HMSO £9.50 net

Forestry Commission Bulletin 62

Silviculture of Broadleaved Woodland

J Evans

Forestry Commission Bulletin 62

Silviculture of Broadleaved Woodland

J. Evans, B.Sc., Ph.D., M.I.C.For.
Silviculturist, Forestry Commission

LONDON HER MAJESTY'S STATIONERY OFFICE

First published 1984

ISBN 0 11 710154 0

FRONT COVER: Beech in the Chilterns, late Spring. (*36593*) *J. Evans*

Contents

Foreword

The object of this Bulletin is to assist all who are concerned with the management or cultivation of broadleaves. Much practical silvicultural advice is included and many recommendations are made with the main emphasis on the silvicultural techniques used to grow good quality timber. But broadleaved woodlands are important for much more than timber production and the silvicultural requirements to serve other objectives such as landscape, conservation and sporting, are also covered.

In producing *Silviculture of Broadleaved Woodland* the Forestry Commission draws on experience of managing some notable broadleaved forests, including for example the Forest of Dean, much of the Chilterns and the New Forest, the wealth of knowledge gained from long association with private woodland owners, and a considerable body of research information. Numerous experiments, mainly concerned with establishment techniques for broadleaved species, were carried out between the 1930s and 1950s. Over the years the results of many of these have been published separately. In 1968 Maurice Nimmo collated and reviewed all this earlier research, many of the recommendations from which are included here.

I commend this Bulletin, which I believe will become the standard reference for broadleaved silviculture in Britain.

G D HOLMES, CB
Director General,
Forestry Commission

Preface

There is a strong revival of interest in broadleaved woodland in Britain which was reflected in the House of Lords Select Committee report *Scientific Aspects of Forestry*, the Broadleaves in Britain Symposium and the setting up, in 1982, by the Forestry Commission of a Broadleaves Policy Review Group. A natural consequence of this interest is the need for an up-to-date account of silvicultural practices and recommendations for broadleaved woodland.

This is not the first attempt to publish a general but comprehensive Bulletin about broadleaves. In the late 1930s *Cultivation of British Hardwoods*, which was then designated as Bulletin 19, reached the page proof stage but the type was destroyed by enemy action in 1941 and the Bulletin was never published. Also, in the early 1970s a collaborative 'state of the art' account was planned. It is a pity neither of these earlier works came to fruition, but there is, nevertheless, a timeliness in the present publication. Not only is there the wide interest in broadleaved woodland already noted, but there are encouraging developments in establishment techniques arising from recent research and there is the increasing realization that much of the substantial area of what was once called scrub is a valuable resource amenable to improvement.

This Bulletin describes silvicultural practices appropriate to a wide range of woodland types and conditions. The recommendations and practices given derive from both research results, new and old, and the very considerable experience, often not formerly recorded, of many people in handling broadleaves. However, in treating broadleaves, very much more than for conifers, two issues complicate the identification and hence the straightforward application of the best silvicultural practice:

1. There are many different legitimate objectives for managing broadleaved woodland, not only the production of hardwood timber.
2. Though widely occurring, many species are treated differently in different parts of Britain. This arises from the large variation in sites and soils, the importance of local markets, the objectives for growing broadleaves, and, indeed, tradition itself. Categorical assertion that one way is right and another wrong can rarely be made.

In seeking to embrace this diversity there has been no conscious attempt to indicate policy but inevitably some readers will disagree with what is said and with some of the practices recommended.

How to tackle as large a subject as broadleaved woodland was difficult. The final result of a blend between forest types – high forest, coppice, upland woods, etc. and management for non-wood values such as recreational and landscaping aspects, with species notes at the end, is inevitably a compromise. Neither the purely ecological approach on the one hand, nor a straightforward management document on the other, would cope effectively with the enormous diversity of interest and use which broadleaved woodlands have. However, obtaining some yield of forest produce is important as the only long-term source of revenue from woodland, other than possibly from sporting and a few opportunities from recreation. Also, since it would lead to fragmentary treatment and possible duplication if all possible objectives of management were covered under various management and silvicultural systems, the main theme running through the first part of this Bulletin is management for wood production. Of course, much of the silviculture described in this first part is applicable to broadleaved woodland managed for other purposes.

Very little is said directly about the vexed question of the economics of growing broadleaves. Not only do sites, species, local markets, and factors of geography differ in every situation but so do an owner's circumstances.

Throughout the text English names are used for nearly all tree species, full scientific names are given in the Glossary at the end.

JULIAN EVANS

ACKNOWLEDGEMENTS

A wide ranging Bulletin of this type cannot be written without much assistance. This the writer has received from a great many colleagues in many Branches of the Forestry Commission's Research and Development Division. It would be invidious to single out any one person but throughout the preparation of the Bulletin Mr D A Burdekin, Chief Research Officer (South), and Mr R E Crowther, Principal Silviculturist (South) provided advice and encouragement, and Mrs E A Walters undertook the typing of the many chapters and their revisions.

Much assistance has also been received from people outside the Research and Development Division. In particular, the members of the Forestry Commission's Broadleaves Policy Review Group gave constructive advice at an early stage. Also, two Conservators and their staff, the Conservator for East England, Mr R H Hewitt, and the Conservator for South-East England, the late Mr C D Begley, commented on several of the chapters. In addition the writer wishes to acknowledge the help of Mr A Joslin and Mr R C Stern, two Forest Officers much involved with managing broadleaved woodland.

Several other people have commented on individual chapters or helped in the preparation in various ways. The writer is deeply grateful for all this assistance.

Most of the photographs were taken by the author (*A10561–A10622*), the others were selected from the Forestry Commission's photographic collection.

All line drawings were prepared by Mr J Williams.

Permission to reproduce certain tables and figures is gratefully acknowledged; the source is indicated in each case in the appropriate part of the text.

CHAPTER 1

Introduction

BROADLEAVED WOODLAND IN BRITAIN

Broadleaved trees and woodland are a dominant feature of much of Britain's landscape. In the past they were the principal source of building material, fencing, and fuel and today continue to supply half the country's consumption of hardwood. Their value for amenity, sporting, and conservation is inestimable. These many roles bring to broadleaved woodland both interest and complexity in management.

The broadleaved resource

In 1980 broadleaved woodland of all types accounted for 37.5 per cent of all forest in Britain. Of the total growing stock of timber broadleaves account for a larger proportion of the total volume (51.5 per cent) because the average age of broadleaved woodlands is greater than coniferous forest and because most isolated trees and small clumps outside the forest are broadleaved. Table 1.1 presents the analysis of the broadleaved resource by countries and woodland types. Further analysis of woodland resources by forest type are included later in the Bulletin in the appropriate section.

Table 1.1 Broadleaved resources in Britain

Woodland areas (000 ha)	England	Wales	Scotland	Great Britain
Broadleaved high forest	429	59	76	564
Coppice with standards	11			12
Coppice	26	2		28
Scrub	80	8	61	148
Volume of growing stock (million m^3)				
Woodland	68	10	13	91
Non-woodland trees	19	3	3	25

Source: Forestry Commission Census of Woodlands and Trees, 1979–82.

Tree flora

Of the 33 tree species generally accepted as truly native, 30 are broadleaves and include most of the more important species found in broadleaved woodland today – see Table 1.2. All native species do, of course, reproduce in this country, though not necessarily very freely, and a few listed in Table 1.2 are now becoming rare, e.g. aspen and Large-leaved lime. Several introduced species are able to reproduce freely, i.e. have become naturalized, notably Sweet chestnut and sycamore and one, Turkey oak, hybridizes with our native oaks.

Woodland types

Throughout much of Britain broadleaved woodland is the natural forest formation and several ecological types are generally recognized (Tansley, 1939; Anderson, 1950; Peterken, 1981). These ancient and semi-natural woodland types (Table 1.3), which amount to about 290 000 ha (Peterken, 1981), consist of either climax or important seral stage species resulting from a combination of site conditions and site history. Groupings, as in Table 1.3, are a silvicutural aid to species choice, to defining the nature of the weed flora, and to understanding natural regeneration processes, but do not necessarily indicate the most productive use of a site. Retaining representative examples of natural woodland types is of great conservation importance.

Also important for conservation, in addition to botanical composition, is how long woodland has persisted on a site. Ancient woodland is defined as being in existence from before 1700. Such woodland may be 'primary', i.e. on land considered always to have been woodland, or 'secondary' on land formerly farmland or moorland within historical times (Rackham, 1980). Ancient woodlands are generally richer than other types but, if their full wildlife value is to be preserved, they usually have only moderate timber production potential. Table 1.4 indicates the main woodland types, classified by their origin, and their relative importance as a proportion of all broadleaved woodland in Britain.

Table 1.2 Status of some commoner tree species

Native species, listed in an approximate order of arrival	Introduced species*					
	Pre 1600		1600–1800		Recent introductions	
Downy birch	White poplar	very early	Common lime	*ca.* 1600	Italian alder	1820
Silver birch	Grey poplar	,, ,,	Horse chestnut	1616	Hungarian oak	1838
Aspen	Wild pear	,, ,,	False acacia	1636	Southern beeches since	1830
Bay willow	English elm	pre Roman	Tulip tree	*ca.* 1650	(*Nothofagus obliqua*	1902)
Common alder	Smooth-leaved elm	,, ,,	Black walnut	pre 1656	(*Nothofagus procera*	1913)
Hazel	Cornish elm	,, ,,	Red maple	1656	Eucalypts	since 1846
Small-leaved lime	Common walnut ?	,, ,,	Dutch elm	1680	Red alder	pre 1880
Bird cherry	Sweet chestnut	Roman	Norway maple	pre 1683	Black cottonwood	
Sallow	Swedish whitebeam		London plane	*ca.* 1685	(poplar)	1892
Wych elm	Sycamore		Scarlet oak	1691	Robusta poplar	1895
Rowan	Holm oak	*ca.* 1500	Cork oak	pre 1699	Hybrid wing-nut	1908
Sessile oak	Oriental plane	,, ,,	Red oak	1724	Commelin elm	1940
Ash	Laburnum	1560	Silver maple	1725	Poplar 'Balsam spire'	
Holly			Sugar maple	1735	(TT32)	1948
Pedunculate oak			Turkey oak	1735		
Hawthorn			Serotina poplar	1750		
Crack willow			Lombardy poplar	1758		
Black poplar			Huntingdon elm	1760		
Whitebeam			Pin oak	pre 1770		
Wild cherry			Grey alder	1780		
White willow			Cricket bat willow	1780		
Field maple			Caucasian wing-nut	1782		
Wild service tree						
Large-leaved lime						
Beech						
Hornbeam						

* includes some cultivars and date when first produced.
Scientific names in Glossary; silvicultural notes in Chapters 17–22. Modified from Mitchell (1981).

Historical management and uses

Almost all woodland in Britain has been subject to man's activities at some time or other; truly natural woodland may occur in remote upland valleys but even there it is likely that grazing by sheep will have occurred at some time.

The dominant historical influence on woodland in Britain has been its clearance for farmland. Much clearance occurred in pre-Roman times; since then the proportion of woodland cover has further declined from about 40 per cent to about 9 per cent today. Up until the late Middle Ages the main use of woodland was in the provision of small and medium sized material for firewood, building poles and wattle, fencing and hurdles. These products were mostly supplied by coppicing. Demand for large timber was satisfied by standard trees left to grow on amongst the coppice or from isolated trees in 'wood-pastures' where animals grazed the undergrowth or grass in between. Widespread planting and replanting are of relatively recent origin and coincided with a gradually declining market for small sized material and increasing demand from shipbuilding and for mill timber.

Numerous other factors have moulded the woodlands we now have: the Enclosures Acts, sheep grazing in the uplands, the rise and later fall in demand for naval timber, declining demand for many rural products owing to substitution and cost, changes in density and dominant species of herbivores, etc. Overall the silvicultural effect of these influences has been a change from a predominance of coppice systems to high forest; a change which has continued. In 1947 coppice accounted for 22 per cent of all broadleaved woodland in England while the figure for 1980 is only 6.5 per cent.

One point concerning the gradual decline in woodland area over the centuries is the mistaken but widely held belief that disappearance of woodland in more recent times can largely be attributed to the demands for charcoal and fuelwood for brick and lime kilns and iron and glass works, and as tanbark for tanneries. It is now increasingly evident that far

Table 1.3 Relative areas of ancient, semi-natural woodland by ecological types

1. ASH-WYCH ELM WOODLAND	
1A. Calcareous ash-wych elm woods	◯
1B. Wet ash-wych elm woods	●
1C. Calcareous ash-wych elm woods on dry and/or heavy soils	•
1D. Western valley ash-wych elm woods	●
2. ASH-MAPLE WOODLAND	
2A. Wet ash-maple woods	◯
2B. Ash-maple woods on light soils	•
2C. Dry ash-maple woods	•
3. HAZEL-ASH WOODLAND	
3A. Acid pedunculate oak-hazel-ash woods	⬤
3B. Southern calcareous hazel-ash woods	•
3C. Northern calcareous hazel-ash woods	○
3D. Acid sessile oak-hazel-ash woods	○
4. ASH-LIME WOODLAND	
4A. Acid birch-ash-lime woods	○
4B. Maple-ash-lime woods	•
4C. Sessile oak-ash-lime woods	•
5. OAK-LIME WOODLAND	
5A. Acid penduncalate oak-lime woods	○
5B. Acid sessile oak-lime woods	○
6. BIRCH-OAK WOODLAND	
6A. Upland sessile oakwoods	⬤
6B. Upland pedunculate oakwoods	○
6C. Lowland sessile oakwoods	●
6D. Lowland pedunculate oakwoods	⬤
7. ALDER WOODLAND	
7A. Valley alderwoods on mineral soils	◯
7B. Wet valley alderwoods	●
7C. Plateau alderwoods	○
7D. Slope alderwoods	•
7E. Bird cherry-alderwoods	•
8. BEECH WOODLAND	
8A. Acid sessile oak-beechwoods	○
8B. Acid pedunculate oak-beechwoods	◯
8C. Calcareous pedunculate oak-ash-beechwoods	●
8D. Acid pedunculate oak-ash-beechwoods	●
8E. Sessile oak-ash-beechwoods	○
9. HORNBEAM WOODLAND	
9A. Pedunculate oak-hornbeam woods	◯
9B. Sessile oak-hornbeam woods	○
10. SUCKERING ELM WOODLAND	
10A. Invasive elm woods	●
10B. Valley elm woods	◦
11. PINE WOODLAND	
11A. Acid birch-pinewoods	○
11B. Acid oak-pinewoods	◦
11C. Calcareous pinewoods	◦
12. BIRCH WOODLAND	
12A. Rowan-birch woods	⬤
12B. Hazel-birch woods	●

Legend

Estimated area (000s ha)	Symbol
Less than 0.2	◦
0.2 – 2	•
2 – 5	○
5 – 10	●
10 – 25	◯
more than 25	⬤

Ecological classification after Peterken (1981).
Areas subjectively estimated by Peterken (personal communication).

Table 1.4 Woodland types classified by their origin, showing examples and relative importance

Woodland type	Example(s)	Proportion of all broadleaved woodland (%)
High forest, recent, plantations	Shelterbelts; amenity plantations; early 19th century hill slope plantations. Now mostly mature, but some recently restocked.	23.5
High forest, recent, semi-natural	The best quality stands amongst the Highland birchwoods and self-sown stands on old heaths and commons.	3
High forest, ancient, plantations	Ancient coppice woods which have been converted to plantations in recent decades; younger oak/ash plantations at Salcey, etc.; mostly young stands. Figure 1.1. The distinction between this and the next category is imprecise.	18
High forest, ancient, semi-natural	Many Chiltern beechwoods; Old Salcey and Alice Holt oak stands; some promoted coppice. Usually mature or maturing stands.	11
Coppice, ancient, plantations	Kentish chestnut coppice. Pure coppices elsewhere, e.g. sycamore, oak, ash, alder.	3
Coppice ancient, semi-natural	Surviving examples of mixed coppice still on or nearly on rotation age. Includes some nearly pure stands. Figure 1.2.	1
Unproductive, recent, plantations	Neglected, worthless shelterbelts and amenity plantations, perhaps gutted of good timber. Failed modern plantations on old fields and heaths.	2.5
Unproductive, recent, semi-natural	Many Highland birchwoods; poor-quality self-sown woods on old heaths and grassland. Usually not more than 100 years old.	6
Unproductive, ancient, semi-natural	Mainly overstood mixed coppices in lowlands and ash/oak and oak coppices in uplands. Some high forest stands of low timber quality. Some woods on inaccessible and very steep ground. About half are nature reserves and/or Sites of Special Scientific Interest (SSSI).	32

Note: Actual areas of each woodland type are not shown because definitions used in the 1979–82 Census (Table 1.1) do not always equate with those used above. Modified from Steele and Peterken (1982).

from exhausting local supplies of wood for these uses the presence of such industries helped sustain and not deplete woodland for the obvious reason they were dependent on a steady supply of wood. This fact, in part at least, accounts for the relatively high proportion of woodland in counties such as Surrey and the prevalence of oak woods on the slopes of Dartmoor and Exmoor.

The 1980s are witnessing a revival in both the traditional uses of woodland products and the traditional woodland management systems, notably coppicing. This latter practice is not only for the small products themselves, for example to satisfy the increasing firewood market, but because the practice is of considerable conservation value. Other influences of landscaping, amenity, public preference for broadleaved woodland, along with the continuing demand for native timbers, suggest that the present time may come to be viewed as a turning point away from many of the trends – clearance, neglect, decline of coppicing – that have affected much of our broadleaved woodland during the 20th century.

VALUES OF BROADLEAVED WOODLAND

Production of wood

Industrial products

At current levels of consumption half of Britain's demand for hardwood is satisfied by home-grown production – Table 1.5.

Table 1.5 Hardwood supply and demand in Britain

	1955	1960	1970	1980
	Volume in 000 m^3 (r)			
Home grown production	1455	1580	1326	1210
Import of logs	556	587	279	114
Import of sawnwood and veneers[1]	1407	1517	1337	1057
Total supply	3418	3684	2942	2381
Domestic consumption of identifiable hardwood	*ca.* (3400)	(3660)	2918	2332
Exports	10	10	24	49

Note: [1] converted from m^3 (sawnwood) by dividing by 0.6.
[r] roundwood volume equivalent.
Source: FAO Yearbook of Forest Products.

Since the Second World War production of home-grown hardwood has gradually declined mainly owing to a reduction in demand for sawn mining timber. Table 1.6 shows home-grown hardwood production for industrial uses. Over the last 30 years there has been a succession of shifts in demand such as away from railway waggon timbers, and the rise and fall in motorway fencing, against the background of substitution of solid timbers in such markets as coffin boards, furniture, shop and office fittings and vehicles. These changes in supply do not appear directly related to the physical availability of wood.

Forecasts for the requirement of hardwood in the future are difficult but, taking into account the decline in the supply of tropical logs, supplies of hardwood from elsewhere in the world, and substitution of hardwood, it seems conceivable that the total British requirements of hardwood timber may not rise substantially above present levels for many decades. Some increase in the penetration of the total hardwood market appears to be within the capacity of home-grown production but the total growing stock of better quality broadleaved trees (clean, large dimension logs) is believed to be a diminishing proportion of the total resource.

Non-industrial products

Broadleaved woodland has supplied many non-industrial products particularly of small sized material arising from coppicing. Demand for these has declined rapidly until the last few years when there has been a small resurgence in rural crafts and in the demand for firewood. This latter use is currently estimated to consume ¼–½ million tonnes of small roundwood annually. Hardwood is attractive for burning as firewood or charcoal and this market currently provides an outlet for early thinnings, crown wood, and improvement cleanings in poor quality woodlands.

The demand for other small wood products such as hurdles, bean and pea sticks, staves, thatching spars and tannery products seems likely to remain small but steady.

Estate uses

Many woodlands on farms and estates satisfy many internal requirements for fences, gates, and all the small roundwood products noted previously. This use, particularly of small areas of broadleaved woodland, is frequently not recorded statistically but represents a useful asset on a farm or estate.

Landscape

Throughout much of Britain, but especially in the lowlands (see Figure 13.1), broadleaved trees and woodlands are a dominant landscape feature and broadleaves are the predominant kind of tree near to where most people live. This importance of

Table 1.6 Post war production of home grown hardwood, industrial wood only

	1948	1955	1960	1965	1970	1975	1980
	Volume in 000 m^3 (s)						
Sawn mining timber			493		255	234	236
Other sawnwood			436		389	376	418
Total sawn material			929		644	610	654
	Volume in 000 m^3 (r)						
Total sawn material			1548		1076	1019	1092
Other broadleaved products			32		(250)	225	118
Total	2030	1455	1580	1501	1326	1244	1210

s = sawnwood, *r* = roundwood volume equivalent.

Table 1.7 Analysis of trees and small woods in Britain

	England	Wales	Scotland	Great Britain
Isolated trees (millions)				
Conifers	1.36	0.17	0.43	1.96
Broadleaves	12.99	1.91	1.25	16.15
Broadleaved proportion(%)	90.5	91.8	74.4	89.2
Trees in clumps (millions of trees)				
Conifers	2.44	0.58	1.02	4.04
Broadleaves	21.02	3.28	4.31	28.61
Broadleaved proportion(%)	89.6	85.0	80.8	87.6
Linear features (millions of trees)				
Conifers	1.45	0.70	1.19	3.34
Broadleaves	23.15	5.95	4.77	33.87
Broadleaved proportion(%)	94.1	89.5	80.0	91.0
Small woods (excluding those owned by the Forestry Commission or under dedication/approved woodland schemes)				
0.25–1.99 ha area				
Total number	72 176	15 000	21 290	108 466
Total area (ha)	74 200	14 115	21 470	109 785
2.0–9.99 ha area				
Total number	40 905	7 180	14 100	62 185
Total area (ha)	160 500	28 460	53 910	242 870
Estimated broadleaved proportion of both small wood sizes combined (%)	87	86	71	83.5

Source: Forestry Commission Census of Woodlands and Trees, 1979–82

broadleaves in the countryside is demonstrated in Table 1.7. About 90 per cent of all trees outside the forest are broadleaved as is the case for over 80 per cent of all small woodlands.

Recreation

The close proximity of many broadleaved woodlands to centres of high population renders specially important their role as an amenity and place for recreation. Thus woodland areas such as the Chilterns, Forest of Dean, Epping Forest, the oakwoods of Loch Lomond, and the New Forest become greatly valued natural amenities because of their location.

Sporting

For many woodland owners the sporting value of their woods can equal or exceed in importance that of forest produce. Sporting provides enjoyment as well as some financial gain and, for many smaller woods, it is their main use and justification for retention on an estate.

The value of broadleaved woodland for sporting arises from the variety of species present in tree, shrub and ground layers which provide good cover, shelter and sources of food for most kinds of sporting animals. Penetration of light through the canopy, presence of glades, opportunities for coppicing, and the small size of many broadleaved woods are all conducive to rich wildlife and safe sporting. However, the benefit is not confined to the woodland itself but also to a general enhancement of the sporting value of adjacent farmland.

Woodlands for shelter

In addition to estate products cut from farm woods, in many areas such woodlands play an important

Figure 1.1 Recent plantation of Southern beech (*Nothofagus obliqua*), aged 27 years, Yield Class 19. Micheldever Forest, Hampshire. (*A10561*)

role as shelter. This may be as shelterbelts to reduce windspeed on the leeward side to aid field crops or as shelter inside the wood for livestock. In upland areas a great many small woods, especially those which are broadleaved, are used for this latter purpose.

Conservation

The conservation importance of much broadleaved woodland has already been emphasized. Most woodland Nature Reserves and Sites of Special Scientific Interest (SSSI) are in broadleaved woodland because they are multi-specific, of predominantly native species, and many are on sites which have supported woodland for many centuries. Ancient, semi-natural broadleaved woodland, apart from meriting conservation as an ecotype in its own right in many instances, often provides a habitat for 200 or more vascular plant species whereas a densely stocked plantation may have as few as 30.

MANAGING BROADLEAVED WOODLAND

Defining objectives

Unlike most coniferous forestry, when the object is almost always to maximize economic return from sale of timber, it is clear from the previous section that there may be many reasons for wishing to grow broadleaves. Thus defining the objective of planting or management of broadleaved woodland involves difficult decisions:

1. there may be several, perhaps conflicting, objectives, e.g. to provide amenity and to maximize economic return;
2. the long-term use of the land may not be certain;
3. retaining flexibility to allow opportunity to change objectives later may be important;
4. the objective itself may be ill-defined and sometimes no more than simply a wish to maintain as woodland.

Table 1.8 Objectives of growing broadleaves and how they interact

	Designated primary objective							
	Commercial timber production	Minor products/ estate needs	Landscape	Recreation	Sporting	Farm woods/ shelter	Conservation general	Conservation specific
Secondary objective								
Commercial timber production	—	*	**	***	**	*	**	***
Minor products/ estate needs	*	—	*	**	*	*	*	**
Landscape	*	*	—	*	*	**	*	*
Recreation	*	*	*	—	**	**	**	***
Sporting	**	**	*	***	—	*	*	**
Farm woods/shelter	**	*	**	***	*	—	**	***
Conservation:								
general	**	*	*	*	*	*	—	—
specific	**	**	*	***	**	***	—	—

Legend Effect on main objective of integrating secondary one:
* little effect, easily reconcilable;
** may locally restrict carrying out of main objective;
*** greatly affect main objective, substantial compromise and considerable care needed to achieve both objectives.

Note: Conservation: general – encouragement of habitats favourable to wildlife;
specific – conservation of rare species or woodland ecotype.

In spite of such difficulties the attempt to clarify objectives and decide priorities is the single most helpful step to resolve silvicultural questions. There are few situations where two or more objectives are wholly incompatible, though often compromise will be necessary. Table 1.8 shows how different objectives interact and where reconciliation may be difficult.

Obtaining some yield of forest produce is important as the only long-term source of revenue from woodland, other than possibly from sporting and a few opportunities from recreation. Also, since it would lead to fragmentary treatment and possible duplication if all possible objectives of management were covered under various management and silvicultural systems, the main theme running through the first part of this Bulletin is management for wood production. Other aspects of management are brought together in Chapters 13 to 16.

Woodland assessment

Where woodlands have received little or no recent management some assessment of their condition will be a prerequisite to setting objectives. It is beyond the scope of this Bulletin to describe assessment in detail, indeed for woodlands of more than a few hectares it is best undertaken by a professional forester, but three kinds of information are sought: condition of the growing stock, access, and the importance of other factors such as conservation or landscaping.

Condition of the growing stock

Table 1.9 outlines the basic information needed about any area of woodland. In many cases, such as in well managed woodlands, information will already be known and incorporated in management plans and will not require specific collection.

Access

Access is an important consideration. If it is difficult and extraction costs high, managing a wood to obtain forest produce may be prohibitively expensive and may be the reason why a stand has been neglected. Factors to take into account include right of access including public rights of way, distance from a public highway, and the load carrying capacity of access and internal tracks.

Other factors

Broadleaved woodland is frequently of high amenity value, sporting potential or conservation importance. Assessment of these attributes, and benefits

Table 1.9 Essentials of growing stock assessment

Parameter	Measured by or observed from	Information gained
Area, ages and species	Map and ground survey. Increment borer, ring counts on stumps.	Extent of stand, proportion of each species, unstocked ground, e.g. tracks, etc., pattern of age-classes.
Quantity of timber	Counting or estimating number of trees. Estimating average tree size. (100% enumeration usual in small stands (<1 ha) otherwise by sampling).	Total amount of timber. Sizes of tree present. Both items essential for stand working and marketing timber.
Rate of growth	Indirectly by determining yield class using age:top height relationship. Current growth can be assessed directly from examination of widths of recent annual rings, i.e. for last 10 years using an increment hammer, and judged from visual signs such as health of callusing over wounds, length of new shoots, etc.	Vigour of stand and fertility of site – high or low yielding potential. How long to reach rotation age. Whether stand is slowing in growth – 'going back'.
Stand quality	Estimate of proportion of good, defective and diseased stems. Stem form, branching on lower bole, dead stubs, etc.	Long-term timber potential. Presence of exceptional quality stems likely to make very high grade.
Origin	Single or multiple stems at base. Pure or mixed species, native or exotic. Even-aged or uneven-aged stands.	Indication of past management, e.g. coppicing, ancient woodland status, former plantation, etc.

such as providing farm shelter, cannot usually be measured in a wholly objective way. Nevertheless, they may be exceedingly important and are considered further in Chapters 12 to 16.

The structure of this Bulletin is by major woodland types. In some instances further analysis of woodland condition is included, for example assessment of poor quality woodland (Chapter 9), and criteria for judging stems of possibly outstanding quality (Chapter 11).

Opportunities

Use and condition of growing stock

If the total annual production of home-grown hardwoods is divided by the total area of broadleaved woodland, average yield is just over 2 m^3/ha/year. This figure is less than half the estimated mean yield class of all broadleaved woodland indicating both substantial under-production and potential for increase. Such calculations disguise many factors which cause below optimum yield – conservation, recreation and sporting constraints, long rotations, and the difficulties of working small woods, etc. – but, nevertheless, show that the recorded annual cut nationally is far short of the annual increment of broadleaved woodland.

In Table 1.4 some 148 000 hectares of broadleaved woodland are classified as scrub. This kind of woodland has a poor stocking of commercial species and relatively little utilization potential. However, the reason for classification as scrub is mainly due to past stand treatment or, indeed, the neglect of it rather than inherently poor site fertility. Many such woodlands offer opportunities for considerable improvement in production. Of course, it is recognized that satisfying other objectives may consign woodland into a relatively non-productive category.

Allied to the above two considerations is the fact that many, especially small, broadleaved woodlands are simply not managed in any consistent way. This is particularly true of farm woods owing largely to a lack of knowledge about what to do on the part of the owner. The principal conclusion of the report by the Countryside Commission (1983) was "that small woods of England and Wales found mainly on farmland are a considerable and quantifiable asset which is badly used and whose value for a range of purposes is diminishing as a result."

Markets

There has and continues to be a ready market for all high quality hardwood logs. With the very long rotations, especially in oak and beech, there is rather more opportunity and more to be gained from timing fellings to coincide with a good market, either by bringing forward or delaying cutting by a few years. Markets for smaller sized material do

Figure 1.2 Ancient woodland site of mixed coppice with standards in Bradfield Woods, Suffolk. This wood has been regularly coppiced for at least 700 years. (*A10562*)

fluctuate, but at present demand for hardwood pulp, fencing and firewood are expected to remain reasonably firm. These markets along with the steady demand for pea and bean sticks, hedging stakes, etc., provide an outlet for early thinnings and some income from cleaning, thinning or coppicing poor quality woodland or scrub.

Silvicultural techniques

Recent improvements in establishment methods, notably use of tree shelters and placed application of herbicide to kill weeds, offer ways of enhancing survival and early growth of broadleaved trees. Tree shelters are also likely to prove useful in enrichment or planting up gaps in existing woodlands.

Scale of inputs

Because of the capacity to regenerate by coppicing (beech excepted), broadleaved woodlands in general can be managed either as high forest on long rotations (high input) or as coppice on short rotations (low input). This latter course, not possible with conifers, offers moderate returns for very low levels of silvicultural input.

Review of constraints

There are many opportunities for managing much broadleaved woodland more productively but equally there are reasons why this has not been done in the past. An important object of this Bulletin is to help in part to rectify this situation.

Not knowing the potential of woodlands and what to do with them was noted in the case of many farm woods, but this also contributes to their continued clearance, especially in the lowlands.

Silvicultural problems in growing broadleaves include restriction to more fertile sites, the prevalence of mammal damage, especially by squirrels, the subconscious attempt to constrain broadleaf growing to the conifer mould of uniform even-age plantations of single species, and, as mentioned, difficulties in resolving conflicting objectives.

The profitability of growing broadleaved high forest has traditionally been considered poor compared with conifers owing to prolonged establishment and longer rotations. This fact is recognized in the present preferential grant system.

HIGH FOREST

CHAPTER 2

Broadleaved high forest in Britain

INTRODUCTION

High forest is taken here to mean woodland in which the main purpose is to grow utilizable timber and in which at least half the species are marketable as distinct from poor quality or scrub woodland with little timber potential (Chapter 9) and from coppice (Chapters 6–8).

EXTENT AND COMPOSITION

The total area of broadleaved high forest in Britain is approximately 564 000 hectares. Table 2.1 shows the distribution by regions and ownership.

Figure 2.1 shows the age-class distribution of broadleaved high forest to be fairly close to 'normal', i.e. with similar areas of each age-class, though very young stands are less well represented.

Oak is the principal species of almost one-third of all high forest. The four species beech, ash, birch and sycamore account for a further 47 per cent of high forest (Figure 2.2).

Figure 2.2 also shows that the bulk of broadleaved high forest is in England. And, within England, most (70 per cent) occurs in the lowlands to the south of a line from the Wash to Shrewsbury — see also Figure 13.1. Thus, silviculturally, compared with much coniferous forest, broadleaves generally experience more sheltered conditions on sites of probably superior fertility but richer weed flora and subject to greater amenity constraints.

GROWTH RATES AND YIELD

The average growth rate of all broadleaved high forest is close to 5 m^3/ha/year (Yield Class 5), see Table 2.2. This mean contrasts with that of about 11 m^3/ha/year for coniferous forest. However, making direct comparison and concluding that broadleaves grow very much slower is somewhat misleading.

Table 2.1 Area (000 ha), distribution and ownership of broadleaved high forest

	Forestry Commission	Private Woodland: Dedicated and Approved	Private Woodland: Other*	Total
England	44.0	86.5	298.8	429.3
Wales	6.1	3.9	49.3	59.3
Scotland	4.0	10.9	60.8	75.7
Great Britain	54.1	101.3	408.9	564.3

* Includes some stands of coppice origin amounting to 61 000 ha of the Great Britain total.

1. Unlike conifers, most broadleaves and especially oak are managed on rotations much *longer* than that of maximum mean annual increment in order to grow large dimension timber. For example, to obtain high quality boles of 60 cm dbh* or more from a Yield Class 6 stand of oak the rotation length will be 150 to 160 years. (This time can be shortened by accelerating growth of individual trees using free growth but the very heavy thinning involved leads to considerable loss in *total* production per unit area.) For oak, mean annual increment culminates between 65 and 90 years; the effect of the much longer rotation is to depress the average increment actually achieved by a Yield Class 6 stand to only about 5 m^3/ha/year.
2. Wood of the major broadleaved species has densities in the range of 630–740 kg/m^3 whereas for the main coniferous ones only 450–550 kg/m^3. In terms of dry matter 30 m^3 of oak equals 45 m^3 of spruce or, put another way, at 60 years of age the total biomass of a Yield Class 6 oak stand exceeds that of Yield Class 9 Sitka spruce.
3. Volumes derived from yield class do not include branchwood. In broadleaved trees branchwood can form a significant quantity of the total

* Stem-diameter at breast height (1.3 m above ground).

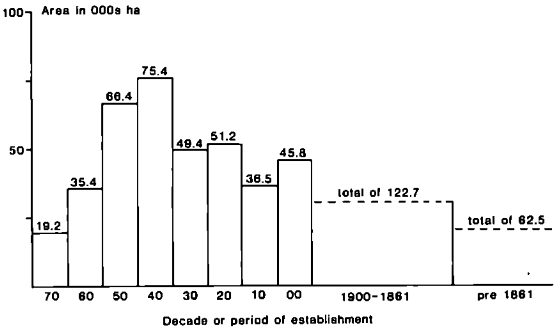


Figure 2.1 Age-class distribution of broadleaved high forest in Britain.

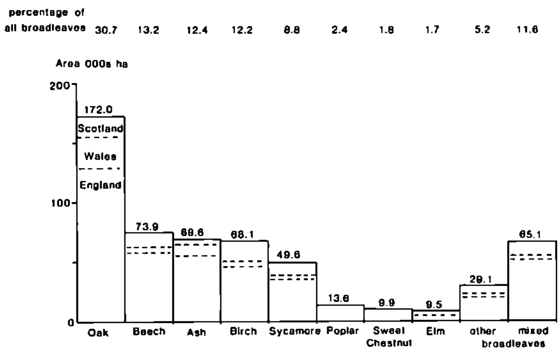


Figure 2.2 Analysis of broadleaved high forest by principal species and countries.

Notes:
1. Almost all poplar and Sweet chestnut high forest are found in England.
2. Other broadleaves mainly consist of alders, cherry, hornbeam, limes and willow.

saleable volume, especially where there is demand for firewood. For oak and beech branchwood volume averages about 50 per cent of stemwood volume (Waters and Christie, 1958).

Table 2.2 indicates the small variation in growth between regions, though generally higher yield classes are found in climatically favoured S.W. England and, to a lesser extent, in Wales and southern and eastern England. Consistently above average yield is shown by sycamore.

Variation in growth in relation to site is mainly a function of exposure, rooting depth and soil nutrient status. Very few stands of broadleaves exceed Yield Class 10, examples being confined to ash and sycamore on moist, fertile and deeply rootable soils, and most stands of Southern beech.

HIGH FOREST SILVICULTURE

Object of management

This part of the Bulletin concerns high forest where the main object is to grow timber of the best possible quality. It is stressed in later chapters that this does *not* preclude other management objectives for such purposes as landscape, conservation and amenity, but these considerations take second place in the silviculture described in the next three chapters.

Rotation length

Rotation length is the main silvicultural tool available to a forester to influence final tree size. Broadleaves, even more than conifers, have re-

Table 2.2 Average yield class by species and region

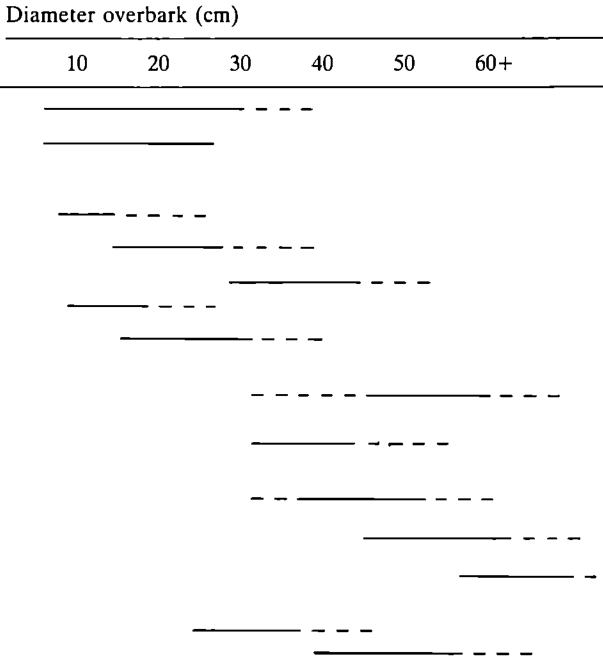
Species	England					Wales		Scotland			
	NW	NE	E	SE	SW	N	S	N	E	S	W
Oak	4	4	4	4	4	4	4	4	4	4	4
Beech	4	6	6	6	6	6	4	4	4	4	4
Ash	4	6	6	6	6	6	6	4	4	4	4
Birch	4	4	4	4	6	4	6	4	4	4	4
Sycamore	4	6	6	6	6	6	6	6	6	6	6
Poplar	4	4	6	6	6	4	6	4	4	4	4
Sweet chestnut	4	4	6	6	6	6	6	4	4	4	4
Elm	4	4	6	6	6	6	4	4	4	4	4
Other broadleaves	4	4	4	4	4	4	4	4	4	4	4
Mixed broadleaves	4	4	4	4	4	4	4	4	4	4	4

Note: The values quoted are to the nearest whole yield class. The figures for poplar are very largely based on widely spaced plantations. Much higher yield classes (maximum mean annual increment) are achieved when poplar is grown at conventional forest spacings of about 2 m.

latively rigid lower diameter limits for particular end uses. These size specifications are shown in Table 2.3.

The large minimum diameter limits to attain prime timber and veneer qualities, combined with relatively slow diameter increments – rarely more than 8 mm/year for ash, cherry, sycamore or walnut, or more than 5 mm/year for oak and beech – give rise to the long rotations associated with growing high quality broadleaves (Table 2.4).

Table 2.3 Diameter specifications for various end-uses



Product	Diameter overbark (cm)	Comments
Firewood		
Pulpwood		white woods preferred
Turnery		
alder, birch, maple, sycamore		
ash, beech		
Fencing (sawn)		mainly oak
(cleft/round)		mainly sweet chestnut
Mining timber (sawn)		mainly oak
Prime timber		
Planking/furniture/joinery		if good quality, smaller sizes of ash and beech usable
high class joinery		mainly cherry/walnut
Veneer (ornamental)		
cherry/walnut		
ash/sycamore/ sweet chestnut		
oak/elm		
Miscellaneous		
sports ash		must be white
peeled poplar for crates		

Table 2.4 Minimum rotation lengths (years)

Species	Prime timber			Veneer[1]	
	Site quality			Site quality	
	fertile	average	poor	fertile	average
Oak	80	100	130	120	160
Beech	75	95	120	110	140
Sycamore	45	60	75	55	70
Ash[2]	55	70	90	70	90
Sweet chestnut	50	65	85	65	85
Cherry[3]	(50)	(65)		60	80
Walnut[3]	(50)	(65)		60	
Poplar[4]				25	30

Notes:

[1] On poor sites (Yield Class 4 or less), slow growth and often defective stems rule out most possibilities of obtaining veneer quality material.

[2] Sports quality ash may be obtained on shorter rotations than shown.

[3] Cherry and walnut are rarely felled only for prime timber: though both are used for high-class joinery, material is mostly obtained from trees felled for veneer.

[4] Shows rotation for peeled veneer for vegetable crates.

Alternative silvicultural treatments

Almost any stand, of whatever age or species, can be treated in more than one way but still with the objective of timber production. Good quality broadleaves can be produced in even-aged or uneven-aged crops, pure or mixed stands, group selection systems, coppice with standards, from hedgerow trees, etc. It is being aware of the options available which allows flexibility in management, and enables other management aims to be embraced as well. Table 2.5 indicates the principal options available for the main stages of broadleaved high forest, along with some comment on the other considerations to be taken into account. Table 2.5 presents the silvicultural possibilities, no mention is made of differences in costs, availability of grants and other financial considerations.

SUMMARY OF SILVICULTURAL PRINCIPLES AND PRACTICE

In spite of the diversity of species and sites there are several general principles and practices which apply in the silvicultural treatment of most broadleaved woodland.

Table 2.5 Silvicultural alternatives where production of timber is the primary aim

Stand or ground condition	Main options	Refer to page	Main considerations
Bare land	Plant.	30–32	Species. Mixtures. Plant supply.
	Direct sow (rare).	32	Predation. Seed costs.
	Foster natural regeneration if suitable adjacent stand.	62–64	Time-scale factors. Protection. Degree of ground preparation.
Recently felled woodland	Replant.	29–30	Acceptability of former stand.
	Direct sow (rare).	32	Species.
	Use natural regeneration.	62–64	Presence of natural regeneration.
	Recruit coppice.	80	Adjacent seed source. Quality of stored coppice timber.
Newly established plantation	Conventional treatment.	33–41	Initial performance. Stocking.
	Beat-up with another species.	33	Weed problem. Protection.
	Use of tree shelters.	40–41	Inter-species competition.
	Accept wildings.	30	
Young natural regeneration	Respace.	62–64	Stocking. Protection.
	Enrich with same or another species.	64	Interspecies competition.
	Use of tree shelters.	64	Genetic quality/marketability of species present.
	Clear and start afresh.	—	
Thicket stage	Clean/pre-thin.	37–39	Species mix. Weed and climber problems. Market for pea and bean sticks. Danger of squirrel damage.
	Differentially clean to favour certain species or good stems.	99	
Pole-stage	Conventionally thin.	52–57	Timing, intensity of thinning.
	Free growth.	54, 160	Markets for firewood, pulpwood, turnery.
	Introduction of understorey.	60, 62	
	Fell for roundwood.	—	Importance of maximizing diameter increment on a few trees at expense of loss of small roundwood. Maintenance of ground cover and stem shading. Browsing damage. Squirrel problems.
Mature woodland	Continue/extend rotation.	64	Size of trees, markets.
	Clear fell and replant.	58–59	Evidence of regeneration.
	Plan for natural regeneration.	62–64	Timescale. Size of coupe.
	Consider selection or group system.	59–60	
Overmature woodland	Clear fell and replant.	58–59, 176	Degree of neglect. Urgency of treatment. Health. Safety.
	Naturally regenerate.	62–64	
	Retain light overstorey.	60–61	Evidence of regeneration.

General principles

1. Broadleaved woodlands can satisfy many objectives and be used for many purposes but, conversely, there are often several constraints on the freedom of silvicultural practice owing, particularly, to their landscaping and conservation importance.
2. Silviculture in high forest managed for timber production is as much directed to enhancing stand quality as maximizing yield.
3. Owing to the importance of stand and tree quality, silvicultural practice should aim to minimize degrade and defects in standing timber – shake, knots, discolouration, grain distortion, etc.
4. Broadleaved species, with the main exceptions of alders and birches, are not pioneer species on raw spoils, though they can colonize grass and heath. In general they benefit from shelter and nursing during establishment and early development.
5. The working unit tends to be small (less than 2 ha), a factor which influences many practices, e.g. protecting a whole stand versus individual tree protection, method of regeneration, etc.

Species and seed origin

Species

1. There is no overriding industrial reason for preferential planting of a particular species.
2. Site considerations should largely determine which species is grown.
3. For conservation, species occurring naturally in the region are preferable.
4. Potential growth rate should not be the only criterion when considering species choice, the relationships between the site and other factors such as timber quality must be considered, e.g. shake in oak on light soils.

Provenance

With the exception of beech and cultivars of poplar and willow, no specific recommendation can be made concerning the best seed origins or parent stock; obtain seed from registered seed stands or, where such stands do not exist, from well formed and well grown parent trees in Britain experiencing a similar climate to the planting site.

Stand composition

1. Most planting of broadleaves in the past has been in mixture with conifers; where they were not they were very densely stocked.
2. Most common broadleaves benefit from some side shelter from other woody growth.
3. Mixtures with conifers should be robust, i.e. delays in removing the nurse species should not seriously impair the broadleaves.

Establishment

Sites

1. To achieve good form (straight stems) most broadleaves require at least moderately sheltered sites.
2. Provided the site is reasonably drained, soil reaction (pH) at the surface and in the subsoil (60 cm depth), is the most helpful guide to species choice.
3. The majority of lowland soils are adequately fertile for satisfactory growth. Only lowland heaths and shallow calcareous soils impose restrictions on the species that can be grown.

Site preparation

1. Broadleaves are readily browsed; ensure that all plantings and natural regeneration are adequately protected.
2. Control of weeds, especially grasses and, to a lesser extent, coppice regrowth is important and is best carried out in the growing season prior to planting in the following autumn.
3. On the better soils used for broadleaves ploughing is rarely required, though wet pockets may need to be planted with ash, alders or poplar.

Spacing

1. Wide spacing between trees leads to poorer choice for the final crop and usually poorer form and individual tree development in the post-establishment phase, especially when planting grassy areas or other open land.
2. When present, retention of other woody growth can substitute for dense stocking of the main crop.
3. Ideal spacing of the main crop is 2 m square or less on open ground, though wider spacings are feasible if there is other woody growth.

Plant type

1. Sturdy 1 + 1 transplants with at least 5 mm

diameter root collar are desirable. Spindly plants and those with little root should be culled.
2. Larger older planting stock confers no survival advantage and dieback tends to be more severe.
3. Container stock is of no advantage except for establishment of birch.

Plant handling

Given the correct planting stock the main cause of poor establishment is bad plant handling before planting, especially failure to prevent desiccation. The time between lifting and planting should be kept to a minimum and roots protected from drying out at all times.

Planting time

Optimum planting time is late autumn (November) though good survival can normally be expected from late winter/early spring planting before mid-March, provided the plants are still truly dormant.

Planting method

No special recommendation. Place roots in spade slot and firm soil around them, do not force in. Pit planting of transplants confers no benefit over other methods. Adequate depth (at least 30 cm) is more important than width of planting slot or hole.

Fertilisers at planting

Very rarely necessary.

Tree shelters

1. Provide complete protection.
2. Have not significantly increased mortality for any broadleaved species.
3. May dramatically improve early height growth of some species, e.g. oak.

Stumping back

1. Rarely necessary provided 1 + 1 transplants are used.
2. Confers no overall growth advantage.
3. May improve form of poorly developing or browsed/frosted/fire-damaged plants.
4. Confine practice to large seeded species with strong taproot, e.g. oak, Sweet chestnut, walnut, and only if plants are less than 80 cm tall.

Weeding

1. Bare soil devoid of weeds, especially grasses, provides optimum establishment conditions. At least 1 m diameter clear of weeds around each tree is recommended.
2. Kill competing weeds with careful application of herbicide.
3. Cutting or rolling weed control methods may aid survival but generally do little to enhance growth because they little affect root competition. Also they may need doing more than once in a growing season.

Post-establishment treatment

Cleaning

1. Undertake minimum to ensure release of main crop species, but pay special attention to climbers.
2. Recruit naturally occurring stems of marketable species to make good any gaps in stocking.
3. Consider need for formative pruning to improve stem quality.

Pole-stage fertilising

Not necessary.

Brashing

Not necessary.

Thinning

1. Generally commence thinning early when stands are 8–10 m top height.
2. Primary objective is to improve quality of a stand. Achieving a particular yield per hectare is generally less important than ensuring well formed trees are favoured in thinning and defective, misshapen and wolf trees are removed.
3. Early selection (but not necessarily isolation) of potential final crop trees (about three times number at final crop stocking) is a useful aid to thinning. In general, only select from well formed dominants.
4. Except at first thinning in very densely stocked stands and row mixtures, all thinnings are selective.
5. The effect of rate of growth on wood quality is generally much less important than achieving even growth. Thus, as far as markets allow, thinning a little and often is the ideal.

Pruning

1. Confine pruning to potential final crop trees and only to stands expected to yield good quality saw timber or veneer.
2. It is rarely necessary to prune above 5 m.
3. Pruning operations should be completed by the time of second thinning.

Regeneration operations

Rotation length

1. Rotation length is principally influenced by technical considerations, usually diameter of log.
2. In oak and beech, rotation age is well past the age of maximum mean annual increment.

Felling

1. When near rotation age, it is usually advantageous to be flexible about the felling date to try and time fellings to coincide with a good market outlet. The occurrence of a heavy mast year or availability of good planting stock for regeneration operations should not be overlooked.
2. Felling method should minimize risk of damage to the butt log, especially by considering direction of fall of large crowned trees.

Regeneration method

1. Clear felling and replanting is the main method of regeneration.
2. Natural regeneration is possible in all common broadleaved species, but it is difficult to encourage artificially.
3. Natural regeneration depends on waiting for a prolific seed year, having the ground in a receptive state, and being prepared to carry out the very heavy thinning or clear felling when these conditions occur.
4. Most common broadleaves, with the main exception of beech, will regenerate from coppice. Many factors influence the success of this technique – see Chapters 6–8.

Protection

Diseases and pests

1. Apart from Dutch elm disease and, to a very much lesser extent, Beech bark disease, broadleaves are relatively free of serious disease and pest problems likely to cause extensive damage of economic importance.
2. For poplars and willows specific cultivars are used to overcome damage from economically important diseases.

Nutritional deficiencies

1. Nutrient deficiencies are unlikely on most sites.
2. Lime induced chlorosis frequently occurs on high pH soils with free calcium carbonate, especially on old arable land.
3. Sites with a long history of coppice working may have depleted phosphate reserves.

Climate

1. The variation in rainfall experienced in Britain is an unimportant factor affecting species choice or growth.
2. On exposed sites broadleaves exhibit slow growth and poor form. Windthrow is rare.
3. Most broadleaved species are damaged by late spring frosts and are generally unsuitable for planting pure in frost hollows.
4. Extreme winter cold is only damaging to exotics such as eucalypts and Southern beech.

Mammal damage

1. On most uncultivated land in Britain, complete exclusion of browsing and grazing animals will result eventually in development of woodland cover.
2. New plantings and young regeneration need protection from browsing, by fencing or individual tree protection depending on size of area and number of trees.
3. Trees of any age can suffer bark stripping when farm livestock are grazed, sheltered, or allowed access to a wood.
4. Squirrel damage occurs on many species but is most frequent on maples, sycamore, beech and to a lesser extent oak. Baiting or trapping are effective means of control.

Other

Broadleaves are not as susceptible to fire damage as most conifers owing to the kinds of sites planted and because there is less fuel on the forest floor.

CHAPTER 3

Establishment of plantations

INTRODUCTION

The bulk of broadleaved planting is not afforestation but re-establishment on woodland sites. Chapter 5 considers planting to supplement natural regeneration and underplanting in managed high forest, and other chapters consider planting in many specific situations, e.g. enrichment of scrub, growing decorative quality timber, for landscaping, or sporting benefit, etc. This chapter primarily concerns planting new ground and restocking clear felled woodland, but many of the silvicultural principles apply to *all* planting of broadleaves. No mention is made of nursery work or details of tools and working methods of forestry operations which are well covered in Forestry Commission Bulletins 14 and 43 and other publications.

CHOICE OF SPECIES

Four considerations determine which species are planted.

1. Purpose of growing trees.
2. Site conditions, mainly climate and soil.
3. Availability of planting stock.
4. Biological constraints.

Objectives

The importance of defining objectives was emphasized in Chapter 1 and Table 1.8; it is stressed that without a clear idea of why trees are to be planted, consideration of technical aspects of species' choice becomes arbitrary. Once objectives are clear it is helpful to work through the following procedure.

1. Define objective or purpose(s) of growing trees.
2. List objective(s) in order of priority, preferably into main, secondary, and minor.
3. List species which satisfy the main objective.
4. Eliminate species ill-suited to site, unavailable, or biologically undesirable, e.g. elm.
5. Eliminate species not compatible with secondary objective.
6. Choose species least in conflict with minor objective(s).

The above procedure is, of course, usually done subconsciously but species' selection merits orderly and logical consideration since the one chosen may occupy the ground for 100 years or more. The consequences of a poor choice can be enormous, e.g. the large amount of reaction wood in many early commercial poplar plantations owing to the widespread use of Serotina poplar which tends to lean with the prevailing wind unless very sheltered, or the high proportion of shake found in oak on light, very freely drained soils.

Site conditions

Matching species with site is fundamental to good silviculture. Both careful site survey and knowledge of a species are required. The species' chapters (17–22) include details of site requirements, the more important of which are summarized in Table 3.1.

Normally a species is chosen to suit a site, but the alternative of modifying site conditions to suit a species is sometimes feasible. The possibilities are limited but should always be considered. They mainly involve improving soil physical conditions – ploughing, draining – and raising nutritional status by adding fertiliser. Modification of microclimate, to reduce frost damage or moderate windspeeds (exposure), may be possible by leaving side shelter or a light overstorey, or by using a nurse species in mixture.

Climate and topography

The main climatic influence on species choice is the limitation that winter cold and frost places on the use of many exotic species, see for example Figure 4.1. Among the main broadleaved species, variation in total rainfall and mean temperature over the British Isles has remarkably little influence on species choice, though Sweet chestnut and walnut do appear to have high sunshine and warmth

Table 3.1 Summary of main site requirements for broadleaved species

Species	Optimum conditions	Suitable soils*	Unsuitable conditions	General remarks
Principal species				
Ash	An exacting species requiring good soil conditions. Grows well on deep calcareous loams, moist but well drained. Thrives on chalk and limestone where soil is deep.	1b 12b,12t 5k 8a	Avoid dry or shallow soils, grassland, heath or moorland, ill-drained ground, heavy clays. Frost hollows and exposed situations are also unsuitable.	Not a suitable species for large-scale planting or for use on exposed ground. Only plant ash if there is local evidence that first-class timber can be produced. It is rare to find suitable conditions except in small patches, thus sites should be chosen with great care. Benefits from shelter in youth. Often best trees found in mixed woodland.
Beech	Good loams of all types if well drained.	1b,1z 12,12b, 12t	Avoid frost hollows, heavy soils on badly drained sites, leached and very shallow soils.	Beech is commonly associated with chalk and limestone areas but though moderately tolerant of calcareous soils it is not often at its best on them. Often grows well on acid soils. Benefits from a nurse on exposed areas. Useful for underplanting. Tolerant of smoke pollution. More tolerant of exposure than oak.
Poplars Black hybrids: (*Populus* x *euramericana* (Dode) Guinier) *P.*'Eugenei' *P.*'Gelrica' *P.*'Laevigata' *P.*'Robusta' *P.*'Serotina'	Will grow on wide range of sites but for optimum growth for peeler quality logs requires loamy soils in sheltered situations. Rich alluvial or fen soils, both well drained and well watered. Banks of streams. Soil pH should be above 5.5	1b 5b,5k 8a,8c 7k 12t	Avoid high elevation, exposed sites and shallow soils. Stagnant water is fatal but occasional floods do no harm. Avoid acid peats and heathland.	Poplars are mostly tolerant of airborne pollution and are a useful species for planting around derelict land. For peeler logs poplars are grown at 6–8 m spacing but much higher yields are obtained by planting more closely, e.g. for fuelwood or pulpwood uses.
Balsam poplars: *P. trichocarpa* Torr & Gray *P.tacamahaca* x *trichocarpa* hybrids	They withstand slightly more acid soils than the Black hybrids and are more suited to the cooler and wetter parts of Britain.		As for Black hybrids.	As for Black hybrids. Often susceptible to a bacterial canker and only clones generally resistant in practice should be used.
Oak Pedunculate and Sessile	• Well aerated deep fertile loams. Grow well on fertile heavy soils and marls.	1b 7,7b 12t	Avoid all shallow, ill drained or very infertile soils, exposed areas and frost hollows. Light, very freely drained soils likely to lead to shake.	Sessile oak tolerates less base rich soils than does Pedunculate oak. Both species are very wind-firm.

* see appendix to Chapter 3 for codes.

Table 3.1 — *continued*

Species	Optimum conditions	Suitable soils*	Unsuitable conditions	General remarks
Principal species – *continued*				
Sweet chestnut	Needs a deep fertile acid soil. Best in warm, sunny localities of southern England.	1,1b,1z 12t	Unsuitable for the less fertile soils, frosty or exposed sites, badly drained ground or heavy clays.	Important coppice species in SE England. When grown for timber should not be left to reach very large size owing to risk of shake. Potential as firebreak species on lowland heaths.
Sycamore	Well-drained fertile loams and sites rich in nitrogen and phosphorus.	1b 12,12b,12t 5k 7k	As for ash but stands exposure.	Fairly frost hardy. Stands exposure and smoke pollution very well. A useful tree for upland planting and as a wind-firm mixture for conifers in shelterbelts. Attractive to grey squirrels. Regenerates naturally very freely; species can be invasive.
Other useful species				
Alders Common Grey Italian Red	Very hardy and accommodating species, preferring wet soils. Can stand flooding. Loam over chalk (Italian alder). Stream sides.	1b,1u,1z 2g,2s 5b,5k,5z 6k 7,7b,7z 8a,8b,8c 12,12b,12t 15	Not suitable for very acid peats, badly aerated soils, or dry acid sands.	Common alder, will grow in conditions of wetness of soil which no tree, other than willow, will tolerate. Useful on industrial waste sites because of nitrogen fixing ability. Only Italian alder is suitable for strongly calcareous soils, but restrict to S. Britain. Red alder most useful for upland planting. Grey alder prefers somewhat drier soils to other species.
Birches Silver and Downy	Prefer light soils in the drier parts of the country, but both species are ubiquitous and will grow well on relatively infertile soils.	1b,1u,1z 2g,2s 3,3m 5 7,7b,7z 12,12b,12t	Should not be planted on any site where they are not clearly wanted for silvicultural reasons or for amenity.	Not usually worth planting as a forest crop but often useful as nurses for frost-tender conifers or for beech or oak, and for amenity/ landscape value. Natural growth may be useful as shelter for a new crop but must be cut out after a few years. Suitable for upland planting and on reclaimed land. Need care in transplanting.
Cherry, Wild (Gean)	Fertile woodland soils, and also on deep loams over chalk.	1b 12,12b	All infertile strongly acid soils, compacted soils and heavy clays.	One of the few trees to produce good timber and showy blossoms. Useful addition to any beech or oak woodland.

* see appendix to Chapter 3 for codes.

