President for 2003-2006, Eike Jablonski of Luxembourg, emerging from a great oak tree in his native country, Germany (© Guy Sternberg)

POST-CONFERENCE TOUR,
United Kingdom

Illinoisan R. J. Fehl watches in disbelief as all sorts of traffic approach our bus driving on the "wrong" (left) side of the road! (© Guy Sternberg)

Mike Tyner proudly models his conference shirt while taking a break under one of the huge oaks at Windsor Great Park

(© Guy Sternberg)

Right: David Gvianidze used his conference tote bag to carry many seeds back to his arboretum in the Republic of Georgia

(© RJ Fehl)

Below: Guy Sternberg lingers behind the group to experience the spirit of the 2.5 meter Vederer's Oak (*Quercus robur*) in the Forest of Dean (© Mike Tyner)

We saw much more than just oak trees – this great cypress tree was planted in the 19th Century at Tregrehan (© Guy Sternberg)

As she left the UK tour early, Margaret Miles of Cornwall routed this card around the bus together with a large bag of delicious Cornwall fudge, to be shared by all North American participants in honor of the wartime contributions of their fathers and grandfathers. It was deeply appreciated, and served as a fitting emblem of the camaraderie of every oak conference.

A message to all North American delegates to IOS conference – 2003. 17 September 2003

As a small child, from 1940–1945, I lived next to a Canadian / U.S. hospital camp. For five years the only sweets we tasted were those given to us by the Canadian and U.S. troops. I think it is now time for pay-back!
So in recognition of the generosity of your fellow country-men and women, and the sacrifices they made, and also the friendships made on this conference – please enjoy the enclosed, small taste of Cornwall.
I wish you a safe journey home and look forward to meeting you all again sometime, Margaret (MILES).

Margaret Miles of Cornwall passed fudge throughout the bus for the North American participants (and everyone else as well!) in appreciation for what their countries did to help her family in Cornwall during World War II – this gesture exemplifies the spirit of the group

The famous Billy Wilkins Oak (*Quercus robur*) at Melbury. Note the tour group dwarfed underneath!
(© Guy Sternberg)

Arriving at Chevithorne Barton, the home and arboretum of our member and generous benefactor Michael Heathcoat Amory and his wife Arabella
(© Guy Sternberg)

Michael Amory has assembled one of the most comprehensive young oak collections in the world, and rigorously protects every tree from livestock and deer (© RJ Fehl)

The famous video camera of Dan "Oakman" Keiser captured the presentation of a tree by returning Vice President Allen Coombes to Michael Amory at the conclusion of our visit to Chevithorne – watch for Dan's growing collection of videos from previous conferences when we meet in 2006 in Texas (© Mike Tyner)

Part of the tour group pauses under the Plague Oak (dated back to the Plague years of the 1600s) at Westonbirt Arboretum. Conference participants came from England, the Channel Islands, Ireland, Scotland, Austria, Germany, France, the Netherlands, Luxembourg, Belgium, Spain, Turkey, China, Georgia, Canada, Mexico, Argentina, USA, and Israel.

(Photo © Westonbirt Arboretum)

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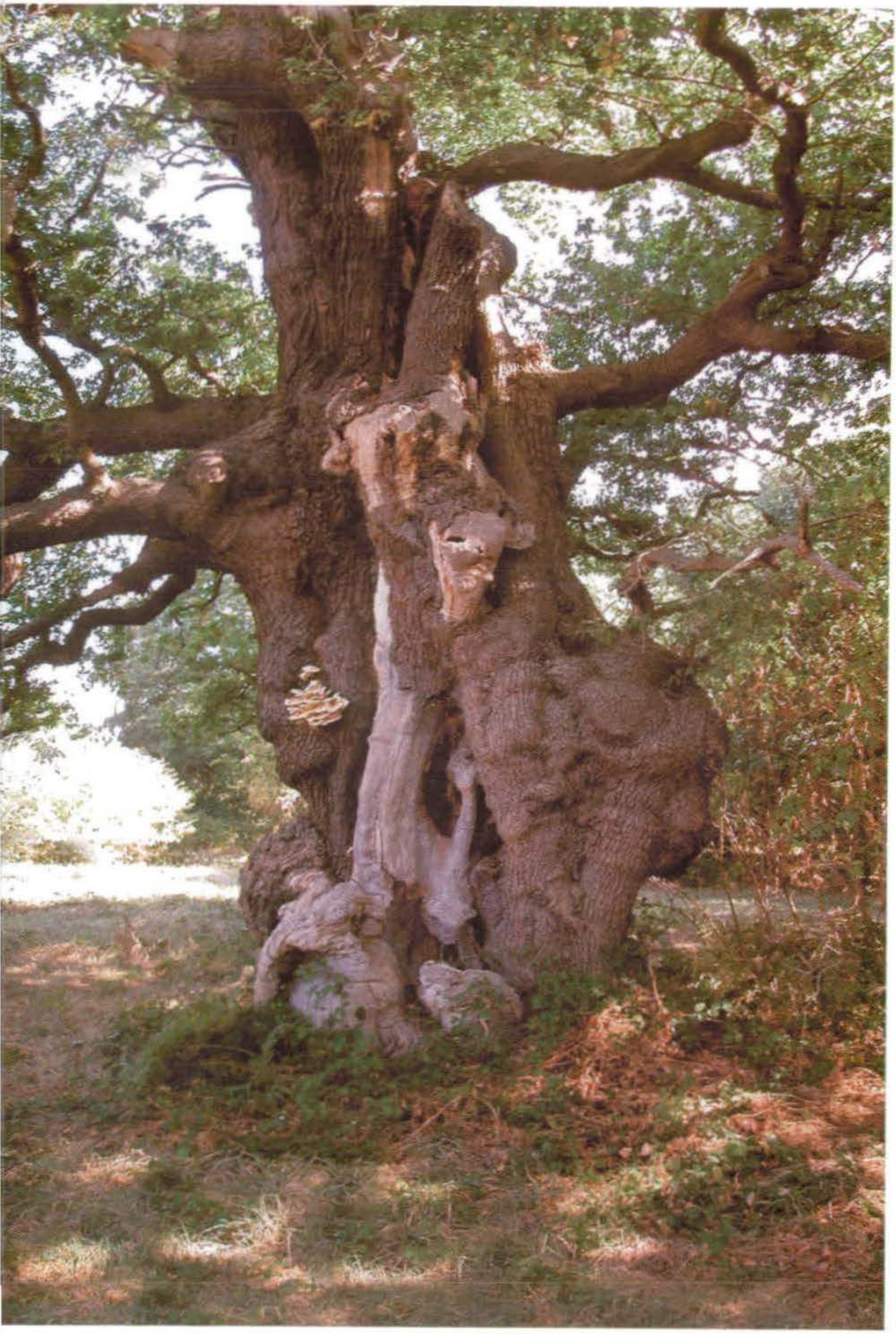

One of the ancient dodder oaks *(Quercus robur)* at Windors Great Park.

2003 PROCEED

International Oak Conference

Winchester, England

This signed, limited-edition print ... oaks, was preser... ster