Table 3.1 — *continued*

Species	Optimum conditions	Suitable soils*	Unsuitable conditions	General remarks
Other useful species – *continued*				
Elms	Fertile, deep, moist light loams.	12t	All infertile soils.	Dutch elm disease makes it unsafe to plant elms. Wych elm thrives under forest conditions particularly in northern and western valleys. Also susceptible to Dutch elm disease. Frost hardy. Resists sea winds.
Hornbeam	Fertile loams of near netural reaction, and heavier clays.	1b 7,7b 12t	Acid sandy soils and high exposure.	Little timber value but excellent firewood. Very frost hardy.
Limes Small-leaved Large-leaved Common	Sheltered fertile sites.	1b 12,12b,12t	All infertile soils. Intolerant of high exposure.	Wind-firm. Viable seed is produced only rarely. Useful as a hedgerow tree to replace elm. Common lime often suckers from base.
Norway maple	Fertile soils including calcareous ones on chalk downland.	1b 12b,12t	All infertile and strongly acid soils.	Useful species for shallower calcareous soils. Susceptible to squirrel damage.
Red oak	As for oak but also more fertile sandy soils.	1,1b,1z 7,7b 12t	Very infertile soils.	Timber not a substitute for English oak, but a good general purpose hardwood for poorer soils. Valued as an amenity tree because of its autumn colour.
Southern beeches *Nothofagus procera* *N.obliqua*	Both species exhibit good growth on a wide range of soils from deep sands to heavy clays. *N.obliqua* performs better than most broadleaved species on poor soils.	1b,1z 7b 12t	Impeded drainage, frost and exposure to very cold winds. Avoid calcareous soils.	Both species have much forest potential, but provenance should be selected carefully. *N.procera* should not be planted in drier, more easterly regions.
Walnuts Common Black	Deep, fertile loams with good drainage. Sheltered site with warm south or southwest aspects.	1b 7k 12t	All infertile soils, exposed sites and frost hallows.	Only grow this valuable timber on ideal sites in S. England. Very susceptible to late spring frost.
Willow (Cricket bat)	Margins of flowing streams or water courses with alluvial soil or similar highly fertile land.	5b,5k	Anywhere other than the optimum described.	Growing Cricket bat willows is a specialized business mainly restricted to Essex and Suffolk – see Bulletin 17 *Cultivation of the Cricket bat willow*.

* see appendix to Chapter 3 for codes.

requirements for good growth. The only recommendations based on gross climatic criteria are to confine planting of these two species to south and south-east Britain and not to plant Southern beech in eastern regions.

More important are local factors of exposure, incidence of frost (see Chapter 4 and Table 4.1) and other microclimatic effects which mostly reflect conditions of local topography. For reasons of exposure and generally poorer soil conditions, attempting to establish productive broadleaved high forest at altitudes above 300 m will rarely be worthwhile. Small woods of alder, birch, rowan and sycamore do occur above this altitude, and occasionally even of ash, oak and beech, but they are mostly slow growing and of poorly formed trees.

Aspect also affects growth, damper north and east facing slopes appearing most favourable, but it rarely influences species' choice apart from special cases such as walnut which grows best on a sheltered southerly aspect.

Soil factors

Although generalizations about soils can be misleading it is clear that in lowland Britain a simple subdivision into those derived from chalk and limestone, clays, and sands does broadly relate to species choice. Lime tolerant species should be selected for chalk and limestone soils. Heavy soils derived from clays can support a wide range of species, though oak is often the best choice. Very acid, predominantly sandy soils are not capable of supporting good broadleaves.

Overriding the factor of soil origin, the presence of water, either too little (summer drought) or too much (winter waterlogging), influences and restricts species choice as does acidity (pH). Measurement of pH, or at least testing for free lime if a high pH soil is suspected (a few drops of acid will make any calcium carbonate present 'fizz'), is useful.

The main edaphic considerations leading to a first approximation of species' choice in lowland Britain are presented in Figure 3.1.

Vegetation

The vegetation occurring on a site has been much used in the past as an indicator of species' choice, see for example Anderson (1956). It is most useful at a local level to indicate site variation and as supporting evidence of where a particular species may do best. Where appropriate, examples are noted in the species' chapters.

Man-made sites

Tree planting is an important component of land reclamation. The potential of such sites to support productive high forest is unknown but Table 3.2 is a simple guide to choice of species known to establish well.

Once forest cover is established and the surface stablized other species are possible. In the Forest of Dean direct planting of beech on coal tips failed but both beech and oak will seed in and grow well if there is a well established pioneer crop of pine.

Availability of planting stock

Sufficient quantities of suitable plants of the desired species may be unavailable for a number of reasons:

1. the chosen species is unusual;
2. the chosen provenance or seed origin is difficult to obtain;
3. seed supply is poor owing to lean seed years;
4. trade losses – production from nurseries disrupted owing to weather, pests and disease problems.

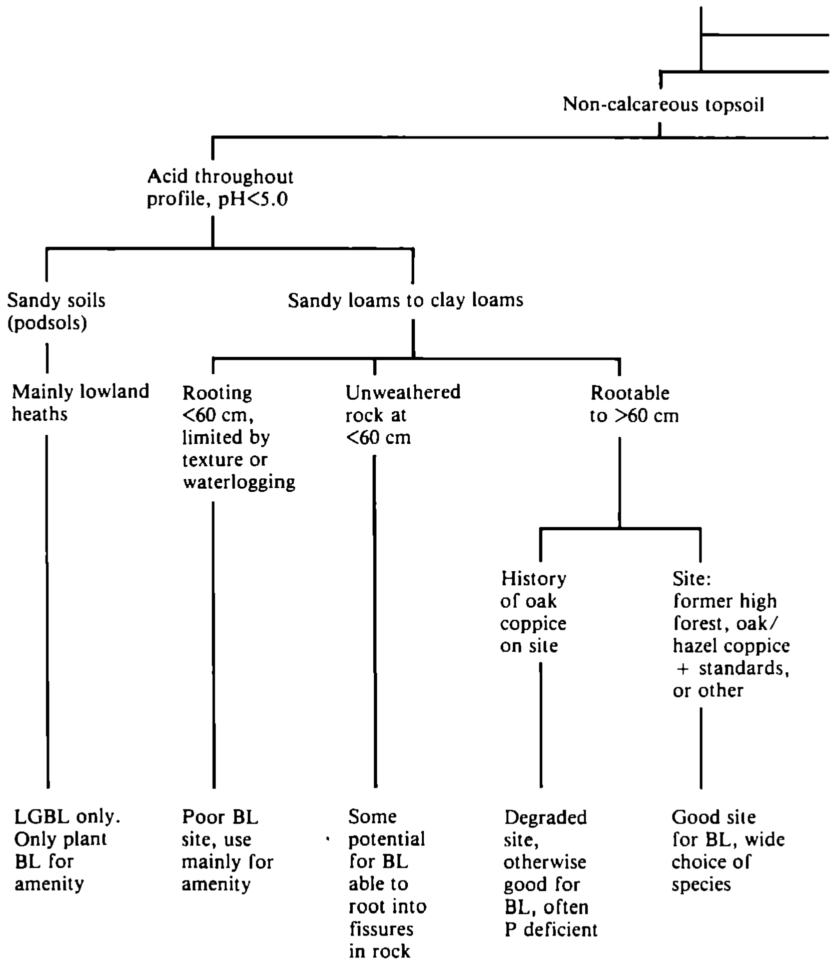
Although availability of planting stock ought not

Table 3.2 Choice of species for man-made sites

	Predominantly sand		Predominantly clay	Calcareous spoils
	Free draining	High water table		
Alders		X	X	(only Italian alder)
Ash				X
Birches	X			
Norway maple				X
False acacia	X			
Sycamore				X
(Willows)	X	X		

X = Species suited to conditions (from Binns and Crowther, 1983).

Figure 3.1 **Soil Factors influencing choice of broadleaved species in lowland Britain**



MAJOR SPECIES (top of list only indicates possible first choice)		C. alder (where wet)	Oak* Sw. chestnut	Oak* Beech Sw. chestnut	Oak* Cherry Beech Sw. chestnut S. beech
			(*not on sandy loam)		
MINOR SPECIES and/or only low potential quality for firewood, pulp, fencing, etc.	Birch Alders (where wet) Oak, R. oak, Sw. chestnut Willows Lime	Birch Oak Willows	Alders R. oak Birch	Alders R. oak Birch	Alders R. oak Birch

LEGEND: BL — broadleaves
LGBL — low grade broadleaves
R. oak — Red oak
N. maple — Norway maple
S. beech — Southern beech
Sw. chestnut—Sweet chestnut
C. alder—Common (black) alder

Calcareous topsoil (fizzes in acid)

Depth to unweathered calcareous rock

Man-made or reclaimed sites (see Table 3.2)

Acid at surface but increasingly base-rich with depth, pH>5.0 at 60 cm

No seasonal waterlogging		Seasonally water-logged near surface		>60 cm	<60 cm
Fertile (N-rich)	Less fertile	Surface water gley on clay	River valleys with alluvial soils	Many chalk and limestone regions	Mainly slopes on chalk downs and some hard limestone areas
Good BL site, wide choice of species	Moderate BL site, avoid most demanding species	Moderate to good BL site but heavy soil liable to compaction, frost lift, etc.	Specialized site type, often highly fertile	Good BL site for lime-tolerant species	Typically former arable soils. If highly calcareous, lime-induced chlorosis can affect any BL species
Ash Cherry Beech Oak Sycamore Sw. chestnut	Beech N. maple Oak Sycamore S. beech Sw. chestnut Grey alder	Oak Cherry (Elms) Ash Sycamore	Poplars Ash (locally where better drainage) Alders (Willows)	Ash/Beech Cherry N. maple Sycamore	N. maple/Sycamore Ash (if rootable below 60 cm) Italian alder
Lime N. maple S. beech Alders R. oak Walnut	Lime Alders R. oak Birch	Alders Aspen Hornbeam Lime Poplar	Aspen	Hornbeam Italian alder Lime Walnut	Beech Hornbeam Lime

Table 3.3 Dominant height (m) at 25 years of broadleaved species pure and in mixture
Experiment Broxa 98, P55, 220 m altitude. *Calluna* dominated heathland on ironpan soil, N. York moors.

Stand	Species			
	Sessile oak	Beech	Birch	Sweet chestnut
Pure	5.38	4.61	8.27	5.57
Nursed by JL	7.18	7.25	8.63	9.44
Nursed by JL & SP	6.85	6.82	7.64	8.58

On this poor site nursing has elevated potential yield class of oak and beech from 2 to 4.

Table 3.4 Dominant height at 10 and 26 years and nursing effects in a mixture experiment
Experiment Gisburn 1, P55, 260–290 m altitude. Former upland pasture on surface water gley, moderately to severely exposed, W. Pennines.

10 years	Height (m) of 'nurse' species in pure plots			
	Norway spruce	Scots pine	Oak	Common alder
	1.83	3.23	2.01	2.44
'Nursed' species	Increase or decrease in height (m) due to nursing in mixed plots			
Norway spruce	–	+0.34	−0.34	−0.12
Scots pine	+0.25	–	+0.34	+0.13
Oak	−0.30	+0.49	–	−0.15
Common alder	−0.18	+0.12	−0.12	–
26 years	Height (m) of 'nurse' species in pure plots			
	Norway spruce	Scots pine	Oak	Common alder
	8.80	11.12	6.58	8.24
'Nursed' species	Increase or decrease in height (m) due to nursing in mixed plots			
Norway spruce	–	+1.82	−0.04	+1.04
Scots pine	+0.42	–	+0.22	0.0
Oak	−0.91	+2.24	–	+0.71
Common alder	−0.67	+1.07	−0.52	–

Scots pine has consistently the greatest 'nursing' effect.

to dictate species choice, because of numerous management factors a delay in planting to wait for the right species can be very costly. When an unusual species is chosen, it is important first to ensure that sufficient plants are going to be available.

Biological constraints

The prevalence of Dutch elm disease rules out elm as a high forest species for the present time. And, if squirrel control cannot be ensured, planting beech, sycamore or Norway maple may be unwise.

MIXTURES

In plantation establishment or restocking there is always the question of whether to use more than one species. The advantages and disadvantages of mixtures are well documented, e.g. Troup (1952), Hiley (1967). Owing to long rotations and slow growth of many broadleaves, supplementing the main crop species by planting another to increase yields, bring early financial returns, or to act as a nurse, is a common practice. In many parts of Britain tradition has been to plant a mixture of four or five species,

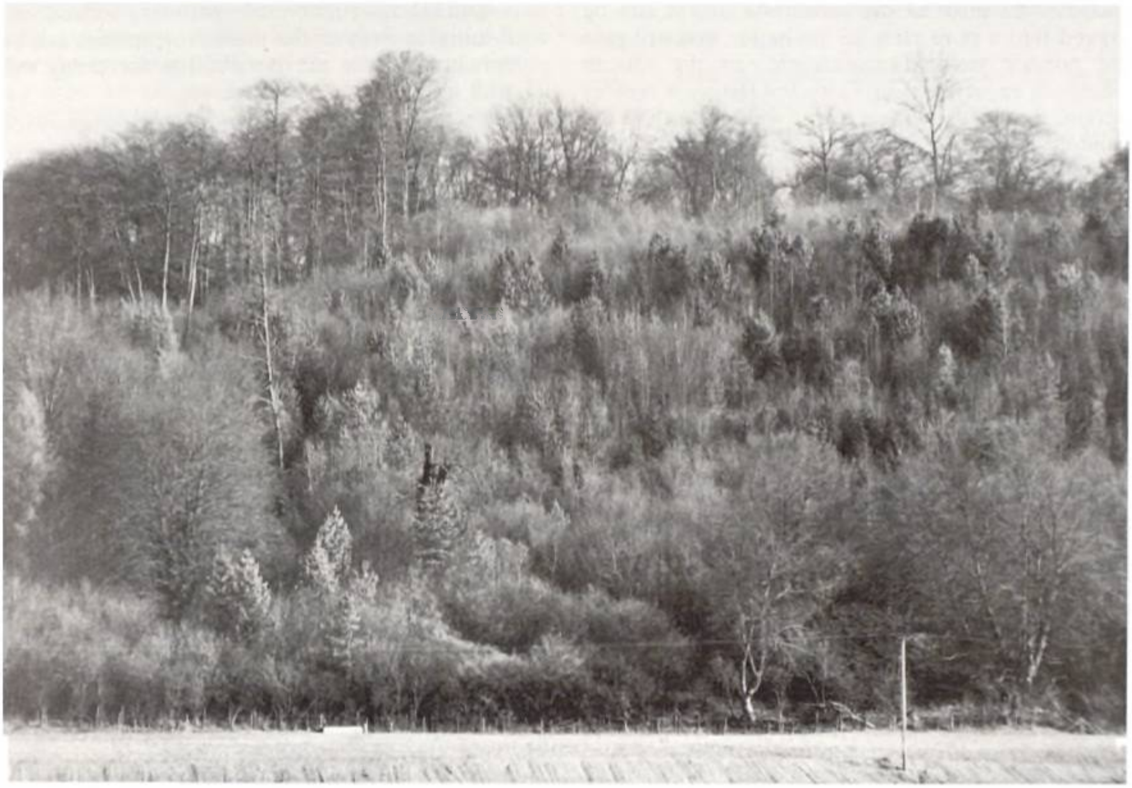


Figure 3.2 Beech and Corsican pine mixture growing on shallow chalky soil. Many Corsican pine are suffering lime-induced chlorosis and have died before reaching utilizable size. (*A10563*)

conifers and broadleaves, and subsequently to favour the best one or two. And, in the past, using conifer nurses to aid establishment of broadleaves was almost universal.

Benefits of mixtures

Early returns

The principal reason usually advanced for not growing a pure crop of broadleaves, especially of oak or beech, is financial. Planting a matrix of another species which matures sooner, especially conifers, brings earlier returns and may improve overall profitability provided it does not have to be cut prematurely.

Nursing

On most sites growth of broadleaves in mixture with conifers is superior to that of a pure crop provided the nurse species is not totally dominating. This benefit is seen particularly on frosty sites, exposed ground and in the uplands. Two upland examples are shown in Tables 3.3 and 3.4. On open chalk downland Brown (1953) and Wood and Nimmo (1962) reported both faster initial growth and better stem form of beech when interplanted among young pine stands or introduced among gorse. In many experiments oak nursed by European larch, when not over-topped, has grown 10–25 per cent faster in height than the pure stand.

The nursing benefit indicated above and in Tables 3.3 and 3.4 comes mainly from side shelter, but a faster growing nurse species may also help reduce frost damage and, in some instances, aid crop nutrition, e.g. improved growth of ash on infertile sites when planted with alders owing to their nitrogen enriching influence.

Site utilization

It has long been claimed that by growing more than one species the mix of different crown structures and rooting habits leads to fuller use of a site's potential compared with a pure stand. It has been difficult to prove that this increases production because no two species ever grow at the same rate and it can be argued that a pure crop of the better one will give the greater yield. For example, in the Queen Elizabeth experiment in Table 9.3 the pure conifer option, though showing a lower yield class than the conifer component of a mixture with oak, still has the highest basal area per hectare.

Mixtures may confer greater wind stability but often this is only due to one species in a mixture failing to grow well and effectively giving the other an early respacing. Differential windthrow is sometimes observed in oak:Norway spruce mixtures on clay soils in central and eastern England with spruce blowing over at pole-stage and the oak, with its deeper rooting habit, remaining firm. Nevertheless, in Parkhill, Forest of Dean, on a heavy clay pure Douglas fir is prone to blow at 25–30 years but in matrix with oak is able to grow to maturity and achieve 40 m height or more.

Problems of mixtures

Deciding on a mixture implies dissatisfaction with use of the chosen final crop species over a whole rotation, but growing a mixed stand also brings problems.

Silviculture

The greatest difficulty in growing mixtures is to ensure that the final crop is not swamped by the supplementary species. Occasionally, the reverse also occurs such as the failure, often at about thicket stage, of pine or Douglas fir 'nurses' in many mixed beech plantations on the South Downs resulting in little yield from the conifer component (Figure 3.2).

Cleaning and frequent thinning at the right time will prevent one species swamping another, but such working yields little produce and is costly. There are two solutions to this difficulty.

1. To grow compatible species, i.e. ones that grow at about the same rate in the early years, such as oak and slow-growing origins of European larch or beech and Red cedar, so that the need for frequent intervention is less. However, attempting to use compatible species severely limits species choice and generally reduces the improvement in yield a second species may bring. Also compatibility between species varies with locality. In the Midlands and East Anglia oak: Norway spruce is widely used on clay soils since the spruce averages Yield Class 10–11 and shows almost identical height development to oak Yield Class 6. In the west of Britain generally better growth of Norway spruce (Yield Class 12–13+) makes it much less suitable in mixture with oak.

   Limitations due to incompatibility are reduced if initial growth of the main crop species can be enhanced; there are possibilities for doing this with tree shelters (see page 40).
2. To design robust patterns of mixtures where each species is able to fend for itself up to the time of first thinning. This usually means having small blocks, strips or bands of species rather than an intimate mixture.

Weed control in conifer:broadleaved mixtures is more difficult owing to the differing susceptibility of the species to herbicide damage.

Landscape

Woodland of intimately mixed species is in many ways aesthetically attractive, but landscape problems arise when, to achieve a robust mixture, planting is done in bands or stripes on a regular pattern, e.g. 3-row:3-row mixtures on hillsides.

Protection

There is evidence that broadleaved trees in mixture with conifers suffer more from squirrel damage than when in pure stands (Rowe, 1983). Conversely, Beech bark disease is less prevalent in beech:pine mixtures than in pure beech.

Recommendations

Broadleaves:conifer mixtures

Where commercial considerations dominate and landscape is not an important issue, growing broadleaves with a conifer will provide an earlier return from timber as the conifer will reach maturity before the broadleaves. The present situation where broadleaved thinnings are more readily saleable as firewood cannot be relied on as a permanent feature of the market. However, there are serious landscape problems generated by row, band or regular group mixtures of broadleaves and conifers and, unless conifer 'nurses' are essential, a better landscape effect will be achieved by keeping the species separate. Conifers can be kept to reverse slopes and broadleaves planted where there is maximum visual impact and where they will mitigate the harsh conifer outlines and skylines. Whilst the use of broadleaves as a screen or belt around conifer plantations can give unfortunate landscape effects in hill country, in the more level scene the practice is effective.

For simplicity and robustness of mixture design it is sensible only to grow two species. For oak or beech a block and matrix layout of groups of 12 or 16 broadleaved trees at 10 m to 12 m centres is effective. With row mixtures alternate rows of different species should be avoided except where Norway spruce is used with the intention of removing most or all as Christmas trees in the first 10 years. It is preferable either to plant each species in bands four or five rows wide or, in order to maximize conifer yield, to limit broadleaves to three row strips alternating with five or six rows of conifers. Each of these designs ensures that the broadleaved groups or strips are separated at about a final crop spacing while allowing relatively straightforward harvesting of the conifer.

Weeding and cleaning must ensure satisfactory establishment of both species. At first thinning, *which must not be delayed*, generally the conifer row next to the broadleaved groups or strips should be harvested (Figure 5.3). Thinning in mixtures is considered on page 55.

Where compatible mixtures are to be grown, the following are found to work reasonably well, always provided the site is suitable in the first place:

ASH	with	European larch and occasionally Norway spruce.
BEECH	with	Lawsons cypress, Western red cedar, Scots or Corsican pine and occasionally with European larch and Norway spruce.
OAK	with	European larch, Norway spruce or Scots pine.

As a guide to compatibility the anticipated conifer yield class should never be more than double that for the broadleaved component except for larch which should not be more than 50 per cent better. For example, oak Yield Class 6 with European larch Yield Class 8 and beech Yield Class 8 with Western red cedar Yield Class 16 are probably compatible, whereas oak Yield Class 6 with Norway Spruce Yield Class 16 is probably not.

Planting conifers with sycamore, Norway maple, Red oak and other species are not shown since these broadleaved species generally exhibit greater vigour and any yield improvement from conifers would be less.

Mixtures of broadleaves

On some sites, especially recently felled woodland, mixtures of broadleaved species are not only feasible but will often arise through natural regeneration among the planted trees. Colonization by Common alder or birches can be used to advantage for side shelter when establishing other broadleaves. Planting formal mixtures of broadleaves is uncommon but inclusion of a small proportion of a second species can benefit both silviculture and other factors such as amenity. The following merit consideration:

ASH	with	Common alder or sycamore
BEECH	with	cherry
OAK	with	Common alder, ash, cherry or Sweet chestnut.

In general incompatibility between broadleaved species is less of a problem than between broadleaves and conifers. Mixture design is relatively unimportant.

In many European countries uneven-aged mixtures are encouraged, e.g. oak with beech understorey in northern France, because it is claimed to aid branch suppression on main crop trees and maintain good soil conditions (Evans, 1982). Deliberate planting of beech (and conifer) for these purposes has been attempted in Britain but is not widely practised owing to the need to protect understorey trees from mammal damage, slow growth of the beech, and because of doubt concerning the benefits claimed. However, where feasible, establishing a crop under a scattering of birches is a useful practice both to help minimize frost damage and significantly reduce weed growth.

SITE PREPARATION

Most land suitable for establishing broadleaves in Britain has the following characteristics:

1. reasonable access, at least in fine weather;
2. relatively small total area;
3. relatively fertile;
4. rich in herbaceous weeds and climbers;
5. suffers deer browsing, with rabbits and squirrels as potential problems.

The aim of site preparation is to encourage rapid establishment and early growth of the planted crop. In most cases, ground suitable for broadleaves does not require substantial amelioration such as deep ploughing, fertilising or draining. The main problems concern site clearance, killing of weeds, and protection from browsing.

Former woodland sites

Assuming the previous crop supported by the site was satisfactory, only three kinds of problems are likely to occur in restocking:

1. access to planting position owing to the presence of debris, stumps, etc.;
2. re-wetting of ground and its effects;
3. profuse weed growth and unwanted coppice.

Access to planting position

Lop and top left on a site prevents easy access for tree planting and subsequent weeding; it also harbours rabbits. It is best disposed of as part of harvesting operations since heaping and burning can rarely be justified economically as a separate operation.

If debris is left, 'opportunity planting' can be done; transplants are planted wherever conditions allow and natural regeneration accepted in inaccessible parts, but subsequent weeding is difficult.

Re-wetting

This occurs on all sites after felling but is particularly serious on clay soils making the site inhospitable to new plants and working conditions difficult. Tussock grass often invades, rushes develop in the wettest parts and the site becomes very frost prone. These conditions are a frequent cause of plant failure including natural regeneration. Compaction and puddling should be minimized by restricting vehicle movement in the autumn and winter or whenever ground conditions are wet.

Heavy clay sites should be planted as soon as possible after felling and use made of microtopography by planting on high spots and away from depressions and compacted areas, e.g. old extraction routes. Former log landings with their excessive compaction frequently merit separate treatment in extra cultivation and/or by planting a different species, e.g. alders. If experience suggests very serious re-wetting it may be better to lessen the problem by not clear felling the former crop but leaving a scattered overstorey which is underplanted.

Control of weeds and coppice regrowth

Killing weeds and stumps before planting greatly reduces the need for subsequent weeding and cleaning. There are no crop trees to protect and all chemicals listed in Figure 3.8 may be used. Indeed, unless the ground is very clean, replanting after felling is best delayed for one growing season to allow the flush of weeds, which arises from the soil seed bank following the influx of light, to be killed off easily and effectively. Similarly, stump regrowth is best controlled by summer application of glyphosate or triclopyr to the coppice foliage; planting can then commence in the autumn or following spring. Alternatively, stumps can be killed by application of ammonium sulphamate (AMS) or triclopyr to the freshly cut surface. This approach is more expensive and after AMS treatment 3 months must elapse before planting.

For details of herbicide use and application refer to Sale *et al.* (1983).

New planting

Usually, only small areas of bare ground are presently planted with broadleaves and these are mostly adjacent to existing forest, on farms, or on artificial substrates, such as motorway verges, industrial waste sites, etc. On new ground the most important consideration is to secure good weed control. Scarifying (discing) for weed control and rapid establishment is beneficial and should be considered when planting more than 0.5 ha of relatively smooth ground. If this is not possible weeds should be killed with herbicide (see later).

Cultivation, in particular ripping, is essential on compacted soil or where planting is likely to be arduous in hard ground, e.g. shallow soil over chalk.

Two kinds of soils may need draining: heavy clays and alluvial soils with high water tables, e.g. many poplar sites in the fens. On heavy clay soils, not only is the soil wet and difficult to work but the site tends to be more frosty which leads to poor survival of plants. Drains, 60 cm deep, dug at 20 m intervals will usually be adequate. On clays drain maintenance is rarely necessary and the draining effect is only required until canopy closure when the crop itself begins to alter substantially the site moisture relations.

Fencing

Adequate protection of newly planted trees from browsing animals is essential and must be maintained until trees are out of danger – refer to Table 4.2 (page 48). Because of the small size of most planting areas for broadleaved crops the question of whether to fence the whole ground or to protect individual trees becomes important. This matter is considered later under Protection (page 46).

PLANTING

Sources of plants

Planting stock is best obtained from nurseries which specialize in producing transplants for forestry.

Use of wildings, that is naturally occurring seedlings, may be feasible for very small-scale planting. However, it is an expensive way to obtain plants because of the labour involved, there is no assurance of genetic quality other than knowing they are of a local race, and planting success may be poor owing to inevitable root damage in lifting.

Plant type

The question of plant type has two parts:

1. what *kind* of plant to use: bare-rooted, container grown, set, etc.;
   and
2. what *size* of plant to use.

Kind of plant

Container-grown plants are always more expensive to buy and to plant than bare-rooted ones. Although one might expect better survival and growth from a tree that goes through the planting process with its roots undisturbed in a plug of peat in a container, extensive trials show there is only an advantage in mid-summer (Figure 3.3). In the usual planting season of autumn and spring bare rooted transplants perform as well or better than stock in Japanese paperpots. This may be because the container is small and the stock usually a one-year-old seedling.

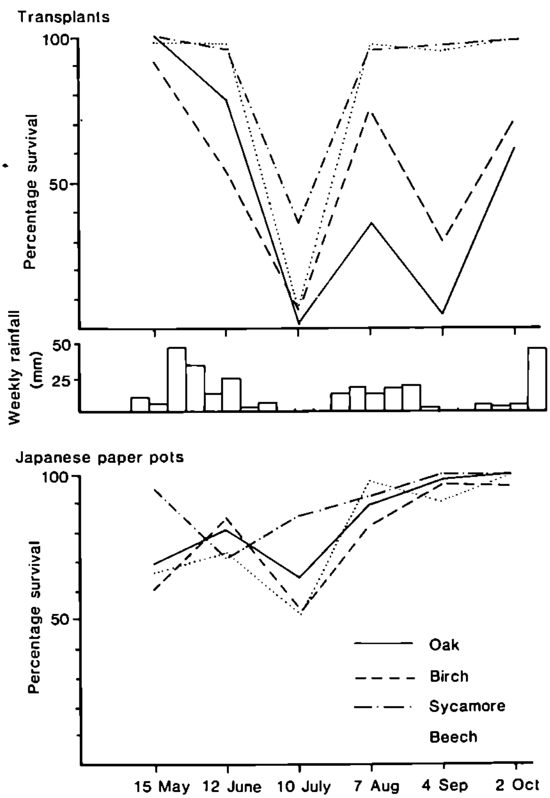


Figure 3.3 Comparison of survival between bare-rooted transplants and stock raised in Japanese paperpots of four broadleaved species planted at 28 day intervals during the growing season.

There are complications in handling and transporting container raised stock and in ensuring they do not deteriorate between nursery and planting site through failure to water.

Container-grown plants are a distinct disadvantage when the growing medium used is very different from the substrate into which the trees are planted. If a peaty root-ball is inserted into clay soil the tree's roots tend only to proliferate in the small pocket of peat, thus the plant not only grows slowly but can become unstable.

Provided planting is done at the right time, for all normal forest purposes, healthy, balanced, bare-rooted plants are ideal (birch excepted).

Size of plant

Large plants over 1 m tall confer no early growth advantage, are expensive, and may check after planting. Similarly very tiny plants, particularly seedlings less than 20 cm tall, lack resources to carry them over the planting phase, are susceptible to damping off and physical damage, and are difficult to see when weeding; they also should not be used. The optimum size for most species is 25–50 cm height. Although height is the commonest method of size grading, root collar diameter is more important since thin, spindly plants are far more prone to die than ones which, although short, are sturdy. For plants between 25 and 50 cm tall root collar diameter should be at least 5 mm and preferably in the range 6–8 mm. This is usually achieved in two years in a nursery, i.e. either 1 + 1 transplants or 1u1 undercut plants.

There are some exceptions to the above rules. Walnuts owing to their frost tenderness should be 70–90 cm tall, but see page 113. Alders should be 1+1s, 45–70 cm tall. Because of rapid seedling growth there is a temptation to plant 15–25 cm tall 1+0 alders, but their survival is often poor. A second year in the nursery appears to help the plants become nodulated (roots infected with nitrogen-fixing bacterial associations) before they are planted.

Plant handling

Poor handling, leading to damaged plants, is the principal cause of poor survival and slow growth of newly planted trees.

Three factors constitute good handling:

1. avoiding physical and biological damage;
2. preventing desiccation and/or overheating of plants;
3. careful planting.

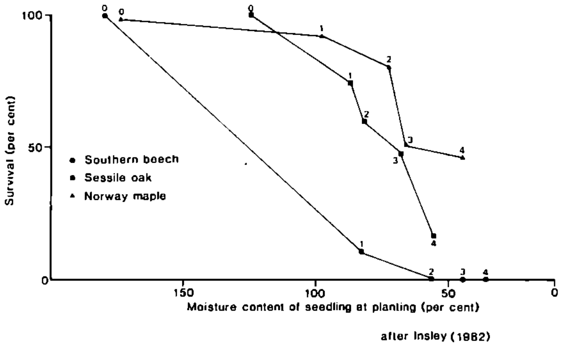


Figure 3.4 The relationship between moisture content at planting and survival of seedlings of three broadleaved species.
Numbers on graph indicate the number of days exposure to drying of each batch of plants.

The damaging effect of drying out of plants is shown in Figure 3.4.

The following will ensure good handling:

1. minimize time between lifting and planting;
2. always keep plants in the shade;
3. cover plants when transporting, do not have shoots or foliage exposed;
4. do not place anything on top of bundles or bags of plants;
5. when planting, place roots in the slit or hole, do not force them down causing distortion or breakage, and firm soil around them.

Season and time of planting

The best time to plant broadleaves is between late September and mid-November during mild, damp weather. Spring planting is often successful, but if it becomes delayed or coincides with a prolonged dry spell losses can be very high. Bare-rooted stock should not be planted later than early May, even if flushing has been delayed by cold storage, unless the weather is very wet and the plants still dormant.

After ensuring good quality plants which have been carefully handled, planting in the autumn or early spring is the next most important criterion for good survival.

Spacing and planting pattern

Stocking

Because many broadleaved species exhibit generally poor stem form and other inferior characteristics, it was traditional to plant at close spacing, 1–1.4 m, with the aim of providing many trees from which to select ones of final crop quality. Such high stocking, 5000–10 000 stems/ha, combined with slow growth and the related high weeding costs, was the main cause of the high establishment costs associated with growing pure crops of broadleaves.

In recent years, spacing in pure plantations has averaged 1.8 to 2 m. The lower stocking increases the importance of using good genetic stock. Spacings wider than about 3 m under-use site potential in the early part of the rotation and, for many species, encourage a spreading crown habit, heavy branching and impaired height development (Figure 3.5a). The saving in establishment costs from wide spacings is less of an advantage when a market exists for firewood since early thinnings from all broadleaved plantations find a ready market for this purpose.

In general, and with the obvious exception of poplars and willows, planting at very wide spacings (greater than 3 m apart) is inadvisable for new plantings unless the site was formerly woodland and other woody growth can provide the necessary side shelter to aid the main crop trees (Figure 3.5b).

Pattern

Owing to the more open and irregular habit of the crowns of broadleaved trees objections to planting in straight lines, even in high amenity areas, are not serious.

Patterns for mixtures are considered on page 28. In broadleaves:conifer mixtures increased choice of final crop trees can be obtained by planting the broadleaves (main crop) at close spacing (1.5 × 1.5 m, 2 × 1 m etc.) in their groups or bands.

DIRECT SOWING

In the past direct sowing of large seeded broadleaved species such as oak, beech and Sweet chestnut attracted much attention as a way of saving on nursery and planting costs. The technique has not generally proved reliable for several reasons:

1. high losses from predation by mice, squirrels and birds;
2. large quantities of seed are needed to achieve reasonable stocking;
3. stocking tends to be patchy with bunches of plants and gaps.

One benefit claimed for direct sowing is that because root growth of the seedling is continuous and not broken by transplanting, both early growth and final tree stability are improved. No experiment has ever shown support for either these claims for direct sowing, though there is some evidence that

Figure 3.5 (a) Oak planted at 10 m spacing in open grass, aged 17 years. Poor height growth and bushy crowns result from an absence of side shelter. (*A10564*)

initial root development and symmetry are better, or that planted trees are in any way unsatisfactory.

If direct sowing is attempted, aim to sow at least 100 000 seeds/ha; in Germany one tonne of acorns is sown per hectare to establish oak. Using such large quantities of seed is only feasible in heavy mast years. Such years occur very infrequently for oak and beech, thus it is difficult to plan afforestation in this way for these species.

BEATING UP

When many plants die soon after planting, replacing them (beating up) will be necessary to achieve adequate stocking. Generally this is undertaken if more than one in five plants die, though in mixtures or where planting is at wide spacing it is important to ensure that almost every plant grows. The need to beat up indicates some failure in establishment as practised and the reason(s), e.g. bad handling, poor plants, late spring planting, etc., should first be identified. Once this is done and the matter corrected as far as possible, beating up should be with healthy, well-balanced plants. Ones slightly larger than average, with a thick stem, are preferable. The expense of using much larger plants such as feathered whips is rarely worthwhile. If gaps are evenly spaced a tolerant fast-growing species such as alder can be used to catch up the original crop and so not unduly prolong weeding.

If substantial beating up is necessary for more than two years species choice and the adequacy of the existing site preparation and protection should be reviewed.

STUMPING BACK

Stumping back is the practice of severely cutting back top growth at or a few years after planting to stimulate a vigorous initial shoot. It is confined to tap rooted species and is the traditional method of improving poorly formed oak, such as results from repeated frosting, and helping walnut above the worst of the frost.

Stumping back confers no overall growth advantage and will usually kill species such as beech and birch. Its use is best confined to ash, oak, Sweet chestnut and walnut to improve the form of trees

Figure 3.5(b) Nine-year-old oak planted at 4 m spacing with enough other woody plants (birch, broom, sallow, etc.) to help upward growth. The only maintenance now required, apart from some deer protection, is occasional cleaning to ensure release of oak. (*A10565*)

becoming bushy, or after fire damage in a young crop. Carry out in late winter and single to one shoot in the summer. If poor habit is due to frost or heavy browsing, a change of species, better protection or use of tree shelters may be called for.

WEED CONTROL

For a background account see Forestry Commission Bulletin 48 *Weeding in the forest* (Wittering, 1974).

The need

Control of weeds helps newly planted trees both to survive and to grow well. Dense weed growth can:

1. kill trees by:
   - overtopping (heavy shading, physical weight, crushing under snow);
   - severe moisture competition, especially in the weeks immediately after planting;
   - harbouring small mammals such as mice and voles;
   - inducing mildew on some species.
2. retard growth of planted trees by competing for:
   - moisture,
   - nutrients,
   - light.

Weeding methods which do not kill weeds but only cut or flatten them generally aid survival, i.e. prevent causes of death in (1) above. Methods which kill weeds (tops *and* roots), herbicides and the old practices of screefing and hoeing, remove competition as well (2 above) and aid survival *and* early growth. The aphorism that weeding helps plants to 'survive and thrive' is particularly true of broadleaves.

The benefits of weed control are illustrated in Figure 3.6.

An entirely weed free site, or a substantial proportion of virtually bare ground devoid of grasses and vigorous herbs around each tree, is usually the best condition in which to establish a broadleaved crop. The only exception may be on very exposed sites where side shelter may aid initial survival by reducing the desiccating effects of persistent wind on young foliage in early summer, e.g. beech on exposed chalk downland (Wood and

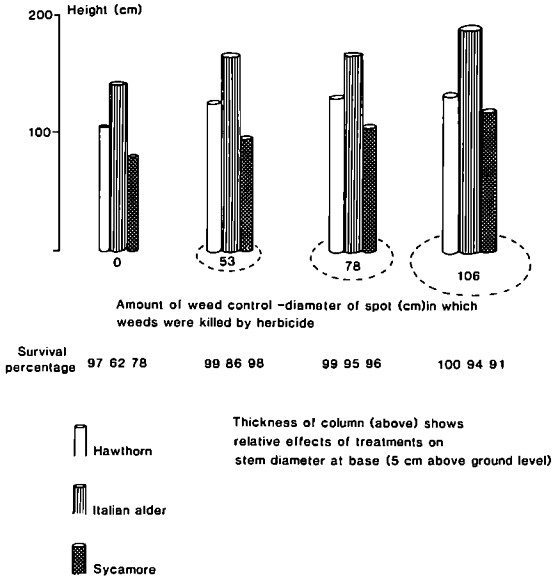


Figure 3.6 Benefit of amount of weed control on growth and survival of three broadleaved species 3 years after planting.

Nimmo, 1962), but this benefit is better provided by a nurse species rather than a potentially competing weed.

Timing

The basis of good weed control is laid during site preparation. A good weed kill then, greatly lessens the problem later on.

After planting, weeding should be done at least when it is needed! For good survival weeds should never become taller than the plants. For good growth a weed free site (bare soil) is best but this is expensive to achieve and maintain and a working compromise is to spot weed around the trees.

It is difficult to prescribe the number of weedings needed in a year owing to differences in type and vigour of weed growth and the control method used. Inspection of each site will indicate need. At least one weeding a year is usually necessary for the first 2–4 years. Although trees may survive a few years without any weeding, when the operation finally becomes essential it is often more expensive than the total cost of light annual weedings which have kept down rank growth.

Cessation of all weeding will depend on crop vigour and spacing but trees rarely need weeding once they are more than 1.2 m tall. Cutting back of woody coppice regrowth may continue to be necessary along with other cleaning operations – see page 37.

Method

The object of weeding is to minimize the damaging effect of other plants on the tree crop. It is not weeds themselves, with the exception of strangulation by climbers or rare cases of allelopathy*, but the effects they have on a tree's environment which cause damage – increased drying out of soil, shading, etc. Thus weed control should be to prevent these harmful effects and not simply how to deal with a noxious plant. Weed control methods, considered in this light, are found to differ markedly in their effects and hence their benefit to the tree crop. This is illustrated in Table 3.5 and Figure 3.7.

* The influence of plants on each other arising from the products of their metabolism, e.g. secretion of a toxin, leachates in water dripping from canopy or passing through litter, etc.

Table 3.5 The effect of screefing and hoeing, compared with normal hook weeding, on growth and survival of ash in seven experiments

Forest and experiment number	No. of replications	No. of years hoed	Age in years when assessed	Height (cm)		Survival %	
				hook weeded	hoed	hook weeded	hoed
Dean 36	3	3	4	43.7	80.3	100	99.1
Dean 40	4	3	3	100.8	183.4	–	–
Rockingham 14	2	4	6	71.6	121.4	100	100
Tintern 10	10–24	3	4	126.4	167.9	97	99
Tintern 11	10–18	1	1	70.6	71.1	99	99
Tintern 15	30	3	3	117.1	127.5	99.5	99.3
Queen Elizabeth 35	2	3	4	13.5 (shoots)	20.6 (shoots)	83.0	87.0

Cutting or rolling vegetation

Traditional hook weeding, mechanical cutting (mower, scythe) and flattening vegetation by rolling do not kill grasses and rarely kill herbaceous plants. They prevent trees being overtopped or heavily shaded but provide no other weeding benefit. Regular cutting, e.g. mown grass, may even stimulate weed growth and hence uptake of moisture to the detriment of trees (Figure 3.7).

Mechanical cutting between rows of trees leaves weeds in the row close to the trees where their influence is most damaging. On smooth ground and gentle slopes it is usually the cheapest weed control method but one of the least beneficial to tree growth.

Mulching

An effective mulch kills weeds and conserves moisture and is a useful weed control method. Permeable inert materials such as pulverized bark are ideal. Mulches are not generally practicable for plantings of more than 100 trees.

Hoeing

Hoeing kills weeds and the soil surface is lightly cultivated. It is a costly but effective and beneficial weed control method (see Table 3.5). It is only practicable for very small areas and where weed growth is already reduced by pre-planting screefing or cultivation. Killing weeds with herbicide will almost always be much cheaper and equally effective.

Cultivation

Cultivation is primarily a pre-planting weed control method preventing weed growth for many months. Post-planting inter-row cultivation is theoretically a desirable control method but is rarely practicable.

Herbicides

Herbicides are usually the cheapest way to kill weeds, though some, for example paraquat, only desiccate shoots and do not kill roots. Use of herbicides in broadleaved plantations needs considerable care since chemicals lethal to broadleaved weeds are equally lethal to trees.

Tree protection must be provided if weeding with a foliar spray of herbicide, except when controlling grasses with atrazine or using propyzamide in the winter. Protection is afforded by using tree shelters, an Arboguard, or carefully 'placing' the herbicide using, for example, a weed-wipe – see Lane (1984). Herbicide application requires care and readers

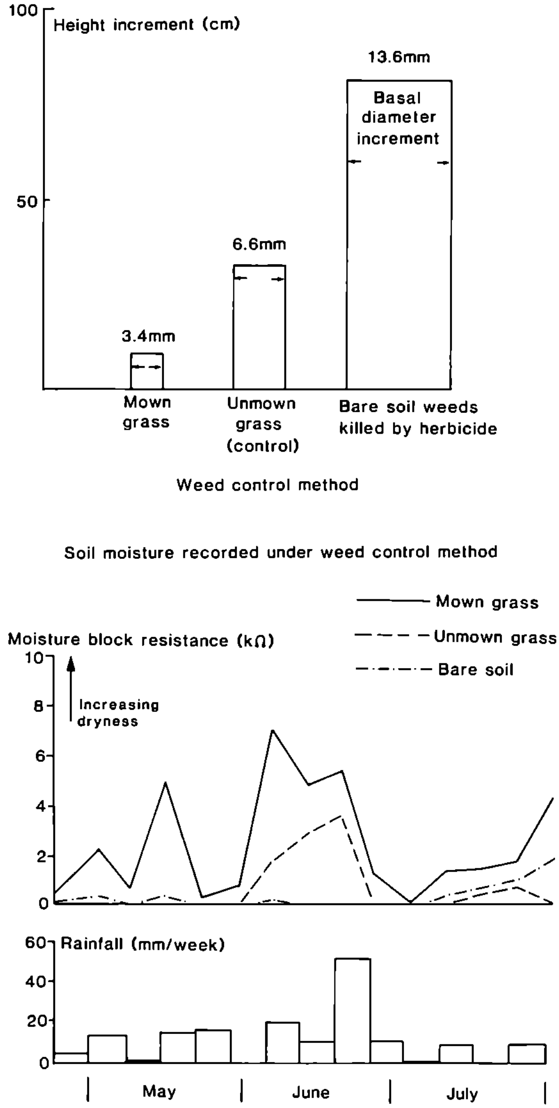


Figure 3.7 (a) First year growth of cherry under three different weed control methods, and the effects of these methods on soil moisture between late spring and mid-summer (modified from Davies, 1984) see also Figure 3.7.b.

should refer to Forestry Commission Booklet 51 *The use of herbicides in the forest* (Sale *et al.*, 1983). Figure 3.8 provides a decision tree for initial selection of herbicides.

Extent of weeding

In general the greater the weeded zone around a tree the better it will grow, see Figure 3.6 and Table

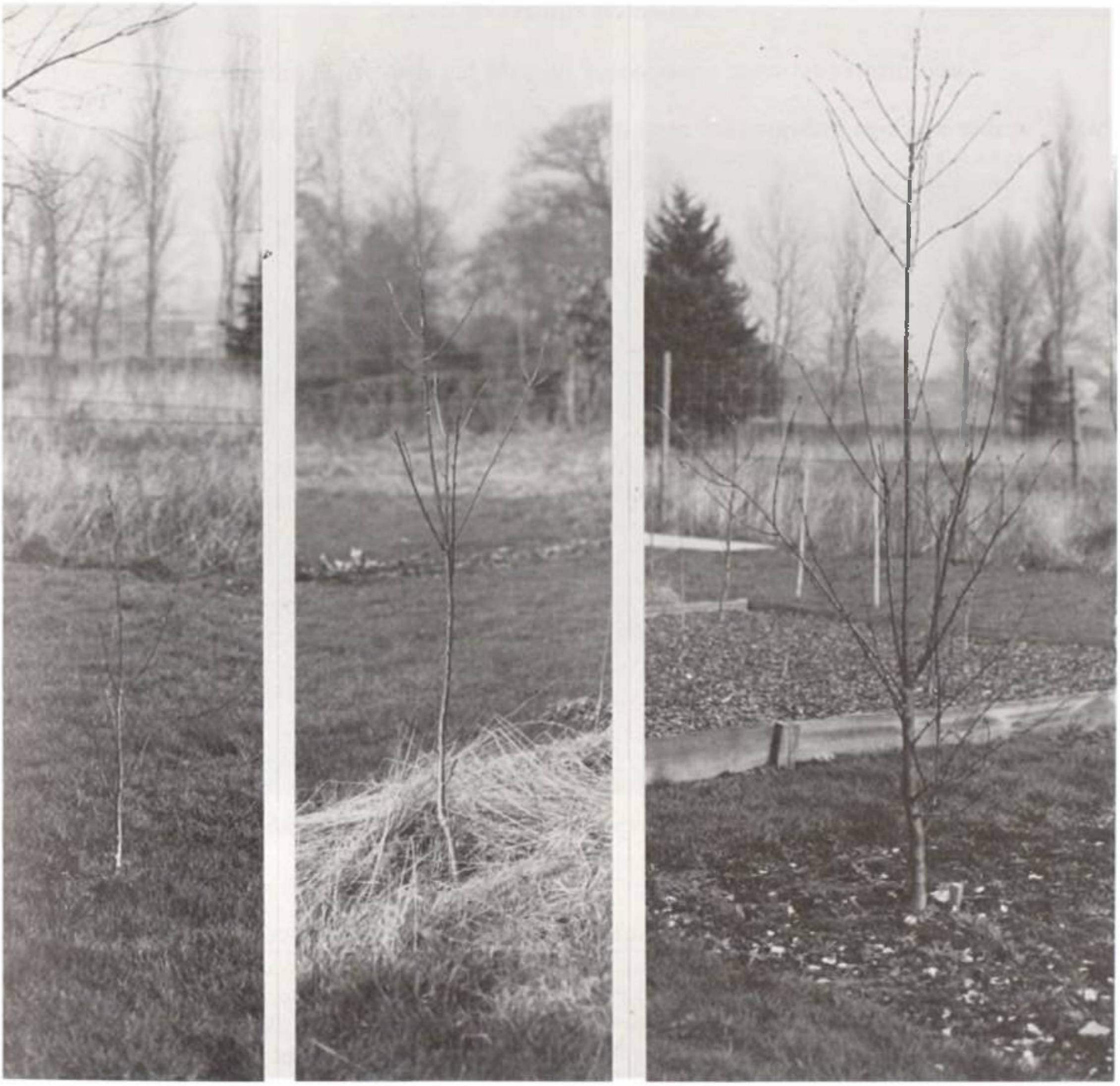


Figure 3.7(b) Average growth of cherry after 2 years on the same site as Figure 3.7a. Left – mown grass sward; centre – unmown grass (no weed control); right – bare soil (full weed control). (*B9161/2/3*)

3.8 (page 41). Using herbicide, strip weeding along a line or spot weeding around a tree are usually adequate. Strip width or spot diameter should be at least one metre or rather more if bracken is the dominant weed.

CLEANING AND SINGLING

Cleaning

Cleaning is a weed control operation carried out in thicket or small pole-stage stands to prevent crop trees becoming swamped or over-topped by vigorous woody growth and to avoid risk of damage by snowbreak or windfall. Because many broadleaved sites are fertile or are old woodland areas, growth of climbers such as *Clematis* and *Lonicera* and regrowth of sallow, hazel and birch can be vigorous, overwhelming the slower growing tree crop (Figure 3.9). Thus cleaning may be essential to secure a stand, especially when it has been difficult to establish, perhaps beaten up over many years, and is growing slowly. Cleaning also improves access into a stand to aid marking for thinning.

Figure 3.8 **Chemical control of weeds**

Decision tree to assist selection of suitable herbicide for control of weeds

Note: Square brackets indicate that crop trees must be protected from direct contact with herbicide.

POST-PLANTING APPLICATIONS

Grasses and broadleaved herbs

- Spring (trees dormant)
  - ATRAZINE*
  - ATRAZINE/DALAPON
  - DICHLOBENIL/DALAPON
- Summer
  - [GLYPHOSATE]
  - [PARAQUAT]
- Autumn (trees dormant)
  - [GLYPHOSATE]
- Winter (December)
  - PROPYZAMIDE**

Bracken (summer)

- Beech, birch, elm, poplar
  - ASULAM
- Other species
  - [ASULAM]

Woody weeds, heather, gorse, broom, brambles

- Summer/early autumn (foliar sprays)
  - [GLYPHOSATE]
  - [TRICLOPYR] (avoid hot days)
- Winter (stem and cut stump treatments)
  - 2,4,5-T
  - 2,4-D
  - GLYPHOSATE
  - TRICLOPYR

*ATRAZINE is not fully effective on peat soils and only controls grasses. *Molinia caerulea, Calamagrostis epigejos* and *Deschampsia caespitosa* are resistant.

**PROPYZAMIDE is not recommended for soils with more than 10 cm of peat and will not control *Dactylis glomerata, Holcus mollis* or *Calamagrostis epigejos.*

PRE-PLANTING TREATMENTS

As above but no crop trees to protect. Recommended treatments which may be needed as part of site preparation are summer ASULAM for bracken, spring HEXAZINONE, autumn GLYPHOSATE or winter PROPYZAMIDE for grasses and herbs, and GLYPHOSATE, TRICLOPYR, FOSAMINE or AMS, as stem or cut stump treatment for woody weeds.

Figure 3.9 *Clematis* overwhelming part of a beech plantation on the lower slope. (*A10566*)

Cleaning is very expensive but the need for it can be lessened by attention to the following at establishment:

1. kill stumps likely to produce regrowth;
2. use healthy, well-balanced plants to obtain good stocking and minimize beating up;
3. use establishment techniques which accelerate early growth of the planted trees.

The need for cleaning may indicate unsatisfactory establishment, but even with the most careful establishment it is usually inevitable on difficult sites such as chalk downland and heavy Midland clays. Some species are less tolerant of competition than others. Oak will survive in thorn scrub where beech will often disappear.

If cleaning can be delayed until near to the time of canopy closure it should only need doing once and will often eliminate the need to do a first, usually costly, thinning, especially in stands not fully stocked. Cleaning costs can also be reduced by not aiming for a wholly pure crop but accepting any potentially saleable species, alder, ash, birch, sycamore, etc., which often constitute the regrowth of woody 'weeds', and concentrating on removing rank growth of climbers, thorns, sallow, etc.

In mixtures, pines and fast growing broadleaves often do not need cleaning but Douglas fir and Norway spruce on many lowland sites usually do.

Singling

Singling is a silvicultural operation to ensure trees have a single straight stem; it is sometimes called formative pruning. The form of most broadleaves is often poor and elimination of forks and multileaders is important. Beech, oak, and walnuts especially benefit from the operation. Singling is usually done as part of cleaning operations and, indeed, aids removal of climbers.

Table 3.6 Effect of tree shelters on growth of Sessile oak at Alice Holt Forest

Treatment	Height of trees (cm)					Diameter of stem (mm) at 5 cm				
	At planting	After 2 years	After 3 years	After 4 years	After 5 years	After planting	At 2 years	After 3 years	After 4 years	After 5 years
Unprotected	22	37	49	65	99	4.1	5.5	9.6	11.4	17.5
Tree Guard*	22	53	71	90	117	4.1	6.4	10.6	14.2	20.5
Tree shelter	22	121	163	170	177	4.1	8.2	12.9	17.9	25.0

* Plastic mesh, formerly called 'Netguard'.
From Tuley and Risby (1984).

Table 3.7 Effect of tree shelters on growth of seven broadleaved species (pooled data from three experiments in southern England)

Species	Increment over three growing seasons (cm)	
	Tree Guards	Tree shelters (PVC)
Sessile oak	34	123
Beech	23	65
Sycamore	35	52
Birch	92	169
Common alder	111	169
Field maple	26	62
Hawthorn	46	133

TREE SHELTERS

The tree shelter is a new technique which offers much promise in aiding the rapid establishment of broadleaved trees. A tree shelter is a transparent or translucent tube, usually 1.2 m tall, made of plastic (Figure 3.10). Many kinds of plastic have been tried and all give the same beneficial effects of fully protecting a tree from browsing and of enhancing growth. Also, the complete protection afforded by the tree shelter allows herbicide weeding around broadleaved species without fear of damage.

Tree shelters were first tried in 1979. Results from some of the oldest experiments are shown in Tables 3.6 and 3.7.

Tables 3.6 and 3.7 show that tree shelters significantly improve early growth of many species, particularly of oak. Indeed, no broadleaved species has so far failed to grow significantly faster in tree shelters on most sites, though some species have been very variable in their response, e.g. Southern beech, and others slow, e.g. beech.

Some benefit from tree shelters occurs regardless of the degree of weed control but there is now clear evidence that good weed control (using herbicide) further enhances the improvement due to the shelter. This is illustrated in Table 3.8, which also shows the considerable benefit of good weeding alone.

Figure 3.10 Tree shelter, 1.2 m tall, made of corrugated polypropylene. Note oak tree shoots emerging out of the top. Photograph taken 2 years after planting. (*A10567*)

The improvement shown in Tables 3.6 to 3.8 is for planted trees, but when a tree shelter is placed over naturally regenerated seedlings improvement in growth is as good or better. This evidence suggests that tree shelters could have a very wide use in direct

Table 3.8 Effect of tree shelters and degree of weed control on survival and growth of oak and sycamore on a grassy motorway embankment 2 years after planting

		Diameter of weed control (cm)			
		0	25	50	100
Survival (%)					
Oak	– without shelter	97	100	98	95
	– with shelter	91	92	97	95
Sycamore	– without shelter	81	66	92	97
	– with shelter	89	98	100	95
Height (cm)					
Oak	– without shelter	60.5	63.8	65.9	63.7
	– with shelter	89.4	102.7	107.0	115.9
Sycamore	– without shelter	87.4	94.5	97.5	110.0
	– with shelter	116.6	133.4	151.0	161.1
Diameter of stem 10 cm above ground (mm)					
Oak	– without shelter	7.2	8.3	8.6	9.6
	– with shelter	6.4	8.0	8.2	8.8
Sycamore	– without shelter	9.9	11.1	12.8	16.0
	– with shelter	8.6	9.9	10.9	12.3

Modified from Tuley (1984).

establishment of new plantations of broadleaves, in enrichment of woodland where there are gaps (Figure 9.3) and in making better use of natural regeneration by protecting and encouraging it to grow.

It must be stressed, however, that the long-term effects of using shelters on tree growth are not known. More information can be obtained from Tuley (1982, 1983). For current recommendations on the use of tree shelters contact the Silviculture Branch of the Forestry Commission's Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey, GU10 4LH.

Figure 3.11
Five-year-old Sessile oak which were grown in tree shelters for their first 3 years after planting. Mean growth data are shown in the bottom line of Table 3.6.
(The tall shelter (right background) is an experimental trial of the tree shelter technique to 4m). (*B9187*)

APPENDIX

SOIL TYPES AND THEIR EQUIVALENT FOREST SUITABILITY GROUPS[2]

Soil group	Soil type	Code[1] (as used in Table 3.1)	Suitability group[2]
The main mineral and shallow peaty soils (peat <45 cm)			
Soils with well aerated subsoil			
Brown earths	Typical brown earth	1	H,J,K
	Basic brown earth	1b	I,J,K
	Andic brown earth	1d	H
	Upland brown earth	1u	H,Q
	Podzolic brown earth	1z	H
	Alluvial brown earth	1v	L
Podzols	Typical podzol	3	R,S
	Hardpan podzol	3m	S
Ironpan soils	Typical ironpan soil	4	U
	Intergrade ironpan soil	4b	U
	Podzolic ironpan soil	4z	U
Limestone soils	Rendzina (shallow soil)	12	C,D
	Brown calcareous earth	12b	G
	Argillic brown earth	12t	M,N
Soils with poorly aerated subsoil			
Ground-water gley soils	Typical ground-water gley	5	BB,CC
	Brown ground-water gley	5b	BB,CC,DD
	Podzolic ground-water gley	5z	DD
	Ground-water gley with humose top soil	5h	DD,EE
	Alluvial ground-water gley	5v	Z
	Calcareous ground-water gley	5k	AA
Peaty gley soils	Typical peaty gley	6	Y
	Peaty podzolic gley	6z	Y
Surface-water gley soils	Typical surface-water gley	7	V,W,X
	Brown gley	7b	P,V,W,X
	Podzolic gley	7z	T
	Calcareous gley	7k	F
Peatland soils			
Flushed peatlands			
Juncus bogs (Basin bogs)	Fen bog	8a	JJ
	Juncus articulatus or *acutiflorus* bog	8b	JJ
	Juncus effusus bog	8c	JJ
	Carex bog	8d	JJ
Molinia bogs (Flushed blanket bogs)		9	HH

SOIL TYPES AND THEIR EQUIVALENT FOREST SUITABILITY GROUPS[2]

Soil group	Soil type	Code[1] (as used in Table 3.1)	Suitability group[2]
Peatland soils – continued			
Unflushed peatlands			
Sphagnum bogs (Flat or raised bogs)	Lowland *Sphagnum* bogs	10a	HH,II
	Upland *Sphagnum* bog	10b	HH
Calluna, Eriophorum, Trichophorum bogs (Unflushed blanket bogs)		11	HH
Eroded bogs		14	HH
Other soils			
Man-made soils	Mining spoil, shaly or fine textured	2m	FF
	Mining spoil, stony or coarse textured	2s	GG
Rankers (shallow soils to bedrock) and skeletal (excessively stony)	Brown ranker	13b	A,B
	Gley ranker	13g	
	Peaty ranker	13p	A
	Rock	13r	A,B
	Podzolic ranker	13z	
	Ranker complex	13c	
	Scree	13s	
	Humic skeletal soil	13h	
Littoral soils (coastal sand and gravel)		15	E

Notes:
1. Modified from Pyatt (1982).
2. Forest suitability groups are broad groupings of soils according to their forestry potential identified by the Soil Survey of England and Wales. The groups are defined and related to soil associations and the Forestry Commission soil types in the regional soil surveys of south-west, south-east, and northern England, and Wales (Findlay *et al.*, 1984; Jarvis, M. G., *et al.*, 1984; Jarvis, R. A., *et al.*, 1984; and Rudeforth *et al.*, 1984) from which this table is summarized.

CHAPTER 4

Protection and nutrition

PROTECTION

Young stands are most at risk from damage and adequate protection is an integral part of their establishment. Silvicultural measures which promote rapid initial growth and tree health minimize protection problems. Conversely, prolonged and difficult establishment may indicate inadequate protection measures, such as poor species choice for a frost hollow or absence of fences exposing trees to unforeseen browsing.

In stands beyond the thicket stage both the opportunities for protection and the risks of damage are fewer. Protection is principally control of squirrels, exclusion of livestock, and care in thinning to remove dead and diseased trees and not to over-expose the remaining ones.

Climatic damage

Drought

Drought can lead to deaths of newly planted trees, particularly in late spring and early summer. As noted in discussion of plant handling (pages 31–32) this is minimized by carefully planting, in autumn or *early* spring, recently lifted, well-balanced plants not in leaf.

Prolonged drought will slow growth of trees of all ages and can be a contributory factor to the death of large specimens already subject to other stress, e.g. root decay, as happened to many beech trees following the 1975/76 drought.

Cold

Damage from cold can arise in three ways:

1. extremely low temperatures in winter;
2. unseasonal frosts;
3. the effect of persistent cold drying winds leading to desiccation or further lowering of temperatures owing to the wind chill factor.

Extreme cold in winter (below –15°C) occurs in most parts of Great Britain about once every decade. This seriously restricts forest-scale use of many potentially valuable exotics and is the main reason why careful provenance evaluation is necessary before fast-growing Southern beech or eucalypt species can be recommended. This is illustrated in Figure 4.1 which shows that many, but by no means all, provenances of *Nothofagus procera* suffered badly in the cold winter of 1981/2. There is also a suggestion that more southerly provenances (in South America) are rather hardier.

Damage from extreme winter cold can occur both to seedlings and to older trees causing death of foliage/buds or cambium. External signs of death are not always reliable and many of the more tender species have remarkable powers of recovery. Cambium damage may not be obvious until the second growing season after it occurs when cankers or dead bark are evident (Figure 4.2). Unless obvious, assessment of death in a stand of tender species should be delayed until late in the summer following the winter when the cold occurred.

Unseasonal frosts, whether in late spring or early autumn, can kill shoots and foliage and cause frost lift on heavy soils. Frosts are particularly damaging in late spring often resulting in forking or in mis-shapen stems as new shoots emerge to replace

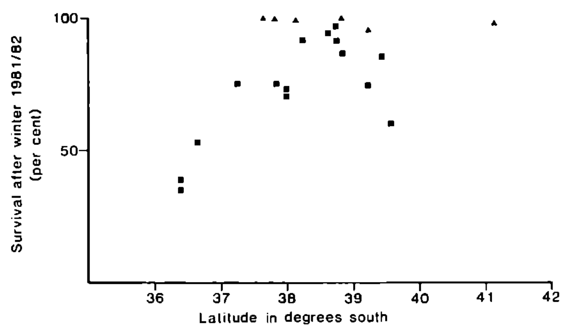


Figure 4.1 Variation in cold hardiness (survival through winter of 1981/82) among species and provenances of Southern beech shown in relation to latitude of seed origin. Mean survival data from nine experiments in southern England. ▲ *Nothofagus obliqua*, ■ *N. procera*.

Figure 4.2 Serious bark lesion on Southern beech (*Nothofagus procera*) which developed after the winter of 1962/63. (*B5385*)

the ones killed back. Frost lift frequently causes death of newly planted seedlings.

To avoid frost problems care should be taken not to plant tender species (Table 4.1) in frost hollows or pockets and to encourage air movement away from such locations. A badly drained site exacerbates the problem. Also the ground surface can affect severity of damage. Coldest temperatures are usually recorded over grass, because it insulates the soil surface and prevents radiation, and the least cold over bare soil. However, on very grassy sites limiting weeding to spot control around trees may increase risk of damage with the small cleared patches becoming frost traps.

A light overstorey will lessen frost damage and, indeed, allow many species to be grown in high frost risk areas such as East Anglia. However, this silviculture, though visually attractive, may create management problems when the time comes to remove the overstorey and usually it is simpler to use more frost hardy species in the open.

Table 4.1 Susceptibility to frost of broadleaved species in Britain

Very susceptible	Walnuts Ash Sweet chestnut Oak Beech
Moderately susceptible	Sycamore Horse chestnut Some poplars Red and Italian alders
Hardy	Birch Hazel Hornbeam Lime Elm Most poplars Common and grey alders

Though at risk from extreme winter cold, Southern beeches and eucalypts are no more than moderately susceptible to frost damage.
Adapted from Peace (1962).

Persistent cold wind can damage foliage of evergreen species such as Holm oak and eucalypts, and the buds and cambium of any exposed trees. Reduction of this kind of damage is one of the nursing benefits provided by growing broadleaves in mixture with conifer or by retaining some scrub when planting exposed sites.

Wind

The problem of wind damage, especially windthrow, in broadleaved stands is rarely serious. There are three main reasons.

1. The sites generally planted are not very exposed and the soils are usually deeply rootable.
2. The deciduous habit in autumn and winter reduces the sail area during the time of year when storms are most frequent.
3. On exposed sites broadleaves generally do not grow very tall and maintain a smaller shoot:root ratio. As a result some species make useful windbreaks; beech is often seen in this role in Scotland and S.W. England.

On exposed sites persistent wind leads to crown deformation and poor growth. Much damage can occur in autumnal storms with branch break and uprooting of old over-mature trees, particularly if roots are diseased, but usually little damage occurs to younger stands. As mentioned, in mixtures, especially on heavy soils, the conifer component may be less stable and differential windthrow can occur particularly after the first thinning.

Figure 4.3 Snow damage to young poplars. (*C258*)

Long neglected broadleaved stands may suffer wind damage when thinning is eventually undertaken because many trees will be tall and whippy.

Snow

Snow is unlikely to devastate broadleaved stands though frequently rideside trees and understorey species such as sallow suffer damage, particularly breakage of side branches. Unseasonal snow, in late April/May or early autumn when foliage is present, can be severely damaging to crowns and side branches of older trees and sometimes to nursery stock (Figure 4.3).

Fire

Because of the kinds of sites planted, the more varied woodland structure, and lower flammability of the species, fire is a less serious problem in broadleaved woodland than in conifer plantations. Moreover, after fire many broadleaves show considerable powers of recovery with new shoots replenishing scorched crowns and vigorous new growth from stem epicormics and basal coppice.

Specific fire precautions for broadleaved stands are only needed where the crop is established on grassland or is in mixture with conifers — see Foresty Commission Bulletin 14 *Forestry practice.*

Mammal damage

Damage from browsing, bark stripping, trampling, etc., can often be the most important protection problem to overcome when growing broadleaves. Table 4.2 summarizes the main forms of mammal damage that can be expected in broadleaved stands.

In considering protection against mammals a decision has to be taken whether to protect a whole stand or just individual trees. This is important in broadleaved stands because planting areas are often small, making the costs of fencing relatively high per unit area or per tree planted. Figure 4.5 shows the relationship in terms of cost per hectare between fencing and examples of individual protection.

Figure 4.4 Bark completely stripped by cattle. Such damage can affect all broadleaved species and be caused by horses, cattle, sheep and occasionally pigs. (*A10568*)

Individual tree protection allows grazing and browsing of herbage amongst the trees and is preferable where there are strong sporting interests. It should generally be considered when planting areas of less than about 2 ha at conventional spacings (up to 3 m) or for larger areas if wider spacings are used. The use of the new technique of tree shelters is discussed on page 40.

Pests and diseases

Brief details of specific pests and diseases affecting broadleaved trees are noted in the appropriate species' chapters (17–22). However, some organisms can do economic damage on a range of species though in no case are specific control measures recommended.

Pests

The Winter moth *Operophtera brumata* and the Mottled umber moth *Erannis defoliara* will defoliate many broadleaved species, though they are most often observed on oak and hazel. Also, several species of common leaf weevil (*Phyllobius* spp.) are a frequent cause of partial skeletonizing of leaves.

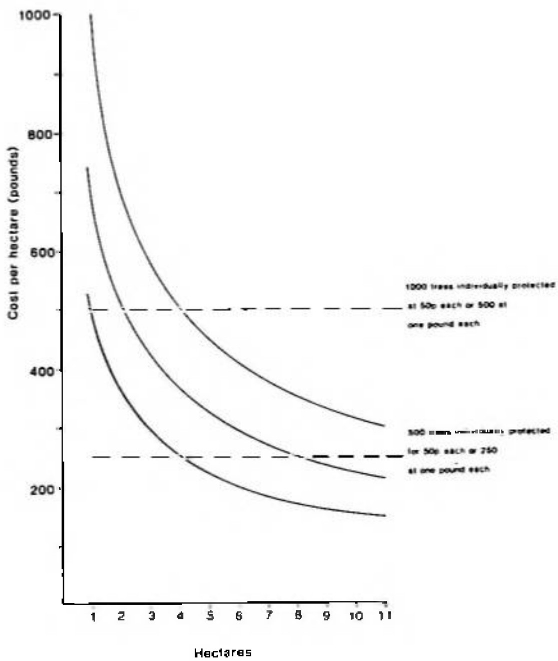


Figure 4.5 Cost of fencing compared with individual tree protection (modified from Burdekin, 1982).

Table 4.2 Main kinds of mammal damage affecting broadleaved tree species

Mammal	Damage: Form	Damage: Extent of problem	Affected trees: Species	Affected trees: Size/age	Time of year for damage	Site conditions conducive to damage	Protection measures	References
Deer roe, fallow sika, red, muntjac	Browsing	Throughout Britain. No red, sika or muntjac in Wales. Browsing can be locally very serious.	All	Up to 1.2 m (roe). Up to 1.8 m (fallow).	Mid-November to early spring.	All woodland of mixed age classes and species provides cover; forest with open spaces and wide rides is favoured habitat.	Protect trees with either deer fencing or individually with plastic mesh guard or shelters. Heaping brash around base is especially useful for protecting coppice, except from muntjac. Deer populations controlled by annual culling.	Leaflets 73, 74 Records 80, 99, and 124 Arboricultural Leaflet 10
	Fraying		Especially sallow.	Young saplings.	March to May and July.			
Fallow, sika, red	Stripping	Fraying damage is selective.	Whips and standards.		August – September.			
Grey squirrel	Bark stripping on the stem, root spurs and branches (Figure 5.3).	England, most of Wales and lowland Scotland. In some years can damage most trees in a stand at one time.	All affected. Sycamore, maple and beech most susceptible. Cherry, limes and Southern beech rarely damaged.	Most serious, in pole-stage stands (10–40 years) up to about 16 m top height when damage is confined to main stem. In older trees damage is less serious, mainly on crown branches and root spurs.	May – July.	Pole-stage woods in close proximity to mature mixed woodland. Risk of damage greatest when populations are high following a combination of good seed years and mild winters. Broadleaved component of mixtures susceptible. Pheasant feeding supplements winter food for squirrels.	Trees cannot be protected though free growing ones in the open are less prone to damage. Squirrels controlled mainly by cage trapping or poisoning with warfarin treated bait. Control should be done every year from April to July.	Leaflet 56 Rowe, 1983
Hares	Clipping shoots, especially tops.	Widespread, only occasionally or locally serious.	All	Seedlings and newly planted trees of less than 10 mm stem diameter.	Mostly winter and spring.	Woodlands bordering farmland, especially new plantings in farm woods.	Rabbit fences ineffective. Hare drives. Plastic mesh guards ineffective, tree shelters or wire netting may afford protection.	
Rabbits	Browsing	Can occur anywhere in Britain.	All	Up to 0.5 m tall.	Winter/spring, occasionally summer.	Presence of much ground cover, heaps of brash, stumps or areas of waste land all can harbour colonies.	Occupier of land legally required to control rabbits if present. Trees protected by rabbit fencing or individually with tree-guards or shelters.	Leaflet 67 Records 80 and 125

	Bark stripping at base of tree.	Locally can be very serious.	All, but especially beech, sycamore and maple.	Up to about 40 years old on stems; restricted to root spurs on older trees.	Winter/early spring.		Rabbit population most effectively controlled by gassing between October and February.	
Voles short-tailed or field	Bark stripping young trees at base.	Through-out Britain. Locally can result in patchy stands and need for beating up.	All, but beech especially prone. Voles often attack unusual ornamental species.	Seedlings to saplings up to 50 mm diameter but dependent on bark thickness.	Spring and summer.	Thick grass and rushes.	Control of animals not usually practicable, best to keep down cover, especially grass. Can use warfarin in short drainpipes, but expensive.	
bank	Bark stripping up stem.	Uncommon						
Wood mice	Destruc-tion of seed.	Usually unimport-ant except in nurseries.	All large-seeded species, but especially beech mast and acorns.		Autumn and early spring.		In nurseries cover newly sown beds with fine mesh netting.	Record 118
Livestock horses cattle sheep pigs	Browsing (not pigs).	Can occur anywhere in Britain but damage usually highly localized. When damage occurs it is usually serious.	All	Up to 2 m.	Mainly in summer.	Wherever livestock are allowed into woodland. Mostly woods on or adjacent to farms and commons. Bark stripping occurs where there is dense stocking of livestock with little forage in wood. Compaction serious on wet, heavy soils. Worst affected areas around access points	Either exclude livestock by fencing young woodland and where natural regeneration is in progess, or individually protect trees. Carefully control access (stocking of animals and period allowed) to old woodland. Fence individual trees continually exposed to livestock. Exclude livestock when ground conditions are wet.	Arboricult-ural Leaflet 10
	Bark stripping on lower stem and root spurs (Figure 4.4).			Any size or age including large old trees.	Any time but especially winter.			
	Soil compac-tion.				Anytime			

Note: Records and Leaflets listed in the references refer to Forestry Commission publications.

Ambrosia beetles are mostly non-selective in their attack of felled or dying trees. Many Cerambycid species will bore in sapwood of freshly felled logs.

Diseases

There are a number of pathogenic fungi which can cause occasional damage to broadleaved trees. Of them, the most important is Honey fungus (*Armillaria* spp.) – see Arboricultural Leaflet 2 *Honey fungus* (Greig and Strouts, 1983). It is however rarely the cause of death of established broadleaved trees, although it may play a part in killing trees which have been heavily stressed, e.g. by severe drought or repeated insect defoliation. The most susceptible species are maples, birch, walnut. cherry and willow (*op. cit.*).

Diagnosis

The correct identification of the cause of damage often requires considerable skill. A watchful eye should be kept open for signs of ill-health in a stand, and suitably qualified experts consulted when problems arise. The Forestry Commission offer a free advisory service in pathology and entomology and enquiries should be directed to: Forest Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey, GU10 4LH, or to Forestry Commission, Northern Research Station, Roslin, Midlothian, EH25 9SY.

NUTRITION

Trees, like other plants, require an adequate supply of several macro-nutrients and micro-nutrients for satisfactory growth. In Britain most commercially managed broadleaved stands are on relatively fertile soils and will not normally require addition of nutrients (fertilisers). Put simply, nutrients are unlikely to be a limiting factor to growth. However, on some kinds of sites nutrient deficiencies may occur:

1. lowland heaths – phosphorus;
2. restored, man-made substrates – nitrogen;
3. chalk downland – nitrogen and potassium;
4. woodland where coppice working has long been practised – phosphorus.

There is some evidence of variation amongst broadleaved species both in their site fertility requirements and response to fertilisers when added. For example, oak is relatively insensitive to soil fertility though not to other site factors such as exposure, whereas ash, sycamore, and eucalypts perform increasingly well with increasingly nitrogen rich sites.

In soils of high pH with free calcium carbonate fragments (chalk or limestone) in the surface layers, iron and manganese become insoluble and uptake by the roots is reduced or prevented. This causes yellowing of the main part of the leaf, while the veins remain green – a condition known as lime-induced chlorosis. Tree species vary in sensitivity: Norway maple, sycamore, Field maple, ash and lime are fairly tolerant; Southern beeches, beech and oak are more sensitive (Patch *et al.*, 1984).

Before applying fertiliser to an established crop foliar analysis should be carried out to determine whether any nutrient appears to be in short supply.

Foliar analysis

Foliar analysis is a diagnostic technique in which samples of leaves are analysed chemically to determine their nutrient content. Both the absolute concentration of nutrient and the ratio of one nutrient to another are compared with average values for a species. Substantial departure from the values usually associated with healthy trees may indicate a deficiency (or, rather rarely, a toxicity). Foliar analysis of broadleaves is still in its infancy but it is possible to indicate average concentrations of the most important nutrients for the main broadleaved species (Table 4.3).

The values in Table 4.3 do not take account of age (or size) of trees. There is evidence that young trees generally have higher concentrations of major nutrients than old ones. Concentrations can also vary considerably between individual trees on one site. Taking these two uncertainties into consideration it becomes essential to look at the balance between the major nutrients as well. Work on conifers has established general ratios between the three most important nutrients, and the analyses referred to above have largely confirmed this. Table 4.4 shows idealized concentrations of major nutrients and the ratios between them. Large departures from these ratios, e.g. a doubling or halving, may be taken as indicating imbalance and therefore a probable deficiency of the nutrient with the reduced ratio.

Deficiency or imbalance shown by foliar analysis can be corrected with an appropriate fertiliser. If, however, analysis reveals a serious deficiency of two or more nutrients, the cause may lie in the failure of the root system following waterlogging or fungal attack, rather than a lack of nutrients in the soil. Weed competition can also affect nutrient uptake, particularly of nitrogen, by young trees. In all such instances fertilisers could make things worse rather than better.

Table 4.3 Indicator levels of foliar nutrients for broadleaved tree species

Species	Concentration in leaves as % oven-dry weight: Probably adequate at	Possibly deficient if less than
	NITROGEN(N)	
Alder, birch, False acacia, lime, walnut, willow	2.8	2.5
Ash, beech, Norway maple, oak, Sweet chestnut, sycamore, cherry	2.3	2.0
Hawthorn, rowan, whitebeam	2.0	1.7
	PHOSPHORUS(P)	
Ash, birch, lime, Norway maple, walnut, willow	0.22	0.19
Alder, False acacia, hawthorn, whitebeam	0.18	0.16
Beech, oak, Sweet chestnut, rowan	0.16	0.14
	POTASSIUM(K)	
False acacia, walnut, willow	1.2	1.0
Other species (as above)	0.9	0.7

Modified from Binns, Insley and Gardiner (1983).

Table 4.4 Examples of nutrient balance

	Concentration in leaves as % oven-dry weight		
	N	P	K
'Demanding' species	2.4	0.24	1.2
'Undemanding' species	1.8	0.18	0.9
Ratios	10 :	1 :	5

It is stressed that many factors can cause variation in foliar nutrient levels and significant departures from the averages in Table 4.3 should only be taken as indicative of a nutrient problem. Similarly, no guarantee can be given that fertiliser application to 'correct' an apparently deficient nutrient will increase growth rate.

To carry out foliar analysis of broadleaved trees the following procedure should be used:

1. Collect leaves in July or August only.
2. Take samples from 3–6 trees in a stand.
3. Take samples from anywhere in a crown except heavily shaded leaves deep inside. Only collect well formed leaves.
4. Collect from each tree enough leaves to cover the surface of an A4 sheet of paper (297 × 210 mm). This will form one sample.
5. Place leaves in a clean polythene bag and label.
6. Send the leaves immediately to an analytical laboratory. If delay in despatch is likely the packed sample should be stored in a cool place.
7. With each sample provide details about the tree(s) – species, age, visual appearance, etc., and the site – exact location, soil, degree of exposure, etc.

Soil analysis

Analysis of soils to assess the fertiliser needs of trees has so far proved disappointing and cannot be recommended. It is, however, always worth checking the soil pH before a site is planted, since alkaline or very acid soils will rule out some tree species (Figure 3.1, on page 24).

Fertilisers and weed control

Fertiliser nitrogen is quick acting and poorly held by most soils, so nitrogen added to the backfill is unlikely to benefit newly planted trees. If fertilisers are used at planting they should, therefore, be low in nitrogen and high in phosphorus and potassium – or even contain no nitrogen at all. Weeds exploit a site more rapidly than trees do, and also respond more vigorously to nitrogen, and in general fertilisers should not be used without effective weed control.

CHAPTER 5

Thinning, felling and regeneration

THINNING

Thinning is an important silvicultural tool to bring the final crop to its best condition by the end of the rotation. For a general account readers are referred to Hart (1967), Hiley (1967), Johnston, Grayson and Bradley (1966) and Forestry Commission Bulletin 14 *Forestry practice*. In plantations and well managed woodland there are few problems, but difficulties may occur when thinning in mixtures and overstocked stands after a long period of neglect.

Definition and object

Thinning is the removal of trees from a stand during the course of a rotation. Five silvicultural objects are served:

1. to improve stand quality by removing poorly formed and defective trees;
2. to ensure that future increment is concentrated on the best formed trees;
3. to provide more growing space for final crop trees and so enhance their diameter increment;
4. to ensure satisfactory development of mixed stands and timely removal of nurse or secondary species;
5. to remove trees which are diseased or damaged in other ways.

Thinning also serves an important economic role by generating revenue during the life of a stand but, particularly for early thinnings of small trees, the operation itself may not always be profitable.

Effects on growth

The effects of thinning on growth of broadleaved stands do not differ materially from that of conifers. Light thinning maximizes production per hectare but growth of individual trees is slower. Heavy thinning enhances individual tree growth at the expense of some loss of total production from the site. Figure 5.1 illustrates two examples.

In practice, applying these general relationships (above and Figure 5.1) by varying thinning intensity to manipulate tree and stand growth requires care with broadleaved crops.

1. Species differ in their capacity to respond to thinning, light demanders such as ash and sycamore generally require more open stand conditions than oak or beech.

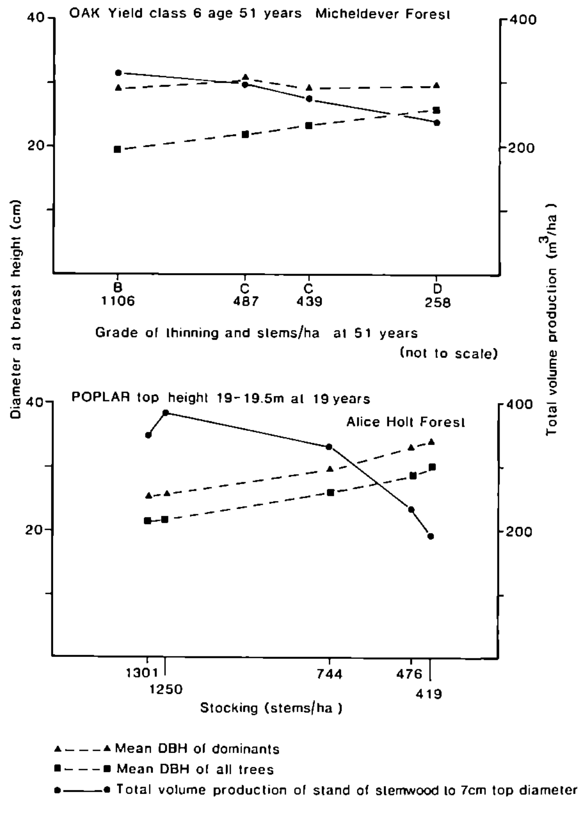


Figure 5.1 The effect of thinning intensity (oak) and initial spacing (poplar) on tree and stand growth.

2. In most stands there are usually few trees of good form, which restricts the choice of ones to favour in thinning.
3. Many broadleaved species do not have strong apical dominance and heavy thinning may depress height increment and encourage the development of spreading, heavily branched crowns.
4. Especially in oak and poplar, heavier thinnings stimulate epicormic branching.

How to thin

Thinning in broadleaved stands to realize their potential is silviculturally very important because of (1) generally poor stem form, (2) the end-use intentions for a stand, and (3) the kinds of sites planted. The option of not thinning at all, as for example applied to some upland coniferous stands to lessen windthrow risk, is rarely appropriate. The question of thinning is not whether it should or should not be done but how best to do it. This resolves into three questions:

1. What sort of trees to remove or favour? – Thinning method.
2. How much to remove over time? – Thinning intensity.
3. When to start thinning and how to time removals with markets? – Thinning cycle and timing.

In general, in thinning broadleaves the emphasis is on selection for quality rather than any important yield constraint. Thinning should aim to produce well balanced, even crowns on final crop trees. Any poor quality trees, particularly if vigorous (wolf trees), must be removed at an early stage. The danger in leaving them is that they leave large gaps when finally removed and create unbalanced crowns later in the rotation on final crop trees.

Additional notes on the thinning requirements of certain species are included in the species' chapters.

Thinning method

Except in strip mixtures and for first thinnings of very dense plantations, mechanical and systematic thinning methods, e.g. removal of one in four rows, generally have no place in thinning broadleaves. The need to favour the well formed trees present takes precedence over the need to open up a stand in a systematic way. However, systematic establishment of racks is needed to minimize extraction damage throughout the rotation.

Selecting which trees to favour is the most important part in thinning broadleaves. Great care must be taken and often the first step is to mark all trees of final crop potential (Figure 5.2); this is best done at the time of the first commercial thinning. Thinning operations then favour these selected trees.

Selection of potential final crop trees is best done in winter when the condition of the upper stem and crown is more easily seen. For most species the following criteria, in order of priority, should be used.

1. Good stem form and freedom from defect on the lower bole (bottom 7 m).
2. Absence of deep forking in crown which increases risk of storm damage and eventual loss of tree.
3. Good vigour.
4. Freedom from defect in upper stem and crown, e.g. squirrel damage, evidence of disease.
5. Low incidence of epicormic branching.
6. Proximity of other selected trees; seeking an even spacing of selected trees should only come after the other criteria above are satisfied.

In conventionally managed plantations it is prudent to select two to four times as many potential final crop trees as are needed to achieve final crop stocking to allow for losses – see Table 5.1. Restricting selection to just the final crop number, e.g. 120/ha for beech, runs the risk of losing some during the course of the rotation and having to make good the stand with greatly inferior trees. In France it is recommended that the least distance between selected trees should be between 50 and 75 per cent of the mean espacement of the mature stand (Oswald, 1981).

Table 5.1 Final crop selection and stocking of major broadleaved tree species

Species	Approximate number of potential final crop trees to select and favour in early thinnings (stems/ha)	Normal final crop stocking (stems/ha)	Normal rotation age (years)
Ash	350	120–150	60–80
Beech	250	100–120	100–130
Oak	200	60–90	120–160
Sycamore	350	140–170	60–80

Later thinnings continue to be selective but increasingly some of the originally favoured trees will be removed. The principle of leaving the best, using criteria 1 to 6 listed above, is generally followed.

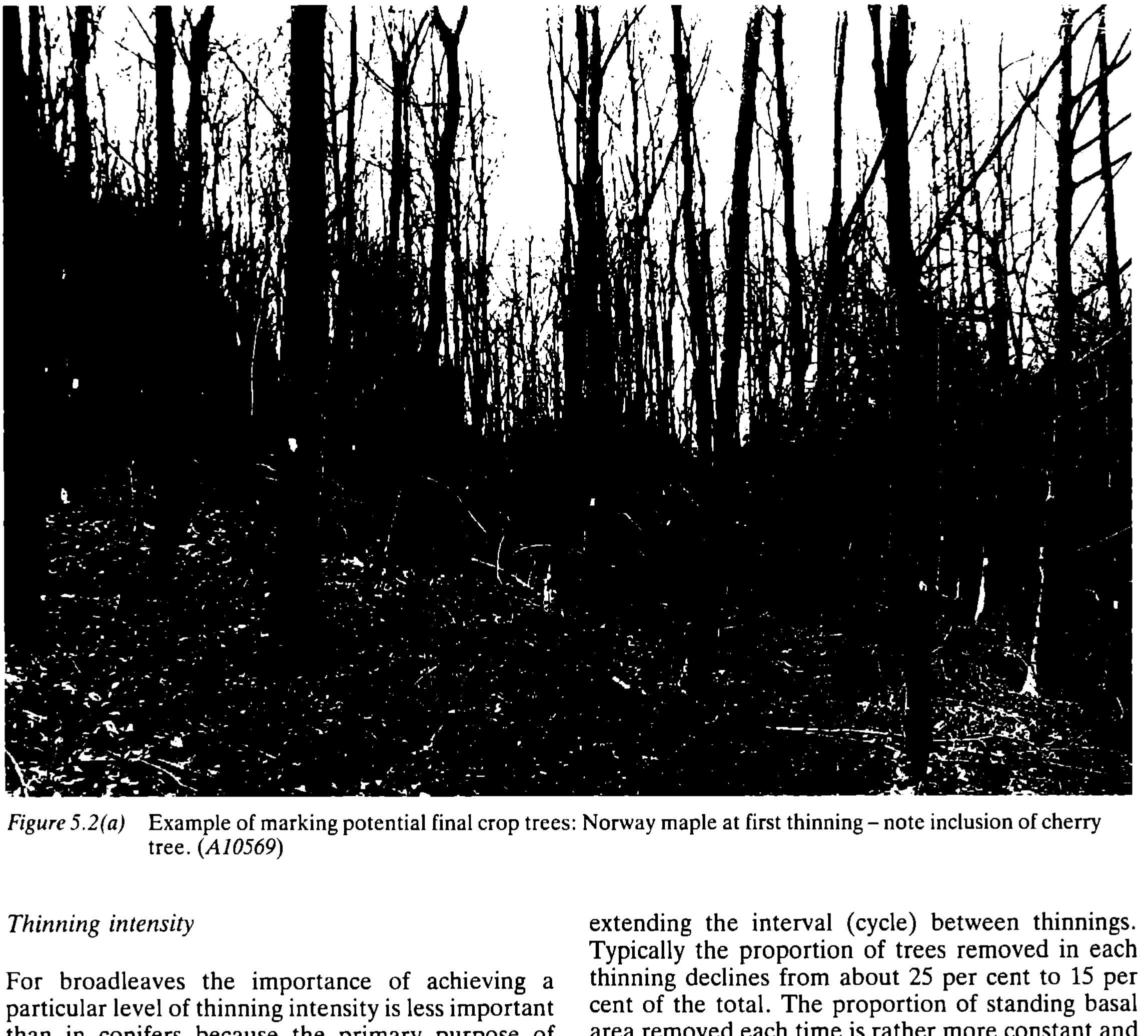


Figure 5.2(a) Example of marking potential final crop trees: Norway maple at first thinning – note inclusion of cherry tree. (*A10569*)

Thinning intensity

For broadleaves the importance of achieving a particular level of thinning intensity is less important than in conifers because the primary purpose of thinning is to favour the final crop trees rather than maximize total production per hectare. However, in conventionally thinned stands, usually receiving moderate crown thinnings, between 45 and 70 per cent of the total stand volume production will be removed in thinning during the course of a rotation. In terms of stocking only 1 to 10 per cent of the trees originally present remain to the end of the rotation. Where thinning rates and levels of stocking follow the Forestry Commission Yield Models based on marginal intensity, during the first part of the rotation the earlier thinnings remove the equivalent of 70 per cent of the maximum mean annual increment (yield class).

However, the rotation age of most broadleaved species is well past the age of maximum mean annual increment and thinning intensity is reduced as stands become older. This is usually effected by extending the interval (cycle) between thinnings. Typically the proportion of trees removed in each thinning declines from about 25 per cent to 15 per cent of the total. The proportion of standing basal area removed each time is rather more constant and averages 10 to 15 per cent of the stand total.

Because thinning broadleaves seeks to produce a final crop of relatively few but well formed trees, one unconventional option is to attempt to identify such trees at an early stage and to favour just these by very heavy thinning to the exclusion of all others: the system is called free growth. It is a technique which has been tried mainly in oak (Jobling and Pearce, 1977) and is considered on page 160.

Thinning cycle

Thinning in broadleaved stands should begin when the top height is about 10 m and basal area between 20 and 30 m^2/ha. However, if a market outlet exists for small sized material thinnings can begin any time once top height is about 8 m or more. Similarly the

Figure 5.2(b) Example of marking potential final crop trees: beech at third thinning. (*A10570*)

thinning cycle need not be a rigid number of years though excessive delays between thinnings should be avoided. Generally intervals between thinnings are 5–7 years in young stands, 8–10 years in middle aged stands, and up to 15 years in older stands. In general the more vigorous the stand the shorter the cycle.

The need to thin can be judged subjectively in summer when the amount of crown overlap and the proportion of trees barely making the canopy can be seen. A more objective way is to determine the basal area per hectare and compare it with the recommended threshold basal area (Rollinson, 1984).

The longer the interval between thinnings, the greater will be the volume of produce harvested on each occasion; this has definite economic advantages. However, the effects on the remaining trees are more drastic, e.g. increased exposure, greater variation in ring width leading to seasoning and working problems, stimulation of epicormics in oak, etc., and the silvicultural ideal for most broadleaved stands is thinning a little and often. This should be followed if markets and circumstances allow.

Thinning in mixtures

Regular thinning of mixtures is essential if the final crop species grows more slowly than other ones in the stand; a common feature of broadleaved:conifer mixtures. Thinning secures the final crop species and prevents trees becoming overtopped, suppressed, or slender and whippy. Neglect or delay in thinning is more serious in mixed than in pure stands since one species eventually tends to dominate and the other becomes suppressed or excessively drawn up. If this dominant species is not the desired final crop one and if regular thinning cannot be assured then there will have been little point in establishing a mixture.

Broadleaves in mixture with light demanding conifers, larch or pine, generally suffer more from delayed thinning than when in mixture with spruce, Western red cedar or cypress. The rapid crown expansion and coarse branching of pine and larch lead to early interference with the broadleaves, particularly if planted in strips three rows wide or less.

Where delay in thinning, poor mixture design or bad choice of species has led to severe suppression or failure of the main crop species, the chances of effecting a worthwhile recovery are slim and replanting is rarely an option because of cost. In the affected part(s) of a stand any surviving main crop trees of reasonable potential should be favoured and the secondary species accepted as a long-term constituent of the crop.

The principles of early selection of potential final crop trees, priority removal of misshapen wolf trees, and the timing and cycle of the thinnings are substantially the same as for pure stands. Thinning intensity in terms of yield per ha per year should be determined separately for each major species component of a stand – see Rollinson (1984). The secondary species in a mixture is mostly removed by about the fourth thinning, i.e. by about half to two-thirds of the way through the rotation of the final crop species, though a few specimens may be retained for amenity and added value.

Types of mixtures

In broadleaved:conifer strip mixtures the first thinning should usually remove one outer conifer row if the species are in reasonable competitive balance (Figure 5.3) or both outer rows if the broadleaved species is becoming suppressed. The broadleaved element is normally selectively thinned and trees extracted using the racks in the conifer. In the second thinning any remaining adjacent conifer row is removed and the rest of the crop selectively thinned. Subsequent thinnings are wholly selective, with most of the remaining conifer being removed in the third thinning unless strips are very wide, such as six rows or more.

Thinning in block or group mixtures is more difficult. Generally make racks in the secondary species (conifer), remove rows adjacent to broadleaved groups and thin selectively in them. Identify one or preferably more potential final crop trees in each group to ensure a predominantly broadleaved final crop.

Thinning mixtures of broadleaves is relatively straightforward, favouring good stems of main crop species and early removal of misshapen trees, fast growing species such as alders and birches, and unwanted ones such as hornbeam and whitebeam. Where intermediate yields of good quality cherry, sycamore and/or ash are sought from mixtures with beech and/or oak, some favouring in early thinnings of both the short rotation and the long rotation species will be necessary.

Thinning in neglected stands

Neglect of or delay in thinning, often for long periods, is not uncommon in broadleaved woodland. In young stands this leads to increased mortality and a preponderance of spindly trees. No great silvicultural harm is done provided a stand can be rehabilitated by opening up gently, i.e. thinning a little and often, to reduce basal area per hectare to normal levels in (say) three thinnings over 10 years. A single heavy thinning will break up the canopy and expose crowns to damage from snow, and the tall thin trees will snap or whip around in the wind.

Older stands

An old, neglected, overstocked stand but which is not yet at the normal rotation age, should be considered for thinning. However, any benefit from thinning will depend entirely on whether the remaining trees are able to respond. Both the lack of thinning in the past and increasing age for some species may reduce this ability.

A response to thinning occurs because crowns intercept more light, have room to expand, and because competition from other trees for moisture and nutrients is reduced. Where, owing to past neglect, crowns have become small, even confined to a tuft at the top of a tree, rapid increase in crown size cannot be expected and only a poor response to thinning is likely, though some species are better able to respond than others. Oak, provided crown dieback has not begun, is generally able to expand its crown following thinning whilst ash is very much less able to do this. Beech and sycamore are intermediate.

All thinning runs certain risks, but in old, overstocked stands they are exacerbated. Opening up a stand increases risk of windthrow, stagheadedness in old trees, development of epicormic branches, snow-break, sunscorch on stems of thin-bark trees such as beech, damage to the butt and surface roots during extraction, and stand collapse in some very old stands, especially of beech.

Therefore, in treatment of old stands the first question to decide is will sufficient trees respond and the stand remain intact? Thinning is inadvisable if there are signs of windthrow, crown dieback or chlorosis. If thinning appears safe it should be done lightly and infrequently. No more than 10 per cent of trees or 5 per cent of stand basal area should normally be removed at intervals of about 8–10 years. Thinning must be selective with the aim of removing dead, dying, and diseased trees, and taking care not to break up the canopy more than is absolutely necessary – that is, a light low thinning.

If neglect has made a stand very fragile (trees drawn up with small, weak crowns) thinning may be too risky. Such stands will eventually have to be felled and regenerated; the longer they are left usually the poorer their condition becomes.

Figure 5.3 Oak:Norway spruce 3 row: 3 row mixture with the spruce row adjacent to oak just removed in first thinning. Note squirrel damage at base of oak tree. (*A10571*)

PRUNING

Many broadleaved timbers (hardwoods) command high prices when free of knots and other defects. Pruning branches to achieve this on the lower bole may be profitable. Moreover, pruning in broadleaved stands is more important than in coniferous ones because:

1. there is a greater price differential between clear and knotty timber;
2. stem form is generally poorer, and singling and pruning are needed to improve it;
3. entry of decay fungi into the bole via dead branches, e.g. *Stereum gausapatum* on oak, is a more serious problem;
4. the lower bole may be rendered less susceptible to damage from squirrels since without branches there is nowhere for them to perch;
5. thinning in broadleaves often seeks to favour only final crop trees, and it is important to ensure these are of best quality.

The need for pruning depends entirely on the degree of branch development on the lower bole. Well stocked, dense stands encourage early side branch suppression and generally require little or no pruning.

Pruning is expensive and should only be considered for potential final crop trees. Costs increase rapidly with increasing branch size and with height up the stem. It is rarely worthwhile pruning branches more than 5 cm in diameter or higher than 5–6 m. It is important to start pruning early in the life of a tree to restrict the size of the knotty core and, because branches are small, no heartwood is exposed and wounds heal more readily. Generally pruning up to 3 m should be done at or prior to first thinning and up to 5–6 m before second thinning.

For rapid wound occlusion most species are best pruned in late winter or early spring, but there are exceptions. To minimize sap exudation birches, maples and sycamore should be pruned at any time except the spring, and walnuts only when in full leaf in July or August. Cherry should only be pruned between June and August to minimize risk of infection from bacterial canker and silver leaf disease. In general, to help prevent entry of disease, pruning should not be done between mid-March and the end of May when a tree is flushing since its resistance to infection is believed to be at a minimum during that period. Also, to restrict decay beneath pruning wounds, branches should not be cut completely flush but slightly proud of the stem to retain the barky swelling, called the 'branch bark ridge', around the branch base (Lonsdale, 1983).

Pruning may be needed to control epicormic branches. This is mainly a problem of oak and in growing high quality poplar and Cricket bat willow, and is discussed in the appropriate species' chapters.

FELLING AND REGENERATION

Several silvicultural systems have been applied to broadleaved stands both for reasons of silviculture and because of landscaping and amenity constraints.

Felling method

Regardless of silvicultural system it is essential that the trees themselves are felled carefully. Inexpert felling of mature broadleaves can cause considerable degrade, especially splitting of the stem. This is most serious in ash but affects all species. Damage is minimized by ensuring full severance of tree from stump before it begins to fall and by directing felling so that a tree does not impact directly on a large protruding branch or hit a ground irregularity such as a gully, rock, or another log.

Method of regeneration

The intended method of regeneration of a stand will significantly influence silviculture. For natural regeneration, preparations must be made to accept regeneration when it comes and thus to be flexible in management near the end of the rotation to bring forward or delay final felling. The decision of how to regenerate depends on many factors but owing to small size of coupe, and more limited availability of genetically superior planting stock, the opportunity for natural regeneration in broadleaved stands is generally greater than for conifers. However, the disadvantages of natural regeneration need careful consideration because it has not proved reliable in Britain. Table 5.2 contrasts the two regeneration systems.

Natural regeneration may be favoured if: (a) the species and quality of the parent crop is considered satisfactory, (b) there is evidence of regeneration beginning, e.g. advance regeneration; or good regeneration is taking place and there is an opportunity to use it, and (c) there is no urgency to fell and regenerate in any one year. Artificial regeneration is necessary if a change of species or provenance is contemplated, if it is essential to achieve rapid and complete restocking, and, of course, if there is no sign of natural regeneration when felling takes place.

Clear felling and replanting

Clear felling and replanting (Figure 5.4) is the usual method of regenerating broadleaved high forest in

Table 5.2 Comparison of natural regeneration with planting

	Natural regeneration	Artificial regeneration (planting)
1. As a management practice	Unreliable	Reliable
2. Source of seedlings	Arise 'freeely' on site.	Purchase from nursery.
3. Stocking of new crop	May be patchy, varying from very dense to sparse.	Uniform
4. Timing a. felling previous crop	Determined by good seed years which complicates marketing and cash flow.	Any time.
b. year of establishment	Uncertain, depending on good seed years.	Replanting can be done in any year provided plants are available.
c. season of planting	Not applicable.	Need to plant in late autumn or early spring.
5. Genetics	No opportunity for species change or crop improvement apart from ensuring good quality parent trees.	Opportunity to introduce new species or provenances.
6. Tending	Shade from parent trees may reduce weed growth and lessen the need for tending, but early respacing of dense regeneration and infilling of gaps may both be needed.	Immediate post-planting growth is usually slow and weed growth tends to be heavy, making regular weeding essential.
7. Other	Parent trees may give some protection from frost.	Complete removal of previous crop leads to wetter ground conditions, especially on clay.

Britain. The silvicultural system concentrates working, maximizes out-turn from a stand and ensures rapid and uniform restocking over a whole site. In carrying out the system several factors need to be considered.

Size of coupe

Large-scale clear felling of mature broadleaved trees is become increasingly rare owing to constraints of amenity and landscape. Typically, felling coupes are of 1–3 hectares. Although this size reduces the visual impact it provides a most favourable environment for deer browsing, which raises the question when replanting of whether to fence the whole area or protect trees individually (see page 46).

Damage to adjacent stand

In deciding coupe size and boundary it should be remembered that clear felling exposes the face of neighbouring stands. Thin barked species such as beech and sycamore may suffer sunscorch and, with oak, epicormics are likely to develop on trees along the newly exposed edge.

Effects on site

Complete removal of a crop exposes the soil surface, encourages vigorous weed growth, increases surface wetness and often leads to a rise in water table (page 30).

Replanting

Traditionally, replanting was done as soon after felling as possible but, unless the ground is very clean, it will often be advantageous to wait until after the first growing season. The flush of weeds and stump regrowth can then first be killed with herbicide and replanting carried out the following autumn or spring (page 30).

Group felling

Group felling is where a patch of trees covering less than 0.5 ha is cut down to open a gap in the stand. Scattered groups may be felled each year, or only every few years, in a compartment. This prolongs regeneration over the whole stand but avoids the sudden impact of clear felling. It is well suited to small-scale working, both for felling and replanting, and is used where it is desirable to maintain woodland conditions for reasons of silviculture, landscape or sporting. It is usually more expensive because of the small-scale of felling, replanting and

Figure 5.4 Clear felling coupe in mature broadleaved woodland, mainly oak and Sweet chestnut. (*A10572*)

subsequent maintenance, but there can be considerable silvicultural gains owing to the protected site and aesthetic advantages. The diameter of the gap created by felling the group should be at least 1.5 times the top height of the stand, and generally not less than 0.15 ha in area to allow adequate room for development of the new crop. Regeneration, whether naturally occurring or from planting, will need to be individually protected.

Shelterwood

This essentially consists of a gradual removal of the former crop with the object of securing good natural regeneration. The shelterwood system has not been widely practised in Britain, but in the New Forest, for example (Figure 5.5 a and b), it has been found to be the best method of regenerating even-aged oak plantations (Small, 1982) though restocking is mostly achieved by planting.

Selection systems

The selection system aims to maintain a full stocking of all tree sizes and ages, from seedlings to mature trees, in any one area. At long intervals, about every 10–20 years, a whole compartment is worked over. The largest trees are felled and the rest of the stand tended, cleaned or thinned as needed.

The system has a low intensity of working but maintains a woodland appearance and continuous ground cover. It is hardly ever used in British forestry, although various forms of selective felling are often miscalled 'selection forestry'.

Two-storey high forest

In this system a second crop is introduced into a stand at some stage during the rotation. The main example in Britain is where beech is introduced into young pole-stage stands of birch, mature pine, or poorly growing ash and even oak to aid its establishment; many stands of Southern beech have also been established in this way. The two storey structure lasts only a few years since the overstorey is removed before its shade seriously impairs growth of the beech. Beech has occasionally been introduced into pole-stage oak, but see comments on page 29. Also, throughout the 1950s and 1960s it was common practice to thin oak stands heavily and

Figure 5.5(a) Late thinning in oak worked on a 200+ year rotation in the New Forest. Clear felling does not occur, the stand is opened up in successive heavy thinnings and regenerated by underplanting and enrichment (as in *b*) and thus is a form of shelterwood silvicultural system. (*A10573*)

Figure 5.5(b) 200-year-old oak heavily thinned and underplanted with oak transplants in tree shelters (New Forest). (*A10574*)

Figure 5.6 Oak (54 years) with understorey of Western hemlock (21 years). (*A10575*)

underplant with conifers to obtain an early return, while at the same time encouraging rapid growth on the best of the oak (Figure 5.6).

Natural regeneration

The basic essentials for satisfactory natural regeneration are plentiful seed, a clean forest floor, adequate protection, and good weed control during the regeneration period. The art lies in bringing together all these factors at the same time recognizing that nature, not the forester, governs seasons and thus, to a large extent, the production of sufficient viable seed.

Advance regeneration

A characteristic of many older broadleaved stands is the occurrence of advance natural regeneration, especially in gaps. This may be taken as evidence that site conditions are suitable for natural regeneration and fertile seed is being set, but unless it is near the end of the rotation or a more uneven aged crop is sought, advance regeneration itself is of limited silvicultural value and is unlikely to survive for very long. Even if the plants do keep going, for say 20–30 years until the end of the rotation, they are often badly damaged during extraction, of poor form, and will only slowly respond to the more open conditions after so many years of partial suppression.

Seeding and mast years

All common broadleaved species in Britain will regenerate naturally, but to be successful there must be plentiful seed. It is difficult to stimulate seed production artificially; it may be encouraged by stress to a tree and be heavier on exposed well-formed crowns, but the first step is to wait for prolific seeding to occur. With some species, e.g. oak and beech, many years elapse between heavy seed crops (see Table 5.3). Three factors appear to be responsible for irregularity in seed production on mature trees capable of bearing seed (Gordon and Rowe, 1982):

1. climatic conditions both in the preceding year and the year of seed development, particularly warm, dry conditions in late summer;
2. the incidence of losses between flowering and seed fall owing to damage from late spring frosts, high winds, defoliation, and seed predation;
3. for some species, the need for a period of time since the previous heavy seed crop to build up carbohydrate levels.

Thus natural regeneration depends on waiting for a good seed year and then being prepared to use it when it comes. Silviculture should follow good seeding and natural regeneration, not try to encourage it artificially.

Table 5.3 indicates seed production for the more important broadleaved species.

Handling the parent crop

Provided thinnings have been carried out regularly, the normal stocking found in broadleaved stands at rotation age is quite suitable for purposes of natural regeneration. The main requirement is to delay any felling in the stand until the winter after a good seed year and to extract trees before the following April. There are two options once a prolific seed year has taken place and good regeneration is expected.

The first option is to restrict felling in the parent stand to a very heavy thinning removing 50–70 per cent of the trees. Thus a shelterwood is formed, though the main purpose of retaining some tree cover is not to provide further seed but to cast shade to restrict vigour of weed growth and significantly reduce the amount of soil re-wetting. The remaining

Table 5.3 Seed production of broadleaved trees in Britain

Species	Minimum seed-bearing age (years)	Interval between large seed crops (years)	Age after which seed production begins to decline (years)	Time of seed-fall or seed dispersal (months)
Alder (Common)	15–25	2–3	—	Sept.–Mar.
Ash	20–30	3–5	80	Sept.–Mar.
Beech	50–60	5–15	160	Sept.–Nov.
Birch	15	1–3	60	Aug.–Jan.
Cherry	10	1–3	—	July–Aug.
Hornbeam	10–30	2–4	—	Nov.–Apr.
Lime (Small-leaved)	20–30	2–3	—	Sept.–Nov.
Norway maple	25–30	1–3	—	Oct.–Feb.
Oak				
Pedunculate	40–50	3–6	140	Nov.
Sessile	40–50	2–5	140	Nov.
Sweet chestnut	30–40	1–4	60	Oct.–Nov.
Sycamore	25–30	1–3	70	Sept.–Oct.

Note: Both rapidly growing trees and ones of coppice origin tend to bear seed earlier than shown. Decline in seed production is not a sudden event and heavy crops can occur, though with longer intervals in between, well past 200 years of age for oak and beech.

over-storey is removed in one or two operations over the next 10 years to ensure adequate light for the developing regeneration. (This is further discussed under 'stand opening'). The felling of these trees causes damage to regeneration but it is usually much less serious than it first appears.

The second option is to clear fell the stand and accept the regeneration that is promised, along with other species that come up. Weed growth will be more vigorous but there will be no further damage to the site from removing the parent trees. This option does not allow for further regeneration from a later seed year and should only be tried if local evidence and past experience have proved its usefulness. If the expected regeneration fails, resort must be made to replanting.

Ground preparation

Conditions on the forest floor influence seed germination and initial growth. In particular, rank weed growth and very wet conditions, often following sudden opening of the stand, seriously impair regeneration chances. A clean floor is particularly important for regeneration of beech and ash, though oak is better able to come up through weeds, including grass swards. Herbicide can be used during the seeding year to control weeds, especially bracken and heavy growth of bramble. An August application of glyphosate is often the most timely.

In the past, it was regular practice to scarify the surface of the forest floor in the year seed was hoped for. This is expensive, and owing to the uncertainty of seeding, is not recommended as a standard practice, though some scarification occurs during extraction.

Protection

Both predation of seed by birds and small mammals (especially squirrels, mice and voles) and damage to young seedlings can negate a promising start to natural regeneration afforded by a plentiful seed crop. Regeneration areas should be fenced against rabbits and, if necessary, deer. If predation of seed by mice is excessively high, as may occur in beech woodland, warfarin-baited cut wheat in a hopper will reduce mice numbers. However, this is expensive as baiting points are needed every 20 m and the bait should be replenished regularly throughout the winter. It should only be considered as a last resort and not used where there are sporting, conservation or amenity interests.

Occasionally severe drought in the late spring at time of germination can devastate regeneration.

Stand opening

Where an overstorey is retained (some form of shelterwood) or only small group fellings carried out, the light regime can become a critical factor. Light penetration to the forest floor is not a primary requirement for satisfactory germination. However, adequate light is essential for growth of seedlings, though the amount of shade that can be tolerated differs between species. For oak, almost full daylight is generally claimed to be necessary which may be one of the reasons why often oak regeneration is best 'outside the wood' or where much sidelight occurs at a woodland edge. However, oak seedlings can survive a suprising amount of shade if free from browsing damage or other defoliation (see page 164). For ash and beech fairly heavy shade can be tolerated for the first two or three years but thereafter, especially for ash, full overhead light is needed. These requirements for light indicate that if regeneration has been achieved using a shelterwood system then further thinning must take place within a few years to ensure an adequate light environment (Figure 5.7).

However, as the overstorey is removed the influx of light encourages weed growth, and weed competition is a major cause of failure of young regeneration. The dilemma in attempting natural regeneration is how to balance opening up the stand, to allow sufficient light for healthy growth of the regeneration itself, with the need to retain enough overhead shade to reduce the vigour of weeds. As Brown (1960) stated for achieving a good crop of young beech seedlings

Figure 5.7 Good natural regeneration of beech. Parent trees are now ready to be removed. (*D5529*)

"the forester's task in the ensuing years is, besides ensuring that rabbits are destroyed or kept out, to increase the light reaching the seedlings without fostering the ground vegetation excessively. On some moist retentive soils it is well nigh impossible to strike a balance between loss of most of the regeneration under dense shade and the encouragement of a smothering ground vegetation by the opening of the canopy".

The only way out of this dilemma is to continue to thin the overstorey to ensure healthy seedlings and, if necessary, carry out hand weeding. The need to thin out or remove the overstorey is judged from seedling development. Spindly, drawn up plants indicate too much shade, too much competition from weeds or overly dense stocking.

Use of tree shelters

The use of tree shelters (see page 40) may significantly improve the chances of success with natural regeneration. The complete protection a shelter affords an individual seedling, the opportunity to control weeds with herbicide, and possible enhancement of early growth, substantially overcome the main problems affecting survival of natural regeneration.

It is suggested that shelters are placed over seedlings during the first year, or later if still surviving, spaced at about 3 m intervals. Use of shelters in this way would obviate the need for fencing.

It must be cautioned that using tree shelters to encourage natural regeneration is a recent practice but appears to be a promising technique.

Maintenance

Once satisfactory regeneration is obtained, control of weeds, adequate protection, and subsequent maintenance, do not differ materially from planted stands (Chapter 3). Dense regeneration may need respacing and bare patches larger than 6 m across and devoid of utilizable species should be enriched by planting.

RISKS WITH VERY LONG ROTATIONS

It may be desirable to retain some timber trees past their normal rotation age for reasons of amenity, landscape, conservation, etc., but there are attendant risks in such a policy. These fall into three categories:

a. development of defects within the stem;
b. tree safety; and
c. loss of yield.

Defects

Overmature trees are prone to disease and dieback. Often decay sets in at this time and the value of the bole rapidly declines. Also, large, old trees are more prone to damage from high wind and snowbreak which, apart from physical damage, provides a further entry point for disease and pests.

Safety

Old trees can be unsafe. This is particularly serious where public enjoyment of woodland is encouraged and where old trees are beside a public right of way. Silvicultural aspects of tree safety are considered in detail in Chapter 13.

Yield losses

Increment of old trees grown beyond normal rotation length is usually poor, with very little height growth and basal area increment less than 1 per cent. This slow growth must be recognized as a loss as site growth potential is not being realized. Seed production also tends to decline markedly.

Table 5.4 gives approximate ages when the above problems of defects, safety and significant slowing in growth usually begin to become serious.

Table 5.4 Age generally indicating significant overmaturity in broadleaved tree species

Species	Age (years)
Alder (Common)	80
Ash	120
Beech	180
Birch	60
Cherry	80
Hornbeam	200
Lime	200
Norway maple	120
Oak	250
Poplar	80
Red oak	120
Sweet chestnut	200
Sycamore	200
Willow	80

Note: Sometimes on infertile but not otherwise inhospitable sites trees may grow slowly and steadily and reach much greater ages than those indicated without the symptoms of overmaturity.

COPPICE

CHAPTER 6

Coppice

INTRODUCTION

Definition

Coppice is a forest crop raised from shoots produced from the cut stumps (called stools) of the previous crop (Figure 6.1). Coppicing is the operation of felling and regenerating crops in this way. Coppicing can usually be repeated many times and is a useful means of regenerating broadleaves at short intervals (less than 30 years) to produce small roundwood. It is the main way of managing underwood and has been widely used in small woods, hence their loosely applied name 'copse'.

Types of coppice

Table 6.1 lists the main forms of coppice and associated terms.

Figure 6.1 One-year-old coppice shoots of Sweet chestnut on stools in foreground. (*A 10576*)

Table 6.1 Coppice types and terminology

Type	Description	Comments	Examples
Simple coppice	Crop consists entirely of coppice all of which is worked on the same cycle (even aged).	May consist of only one species (pure) or several (mixed).	Nearly all Sweet chestnut is worked as pure simple coppice.
Coppice with standards	Two storey forest. Coppice (underwood) with scattering of trees (standards) being grown to timber size.	Standards may be of seedling origin (maidens) or develop from a stump shoot left for the purpose (stored coppice). Standards retained for a period of 3–8 coppice cycles. Oak is much the commonest standard species.	Oak:hazel
Stored coppice	Tree or stand of coppice origin as a result of growing coppice on beyond its normal rotation.	Many woodlands, resembling high forest, are stored coppice owing to decline in coppice working this century.	Much of the oak around Dartmoor and Exmoor.
Short rotation coppice	Arbitrarily designated as coppice worked on a rotation of less than 10 years to produce stick size material.	Provides material for many rural crafts. Recent interest in production of biomass for energy.	Osiers (willows) grown for wicker work, hazel, and underwood worked for spars, pea and bean sticks, etc.
Pollards	Trees cut off at 2–3 m above ground so that the shoots which sprout are not in danger from browsing.	Regenerative mechanism identical to coppice. Formerly component of 'wood-pastures' now little practised in traditional form.	Riverside willows. Similar effect seen in 'topped' poplars and alders used for screening and shelter.
Underwood	General name for all coppice or scrub occuring under another tree crop.		Hazel component of oak: hazel coppice with standards.

Species

All broadleaved species will coppice, most conifers will not, with the main exceptions of Monkey puzzle *Araucaria araucana* and Coast redwood *Sequoia sempervirens*. A few broadleaved species do not coppice vigorously or only have the capacity to do so when young when the stump is fairly small: beech, birch, cherry, and some poplars.

The following species have recently been or are presently worked as pure coppice: ash, birch, hazel, hornbeam, lime, oak and Sweet chestnut.

Physiology of coppice

Coppicing is a form of vegetative propagation. The coppice shoots arise either from dormant buds on the side of the stool or from adventitious ones developing in the cambial layer in callous tissue around the edge of the cut surface or, in the case of birch and hazel, mainly from root buds close to the stump. Shoots emerge either from the above-ground part of the stool (most species) or from just below the surface, e.g. hazel. Usually many shoots are produced on a stool. The development of such shoots is not materially different from profuse epicormic branching on a stem following thinning or the emergence of root suckers, and is initiated by a change in the auxin environment following removal of the crown and stem. See Lust and Mohammady (1973) for a detailed account of coppice regeneration.

The dormant buds which give rise to coppice were originally formed on the leading shoot of the seedling and grew outward with the cambium but previously failed to develop. The bud pith is traceable to the pith of the original stem, but if this connection is broken or the bark covering a bud becomes too thick, a shoot will fail to emerge. Therefore, sprouting of coppice generally tends to decline with tree age. However, where coppicing has been practised regularly an ever enlarging stump can be maintained for many hundreds of years, notably with ash, Field maple, and Small-leaved lime (Figure 6.2).

COPPICE IN BRITAIN

History

The ability of our native broadleaved trees to regenerate themselves from the cut stump, i.e. coppice, has had a great influence on woodlands in Britain.

The practice of coppicing, on both short and long rotations, can be traced back to neolithic times (4000 B.C.). Evidence of use of coppice products for numerous rural needs can be found throughout the Bronze age, Roman, and Saxon periods and by 1250 coppicing was almost universal and even in such large woodland areas as the Forest of Dean (Rackham, 1980). Working native woodland in this way ensured a supply of small-sized, easily handled material for firewood, trackway construction, building materials and fencing.

Since the 12th century the history of coppice working is well recorded and it is clear that until 150 years ago it was the most widespread silvicultural practice. Coppice with standards dates from medieval times and retention of standards for timber was required by law in the 16th century. In the 17th and 18th centuries coppice not only continued to supply building and fencing materials and domestic firewood but was also increasingly in demand for charcoal for the iron and glass industries and, with oak, to supply bark for tanning.

In the middle of the 19th century the importance of coppicing began to decline as many traditional products were superseded. This decline accelerated after the First World War as rural electrification programmes and other more convenient energy sources finally supplanted firewood, so that by the mid-1950s regular coppicing, apart from Sweet chestnut, had become rare.

Figure 6.2 Mass of 20-year-old lime coppice shoots on a large old stool. Coppicing has been practised in this lime wood for many hundreds of years. (*A 10577*)

The singular exception of Sweet chestnut coppice developed because of demands for long, straight, durable poles needed by the hop-growing industry, which could be produced conveniently on an 8–10 year rotation. Substantial planting of chestnut coppices, often on poor agricultural fields but occasionally by enriching mixed woodland by planting or layering, began in the 1820s and became widespread 30–40 years later when prices for chestnut were high. For example in 1868 best quality cants realized £90/ha (£2500 at 1984 prices) on the Cowdray Estate, West Sussex (Roberts, 1929).

Prices for chestnut coppice fell rapidly at the end of the last century, owing to much increased supplies from the many newly established coppices and to declining demand in the hop industry as wire supports replaced poles. However, a new market emerged using cleft chestnut from 12–16-year-old crops for fence palings, which has continued to this day. Also, at the present time, interest in coppice has re-awakened owing to some resurgence in rural crafts, e.g. thatching, increased demand for firewood, and as a conservation measure to maintain woodland flora and fauna long associated with coppice working in Britain.

Present status of coppice

Although active coppice management, apart from chestnut, has declined it is still a significant forest type (Table 6.2). This table also shows that the total area of woodland that has been influenced by past coppicing is substantial and that 95 per cent of actively worked coppice is in England. The analysis for England by species, Table 6.3, shows the dominance of Sweet chestnut.

Table 6.2 Areas (ha) of coppice by countries and type

	England	Wales	Scotland	Great Britain
Simple coppice	25 711	1 849	4	27 564
Coppice with standards	11 473	80	15	11 568
Stored coppice* (estimated)	48 100	17 900	5 900	71 900

* now classified as high forest but clearly identified at present as of coppice origin. Data from survey of 'other woodland' type, as indicated in footnote to Table 2.1, and a subjective estimate of extent in Forestry Commission and Dedicated and Approved woodland.
Source: Forestry Commission Census of Woodlands and Trees, 1979–82.

Wood production

It is difficult to estimate the exact total yield from all coppice working in Britain but it is of the order of 200 000 m^3/year. The principal markets are pulpwood, turnery, fencing and firewood.

Woodland potential

Much of the total area of coppice (Table 6.2) is a neglected resource which for many reasons has not been brought back into effective use. It is important to distinguish between neglected hazel coppice and mixed coppice of potentially valuable species. Hazel coppice, from which the standards have been removed and where hazel and other valueless species have prevented the growth of self-sown

Table 6.3 Area (ha) of worked coppice in England by types and species

	Principal species of coppice						Total
	Sycamore	Ash	Sweet chestnut	Hornbeam	Hazel	Other species	
With standards	115	193	5 275	1 697	1 465	2 728	11 473
Coppice only	2 297	1 184	13 816	1 716	1 573	5 125	25 711
Total	2 412	1 377	19 091	3 413	3 038	7 853	37 184
% of coppice total	7	4	51	9	8	21	100

Source: Forestry Commission Census of Woodlands and Trees, 1979–82.

more valuable species, has little potential to develop into high forest. The mixed species coppice on the other hand has the capability of developing into forest with the aid of some thinning. Many woods have developed in this way.

Other values of coppice

Conservation

Coppice forestry has considerable conservation importance.

1. Coppice crops are mostly worked in small coupes, thus even small woodlands usually contain several different age classes. This provides great structural diversity – stands at different stages of development, much 'edge' effect – leading to a variety of habitats able to support a wide range of wildlife.
2. The relatively short rotations (less than 30 years) means that the period of complete canopy is short so allowing seeds of herbaceous and other ground flora to survive ready to take advantage of the light following the next felling. Many traditional woodland flowers are at their best two to three years after coppicing giving spectacular displays, especially in the spring. Though the quantity of herbaceous plants may be greatest in the years immediately after coppicing the total number of species may continue to increase up until about the fifth year (Table 6.4).
3. Apart from Sweet chestnut and some forms of short rotation coppice (Chapter 8), most coppices in Britain consist of native species, often in mixture. Such species generally have a rich associated fauna and flora.

Table 6.4 Ground flora under different ages of Sweet chestnut coppice with oak standards

Flora characteristics	Age of coppice (years)				
	1	2	5	9	15
Number of plant species	14	23	30	23	8
Total biomass (kg/ha)	135	2160	956	279	16

From Ford and Newbould (1977).

4. Many coppices have been worked for hundreds of years and this historical continuity of the woodland environment enables survival of many woodland species not easily able to colonize new woodland, e.g. oxlips and Ragged robin. As there are virtually no 'wildwoods' in Britain – woods that have not been actively influenced by man, these ancient coppices are particularly valuable scientifically.

As an illustration of these benefits, it is reported that one 0.7 ha area of Bradfield Woods, Suffolk, where coppicing has been practised regularly since at least the 12th century (Figure 1.2), contains at least 118 vascular plants (Rackham, 1980).

Landscape

The scenic impact of the large area of coppice (Table 6.2) is enhanced because coppice woodlands tend to be small and scattered and rotations short. Actively worked coppice with standards is aesthetically very attractive exhibiting a more diverse structure than most woodland e.g. Figure 7.4.

CHAPTER 7

Coppice silviculture

INTRODUCTION

This chapter concerns first the principles and practice of coppicing in general, followed by the silviculture of mainly long rotation (10–30+ years) coppice types. Chapter 8 concerns short rotation coppice. Forestry Commission Leaflet 83 *Coppice* (Crowther and Evans, 1984) contains additional managerial information.

Establishing new coppice

The principles involved in establishing a new coppice differ little from establishment of conventional plantations. The subject is considered in Chapter 8 in the section on firewood coppices since these are likely to be the commonest form of new coppice at the present time. Coppicing may begin either once the trees are established (age 5–8 years) but before producing much saleable material, or after they have reached marketable size. In the former the first full coppice crop is reached sooner while in the latter some yield is obtained from the maiden crop.

WORKING EXISTING COPPICE

Organization

Because most working is by individual contractors or small firms and coppice felling and conversion is labour intensive producing many different products, coupe sizes are small (typically 0.5–3.0 ha). Thus, frequently, large compartments to be coppiced are sub-divided into smaller working units called 'cants' in S.E. England and 'haggs' in the case of oak in Scotland.

Felling

A sloping cut is traditional arising from the use of edge tools and though it will shed rainwater this is not a crucial factor in reducing the incidence of decay. Low cuts maximize the yield and may increase the tendency for coppice shoots to develop their own root system independent of the original stool. The bark on the stump below the point of cut should be left intact and undamaged. Use of chainsaws appears to reduce somewhat the number of coppice shoots on a stump compared with axe cutting, but there is no effect on height growth (Phillips, 1971) and either method is acceptable.

Timing

Traditionally, coppice is cut in the winter (October to March) for several reasons. Working is easier without the presence of foliage, there is a full season's growth for the new shoots, and, at least in the past, coppice workers have had other work to do in the summer. However, there are no overriding silvicultural reasons for winter working and coppice can be cut successfully at any time of the year except in late summer (August) when shoots may not harden off before the winter. The first cut of a newly established coppice should be made in March or early April so that the new shoots do not emerge until June when the risk of severe frost damage is slight.

Stools and stocking

Although coppice crops are worked on short rotations and therefore need to achieve full use of site potential in a short time, spacing of stools is not as close as initial spacing in conventional plantations because each stool produces many shoots which grow out from the base. Since thinning of coppice (singling) is rarely carried out the general rule is that the longer the rotation, and hence larger the roundwood desired, the fewer the number of stools per hectare. For example hazel worked on a 7–10 year rotation for bean sticks, thatching spars and hurdles has 1500–2000 stools/ha, Sweet chestnut worked on a 15 year rotation for fence palings has 800–1000 stools/ha and oak and ash worked on longer rotations (25–35 years) have commonly 200–500 stools/ha.

In time some stools become very large (Figures

Figure 7.1 Large old ash stump covered with numerous coppice shoots. (*A10578*)

6.2 and 7.1) and after several coppicings fewer may be needed to achieve full stocking. Conversely, at each coppicing due to natural decay, extraction damage, burning lop and top nearby, etc., stools may die and a gap occur. These should be made good (gapping up) at the time by planting a large healthy tree 0.5–1.0 m tall with a good root system, or by layering one of the shoots from an adjacent stump left uncut for the purpose.

Layering involves bending over a stem of about 4–6 cm diameter at the base and pegging it firmly to the ground across the gap. The stem is very lightly covered with soil but not buried. The operation is done in late winter and a wealth of shoots develops along the layer a few months later. Good roots develop on the layer below the more vigorous shoots and any one of these 'new' plants can be recruited to fill the gap. Black (1963) gives a detailed account of layering Sweet chestnut coppice.

Fertilising

Cutting successive coppice crops may eventually deplete a site of available nutrients, especially of phosphorus. However, there is little evidence to show that this has led to decline in growth. Application of fertiliser should only be considered if foliar analysis (see page 50) has indicated a possible nutrient deficiency.

Protection

In general, coppice forestry is remarkably free from protection problems.

Late spring frosts can be damaging, particularly to Sweet chestnut, but damage from snow or wind is rare since coppice shoots or branches never reach very large size.

Fires are rare owing to relatively little ground vegetation and the broadleaved nature of the crop.

Browsing by deer and rabbits can be serious but the rapid growth of coppice shoots limits damage very largely to the first growing season. Specific protection measures are rarely undertaken since when the crop is most susceptible there is usually much other herbaceous vegetation as alternative browse. If browsing pressure is slight, heaping brushwood over stumps (Figure 8.2) gives adequate protection except from muntjac; if it is more intense fencing and/or control of animal populations will be necessary. Livestock must be excluded from coppice.

GROWTH, DEVELOPMENT, ROTATIONS AND PRODUCTIVITY

The growth and development of a coppice crop differs markedly from a plantation. The stools, supported by large root systems, produce numerous shoots leading to very high numbers per hectare (upward to 100 000), rapid site occupation, early canopy closure, and earlier culmination of maximum mean annual increment.

Numbers of shoots

The number of coppice shoots per stool varies with age and size of stool and cutting tool used (Phillips, 1971). A large number of shoots emerge in the first year, typically 50–150 per stool (Figure 7.1), but self-thinning takes place and each year some of the smaller shoots die so that by about mid rotation there are 5–15 live ones (Figure 7.2). The final number of shoots surviving depends on species, spacing between stools, and rotation length, e.g. mixed underwood worked on an 8-year rotation (Chapter 8) may have 10 000 to 20 000 shoots/ha when cut, while Sweet chestnut coppice at 16 years has about 5000.

Growth and biomass

Compared with a planted tree the initial growth of a coppice shoot is very vigorous and goes on growing throughout most of the first season. Oak will commonly reach 1 m and ash, sycamore and Sweet chestnut may grow as much as 1.5–2.5 m in the first year. Even greater height increment may occur in the second year but thereafter height increment of most species is increasingly restricted to the early

Figure 7.2 Sweet chestnut coppice, 9-years-old, showing 5–15 shoots on each stool. (*C1350*)

part of the growing season and becomes closer to that for a planted tree of the species.

Rapid height growth and large numbers of shoots lead to canopy closure occurring in the second or third year for more vigorous species. Similarly, biomass development is rapid (Figure 7.3), hence the interest in coppice as a potential source of wood energy (Chapter 8). The oldest crop in Figure 7.3 has achieved a mean above-ground biomass increment of 5 tonnes/ha/year (approximately 4 tonnes/ha/year of stemwood to 7 cm top diameter) in just 18 years. In a conventional plantation this level of mean annual increment is only achieved in such a short period by much more productive crops (Sitka spruce, Yield Class 16, Japanese larch and sycamore, Yield Class 10), while conifers of comparable productivity (Yield Class 4) take 50–80 years.

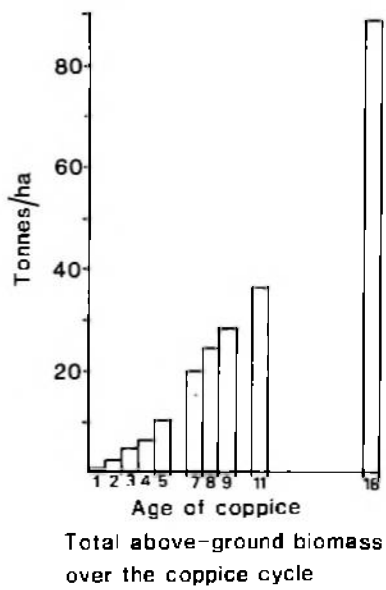


Figure 7.3 Biomass development in Sweet chestnut coppice (from Ford and Newhould, 1970).

Thinning

Thinning to reduce the number of shoots on a stool is rarely practised because of cost. Rotation length is the main control of final stem size and in working coppice the range in quality and size of poles produced is used to advantage to satisfy different markets.

However, the effect of thinning is the same as in conventional forestry and artificial reduction of shoots will lead to better growth of the remainder and therefore can be used to attain maximum growth of individual poles. Harris (1956) compared the effects of reducing stem numbers in 20–30 year old oak coppice from about five per stool to either two or one shoot per stool. The percentage increase in individual stem volume over the next 4 years for the single stem stools was nearly double that for the two stem stools but, as would be expected, there was some loss in total volume increment per hectare.

Rotations

The age at which felling takes place is determined by the size of roundwood required and depends on species and site. Except for short rotation hazel (Chapter 8) all normal coppice rotations are shorter than the rotation of maximum mean annual increment (Begley and Coates, 1961). However, there are several disadvantages to extending the rotation to maximize yield: (a) large size roundwood; (b) the larger stumps may coppice less well; (c) in mixed coppice the smaller coppice species, especially hazel, become suppressed; and (d) the conservation value diminishes since fewer plants can survive the longer period of dormancy.

Yields

Yield data from coppice crops are not comprehensive. It is not possible to indicate the range of yields by species on different sites nor to give reliable figures on the quantity of small diameter material under 5 cm in diameter. According to Begley and Coates (1961), the mean annual increment over a coppice rotation, in terms of dry wood per hectare per year measured to 5 cm diameter, is about 2½ tonnes for sycamore, birch, ash, lime, oak, alder and Sweet chestnut. Only poplar and willow exceed these figures at about 6 tonnes/ha/year. Yield of Sweet chestnut measured to include twigs is about 4 tonnes/ha/year (Begley, 1955). The dry weight yield of hazel, from which material down to 2 cm is used for hurdles and other products, is also about 2½ tonnes/ha/year.

Long-term productivity

In principle coppice can be worked indefinitely but two factors, site exhaustion and stool mortality, could lead to declining yields with time.

Although the regular removal of produce from a site may cause net loss of nutrients over time there is no recorded evidence of fall-off in yield though, according to Rackham (1967), the reason for lengthening of coppice rotations in the late middle ages may have been due to declining fertility. However, even in the most intensive form of coppicing – osier growing – but possibly due to high site fertility, continuous annual cropping can be maintained for at least 30 years without needing to fertilise (Stott, 1956).

More important as a potential cause of yield decline is stump death. Provided shoots emerge there is no evidence that the vigour of shoot growth is affected by the number of previous coppicings and the term 'tired coppice' is quite misleading. Indeed, some stumps are known to have produced vigorous coppice over many hundred of years (Figures 6.2 and 7.1). However, stump mortality does significantly reduce yield per hectare by lowering stocking and, as mentioned earlier, replacement should be carried out. In Sweet chestnut coppice typically 5 per cent of stumps die at each cutting, but in lime the figure is only 1–2 per cent.

TYPES OF COPPICE

Sweet chestnut

Sweet chestnut is the most important commercial coppice crop of which more than 90 per cent occurs in the counties of Kent, East and West Sussex (Table 7.1).

Table 7.1 Areas (ha) of Sweet chestnut coppice by region and type

Region	Coppice type		Total
	simple	with standards	
Kent	9 163	3 381	12 544
E. Sussex	2 334	1 015	3 349
W. Sussex	1 102	291	1 393
Elsewhere in S. E. England	681	99	780
S. W. England	360	39	399
E. England	159	425	584
Northern England	17	25	42
Wales	—	—	—
Scotland	—	—	—
Totals	13 816	5 275	19 091

Source: Forestry Commission Census of Woodlands and Trees, 1979–82.

Sites

Sweet chestnut grows best in warm, sunny localities where rainfall is 500–850 mm/year, hence its widespread occurrence in south-east England (Table 7.1). Optimum growth is usually found on sheltered southerly aspects. Late spring frosts are damaging and if establishing a new coppice, planting in frost hollows should be avoided.

Sweet chestnut does not require highly fertile soils but should never be grown on poorly drained clays or calcareous soils. Its best growth is obtained on acid soils (pH 4–5) ranging from loamy sands to clay with flints, but podzols of very low pH, surface water gleys, and peaty gleys are unsuitable.

Protection

Sweet chestnut trees and coppice suffer one serious disease, a root rot caused by *Phytophthora cinnamomi* and *P.cambivora*. It is called 'ink disease' owing to the violet or blue-black stain or fluid around damaged roots and the base of a tree or stump. Symptoms are small leaves or premature yellowing, but in coppice some shoots on a stump with diseased roots often appear quite healthy. As with most *Phytophthora* damage the disease is prevalent on wet ill-drained soils, especially shallow, compact clays; these should not be used for Sweet chestnut.

Rotations and yields

Rotation length varies between 10 and 20 years (most commonly 12–16 years) though a few crops may be worked on a very short rotation (Chapter 8).

A full account of growth rates and yields is found in Begley (1955). The total yield from a crop of 10 m average height (age about 15 years) is about 110–180 tonnes/ha fresh felled weight or 55–90 tonnes oven-dry weight. The volume per hectare of material over 6.3 cm diameter and more than 90 cm length ranges from 50–110 m^3. This is equivalent to a mean annual increment of between 3 and 7 m^3/ha/year.

Begley (*op.cit.*) gives the following average outturn figures per hectare:

posts (mainly 1.4–1.6 m)	2500–5000
poles (1.0 m long)	900–2500 (bundles of 25)
pea sticks	50–100 (bundles of 25)
roundwood waste (firewood)	45–60 stacked m^3

Eeles (1949) estimated that one hectare of average coppice (12–15 years old) would yield 5000 poles 5–6 m long and of 7–8 cm diameter. One straight pole of this size yields about 10 palings.

Coppice quality

There is no system in Britain for assessing yield class of coppice crops but a recent survey has shown there is little variation in performance of Sweet chestnut coppice across Southern England. When purchasing chestnut coppice, as well as considering vigour, a buyer assesses quality visually, looking primarily at stem straightness and internode length, and average size of stem diameter, to estimate the kind of products the crop will yield. Volume per hectare influences this assessment in that a well stocked stand not only carries a larger quantity of material but tends to have a lower incidence of severe basal sweep, a detrimental characteristic of open understocked stands.

Markets and end uses

Sweet chestnut coppice has many possible uses including fence posts, fence palings, hop poles, bean sticks, hurdles, rustic furniture, corduroy roading, riverbank revetment, woodpulp and firewood. The main uses are for fencing and poles owing to the very high natural durability of the wood.

Pure coppice of other species

In Britain several other broadleaved species are coppiced and are locally significant crops although none is as important as Sweet chestnut. Table 7.2 gives data by species.

Coppicing mixed broadleaved woodland

In the past many semi-natural lowland woodlands were managed for hundreds of years either as simple coppice or coppice with standards (Figure 1.2). The neglect of regular coppicing in many parts of the country during the last 40 or 50 years has led both to much overgrown or stored coppice and to a lack of awareness of the traditional methods of management.

Quite apart from the ecological advantages of coppicing such woodland, see previous chapter (page 72), coppicing mixed broadleaved woodlands is a low input system of management which yields some produce at intervals. Resumption of coppicing, even after 50 years of neglect, is usually successful provided farmstock are excluded and other browsing pressure is only slight. Yields of the order of 3–5 tonnes/ha/year can be expected from such coppices. Sale of produce, for fencing material, firewood or pulp will normally cover the cost of the operations.

Table 7.2 Details of pure coppice (excluding Sweet chestnut and hazel)

Species	Area (ha)*	Soils and sites	Occurrence	Rotations (years)	Markets and uses**	Comments
Alder	<200	Rarely on clays. Valleys, fens and plateau sites with high water tables.	S. England especially Surrey, E. Sussex and Wiltshire.	10–20	Turnery (brush heads, chair legs).	
Ash	1747	Moist, fertile, loams, not heavy or strongly acidic.	Wales, E. Midlands especially Leicestershire and S. England especially Kent, Sussex, Avon and Gloucs.	10–25	Turnery, thatching sways, scythe and tool handles, split rails.	Rarely with standards, stools may not coppice until second season after cutting.
Birch	<500	Mainly acid, sandy heaths.	All regions of England but especially Kent, Sussex, Surrey, Hants, Berks, N.W. and E. England.	15–25	Turnery (brush heads, cotton reels), horse jumps.	Coppicing not generally important, most birch arises from natural seeding. Coppicing poor if trees over 25 years.
Hornbeam	3413	Acid soils of moderate clay content.	S.E. and E. England especially Kent, Surrey, Sussex, Herts, Beds, Essex, Suffolk.	15–35	Firewood	Often with standards.
Lime	<300	Acid soils, often loess rich over boulder clay.	Mainly Gloucs., Hereford and Worcs, Essex, Suffolk.	20–25	Turnery	
Oak	<300	Moderately acid soils, loams to clay loams.	Wales, all regions of England except N.E. but especially Herts, Sussex, Cornwall.	18–35	Fencing (round, cleft or sawn). Tanbark.	Formerly widespread, much converted to high forest by storing coppice.
Sycamore	2526	Wide range of soils.	S. England, but especially Kent, E. Sussex, Dorset and E. England.	10–20	Turnery	Rarely with standards.

* Actual figures from Forestry Commission Census of Woodlands and Trees, 1979–82.

** All species marketable for firewood and pulpwood, though some may be preferred, e.g. hornbeam for firewood, white woods for pulp.

Coppice with standards

Coppice with standards is a two-storey forest where among the coppice (underwood) some trees (standards) are grown on for larger size timber (Figure 7.4). This silvicultural system was very widely used and indeed was the legally required way of managing coppice woods in the time of Henry VIII (Stewart, 1982) when a stocking of at least 30 standards/ha had to be left. The present area by species is shown in Table 7.3

Too many standards overly shade and depress growth of the coppice and generally between 30 and 100/ha are retained depending on tree size. Standards may be even-aged but are more commonly made up of several age classes with each occupying about the same area. Standards should be evenly spaced and a typical overstorey structure is shown in Table 7.4.

At the end of each coppice rotation mature standards are felled, intermediate aged ones thinned, and new ones planted or recruited either from natural regeneration or occasionally by retaining a coppice shoot to grow on to large size (storing coppice). The length of time a standard is retained will depend on desired log size and species growth rate; oak are generally retained for 5–6 coppice cycles (100–130 years) and ash for 3–5 cycles (60–100 years).

Standards may be the same as or different from the coppice species, with the obvious exception of hazel. Ideally standards should cast only light shade, have strong apical dominance, a deep root system and thick bark. In practice, the only unacceptable species for a standard is beech because of the very

Figure 7.4 Coppice with standards; oak standards over lime underwood. (*A10579*)

Table 7.3 Area (ha) of coppice with standards in England by principal species of both coppice and standards

Principal species of standard	Principal species of coppice						Total	% of total
	Sycamore	Ash	Sweet chestnut	Hornbeam	Hazel	Other species		
Conifers	0	0	16	4	0	0	20	<1
Oak	97	173	4897	1594	1444	2728	10 933	95
Ash	8	20	0	88	21	0	137	1
Sweet chestnut	0	0	353	0	0	0	353	3
Other broadleaves	10	0	9	11	0	0	30	<1
Total	115	193	5275	1697	1465	2728	11 473	100
% of total	1	2	45	15	13	24	100	

Source: Forestry Commission Census of Woodlands and Trees, 1979–82.

Table 7.4 Traditional stocking for standards

Age class/ coppice rotation	1	2–3	3–4	4–6
Name of 'standard'	Teller	2nd Class	1st Class	Veteran
No. of stems per hectare	50	30	13	7
Percentage of area occupied	10	10	10	10

dense shade it casts, but oak is much the commonest species used (Table 7.3). Standards develop large open crowns, exhibit rapid diameter growth similar to that under free growth conditions (see Chapter 17, page 160) and reach timber size in about three to six coppice rotations. Oak standards often develop vigorous epicormic branches and unless these are pruned off or controlled in some other way high quality timber cannot be produced.

Stored coppice

Large areas of woodland are of coppice origin (Table 6.2) owing to a decline in coppicing mostly since the 1920s. Timber size material is obtainable from such woodlands but the quality may be inferior owing to (1) the tendency of decay and stain to invade the base of trees developing from stools, though this will usually not extend beyond wood present at the time of wounding, and (2) curved or swept butts (Figure 7.5).

Overall the yields from stored coppice do not differ greatly from that of a self-sown or planted crop, but the pattern of growth is different. See page 159 for yield of stored oak coppice. Storing coppice is a means of conversion to high forest (below) but it need not permanently consign a stand to high forest status since coppicing can usually be revived even after 100 years of neglect (Rackham, 1980).

Figure 7.5 Swept butts of Sweet chestnut coppice left uncut for 35 years. (*A10580*)

'Conservation' coppice

This is coppice where the main object of working is benefit to conservation. Size of coupe, cutting cycle and species (if planted) are designed to maintain structural diversity and species' richness, e.g. ensuring that all main stages of the coppice cycle are always present within a wood. The principles can be applied both to renovation of old coppices and planting new ones (Poore, 1982).

CONVERSION OF COPPICE TO HIGH FOREST

Much has been written about conversion of coppice to high forest. Today there is less pressure to attempt this change and, indeed, resumption of coppicing is one way of bringing into use poor quality woodland.

Conversion can be achieved in two main ways.

Use of stored coppice

Coppice shoots retained on a stool past the normal coppice rotation are capable of growing on to timber size. On each stool only one well formed vigorous stem should be left to grow on, all other woody material is cleaned or thinned from the stand. Where, owing to poor stocking of stools or very occasionally death of retained stems, there is no utilizable natural regrowth, enrichment with a small group of fast growing species may be attempted if the gap is very large (more than 30 m diameter). Conversion in this way should aim to leave an even spread of good stems of coppice or maiden origin equivalent to not less than half the stocking of a conventionally managed high forest stand of the same age. Subseqent thinning follows normal practice, though stems developing severe butt sweep or other basal defects should be looked for and marked for early removal.

The out-turn of saleable produce will usually pay for or even realize a profit from the conversion operations. It is a low input:low output system; subsequent timber yield is entirely limited to the capabilities of the existing species. Much oak coppice has been converted to reasonable high forest in this way, e.g. Pearson (1948); a practice which is continuing (Figure 7.6).

Figure 7.6 Oak coppice singled to one shoot per stump to convert from coppice to high forest. (*D3886*)

Establishment of a new crop

Complete clearance of old coppice using heavy machinery followed by replanting is very expensive and often damaging to the soil. The cheaper alternative is to carry out a final coppicing and then plant trees between the stools or encourage any natural regeneration. The main problem is to prevent coppice regrowth from swamping the new crop (see page 30). One option is to kill the stumps with herbicides immediately after cutting, but it is expensive, unpleasant, and difficult to achieve satisfactorily although AMS (ammonium sulphamate) and triclopyr are reasonably effective. A second and better option is to kill the fresh coppice (and the stumps) by applying these powerful herbicides or glyphosate early during the summer after the final cutting and then plant the new crop in the following autumn or spring. For details of herbicide treatments refer to Forestry Commission Booklet 51 *The use of herbicides in the forest* (Sale *et. al.*, 1983).

Where stump killing is not attempted, plant healthy transplants well furnished with roots or accept natural regeneration equidistant from and not next to stumps. Enclosure in tree shelters will aid initial growth. Control coppice regrowth once a year for about the first 2 years using glyphosate in May. Take great care to protect newly planted trees. Provided trees are given room in cleanings between the ages of four to about 10 years, what remains of the old coppice can then be cut and a reasonably well stocked crop will result. Over the next few years this new crop will begin to close canopy and shade the old coppice underneath. This will greatly reduce its vigour and in due course, provided thinning of the new crop is not heavy, eliminate it.

CHAPTER 8

Short rotation coppice

INTRODUCTION

Short rotation coppice is loosely defined as coppice worked on a cycle of less than 10 years. Several broadleaved crops are worked in this way and are conveniently divided into two groups according to end use: rural crafts and fuelwood. Both groups are of only minor significance; the rural crafts because the scale of working is small, and the short rotation coppice for fuelwood because it involves techniques that have not been fully tested in practice.

RURAL CRAFTS

In the past much underwood has been cut on short rotations to yield sticks and small poles for many different rural uses. For convenience five kinds of crops are considered:

- mixed underwood
- hazel coppice
- short rotation Sweet chestnut
- osier beds
- pollarded trees

Figure 8.1 Mixed underwood of birch, alder, hazel and sallow being cut on an 8 year rotation for bean sticks, pea sticks, hedging stakes, etc. (*A10581*).

Mixed underwood

If left undisturbed and protected from browsing almost any area of land in Britain below 300 m altitude will, in a few years, be found carrying a dense thicket often of many woody species. This is usually most profuse on recently cleared woodland, but in the lowlands generally a feature of young plantations is unwanted woody growth which often has to be cleared from the stands to release the planted trees. Such woody growth when 4–6 m tall can yield many small roundwood products: hurdles, bean and pea sticks, hedging stakes, turnery material, etc. This may be obtained casually as a by-product of cleaning operations, or areas of underwood can be worked on a regular cycle usually of about 8 years, Figure 8.1.

Although traditionally winter work, cutting may be done at any time of the year. It is done by hand and in the course of working a skilled operator selects, cuts and sorts the material for many different end-uses.

Hazel coppice

In the past, hazel was a valuable shrub in temperate regions providing firewood and food, and satisfying numerous rural needs for long, flexible, small diameter sticks for wattle and daub plaster work, thatching, crates, hurdles, garden fencing, barrel hoops, etc. A full account of the hazel coppice industry in the 1950s will be found in Forestry Commission Bulletin 27 *Utilisation of hazel coppice* (Anon., 1956).

Since 1956 the area of worked hazel coppice has declined from about 60 000 ha to no more than about 3000 ha (Table 6.2). A large area of unworked hazel exists and if markets reappear such crops can be brought back into production provided the last coppicing was less than 40 years before; stools neglected for longer than this rapidly die. However, as noted in Chapter 6, since the option of storing coppice does not exist for hazel, coppice conversion to high forest is expensive, especially if there are no standards to be harvested.

Figure 8.2 One-year-old hazel coppice under oak standards. (*A10582*)

Hazel is usually grown as coppice with standards (Figure 8.2) and is ideally worked on 7–9 year rotations yielding shoots 4–5 m long. Cutting may be carried out at any time but winter working, when the wood is drier, is preferable for hurdle making.

Regrowth of coppice after cutting is profuse but not especially vigorous and must be protected from browsing. Where fencing cannot be done, heaping brushwood over the stool will give some protection to the young shoots (Figure 8.3). Growth rate of hazel is similar to young coppice of oak or lime but declines rapidly after 15 years. On fertile sites and with a stocking of 1500 stools/ha yields of oven dry wood are about 25 tonnes at 10 years and 45 tonnes at 15 years.

Figure 8.3 Brushwood covering hazel coppice to afford some protection from browsing animals except muntjac. (*A10583*)

Hazel coppice is likely to continue as a minor underwood crop owing to the steady demand for hurdles for garden fencing and thatching spars. About 5000 houses are thatched each year and on average 3000 spars are used per house. This requirement for 15 million spars (1 m long) can be provided from about 1500 ha of hazel.

Short rotation Sweet chestnut

A minor but specialized market exists for walking sticks cut from Sweet chestnut as only this species is acceptable for sticks used in hospital practice (BS 5181, 1975). The market requires material in clean 1.2 m lengths with a base diameter ranging from 2.4 to 3.2 cm depending on grade of stick. Crops are normally worked on a 3-year rotation, though 2 years is sufficient if summers are sunny and warm.

Osier beds

Although not traditionally considered as forestry, growing willows for osier wands for basketry is a long practised system of short rotation coppice – see Stott (1956) for a general account. Cultivars of two willows, *Salix triandra* and *S. viminalis*, are used. A bed is established on deep ploughed and well harrowed ground using sets 30 cm long and spaced at 30 × 60 cm to give a stocking of 55 000/ha. Each year the slender shoots, 2–3 m tall, are cut between November and March. Differences in processing the long flexible withies give the range of colours from white to brown.

In Britain only about 150 ha is under osier cultivation and is now entirely restricted to the moist, rich alluvial soils in parts of the Somerset levels.

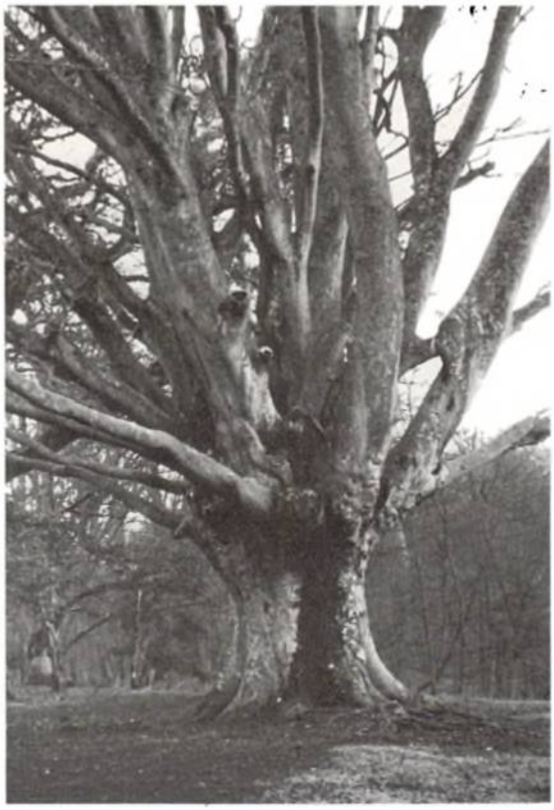


Figure 8.4 Beech pollard in the New Forest. (*A10584*)

Pollarded trees

Pollarding is the same as coppicing in all respects except the new shoots emerge on the top of a short trunk 1.6–3 m high rather than at or near ground

Figure 8.5 Pollarded poplar used as shelter around a hop field. (*A10585*)

level. The shoots at this height escape browsing, especially by cattle and deer, and in the past pollarding was a widespread alternative to coppicing and accounts for the multi-stemmed habit of many older trees, e.g. in the New Forest (Figure 8.4).

Today pollarding is restricted mainly to riverside willows, mostly *Salix alba*, though a similar operation is sometimes applied to trees to improve the side shelter they give by stimulating new branches all along the bole, e.g. poplars around hop fields (Figure 8.5). Of course, identical effects are often seen in towns when crowns of street or garden trees are severely reduced or completely removed.

If new pollards are planned they should be kept as low as possible (boles rarely need be more than 2 m high) to ease the strenuous work involved. For willow a stout, straight, live branch is inserted into the riverbank and left to root and become established. After two or three years the top is cut off (polled) at 2 m above ground. A profusion of shoots arises the following spring. As with coppice these will grow to utilizable size in 5–10 years. Poles can be regularly harvested in this way for at least 100 years.

FUELWOOD

In many countries wood is the most important fuel but in Britain, with reserves of coal, oil and natural gas, it provides less than one per cent of our energy. Most is used in stoves or boilers for estate or domestic purposes with wood supplies coming from thinnings, residues from felling, or slabwood from sawmills. Two related developments may increase the use of wood for fuel and lead to tree planting for this purpose.

1. *Firewood coppices.* Rising fuel costs, ideas of self-sufficiency, and unavailability of gas and electricity grid supply in some remote places are renewing interest in working existing coppices and establishing new ones for firewood.

2. *Energy crops.* Owing to the finite size and eventual exhaustion of fossil fuels consideration is being given to alternative, especially renewable, energy sources: growing woody material on very short rotation coppice systems is one possibility.

Firewood coppices

Growing one's own energy is an attractive prospect and planting trees is one obvious way. However, wood is not necessarily an easy or cheap alternative to other fuels and several factors must be considered.

Quantity of fuel needed

Heating a three-bedroom house consumes about 130 GJ of energy per year which equates with the following amounts of fuel:

36100 kwh of electricity
1230 therms of gas
2.7 tonnes of domestic heating oil
4.3 tonnes of coal
8 tonnes of air dry wood
7 tonnes of oven dry wood

Stacking space for drying wood

Burning wood which has a high moisture content is inefficient yielding little heat and causing tar deposits in the stove and flue. The moisture content needs to be less than 20 per cent, thus no freshly felled or green timber should be burnt; even the moisture content of ash is over 30 per cent when felled.

The moisture content of wood is reduced by cutting it into lengths suitable for burning, splitting and then stacking in a dry place with good air circulation, e.g. a lean-to shed beside a house. The amount of space needed per tonne of air dry wood (17–18 per cent moisture content) will depend on wood density. Less dense woods, such as poplar, willow and most conifers with a specific gravity of about 0.35, occupy about 2¼ m^3 of space/tonne, dense woods such as beech, hornbeam and oak, with specific gravity of about 0.5 occupy 1½ m^3 of space/tonne.

For air-drying wood, at least 6 months should be allowed between felling and burning, though for species such as elm a year is necessary.

Land needed

In working existing woodland, which will consist of native or long naturalized species (oak, ash, Common alder, hornbeam, Sweet chestnut, lime, sycamore, birch) an annual increment of 2–3 tonnes of air-dry wood/ha can be assumed from a 10-year cutting cycle. Thus to produce annually 8 tonnes of air-dry wood 3–4 ha of coppice is needed with about one-third of a hectare being cut each year. Higher productivities, up to 6 tonnes/ha/year, are obtainable with willows, poplars, exotic alders, Southern beech and eucalypts, but in almost all cases a new coppice will need to be established.

Establishing a new coppice

Conditions on the site available will influence which species can be planted, but for fuelwood production achieving rapid growth is essential. Although experience in Britain with the more rapidly growing exotic broadleaved species as coppice crops is limited, there is evidence of their ability to coppice and to produce substantially greater yields than the more common broadleaved species. The species in Table 8.1 are suggested for firewood coppices for those who are prepared to take the risks involved in trying new techniques.

The much commoner broadleaved species mentioned earlier can also be used and though slower growing are more useful for conservation purposes.

On heathland sites in lowland areas cultivation and fertilisers are beneficial; very limited experience suggest that birch, Sweet chestnut, Southern beech and eucalypts are the most likely candidates.

On moist upland sites only birch or sycamore should be tried.

Removal of competing vegetation should be undertaken, preferably with a herbicide before planting. This could be a total or spot treatment. The method of weed control to be used after planting will influence the spacing adopted and must be decided before planting commences.

Healthy plants, well furnished with roots, and between 0.5 and 1 m in height should be planted into clear ground at 2.5 or 3 m square spacing. The ground should be weed free so that early growth is assured. Control of competing weeds should be maintained to ensure continued vigorous growth of the trees until vegetation is suppressed after the first cutting cycle. Newly planted trees are vulnerable to damage from livestock, rabbits, hares and deer, and fencing or individual tree protection may be necessary.

When to cut coppice

When establishing a firewood coppice newly planted trees should not be cut until there is material

Table 8.1 Choice of species for firewood coppices

Site	Name	Species or variety
Stream and pond sides	Willow	*Salix alba* and cultivars *Salix fragilis*
Moist but well drained	Alder	*Alnus cordata** (calcareous or neutral soils) *A.incana* or *A.rubra* (other soils)
	Poplar	*Populus nigra* *P. x euramericana* cultivars *P. trichocarpa* 'Fritzi Pauley' *P. trichocarpa* 'Scott Pauley'
Well drained fertile lowland sites. Avoid frost hollows.	Eucalypts	*E.gunnii, E.nitida*
	Southern beech	*Nothofagus procera* in the west *N. obliqua* in lower rainfall areas (but not East Anglia)

* Coppicing ability variable.
From Crowther and Patch (1980).

suitable for the fire. Depending on species and site this may be between 7 and 10 years, by which time trees should have developed a reasonable basal stump. Coppice regrowth from the stump will usually be more vigorous than the original seedling crop.

The interval between cutting firewood coppice crops, the coppice cycle, will be 6–10 years and should be fixed to yield material convenient for manual handling and conversion, typically stems 6–8 m tall and 7–10 cm in diameter. Production of suitable poles will be achieved a year or two earlier if the number of shoots on each stool is reduced to about five in the second year after cutting. This concentrates growth on a small number of shoots.

Regular coppicing in this way can be carried on indefinitely and yield per unit area maintained provided dead stumps are replaced by new plants or by layering.

Energy crops

In many countries trials are under way to assess the potential of tree crops as a large scale renewable energy source. The need for fully mechanized harvesting, producing woodchips, repeated cuttings, and obtaining maximum yields using all above

Figure 8.6 One-year-old poplar coppice. (*A10586*)

ground woody material, has led to research into measuring productivities of vigorously coppicing broadleaves, planted at close spacing (0.3–1.5 m) to give 4000–100 000 stems/ha, and cut on cycles of 1–5 years. Several trials are established in Britain and include alders, birches, eucalypts, poplars, Southern beech, and willow (Figure 8.6).

On fertile sites yields from such energy crops achieve about 10 tonnes/ha/year 5 years after planting and may reach 11–15 tonnes/ha/year on a 3–4 year coppice cycle (Cannell, 1982). As well as energy from the wood it has been suggested that the foliage could be used for fodder.

Energy crops are unlikely to become widespread in Britain since large tracts of fertile land are unavailable.

OTHER WOODLAND TYPES

CHAPTER 9

Poor quality woodland

DEFINITION AND EXTENT

Introduction

In Britain some woodland areas have little or no utilization value yet are clearly land under forest. Such poor quality woodland is defined as an inferior crop which has a poor stocking of marketable species, other than for firewood, and where more than half the trees are of poor form or defective. This definition equates with the 'scrub' category used in the 1979–82 Forestry Commission Census of Woodlands and Trees. Poor quality only indicates poor timber potential and does not imply that the woodland is low grade or unsatisfactory for any other purpose such as landscape, amenity, conservation or sporting. Moreover, poor quality status rarely need be permanent since the condition is often due to past treatment, such as war-time fellings or creaming of high quality stems, rather than an inherently poor site.

Some specific woodland types, considered elsewhere, may often fall within this definition of poor

Figure 9.1 Poor quality woodland – low stocking of poorly formed trees. (*A10587*)

quality, most notably upland woods (Chapter 10), farm woods (Chapter 12) and urban woods (Chapter 16).

Characteristics

The low timber potential of poor quality woodland is due to one or more of the following characteristics.

Poor stocking

The crop does not make full use of a site's timber growing potential because there are few marketable trees per hectare (Figure 9.1). Woodland is substantially understocked if the distance between potentially usable trees is more than average tree height. The following guide is used by the Forestry Commission for classification as scrub (Simpson, 1974):

a. for growth up to 50 years old – fewer than 300 utilizable stems/ha.
b. for growth over 50 years old – fewer than 150 utilizable stems/ha.

Poor form and other defects

More than half of potential timber trees do not have a reasonably straight, defect-free butt of at least 3 m length. Crop typically has mainly crooked, twisted, forked, stunted, damaged or defective trees.

Unmarketable species

More than half the crop, especially in thicket stage, consists of species such as dogwood, elder, Field maple, hazel, holly, rowan, sallow, thorns, and whitebeam (Figure 9.2). Much poor quality woodland contains a mixture of species whereas predominance of a single species is one sign of recent management or plantation status. However, presence of many species is not itself a disadvantage unless (1) there are few readily marketable ones such as ash, beech, cherry, elm, oak and sycamore, or (2) local markets do not exist for lesser species which may dominate such as alder, birch, hornbeam and lime.

Figure 9.2 Poor quality woodland – thorn, bramble and open ground with few marketable species. (*A10588*)

Five other characteristics, which reduce marketing potential, tend to be associated with poor quality woodlands: (1) unmanaged condition – no fences, overgrown rides; (2) a range of tree sizes and age-classes – notably presence of an occasional overmature tree of poor form; (3) small size; (4) poor access to the wood; (5) uncontrolled browsing.

Extent and composition

The total area of poor quality woodland (scrub) is nearly 150 000 ha (Table 9.1), which represents 20 per cent of all broadleaved woodland (Table 1.1). Most, of course, is not covered by any form of management plan and consists of numerous small woods.

The principal species are shown in Table 9.2. Birch is the most widespread scrub species accounting for 40 per cent overall, and more than two-thirds of such woodland is in Scotland. More than one fifth of all poor quality woodland is dominated by hawthorn, sallow or elder.

Table 9.1 Area (ha) of poor quality woodland by region and ownership

Region	Ownership			Total
	Forestry Commission	Private		
		Dedicated and Approved	Other	
S. England	1 420	3 211	43 218	47 849
N. and E. England	590	3 138	27 921	31 649
Wales	1 017	447	6 758	8 222
Scotland	2 724	6 006	51 785	60 515
Great Britain	5 751	12 802	129 682	148 235

Source: Forestry Commission Census of Woodlands and Trees, 1979–82.

OTHER VALUES OF POOR QUALITY WOODLAND

Poor quality woodlands occupy a significant area which, along with their great number, location, characteristic diversity of tree species and sizes, and perhaps even lack of management, often confer on them high conservation, landscape and sporting value. Indeed, the characteristics which downgrade their importance as a timber crop are those commonly equated with such values (Peterken, 1981).

These non-timber values need to be carefully borne in mind when handling poor quality woodland and are considered generally along with other woodland types in Chapters 13 to 15.

SILVICULTURE

Before applying any silvicultural prescription to poor quality woodland, clear management objectives should be set, even if it is a positive decision to

Table 9.2 Area (ha) of poor quality woodland by principal species

Species	Region				Great Britain
	S. England	N. & E. England	Wales	Scotland	
Alder	1 912	2 824	1 375	2 254	8 365
Ash	5 968	1 308	224	376	7 876
Beech	672	103	38	257	1 070
Birch	11 174	9 216	1 128	41 743	63 261
Hazel	4 142	1 029	965	2 423	8 559
Hornbeam	291	109	10	0	410
Oak	11 135	1 433	1 382	4 103	18 053
Sweet chestnut	240	16	0	8	264
Sycamore	1 292	619	82	374	2 367
Willow	617	3 388[1]	367	594	4 966
Other broadleaves[2]	9 636	11 550	2 646	6 765	30 597
Conifers	770	54	5	1 618	2 447

[1] mainly in E. England
[2] mainly hawthorn, sallow or elder

Source: Forestry Commission Census of Woodlands and Trees, 1979–82.

do nothing for the time being. Casual neglect of poor quality woodland is widespread; for example Towler and Barnes (1983) report that 75 per cent of all small (<10 ha) non-commercial woods in Norfolk are neglected by their owners. Such neglect avoids rather than solves the problem of what to do, and indeed may lead to further decline and loss of value.

Silvicultural decisions about woodland can only be taken if its condition is known. Obtaining information about size, stocking and species is a preparatory step both to setting objectives and deciding silvicultural treatment. The outline of procedures described in Chapter 1 (page 8), which is applicable to all small woods, should be used.

Clearance for agriculture

One option, applicable in a few instances, is to clear very poor quality woodland for agriculture. Such action may be subject to legislation, e.g. Tree Preservation Orders, status of site as of special scientific interest (SSSI) or location in an area of outstanding natural beauty (AONB). Withdrawal of land from wood growing potential can rarely be justified on silvicultural grounds.

Silvicultural options

Low potential yield class is not a characteristic of poor quality woodland. In the lowlands especially, many scrub woodlands are on fertile sites as shown by high yield classes in adjacent stands or when scrub is cleared and replanted, e.g. Table 9.3. Thus most poor quality woodland has considerable silvicultural potential.

Two factors primarily determine what silvicultural treatments may be most appropriate: (1) the condition, including age, of the woodland (referred to earlier) and (2) the level of inputs available (finance, labour, etc.). The flow chart in Figure 9.3 shows this and how it leads to choice of possible silvicultural treatment. Five main options are shown, indicated by a capital letter, and consideration of each in detail forms the rest of the chapter. Of course, for any one woodland more than one treatment may be appropriate or treatments may be combined.

The analysis of woodland condition leading to silvicultural recommendations (Figure 9.3) is based on a series of experiments, initiated after the Second World War by Lord Robinson, to devise ways of rehabilitating what was then called 'derelict woodland' (Wood, Miller and Nimmo, 1967). In the six main experiments stand development was followed for a period of 25 years after the treatments were first laid down, data from three of them are summarized in Table 9.3.

The treatments below relate directly to the silvicultural alternatives indicated in Figure 9.3.

C – Coppicing

Almost all broadleaved species coppice vigorously – see Chapters 6–8. A ready market for firewood and hardwood pulp can make the operation profitable and it is a simple way of coping with poor quality woodland. However, no stand improvement is effected, the prospects for creating high forest by storing coppice stems of the best species are uncertain, and it is only feasible if tree species predominate, i.e. it is an unsuitable treatment for poor quality woodland mainly consisting of species such as elder, sallow or thorns.

Where expenditure must be severely limited and care of the stand likely to be only intermittent, working the woodland on a coppice cycle as a whole, or preferably in three or four compartments at different stages of the cycle, can be the best management choice. Input is low, some return can be expected at each coppicing, working is concentrated as much as possible, and ecologically the practice has many advantages. It is well suited to small woods of mixed tree species in relatively inaccessible places.

E – Enrichment

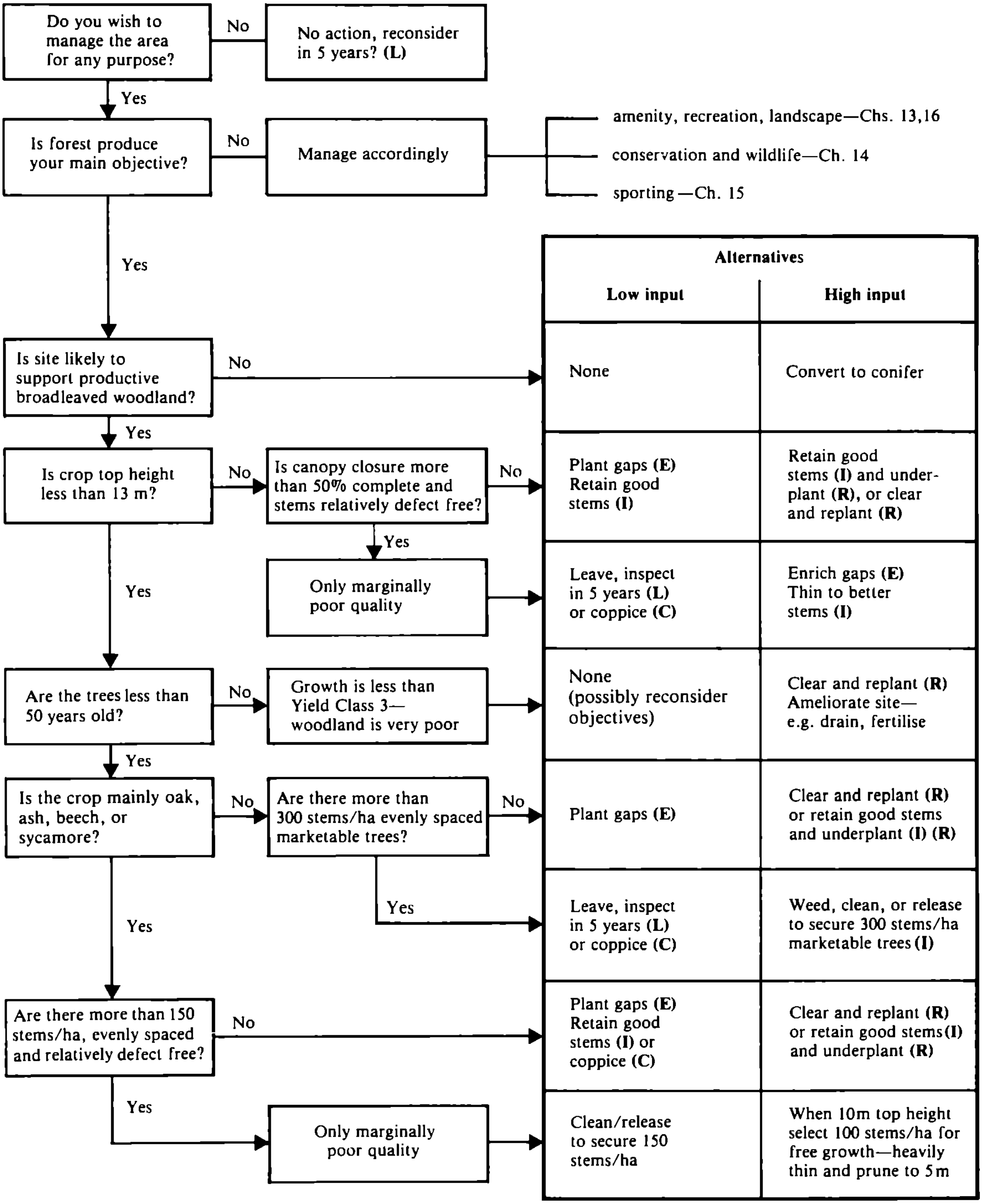
Enrichment involves planting extra trees in a stand to increase the stocking of utilizable ones. It can be an important silvicultural technique because many poor quality woodlands have gaps and bare areas. Care must be exercised before choosing this option to ensure:

1. adequate protection and post planting attention can be given to individuals or groups of planted trees;
2. the gap is large enough to merit enrichment and will not be occluded by existing adjacent trees in less than 10 years;
3. that in older stands the two storey structure which results from planting gaps or swathes is an acceptable silviculture for long-term management.

If the above criteria cannot be satisfied enrichment should not be attempted.

Enrichment techniques in poor quality woodland differ little in practice from their formal use in broadleaved high forest to supplement natural regeneration.

Figure 9.3 **Silvicultural options for treating poor quality woodland**



Note: C—coppice, E—enrichment, I—improvement, L—leave, R—replacement.

Table 9.3 Summarized results of three rehabilitation experiments

EXPERIMENT: Alice Holt 24/54 in Cathams Copse, Hampshire.

Site: 100 m a.s.l. N. facing 5° slope. Soil: Silty clay overlaying gault clay.

Condition of woodland before treatment: Oak standards recently felled leaving 18-year-old hazel and ash coppice with a few Field maples; some oak regeneration.

Treatment	Silvicultural option (Fig. 9.3)	Crop after 24 years			Input*			Comments
		Species	Basal area (m^2/ha)	Yield class	EST (manhours/ha)	MNT	REL (%)	
1. Retain promising oak, replant remainder with oak:NS 3 row:3 row mixture	I+R	oak oak (planted) NS	<3.0 7.7 14.9	 8 18	753	380	91	Retained oak poor and stag-headed and caused one-third loss in basal area growth of planted crop compared with treatment 4.
2. Strip felled leaving 3m wide 'hedges' every 16m. Replant with oak:NS as 1 above.	E	hedges oak NS	— 10.4 11.6	 8 18	716	435	93	More oak than in 1, perhaps due to side shelter from hedges, but loss of yield still evident compared with 4.
3. Thin heavily. Underplant with alternate rows of Be:RC. Shade felled after 5 years.	I+R	Be RC	25.4 10.5	10 18	673	626	105	Resulted in good beech crop. Initially cheapest option but later removal of overstorey was time consuming and costly. Many RC suppressed.
4. Clear and replant with oak :NS 3 row:3 row mixture	R	oak NS	11.4 18.0	8 18	814	427	100	Well stocked. Planted oak in this and other treatments only moderate form.
5. Untreated control	L	oaks ash other	6.2 12.6 9.6		0	0	0	Only suitable for firewood/ pulpwood. Very few trees of good form of timber potential.

Summary All treatments have improved the crop but at great expense. There was little merit in retaining 'hedges', odd stems, or dappled shade. Doing nothing has only produced a low value crop which now could be cleared at profit. Net cost of initial clearance, after deducting revenue from sale of produce, was £59/ha.

* See footnote on p. 97.

Table 9.3 – *continued*

EXPERIMENT: Dean (Flaxley) 1/57 at Edgehill, Gloucestershire.
Site: 100–140 m a.s.l. NE aspect 15° slope. Soil: Fertile loam of pH 4.5–6.0. Part old red, part calcareous sandstone. Condition of woodland before treatment: Mostly dense woodland of 8–12 m height, basal area of 23 m^2/ha, and volume of 94 m^3/ha. High proportion of lime and birch with a few sycamore, alder, ash and Sweet chestnut.

Treatment	Silvicultural option (Fig. 9.3)	Crop after 24 years: Species	Basal area (m^2/ha)	Yield class	Input*: EST (manhours/ha)	MNT (manhours/ha)	REL (%)	Comments
1. Clear and replant with oak:EL 3row:3row mixture. Thin to favour oak.	R	oak EL	7.8 13.5	8+ 12	377	138	91	After 18 years selected oak given free growth, hence low basal area.
2. Clear and replant with DF	R	DF	38.7	24	377	188	100	Highly productive, some thinning around single trees.
3. Thin heavily to better stems and underplant with WH. Overstorey felled after 7 years.	I+R	WH	44.2	24	282	103	68	Highly productive, unthinned.
4. Thin heavily as 3 and underplant with Southern beech. Overstorey felled after 5 years.	I+R	*N. procera*		19	329	90	74	One of the best stands of Southern beech.
5. Control, untreated for 7 years then cleared and enriched.	L	1. Clearance after 7 years yielded 145 m^3/ha, i.e. an increase of 51 m^3/ha. Coppice MAI 7–8 m^3/ha/year. 2. Enrichment with *A. matsumurae* failed. Current basal area after 18 years is 20.2 m^2/ha.						

Summary All treatments have produced highly productive crops. Relatively low maintenance expenditure because of rapid establishment of vigorous crops. Most interesting data concern costs and returns of clearance – treatments 1 & 2 yielded £4.80/ha surplus when done; 3 & 4 £30–60/ha surplus from clearance and removal of overstorey; and 5 £274/ha surplus when cleared 7 years after the rest of the experiment was begun.

Table 9.3 – *continued*

EXPERIMENT: Queen Elizabeth (Hursley) 1/54 in Ampfield Wood, Hampshire.
Site: 40 m a.s.l. N aspect 5–10° slope. Soil: Silty brown earth, clay loam texture overlaying London clay.
Condition of woodland before treatment: Previous good oak heavily cut in Second World War leaving a few poor pole-stage oak and ash (6–10 m tall) with hazel understorey and some oak natural regeneration (1–2 m tall).

Treatment	Silvicultural option (Fig. 9.3)	Crop after 27 years			Input*			Comments
		Species	Basal area (m^2/ha)	Yield class	EST (manhours/ha)	MNT	REL (%)	
1. Clear and replant with oak:NS 3 row:3 row mixture	R	oak NS other	6.0 15.0 4.1	8 18	568	442	93	One row in three of NS thinned at 25 years, add 6.0 m^2/ha to basal area. (Figure 5.3).
2. Clear and replant with DF	R	DF	29.0	14	543	541	100	Patchy stocking, poor growth. Much beating up done.
3. Accept promising regrowth, enrich gaps with large oak.	E	oak ash other	7.4 5.3 7.8	8	62	163	15	Variable plots but acceptable crop created at little expense – see Figure 9.5
4. As 3 but enrich with EL	E	oak EL other	8.2 1.8 15.9	8 8	63	257	24	EL enrichment not very successful, much beating up with various other conifer species.
5. Untreated control	L	Basal area of 33.5 m^2/ha of oak, ash, birch and other species. Data from only one plot therefore not strictly comparable.						

Summary Conversion to conifer expensive. Satisfactory crop produced by accepting existing regrowth and enriching.

Notes: Treatments were usually replicated three times in experiments.
* Input column: EST = establishment, MNT = maintenance operations, REL = relative input compared with clear and replant option. Though machines and methods have changed since laying down experiments the manhour data still indicate the relative order of inputs needed. Species: Be = beech, DF = Douglas fir, EL = European larch, NS = Norway spruce, RC = Western red cedar, WH = Western hemlock.

Method of enrichment

There are two main approaches.

1. Opportunity planting – accept the bulk of existing crop and plant in gaps and poorly stocked areas where they occur. Gap (glade) diameter should be at least 1½ times the height of the tallest nearby trees.
2. Partial conversion – reject existing crop and systematically plant in swathes cut at intervals to produce strips of 'better' forest interspersed with whatever develops from the poor quality woodland.

The second approach usually requires much greater expenditure than opportunity planting but, while falling short of full replacement (below), it does maintain forest cover and woodland appearance. However, costs are less than full conversion only if swathe clearance involves less than 50 per cent of the stand. Moreover, if the uncleared strips contain vigorous trees their crowns may rapidly expand and shade the new plantings. As a rule swathe width must be at least equal to the height of adjacent trees, with 4 m as a workable minimum.

Choice of species

Normal criteria apply, though rapid early growth is particularly important because of competition from vigorous coppice. Norway maple, Southern beech and sycamore are all promising, though oak and beech in tree shelters may also be satisfactory. Western hemlock and Western red cedar are generally the most useful conifers.

Planting and maintenance

Plants need to establish quickly and grow vigorously to compete with weeds and the coppice which come up in a gap or newly cut swathe. Large healthy plants (2 m tall) can be very successful provided they are well furnished with roots. The use of transplants enclosed in tree shelters (see page 40) now appears the most promising possibility (Figure 9.4). No intermediate yields are expected from enrichment and plants are best spaced 3–4 m apart or three or four per 0.01 ha of gap.

All enrichment techniques require regular attention to ensure that the introduced trees are not

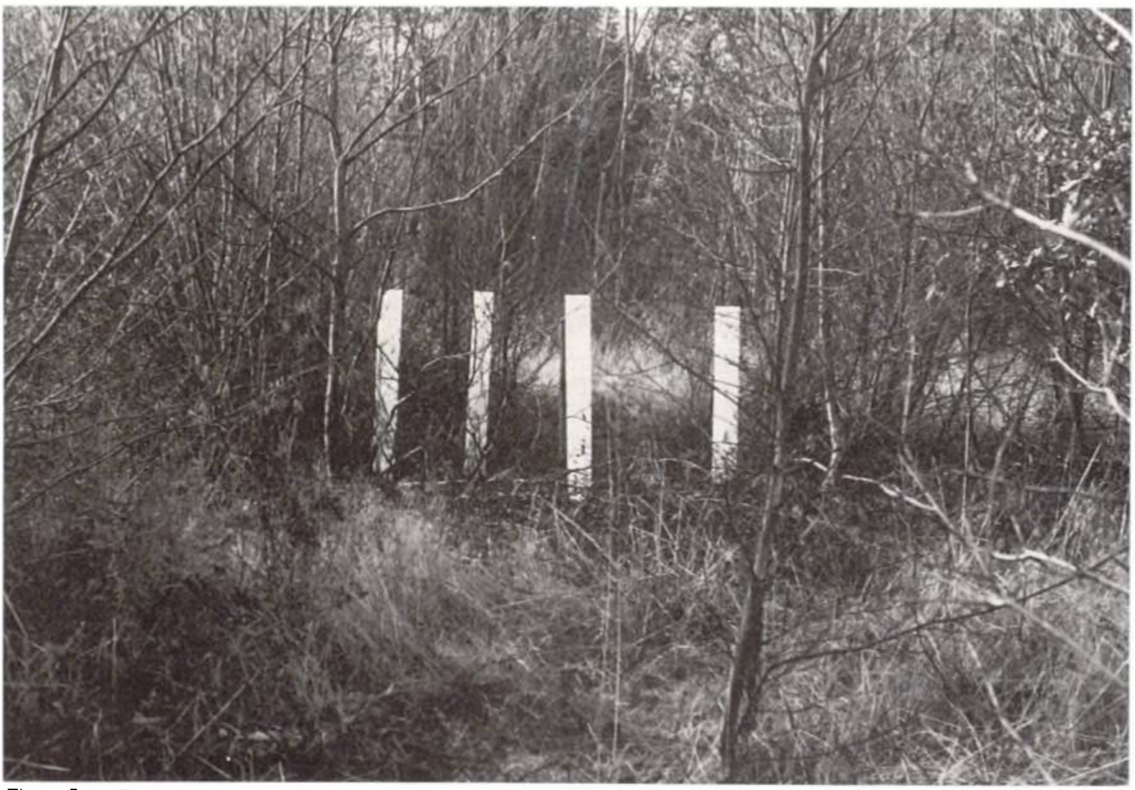


Figure 9.4 Enriching poor quality woodland with a group of trees planted in tree shelters. (*A10589*)

suffering from competition. Intensity of regrowth and crown expansion of remaining trees determine the need for cleaning and release. Regular execution of these operations cannot be stressed too strongly if the initial outlay on enrichment is not to be wasted. For example the scrub next to the trees in Figure 9.4 will almost certainly need cutting back during the next growing season.

Use of enrichment

Opportunity planting using transplants in shelters is presently the most attractive treatment. It is relatively inexpensive and provides full protection of planted trees which can be readily identified.

Partial conversion is generally found less satisfactory owing to expense, risk of stripy appearance, and relatively poor basal areas achieved, see Table 9.3.

I – Improvement of existing stand

The first essential point is that there must be something worth improving; the initial inspection will show whether this is so. Improvement seeks to build on what is already present; it is only worth investing future increment on good, defect-free stems of marketable species of final crop potential.

Improvement has three components: (1) a decision to accept certain stems, (2) securing their future by release cleanings and thinnings, and (3) pruning to remove side branches or singling forks.

Acceptance of stems

Where trees are past the thicket stage, stems should be considered individually and judged according to species, form and freedom from defect. Accepted trees should be marked to help identify them for subsequent treatment (below). If the poor quality woodland consists of pre-thicket stage regrowth the main consideration is the stocking of acceptable species.

Securing a crop

This is the main expense involved in the improvement option. Because, unlike a plantation, choice of final crop tree is severely limited, trees which are accepted as suitable must be directly favoured in cleaning and thinning. The object is to obtain at least 100 trees/ha of marketable potential. The recommended silviculture is a form of final crop selection with partial free growth. In pole-stage crops and older (more than 10 m top height) the most profitable course is often to thin out all material except the selected stems. Thus a single operation fully releases the trees which will need no further thinning, while sale of the large quantity of produce usually more than pays for the operation.

In woodland between thicket and pole-stage, trees should be inspected and tending operations carried out at least once every 4 years. Climbers should be cut or removed and all competing shrubs and trees cut to allow complete crown freedom of the selected tree.

In thicket or pre-thicket stage regrowth on a former woodland site, a utilizable crop will usually develop without the need for cleaning unless the site is subject to invasive weeds such as clematis, rhododendron, or vigorous bracken.

Pruning

Not essential. It is useful: (a) for upgrading marginal quality stems, e.g. by singling, which are needed to increase stocking of a poor area, and (b) to improve stem quality of accepted trees which are already being favoured. It may be necessary to control epicormics following release.

Experience with improvement

Improving poor quality woodland as described can be a cheap and effective silvicultural treatment – see Queen Elizabeth experiment in Table 9.3 and Figure 9.5. Necessarily only the naturally occurring species can be grown but, accepting this limitation, surprisingly few poor quality woodlands are entirely devoid of improvement potential. Moreover, in many stands the costs of the work can be fully recouped if there is a market for pulpwood, firewood, or posts and rails (Figure 9.6).

L – Leaving : positive non-intervention

This option should only be taken after careful consideration, i.e. positive non-intervention. *Woodlands do not benefit from prolonged neglect* and a decision to leave should not be equated with abandonment. Figure 9.3 suggests a review 5 years after the original decision to leave. Three factors may lead to choosing this option.

Condition of woodland

There is never any point in treating woodland just for the sake of it, and previously well managed woods can usually survive a decade without any attention. A stand may be left provided it is not 'going back' (crown dieback, defective stems, overmaturity, browsing damage), and potential crop trees are not being suppressed, and human safety is not at risk.

Figure 9.5 Final crop trees of acceptable form and species secured by heavy thinning in a poor quality woodland which had received some limited enrichment – treatment 3 in Queen Elizabeth experiment, see Table 9.3 (*A10590*)

Where natural regeneration is satisfactory or the crop at the thicket stage, nothing may need doing for 10 or 15 years. This is illustrated by the change between 1965 and 1980 in the amount of woodland classified as scrub which in S.E. England fell from 30 down to 12 per cent of all woodland (Forestry Commission Census of Woodlands and Trees, 1979–82). Many such areas resulted from wartime and immediate post-war fellings which, when last assessed in the early 1960s, were naturally developing thickets 10–20 years old. Since then improvement in quality and stocking, partly by replanting and partly by colonization and natural development, has brought much 'scrub' into the high forest category. This effect is also evident to some extent in the untreated controls (treatment 5) in Table 9.3.

Conservation reasons

As noted at the beginning of the chapter, many poor quality woodlands have high conservation value. Where the need to obtain financial return from the woodland is not pressing there are benefits in identifying or classifying it as of potential conservation interest, see Figure 14.1 for conservation assessment. Even if its size, location or species composition may not lead to formal recognition as a nature reserve or Site of Special Scientific Interest, certain management practices can enhance wildlife value (Chapter 14) and often local conservation bodies (e.g. British Trust for Conservation Volunteers) are willing to assist in such work.

Economic reasons

The low commercial value of poor quality woodland is often partly due to poor access. Thus, where there are no other pressing reasons or liabilities, careful timing of operations to coincide with a good market for produce to maximize revenues may mean the difference between substantial outlay and showing some profit. A few years' delay can be rewarded in this way, e.g. Dean experiment in Table 9.3, but to take advantage of it an owner or agent must be constantly aware of market trends; it should not be an excuse for neglect.

Figure 9.6 Woodland, recently given a heavy pulpwood thinning, which had formerly been classified as scrub and remained untouched since being cleared during the First World War. (*A10591*)

R – Replacement

Replacement involves removing the poor quality woodland and planting a new crop, though complete removal may not always be done and a light scattering of the former crop left, technically making the replacement crop an underplanting.

The replacement option may be chosen if the existing stand has few or no trees of final crop potential (Figure 9.2) or if it is desired to increase substantially the yield class by planting high yielding species, such as Southern beech, or conversion to conifers. This latter course is no longer pursued by the Forestry Commission, the policy being to retain the essential character of any broadleaved woodland.

Replacement has two phases, removing the existing crop and planting the next.

Removing existing poor quality crop

Two options are possible: complete clearance, and killing scrub with herbicide. Complete clearance using heavy machinery is straightforward and easy to supervise. The work can be done by contractors sometimes at little or no cost if they can profit from sale of small-sized material, pulpwood, firewood, mining timber, etc., obtained from the site. Without this outlet clearance can be very expensive, costing several hundred pounds per hectare. Other disadvantages include compaction of soil if machinery is used, exposure of soil surface, encouragement of vigorous weed growth, and increased surface wetness which can make conditions difficult on heavy soils. If clearance is limited to cutting, stump regrowth must be controlled chemically (see page 30).

Killing scrub with herbicides is relatively cheap but will often conflict with amenity/conservation interests. It should only be attempted at the pre-thicket to thicket stage. Treat area with foliar spray of glyphosate in the summer prior to planting. Any larger stems can be killed with ammonium sulphamate (AMS) applied to a frill cut around the stem; this should be done at least 3 months before planting. For details refer to Forestry Commission Booklet 51 *The use of herbicides in the forest* (Sale *et al.*, 1983).

Planting

Normal species selection criteria apply but two special factors must be borne in mind in replanting poor quality woodland sites:

1. there may be a high incidence of Honey fungus;
2. weed growth will be profuse.

Use plants well furnished with roots to ensure a good take, and control all weed/coppice growth within one metre radius. Early growth will usually be enhanced by tree shelters.

Use

Crop replacement was much practised in the past but is now less widespread owing to cost. The successor crop must be much more profitable but the undesirability, on non-commercial grounds, of generally converting broadleaved woodland to conifers rules out the traditional choice. For establishment of a pure broadleaved crop (an opportunity which replacement affords) see Chapter 3.

CHAPTER 10

Upland broadleaved woods

INTRODUCTION

In Britain there are small but significant areas of broadleaved woodland in the uplands (above 240 m) of England, Wales and Scotland and in remoter parts of the western seaboard, e.g. W. Scotland (Figure 10.1). Many such woods are considered remnants of once extensive natural forest or derived from ornamental planting, commonly of beech and pine, during the 18th or 19th centuries (Allaby, 1983). The small areas of relic woodland remaining largely escaped clearance for agriculture owing to their inaccessibility on steep slopes, glens, or wet bogs. In the past the more accessible woods were sometimes coppiced to yield firewood, charcoal for smelting, poles, wood and bark for tanning and alcohol distillation and, in the case of birch, for bobbins. The areas now remaining receive little or no management for commercial purposes though many are used to shelter livestock.

Upland woods are considered separately because, though an important feature of upland scenery, they have little commercial potential unlike most 'poor quality' woodlands in the lowlands (Chapter 9).

Figure 10.1 Oak woods near Arisaig, West Scotland. (*A10592*)

CHARACTER AND EXTENT

Characteristics

Upland woods have most of the following characteristics:

1. remote and inaccessible;
2. small size;
3. a low stocking of trees which are often overmature;
4. few trees of commercial value apart from firewood;
5. slow growth;
6. receive very little or no management, apart from those in nature reserves, but many are used by farmers to shelter livestock and supply firewood and fencing material and, for many upland birchwoods in Scotland, for wintering in commercial deer 'forests';
7. usually in areas of high scenic and hence tourist importance;
8. often in places devoid of other tree cover;
9. generally suffer intense grazing and browsing from sheep, rabbits and deer;
10. when not grazed intensively, support a rich flora and wildlife, often as oases of ecological variety in moorland.

Very little direct financial return can be expected from management of these woodlands but on every other ground it is desirable to sustain and perpetuate them as an important amenity, the principal requirement being to fence out livestock for a period of time to allow regeneration or replanting.

Woodland types

There are four main types of semi-natural woodland reflecting the dominant tree species: oak, ash, birch, or alder. Which species dominates is largely due to soil conditions.

Oak woods

These woods are widely distributed and are mostly dominated by Sessile oak though in both Wales and Scotland Pedunculate oak may also occur. In south-west England oak woods are found to an altitude of 400 m and even somewhat higher in Wales, but in Scotland they rarely occur above 200 m in the Highlands except in south-eastern parts where they may reach up to 250 m. Oak woods mostly occur on acid soils in high rainfall areas. Many other tree and shrub species will often be present and particularly at higher altitudes in Scotland the oak woods phase into areas of birch and rowan.

Ash woods

These woods are much less extensive than oak, the presence of ash only becoming important on base-rich soils or dominant on calcareous ones. Examples of ash woods are found in the Mendips, Derbyshire Dales, and parts of the northern Pennines where they occur up to altitudes of 360 m. There are few natural ash woods in Scotland.

Upland birch woods

Birch is often a successional stage between oak or pine woods but extensive semi-natural communities are found in Wales and especially in Scotland. Britain's most northerly broadleaved woodland on Hoy in the Orkneys consists mainly of birch with some rowan, willow and aspen.

In Scotland, birch woods, sometimes with an admixture of rowan, often replace oak at higher elevations and may be found up to altitudes of 600 m. Natural regeneration is often profuse at the edge of a wood and particularly where soil disturbance has occurred, but it suffers badly from uncontrolled grazing and browsing.

Upland alder woods

Alder woods are very widespread but edaphically localized to wet soils beside streams and rivers (Figure 10.2). They are typically found in upland valley bottoms and glens or on flat areas of wet ground with impeded drainage. In total their extent is not very great but they often form a small well-defined component in the other woodland types wherever soil drainage is impeded.

Other types

Other types of upland broadleaved woods were mostly planted (Figure 10.3). Those of beech, often with some Scots pine, were mainly established between 1750 and 1840 (and many in Scotland more recently) to provide shelter on exposed farms or as ornamental features. Such stands, even at elevations of 300 m, can grow to 25 m height (Brown, 1953). The use of conifer nurses to establish upland woods of what are now pure broadleaves was widespread in Victorian times (Harkness, 1983).

Sycamore begun to be planted in the 15th and 16th centuries but only came to be widely used in shelterbelts and around upland farms (Figure 10.4) from the end of the 18th century (Jones, 1945). It occurs at higher elevations than any other broad-

Figure 10.2 Common alder on Rannoch moor, Scotland. (*A10593*)

leaved species apart from birch and rowan; it is the only common tree on the shores of Caithness and is one of the few species to thrive in the Orkneys and Shetlands (Figure 20.7).

Experimental plantings and species trials are referred to later.

Extent and change

Areas and size

The exact area of upland broadleaved woods is not known though nearly all fall in the scrub category shown in Tables 9.1 and 9.2. Allaby (1983), reporting on a survey of the 12 major upland regions of England and Wales, found broadleaved woodland on farms accounted for only 1.4 per cent of all land. Other forest, which accounted for just over 10 per cent of the study area, mostly consisted of conifer plantations.

In Snowdonia semi-natural woodland covers 2.5 per cent of the land (Smith, 1983).

The size of most upland woods is small; the analysis for Snowdonia is typical – Table 10.1.

Decline

All surveys show the area of upland broadleaved woods to be declining (Allaby, 1983; Goodier and Ball, 1974; Harkness, 1983; Lindsay, 1976; Smith, 1983). All attribute the primary cause to uncontrolled grazing and browsing by wild animals and livestock which prevent natural regeneration (Figure 10.5). In Snowdonia 80 per cent by area of amenity woods (Table 10.1) had negligible regeneration, despite the fact that more than 90 per cent are dominated by mature or overmature trees, and similarly in the Lake District seedlings were common in only 8 per cent of broadleaved woods (Towler, 1980).

Figure 10.3 Old plantation of beech at 350 m altitude in the Peak District. Broken down walls have long since allowed livestock into the wood preventing any regeneration. (*A10594*)

Table 10.1 The size distribution of amenity woodlands in Snowdonia (Gwynedd County Council, 1978)

Area of woodland (ha)	Number of woodlands	Number of woodlands as %	Total area of woodlands (ha)	Total area of woodlands as %
0.5 – 0.9	467	28	313.1	6
1.0 – 1.9	520	32	706.5	13
2.0 – 4.9	431	26	1291.6	24
5.0 – 9.9	126	8	864.2	16
10.0 – 19.9	72	4	967.0	18
28.0 – 49.9	36	2	1052.1	19
50.0+	4	0	222.2	4
All woodlands	1656	100	5416.7	100

From Towler (1980).

Figure 10.4 Farmhouse in Snowdonia, N. Wales, sheltered on both sides by sycamore. Altitude 330 m. (*A10621*)

SILVICULTURE

The main object of silviculture is to perpetuate upland broadleaved woods and arrest their decline. This is ensured if enclosed by new planting but for most woods on open farmland this is not an option. As well as the high conservation and scenic importance of such farm woods, their very use as shelter for livestock and, to a lesser extent, for firewood and fencing material, demonstrates they are clearly of value to hill farming. Thus silviculture must be directed to ensure that regeneration occurs and develops.

A few upland broadleaved woods will not be in the poor condition described earlier or may be on fertile ground and therefore susceptible to other silvicultural options than simply trying to perpetuate them. The silvicultural possibilities discussed in Chapters 9 and 12 will be applicable.

Woods within hill farms and sporting estates

Several factors generally prevent successful regeneration.

1. Over-grazing and browsing. The single biggest factor preventing successful regeneration is browsing of young seedlings as they come up (Figure 10.5). Most damage is done by sheep and deer, especially red deer in the Scottish Highlands, but rabbits, hares, and cattle may be locally important.
2. Seed years are often irregular and quantities of seed very variable. This particularly affects oak; ash, birch, and alder usually seed in most years, but see also Table 5.3.
3. Unfavourable micro-site. Oak and birch often will not freely regenerate under their own canopy for reasons discussed elsewhere (page 164), thus regeneration cannot be expected in dense stands of these species. This is less of a problem in other woodland types though some canopy opening is needed for satisfactory seedling development.
4. Uncontrolled burning. Fires frequently enter woodland from adjacent moorland during spring burning. In the case of birch, regeneration just beyond the edge of a wood where it is most abundant is also at risk.

Figure 10.5 Oak wood in the Lake District completely open to livestock. No natural regeneration is possible and, unless measures are taken to exclude livestock or to plant well protected trees, the wood will eventually disappear. (*A10595*)

Regeneration may be achieved in one of three ways but an essential pre-requisite for all of them is full protection from browsing and fire.

To protect from browsing, either livestock must be excluded from the wood or young trees individually protected with robust guards or tree shelters. If the wood is used to shelter livestock, individually protecting trees or fencing off only part of the wood for regeneration at any one time allows this benefit to continue. In fact, regenerating a wood in three or four stages, over as many decades if the wood is already overmature, or on a rotational basis, is generally preferable to a single attempt over the whole wood which may fail owing to an unforeseen calamity.

Prevention of fires burning into a wood is achieved through co-operation with the owner of neighbouring land and perhaps maintaining a firebreak. A simple break can be prepared by a heavy application of lime to a strip of grassland, about 10 m wide, external to the woodland fence. Livestock, especially sheep, will be attracted to the sweet grass and maintain a close cropped sward.

Natural regeneration

This is possible in most upland broadleaved woods. If any regeneration is acceptable, in most cases protecting the area from livestock and fire is all that is needed. for regeneration of the original crop three silvicultural steps are necessary.

1. Wait for a good seed year.
2. Protect area from fires and, once regeneration is present, from livestock,
3. Following a good seed year when regeneration begins to show, open up gaps in a stand equal to about 1½ times the average canopy height. For birch some soil working may be helpful though it will seed directly into heather. Also, control of weeds will be needed if their growth is vigorous or they are very dense, e.g. bracken, rhododendron, etc.

The above procedure calls for careful timing. If there is no evidence of regeneration beginning to occur following a good seed year, recourse should be made to planting (below) so that the expenditure on protection is not wasted.

Coppice

In the past many upland broadleaved woods were coppiced but the practice virtually ceased between the two World Wars (Lindsay, 1976; Tittensor, 1970). Resumption of coppicing may be feasible provided the stools are fully protected from browsing. However, before trying this approach extensively as a means of regeneration a small-scale trial ought to be laid down first.

Little is known about growth and survival of coppice shoots on very exposed sites and where the trees/stumps may be very old.

Planting

Where other regeneration systems fail, or are unsuitable, planting to enrich a wood can be undertaken, but it is an additional expense and still requires the same level of protection as other methods of regeneration. Where planting is contemplated, enrichment of large gaps and openings with healthy individually protected trees is the best course. For woodlands of important conservation value it may be desirable to use plants raised from seed collected from trees naturally growing in the woodland in question.

Planting can recreate forest cover in denuded areas and even simulate natural woodland if the species used are indigenous to the area. This has been successfully achieved on the Isle of Rhum in the Hebrides.

Woods within plantations

Some upland broadleaved woods occur within fenced plantations. Depending on their time within an enclosure and on canopy density and structure, they are either under active successional changes including natural regeneration, or under conversion to conifers. Where conversion is in process, mostly begun 15 or more years ago, the broadleaved trees will eventually be eliminated unless specific measures are taken to maintain or regenerate them.

Most enclosed woods are no longer underplanted and the absence of browsing pressure leads to fairly rapid regeneration, usually with pioneer birch and rowan to begin with if seed sources are near. Natural regeneration of oak and ash, where this forms the overstorey, will frequently occur but may need some attention – protection from rabbits, adequate overhead light, weed control – to secure a new crop. Enclosure can aggravate problems of colonization by invasive aliens; both *Rhododendron ponticum* and beech are observed to do this (Goodier and Ball, 1974).

Experimental plantings and species trials

Many silvicultural experiments in the uplands and exposed maritime regions have included some broadleaved species. In the great majority, most broadleaved species grew very poorly and usually died within 20 years of planting, though there were some exceptions notably rowan (when included), alders and birches (see species' chapters for details). Even where survival was satisfactory, growth of broadleaves is usually much inferior to conifers; this is illustrated in Table 10.2.

One cause of poor performance of broadleaves in the uplands is exposure, and several trials have sought to overcome this by planting trees in well established young conifer stands, often by replacing alternate rows. Some improvement in survival and growth occurred, see the account by Stewart (1961), but the introductions suffered much browsing and the small benefits obtained do not radically improve the prospects for most broadleaved species. Where sites are reasonably well drained and other environmental factors not too unfavourable, planting broadleaves with a conifer nurse can greatly aid establishment and early growth; examples of this on upland sites are illustrated in Tables 3.3 and 3.4 (page 26). As was noted earlier, this has been the traditional method of establishing shelterbelts, especially of beech.

Reports of species trials in the Orkneys and Shetlands confirm the usefulness of sycamore (MacDonald, 1967; Neustein, 1964; Stewart, 1962) but the species has not always shown the expected promise in upland experiments and improving ways of establishing it have proved difficult.

More recently Southern beech and eucalypts have been planted on upland sites. The more extensive and longer established trials of the former suggest that *Nothofagus procera* can achieve Yield Classes 10–14 at elevations between 150 and 300 m if not severely exposed, and *N. obliqua* one Yield Class less. Very recent trials indicate significant variation in growth and survival of upland plantings with provenance (c.f. Figure 4.1) with some showing rapid growth and outstanding resistance to dieback.

Performance of broadleaves in low altitude and usually sheltered localities in upland country does not differ materially from that in the lowlands of Britain except where soil conditions are inferior such as on acid, ill drained peats or peaty gleys.

Table 10.2 Mean height growth (m) by species from a representative range of trials in upland and/or exposed maritime localities in Britain

Experimental site			Species										
Location	Altitude (m)	Assessment age (years)	Sitka spruce	Lodge-pole pine	Japanese Larch	Oak	Red oak	Beech	Syca-more	Birch	Ash	Alders	Rowan
Forss 1, Caithness	85	15	2.4	3.2	2.4			0.5	1.2		1.7		
Forss 3, Caithness	85	15	2.6	2.2	2.6		0.4	0.8	0.9				
Skiall 2, Caithness	90	15	2.7	3.8	2.7			1.0	1.1		0.9		
Skiall 3, Caithness	90	15	2.1	1.7	2.4			0.8	0.9		0.7		
Shetland 1	70–120	18	3.3	2.5	3.2[1]				3.0				
Rosedale 9, N. Yorks	265	15	5.4		5.6	2.4	1.4	1.9					
Ae 24, Dumfries and Galloway	260	15	6.0	5.5	6.5							3.0	
Kielder 60, Northumberland	185	14	2.5	7.4								2.8	2.8
Pennines[2], collated data from 28 experiments grouped by soil type (from Lines, 1984)													
Surface water gleys	240–350	10	2.1	4.7	3.3	0.7 F	0.1 F	0.8 F	0.8 F	2.2	1.7	1.5–4.0 F	
Peats	240–350	10	1.2	2.3	1.0 F	F	F	F	0.8 F	2.0		F	
Moderately well-drained soils	240–350	10	1.5	2.5	2.0	0.8 F	1.0 F	0.5	0.7	3.1	F	1.5–2.5	

Notes: A blank space indicates the species was not included. 'F' indicates a species was planted but had died (failed) by the time of the assessment.

[1] Hybrid larch

[2] Not all the Pennine experiments contained all species. Also, within a soil group a species may have survived in some experiments but not in others. Where a species failed on more than one site but survived on some others, 'F' is shown after the mean height.

CHAPTER 11

Growing decorative quality timber

INTRODUCTION

Several broadleaved species grown in Britain can, under the right conditions, produce timber suitable for decorative or facing veneers and high quality joinery. Although specifications are exacting, the very high prices commanded – several hundred pounds per cubic metre – mean this market should never be ignored. Since the supply of high quality tropical hardwoods is gradually diminishing, a firm market can be expected to continue for all good quality hardwoods.

This chapter mainly concerns walnuts and cherry with brief notes on False acacia, laburnum and yew. These species are very rarely grown in plantation; it is the individual tree which attains large size, often under open-grown conditions, that is valuable. This emphasis on individual high quality specimen trees distinguishes their cultivation from the silviculture of high forest described earlier.

However, decorative quality timber is not confined to the above species and outstanding stems of this quality occur in all the major broadleaved species grown in Britain. These may be from high forest stands, among standards over coppice and occasionally hedgerow trees of ash, oak, sycamore and, to a lesser extent, beech. Identification and separation of such trees at harvesting is always worthwhile.

IDENTIFYING HIGH QUALITY STEMS

Not all the desirable characteristics which dictate high quality are visible externally and selection of superior butts after felling must follow the initial identification of a good stem (Figure 11.1).

Owing to the great natural variability among broadleaved trees only a very small proportion make this top class, and it is futile for example to expect an entire stand to achieve such exceptional quality, though by pruning and care the proportion of good stems can undoubtedly be increased.

Table 2.3 indicated the size requirements sought, by species, for high quality joinery (cabinet making) and decorative veneer end uses. In addition to size, the criteria in Table 11.1 must be met.

Table 11.1 stipulates the general criteria for top quality, but opportunities for marketing other material for decorative uses occasionally arise. Some turners, cabinet makers and fine craftsmen will specifically seek to feature the unusual in their product and an ill-shapen, gnarled butt, even from scrub trees, can sometimes be sold for this purpose. There are probably 1500–1700 such craftsmen in Britain who use some 10–12 000 m^3 of hardwood annually (Fraser, 1982).

WALNUTS

Species

Both Common walnut *Juglans regia* and American or Black walnut *J.nigra* will grow in Britain and produce high quality timber. Black walnut is generally a little faster growing than Common walnut and, until further information is available, only northerly seed origins should be used. Only Common walnut yields edible fruit.

Figures 22.7 a and b show the natural distribution of walnut (page 210).

Silviculture

The silvicultural recommendations below apply equally to both walnut species.

Sites

Walnuts thrive in warm summers; their cultivation should only be attempted in central and southern parts of Britain. The cool, moister summer climate of north western Britain is not generally suitable. Though walnuts are extremely susceptible to frost damage, particularly late spring frosts, they are not damaged by extreme cold in winter. Walnuts should never be planted in shade.

Table 11.1 Requirements of butts for decorative quality timber

Feature	Criteria	External evidence	Comments
Length	2–5 m. Occasionally minimum of 1.5 m acceptable for some species, e.g. walnut. Long butts usually divided into 2 × 2 or 2 × 2.5 m lengths.	Measured from top of root spur (buttress) to crown break or first branch.	Very rare for more than 5 m of butt to make top quality.
Form	Straight, cylindrical with low taper. Not curved (swept), twisted, fluted or markedly elliptical.	Bark orientation will usually indicate twisting. Leaning trees or imbalanced crown (lop-sided) often cause differential growth and poor stem circularity.	Twisting freqently observed in Sweet chestnut.
Knots	Free of knots except for small ones in central core.	No branches or evidence of pruning scars. Though healed pruning scars persist for many years their obvious presence in the bark of a butt is likely to indicate pruning of too large a branch too recently.	A few tiny epicormics or ones known to be of very recent origin, i.e. knots only in sapwood, may be acceptable. Exceptional markets occasionally for wood peppered with small knots, e.g. pippy oak and yew.
Growth rate	Uniform growth rate desirable, with even rings not widely fluctuating in width. Rapid, even growth acceptable.	Habit of tree — open-grown, confined in stand — likely to indicate growth rate. Tree/stand history e.g. incidence of thinning, determines evenness of growth.	Very slow growth unacceptable for some high quality end-uses, e.g. sports ash, and also butt more likely to be diseased or defective, especially for cherry and walnuts.
Grain	Straight grained, not spiral.	Bark orientation may indicate spiral grain.	Curly grain in sycamore can be very valuable.
Shakes and splits	Must be entirely absent.	Ribbing, even slight, or unusual fissures generally indicate internal shake or split. Ring shakes may be visible in branch wood.	Splayed base of maiden oak may indicate shake. See Figures 17.5 a and b.
Disease or insect damage	Must be free of rots, decay or wood borer damage unless entirely restricted to outer sapwood, i.e. of recent origin.	Sporophores, weeping fluid, loose bark, holes, decayed branch stubs.	'Brown oak' resulting from early stages of *Fistulina hepatica* infection can be of special value.
Other damage or defects	No extraction damage or inclusion of stones, metal e.g. fence wire, in wood.	Scars, wound tissue, protruding wire, etc.	Tree straddling a boundary will need very careful inspection.

The ideal site is on sheltered, mid-slope positions with a south or south-west aspect. The lower side of a hanging wood is often considered the optimum (Chard, 1949).

Soil requirements are moderately exacting. The soil should be at least moderately fertile, deeply rootable, well drained, and of medium texture. Very sandy and very clayey soils are unsuitable. The optimum pH should be near neutral (pH 6 to 7). Trees grow well in regions of chalk downland and limestone hills where there is at least 60 cm depth of soil over the strongly calcareous horizons or chalk bedrock.

Plant type

Walnuts are traditionally planted as large, sturdy 2+2 transplants, that were stumped back as 2+0s, about 70–90 cm tall with a root collar diameter of about 15–20 mm. Smaller plants are prone to drying out and frost damage just after planting. They can be used, e.g. 1+1s, if they are handled with great care and planted soon after lifting or removal from cold store. Growth is enhanced by tree shelters.

Direct sowing of nuts is feasible and potentially a much cheaper method of establishment but losses are usually high and newly emerging shoots are very frost tender. The technique should only be tried in near frost free areas and where full protection from predation can be assured. There has been little success to date with direct sown walnuts in tree shelters.

Figure 11.1 Fine oak butt on 170-year-old tree; diameter breast height is 76 cm. Butt quality will need confirming after felling to see if rot has entered through the dead branch (top right) and whether shake is present. (*A10596*)

Establishment

Walnuts are best planted in November, though any time up to mid-March should produce reasonable survival. Plant with care using pit planting or on ploughed/rotovated ground.

If a stand or grove of walnut is being established either plant trees at about 3–4 m spacing or in small groups of four to six at 12–15 m centres. The object is to obtain 40–70 well spaced final crop trees per hectare. Walnuts require full overhead light and ample side light and growing another tree crop between them may restrict the development of an open spreading crown and hence growth rate, unless frequent cleaning and thinning are assured. The intervening ground could be used for Christmas trees, cutting hay, grazing livestock if the trees are protected, or cultivating market garden produce.

For good initial growth every effort should be made to clean weed around the trees, either by hoeing or careful use of herbicide – see page 34. The presence of bare soil will lessen the risk from radiation frosts and eliminate all weed competition, of which grass is the most serious. If the whole site cannot be clean cultivated the diameter of the clean weeded area around the tree should be at least one metre.

Provided care has been taken in site selection and establishment, application of fertiliser is unlikely to benefit the trees. Application of nitrogenous fertilisers can be positively damaging and increase deaths in the first year.

Pruning

Walnuts do not have a strong central axis, their growing habit being sympodial, and formative pruning to ensure a single stem is usually necessary to achieve the essential straight bole of 1.5–3 m. Side branches on the bottom 2–3 m should not be allowed to become thick and should be cut close to the stem using secateurs. If pruning of large branches is necessary, weeping of sap occurs in spring and early summer, therefore the operation should be done in July or August.

Thinning

Walnuts should be open-grown (Figure 11.2) to encourage well developed crowns and ensure maximum radial growth of stem. Thinning should begin before canopy closure or any competition between crowns occurs. The aim should be an 'orchard-like' grove or plantation. Under these conditions stem diameter increment can reach 1 cm/year.

Select final crop trees on basis of vigour and stem quality: length, form, defect-free (see Table 11.1).

Rotation

Rotation length is primarily a technical consideration. Walnut butts are saleable once they attain 30 cm in diameter though in general, the larger the butt the more valuable it is.

On good sites walnuts reach 30 cm diameter in about 40 years.

Marketing and end uses

Suitable walnut butts are sold individually and a price is agreed after felling once a detailed inspection has been made.

Good quality walnut commands very high prices and is mostly used for slicing veneer for decorative purposes notably television cabinets. Other uses, now only for very best quality, include rifle butts (see Fairley, 1955) and high class joinery. Some of the most attractive wood comes from the root crown area from which fine burr walnut veneers can be obtained.

Cultivating common walnut for food

Almost all walnuts are imported. Some trees will fruit in Britain but cultivation for this purpose has not been very successful. An account of practices is given by Glenn (1946).

CHERRIES

Of the two native species, Wild cherry or gean *Prunus avium* and Bird cherry *Prunus padus*, only the former grows to timber size. The American or Black cherry *Prunus serotina*, though quite vigorous and attaining moderate size, has not shown itself superior to Wild cherry and is undesirable because it is an alternate host to an aphid carrier of a sugar beet virus.

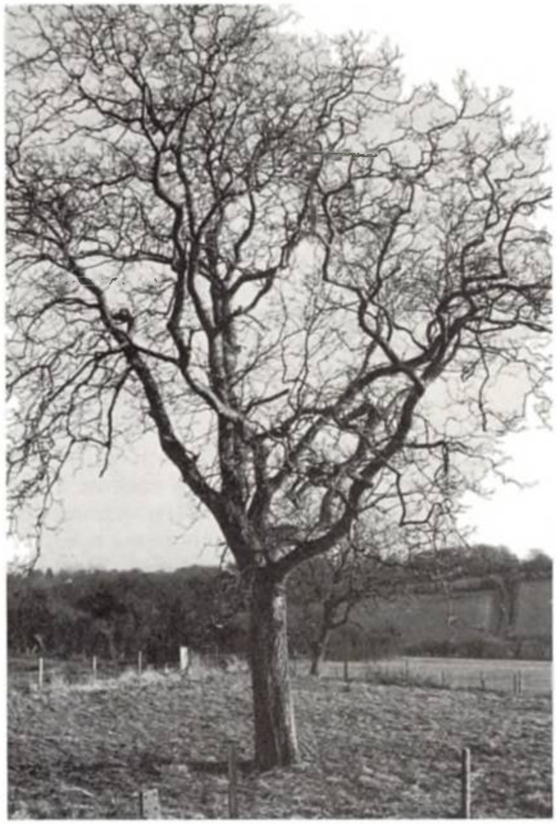


Figure 11.2 Well grown Common walnut on south facing slope of a Hampshire farm. (*A10597*)

Figure 22.1 shows the natural distribution of Wild cherry (page 202).

Silviculture

Wild cherry occurs naturally throughout Britain and is chiefly found in southern and eastern England as a woodland tree and in east Scotland in hedgerows and copses. The species is rarely grown in plantation but is an important minor species on the Downs of south-east England and the beech woods of the Chilterns and Cotswolds where perhaps its best development occurs.

Under favourable conditions Wild cherry will reach 20 m height and 60 cm breast height diameter in 50–60 years.

Most Wild cherry harvested in Britain has arisen naturally as a minor component in existing broadleaved woodland. They are a valuable addition to a stand, both for timber and as part of the landscape, and vigorous, straight trees with fine branching should be favoured in tending and thinning – see, for example, Figure 5.2a.

Cherry is prone to 'sudden death' often accompanied by rapid decay of the butt, and only vigorous, healthy trees should be retained. The aphid *Myzus cerasi* is quite a serious pest, leading to crown dieback most noticeable in May and June. The tree is relatively short lived and best results are achieved when it is grown to merchantable size as fast as possible.

Planting

For production of timber, seed for raising cherry plants should be obtained from naturally occurring, healthy forest trees of good vigour and form. Vegetative propagation of young cherry (up to 2 years old) is straightforward but cuttings from older trees are difficult to root.

Cherry should only be planted on fertile, deep, well drained soils; heavy soils are generally unsuitable. Soil reaction should be on the acid side of neutral, pH 5–6.5. Avoid both exposed sites and depressions where waterlogging may occur. Cherry is a species always worth including as a component of broadleaved woodland when planting in the lowlands of Britain.

For amenity planting, site requirements need be less exacting since the species will grow moderately well on a very wide range of soils and indeed tolerates grass competition and drought better than most species.

Regular blocks of cherry can be very monotonous and it is best planted as small clumps wherever shelter and fertility provide ideal growing conditions or in mixture with other broadleaves.

Post-planting treatment

Though tolerant of grass, cherry responds well to a high standard of weed control, see Figure 3.7. Cherry shows rapid early growth but needs to be kept well thinned, verging on open-grown, to enhance both diameter growth and flowering. High prune to achieve top quality stems, but only carry out between June and August to minimize infection risk from bacterial canker and silver leaf disease.

Markets

Cherry has a rich reddish brown heartwood which is very rarely if ever shaken. It is suitable for turnery, furniture, veneers, and decorative panelling. A ready market is likely to remain for good quality timber thus justifying continued planting of cherry, if only on a limited scale. The prospects for large-scale production from extensive new plantings are poor since few very suitable sites are available.

FALSE ACACIA

False acacia *Robinia pseudoacacia* was introduced from eastern North America in the first half of the 17th century and is a popular tree in streets, parks and gardens of southern England. It grows well on light sandy soils in warm summers. False acacia flowers copiously but only sets fertile seeds intermittently.

William Cobbett was an enthusiastic planter of False acacia and made a serious attempt to popularize its use, indeed advocating its widespread planting in the New Forest to provide trennels (dowels) for ship construction.

The species coppices freely even from old trees, its shoots having the ability to force their way up through competing shrubs. It also has a tendency to produce suckers.

In common with other leguminous plants it is capable, through root nodules, of fixing nitrogen. For this reason it grows well on sandy soils and on man-made waste such as opencast sites and mining spoil which are mostly impoverished of nitrogen. The main obstacle to growing False acacia is that the foliage is extremely attractive to browsing by rabbits and hares, the thorns proving to be no deterrent.

The timber is tough, very porous, and light brown to yellow in colour. Many mature False acacia trees develop a lean during their life and the resulting stem deformity reduces its milling potential, though for small articles the wood has considerable merit.

LABURNUM

Although never a forest tree all three species of laburnum (Common, Scots, and the hybrid of the two) can grow to 12 m height and 30 cm in diameter in about 25 years. Its wood is very dark and dense and is highly prized by craftsmen and furniture makers. This consideration is worth bearing in mind in small scale amenity plantings. Common laburnum, now much less easily available than the hybrid, has highly poisonous seeds.

YEW

Yew *Taxus baccata* is included in a Bulletin on broadleaves because it is the only conifer likely to yield decorative quality timber and because it is mostly found occurring in broadleaved woodlands.

Yew has a wide distribution in Britain occurring naturally as scattered trees on many sites, but is particularly common on limestone and chalk. There are a few woods of nearly pure yew on the Downs of southern England which have probably arisen from colonization of pasture from seeds spread by birds. By a similar means yew seedlings often occur in the dense shade of young oak stands where they grow slowly with a persistent leading shoot. Seedlings are browsed by deer but the foliage when cut is very poisonous to domestic animals.

Yew timber has excellent decorative characteristics and, when of the right quality, can fetch very high prices for veneer. Unfortunately, most yew trees tend to be forked, fluted, and with depressions at the branch : stem junction. Pin knots resulting from epicormic shoots are regarded as a feature rather than a defect.

Planting of yew is not advocated on anything but the smallest scale. If this is intended it is suggested that hardwood cuttings are taken since the tree can be easily propagated vegetatively. Take cuttings from trees with good, straight stems with a minimum of fluting. Where yew is occurring naturally in a broadleaved stand it will be worth retaining those of good quality and, provided the tree is still fairly young (i.e. less than 15 cm dbh), some high pruning may be beneficial. Only straight, unforked trees, should be favoured in this way.

CHAPTER 12
Woods on farms

INTRODUCTION

Woods on farms do not represent a separate silvicultural type; they can be of high forest, coppice or poor quality scrub and be located in either the uplands or the lowlands. However, 'woods on farms' is a useful grouping because, regardless of what they are like silviculturally, several characteristics are common to most. Also they are a dominant feature in the countryside. Thirty-nine per cent (295 000 ha) of all broadleaved woodland consists of small, predominantly farm woods of less than 10 ha and most of the 202 000 ha of clumps and lines of broadleaved trees, not classified as woodland (Forestry Commission Census of Woodlands and Trees, 1979–82), occurs on farms. For these reasons woods on farms merit separate consideration, though most of the appropriate silvicultural practices are covered elswhere (to which reference is made) and not repeated here.

The subject of farm woodlands is currently of much interest and many useful information leaflets and guides to practice are available, e.g. *Countryside Conservation Handbook* (Countryside Commission), *Managing farm woodlands* (Forestry Commission, 1984) and *Farming and the countryside* (MAFF, 1982).

CHARACTERISTICS

Size

Most farm woods are small, less than 10 ha. Table 12.1, which gives the size distribution of non-commercial woods in three East Anglian counties, shows that 60 per cent of all woods are in the smallest category, and nearly 94 per cent of the total number are less than 10 ha. Similar evidence is provided by the Countryside Commission (1983) – Table 12.2.

The small size of most farm woods brings special difficulties.

1. The quantity of produce obtained at any one time will necessarily be small which makes it uneconomic to build roads or use expensive equipment for extraction.
2. The ratio of length of boundary to total area is high thus:

   a. there are many edge trees which are often leaning, of poor form or heavily branched; and

   b. the cost of fencing in relation to area enclosed makes regeneration or replanting more expensive.

Table 12.1 **Non-commercial[1] woodland cover in Cambridgeshire, Norfolk and Suffolk**

County	Woodland size (ha)										Total	
	0.25–2		2–10		10–20		20–50		50+			
	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Cambridgeshire	660	560	500	1680	67	790	44	1100	7	610	1278	4740
Norfolk	2890	3300	1770	6540	200	2430	100	2480	21	1390	4981	16 140
Suffolk	2540	2580	1430	5470	160	1975	65	1670	9	700	4204	12 395
Totals	6090	6440	3700	13 690	427	5195	209	5250	37	2700	10 463	33 275

Note: [1]Woodlands other than Forestry Commission or those managed under dedicated or approved woodlands schemes.
Source: Forestry Commission Census of Woodlands and Trees, 1979–82. (c.f. Towler and Barnes, 1983).

Table 12.2 Proportion of total area of non-commercial woodland[1] cover by size classes from a survey of nine counties in England and Wales

Size of wood (ha)	Proportion of total area (%)	
	Range[2]	Average
Less than 0.25	11 – 51	23
0.25 – 1.0	28 – 60	40
1.01 – 5.0	15 – 47	33
5.01 – 9.9	1 – 7	3
10+	1 – 4	1

Note: [1] definition as in Table 12.1
[2] among counties surveyed.

Access

Many farm woods are surrounded by fields (Figure 12.1) and not served by roads capable of supporting even light lorries. Usually the only way to get logs to roadside is by tractor skidding, but this is expensive if distances are great – more than 400 m.

Management

Many farm woods are unmanaged, not because they lack timber potential or can make no contribution to estate needs, but because the owner is often unaware of what can be done.

Surveys report, e.g. Downing and Fitton (1981), that the main reason why a farmer does not manage his woodland is because he does not know what to do with it and what can be obtained from it.

Frequently, the main obstacle to management is a lack of any clear objective for a wood. With all the other activities on a farm dictated by the season, work in woodlands usually has low priority. Yet if a wood is assigned some specific purpose or there is some clear object of management then the work done towards that, whenever it can be fitted in, will be more rewarding.

Condition of growing stock

Species

Most farm woods consist of mixed broadleaves of native or naturalized species.

Stocking

Stocking of merchantable trees is variable, but many woods have large bare areas often densely overgrown, poor stocking, and/or thickets of dense, spindly unthinned trees.

Timber quality

Merchantable trees are often of poor quality – leaning, heavily branched, or defective in other ways.

Age structure

Particularly in small woods, there are few or only one age class. Many woods are mature or overmature.

Regeneration

Regeneration is often lacking. The main reason is browsing and grazing by rabbits, hares, deer and livestock including horses.

Many of the above are the result of an absence of management for many years and consign a wood to the poor quality category discussed in Chapter 9. Not all farm woods are in this condition and neither are they of inherently poor growth potential. The Countryside Commission study (1983) showed not only that many woods contain Yield Class 6 ash and sycamore. Yield Class 8 oak, and Yield Class 10 and above birch and poplar, but that more than 80 per cent were judged to have some standing value.

This great variability in condition makes essential some form of assessment (page 8) before starting management, where this has been long neglected, to identify woodland quality and potential and to devise the most appropriate silvicultural treatment.

Conservation value

Woods on farms often have high conservation value.

1. Particularly in regions of intensive farming, a wood surrounded by fields can be a reservoir or island of wildlife.
2. A great many farm woods are ancient and/or former coppices.

This characteristic may lead a farmer to do very little in a wood both because conservation is often misguidedly equated with preservation and it is convenient to label neglect of a woodland as 'good conservation'.

VALUE OF SMALL WOODS AND INTEGRATION WITH FARMING

Uses

Estate needs

A small woodland can satisfy many estate needs. These include fence posts, poles, rails, bean and pea sticks, hedging stakes, etc. Recent developments in

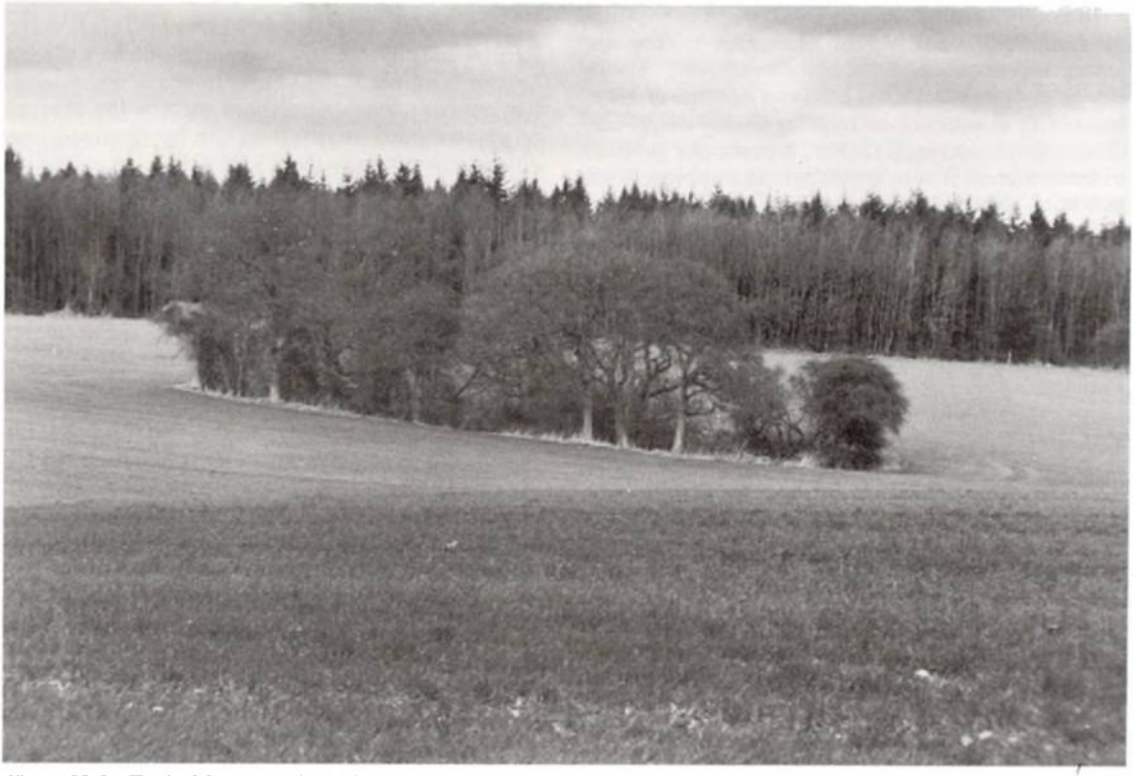


Figure 12.1 Typical farm woodland (middle-ground), small in size and inaccessible except by tractor. (*A10598*)

portable sawmills, such as the Trekkasaw, are making feasible the on-site conversion of logs into planks and posts and so increase the possibilities of supplying estate needs.

Mill timber

Although large quantities of high quality timber cannot be expected from small farm woods, most woods are capable of supplying some material of sawlog potential. If several woods are managed together yields can be combined to make a saleable lot. This co-operative approach has been successful in the Gwent Small Woods Scheme (Zehetmayr, 1981). The possibility of timber production should never be overlooked in small woods, indeed they can be a valuable asset especially if the woods contain large cherry or even some walnut trees which are often found on farms.

Firewood

With the increasing use of wood-burning stoves obtaining firewood from small woods becomes an attractive possibility. Although large trees can be felled and cut up for firewood, or those parts of them which are not usable or marketable for other purposes, nevertheless it is the smaller sized material which finds the most ready market for firewood. Where a landowner has a wood of several hectares it becomes feasible to use wood as the main form of energy for domestic and farm heating, see page 85.

Pulpwood

All broadleaves are marketable for wood pulp. A minimum load of 10 tonnes (one lorry load) is required and the market is best utilized by co-operative marketing from several small woods.

Provision of shelter

In livestock farming small woods are often used for shelter. Although this object can conflict with good silviculture, and will certainly inhibit regeneration and may lead to bark stripping (Figure 4.4), most woodlands can be managed to provide both forest produce and some shelter where soils are coarse textured and freely drained and the trees are mature with thick bark (Patch and Lines, 1981).

In arable farming, small woods, when constituted as shelterbelts, can benefit the adjacent crop and lessen soil erosion by reducing windspeed. Poorly designed or wrongly sited belts can damage crops by increasing turbulence or creating overly damp conditions from too much shelter, a particular problem in the lowlands. These arguments also apply to some extent to hedgerows and hedgerow trees on farms.

Sporting

Almost all woods have some sporting potential and for many owners of small woods this is their main value – see Chapter 15.

Improved amenity

As has been stressed, small woods are an important feature in the countryside in terms of landscape, or recreation, or for their conservation value. By maintaining or adding to them the farmer assists in preserving the landscape and the associated wildlife which are so much enjoyed (Figure 12.2).

Integration

Farm woods have many uses some of which directly benefit farming. Where farming and forestry activities are consciously integrated there is the prospect of greater productivity than can be obtained from either activity alone (RICS, 1982).

Examples of integration, in addition to those mentioned, are:

1. provision of shelter for livestock through carefully sited planting, especially in the uplands;
2. fencing erected to keep stock out of woodland also serves to control grazing;
3. improvement of farm access by the construction of forest roads;
4. provision of productive winter work, e.g. coppicing, at a time when on-farm labour needs are often slack.

Effective integration is not necessarily simple and will depend on positive management. Compared with many other European countries, Britain has been slow to relearn the mutual advantage of farm to forest and *vice versa*.

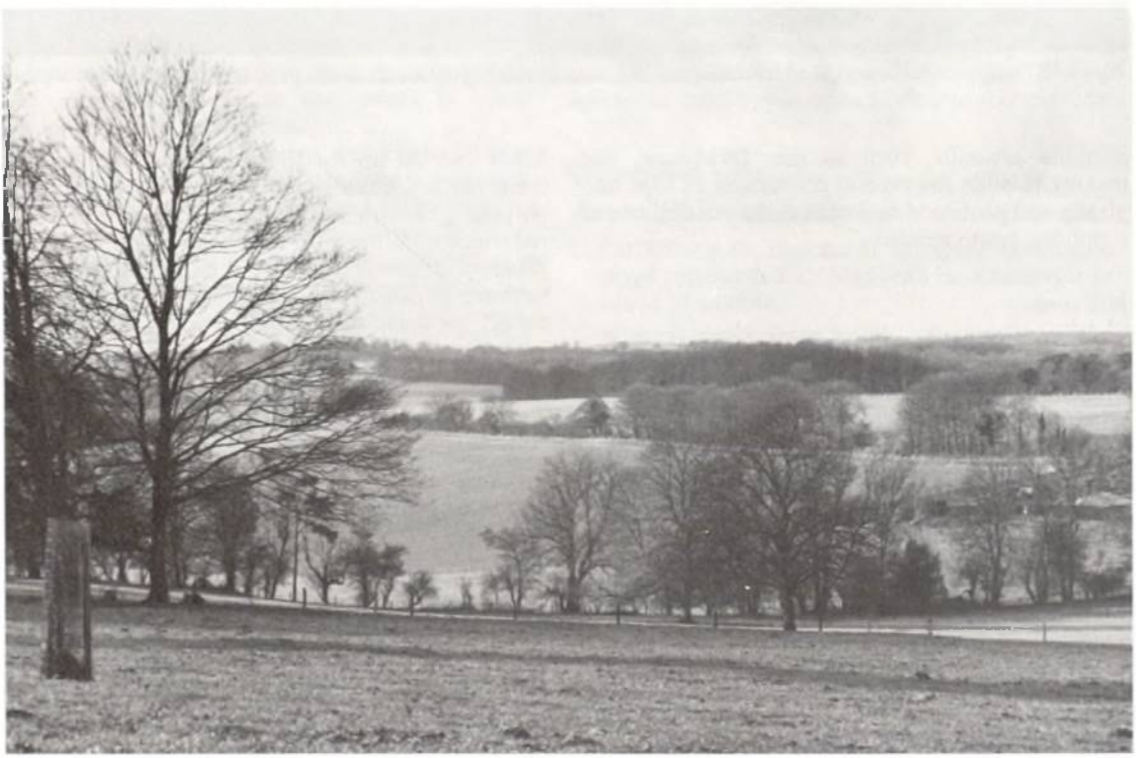


Figure 12.2 Farm trees and woodlands in the countryside. Note well protected newly planted tree in left foreground. (*A10599*)

SILVICULTURE IN FARM WOODS

Most of the silvicultural practices suitable for farm woods have already been described in preceding chapters. But an owner of such woods needs to know which practice or treatment is the appropriate one. This depends on how much woodland there is, its condition, how easy it is to manage (notably access) and what are the main objectives. If there has been little or no recent management of a farm wood the first step to finding the appropriate silviculture is to assess its condition.

Assessing potential of existing woodland

Information about areas, access, species, stocking, age, and stand health is required, i.e. to appraise the characteristics referred to earlier in the chapter. These requirements are similar to those confronting any owner or manager of woodland and are considered on page 8. Similarly, the procedures outlined in Table 1.9 may be followed in the case of farm woods. Characteristics which classify woodland as poor quality (scrub) are itemized in Chapter 9. Survey work is best undertaken by a forester.

Deciding objectives

Once some form of woodland assessment has been made it is easier to decide what the objectives are for the woodlands on a farm. The possibilities were enumerated in the previous section, but it is important to stress that the objectives rarely need be mutually exclusive, but see Table 1.8. Cutting firewood, providing shelter, and giving some sporting benefit can all be combined in the same wood or group of woods.

Silvicultural treatments

If assessment of farm woods has shown a large area (over 5 ha) of well stocked woodland (albeit perhaps unmanaged) with good vehicle access, such woods have considerable forestry potential and value for almost any other objective. However, as noted, most farm woods are not in this condition: the characteristics most frequently encountered are listed in Table 12.3 with comment on their potential, the most appropriate silviculture, and reference to relevant part of this Bulletin.

The characteristics in Table 12.3 are not mutually exclusive and several may apply to a single wood,

Table 12.3 Woodland condition, potential and appropriate silviculture

Woodland characteristic	Comment on potential and use	Main silvicultural considerations	Relevant page or chapter
Small woods (a) less than 1 ha	Limited timber potential, best used to supply estate needs or occasional firewood requirement. Often of high amenity and sporting value.	Generally work over half or whole of wood at one time. Planting probably only feasible method of regeneration. Individually protect trees.	46–47
(b) 1–5 ha	Some timber potential, but best treated as above unless marketing can be through a co-operative or association.	Work in several 0.5–1.0 ha units. Either fence whole wood or protect trees individually.	46–47
Poor stocking	Will generally need enrichment or improvement to sustain yield of forest produce.	Treat as poor quality woodland – refer to Figure 9.3.	Chapter 9
Overmature woodland	Timber potential likely to be diminishing. Regeneration urgent. Woodland likely to have high amenity, especially landscape value.	Replanting usually essential unless evidence of natural regeneration.	Chapter 5 Chapter 13
Young woodland, trees less than 8 m tall	No forest produce immediately available except sticks and some firewood. Thicket stage woods often rich in wildlife and of high sporting value.	If becoming overgrown, clean to favour useful stems, otherwise no treatment needed.	Chapter 3

continued overleaf

Table 12.3 Woodland condition, potential and appropriate silviculture *(continued)*

Woodland characteristic	Comment on potential and use	Main silvicultural considerations	Relevant page or chapter
Woodland open to regular grazing	Widespread characteristic, especially in uplands. If shelter value is important, integrate woodland and stock management, perhaps using rotational grazing. Wood usually of poor sporting or conservation value.	Exclusion of livestock is essential for regeneration and long-term survival of woodland. Bark stripping usually indicates overstocking of animals or over-use of wood.	Chapters 4 and 10 Page 47
Former coppice	Coppicing is one of the simplest and cheapest silvicultural systems providing a regular supply of small sized produce. Standard trees, if present, can yield sawlog material. Often of high conservation value, but woodland can satisfy most objectives.	Resume coppicing or continue to store best stems and treat as high forest.	Chapters 6–8
	Limited market for hazel coppice products, hazel woods best retained for sporting, conservation, market garden products or converted to better broadleaved woodland using revenue from standards if present.	Hazel coppice converted by encouraging natural enrichment, i.e. individually protect and open up around self-sown seedlings, or opportunity planting.	Chapter 7 Chapter 9
Ancient woodland	Confers high conservation value. Some yield of forest produce possible without harming wildlife.	Light and selective treatment. Restrict regeneration to native species.	Chapter 14
Poor access	If no load bearing tracks or roads lead to or occur within wood, extraction of forest produce must be by tractor skidding over long distances. Consider alternative of on-site conversion of logs using portable sawmill.	Concentrate working for forest produce in large units at infrequent intervals. Extract when ground is firm and dry.	

e.g. small size, overmature and heavily grazed (Figure 12.3).

PLANTING WASTE GROUND

Identifying unused ground suitable for tree planting

One result of assessing the potential of the existing woodland on a farm (previous section) and then deciding the objectives is that there may be insufficient area of woodland to satisfy the objectives fully. Seymour (1974) estimates about 7.5 per cent of any farm to be agriculturally unproductive land suitable for woodland which could attract good sporting rents and supply some forest produce. Thus it may be desirable to plant new areas.

Nearly all farms have patches of ground which are mostly unused and where tree planting can be carried out to effect. These are typically found in field corners, beside roads and tracks, in small wet areas not meriting drainage, in old orchards not worth grubbing out, and, of course, in understocked parts of existing woodlands. The simplest way to identify these areas is to mark on a plan of a farm all fields which are in intensive use, then to mark in all

Figure 12.3 Small wood of mature oak open to grazing. (*A10600*)

the buildings and roads and then to examine those parts of the farm still left blank.

Assistance with planting

The following organizations provide advice and some financial assistance to encourage tree planting. The amount of any grant varies depending on object of planting, size of wood, species, etc.

Countryside Commission
County Councils
District Councils
Nature Conservancy Council
Forestry Commission
Ministry of Agriculture, Fisheries and Food

The first three organizations only assist with small plantings of up to ¼ hectare and the Forestry Commission for areas larger than this.

Choice of species

The best species for a site depends on the conditions of the site and the object of growing trees – see Chapter 3. For most purposes a tree species already growing well in the locality will be the best choice. In particular, a farmer should avoid establishing a species which requires special attention or is only of use for a highly specialized market, unless the purpose of planting is purely for an amenity benefit. The selective planting on good sites of a few walnut and cherry trees was emphasized in the previous chapter.

Planting in mixture usually brings benefits when considering a small wood, both in the variety of produce likely to be obtained and the insurance of not planting only one kind of tree.

Stocking

Forest plantations are usually established with a 2 m spacing between trees. This requirement is not so necessary with farm woods and both much closer and much wider planting espacements may be sensible. For example, if there is no intention of obtaining any early yield then a spacing of 3 or 4 m may be the most desirable, and even 6 or 8 m for poplars. Similarly, planting along river banks or beside roads should usually be done at wide spacing. By contrast, planting trees as a single line shelterbelt along a field edge is often best at about 1.5 m spacing.

Protection

It has already been stressed that trees must be protected from browsing and livestock numbers in woods controlled to avoid bark stripping. Most areas of waste ground suitable for planting will be small in area and individual tree protection will usually be the most economical method (see page 47).

Other silvicultural requirements

Cleaning and thinning and other operations apply equally to newly planted stands as for enrichment in existing woods (pages 37–40 and 52–57).

HEDGEROWS AND HEDGEROW TREES

This subject has been much discussed in recent years because of the steady removal of hedges throughout Britain and the killing of many hedgerow elms by Dutch elm disease. Ninety per cent of hedgerow trees are broadleaved but they and hedges bring both advantages and disadvantages to a farm.

Hedgerows and hedgerow trees are of great conservation and landscape value. Also they provide a distinct boundary to land and confer some immediate shelter, particularly for livestock in bad weather.

The main disadvantages of hedges are the amount of land that they, in theory, displace from food production, the harbouring of harmful animals and pests, and the need for regular management if they are to remain stock-proof and in good condition. It is not possible, nor appropriate, in this Bulletin to evaluate the advantages and disadvantages of hedges since each farm will vary. But it is important to recognize that there will often be new areas of land such as field corners which can be planted to compensate in part for any loss of hedges that may have occurred. The main disadvantage claimed for hedgerow trees is shading of crops. However, where the hedge is a boundary one next to a road the shade effect is only on one side and even then will be of little influence if the fields are to the south of the line of hedgerow trees.

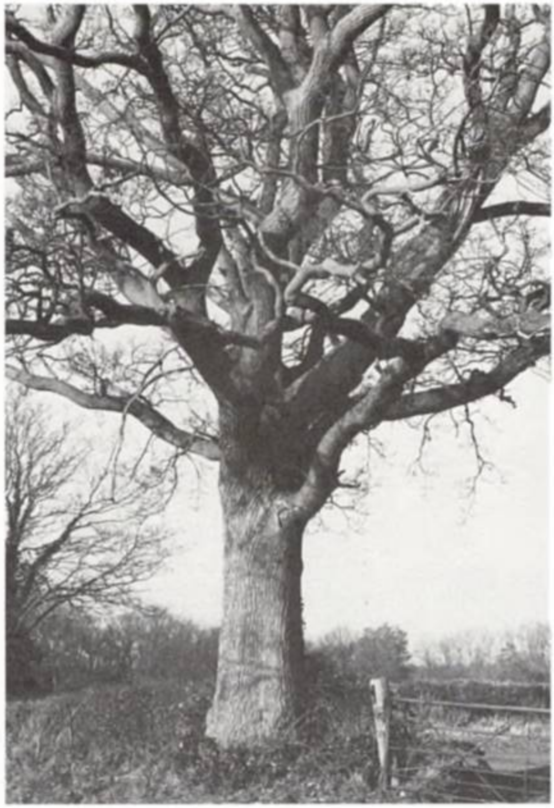


Figure 12.4 Large hedgerow oak with reasonable quality butt and much branchwood which will be suitable for firewood. (*A10601*)

Hedgerow trees are an important source of hardwood timber (Figure 12.4) which, along with fellings from small woods of less than 2 ha, contribute about 20 per cent of the total output in Britain. There are some 23 million m^3 of timber (hardwood) in hedgerow trees, isolated clumps less than 0.25 ha in area, and lines of trees (Forestry Commission Census of Woodlands and Trees, 1979–82).

In the past many hedgerow trees were pollarded for firewood and other estate uses (Rackham, 1976) but it is scarcely practised today. The best way to encourage hedgerow trees is to leave some shoots in the hedge to grow up if suitable species are present (Figure 12.5). This can be incorporated in the annual hedge trimming by leaving a very small part of the hedge uncut for a succession of years; plastic markers can be inserted to warn the hedge cutting operator where to leave a tree. Very quickly one or two shoots will develop in this section of hedge, which need be no more than 1 m long, and one stem singled out and allowed to grow on.

Figure 12.5 Recently laid hedge with ash saplings carefully selected out to grow on. (*A10602*)

MANAGEMENT FOR NON-WOOD VALUES

These chapters seek to provide silvicultural information and advice where management includes consideration of or is even dominated by these other important values of so much of broadleaved woodland.

CHAPTER 13

Landscape and recreation

INTRODUCTION

Broadleaved trees and woodland are a major feature of the landscape and, in some areas, constitute an important recreational amenity. Not only should these roles influence silvicultural practice within broadleaved woodland but, as a result, broadleaves can often be used to enhance these environmental qualities. A useful summary of this has recently been presented by Workman (1982).

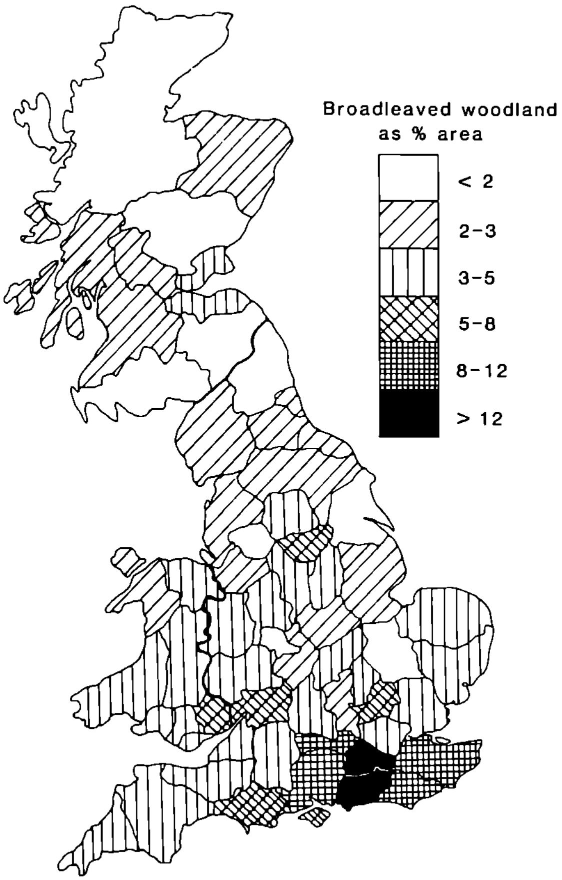


Figure 13.1 Proportion of county (England and Wales) or region (Scotland) occupied by broadleaved woodland. (Data not included for Western Isles, Orkney or Shetland).
Source: Forestry Commission Census of Woodlands and Trees, 1979–82.

It must be stressed at the outset that consideration of landscape and recreational aspects of broadleaved woodland management need not conflict with the production of timber, or most other uses. Indeed, well managed broadleaved woodland can be one of the most attractive features of a landscape. Moreover, it is generally found that if proper attention is given to landscape considerations a woodland's potential for recreation will usually be satisfactory as well.

Where woodland is the principal land use, forest operations often enhance rather than detract from the landscape. Thus, ensuring both forests and forestry activities look right in the landscape should be an integral part of forest management.

In considering the landscape and recreational value of broadleaved woodlands, it is important to recognize that the British landscape is highly artificial and that historical influences, such as the Enclosure Acts and opening of commons, have been an important determinant of the countryside as it now exists. Thus the rural landscape we admire is not what would develop under natural conditions. This point must always be borne in mind when considering questions of landscape in woodland: the solution to 'allow nature to have its course' will rarely be the right one. And, this historical influence on our present landscape, emphasizes our continuing responsibility of how we handle it for posterity.

IMPORTANCE OF BROADLEAVED WOODLANDS IN THE COUNTRYSIDE

Predominance in lowland Britain

Most woodland in the lowlands of Britain is predominantly broadleaved in character (Figure 13.1), and much of it as small scattered woods and groups of trees which is so much admired (Figure 13.2). But

Figure 13.2 Countryside of fields, woods and trees typical of much of lowland Britain. (*D3075*)

the lowlands also are where the great proportion of people in Britain live. Thus for most people broadleaved woodland scenery is the one they most see and are most familiar with. This fact, as much as any other, explains why broadleaves are considered to be so important.

Large trees and old trees

Distinct from the general presence of broadleaved woodland in the countryside is the specific preference many people have to see and walk through woodland with large trees. There are several reasons for this:

1. the feel of apparent timelessness of such large old plants – always there, always seemingly unchanging – which contrasts with everyday life;
2. their appearance and interest artistically; and
3. historic associations.

Because of this interest in large trees or ones of great age, consideration will have to be given on occasion to leaving particularly attractive woodland to grow on long past the normal rotation age (Figure 13.3). Similarly individual trees or groups may be singled out for special attention and access provided, such as for the oaks in Sherwood Forest or the Burnham beeches.

Diversity, structure and composition

Broadleaved trees and woodland are usually diverse in habit and appearance. Even where large areas are dominated by one species, such as the Chiltern beechwoods, the irregular shape of tree trunks and the asymmetry of crowns bring an interesting diversity, e.g. Figure 18.6.

The structure of broadleaved woodland in the lowland landscape is also varied. This may have arisen for many reasons such as war time fellings, coppicing, regrowth on abandoned land such as old railway tracks, and successful natural regeneration, but they all add to the interest and character of broadleaved woodland.

Broadleaves have one other important characteristic; nearly all species are deciduous. This intro-

Figure 13.3 Ancient and ornamental woodland in the New Forest showing old pollarded beeches and, in the foreground, protection for young saplings growing in an opening. (*A10603*)

duces variety and change through the seasons to woodland appearance, internal views and lighting from the canopy as illustrated on the front cover!

Because of all these values, a desirable aim of broadleaved management should be to achieve as much diversity of structure and composition as possible within the overall management objectives.

CLASSIFICATION OF WOODLAND

Having emphasized the importance of broadleaved woodland the next step is to identify those woodlands and areas where landscape and recreation are of particular importance.

Woodlands of landscape importance

Two aspects need to be considered:

1. the general vista;
2. the immediate foreground or internal view.

Generally, woodlands tend to be of greater or lesser landscape importance depending on their position in the local terrain. Their importance increases as terrain becomes more hilly or mountainous because the shape and composition of a woodland as a whole are more easily seen. In such areas natural landforms are much more obvious and incongruity introduced by planting up to a straight edge or perhaps by afforesting a whole hillside with a single species becomes more evident. In flat areas, although local undulations can sometimes be enhanced to provide an attractive landscape, the foregound view becomes more important since woodland is mostly seen edge-on.

The importance of landscape considerations increases where the countryside is a statutory amenity area such as a National Park, Country Park, or Area of Outstanding Natural Beauty. Moreover, such regions attract visitors and the recreational importance of woodland becomes greater. Sometimes these considerations dominate and all other aspects of woodland management are agreed of secondary importance, or felling may be strictly controlled through issue of a Tree Preservation Order.

The foreground view is experienced where the public have rights of access through woodland and from recreational facilities provided. This 'internal' landscape is valued most where there is variety in species, tree size, and the contrast of open areas and dense woodland, as well as views out.

Woodland of recreational importance

Apart from the aesthetic quality of the woodland itself, the main factors influencing recreational importance are accessibility, importance of tourism in the area and constraints of management such as fire risk, land tenure and conservation. For example, woodland near to town roads and paths will obviously attract many more people than woodland in remote places. Observation of visitor use will almost always indicate those woodlands of considerable recreational importance and by providing public car parks and access, recreational use of such woodland can be encouraged and also controlled. Large tracts need not be set aside since even in the popular New Forest just 5 per cent of the total area satisfies the needs of 95 per cent of all visitors. This emphasizes the importance of zoning woodland as a management tool in providing for recreation and is illustrated in the case of urban woodland (Chapter 16).

PRINCIPLES OF LANDSCAPING

This Bulletin cannot comprehensively cover this subject, only a few general guidelines are indicated. Fuller consideration will be found in Forestry Commission Booklet 44 *The landscape of forests and woods* (Crowe, 1978). For specific recommendations, especially for woodlands in sensitive areas, the services of a landscape architect should be sought. Below are principles of landscaping generally applicable to all situations.

Forest design and silvicultural operations should in general seek to:

1. blend sympathetically with and reflect the form of the land;
2. minimize intrusive effects;
3. enhance visually important natural features such as gullies and crags;
4. avoid unnatural straight lines, regularity or geometrical pattern and shape;
5. be of a scale appropriate to the land form;
6. integrate visually with adjacent farmland and become increasingly irregular near to water;
7. encourage diversity in species, ages and stand composition.

In many instances the nature of broadleaved trees and woodland confers on them an important role in execution of these principles. Consideration of this and the application of the principles to broadleaved woodland and silvicultural operations occupies much of the latter part of this chapter.

MAINTAINING EXISTING WOODLAND

Retaining woodland character

Natural mixed woodland left to itself with no maintenance of any kind will usually survive. But, compared with woodland sympathetically managed, it will not be particularly attractive to human beings (Fairbrother, 1974). Entirely unmanaged woodland, though in some instances of conservation importance, is not easily usable for recreation. But, equally, over-managed and over-'cared for' woodland, which may be excessively tidy or contain formal urban designs and materials, may be less attractive as well. What is important for most people is that the woodland character of the countryside with which they are familiar should appear to remain substantially unchanged. While this can be achieved on the large scale and over a long period of time, the main challenge confronting a forester with a particular woodland of high amenity or recreation value is how to maintain it substantially in its present appearance and at the same time ensure that productivity is sustained and that provision is made for regeneration. However, forest operations themselves are a part of the rural scene and of the continuity of tradition (even though a predominantly urban public may need constantly reminding of this) and therefore should not simply be neglected.

The most important step is to plan in the long term what operations are going to take place and how these can best blend in with the recreation and landscape needs of the woodland concerned. In seeking to retain woodland character the greatest potential intrusion is clear felling. However, if carefully planned, it can provide an opportunity to improve poor design of existing forest layout as well as introduce to the woodland scene further diversity in clearings, enframement of views and, by progressive replanting, of age and height of trees. In woods of high landscape value the size and shape of the coupe and how cutting will affect the horizons are all important. These, and considerations of whether any trees or groups are to be retained and how one year's coupe blends with the next, are best decided after careful landscape appraisal the results of which often form the basis of a landscape plan (page 136). In general the aim is:

1. to ensure a harmonious relationship of shape and scale between each successive felling where a hillside or particular landscape composition is to be felled over a number of years;
2. to shape and scale felled areas, and any retained woodland within them, to reflect landform shape and scale;
3. to avoid leaving long belts of trees but rather groups irregularly shaped and sited;
4. to use felling to re-open views, expose significant landscape features, and to break up intrusive straight lines and other geometric shapes.

In woods much used for recreation, maintaining many large trees is desirable, with any felling being done selectively or in small groups (Figure 5.5 a+b). Judicious felling of some trees may open up a new vista and such opportunities should be considered as a way of increasing the interest of the woodland area. Indeed the use of felling can be put to advantage as uniform woodland, even if mature, can be enhanced in character by introducing gaps and glades and other open spaces.

Regeneration

The subject of regenerating older woodland has been dealt with in Chapter 5 but it needs re-emphasizing that old woodland, despite its timeless appearance, does not last forever. Provision must be made for regeneration well in advance of the time the operation becomes a necessity. In Britain, amenity woodlands often have trees all of a similar age and, at the present time, many are mature or over-mature requiring urgent attention to secure their future. Nevertheless, even very old woodlands can stand being regenerated over a period of one or two decades. If some areas of large trees can be retained even longer, woodland character is further maintained. Ideally, regeneration of a whole wood should take place over many years. Where natural regeneration is not possible usually it will be desirable to replant with species which are best suited to the site and characteristic of the locality.

The most important silvicultural consideration when regenerating high amenity woodland is to ensure that the young plants are adequately protected both from the attentions of people and from browsing. This may necessitate fencing or laying down specially designated paths and interpretation of the work to the public.

In many lowland woods coppicing was the method of regeneration and its resumption, even if neglected for 50 years or more, can be effective in recreating a traditional landscape and encouraging woodland plants and wildlife, as well as opening new views and providing small sized produce. As with clear felling, coupe shape and size should be related to the landscape while allowing a wood to be steadily worked through over a coppice rotation.

Safety considerations and prolonging life of old trees

Where the public are encouraged into woodland by provision of a car park, or nature trails, or there is access from a public right of way, consideration must be given to whether any trees are dangerous. There is a responsibility on the manager and owner of amenity woodland to assess tree health and, as far as possible, to remove obviously dangerous trees or branches in places frequented by the public.

The ages at which different species begin to reach over-maturity and become more of a hazard to safety are shown in Table 5.4.

It is not recommended that lower branches are pruned to prevent tree climbing since this can give woodland an unnatural park-like appearance, though of course pruning may be done to improve or create vistas.

Large old trees of historic interest may need to be fenced around the base both for safety reasons and to reduce the amount of trampling and soil compaction in the immediate vicinity (Figure 13.4). It is thought that this latter effect is responsible for dieback and decline of some of the most impressive oaks in Sherwood Forest.

CREATING NEW LANDSCAPES AND AMENITIES

Considerations when establishing plantations

In new planting analysis of the landscape and survey of sites provide the basis for applying landscaping principles which, for significant or sensitive areas, should be formulated in a landscape plan (page 136).

There are two main situations to consider: the use of judicious planting of broadleaves to enhance a predominantly coniferous landscape, and how to make the most of a new broadleaved plantation.

Use of broadleaves in coniferous forestry

Much planting of broadleaves, particularly in the uplands, has been done in the name of amenity to mitigate the uniformity of some coniferous afforestation. When done with care, allocation of 5

Figure 13.4 The Knightwood oak (New Forest), 350 years old. Fencing prevents trampling and compaction of soil around base of tree by the many visitors who come to view this ancient pollard. (*A10604*)

or 10 per cent of the total area to broadleaves can greatly improve the landscape (Figure 13.5). In doing this the following principles should be followed:

1. ensure a good match of species with site so that the trees will grow;
2. use broadleaves to emphasize the natural land form by planting up a gully or areas beside watercourses;
3. plant in clumps and irregular shapes related to land form and avoid straight edges, aim for simplicity and appropriate scale;
4. make use of or augment existing broadleaved trees and woodland, e.g. on exposed crags or along a lower boundary to link with hedgerows.

The site conditions will usually determine species but some generalizations can be made:

1. oak, beech, ash and sycamore are remarkably hardy and moderately tolerant of exposure and, though slow growing, will often survive at high elevations (generally up to 450 m in England and Wales and 300 m in Scotland) provided phosphate nutrition is adequate and that trees are protected from browsing and are reasonably sheltered by other woody growth or the lie of the land;
2. alder, often the first choice for a wetland or stream site, can be a dull tree having no autumnal colouring, and alternative species such as sallow or poplar might be considered;
3. birch, rowan, and Bird cherry are the hardiest broadleaved species to plant at highest elevations;
4. choose species which are characteristic of the area;
5. avoid frivolous planting of horticultural cultivars such as flowering cherries or laburnum.

Frequently, amenity planting of broadleaves either precedes or, more often, follows the initial establishment of coniferous forest and separate protection may be necessary. Individual tree protection will often be the most suitable solution to this problem.

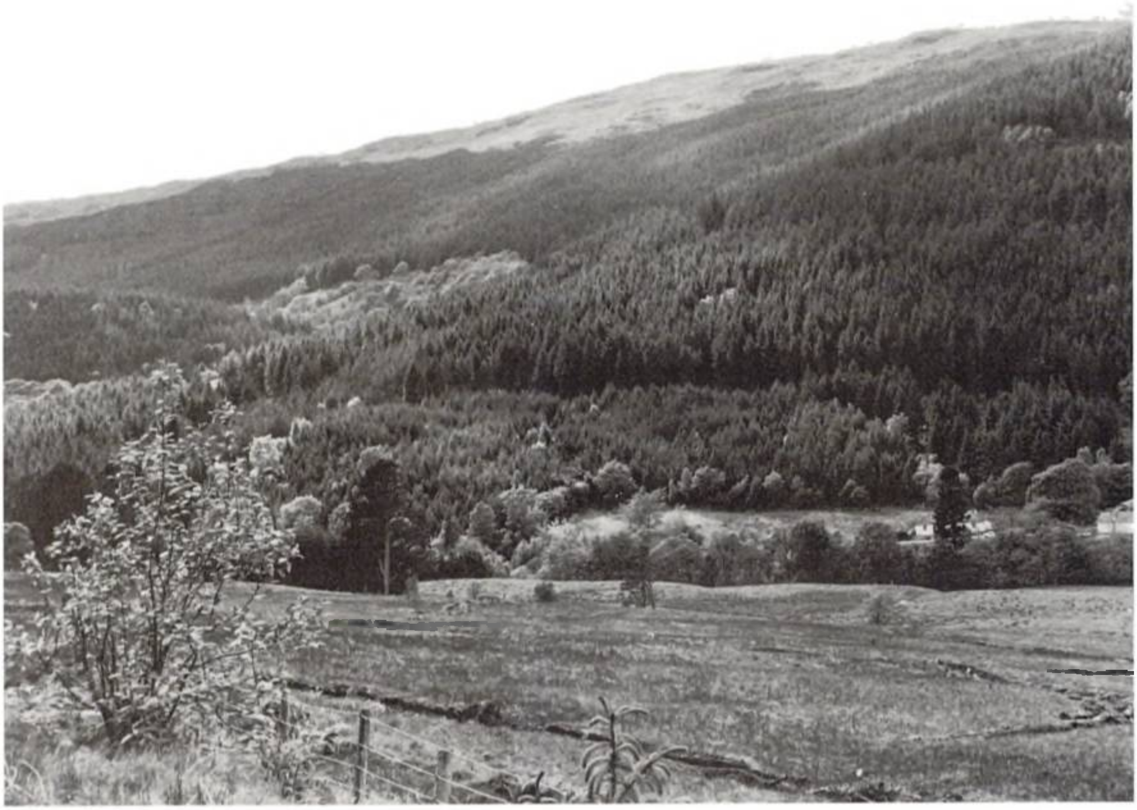


Figure 13.5 Broadleaved woodland blending in and breaking up the boundaries of conifer afforestation. (*C4032*)

Establishing a new broadleaved plantation

Pure young stands of broadleaves can be very uninteresting scenically. Care in layout and management to enhance their amenity is no less important than for conifers. Preparing a landscape and recreational plan (page 136) prior to planting should always be considered.

The general principles enumerated in the previous section apply equally to the broadleaved plantation, but in addition there is the question of broadleaved: conifer mixtures. The difficulty is how to avoid spotty, striped, chequered or other intrusive effects in a sensitive landscape. In general the problem can be minimized by:

1. not planting in strips;
2. varying the number of trees, shapes, and separation of groups in group planting, or using a diamond pattern if a more organized layout is required;
3. using intimate single row mixtures;
4. avoiding mechanical thinnings which emphasize and perpetuate the mixture pattern.

Clearly, these solutions will at times conflict with silvicultural and management considerations and, on prominent hillsides, broadleaved:conifer mixtures are best avoided altogether as discussed in Chapter 3 (page 28).

Mixtures of broadleaved species usually present no landscaping problem. Pure broadleaved stands can be monotonous to walk through and occasional conifers, singly or in a group, add interest.

Elm replacement

Since the late 1960s the loss of elm trees throughout much of Britain has altered many traditional rural landscapes. Although many of the hedgerows where elms have died are now regenerating vigorously from suckers, there is no certainty that such regrowth will eventually grow into large trees since they remain equally susceptible to Dutch elm disease. Therefore it is important to plant different species and those listed in Table 13.1 are suggested as possible alternatives.

Table 13.1 Trees suggested as suitable for replacing elm in rural areas

Species	Stature	Habit	Autumn colour	Remarks
Pedunculate oak	Large	Broad dome	Russet	Fine timber.
Sessile oak	Large	Broad dome		Fine timber.
Turkey oak	Large	Tall dome; open crown		Great vigour; poor timber.
Beech	Large	Tall dome or broad	Orange-brown	Unsafe when old. Bears a little shade. Good timber.
Sweet chestnut	Large	Tall dome; broad with great age	Yellow; russet	Great vigour; long-lived. Timber often split and shaken.
Small-leaved lime	Large	Big domes; dense		Usually vigorous; attractive foliage; soft white timber.
Large-leaved lime	Large	Broad dome		Vigorous; good shape.
Ash	Large	High, open dome		Fast on rich, damp soil, producing timber of high quality. Roots too strong for favour in hedges by crops.
Grey poplar	Large	High domes	Yellow	Silvery foliage in spring; vigorous; strong roots and suckers.
Sycamore	Large	Broad, dense dome		Damaged by squirrels; unpopular with farmers and conservationists; timber very good.
Hornbeam	Large	Broad; light fine twigs	Russet	Attractive; quite vigorous; timber too hard for normal use; very strong.
White willow	Large	Tall, acute then domes		Vigorous; pale blue-grey.
Italian alder	Large	Tall, conic, dense		Vigorous; adaptable and handsome. Suitable for calcareous soils.
Norway maple	Large	Broad dome	Gold, orange or red	Mass of yellow flowers in April; vigorous.
Common alder	Medium	Conic		Base-rich very moist soils preferred.
Crack willow	Medium	Broad, low dome	Brief yellow	Long, glossy, bright leaves; handsome.
Grey alder	Medium	Broad column		Vigorous on wide variety of soils.
Wild cherry or Gean	Medium	Broad dome	Yellow, pink and dark red	Mass of white flowers in early May. High quality timber.
Bird cherry	Medium	Ovoid	Yellow, pink	Tassels of white flowers, June.
Field maple	Medium	Broad dense dome	Gold, some crimson	Can be 25 m tall; not slow.
Wild service tree	Medium	Conic, then domed	Crimson, dark red	Very handsome; unusual native.

Notes:
Stature – Large: On reasonable site often 23–25 m tall, to 30 m or more.
Medium: On reasonable site seldom above 20 m.
Autumn colour: Unshaded tree in good year; mentioned only where a feature.
From Mitchell (1973).

Small plantings of high amenity

There are two situations where tree planting can perform an unusually important service to the environment:

1. screening ugly features; and
2. planting at strategic points such as near the entrance to woodland or close to a road.

In both situations it is the individual trees, as much as their combined effect in a small stand, which is important. The first consideration is the factor of scale. For the tree planting to achieve its effect the ultimate size of the trees and the amount of planting undertaken must be in proportion to the landscape needs. For example an ugly factory is not effectively screened by a row of dwarf maples and a small woodland office is not best shrouded by some very large trees. Silviculturally the most important factor in planting in visually sensitive locations is for healthy, rapid growth of the planted trees. Although some immediate effect may be achieved with half standard or standard trees such large plants can check after planting. In most amenity planting it is best to use ordinary transplants and to ensure good matching of species and site, good preparation of the ground including pit planting if necessary, a high standard of weed control and other tending, and full protection. In this way establishment will be rapid and the desired landscape effect achieved in a short time. Moreover, rapidly growing young trees are generally more attractive than stagnating, semi-mature ones, perhaps hastily planted just for effect.

Regarding species choice for high amenity locations, the considerations enumerated earlier all apply. But, it is important to avoid the desire to have complicated species' mixtures, the effect of which is entirely lost when viewed from a distance. This applies equally to achieving a desirable landscape as to an area of recreational potential.

THE LANDSCAPE AND RECREATIONAL PLAN

Since each forest and woodland is a complex multi-purpose landscape, a comprehensive landscape and recreational plan is a helpful tool to make the best use of all resources, to ensure that no one use will conflict with another, and to bring all uses together into a landscape which will both function well and look well. An analysis of the character of the landscape should be made, and a plan prepared.

The plan should be based on contoured surveys supplemented where appropriate with aerial and ground level photographs, sketches, etc., showing natural features, outstanding views, points of public access and areas of particular attraction to visitors. It should also record any fragile areas needing protection from over-use, and soil conditions relating to wear capacity. It should cover enough of the surrounding land to put the forest into context, including the footpath and bridleway links to the countryside and villages outside the forest.

This factual survey can help to ensure that while attractive natural features are enjoyed, no part of the forest receives more wear and intrusion than it can support. Conservation of resource should always take precedence over demands for use.

Before work starts a useful aid to planning is to prepare sketches and design scenarios to show the landscaping and recreational effects intended.

CHAPTER 14

Conservation

IMPORTANCE OF CONSERVATION

Introduction

Conservation is the management of habitats to maintain or increase their value for wildlife. Woodlands serve a dual purpose in this role. They are collections of woody plants of interest in themselves and they also provide a great number and variety of habitats which are vital for a substantial proportion of the British flora and fauna. This is because woodland, particularly broadleaved, is the climax vegetation over most of Britain. Complete destruction of woodland would lead to extinction of a high proportion of native plants and animals. Because in Britain the woodland area is only 9.4 per cent of the total land surface, and less than half of this consists of native woody species, what semi-natural woodland remains is of great ecological and conservation interest.

Maximizing the conservation value of broadleaved woodland will only occasionally mean non-intervention to 'allow nature to take its course'. A second point also needs stressing. There are three distinct aspects to conservation:

1. improvement of habitats and ecological diversity in any woodland by adopting often simple and usually small-scale changes in conventional silviculture, e.g. one-sided cutting of rides alternating each year, not planting right up to the edge of a stream, retaining a few old trees past rotation length, etc;
2. maintaining certain woodland types, either because they are an important ecotype (see Table 1.3) or are ancient in the sense that the land has been under woodland for many centuries, since such woodlands, even if they have been regularly worked, are often some of the richest ecosystems in Britain;
3. managing a habitat specifically to conserve rare plants and/or animals at risk from unsympathetic treatment as may result from normal forestry operations.

Much recent attention has concerned the second aspect of conservation – the 'preservation' of ancient woodland. But, as was pointed out in Chapter 13, because almost all woodlands have been influenced to a greater or lesser extent in the past by man the ideal conservation approach is not neglect but frequently the perpetuation of traditional and long used practices. These very practices have led to and maintain the characteristic woodland flora and fauna so much admired today, which are found in relics of wood pasture, ancient coppice woodlands, and ancient high forest. From such woodlands there is a substantial yield of forest produce, though rarely is it the silvicultural maximum the site might theoretically produce. This difference is the 'price' of conservation, but comparing on economic grounds the timber yield forgone with rarity, abundance or variety of wildlife, is to use only one criterion.

Obtaining yield of forest produce and conserving a woodland need rarely be in direct conflict. Forest operations, particularly in the uplands, generally increase habitat diversity. In the lowlands most woodlands where conservation of the existing ecosystem is considered of great ecological importance are already classified as National Nature Reserves, Sites of Special Scientific Interest (SSSI) or Local Nature Reserves (administered by local authorities) or are under the control or management of organizations such as the Woodland Trust and local Naturalists' Trusts. Moreover, active forest management and regular income from woodland greatly reduce the chances that such woodland areas are grubbed up and used for farming, which in almost every case is a loss to conservation. Indeed, some of the most important woodland conservation areas in Great Britain survive because active forest management has been and still is practised.

Further consideration of the importance of broadleaved woodland and where it is located will be discussed, but the bulk of this chapter concerns the three aspects of conservation noted above. The classification or identification of woodland which may merit priority treatment for conservation is considered briefly, and those conservation practices which enhance any woodland are enumerated in some detail. The reader is referred to Peterken (1977, 1981) and Rackham (1976, 1980) for fuller consideration of this subject.

Importance of broadleaved woodland

Broadleaved woodland is generally valued for conservation of wildlife. According to Peterken and Steele (1982), of 300 000 ha of woodland considered of highest conservation value, 290 000 ha are broadleaved. There are five main reasons for this importance and why broadleaved woodlands tend to be rich ecosystems.

Ecological types

Most native tree species are broadleaved and they make up the great majority of ancient, semi-natural woodland types recognized botanically (Table 1.3).

History

Broadleaved woodlands which have been present for many centuries develop a stable woodland flora and often support plants which can only survive in such situations, the oxlip or the more familiar plant, Yellow archangel, are notable examples. This factor of time, leading to the recognition of what is called 'ancient' woodland (Figure 1.2), is one of the most important factors to determine when considering the conservation value of a wood. Typically, ancient woodlands, with open rides and free from heavy browsing, often have 200 or more vascular plant species while recent even-aged plantations established on open ground may have only 20 or 30 such plants, though rather more if there are wide open rides and breaks. If ancient woodland is clear felled there is usually little or no loss of plant species, except for lichens and other bryophytes, provided it is replanted with native broadleaves. Some loss is sustained if replanting is with heavy shade-bearing conifers, though retention of open rides, unplanted areas, etc., will minimize this. However, the largest potential loss is not due to which species is replanted but whether the soil surface, with its seedbank, is severely disturbed. Clearance which includes uprooting of stumps and bulldozing of the ground causes the greatest destruction.

The second factor of history is that ancient woodland will commonly comprise almost wholly native species.

Species characteristics

Three features of broadleaved woodland encourage a rich ground flora and consequently a rich fauna.

Firstly, a dense canopy is only complete for part of the year and, particularly in the spring, light reaches the forest floor allowing plants such as bluebells, Wood anemone and celandine to thrive. Also the canopy itself is often structurally varied and relatively open. Although ground cover is poor for a time under most pole-stage broadleaved plantations, only under beech and some dense coppice crops of Sweet chestnut, lime or hornbeam, is ground vegetation greatly reduced, and then only for a few years in the case of coppice.

The second characteristic is that the litter derived from broadleaved species is usually mull-forming and breaks down relatively quickly. The importance of this, apart from the complex and difficult-to-quantify chemical effects on soil development, concerns the packing down of the litter layer. Species with leaves or needles which pack down loosely and only decay slowly, e.g. chestnut and pine, form a litter which tends to dry out. This appears inhospitable and the ground flora is reduced compared with that under species with small leaves which are more easily packed (Anderson, 1983).

The third feature is that most broadleaved woodland consists of native or long naturalized species, several of which are often present in a stand. The classic work of Southwood (1961) demonstrated that in general a greater variety of insects are associated with native trees and shrubs than with recently introduced species, though there are exceptions such as Southern beech (see later). Few studies have compared directly the flora growing beneath exotic tree plantations with native ones established on similar sites. The richer flora found in woods of native species is usually associated with their ancient or coppice status. Indeed, differences attributed to the dominant tree species being native or exotic may not be very great at all. Recent work by Anderson (1979) and Hill (1983) indicates that, although initially the ground flora under native species may be richer compared with exotics, by the time stands become middle aged and have been influenced by thinning the flora is often very similar.

It appears that after the thicket stage the amount and intensity of thinning is the most important factor. Moreover it is being increasingly found that differences in ground flora between plantations of conifers and broadleaves also diminish somewhat once thinning commences, and all woodland crops of this type slowly tend toward a similar association of ground vegetation species. After middle age, if a stand is well thinned allowing light on to the forest floor and facilitating breakdown of litter, the influence of the overstorey tree species appears to become rather less significant.

Comparing bird populations found in broadleaved woodland with those of coniferous woodland shows that in the lowlands, broadleaved woodland, especially when including mature and overmature trees, supports a wider range of species. Densities, but not always varieties of species, are highest in mixed woods followed, in descending order, by woods of oak, birch, beech and pine.

Occurrence

Over Britain as a whole most broadleaved woodland occurs on more fertile sites than coniferous forest. A fertile site usually has a richer flora and fauna than an infertile one. Thus broadleaved woodland habitats can be expected to contain more species than most coniferous ones.

Importance of geographic location of broadleaved woodland

Broadleaved woodlands predominate in the lowlands (Figure 13.1) and are one of the principal wildlife refuges. But it should be noted that two woodlands of comparable species and ecological richness may not have the same conservation importance. In an area with few woods, loss of any one of them will have a much greater impact on the local wildlife than in areas relatively well wooded. Moreover, lack of woodland cover in an area indicates much pressure from other land uses in the past and which are likely still to be present, e.g. conversion to arable farming, grubbing up hedgerows, etc. Similarly planting up small waste areas on a farm will be much more important in some regions than others.

The second aspect of geographical location concerns the locality itself. Because the woodland boundary or edge is of particular conservation value, mainly owing to the shrub layer usually present, a spinney, perhaps connected by hedgerows to adjacent woodlands, for its size plays a more important conservation role than a comparable area within a large woodland. However, this aspect should not be pressed too far because it is now well recognized (Peterken, 1981) that very small isolated woods often only support a meagre wildlife. In general, the larger the wood the better for fauna and flora, but some small woods may be especially rich and any wood, or even a row of trees, is better than none at all. As Arnold (1983) showed from studies of farmland, the average number of bird species per site in winter increased from 5 on arable land to 7.5 when a ditch was present, to 12 if there are short hedges or trees, to 17 if these are tall hedges, and to 19 if there is a strip of woodland.

CLASSIFYING WOODLAND AND ASSESSING CONSERVATION VALUE

Other things being equal it is both sensible and realistic to concentrate conservation measures on those woods of intrinsically high conservation value. As mentioned previously, many such woodlands will already have been designated as Nature Reserves or Sites of Special Scientific Interest, but it is important to recognize those characteristics which may classify a stand in this category. Much has been written on this subject and the reader is referred to Peterken (1981).

The chart in Figure 14.1 may be used to indicate the *possible* conservation importance of a woodland.

AIDING CONSERVATION IN WOODLAND MANAGEMENT

There are many ways that the conservation value of a woodland, whether coniferous or broadleaved, can be enhanced often by relatively minor adjustments. Such works will be beneficial in all woodland types. Where conservation is an important priority for the owner the following principles will aid this objective.

Use of species

Conservation aims are best served by maintaining or encouraging native species which naturally occur in the region. The optimum is for woodland to be kept free of introduced species, and native interpreted in the strict sense, i.e. native to the locality, not simply to Britain. For example, beech does not occur naturally in north and west Scotland and would not be considered 'native' there though, of course, as a useful species for upland planting such as in shelterbelts, it can play an important conservation role in providing shelter, diversifying habitats, etc.

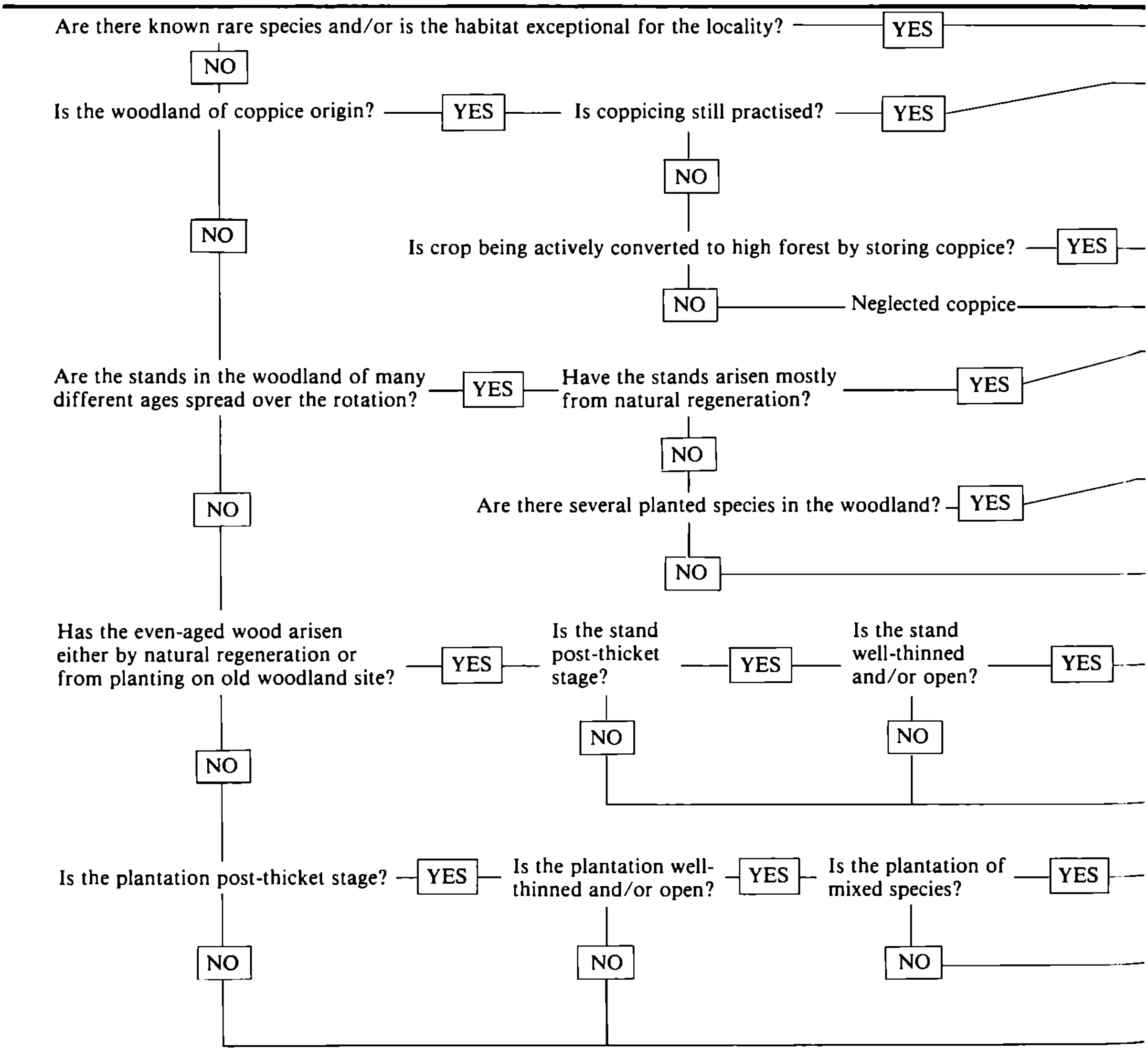
In other woodland types or new plantations the retention of any native trees and shrubs in groups, pockets or along boundaries will be beneficial.

The consideration of the conservation aspects in influencing the *choice* of broadleaved species in new planting should not be overstressed at the expense of other measures. There is evidence that even a recent exotic such as Southern beech supports a richer wildlife than native beech (Wigston, 1980; Welch, 1980) and that the long naturalized exotic, sycamore, has been underestimated in value (Stern, 1982). Also, for numbers and species of songbirds, although broadleaves are preferable to conifers,

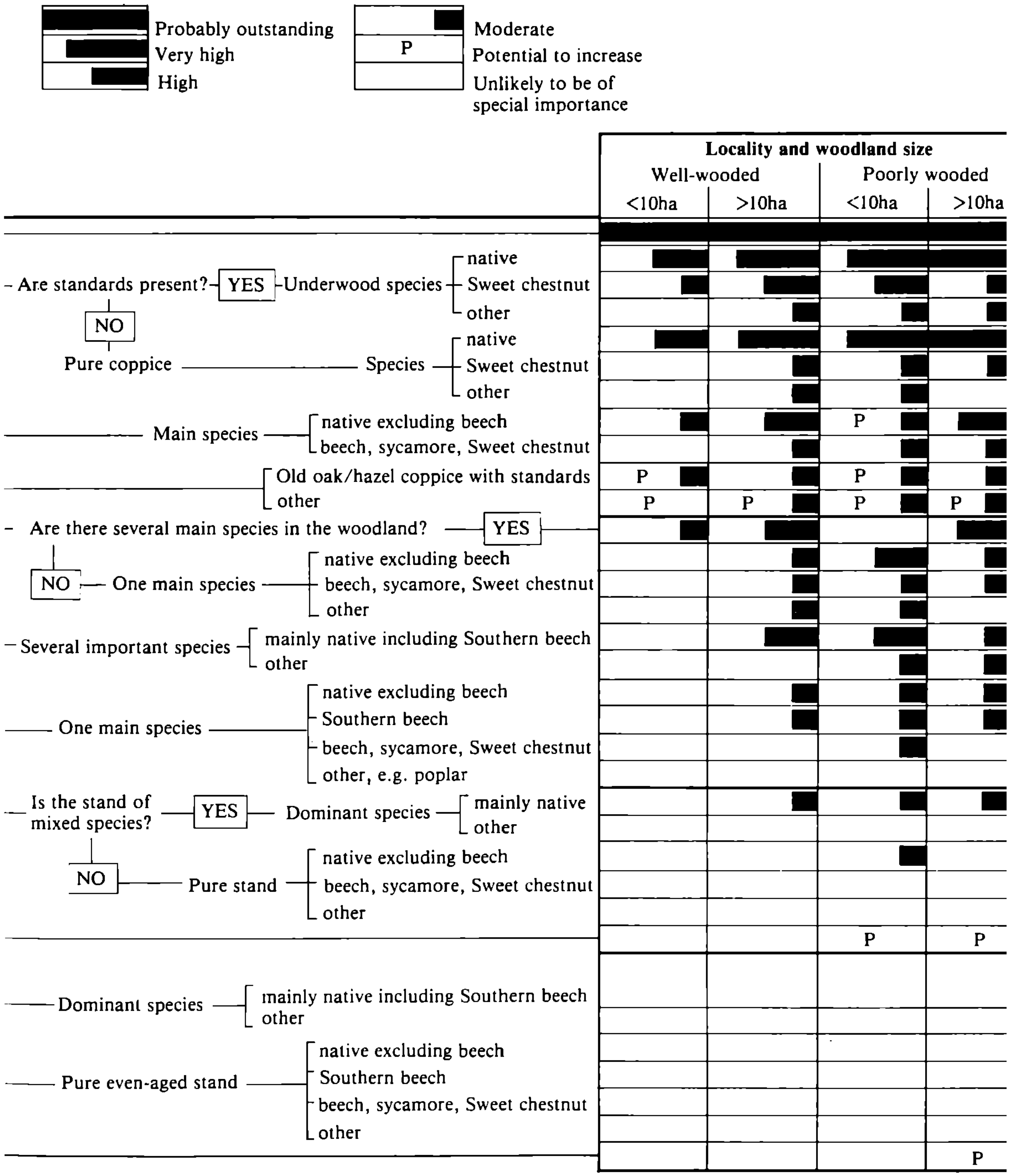
Figure 14.1 **Assessment of possible conservation importance of a lowland wood**

Notes:

(1) This key indicates general benefit to conservation, not whether a specific woodland type (ecotype) should be conserved or is rare.
(2) All woodlands have some conservation value compared with none at all.
(3) Conservation importance is not static and changes with woodland condition.
(4) Glades and wide rides generally increase a woodland's conservation importance, heavy browsing decreases it.
(5) If historical evidence suggests the woodland site is 'ancient', i.e. has been continuously under forest since medieval times, conservation importance should be uprated about one category.



Key to conservation importance



mixed broadleaved stands containing a few conifers are even richer (Newton and Moss, 1981).

More important than 'which species?' is the planting of new woods in poorly wooded regions.

Natural regeneration and local seed

Natural regeneration can be used to perpetuate woodland of native species and it ensures that the local gene bank is maintained. Where natural regeneration is not easily forthcoming one alternative is to collect seed locally and by using nursery techniques produce transplants for restocking. In this way the regeneration process is aided without introducing alien genetic material.

Stand structure

A uniform even-aged crop all of similar sized trees has fewer habitats and is of less conservation value than a woodland or forest with many different age classes and many different tree sizes. A 'normal' forest, i.e. one with more or less equal areas of all age classes present, is of greater conservation benefit than a uniform block. Felling to increase structural diversity in the course of normal management will aid conservation, though in many instances owing to patches of poor growth, areas of windthrow, and other similar factors some diversity will usually occur anyway.

Gaps and rides

Gaps, rides and forest roads create ecotones (transition zone habitats), add structural diversity, and help to provide warm, sheltered and secluded open spaces (Figure 14.2). Leaving small areas unplanted is invariably of value and often silviculturally desirable in very wet areas, rocky outcrops, etc.

Forest rides and roads are artificial gaps created for management reasons. It is clear from studies of ancient rides, particularly in lowland woods, that they afford a very valuable secondary habitat. The

Figure 14.2 Diverse woodland structure of mature and freshly cut coppice, oak standards, individual beech trees, a wide ride, young coppice and mature standards (upper right) all within a short distance. (*A10605*)

ride centre itself, verges, and the damp ditches on either side, all create micro-sites of considerable ecological interest. Management of such rides, by preventing their being overgrown or becoming heavily shaded, maintaining glades, and the prevention of too much vigorous woody growth along the verges can both aid conservation and benefit management. For example, if the side of a ride which is cut is alternated each year the structure and type of plant flora encouraged will much improve the habitat for some butterflies.

In upland woods rides are probably of less value than forest roads, indeed this applies equally to an untended firebreak which is usually colonized by two or three aggressive species such as *Molinia* or heather. A forest road, which is usually much wider than a ride, has a greater range of habitats – the crown of the road, sloping verges, and edge ditches rising up to banks into the wood. This road environment enables several mainly lowland adapted species to colonize upland woods (Hill, 1983).

Rotations and felling

Large old trees often support an abundance of fauna and flora; they are particularly important for some epiphytes, and as nesting sites. However normal silvicultural practice precludes trees reaching this age because economic considerations generally dictate that felling occurs before most species reach overmaturity. On occasion there will be justification in retaining stands of trees beyond their theoretical optimum economic rotations, particularly where other factors such as landscape, sporting and amenity also prevail, or perhaps if a market is depressed. However, these considerations are generally the exception rather than the rule and retaining a stand for many years past its normal rotation may lead to loss of revenue – see page 64. A compromise is to prolong regeneration by irregular group felling over 25 or 50 years or to retain one or two small groups or a few stems well beyond the normal rotation. Provided the latter are not being used as a seed source the poorest, most misshapen and least valuable trees can be left indefinitely adding both ecological diversity and considerable scenic and artistic interest to a wood.

Structural diversity and edge effects are increased in a woodland where the felling coupes are kept to a small size (1–3 ha). Similarly regeneration by groups is preferred over extensive clear felling.

Exclusion of domestic animals

In general, nature conservation is enhanced if browsing and grazing of domestic animals in a wood is prevented. This is not always the case since some plant species are preferentially favoured by grazing, and grazing is an integral component of the traditional wood pasture habitat. Nevertheless, most typical woodland plants are damaged if domestic stock are allowed into the wood. And, as has been pointed out, intensive browsing will prevent natural regeneration, and a heavy stocking of livestock will lead to bark stripping.

Coppicing

Where appropriate, the re-introduction of former management practices, most notably coppicing, may confer the single greatest benefit in preserving the characteristic woodland flora of the lowlands (page 72). In the case of the large area of overmature hazel this presupposes a major change in present markets and outlets for the produce, but for other species there is a good demand for pulpwood or firewood. According to Peterken and Steele (1982) about 160 000 ha of existing broadleaved woodland were formerly coppiced and restoration of this practice would be the most beneficial change to improve their conservation value.

Other measures

There are several other measures which could be introduced and may be beneficial locally, e.g. not cutting down ivy, planting or leaving shrubs such as sallow for Purple Emperor and Wispy honeysuckle for White Admiral, irregular opening up along streams, ditches and pond edges, creating glades (Ratcliffe, in prep.) such as by enlarging ride junctions, destruction of rhododendron, etc. The Nature Conservancy Council and County Naturalist Trusts are usually well placed to advise on conservation measures.

The direct effects of forest operations vary. Thinning, as noted, is generally beneficial. Weeding and cleaning may temporarily reduce diversity. Use of chemicals to control pests and diseases is uncommon in forestry, and even herbicides are in use for less than 10 per cent of the rotation and then are rarely applied broadcast but are confined to spot applications.

Conservation plan

Preparing a conservation plan is a useful way of helping to ensure that agreed measures are incorporated in woodland management.

CHAPTER 15

Sporting

INTRODUCTION

For many woodland owners the sporting value of their woods can equal or exceed in importance that of forest produce. Sporting provides enjoyment as well as some financial gain and for many smaller, mainly broadleaved woods, copses and spinneys, it is their main use and justification for retention on an estate. According to Piddington (1981) one-third of all woodland owners have planted or retained coverts or belts of trees specifically because of a sporting interest, and some 18 per cent took sporting interest into account when choosing which species of tree to plant. The sporting value of hedgerows and small woods is an equally significant factor favouring their retention as that of amenity or wildlife conservation.

Where shooting is involved, the overriding management objective is to present animals to the gun in a safe way, usually at definable locations. This means:

1. providing an environment to facilitate shooting; and
2. providing suitable conditions in the wood for reproduction, growth and protection of the animals concerned.

Satisfying these two aims, even where sporting is the principal objective, need not preclude all yield of forest produce. Equally, in woodlands managed for timber, sporting value can be enhanced with only small changes and little serious conflict with silviculture (Seymour, 1974).

This chapter considers each of the main animal groups individually and indicates the main woodland management considerations for sporting. It is important to distinguish between lowland and upland areas and this is done where appropriate.

Sport is a large subject and the reader should, of course, refer to the specialized literature concerned, e.g. that of the Game Conservancy, and the abundance of material dealing with the subjects of hunting, shooting and angling.

Importance of broadleaved woodland

Although almost all woodlands will provide a little sporting, broadleaved woods are particularly valuable for a number of reasons. The greater variety of species, both in the tree crop and ground and shrub layers, provide better cover, shelter, and sources of food for most kinds of sporting animals. Also in broadleaved woodland more sunlight tends to reach the forest floor and the woods themselves are usually in more sheltered areas favoured by wildlife for warmth and protection from exposure. The small size of many broadleaved woods and presence of glades and openings increases woodland edge which is so important in the life of many animals: very few 'woodland' species spend all their time actually in dense woodland.

In addition, all types of coppice (ash, oak, lime, hornbeam, Sweet chestnut, mixed species, etc.) especially with standards (Figures 1.2 and 7.4) provide particularly favourable habitats for many game animals and other wildlife.

GAMEBIRDS

Much the most important woodland gamebird is the pheasant, though in the uplands black game and capercaillie are locally important. Partridge and red grouse are agricultural and moorland birds and are not considered here except to mention that their habitat is radically altered and effectively reduced by large-scale afforestation.

Woodland conditions for rearing pheasants

For pheasants to thrive, whether wild or reared, several conditions are needed. The woodland must not be draughty; the presence of ground cover and perhaps a perimeter hedge improves the necessary shelter and warmth. The canopy must not be so dense as to suppress all ground vegetation and create a cold forest floor. Sources of food are also needed and these can be provided directly in the form of grain or corn (which will also be eaten by squirrels) using a hopper or spread by the keeper; by growing berry-producing shrubs such as hawthorn, sloe or cotoneaster; or by having an awkward corner or small field nearby put down to mustard or kale. The fourth essential ingredient for rearing pheasants is their protection. Direct predation of eggs or young birds must be minimized by control of foxes, crows, jays and magpies. It is equally important to limit human trespass in areas where pheasants are being reared. In particular dogs running wild are a serious disturbance.

Most forestry operations disturb game birds and raising pheasants or providing food, etc., are best not attempted in the part of the wood affected. Alternatively, plan the operations for outside the nesting or shooting seasons.

Presenting to the gun

For good sport pheasants must rise fast and high. The woodland or covert should have areas to encourage this – patches of flushing cover – so that the birds are not forced to fly up through the canopy or only to take wing when at the edge of the wood.

Flushing cover needs only to be a very small proportion of the total woodland area and can be low shrubs, areas of young coppice, or young natural regeneration. If several patches are present, each about 10 m across, then there are a number of opportunities for the birds to rise as the wood is beaten. The other requirement for achieving good presentation of birds is to ensure that beating the covert can be done slowly, steadily and thoroughly. Reasonable access is therefore necessary and some cleaning or brashing may be required in impenetrable areas.

Design of new woodland

Much has been written on this subject and there are many sophisticated woodland designs such as described in Game Conservancy Booklet 15 *Forestry and Pheasants*. Woods designed for sporting will not maximize the site's timber growing potential, but a worthwhile yield of forest produce will almost always be obtainable. For predominantly broadleaved woods in the lowlands the main requirement is to limit the extent of pure stands particularly of beech and sycamore, and to provide some peripheral shelter so that the woodland is not draughty. Ideal tree species include Sweet chestnut, oak, whitebeam, and ash. Where conifers are included pines and larches are preferred to spruce. Shrub layer species should bear fruit or seeds profusely; hawthorn, rowan and whitebeam are all useful, but privet and rhododendron should be avoided. The best cover shrub to provide shelter is Shrub honeysuckle *Lonicera nitida* though both snowberry and common laurel are useful.

In laying out the woodland, wide rides, which are never completely shaded, are desirable. These are warm and sheltered and provide an area where pheasants can be fed. The need, later in the rotation, to have breaks in the canopy and areas of flushing cover was mentioned in the previous section.

In upland forest, where coniferous species will often be the main choice of tree, some provision can be made to enhance the sporting value of a forest. In particular this is aided if wide rides have a fringe of broadleaves such as rowan or birch, and if small areas of sallow or thorn are allowed to remain in sheltered places and around rocky knolls. In uniform areas of spruce, introduction of pine and larch will be beneficial where site conditions permit.

Where new woodland is intended to provide shelter in addition to a sporting habitat, it should be at least 30 m wide and consist of several species of trees and shrub to introduce many vegetation layers (Figure 15.1). An outer hedge, along with one or two rows of Christmas trees and a row of coppiced trees on the edge of the main belt of trees, is ideal.

Enhancing existing woodlands

For both lowland and upland woods the conditions referred to above need to be provided. Neglected woods or outgrown coppice are frequently draughty and of little value to sportsmen or, indeed, foresters.

For lowland woods the main improvements most frequently needed will be encouragement of low growth, especially along the perimeter, control of predators, a careful check on public use of the wood, provision of flushing points or flushing cover, new rides and re-opening overgrown ones, and reasonable access through the crop perhaps by cleaning.

Mature woodland in exposed locations may need ground shelter by encouraging or planting shrubs or by starting their regeneration.

In upland woods the most common requirements to improve sporting potential are to diversify structure and to introduce broadleaved species in what will usually be areas of pure conifer. The idea of 'game strips' is a useful one and involves planting broadleaved species or, if impractical, pines and larches, in an irregular strip along a contour between areas of spruce. Encouraging regrowth of broadleaved vegetation along the edges of firebreaks is also beneficial. Similarly when roading is carried out in upland plantations, usually just before the time of first thinning, sporting will be enhanced if the total width of road and verge is at least 25 m and if broadleaved species are encouraged along the verge. Also, as suggested in the chapter concerning

Figure 15.1 Farm shelterbelt on chalk downland, designed also for game. About 30 m wide with outer shrub layer, three rows of pine on each side and a central band of beech. (*A10606*)

landscaping, retaining and encouraging scattered broadleaves up gullies and beside streams also helps the sporting value of the wood (Figure 13.5).

WILDFOWL

Wildfowl species are not, of course, woodland birds but often ponds and dams in woodland are used by duck and geese and are therefore of sporting potential. The encouragement of such wildfowl species, whether for conservation or sporting interests, is helped by having shallow ponds, less than 30 cm deep, with grass banks and some surround of broadleaved shrubs of willow/sallow species except on the south side which is best left open.

In general, for wildfowl to be attracted to woodland ponds the pond must be clearly visible from overhead and not heavily shaded in some depression. Indeed, ponds in elevated positions are the most suitable.

Where ponds are managed for wildfowl or new ones sited for sporting purposes there is no reason why they cannot double up as fire ponds. The only requirement is good road access to one point on the pond edge.

ANGLING

Fishing, of course, is not peculiar to streams or rivers in broadleaved woodland but the presence of broadleaved shrubs and trees along a stream edge, appropriately interspersed with gaps to achieve the optimal half-shade condition (Dawson and Haslam, 1983), can enhance the fishing potential. An important factor is provision of fish food, and shrubs or trees that carry an abundant insect fauna are helpful in this respect. In terms of insect biomass, sycamore appears surprisingly good (Mason, 1982). Establishment of broadleaves and introducing openings next to streams flowing through coniferous forest can reduce the amount of heavy shading, which is also beneficial.

DEER SPORTING

The deer population has increased rapidly in size and spread since the Second World War such that today most woodland of more than a few hectares contains some.

Three species of deer, fallow, roe and muntjac, are of concern in lowland broadleaved woodland. Unlike most other sporting animals, deer can cause damage in woodland and they may cause damage on farms, notably from fallow, muntjac, and red deer eating the tops of winter root crops; roe will browse in gardens in the winter. Thus deer sporting has both the element of utilization – stalking income and meat – and the need to control numbers to reduce damage to other crops. Deer management must seek to balance these two objectives.

Culling deer to control numbers will not entirely prevent browsing damage to young broadleaved trees and where a crop is being planted or naturally regenerated either deer fencing must be erected or individual tree protection used. Open spaces, such as rides, breaks or young crops allow safe sight lines to shoot deer, as well as being where deer usually feed, and high seats can be erected at such locations for the purpose. If glades do not exist they may be created for this purpose (Ratcliffe, in prep.). Not all broadleaved woodlands have a resident population of deer, in particular small spinneys of mature trees are unlikely to have any. The most favourable habitats are young crops with much undergrowth providing food, e.g. brambles and shrubs, and thicket stage stands providing shelter. Deer may pass through older woodland but from pole-stage onwards the habitat becomes increasingly less desirable. As for nearly all sporting interests, coppice is a good habitat.

FOX HUNTING

This widespread country sport depends on areas of woodland for its quarry. Woodland management to facilitate fox hunting has two components:

1. actually preserving a fox population so that there are animals to hunt; and
2. making provision for the movement of the hunt through the wood.

Although encouraging foxes may in part conflict with other sporting requirements of a wood, e.g. rearing pheasants, and the interests of neighbouring farms with poultry or lambs, maintaining a moderate population usually causes little damage.

However, where fox hunting is the dominant consideration in woodland management the best cover is provided by coppicing on a short rotation of 5–10 years. Some large hunts own woods and spinneys in their area specifically to manage in this way.

A dense impenetrable wood is no good for hunting. Rides and roads and indeed narrow paths are needed for the hounds, huntsmen, and the field. Ensuring these routes are not overgrown providing easy access into and out of the wood, and keeping hedges 0.9–1.5 m high, are important both for success of the hunt and for minimizing damage.

Where the public are encouraged into a woodland or where woodland is of particular value, e.g. an arboretum, nature reserve or Site of Special Scientific Interest (SSSI), agreeing access and, in particular, which routes are for hunt servants only and which for the whole field is important.

ROUGH SHOOTING

Rough shooting is informal shooting of game species and animals such as rabbits, hares, squirrels, pigeons, jays, and magpies in woodlands where sporting is not the principal management objective. Almost all woodlands in Britain will have some of these animal species present but they are often abundant in broadleaved woods. Woodland management will never seek to encourage them simply for their rough shooting value, but in deciding the method of control for other reasons, e.g. preventing rabbit damage to young trees, the importance of rough shooting should be borne in mind though never relied on as the main control method. Of course, rough shooting during the close season for other sports can be used to keep down predators as well as provide some sport.

CHAPTER 16

Urban woods

INTRODUCTION

In Britain there are numerous woodlands in and around towns and cities. They are predominantly broadleaved, usually small in size, and often the most important natural amenity people enjoy near to their homes (Figure 16.1).

It is difficult to overestimate the contribution of many such urban woods to the built environment. As well as having some limited timber potential they confer one or more of the following benefits.

1. *Visual relief* – screen industrial and residential developments, break up uniform areas of suburbia, provide contrast to the straight lines and symmetry of built development.
2. *Recreation* – woodland is able to absorb large numbers of people and provide an environment for many kinds of recreational pursuits, e.g. walking, horse-riding, and nature study.
3. *Conservation* – some urban woods are vestiges of large areas of woodland dating back to the Middle Ages and most provide a valuable habitat for an abundance of wildlife and plants.
4. *Education* – the urban woodland provides a rural and biological laboratory accessible to schools not able to make visits to the countryside.
5. *Reduce pollution* – woodlands absorb noise, are generally quiet places and, to some extent, trap dust.
6. *Microclimate* – slow windspeeds and slightly increase relative humidities.

Because of their importance to the community many urban woods are in public ownership, many people are interested in their preservation, and thus any work carried out in them arouses much interest. Urban woods generate little income because there have been few opportunities to manage them for timber production and the enjoyment of such woods by the public has traditionally been free. Consequently, expenditure on urban woods tends to be the minimum needed to maintain their present woodland condition. Also such woodlands often form part of the outdoor recreation facilities available in a locality and their management tends to be overshadowed by that of parks, greens and recreation fields. Within the context of their many roles this chapter seeks to provide silvicultural guidelines for positive management of urban woods.

SPECIAL PROBLEMS INFLUENCING SILVICULTURE

Fragility

Most problems affecting urban woods directly reflect man's activities in or around them. But, in addition, their small size, often old age, and frequently past neglect, bring special difficulties which make the woodland fragile, i.e. it will often not respond well to opening up, the remaining trees being vulnerable owing to overstocked condition, whippy stems, poor form, decay, etc.

Small size

In small woods, e.g. less than 2.0 ha, it is difficult to phase regeneration operations or to confine them only to one part. In small amenity woods a decision may be between clear felling and replanting or postponing the decision and prolonging the life of increasingly ancient trees. Postponement brings problems associated with neglect.

Age

As trees in a wood become older their contribution as an amenity usually increases, but eventually the need for regeneration has to be met. But because old trees do not readily respond to change, many have poor coppicing ability, produce little seed and are prone to disease and dieback, often attempts to do something in an old wood are counter-productive. Unfortunately, many of the smaller urban woods are even-aged which heightens the problem as it has to be faced for the whole wood at the same time, thus early management should aim to produce a range of age classes.

Neglect

Active management of many urban woods has not been practised for many years and interest in them only resumed in the last decade. The main effects of neglect are failure to provide for or anticipate regeneration, storing of coppice, overmaturity of many trees and a high stocking of whippy stems with drawn-up crowns. If gradual opening is attempted and a coherent canopy broken, instead of responding to thinning, many stands will 'collapse', stems snap, decayed branches fall and crown dieback set in.

Pollution

The proximity of urban woods to towns exposes them to airborne pollution (dust, sulphur dioxide, exhaust fumes near roads) and to use as a dumping ground for rubbish. Narrow strips of 'ribbon' woodland beside roads or industrial or housing estates are particularly susceptible. These kinds of pollution can damage health of older trees and harm regeneration.

Vandalism

Urban woods are marvellous places for youngsters to play, but inevitably damage occurs though most of it is not usually malicious. Breaking branches or carving names are only of minor silvicultural consequence, but damage to young trees and saplings – uprooting, breaking, stripping bark – can prevent efforts at effective regeneration whether natural or planted.

People pressure

When a wood is popular and enjoyed by many, several kinds of damage can occur:

1. wear and tear of tracks and paths often leading to localized erosion;
2. compaction of soil around prominent features, e.g. a noteworthy tree;
3. theft of plants, holly, Christmas trees, etc;
4. disturbance of wildlife;
5. walking and trampling over young seedlings and other plants;
6. accidental fires.

Safety

An urban wood open to the public can be a dangerous place. Old trees become decayed, while trunks and branches may have structural weaknesses all of which can fail, particularly in stormy weather. Also the urban wood itself provides cover for the criminal.

Other problems

Some urban woods have poor vehicular access which can increase the difficulty of carrying out silvicultural work and obtaining produce. Urban woods may suffer from pests, such as grey squirrels, though not generally to a greater degree than other woodland.

The above problems show that a *laissez faire* approach to management can not ensure the long-term survival of urban woods, and may even contribute to their demise. Their maintenance and perpetuation is essential. The only woodland environment experienced by many people in Britain is that of the urban wood: their amenity value is inestimable.

WOODLAND MAINTENANCE

Amount of use

In seeking to manage an urban wood the first step is to determine the amount of public use. Most silvicultural problems relate directly to usage and woods should be classified according to this. For large woods an attempt should be made to zone areas according to different degrees of usage. Once these steps have been taken priorities can be accorded and a reasonable attempt made to apply a suitable silviculture.

Visitor surveys are not usually necessary to obtain information about use of an urban wood. Simple inspection will show where most people go and, obviously, car parks and rights-of-way indicate where the main public use is likely to occur. The pattern and degree of use may change following management.

Four degrees of usage can be conveniently identified; they are listed in order of increasing usage:

A. little visited (fewer than 100 people/ha/year) owing to poor access, type of woodland, etc.;

B. moderately used (100–1000 people/ha/year). Mainly visited by those enjoying longer walks or wanting to undertake special studies, sport, etc.;

C. well used (1000–10 000 people/ha/year). Commonly areas of woodland within 100–200 m of a public road or car park;

D. very well used (more than 10 000 people/ha/year). Mainly the edge of woodlands beside car parks and near to housing estates.

Not all woods will have every category or zone. In

Figure 16.1 The entrance to Petts Wood. A mixed woodland owned by the National Trust and just 18 km from central London. It was formerly worked as coppice and coppice with standards but since the 1930s has been managed for public enjoyment; it is presently administered by a keeper in conjunction with a local management committee representing nearby residents. (*A10607*)

particular, only large woodlands may have parts which fall into zone A.

The overriding silvicultural need in urban woods is to maintain and perpetuate tree cover. These aspects of management are considered for each zone category, but first it is important to outline some general principles in handling the woods and the people who enjoy using them.

General principles

The public generally have little knowledge of woodland management or experience of silvicultural operations, although they quite often have sympathy with conservation aspects. However, most people are happy to see operations being done which they know will help perpetuate the woodland they enjoy. Appreciating these two points is fundamental to successful management of urban woods. Indeed, the foundation of successful silviculture is local support and encouragement – making the urban wood the community wood.

The following principles flow from what has been said.

1. Encourage good relations between owners/managers and the public.
2. Publicize silvicultural intentions particularly among local residents' associations, conservation groups, etc., or even involve local people directly in management committees such as those for many National Trust woodlands (Figure 16.1).
3. Erect signs to warn of dangerous operations and where appropriate, include on-site notices describing what is being done and why and/or make mention of it in the local press.
4. Most people only take short walks and usually prefer to follow a prescribed route or path for comfort and convenience, thus these should be carefully planned and maintained, especially in

much visited parts and so that visitors are channelled away from danger.
4. Neatness or tidiness are not features of a woodland, indeed semi-natural regrowth is desirable because it has a 'wild' appearance, but rubbish and litter greatly detract from enjoyment of a wood and engender a less caring attitude on the part of the visitor.
5. Some practices seem to attract damage and are especially vulnerable, most notably the planting of single trees in readily accessible open spaces.
6. Where fencing is necessary, e.g. around regeneration, chestnut palings are often the most suitable being difficult to climb over.
7. Opening the canopy can increase enjoyment by creating glade effects and more diverse wildlife habitats.
8. The urban wood, no less than any other, benefits from management and the silvicultural principles and practices discussed in earlier chapters equally apply.

Silvicultural recommendations

In the recommendations below it is assumed the public enjoy right of access to the whole wood.

Zone A: In large urban woods where some parts are little visited opportunity can be taken to pursue normal silvicultural practices to produce timber (Chapters 3–5). This is generally only worthwhile if at least 10 ha can be set aside. Such areas are often best managed by reintroduction of coppicing on a regular cycle, e.g. 2 ha every 3–5 years, where this has been practised in the past (Chapter 6–8). Thinning or felling operations should be confined to the winter for reasons of safety when few visitors are expected.

Enclose areas of regeneration. Keep paths and ditches clean and open.

Consider using part of this area for nature study/education or for a specific recreational activity. Also, in the very long-term, consideration can be given to bringing parts of Zone A areas into greater public use to relieve pressure on parts of a wood classified in Zones C or D.

Zone B: Where there is moderate use of woodland by the public some yield of timber is feasible from thinnings to maintain stand health and from regeneration operations. If the size and structure of the woodland permits, felling or coppicing should be done in small areas, up to 0.5 ha, and fenced if necessary.

Zone C: Where a woodland is well used the matter of public safety becomes especially important. Felling operations should initially be limited to the removal of unsafe trees. Where large gaps occur, diameter at least 1.5 times adjacent tree height with much sky exposed, they can be exploited for regeneration by accepting any naturally occurring seedlings or planting small groups of individually protected trees. Often satisfactory regeneration will come up in a thicket of brambles and other undergrowth; such areas should be encouraged and not cleared.

Directly influence public enjoyment of the wood by making paths obvious, keeping them open and providing an all-weather surface. Consider having a circular route through the area which, if containing items of special interest, could be way-marked.

Zone D: Usually only small parts of a wood will experience very high use but in these personal safety must be of paramount importance. Remove decayed branches and fell unsafe trees (see Zone C above). Plant in gaps by enrichment using individually protected trees. On occasion there may be benefit in planting a standard or half-standard tree but they are expensive.

Consider providing public facilities such as car parks, toilets, paths, picnic areas and litter baskets. Also, consider in the very long term, relieving pressure on Zone D areas, particularly if regeneration is proving difficult, by establishing new facilities elsewhere in the wood.

ESTABLISHING A NEW WOOD

Establishing new urban woodlands has been and continues to be important, particularly in new town development. The principles do not differ from those in Chapter 3 but the following points are emphasized.

1. Positive management of a wood is aided by adopting a management plan.
2. The sites available are often poor, perhaps derelict land, industrial waste or areas devoid of topsoil.
3. If the new woodland site is an unweathered structureless substrate, as occurs after earth moving operations or restoration of a waste tip, whenever possible ensure that topsoil or selected subsoil is retained for respreading. At least 50 cm depth is essential; for details of specific treatments see Binns and Fourt (1980).
4. Foster any natural regeneration that develops.
5. In general, select tree species which naturally occur in the vicinity. Plant group mixtures of a small number of species. Nitrogen fixing species such as alder can be particularly valuable on

impoverished sites. Some admixture of conifer is attractive and may provide some nurse effect.

6. Plant healthy, sturdy transplants. These are much cheaper than larger stock and provided planting is done in late autumn or early spring will survive and grow just as well.
7. Plant in groups not in regular blocks.
8. To achieve rapid establishment control competing weeds around young trees. Herbicides can be applied directly and should not create safety problems (Lane, 1984; McCavish and Insley, 1983).
9. Only apply fertilisers if a nutrient deficiency is expected or identified (page 50).
10. Ensure protection from fire and browsing, notably livestock.
11. If the area is large, establish the urban wood over several years.

DETAILS OF BIOLOGY, SILVICULTURE AND UTILIZATION OF SPECIES

These chapters amplify and augment what has been written in the main body of the text. They are not exhaustive accounts of each species and where there is no mention of a particular subject it is considered to have been covered adequately in an earlier chapter.

The consideration given to each species generally reflects its present forestry importance in Great Britain.

CHAPTER 17

Oak

In Britain there are two native species of oak, Pedunculate or Common oak *Quercus robur* and Sessile oak *Q.petraea*. Together they are the dominant species in almost half of all broadleaved woodland and are the most important hardwood mill timber accounting for 25–30 per cent of total consumption. Several exotic oaks have been introduced with limited success.

The great bulk of this chapter concerns only the two native species and discussion of them is not separated except to highlight points of difference. Much has been written about oak; Jones (1959) and Morris and Perring (1974) are important compilations of information.

TAXONOMY, DISTRIBUTION AND VARIATION

Taxonomy

FAMILY: Fagaceae

GENUS: *Quercus* L.

The genus is large consisting of about 450 species distributed throughout north temperate regions, the Mediterranean basin and montane tropics and sub-tropics.

SPECIES: There are two native species.

Pedunculate, Common, or English oak *Quercus robur* L. (*Q.pedunculata* Ehrh.).

Sessile or Durmast oak *Q.petraea* (Matt.) Liebl. (*Q.sessiliflora* Salisb.)

Because Pedunculate and Sessile oak grow at similar rates, achieve broadly comparable stature, produce nearly identical timber, and are managed in much the same way, foresters have tended not to distinguish between the two species silviculturally. This is unfortunate: the species can be separated botanically (Jones, 1959) – see Appendix 1, though Penduncculate oak is very variable and, although hybridization does occur, extensive gene introgression mainly occurs in northern Britain (Cousens, 1965; Gardiner, 1974), elsewhere species affinity can usually be identified. Also, differences in site preference and early survival of seedlings suggest the species merit individual consideration particularly when choosing planting stock for a site.

Several species have been introduced and the following are of some forestry interest:

Turkey oak	*Q.cerris* L. – naturalized in southern Britain and forming hybrids with native oaks.
Red oak	*Q.rubra* du Roi (*Q.borealis* Michx. f.) – most widely planted exotic oak.
Holm oak	*Q.ilex* L. – common as specimen trees, locally naturalized.
Pin oak	*Q.palustris* Muenchh.
Hungarian oak	*Q.frainetto* Ten.
Scarlet oak	*Q.coccinea* Muenchh.

The last three are of research interest; their forest potential is under investigation.

Natural distribution and occurrence in Britain

Figures 17.1a and b show the natural distribution of each species. Both species are important forest trees throughout central and western Europe. In Britain both Pedunculate and Sessile oak occur in all parts though the former is the commoner species except in western upland areas.

It is difficult to separate planted from natural occurrence but most Pedunculate oak occurs in mixed woodland or as the overstorey in coppice with standards whereas Sessile oak more often occurs in pure high forest or as pure coppice.

Natural variation and provenances

The wide distribution of both species can be expected to lead to considerable differences between seed origins. This has been confirmed by a few provenance trials in Europe but none included provenances from the whole range of the natural distribution and British origins have been poorly represented. Similarly, in Britain, there are few experiments comparing either oak species or diffe-

Figure 17.1 (a) Natural distribution of Pedunculate oak.

Figure 17.1 (b) Natural distribution of Sessile oak.

rent seed origins and evidence from the best replicated trial (Table 17.1) suggests that locally collected seed is as good as any other origin.

Table 17.1 indicates considerable heritable variation between seed origins but the absence from the experiment of mainland European seed origins nullifies any generalization about British versus other origins even though growth rates of the Scandinavian sources were poorest. The best and poorest British origin, incidentally Sessile and Pedunculate respectively, differed by 1.5 m in top height at 28 years which equates to a difference of nearly one yield class. The data however do not in general lend support to the claim (Johnston, 1956) that Sessile oak is more vigorous than Pedunculate. The data do support the view that Pedunculate oak is more prone to epicormic branching than Sessile.

No firm recommendation can be made regarding choice of provenance for either species of oak.

PHENOLOGY AND REPRODUCTIVE MATERIAL

Growth pattern

Neither oak species show rapid initial growth and under normal conditions transplants grow 10–20 cm per year for the first 5–8 years. Thus they suffer weed competition for a long period. Once seedlings become established and begin to grow above ground vegetation growth begins to accelerate to reach annual height increments of as much as 50 cm/year on fertile sites between the ages of 10 and 25 years. Thereafter height growth gradually slows with only a small increase after 100 years.

In the early years coinciding with rapid height growth there are usually two periods of shoot growth, the initial shoot elongating in May and June followed by lammas growth in July and August. The frequency of lammas growth declines with age and is rare in trees over 100 years old. One effect of tree shelters (Chapter 3) is to stimulate lammas shoots with several occurring in one season and explains oaks' capacity generally to respond well to the technique.

Crown development is dependent on growing space. Open grown trees generally increase in crown diameter by 20–30 cm/year.

Current annual increment in stem volume peaks at about 40 years; maximum mean annual increment occurs between 60 and 90 years depending on site fertility.

The above generalizations apply to all oak allowed to develop normally whether in a high forest stand or open grown. But oak, more than most broadleaved species, can respond to sudden change in the environment and grow vigorously, especially in crown size and stem diameter, even after many years of partial suppression. It is sometimes observed that closely grown oak when released by thinning, and even if over 100 years old, can begin to build a crown and start to grow more rapidly.

Seed production and storage

Both oak species start to yield seed at about the same time; though Pedunculate oak may begin flowering somewhat earlier than Sessile oak. For open-grown trees fertile seed is produced after 35–40 years and for trees in a closed stand after 40–50 years. Coppice shoots of oak can bear seed as early as 20 years after coppicing. Heaviest seed crops occur between 80 and 120 years old but a worthwhile crop may continue to be obtained from trees up to 220 to 240 years of age.

Neither oak species yields a seed crop every year.

Table 17.1 Comparison of 11 oak seed origins at 27 years of age from a well replicated experiment at Penyard, Forest of Dean, Gloucs.

Oak seed origins	*Epicormic branches* No. of epicormics between 1.3 and 2.3 m on stem		*Form* Visual assessment 1 = very poor 8 = very good i.e. straight unforked stemy with strong central axis		*Height*		*Diameter at breast height*	
	Number	Rank	Number	Rank	(m)	Rank	(cm)	Rank
Pedunculate								
Lodgehill, New Forest, Hampshire	27.5	10	3.1	7	9.2	9 =	12.2	5
South Side Wood, Powys	57.8	11	2.7	10	9.9	5	12.7	2 =
Sessile								
Pritchards Hill, Forest of Dean, Gloucs.								
General collection	16.9	7	3.9	2	10.1	3	12.3	4
Best single parent tree	13.2	4	3.5	4	10.0	4	11.9	7
Hadnocks, Forest of Dean, Gloucs.								
General collection	15.3	5 =	4.0	1	10.2	2	13.4	1
Best single parent tree	19.0	8	3.1	6	9.4	7 =	11.6	8
Bonds Wood, Forest of Dean, Gloucs.	13.6	5 =	3.7	3	10.7	1	12.7	2 =
Skiltons Paddock, Alice Holt Forest, Hampshire	20.9	9	3.0	8	9.7	6	12.1	6
Vestmorland, Norway	12.3	2 =	2.9	9	9.2	9 =	11.3	9
Lot 1, Sweden	11.4	1	2.6	11	9.2	9 =	10.8	11
Lot 2, Sweden	12.3	2=	3.3	5	9.4	7 =	11.1	10
S E D approx. significant at 5%	15.9		0.87		0.6		0.9	
Significance	***		*		***		***	

Notes: Assessment of epicormics, form, and height was made on the two largest dbh trees per plot.
Diameter at breast height is the mean dbh of six largest dbh trees per plot.

In the south of Britain for Pedunculate oak there are good mast years every 3–4 years and for Sessile oak every 4–5 years. In northern Britain mast years are less frequent. Between mast years seed production is small or absent. It is generally claimed that Pedunculate oak seeds more freely than Sessile oak but Sessile acorns are less conspicuous and seed production less noticeable to the casual observer (Jones, 1959; Shaw, 1968, 1974).

Mast years consume large amounts of energy and nutrients, and vegetative growth is often reduced leading to a narrowing of the annual ring.

Acorn yields

Mature oak trees about 120–140 years old produce about 50,000 acorns in a good seed year, but this total is very variable depending on tree size, canopy position, damage to flowering, etc. In a good mast year densities on the forest floor of 50 acorns/m^2 are common and have been observed as high as 800/m^2.

The size of acorns differs between Pedunculate and Sessile oak with Pedunculate ones being generally larger. The difference is not very great as the numbers per kg indicate:

Pedunculate oak	110–450 acorns/kg
Sessile oak	130–500 acorns/kg

Large acorns are found to have a higher percentage germination than small ones and also lead to larger plants at the end of the first growing season. They appear better able to survive initial weed competition and other damaging agencies.

Obtaining seed

Appendix 2 lists the registered seed sources for oak.

Storage of acorns

Storage of acorns for more than one year is difficult though 50 per cent germination can be maintained for up to 3 years by carefully storing acorns in a moist environment at 2°C. For storing just over the winter acorns should be laid out to dry in a cool, well ventilated mice proof shed. After they are surface dried, and the acorns have stopped 'sweating', they should be stored either on a tray or loosely in a hessian bag. Once a month they should be lightly sprinkled with water and turned to keep them full and prevent wrinkling. Acorns can, of course, be sown directly after collection.

An alternative to attempting long-term storage of acorns in order to make available a particular seed origin over several years, is to perpetuate the genetic material as nursery plants. All acorns are sown in the first year when viability is highest but a portion of the seedlings are conditioned (undercut and topped) to slow their development. Short sturdy plants produced in this way over 4 or 5 years will still grow vigorously when planted.

Vegetative propagation

Because of the long time to reach sexual maturity vegetative propagation of oak is an attractive alternative for producing planting stock. However it is not an easy solution and until recently has been little attempted.

Due to the difficulty of rooting softwood cuttings from old or mature trees, propagation programmes are concentrating on the production of cutting material from budded or grafted trees grown in glasshouse conditions. To produce a continuous supply of softwood cuttings from the stock plants it may be necessary to provide a lighting and heating regime which will break or prevent dormancy. The cutting material produced under these conditions may then be usable, the aim being to produce shoots that will not wilt and which provide a good rooting surface. It is also possible to use stump shoots (very young coppice) of mature trees after felling.

After collection, cuttings 12–15 cm long are dipped in a rooting hormone and inserted into a suitable substrate under mist. A common problem with oak cuttings is the formation of callus at the base of the cutting without any subsequent rooting. Rapid root initiation is encouraged by bottom heating. A 75%:25% peat/grit mix has been found the most suitable substrate for rooting.

SITE SELECTION

Climate and elevation

Throughout the British Isles the growth of oak is remarkably uniform and no region (Conservancy) has very much more productive oak stands than any other.

Unlike most species, Nicholls (1981) reported for oak no significant correlations between growth and elevation. Several Yield Class 6 oak stands can be found above 300 m and, conversely several Yield Class 2 stands below 100 m. Over Great Britain as a whole there is evidence that oak does less well in high rainfall areas, but the effect is slight.

There is little evidence that either climate or physiographic location greatly influence the performance of oak on one site compared with another.

Micro-site

Newly opened oak foliage is more susceptible than most broadleaved species to late spring frosts – frosts occurring after about 10 May. Repeated frosting can prevent oak becoming established – temperatures of only −3°C are sufficient to kill young leaves. Also, losses from frost-lift due to exposure and drying out of roots can be serious where oak is planted on clay soils, as is widely practised in the lowlands. Though there is some evidence that Pedunculate oak is slightly less sensitive to frost damage than Sessile, oaks should not be planted in frost hollows.

On exposed, windy sites height growth of oak is impaired but the more deleterious influence is poor tree form. Very exposed sites should not be planted; ideally oak should be restricted to sheltered or slightly exposed sites only.

Soils and geology

Though both species occur on all major soil types their natural distribution and optimum growth tend to be associated with somewhat different conditions. Table 17.2 lists the edaphic preferences.

As well as growth, some other factors are associated with soil type, the most important appearing to be the incidence of shake (see later) which seems to underlie the assertion that a particular area is or is not 'good oak ground'.

Table 17.2 Soil requirements for oak

	Pedunculate	Sessile
Nutritional status	High fertility	Moderate-high fertility
Texture	Most textures suitable, but possibly better than Sessile on heavy soils – clay loams, clays	Most textures suitable, but grows better than Pedunculate on lighter soils
Acidity (pH)	4.5–7.5	4.0–6.0
Drainage	More tolerant of water-logged conditions than Sessile oak	Well-drained soils
Rooting depth	Deep rooting species, at least 60 cm rootable depth, Preferably >1 m	As for Pedunculate
Flooding	Mature trees tolerant including sea water	Less tolerant of flooding than Pedunculate oak

Recommendation

There is no climatic restriction in Britain of where oak may be grown though exposed sites and frost hollows should be avoided. To achieve Yield Class 6, only fertile soils should be planted. Pedunculate oak may be used on heavier soils but in general Sessile oak should be the species to plant. Because of the association with shake, light, very freely drained soils (see page 163) should not be planted if the aim is to grow good quality timber. Oak should not be planted on strongly calcareous soils. Fertilising oak at planting will rarely be necessary.

DISEASES AND PESTS

Oak is relatively free of serious disease and insect pest problems. The following occur widely and can cause damage of economic importance.

Diseases

Leaf diseases

Oak mildew *Microsphaera alphitoides* may occur on trees of any age, but is most damaging on seedlings which can be killed if the fungus is left uncontrolled in the nursery; damage to trees and coppice shoots is rarely troublesome. Sessile oak may be somewhat less susceptible than Pedunculate oak.

Decay fungi

Many decay fungi have been recorded on standing oaks; two are widespread: *Laetiporus sulphureus* (*Polyporus sulphureus*) causing brown cubical rot, and *Stereum gausapatum* causing pipe rot. Both frequently enter through dead side branches and stubs where hardwood is present (i.e. branches of 5 cm diameter or more) though *L.sulphureus* also enters through the roots. Other butt rots which can cause extensive decay are *Inonotus dryadeus* (*Polyporus dryadeus*) (white rot in heartwood and also root decay leading to windthrow and dieback), *Ganoderma resinaceum*, and *Grifola frondosa* (*Polyporus frondosus*) (white rot).

Insect pests

Defoliators

Oak leaf roller moth *Tortrix viridana* and Winter moth *Operophtera brumata* cause widespread defoliation, often for several years in succession. Trees are very rarely killed by defoliation alone; if it occurs early in the growing season a second flush of leaves is produced. However, successive defoliations may weaken or occur on already weakened trees and increase the likelihood of infection from other pathogens such as Honey fungus *Armillaria* spp. Defoliation does not affect spring wood production but some loss of increment may occur as the amount of summer wood can be reduced by up to 60 per cent (Varley and Gradwell, 1960). One study concluded that a complete absence of defoliation be caterpillars would have increased total production by 40 per cent over the 8 year period investigated (Gradwell, 1974). The later flushing habit of Sessile oak makes it less susceptible than Pedunculate oak to heavy infestation.

Other defoliators of occasional importance are the moths Buff tip *Phalera bucephala* and Mottled umber *Erannis defoliaria*.

Galls

Spangle galls caused by *Neuroterus* spp. are spectacular but of no economic importance. Knopper galls induced by *Andricus quercuscalicis* on acorns locally cause very considerable losses in poor mast years, their alternate spring generation is on Turkey oak catkins (Jukes, 1984).

Aphids

Phylloxera glabra (*P.punctata*) causes significant loss of photosynthetic area of leaves and can be responsible for extensive browning of foliage in summer.

Beetles

The oak pinhole borer *Platypus cylindricus* bores deeply into wood of poorly growing trees and may be found in dead parts of healthy trees. Serious degrade can be caused to logs left lying in the forest or timber yard. The oak bark beetle *Scolytus intricatus* only affects felled or dying trees.

The broadleaved ambrosia beetle *Xyloterus domesticus* is similar to the oak pinhole borer but confined to the sapwood.

YIELDS AND GROWTH RATES

Oak high forest

Compared with most species oak is relatively slow growing; but see general comments about yields of broadleaved species (page 12). The average yield class of high forest oak in Britain is about 5 m^3/ha/year. Only a very few stands achieve Yield Class 8.

Coppice with standards

Compared with high forest, oak standards generally show less good height growth but much greater diameter growth (see later under open-grown trees) and reach large timber size in 100–130 years – see page 79. The pattern of growth of standards is in part related to the coppice cycle. Growth of standards increases immediately after a coppice cutting, probably owing to a temporary reduction in competition for moisture and nutrients from the coppice stools.

Oak coppice

In the past much oak, particularly in the West Country, has been grown as coppice (Chapters 6 and 10). The initial vigour of coppice is much superior to maiden stands and 1.0 m height increment in the first year is not unusual. This greater vigour gradually diminishes and by 70–80 years the initial growth advantage is no longer evident. There is some evidence that in older stored coppice stands, >100 years, that increment is poorer (Groos, 1953).

Yield of oak coppice depends, as with all coppice, on the stocking of stools and site fertility. On a moderately fertile site of Yield Class 6 potential some 80–120 tonnes/ha of dry matter would be produced after 30 years. This is a mean annual increment on such a cycle of 2.5–4.0 tonnes/ha/year. (Begley and Coates, 1961).

UTILIZATION

End uses

Heartwood

For all high quality end uses, only heartwood is used. Heartwood begins to develop in trees over 20 years old, though somewhat older in small, slow growing ones. Once heartwood formation has begun sapwood is generally restricted to the outer 10–20 rings, but even in large trees the proportion of heartwood rarely exceeds 80 per cent of butt volume.

Roundwood

In many areas small sized oak, typically from first and second thinnings, finds a ready market as firewood owing to its high density and good burning properties. Oak is acceptable for hardwood pulp. Reasonably clean poles are acceptable as rails in fencing and poorer quality logs in the round (30–40 cm diameter) find a ready market as fence corner posts or gate posts.

Sawn timber

1. Much small sized poor quality oak is used for sawn mining timber. The minimum diameter is 20 cm and minimum length 1 m.
2. Larger butts, above 30 cm diameter, may be suitable for sawn fencing or in some areas for cleft fencing when even moderately shaken trees may be usable.
3. Planking quality requires a minimum diameter of 45 cm, no knots and evidence of few epicormic shoots.
4. Some very large butts (>60 cm diameter) may be used for scantlings, beams, or in constructional and sea defence work. Large straight logs without shake or rot are required, though blemishes due to epicormics and small knots are acceptable provided the log is sound.

Veneer

A veneer quality butt must be absolutely clean with straight grain, no occlusions, shake, rot, knots or other faults. Minimum diameter is 60 cm.

For high grade joinery and veneer, growth rate is unimportant, 4–5 mm wide rings (5–6 rings per inch) are generally as acceptable as 1–2 mm wide rings (12–25 rings per inch). Much more important is even growth; very uneven growth tends to produce difficulties in seasoning and stability.

Degrade in standing timber

All oak trees of acceptable size are suitable for firewood, mining timber, pulpwood, and fencing material provided the wood is substantially free from rot. Larger sized trees grown for planking or veneer quality may suffer one or more of three serious defects which can greatly reduce their value – heart rot, shake and knots. None can be wholly prevented, though silvicultural practice can help to reduce their occurrence; shake and knots are considered in detail later under special silvicultural considerations.

Heart rot

Several heart rot fungi can damage standing oak (page 158) but two, *Stereum gausapatum* and *Laetiporus sulphureus*, can enter through dead branches more than 5 cm in diameter. Large branches on the lower stem should be prevented from dying by regular thinning to lessen the risk of branch suppression and, on final crop trees, by high pruning if necessary.

It should be noted that very occasionally infection from the fungus *Fistulina hepatica* in older trees, often ones which are stag-headed, can add to the value of heartwood because of the uniform brown colouring it causes. Brown oak is rare and is much sought for panelling, cabinet work and other furniture uses.

SPECIAL SILVICULTURAL CONSIDERATIONS IN GROWING OAK

Open-grown trees, standards, and free growth

In the past much oak timber has come from open-grown trees whose crowns have been little restricted by competition, e.g. standards and hedgerow trees. Such conditions lead to more spreading crowns with live branches retained lower on the stem than in a closed stand, less height increment, but more rapid stem diameter growth. This last benefit is the basis of the free growth technique (Jobling and Pearce, 1977). The object is to accelerate diameter increment on selected trees by freeing their crowns from competition. The technique has been mainly applied to oak on an experimental basis (Figure 17.2).

Growth

Compared with conventionally thinned oak basal area increment of open-grown or free growth trees is doubled: typically diameter increment is 7–9 mm

Figure 17.2 Oak managed using free growth. Age 53 years, diameter breast height 36.7 cm. (*A10608*)

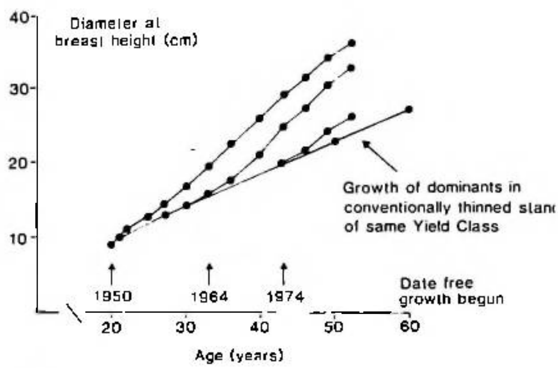


Figure 17.3 Responses to free growth up to 1983 in diameter increment of oak at Crumbland, Tintern Forest. Free growth has been applied to trees starting at three different ages – 20, 33 and 43 years.

per year compared with about 5–6 mm per year for dominants in a conventionally thinned stand (Figure 17.3). On a Yield Class 6 site free grown trees can be expected to reach 60 cm dbh in about 100 years. Oak of almost any age will respond to free growth, but for growing timber trees the technique is best begun in plantations, pure or mixed, when 20–40 years old.

It must be pointed out that because only a few trees are favoured, and those by very heavy thinning, there is some loss in total yield per hectare. This is estimated at 30–40 per cent of the maximum possible. However, the faster growth of the crop trees leading to a shorter rotation length is shown more than to compensate economically for this loss (Jobling and Pearce, 1977).

Application

In existing oak plantations where mean height is greater than 8 m the following procedure may be adopted.

1. Select 60–80 trees/ha of excellent form, unblemished, few epicormics, and of good vigour; the trees should be evenly spread through the stand.
2. Favour these selected trees by very heavy thinnings so that the crowns are entirely free of competition from neighbours, but do not remove the rest of the intervening matrix trees.
3. High prune to remove side branches and epicormic shoots, ultimately to a height of 5 m, but not all at one time if the trees are less than 10 m tall.
4. Rigorously control epicormics if they occur (see below).
5. Repeat thinning around selected trees every 5 years to maintain their crown freedom.
6. The matrix trees, which are steadily removed to favour selected trees, receive no other silvicultural treatment though they are usually marketable for firewood or other low grade end uses.

In theory, oak can be open-grown from the time of planting but unless there is some form of side competition, height growth will be slow, a spreading open crown will develop virtually to ground level (Figure 3.5a and b) and regular pruning will be essential to produce a reasonable stem. The use of tall tree shelters (see page 41) may alter this situation, but at present widely spaced oak with no intervening woody growth cannot be recommended as a way of growing timber quality trees.

Problems

There are two important silvicultural problems associated with open-grown oak.

1. Introduction of free growth into an existing stand invariably stimulates epicormic branches. Because only a few trees are favoured it is essential they are of very high quality so that they attract a good market. Epicormic branches seriously reduce this potential quality because of the small knots they produce. Such branches must be controlled and this is not straightforward (see below).
2. If free growth is applied to a tree and then not continued or the tree's crown comes into competition with neighbouring trees or a vigorous understorey is allowed to grow up as in standards amongst coppice, then the lower side branches are often killed or die back. As mentioned above, this can lead to degrade by allowing entry of decay fungi.

Epicormic branches and knots

Development of epicormic branches is a major problem of oak silviculture, for recent accounts see Evans (1982b and 1982c). When they persist for more than one year a knot is formed in the wood. For high quality timber such knots must be small, and absent altogether for veneer.

Epicormic shoots arise either from adventitious buds in callous tissue, e.g. pruning scar or, more often, from dormant buds on the stem which are stimulated to sprout by a change in the tree's environment, most commonly as a result of thinning (Figure 17.4a). With adequate light, an epicormic shoot will develop into a large side branch (Figure 17.4b) but more usually will remain as a semi-moribund shoot neither dying nor growing vigorously.

The incidence of epicormic branching is clearly under some genetic control. Exotic oaks such as Red and Hungarian oak generally have few epicormics and, in Britain, Sessile oak has fewer than Pedunculate oak (Table 17.1). Table 17.1 also suggests variation in degree of epicormic branching among seed origins of Sessile oak. And, within any one stand, it is always observed that some trees may have many, some only a few, and occasional individuals no epicormics at all.

Control

Control of epicormic branches has two aspects:

1. preventing them emerge;
2. preventing them becoming large branches.

Initiation of epicormics is obviously reduced by growing oaks which are less prone to them, e.g. Sessile oak. But the most important silvicultural tool is to avoid sudden change in stand conditions. This,

Figure 17.4 (a) Young epicormic shoots on many stems in a recently thinned stand of oak. (*A10609*)

Figure 17.4 (b) Large old epicormic branches allowed to develop for many years. (*A10610*).

of course, conflicts with the desirability of regular thinning and especially the use of free growth. Nevertheless, it is clear that frequent, light thinnings reduce the problem.

It also needs to be emphasized that even following heavy thinning the initial profusion of epicormics will not go on being produced year after year. As a tree adjusts to its new environment the emergence of new epicormics declines. Similarly, it is found that trees least influenced by thinning, the dominants, generally have fewer epicormics than other crown classes. Thus control of epicormics is most important immediately after a thinning or other sudden change in a stand.

Prevention of epicormic shoots becoming large branches can be achieved in several ways. Naturally, this can be done by manipulating the light regime and keeping the stem dark. The use of a beech understorey, or other shade-bearing species, is an effective though a costly means of control unless the understorey is there naturally. This is the main tool used in French silviculture to restrict development of epicormic branches (Evans, 1982a). Epicormics can also be controlled directly by pruning. However, to be effective, pruning needs to be done regularly, preferably each year with the shoots being removed or rubbed off in mid-season. Experiments are under way investigating chemical and other means of control, and so far the growth retardant maleic hydrazide (proprietary name Burtolin) appears promising.

Recommendations

1. Grow Sessile oak.
2. When thinning, remove epicormic ridden trees and favour ones relatively free of them.
3. If a conventional thinning policy is followed, thin frequently and lightly.
4. If heavy thinning or free growth is planned, begin early in the life of a stand to build the selected tree's crown and vigorously control epicormics, preferably by annual removal, following each thinning.

Shake

Shake is longitudinal fissuring or separation of wood found in freshly felled timber usually either radiating from the pith (star shake) or as a cleavage along an annual ring (ring shake). Figures 17.5a and b illustrate the two types. Shake may be restricted to the lower butt or extend over a whole bole and into branch wood. Presence of shake in a tree cannot be predicted reliably from external signs though when they occur, deep fissuring in the bark or longitudinal ribbing are usually sure signs of serious star shake. Shake is a serious defect greatly reducing the conversion potential of a log since the timber invariably splits or separates along the line of the shake.

Figure 17.5 (a) Star shake in newly felled oak. (*A10611*)

Figure 17.5 (b) Ring shake in newly felled oak. (*A10612*)

Shake occurs primarily in oak and Sweet chestnut. Its cause is not well understood but may be initiated by damage to the bark and cambium of young trees and later spreads because of internal stress such as a substantial water deficit. The possibility that damage, and the callus which heals over the wound, is the point of weakness at which shake begins, is sufficiently plausible to stress the need for great care in handling and planting oak, in ensuring good protection, and avoiding all damage.

The incidence of shake within any one stand is usually very variable but the proportion of trees affected appears primarily related to soil conditions. Oak on heavy soils, clays and clay loams, generally has less shake than stands on lighter soils, especially sands. This is illustrated in Table 17.3 based on a survey of 110 oak stands throughout England and Wales felled during the Second World War.

The evidence of Table 17.3 is borne out by current observation that oak on heavy SE England soils is less shaken than, for example, those on Triassic sands in the Midlands. Similarly, in the Forest of Dean most shake occurs in oak on the light, very freely draining soils.

There is no evidence that elevation, aspect or exposure are related to the occurrence of shake. The survey reported in Table 17.3 did suggest that oak stands in the west of Britain were a little more likely to have serious shake than elsewhere.

Recommendation

A timber crop of oak should generally not be established on lighter soils and sands, unless there was little evidence of shake in a previous oak crop.

Table 17.3 Proportion of stands affected by shake according to soil texture (percentage)

Soil type	No. of stands	Ring shake	Star shake	Practically sound	No record, presumed sound
Sands and sandy loams	33	40	53	17	16
Loams	23	5	50	38	11
Clay loams and clays	54	4	27	48	22

Note: Percentages do not total 100 because some stands were affected by both ring and star shake.
From Brown (unpublished).

Natural regeneration

It is often considered more difficult to secure natural regeneration of oak than either ash or beech. However, provided the time is available there are few sites where it cannot be carried out (Figure 17.6). Oak seedlings spring up relatively freely at the edge of a wood in grass and in thickets such as thorn but it appears less easy for them to get established within a woodland, though Rackham (1980) believes this is a relatively recent phenomenon. Often acorns germinate and seedlings develop only to disappear within a year or two. Many reasons have been put forward to account for this including the light regime, condition of the soil surface, browsing by animals, etc. Two factors of undoubted importance are drought, owing to germination taking place in a thick layer of organic matter (or occasionally grass mat) but inadequate rooting into the mineral soil, and failure of seedlings to recover from defoliation by insect larvae which frequently occurs when growing directly under an oak canopy (see Shaw, 1968, 1974).

Details of carrying out natural regeneration, including oak, are considered in Chapter 5. Provided the parent crop is not well past maturity and one is prepared to wait for a good mast year, achieving natural regeneration following large group fellings or small clear fellings is feasible.

A detailed account of the regeneration of both oak and beech is found in Newbold and Goldsmith (1981).

RED OAK

(*Quercus rubra* du Roi)

Red oak is the only exotic oak meriting some consideration for forest planting but its wood must only be regarded as a general purpose hardwood and not a substitute for English oak in its more specialized uses. Red oak is sometimes planted as an ornamental for its rich autumn colouring after a dry summer.

Red oak is a native of North America, see Figure 17.7.

Growth rates and yields of Red oak are compara-

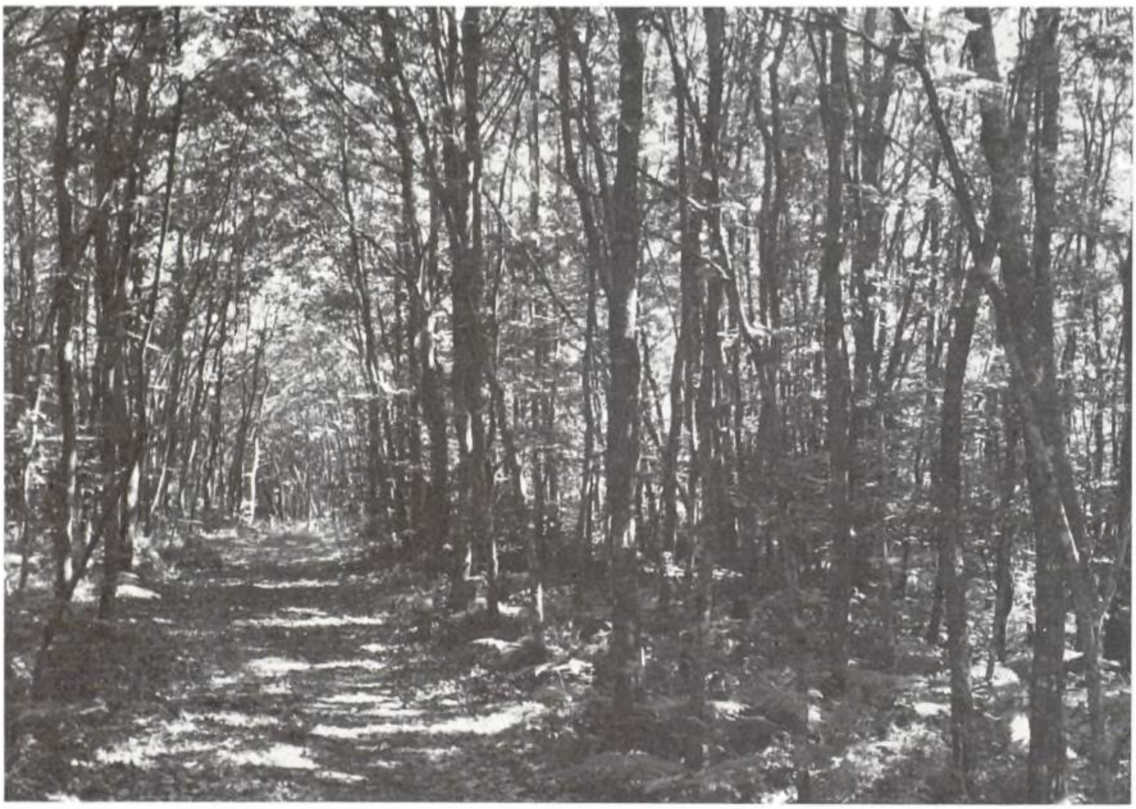


Figure 17.6 Dense natural regeneration aged about 20 years, Tintern Forest, Gwent. *(C1516)*

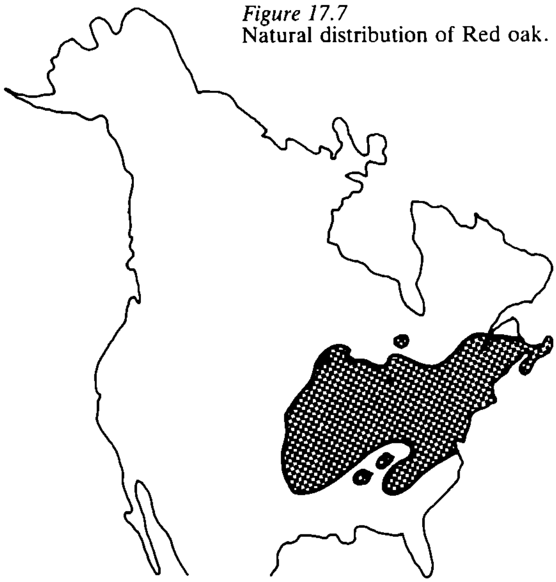


Figure 17.7
Natural distribution of Red oak.

ble to native oak on fertile sites, but tend to be superior on poor, especially sandy, soils. Stem form is mostly good and epicormic branches less profuse, though they do occur.

Only a small area of Red oak exists in Britain and it is unlikely to be more widely planted.

There are two managed seed sources of Red oak in Britain (Appendix 2, page 167).

TURKEY OAK
(*Quercus cerris* L.)

Turkey oak is widely naturalized in southern Britain and grows more vigorously and is frequently of better form than native oaks. Its timber is inferior to native oak in durability, strength, and seasoning properties and is virtually unsaleable for sawing. However, the wood is of higher density making it an attractive firewood.

APPENDIX 1

FEATURES DISTINGUISHING PEDUNCULATE AND SESSILE OAK

Feature	Pedunculate oak	Sessile oak
Leaves of spring shoots in crown	(1) obovate (2) widest part well above middle of leaf. (3) deeply and irregularly usually 2–5 lobed. (4) very short petiole 2–7 mm. (5) no tufts of hair in vein axils.	(1) ovate (2) widest at or near middle of leaf. (3) shallowly and regularly lobed, 5–8. (4) long petiole 13–25 mm. (5) hairs in vein axils.
Acorns	(1) pale fawn with olive-green longitudinal stripes when fresh and mature. (2) usually larger, less rounded, more oblong. (3) usually on long (2–9 cm) slender peduncle.	(1) uniform dark brown with no stripes. (2) usually smaller, more rounded. (3) usually no peduncle or only short (3–4 cm) and thick.
Terminal bud	small, obtuse	large, acute.
Bark	thick, deeply fissured, not scaling.	thinner, shallow fissures, may exfoliate.
Habit	(1) central axis (main stem) less persistent through crown. (2) wide angles between branches. (3) abrupt decrease in size from main boughs to twigs.	(1) more persistent central stem through the crown. (2) narrower angles between branches. (3) branching more regular with more gradual decrease in size in successive orders of branches.

Modified from Jones (1959).

Wood structure From Fletcher (1983).	(1) wide band of early wood vessels making up >25 per cent of ring width. (2) usually round early wood vessels.	(1) narrower band of early wood vessels. (2) usually oval early wood vessels.

APPENDIX 2

REGISTER OF MANAGED SEED SOURCES

Pedunculate oak

Identity number	Estate or forest	Date registered	Area (ha)	Estimated planting year	Location	National grid reference
1001	Wells	1973	5.2	1750	Lothian	NT592175
2001	Lennox Love	1973	2.5	1844	Lothian	NT515722
2002	Roxburgh	1977	6.0	1834	Lothian	NT692336
2003	Hirsel	1978	1.8	1880	Berwick	NT821399
3001	Forde Abbey	1973	0.5	1800	Dorset	ST372055
3002	Forde Abbey	1973	2.0	1800	Dorset	ST355043
3003	Exeter	1974	2.0	1862	Devon	SX921958
3004	Hutton-in-the-Forest	1982	7.2	Pre–1900	Cumbria	NY467360
4001	Dean	1973	7.2	1901	Gloucestershire	SO656095
4002	Sarnesfield	1973	4.9	1897	Hereford	SO378520
4003	New	1973	1.5	1808	Hampshire	SU286047
4004	Foxley	1973	6.0	1820	Hereford	SO418458
4005	Windsor	1973	25.0	1850	Berkshire	SU941708
4006	Windsor	1973	3.2	1920	Berkshire	SU925740
4007	Dean	1974	10.0	1909	Gloucestershire	SO665120
4008	Parham	1975	3.0	1700–1750	W. Sussex	TQ066153
4009	Badminton	1976	1.0	1820	Avon	ST815834
4010	Godinton Park	1976	4.0	1820/1900	Kent	TQ985440
4011	Boughton	1977	1.0	1850	Northamptonshire	SP938805
4012	Sherwood	1977	5.0	1800	Nottinghamshire	SK614708
4013	Bradford Estate	1977	3.0	1939	Staffordshire	SJ815165 SJ821173
4014	Whiligh	1977	1.0	1800	E. Sussex	TQ661315
4015	Deerfold	1977	2.0	1900	Hereford	SO465634
4016	Bucknell	1977	1.5	1870	Shropshire	SO478826
4017	Westonbirt	1978	2.5	1830	Gloucestershire	ST848899
4018	Hazelborough	1979	2.0	1826	Northamptonshire	SP644431
4019	Bramfield	1980	3.0	1825	Essex	TL477082
4020	Belvoir	1980	3.0	1750	Leicestershire	SK820335
4021	Leaton Knolls	1981	2.0	1800	Shropshire	SJ456186
4022	Beaulieu	1981	1.0	1850	Hampshire	SU388005
4023	Brocklesby Park	1982	2.5	1830	Lincolnshire	TA186053
4024	Mansgrove Farm	1982	2.8	1937	Bedfordshire	TL011150
4025	Boughton	1983	5.6	1901	Northamptonshire	SP917818

Sessile oak

Identity number	Estate or forest	Date registered	Area (ha)	Estimated planting Year	Location	National grid reference
1001	Fleet	1973	4.0	pre–1900	Dumfries and Galloway	NX663679
2001	Belladrum	1973	4.0	1802	Highland	NH519403
4003	Garnons	1973	3.5	1815	Hereford	SO405435
4004	New	1973	1.0	1859	Hampshire	SU270053
4005	Dean	1974	10.0	1872	Gloucestershire	SO663097
4006	Dean	1974	8.0	1846	Gloucestershire	SO596141
4007	Alice Holt	1976	2.0	1880	Surrey	TQ015340
4008	Hereford	1978	91.0	1840–60	Gloucestershire	SO691278
4009	Beacon Hill	1976	0.5	1900	Hereford	SO696455
4010	New	1974	18.0	1700&1840–60	Hampshire	SU309057 SU268051 SU327041 SU235127 SU221043
4011	Powys	1978	7.3	1750/1850	Powys	SJ199056
4012	Broomesberrow Place	1981	1.2	1880	Gloucestershire	SO756348
4013	Dean	1982	5.0	1860	Gloucestershire	SO600190
4014	Bigsweir	1982	4.0	1880	Gloucestershire	SO538042 SO544044

Red oak

Identity number	Estate or forest	Date registered	Area (ha)	Estimated planting year	Location	National grid reference
4001	Windsor	1973	0.2	1870	Berkshire	SU973714
4002	Windsor	1973	0.3	1933	Berkshire	SU961692

Note: Collections of acorns from registered sources are made and sold privately. The local Conservator must be notified when a collection is made and a sample of the seed sent for testing at the Official Testing Station at the Forestry Commission Research Station, Alice Holt Lodge, Farnham, Surrey. Seed from unregistered sources may generally only be used for plants not intended for timber production and will be ineligible for planting grants. Exceptions should be referred to the Forest Management Division of the Forestry Commission.

CHAPTER 18

Beech

Beech *Fagus sylvatica* is second only to oak in importance as a major broadleaved species. It is the principal species of one sixth of all broadleaved woodland and in some regions beech woodland dominates the landscape – the Chilterns, the Cotswolds, parts of the South Downs. Mature trees are frequently picturesque.

Earlier and more detailed accounts of British beechwoods will be found in Watt (1923–25; 1931) and Forestry Commission Bulletin 20 *Studies on British beechwoods* (Brown, 1953). Recent accounts of beech silviculture will be found in Aldhous (1981) and Penistan (1974).

TAXONOMY, DISTRIBUTION AND VARIATION

Taxonomy

FAMILY: Fagaceae

GENUS: *Fagus* L.

The genus has 10 species all occurring in north temperate regions.

SPECIES: Common or European beech *Fagus sylvatica* L.

Only Common beech is of forest importance in Britain though Oriental beech *F.orientalis* (Lipsky) is included in some research trials.

Natural distribution and occurrence in Britain

Figure 18.1 shows the natural distribution of beech.

In Britain beech woodland can be found in all parts of the country but most originates from planting. The species is thought to be indigenous only to East Anglia, the south Midlands and southern England as far west as Dorset and possibly south-east Wales, but it is widely naturalized and is capable of regenerating naturally as far north as Caithness (Highland).

Beech woodland tends to be associated with chalk and limestone formations (Figure 18.2) but the species is tolerant of a very wide range of soils and site conditions.

Natural variation and provenances

Several trials have been laid down to compare the growth and form of different provenances. Although the whole of the species' natural range has not been systematically sampled for trial – such work is currently underway in West Germany – seed lots from many parts of Europe have been compared with material collected in Britain. Seed from the best stands in Britain, e.g. Kingscote, Gloucs., Slindon Park, W. Sussex, etc., appear at least as good as most European sources with the exception of the Forêt de Soigne, Belgium, origin which is outstanding for both vigour and form.

When obtainable the Forêt de Soigne provenance should be used.

There are several varieties of Common beech of arboricultural interest, most notably Copper beech, the fastigiate Dawyck beech, and Fern-leaf beech.

Figure 18.1 Natural distribution of beech.

Figure 18.2 Beech shelterbelt and clumps on chalk downland, Salisbury Plain. (*A10622*)

PHENOLOGY AND REPRODUCTIVE MATERIAL

Growth pattern

Once established young beech grows about 20–30 cm/year for the first 15–20 years on moderately fertile sites. Between 20 and 60 years height increment can attain 60 cm/year. Thereafter height growth gradually slows with only a small increase after 120 years.

Shoot elongation takes place in May and June which on young trees may be followed by lammas growth in July or occasionally by short, hairy shoots in late August. Lammas is much less common in beech than oak but is of silvicultural interest because of its susceptibility to frost and insect damage which sometimes results in poor form.

Current annual increment in stem volume peaks at 45–60 years; maximum mean annual increment culminates later than in oak at between 80 and 110 years depending on site fertility.

Seed production and storage

Beeches in closed canopy rarely produce fertile seed in any quantity before 60 years though on open-grown trees and under conditions of stress seeding at a much younger age may occur. Heaviest seed crops occur between 80 and 140 years but worthwhile crops may continue to be obtained up to about 200 years.

Mast years are infrequent in Britain occurring at intervals of between 5 and 15 years. They normally follow warm, dry summers, with trees on southerly aspects tending to be the most prolific, but other factors such as frost damage to flowers, period since last mast year, etc., greatly affect seed production.

Obtaining seed

A list of registered seed sources for beech is in the appendix to this chapter (page 176).

Seed is collected between September and November usually by sweeping up mast fallen onto a tarpaulin or hessian sheet laid beneath selected trees.

See footnote to Appendix 2 of previous chapter (page 167) for general information about seed collection and sale.

Seed treatment and storage

Seed to be sown the following spring should be stored in a cool, ventilated, vermin-proof store in a layer no deeper than 20 cm. It should be turned

Figure 18.3 Farm shelterbelt of beech and Scots pine. (*A10613*)

daily until surface dry, then once a week until the end of December, then once a month until it is sown in April.

For long-term storage (up to 3 years) only best quality seed in good condition should be used. Seed is air-dried at 18°–20°C, though sometimes a little more warmth is needed, to reduce moisture content to 6–10 per cent. The dry seed is stored in air-tight containers below freezing at −5° to −10°C.

Vegetative propagation

Beech is generally similar to oak (page 157) but does not suffer so much from the problem of cuttings forming callus but no roots.

SITE SELECTION

Climate

Beech grows well in all parts of Britain; its performance generally bears little relation to annual rainfall amount or latitude though growth is a little slower and stature somewhat smaller in northern Britain. It is more tolerant of exposure than oak and ash and can often be found at altitudes above 300 m, particularly in the West Country and the Pennines, as clumps on exposed knolls and as hedges – see Figure 10.3. Its tolerance of exposure makes it useful as a shelterbelt tree (Figure 18.3) for which it is widely used in Scotland.

Micro-site

In low rainfall areas where soils are shallow, beech is found to grow better on the damper north to east aspects, this is especially true of downland sites. This suggests that moisture supply can be critical, a point confirmed by stress of beech on some sites following the droughts of 1975 and 1976. Similarly, microtopography can be important, with well-watered dip and scarp slopes often exhibiting good growth.

Beech forest is generally absent from frosty valley bottoms and depressions. As a frost tender species beech requires a hardy nurse, or light overhead cover, where required in frosty sites whether local or regional.

Soils

Beech grows on a very wide range of soils, including acid, neutral and alkaline. Best development tends to be on near neutral to slightly alkaline soils, but poorest growth is found at both extremes – very acid and very alkaline. The reputation beech has as a species for chalk and limestone downland should not include strongly calcareous, shallow soils with free calcium carbonate to the surface (usually old arable sites or on steep slopes in downland areas). Although the species is one of only a few which will grow on such sites (see also Norway maple, sycamore and Italian alder) it rarely does well, and often develops lime-induced chlorosis soon after canopy closure. Affected trees show yellow foliage due to reduced uptake of iron and manganese, and are often on sites with adequate supplies of nitrogen and potassium where early growth may be good. Symptoms are most noticeable in dry seasons. It is a difficult condition to remedy and can also affect nurse species planted in mixture with beech such as Corsican or Scots pine (see Figure 3.2); Western red cedar is rather less susceptible.

Poorly drained sites with clay or silty clay textured soils are unsuitable. Periods of waterlogging are lethal, especially to small plants. Also unsuitable are very shallow soils over impermeable substrates which are liable to excessive drying out. Beech grows best on deep, well drained loams to clay loams, including those over chalk and limestone, as well as generally on deep, sandy loams to loams of moderate acidity.

Recommendation

Pure or mixed plantations of beech are suitable for many lowland sites with light soils. Also, the species is one of the most useful broadleaves for upland sites provided there is no true peat over mineral soil.

ESTABLISHMENT AND STAND DEVELOPMENT

Beech is a shade tolerant rather frost tender species and does not make a good pioneer species for planting on open ground. The benefit of nursing on chalk downland sites was cited on page 27, but, more generally, beech usually grows better with side shelter or even light overhead cover for the first few years (Brown, 1955). Thus the species establishes well on former woodland sites, can be grown initially as an understorey crop, and is capable of being regenerated naturally using shelterwood and small group systems (Figure 5.7) though mast production and subsequent survival of seedlings are sometimes unpredictable (pages 49, 63).

Though beech withstands considerable shade and benefits from sheltered conditions, less than full daylight does in fact reduce total growth (biomass) though height increment may be enhanced. Severe shading (less than 25 per cent daylight) causes flattening of side branches. Thus nurse species in mixture must not be allowed to dominate the beech and only the lightest overhead cover used, which should be removed once the crop is well established.

In the years following establishment on woodland sites dense bramble growth can be particularly damaging causing misshapen stems and poor form. This problem is minimized by ensuring good stocking and not overly wide spacing (>2 m). (For control of bramble see page 38). In general, because few trees in a stand are naturally of good form, maintaining high levels of stocking and keeping stands dense are required to provide a reasonable choice of final crop trees when thinnings commence.

THINNING

In younger stands, up to about 80 years of age, beech is generally responsive to thinning and can be thinned even after a period of neglect. Response to thinning appears wholly related to the size and shape of the remaining crown. Since beech does not suffer the problem of epicormic branching thinning can be heavy and infrequent. Early selection of vigorous well formed trees (Figure 5.2b) which are favoured by moderate to heavy crown thinning will generally ensure a vigorous and responsive stand.

In very densely stocked stands it is costly to make the first thinning selective and some form of mechanical thinning, e.g. one in four line removal, may be necessary. Stem selection should then be made prior to second thinning. The procedure of identifying in advance the potential final crop trees is important because relatively few stems in beech stands are of good quality; the ones that are merit favouring and nurturing including, possibly, high pruning. However, a danger exists in heavily thinning stands with a poor selection of well formed trees, which may result in coarse unmarketable trees; on the other hand positive neglect of thinning in poor crops may result in a higher density, eventually, of acceptable stems whose crowns will respond to later thinning.

It was noted in Chapter 5 and is again stressed here that in older beech stands, especially if over 100 years old and previously neglected, thinning can have potentially very damaging effects. Once trees are drawn up and small crowned, thinning in mature or over-mature stands can lead to sun scorch of remaining trees and stand collapse; this is considered further under special silvicultural considerations in connection with discussion of beech woods in the Chilterns.

DISEASES AND PESTS

Beech suffers one serious disease (beech bark disease) and this is considered later. The diseases and insect pests below are less serious but do occur widely and may occasionally cause damage of economic importance.

Diseases

Leaf disease

Leaf spot caused by *Gloeosporium fagi*, often abundant on leaves infested by aphids, can sometimes cause spectacular browning of the crown not dissimilar in appearance to 'wind scorch' by salt-laden air near the sea.

Canker, dieback and bark diseases

See page 174 for beech bark disease associated with *Nectria coccinea*. Another species, *N.ditissima*, is also widespread causing cankers, severe twisting and distortion of young stems and shoots. Girdling of the the whole stem may result in crown dieback.

Decay fungi

Many decay fungi affect beech. *Bjerkandera adusta (Polyporus adustus)* is common on trees damaged by beech bark disease. It causes a white rot which breaks up the stem leading to 'beech snap'. *Ganoderma applanatum* and *G.adspersum* both cause butt and branch rot of over-mature beeches. *Ganoderma pfeifferi* may decay roots, stems and branches and kill the whole tree. *Pleurotus ostreatus* (the oyster mushroom) can cause extensive decay of stems and branches. *Meripilus giganteus (Polyporus giganteus)* decays and kills the roots and the ascomycete *Ustulina deusta* can rot the stem base and major roots; both diseases can render trees liable to windthrow.

Insect pests

Defoliators

The beech leaf miner *Rhynchaenus fagi* is a weevil causing patches of dead tissue on leaves. It can greatly reduce the photosynthetic capacity of large trees, as occurred in the Wye Valley and Northamptonshire in 1982, and cause premature leaf fall in the autumn.

Occasionally *Phyllobius viridicollis* causes defoliation by skeletonizing leaves.

Buff-tip moth *Phalera bucephala* may completely defoliate a group of saplings, just as with oak.

Aphids and scale insects

Felted beech coccus *Cryptococcus fagisuga* is a serious pest associated with beech bark disease. The beech woolly aphid *Phyllaphis fagi* may heavily infest juvenile foliage, for example in beech hedges.

Galls

Two midges (*Hartigiola annulipes* and *Mikiola fagi*) cause leaf galls which often attract attention when present but are of little silvicultural significance.

YIELD AND GROWTH RATES

Beech is generally slower growing than most broadleaves with the exception of oak. The mean yield class in Britain is close to 6 m^3/ha/year, a figure which does not vary much between different regions apart from Scotland where Yield Class 4 is the average (Table 2.2). A few stands on fertile sites achieve Yield Class 10.

As well as the slightly higher yield class generally achieved by beech compared with oak, yield from beech woodland over time tends to be substantially higher than oak. This is because the normal rotation length for beech (100–130 years) is close to the age of maximum mean annual increment (see page 12) whereas for oak it is many years after. Thus beech stands, unlike oak, are generally felled near to the age which optimizes yield from a site over time.

UTILIZATION

Roundwood

At the present time thinnings from young beech stands usually find a ready market both for pulpwood and firewood. Beech makes a good charcoal. Some beech is used in turnery.

Sawn timber

Good quality beech is a prized furniture timber and much is imported from northern France for the purpose. Best grades are white wood, free of defects. Poorer quality beech, exhibiting pinkish or reddish brown colouring and small knots, may still

Figure 18.4 Smooth bark and 'pear rind' type bark (*right*) of beech (see text). (*A10614*)

be used in furniture making in those parts which are hidden from view.

Beech is also used widely in joinery, flooring, and plywood manufacture.

Defects in standing timber

Pink or reddish brown colouring in beech wood is an undesirable feature associated with certain stands in certain areas. It is not possible to predict from the appearance of a tree whether this feature is present; only past experience will indicate whether a high proportion of the trees in a stand can be expected to have this pinkish colouring.

Some beech also appear to have hard and cross-grained wood which makes for very difficult sawing and working. There is some evidence that this chacacteristic is associated with a roughened, dimpled bark, sometimes known as 'pear rind' bark (Figure 18.4).

Twisted grain also occurs in beech and tends to be found more frequently with trees whose bark is deeply fissured and appears somewhat like oak. However this bark characteristic is not a certain guide to the quality of the wood.

In general, the finest quality beech wood comes from smooth thin barked trees which have grown vigorously.

SPECIAL SILVICULTURAL CONSIDERATIONS

There are several aspects of beech silviculture which merit further comment.

Squirrel damage

Beech, in common with several other thin barked species such as maples and sycamore, is very susceptible to damage from Grey squirrels. Damage usually occurs in trees between the ages of 15 and 40 years. Bark is gnawed away on the stem, and on larger branches in the crown, but most often at the base of a tree. All such damage introduces a defect into the wood, but squirrel damage becomes serious when a complete ring of bark is removed and the crown dies. The occurrence of squirrel damage varies greatly from year to year for a number of reasons – see Rowe (1983) and Forestry Commission Leaflet 56 *Grey squirrel control* (Rowe, 1980).

Although all stands of beech when at the susceptible age are liable to squirrel damage, the problem should not negate the planting of this species. Reduction of squirrel numbers during late spring (when damage mostly occurs) is best effected using warfarin-baited hoppers. Also, high pruning of selected trees helps to ensure that damage does not occur on the lower bole since the squirrels have no place on which to perch.

Where control of squirrels in adjoining woodlands is poor or entirely lacking the risk to beech can become unacceptably high and make the growing of this species questionable. This can be resolved by agreements to trap in adjoining woodland or by a combined operation of interest to adjoining owners.

Beech bark disease

The bark of beech sometimes displays dark weeping 'tarry' spots. This external sign indicates the presence of patches of dead bark which, in many cases, have been invaded by the weakly parasitic fungus *Nectria coccinea*. This fungal invasion is frequently associated with a dense infestation of the felted beech coccus *Cryptococcus fagisuga* (Figure 18.5) a minute sap-sucking insect, and it is the result of the combined attack of insect and fungus which is termed 'beech bark disease'. This disease has caused mortality in pole-stage stands in Britain over the last 20 years and at other periods during at least the last 150 years. Doubts have been expressed over the future of the affected stands but it now seems clear that most of the losses occur during a 'peak phase', after which the mortality rate is much reduced. During the peak phase, the rate sometimes exceeds the reduction in stocking density which would occur due to suppression and early thinning but very few stands are irretrievably damaged. Among the surviving trees some may develop defective stems, but this is not a serious problem on most sites.

Figure 18.5 Felted beech coccus *Cryptococcus fagisuga* on bark of 28-year-old beech tree. (*A10615*)

Older beech trees have been affected in continental Europe and in North America, with serious economic loss, but it is unusual to find heavy infestations of the Felted beech coccus on British beech over 60 years of age. However, beech bark can become susceptible to attack by *Nectria* as a result of stress induced by agents other than the coccus. Thus, trees affected by drought, nutritional imbalance, root disorders, etc., may develop some of the symptoms of beech bark disease even in the absence of heavy coccus populations. Many older trees were thus damaged or killed following the drought of 1975/6, the disorder often being somewhat erroneously termed 'beech bark disease'. As in the case of true beech bark disease, recovery can occur, although some defects ('T-defects') will be present in the timber. Decay may also develop following bark death.

The effect of site factors and silvicultural practices on the incidence of beech bark disease are poorly understood, but any factors likely to induce stress will probably increase the severity of the attack. An example is provided by the condition known as lime-induced chlorosis (Lonsdale and Pratt, 1981) which affects beech planted on excessively calcareous soils (see pages 50, 171). Climatic factors can affect the course of the disease in various ways; for example high rainfall can inhibit the build-up of coccus populations due to washing-off effects, but the disease nevertheless occurs over most of the geographic range of European beech. The planting of beech in mixtures with conifers is of special interest since the build-up of coccus populations seems generally slow in such stands, except where the conifer is larch. It is not clear whether the apparent benefit is sustained after the removal of a conifer nurse. In general the use of species mixtures seems likely, for several reasons, to discourage severe outbreaks of the disease, and the same may be true for mixed age stands.

No clear guidance can be given for the management of diseased stands, since eradication is not practicable and sanitation is unlikely to reduce the incidence of the disease. The best that can be done is to salvage severely affected stems if this is economically worthwhile, a judgement aided by recognition of the phase which an outbreak has reached – early, peak or aftermath.

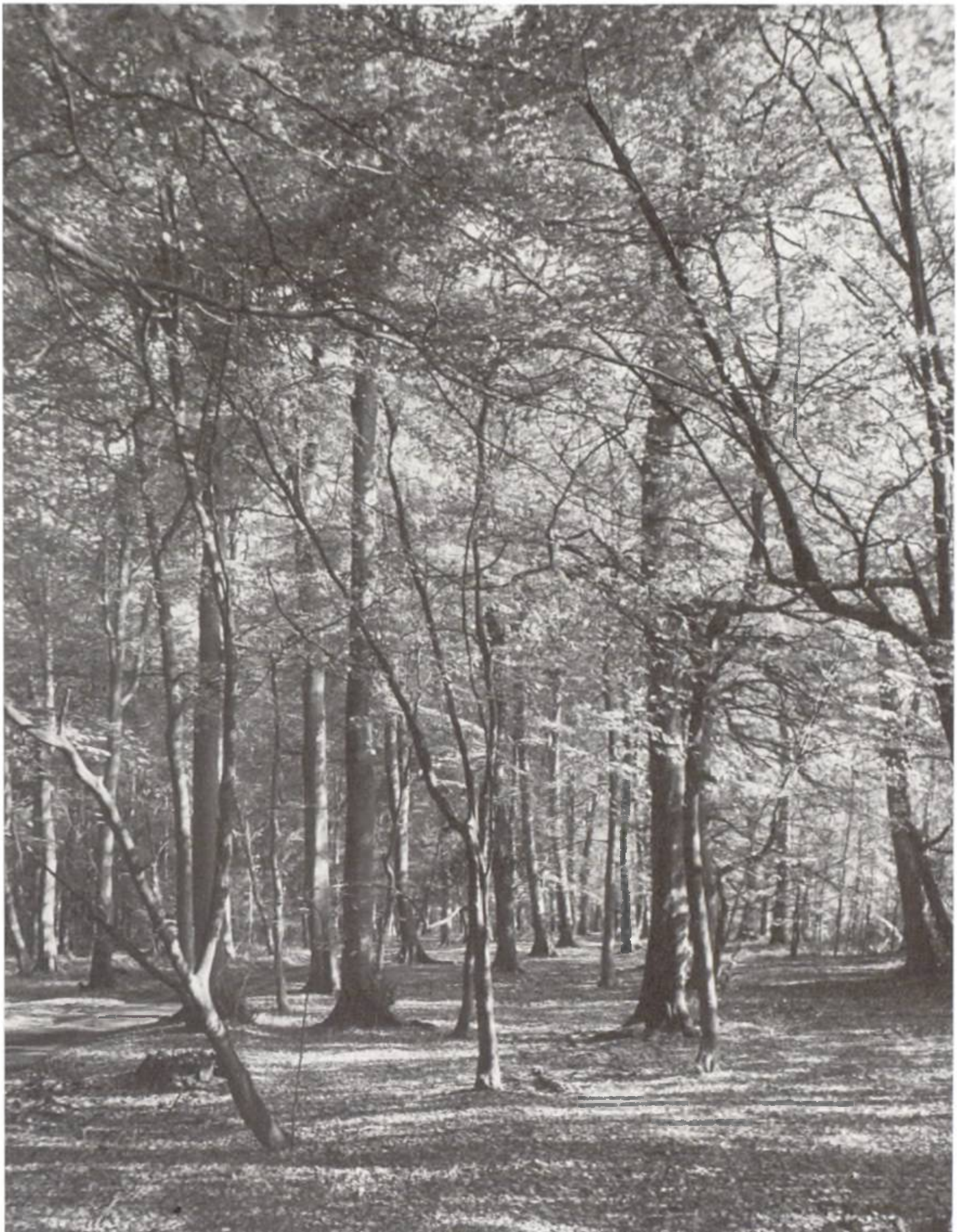


Figure 18.6 Beech in the Chilterns, an outstandingly important natural amenity. (*Photo: A. C. Miller*)

Beech in the Chilterns

The largest area of beech woodlands in Britain and probably the most intensively studied, occurs in the Chiltern Hills. However, 46 per cent of this area, just over 6000 ha, consists of mature or over-mature woodland and there has been concern, principally emanating from the surveys of Bourne and his findings over natural regeneration (Bourne, 1942), about how best to maintain this important forest area and amenity (Figure 18.6) near to London – see *A plan for the Chilterns* (Anon., 1971).

Surveys of Chiltern beechwoods show them to be remarkably even-aged with very few stands in the range of 30–80 years of age. The general impression of the Chiltern woods is one of even-aged stands of low quality and poor stocking, owing largely to past use of the so-called Chilterns Selection System which steadily creamed the best beech stems and all the oak. Throughout the present century continuing attempts to manage the woodlands on a selection system mostly failed resulting in the present urgency to regenerate effectively large areas of old trees.

The problem of over-maturity is exacerbated by the fragility of many such stands. It is frequently observed that when old but healthy stands are thinned they rapidly die back and become unhealthy with the trees quickly losing marketable value; a condition described as stand collapse. It appears that only the most healthy stands can be successfully thinned and then only very lightly and with great care. Thus for the bulk of the over-mature stands the only management option is to regenerate them.

In order to reconcile silvicultural needs, salvaging what timber there is and taking into account landscaping and amenity considerations, stands in a locality are first classified according to their health and vigour. Then, following the Chilterns Plan recommendation, over-mature woodland is regenerated over a 30-year period beginning first with the least healthy stands.

Where the stock is poor with sparse crowns and a high incidence of black spot (sap exudation through patches of dead bark) and stand collapse already in progress, the only option is to clear fell and replant. In stands where only some trees appear unhealthy and lacking in vigour, group fellings of the poorest parts are carried out to diversify structure. Size of opening is generally 0.2–0.4 ha though may extend to over 1 ha. In stands which appear completely healthy and still growing vigorously, very careful thinning may be carried out with a view to commencing the regeneration sequence in 20 or 30 years' time.

The use of natural regeneration within the Chiltern beechwoods has been successful on several sites (Figure 5.7) but it is not generally recommended owing to its uncertainty and because the quality of Chiltern beech is not especially good. Where natural regeneration comes up at the time of felling clearly it can be used to advantage but, in general, planting, typically with mixtures of beech, oak, Wild cherry and larch, is the main means of re-establishment.

APPENDIX

REGISTER OF MANAGED SEED SOURCES FOR BEECH

Identity number	Estate or forest	Date registered	Area (ha)	Estimated planting year	Location	National grid reference
2001	Yester	1973	1.0	1680	Lothian	NT534674
2002	West Field	1975	0.8	1831	Grampian	NJ154654
3001	Lowther	1973	0.8	1870	Cumbria	NY523256
4001	Dropping Well	1973	1.0	1850	North Yorkshire	SE346568
4002	Slindon Park	1973	19.5	1745	West Sussex	SU954074
4003	Cirencester	1973	15.0	1735	Gloucestershire	SO999024
4004	Kingscote	1973	11.7	1825	Gloucestershire	SO830972
4005	Uley Woods	1973	4.9	1885	Gloucestershire	ST779970
4007	Badminton	1976	2.0	1800	Avon	ST800826
4008	Badminton	1976	3.0	1800	Avon	ST785845
4009	Ebworth	1976	8.0	1850	Gloucestershire	SO875085
4010	Queen Elizabeth	1978	10.0	1908	Hampshire	SU594138
4011	Sonning Common	1982	70.0	1860	Oxfordshire	SU697808
4012	Queen Elizabeth	1982	6.0	1916	Hampshire	SU387284

Note: There is also one clonal (Kingscote) seed orchard for beech, number NT5. The owner is the Forestry Commission, and the orchard is sited at Alice Holt, Surrey, National Grid ref. SU813429. This consists of 12 clones covering 0.4 ha and was established in 1960–62 and registered in 1973.

CHAPTER 19

Ash

Ash *Fraxinus excelsior* is the third most widely occurring broadleaved species after beech and oak and, when well grown on fertile sites, produces one of the finest quality timbers.

There are few published accounts of ash in Britain though it formed the subject of a British Ecological Society symposium in 1950. Readers are also referred to papers by Wardle (1961) and Helliwell (1981).

TAXONOMY, DISTRIBUTION AND VARIATION

Taxonomy

FAMILY: Oleaceae (olive family)

GENUS: *Fraxinus* L.

The genus consists of about 65 species mainly found in temperate latitudes of the northern hemisphere; three species are tropical or sub-tropical.

SPECIES: There is one native species, Common ash *Fraxinus excelsior* L.

Only one exotic ash had been considered of any possible forest potential, American White ash *F.americana*, but experience is limited to a few research plots none of which has shown very great vigour. Several American, Chinese, and Caucasian ashes grow well as specimen trees and may merit wider trial, notably Narrow-leaved ash *F.angustifolia* Vahl.

Natural distribution and occurrence in Britain

Figure 19.1 shows the natural distribution of Common ash.

Ash is mostly confined to the lowlands but is found at higher altitudes than oak (up to 450 m). It is an important component of mixed semi-natural woodlands but with the gradual clearance of these for agriculture and the favouring of oak, ash has diminished in importance over the centuries. Ash is widespread on the heavier calcareous soils of the English Midlands and is the dominant woodland species on the peat-free hillsides in limestone formations, notably the Mendips, southern Pennines (Peak District), West Yorkshire, and N. Lancashire. It is also found on fen or base-rich peat deposits. Ash is widely distributed in Wales but is less common in Scotland and natural stands are rare, but not absent, north of the Great Glen.

Ash has been planted throughout Britain, both as a forest tree and for amenity, but most arise through natural regeneration.

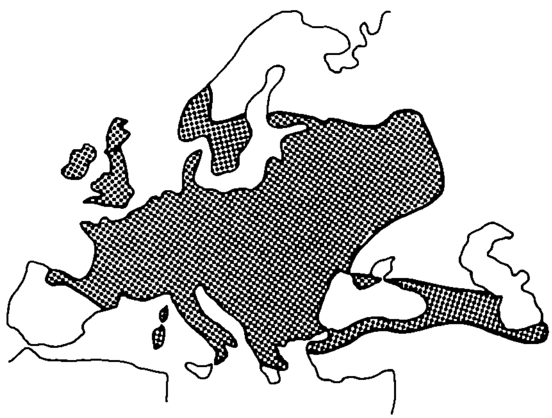


Figure 19.1 Natural distribution of ash.

Natural variation and provenance

In Britain performance of ash is strongly site related. There is very little information about effects of seed origin though a few trials, laid down in the 1930s, compared progeny from stands on chalk with other soil formations in Britain mainly because in Europe, notably Germany, it has been claimed that two distinct races of ash occur in relation to site type: water ash and limestone ash. Whilst there is no evidence of this distinction of races in Britain or of any other significant varietal or provenance variation (Helliwell, 1981), the site distinctions exist.

Individual trees may bear wholly male, female, or hermaphrodite flowers; those with male flowers often exhibit the best stem form because female flowers are terminal.

PHENOLOGY AND REPRODUCTIVE MATERIAL

Growth pattern

Initial growth of ash can be extremely rapid showing annual height increments of 50–100 cm within a few years of planting. Current annual volume increment peaks at 20–25 years with maximum mean annual increment at about 40–45 years. Beyond this age growth slows and, particularly in pure stands, often appears to stagnate after about 60 years. Also, by this age, growth of ash is slower than beech of the same age and comparable yield class.

Seed production and storage

Ash trees exhibit a wide variety of flowering habits, as noted above, and a few trees have even been observed to bear flowers of different sex in succeedding years. Flowers open in late April or early May before the leaves. Clusters of winged seeds (keys) ripen by September though they may remain on the tree throughout the winter.

The first good seed crops occur at 25–30 years of age with maximum production between 40–60 years. Seed production is not cyclic and trees bear good crops in most years.

There are no registered seed stands of ash at the moment because it is not a species registerable under EEC regulations. Seed should be collected from stands or individual trees with well formed stems and fine branches.

Seed treatment and storage

Seed collected green in August, i.e. which has not dried on the tree, may be sown immediately and will give moderate germination the following spring. Dry seed collected in October is dormant and will not germinate until the second spring after collection. Such seed should be stored until the following August and stratified in readiness for sowing the next spring.

Dry ash seed (7–8 per cent moisture content) will retain high viability for up to 7 years if kept in sealed polythene bags in a refrigerator at 2–4°C.

Vegetative propagation

Ash, like oak, is not easy to propagate vegetatively though softwood cuttings taken from young (1–3 years) stock plants are easier to root. It is difficult to root cuttings taken from old trees.

SITE SELECTION

Climate

The influence of climate on the growth of ash in Britain appears much less important than soil conditions. Indeed ash will grow well in all parts of Britain where the soil is suitable. Upper altitudinal limits are probably set by a combination of exposure and unsuitable soils.

Micro-site

Ash foliage is particularly susceptible to late spring frost, thus planting in frost hollows is best avoided. Healthy plants will usually recover from frost damage but will almost invariably be forked. However, some frost prone sites have the potential to support good ash, e.g. at the foot of limestone slopes, and can often be established by growing ash in mixture among regrowth of alder, birch, etc.

Ash does not grow tall in exposed locations but can often be seen on sea cliffs in carboniferous limestone regions. In general topographic as well as wood edge shelter against moisture stress seems essential for good growth and is another reason why ash is best grown in mixture and not planted on open ground. Ash usually grows well in tree shelters.

Soils

Ash grows on all soils above pH 5.5 but its best development is on deep, moist, freely draining and fertile ones of about neutral reaction. Such good sites are not widely available for planting but attempting to grow high quality ash on any other site is not likely to be successful, because high quality ash needs to be grown rapidly. It is probably better not to grow it if this cannot be reasonably assured.

Although ash requires moist soil conditions it will not tolerate prolonged flooding, waterlogging or compacted soils. Ash is demanding of the soil and has one of the highest nutrient uptake requirements of any species. Nitrogen rich soils especially are desirable.

Plant indicators of potentially good ash soils are Dog's mercury *Mercuralis perennis*, nettles *Urtica dioica*, Wild garlic *Allium ursinum*, and Wild angelica *Angelica sylvestris*.

Recommendation

Pure ash should only be grown on the best sites. A few high quality stems are usually found in mixed stands (Figure 19.2) on good sites, including clay with flints and deep calcareous soils, since ash appears well adapted to growth in mixtures with oak, beech or sycamore.

Figure 19.2 Good ash stem in mixed woodland. (*A10616*)

STAND DEVELOPMENT, THINNING AND PRUNING

Except at the seedling stage ash is a strong light demander. Management of ash, whether in pure plantation or in mixture, must take account of this fact and the trees always kept open to full overhead light. However, since exposed and open conditions often lead to stagnating growth in ash stands the retention of some side shelter is important. Thus the basis of handling young ash stands is to balance these two needs: maintaining high light conditions while still providing some side shelter.

Thinning

Rapidly grown ash attracts the best markets. As well as careful site selection this is achieved through regular thinning whether in pure or mixed stands. In plantations thinning should have commenced by the time stand top height is 10 m. Use moderate crown thinning of the best stems. Such trees should be afforded plenty of light and space with only side shade. In this way they will be furnished with a crown down to half stem height and therefore well able to respond to subsequent thinnings. Under-thinning rapidly restricts crown size which for ash, unlike oak, is not easily increased again when stand opening does occur. Conversely, sudden opening of a stand by heavy thinning may over-expose crowns and cause partial stagnation of growth.

Pruning

Pruning is sometimes necessary to achieve good quality ash. Frost and several insect species can lead to forking of stems and it is important that such trees should be singled at an early stage while the shoots or branches are still small. Best quality stems should be high pruned to 5 m but there is unlikely to be any problem with epicormic branches so only one operation is usually needed.

DISEASES AND INSECT PESTS

Ash is relatively free of serious disease and pest problems though the following often occur.

Diseases

Leaf diseases

Powdery mildew *Phyllactina corylea* occasionally leads to some defoliation; of minor importance. Various minor leaf spot diseases occur.

Cankers

Bacterial canker caused by *Pseudomonas savastanoi* sub-sp. *fraxini* is the most damaging disease of ash in Britain causing considerable stem degrade. Sunken cavities develop and wood becomes stained and liable to rot. Diseased trees should be removed in thinning.

Several other cankers occur caused by or associated with species of *Nectria*, *Phomopsis* and *Hysterographium* but are usually of minor significance though occasionally the former may cause death of small trees.

Decay fungi

Inonotus hispidus is the most frequent cause of decay in ash. *Daldinia concentrica* is also a frequent cause of branch rot. *Armillaria mellea* may attack ash and *Fomitopsis cystina* has been found causing basal rots.

With ash more than most species, the incidence of disease is much increased on poorly growing trees. Growing ash vigorously is the best means of avoiding disease.

Insect pests

Defoliators

The Ash bud moth *Prays fraxinella* causes death of shoot tips, especially on saplings. The Privet hawk moth *Sphinx ligustri* will occasionally defoliate a branch.

Aphids and galls

Two scale insects occur on ash, Willow scale *Chionaspis salicis* and Ash scale *Pseudochermes fraxini*. Neither is economically important.
The Ash leaf gall psyllid *Psyllopsis fraxini* causes distortion of foliage on young plants.

Beetles

Four bark beetles affect ash, of which the most frequently met is the Common ash bark beetle *Leperesinus varius*. It is an important cause of degrade in ash walking sticks.

Mites

Aceria fraxinivora causes flower galls which reduce seed production.

YIELD AND GROWTH RATES

High forest

On the best sites ash has the capacity for faster growth and higher productivity than either oak or beech, achieving Yield Class 10 or 12. However, owing to the widespread planting of ash on sites far from the optimum the average growth rates recorded are much poorer, typically Yield Classes 5–7.
As has been stressed, growth of ash is closely related to site and good correlations have been shown between height growth, foliar nitrogen levels, and soil nitrogen availability (Gordon, 1964).

Coppice

Pure ash coppice occurs in some localities and ash is a frequent component of ancient mixed coppices (Figure 1.2). Ash stools will continue to sprout for many coppice generations and may last hundreds of years (Figure 7.1). Initial coppice growth is frequently very vigorous with shoots exceeding 1.5 m in the first and second years. It should be noted that after coppicing, sprouting on some ash stools is delayed until the second spring.

UTILIZATION

Felling

It is generally recommended that ash is felled in the winter. The prejudice against summer felled timber is mainly due to the fact that weather conditions in summer favour the occurrence of splits and checks, owing to too rapid drying, and deterioration caused by insect and fungus pests. Trees felled in full leaf are also considered to be more liable to felling shakes, owing to their heavier tops, than they would be if felled in winter. So far as other types of defect are concerned, provided that the logs are extracted immediately after felling and converted or stored under appropriate conditions there is no need to discriminate against spring or summer felled timber. The danger lies in leaving logs in the woods during the warm summer months.

Roundwood

Ash is suitable for pulpwood and very readily saleable as firewood owing to its reputation to burn 'straight from the tree'. This is due to its low initial moisture content (30–35 per cent) but for efficient use ash firewood should be seasoned (dried) for a few months to achieve a moisture content of about 15 per cent.
Small roundwood still finds a market for turnery, and handles of striking tools such as axes and hammers, and other tools.

Sawn timber and veneer

Well-grown ash of good quality always finds a ready market for veneer, planking or furniture. A few exceptional trees make sports grade ash for hockey sticks, skis, cricket stumps, etc.
In marketing and buying ash the quality of individual trees is the main concern. The following notes are taken from Building Research Establishment (BRE) Technical Note 54 *Selecting ash by inspection:*

> The first consideration should be to choose trees with a good length of straight, clean bole, clear of side branches, and with a well developed, healthy crown at least one-half the height of the tree. Such trees are likely to be found in fairly open woodland; they should be preferred to tall,

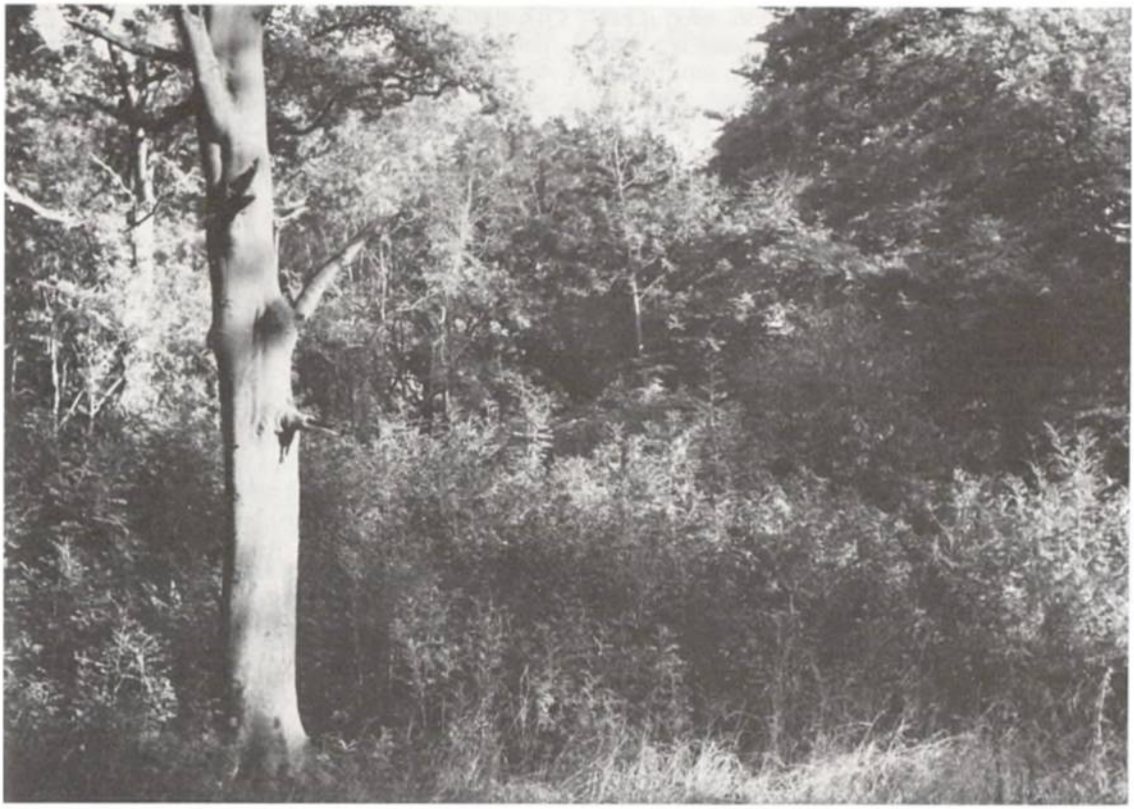


Figure 19.3 Dense natural regeneration of ash in a 0.1 ha opening in mixed woodland. (*A10617*)

spindly trees with small crowns such as are found in woods where the trees are rather crowded. Leaning trees are often elliptical in section with the heart (pith) off-centre and the wood from such trees is apt to be defective. Trees with dead branch stubs are likely to be infected with decay and should be avoided.

It has been found by experience that the best sports ash comes from trees between 30 and 40 cm in diameter and not more than 80 or 90 years of age. Wood from larger trees tends to be deficient in strength.

The appearance of the bark is often a guide to the rate of growth, a thick, rough bark indicating slowly grown, porous wood which is unlikely to be tough.

Degrade in standing timber

Ash suffers several pests and diseases but one 'defect' in particular greatly affects the quality, though not strength or toughness, of the wood. This is the occurrence of dark brown or black stains in the wood. Few ash stands are completely free of this defect and thus White ash is much prized. The occurrence of 'Black ash' or 'Black heart' appears partly associated with at least three factors.

1. Site – ash on wet swampy ground is more prone to discoloration.
2. Tree age – incidence of staining appears to increase in older, slower growing trees over 80 years of age.
3. Origin of stem – stored ash of coppice origin appears more susceptible.

SPECIAL SILVICULTURAL CONSIDERATIONS

Natural regeneration

Throughout Britain ash shows a remarkable capacity to regenerate naturally both in woodland and in non-woodland situations. However, such regeneration will not necessarily make a worthwhile crop and should be viewed critically for three reasons.

1. Occurrence of young regeneration, even if profuse, is no indication that the ground is a good ash site as described earlier. Often on ill-suited sites such regeneration disappears after 3–4 years.
2. No control has been exercised over the genetic quality of the parents; many poorly formed trees are profuse seed bearers and indeed may have been left behind because of their poor form.
3. Uniform regeneration is very difficult to obtain, it usually comes up in dense groups interspersed with large gaps.

Despite the above reservations naturally occurring trees are often a valuable addition in mixed woodland (Figure 19.2) and frequently add value to a stand. Also, in mixed woodlands regeneration in small openings (Figure 19.3) is a useful way of re-stocking, especially if it continues to grow well beyond the fifth year. If ash regeneration is actively sought it should be remembered that seedlings do not come up until the second spring. It is generally better to develop groups of regeneration that do occur rather than trying to encourage it specifically. The timing of canopy opening requires care to allow enough light for satisfactory growth of the regeneration, while avoiding large gaps which encourage weed growth and may even become frost hollows.

If very dense, natural regeneration may be thinned at the sapling stage by swiping, though in general selective thinning is much preferable.

Ash dieback

Ash dieback, sometimes known as ash decline, has been reported from the south Midlands since the 1950s but appears to have become more widespread in recent years. From a survey in 1983 (Pawsey, 1984) some 22 per cent of ash in eastern central England suffered from dieback, i.e. with more than 10 per cent of outer crown branches without any or only very sparse leaves. In a few localities more than half of all ash trees were affected.

No specific cause has been adduced, but the survey found that ash in field-side hedgerows in areas of intense arable farming had the highest incidence of dieback, while trees in towns and woodlands were mostly unaffected.

CHAPTER 20

Alders, birches and maples

The three genera, alders, birches, and maples (which includes sycamore), make up about 25 per cent of all broadleaved woodland in Britain.

ALDERS

Taxonomy and distribution

FAMILY: Betulaceae

GENUS: *Alnus* Mill.

SPECIES: There is one native species, Common or Black alder *A. glutinosa* (L.) Gaertn.

Three introduced alder species are of some forestry importance:

Grey alder *A. incana* (L.) Moench.
Italian alder *A. cordata* Desf.
Red or Oregon alder *A. rubra* Bong.

The Sitka alder *A. sinuata* is of research interest for upland planting.

Alders are widely distributed throughout the northern hemisphere. Figures 20.1a, b and c show natural distributions.

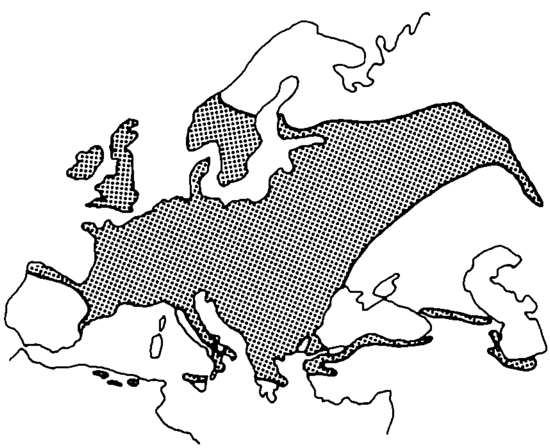


Figure 20.1 (a) Natural distribution of Common alder.

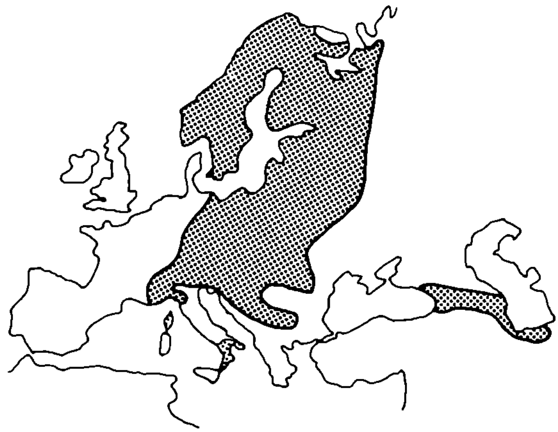


Figure 20.1 (b) Natural distributions of Grey alder (dark stipple) and Italian alder (light stipple – southern Italy and Corsica).

Figure 20.1 (c) Natural distribution of Red alder.

Figure 20.2 Well grown Common alder beside stream. Stand was coppiced about 40 years ago but not treated since. (*A10618*)

Common alder

Detailed accounts of Common alder and its ecology will be found in papers by McVean (1953, 1955–1959).

Sites and silviculture

Common alder grows naturally and has been planted throughout Britain, from sea level to over 500 m altitude (Figure 10.2). Natural and semi-natural stands occur predominantly on wet ground almost regardless of the parent material of the soil, being found both in regions where acid rocks and in regions where limestones predominate. Although typically a streamside tree (Figure 20.2) it is not restricted to this site and is often found growing elsewhere, e.g. alder woods are common on S and SW facing slopes in Scotland.

Common alder is remarkably tolerant of very wet soil conditions during the dormant season, whether heavy soils or those which are marshy or liable to flooding, but does not grow well on poor, acid peats. It tolerates a wide pH range, but optimum development is usually on soils ranging between pH 4.0 and 7.5. Along with other alders, Common alder is able to fix atmospheric nitrogen (see below) and therefore is an important species for reclamation work and plantings where the soils are poor in organic matter and nitrogen.

The species is a light demanding pioneer which naturally regenerates easily to form small pure stands on areas of freshly exposed soil in wet localities (Figure 20.3). Also, it frequently occurs in mixtures with ash, hazel and birches. Young pure or mixed stands containing alder can be used as nurse crops for oak provided the oak is not overtopped.

Common alder should always be considered for planting where drainage is poor or sites are wet, even if only of moderate fertility, as frequently occur beside lakes, streams and rivers, particularly in the uplands (see Chapter 10). The species is a useful nurse when planting oak on wetter, heavier soils and also for ash where its nitrogen enrichment role is often beneficial (page 187). Alders grow

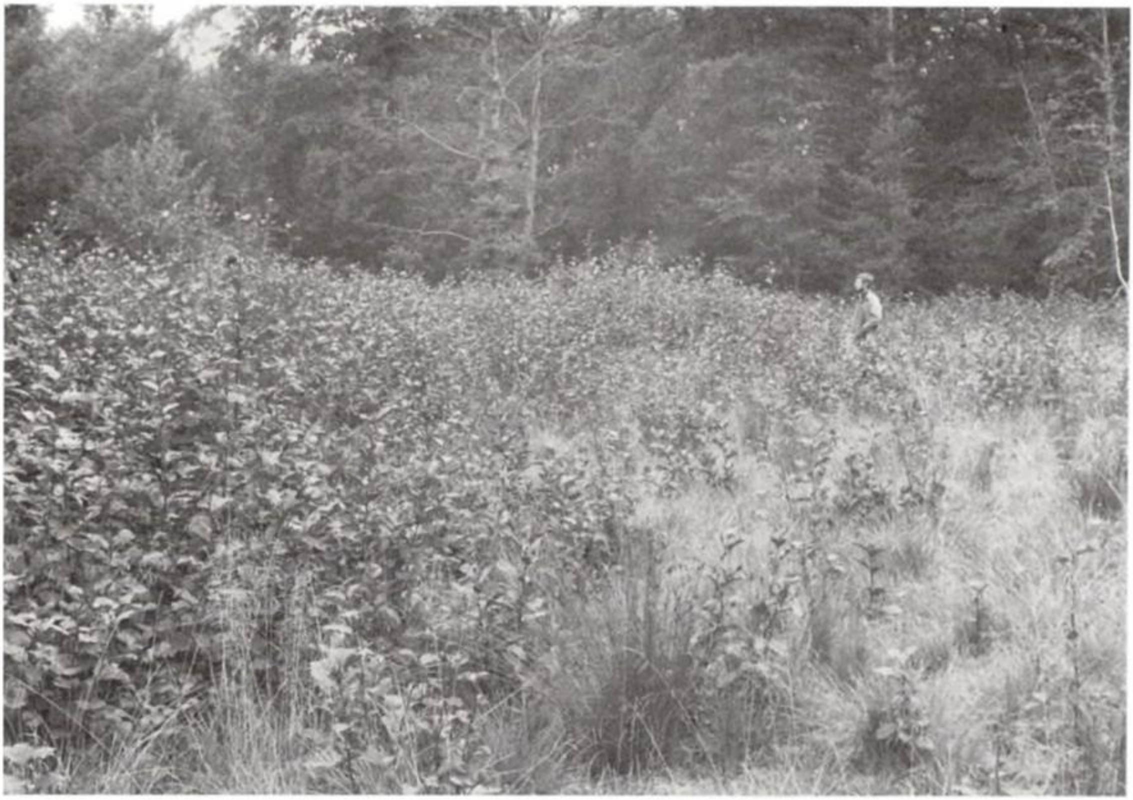


Figure 20.3 Natural regeneration of Common alder on wet ground in the Forest of Dean. (*A10619*)

vigorously in the nursery and there is often a temptation to use one-year-old seedlings. As mentioned in Chapter 3, such seedlings often do not establish well and it is better to use 2-year-old transplants (1+1, 1u1) since they appear better furnished with nitrogen-fixing root nodules.

Common alder coppices vigorously and occurs both as pure coppice (Table 7.2) and as a component of mixed coppices.

Protection

Common alder is hardy to late spring and early autumn frosts. It is deeply rooting, even in poorly aerated soils, and thus is generally wind firm. It makes a useful shelterbelt tree, but is not tolerant of salt spray. Well established trees are only moderately drought resistant, and appear to have high moisture requirements. Dieback and distress flowering due to drought is often observed in trees on colliery spoils with a low water-holding capacity. Newly germinated seedlings are very susceptible to drought and will usually only establish on a soil surface that comes within the capillary fringe of the water table and remains moist during late spring and early summer.

Common alder appears less subject to browsing damage than many other broadleaved species, since often only the leaves are eaten by sheep and hares. It is seldom damaged by squirrels.

There are no economically important insect pests.

Three species of the fungus *Taphrina* attack leaves and flowers of alder but none is important.

Growth

Initial growth of Common alder is rapid and height increments of 0.5–1.0 m per year are typical for the first 15–20 years. The species only occasionally attains more than 20 m in height and 40 cm in diameter, though on some sheltered, fertile sites very much larger trees may grow. It is generally a short lived tree usually attaining its full development within 30–40 years. Significant height growth usually stops at about 60 years. This pattern of rapid and early maturation makes alders a valuable secondary species in mixtures, provided they are not allowed to overtop the main crop.

Maximum mean annual increment culminates early and, under favourable conditions, Common alder will achieve Yield Class 12 in 20–25 years. If regularly thinned average tree diameters are, for the same age, likely to be 5 cm greater than sycamore, ash or birch on good sites (Yield Class 12) and about 2 cm greater on poor sites (Yield Class 6). On suitable sites Common (and other) alders offer the prospect of high yielding crops on short rotations.

Utilization

Wood of Common alder is diffuse porous with a coarse texture which, when dry, is light reddish brown without a distinguishable heartwood. It is a medium density straight grained wood which is easy to work. It is a useful general purpose hardwood and is particularly suitable for turnery. It makes a good charcoal, but as a firewood tends to burn quickly. It is suitable for pulp.

Grey alder

Grey alder has been the most widely planted exotic alder. Figure 20.1b shows its natural distribution. It is similar to Common alder, but there are some silvicultural differences which encourage discrimination in its use.

Grey alder tolerates a wide range of soil conditions and is better adapted to drier sites and heavy clays than Common alder. It is able to stand rather more shade but is not as frost hardy as Common alder.

Grey alder will produce root suckers, often at a great distance from the parent stem and beginning as early as 3–5 years of age. This is a useful habit when the species is planted on industrial and other wastes but may be a nuisance when used as a nurse for oak or ash.

Growth and final size of Grey alder are similar to Common alder, though on suitable sites it will grow even faster in the early years. A maximum mean annual increment (yield class) of 14 m^3/ha/year in 20 years has been recorded; on poor sites 6–8 m^3/ha/year in 30 years is typical.

The wood of Grey alder is similar to Common alder and in countries where both species occur they appear to be used for the same purposes without discrimination.

Italian alder

Italian alder has a very restricted natural distribution (Figure 20.1b) and little is known about its silviculture and wood properties.

The species was first introduced to Britain in 1820 and, until quite recently, attracted little attention as a possible forest tree. However, there are now several plots both in southern England and west Scotland which indicate that Italian alder can grow more rapidly and be a larger volume producer than either Common or Grey alder. On favourable sites height increments well in excess of 1 m/year are frequently recorded.

The most important distinguishing feature of Italian alder from other alders is its ability to thrive on calcareous soils which are alkaline at the surface. Although it grows well in wet conditions, this does not appear an important site requirement. It grows well on mining spoils, and is the only suitable alder if pH is high.

The full potential of Italian alder has not yet been realized. It is the alder species to plant whenever the soil is above pH 7. Its use should be confined to the warmer conditions of southern England. There is some evidence to suggest it may be a good nurse crop for beech or ash on drier calcareous soils. Its coppicing ability appears to be variable.

Yield data of Italian alder are scanty. A permanent sample plot in Queen Elizabeth Forest, Hampshire, has achieved Yield Class 11 in 30 years. A small plot in Micheldever Forest, Hampshire, adjacent to the Southern beech illustrated in Figure 1.1, achieved a top height of 17 m and a mean diameter of 22 cm in 21 years which is approximately equivalent to Yield Class 12.

Red alder

Red (or Oregon) alder is extremely fast growing and will usually outgrow other alders in the early years on heavy soils. Because its natural distribution (Figure 20.1c) coincides very largely with that of Sitka spruce it has been used in Britain in many upland trials. However, its early promise as a suitable broadleaved species for upland planting has not been fully sustained. Provenances of Red alder so far tested are generally found susceptible to autumn frost and, like all alders, apparently well established stands are prone to early deterioration in growth followed by dieback of many trees, especially on poor sites (Lines and Brown, 1982).

Using very northerly provenances of Red alder has only been partly successful in overcoming its sensitivity to frost. However, origins from high elevations in British Columbia, the Cascade, Coastal and Olympic mountain ranges of NW America may confer greater hardiness. Testing this possibility, and hybridizing Red alder with Sitka alder are both being tried as a means of improving frost resistance.

Trial plots in southern Britain suggest that Red alder is less windfirm than other alders.

Wood of Red alder is less dense than Common alder but may generally be used for the same purposes. In western North America nearly all Red alder is used in the furniture industry. It has excellent working qualities and will take and maintain a high finish. As with other alders it makes a good charcoal as well as being useful for pulp and particle board manufacture.

Sitka alder

The Sitka alder is a large shrub/small tree which is very frost hardy. Although of no timber growing potential, because it is hardy and like all alders is able to fix atmospheric nitrogen, it is being considered as a soil improving species in mixture with conifers in upland planting. Unlike other alders it will not suppress the conifer component in a mixture and thus offers the possibility of planting a self-thinning stand which confers the added benefit of 'biological manuring'.

Special silvicultural considerations for alders

Nitrogen fixation

In association with the Ascomycete fungus *Frankia*, alder nodules are able to fix atmospheric nitrogen. Although the strain of *Frankia* differs between Eurasian and North American alders, the latter are able to utilize European strains when grown in this country.

The evidence for nitrogen fixation by alder root nodules has long been established e.g. Bond (1956). This fixation process allows alders to thrive on otherwise nitrogen deficient soils and renders alder foliage especially nitrogen-rich (Table 4.3). Soil improvement by alders, and their benefit when used as a nurse for such species as ash, is largely due to this nitrogen-rich foliage which falls each autumn. Such litter is readily broken down thus enriching the soil with the nutrients released.

The numbers and size of nodules on alder roots are affected by many factors but the principal one seems to be soil fertility. On nitrogen rich, fertile soils alder may be found growing with very few or even no nodules at all. Conversely, on poor soils, especially those deficient in organic matter, most alder roots will bear nodules, especially near the main stem.

Use of alders for reclamation

Because of their nitrogen-fixing ability alders are one of the most useful broadleaved species in reclamation work. Mining wastes and spoils resulting from many industrial processes can be deficient in nitrogen and often low in organic matter. Alders are amongst the few species which will grow well but only if compacted ground conditions, commonly associated with heavy earth moving machinery, are alleviated by appropriate topographic re-shaping and sub-soiling (Binns and Fourt, 1980).

Between 1967 and 1976 Common alder and Italian alder were the most important species in reclamation work and, in the case of regraded colliery spoil heaps, accounted for about 60 per cent of all planting (Jobling and Stevens, 1980). Since 1976 the planting of alders has declined, especially in drier, eastern regions, as evidence accumulated of their intolerance to drought with many young stands checking or dying back when 2–4 m tall despite initial promise.

Stand collapse

It is quite frequently observed that in both pure and mixed plantations of alder, some trees dieback at young pole stage. Sometimes this dieback becomes serious and the stand fails. This phenomenon is observed throughout Britain and appears unrelated to species or site. No one cause can be adduced and, in many instances, no explanation has been found. In some cases factors such as poor matching of species with soil conditions, drought, *Phytophthora* root rot and the effects of the scale insect *Chionaspis salicis* may have been contributory.

BIRCHES

Birch is a very widespread and common tree, indeed, in Scotland it is the most widely occurring of all broadleaved species where there are 16 650 ha of high forest and 41 740 ha of scrub birch. It is helpful to distinguish between highland birch woods (Chapter 10, see page 62), which are such an important natural feature of the uplands of Scotland, and lowland birch woods where the species is an invader of waste ground, unmanaged heathland (Figure 20.4) and some felled woodlands. The two native tree birches occur both in highland and lowland birch woods and are considered together in this section, though points of difference in their silviculture are highlighted.

Interest in birch has reawakened in the last decade (Philip, 1978), and was the subject of a symposium in 1982 (Mann and Henderson, 1984) and a review by the Countryside Commission for Scotland (Brown, 1983).

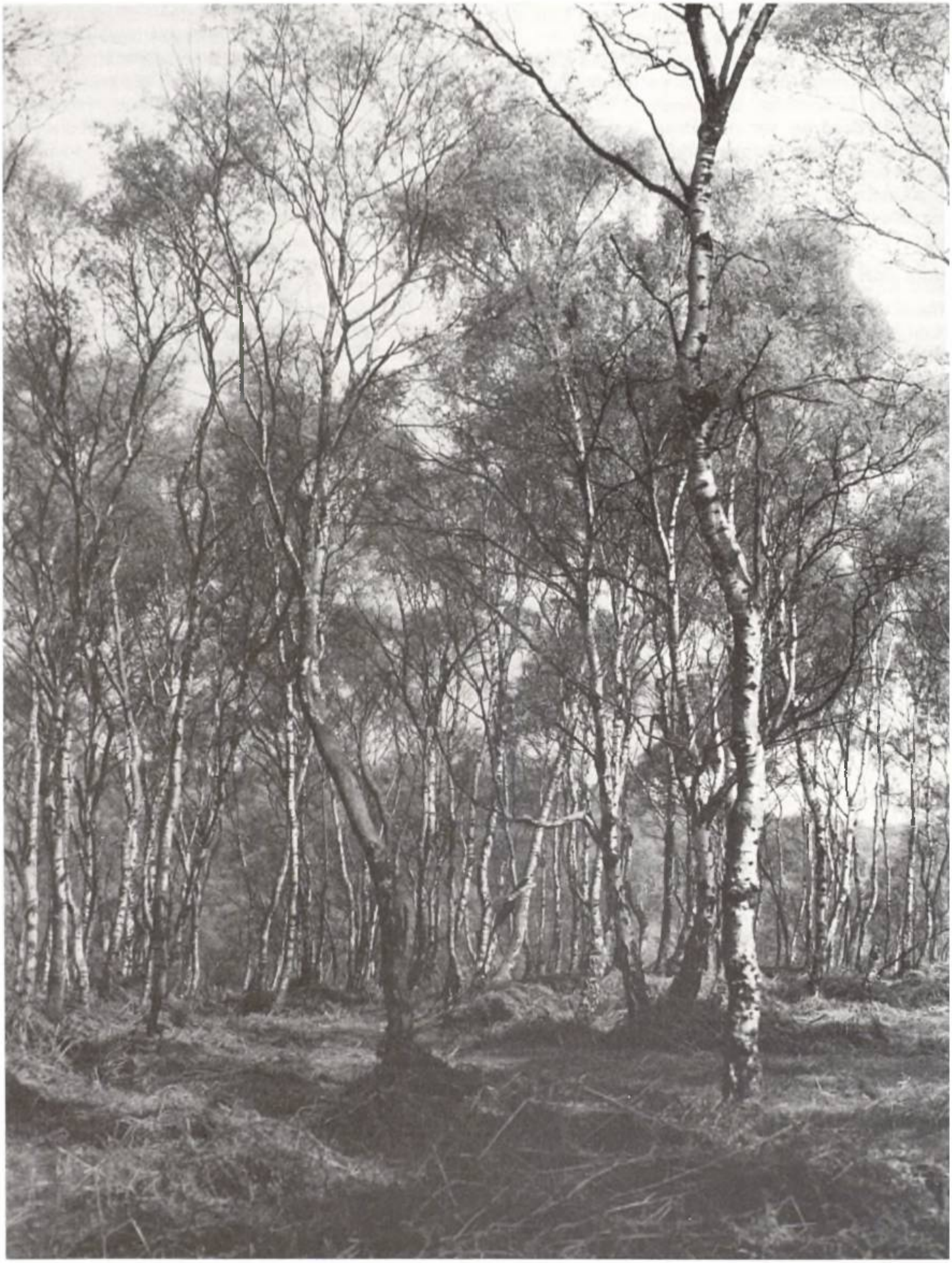


Figure 20.4 Silver birch on heathland in Staffordshire. (*Photo: A. C. Miller*)

Taxonomy and distribution

FAMILY: Betulaceae

GENUS: *Betula* L.

SPECIES: There are three native birches: Silver birch *B. pendula* Roth., Downy birch *B. pubescens* Ehrh., and a dwarf species *B. nana* L.

Throughout the northern hemisphere there are about 30 species of birch but no exotic species is considered of forest potential in Britain at the moment.

Silver birch and Downy birch occur throughout Europe and into parts of Asia (Figure 20.5a and b.)

Characteristics of birches

Sites and silviculture

Both birches produce seed very freely, frequently and from an early age (Table 5.3). Although seed viability is not always very high the very large quantities produced, and the fact that the seed is light and winged, enable colonization by the species of almost any suitable site in Britain. Birches are pioneer, light-demanding species and form a component of British woodlands almost wholly as a result of natural regeneration.

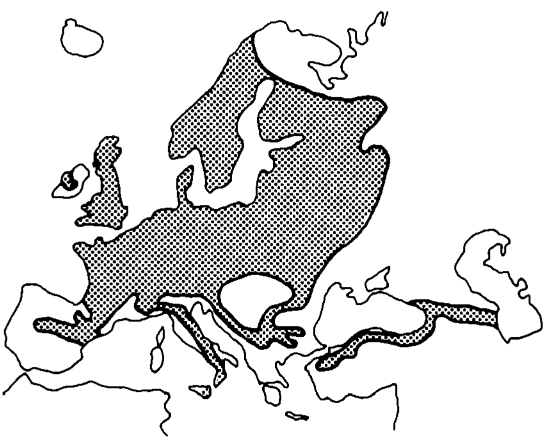


Figure 20.5 (*a*) Natural distribution of Silver birch.

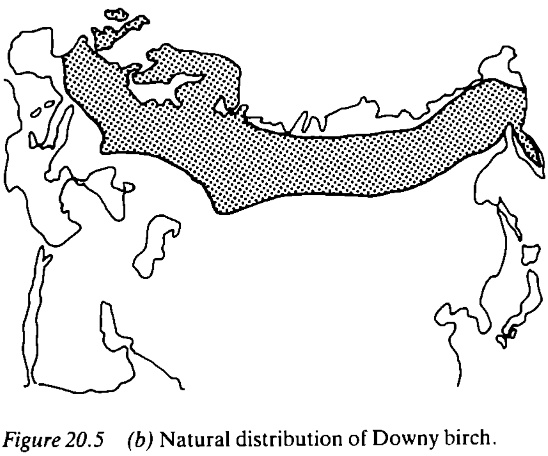


Figure 20.5 (*b*) Natural distribution of Downy birch.

Birches become readily established wherever there is bare mineral soil of moderate phosphate status. Few seedlings are able to establish themselves where there is existing ground vegetation other than heather. Open, disturbed sites are where birch grows best.

Soil texture appears relatively unimportant for the establishment of birch though the species tend to predominate on the lighter, sandier soils. Both species tolerate a wide range of pH (3.5–7.0) but do not grow well on strongly calcareous soils unless there is an acid surface layer. Downy birch is better able to grow on peaty and more waterlogged soils than Silver birch; the latter grows better on dry sandy soils.

Silviculturally, because birch is a pioneer, it can be a useful nurse species for other broadleaves provided its very rapid initial growth is not allowed to swamp the main crop species. Examples of its role in this way have been quoted previously in this Bulletin. Its own potential as a forest crop is more limited than many broadleaved species because it has little sawmilling potential (see below).

Apart from amenity, birch is not widely planted in Britain. The species has a reputation for being difficult to plant with often high post-planting mortality. Apart from careful handling and preventing bare-rooted stock from drying out, this appears largely a factor of plant size: large plants neither take well nor grow rapidly in the first few years after establishment (Brown and Kennedy, 1981). Small plants, e.g. one-year-old seedlings 25–50 cm tall, show proportionally much greater height growth in the year after planting than large planting stock. Use of container grown birch seedlings, e.g. in paper-pots, usually improves survival after planting (Figure 3.3).

Protection

Birch is very frost hardy. The only frost damage usually reported is when young seedlings are killed by frost heave, i.e. when the soil cracks and lifts during a hard frost and exposes the roots. Birch is tolerant of exposure, occurring at higher altitudes than most other broadleaved species, though in exposed locations it has poor form. In hot dry summers birch is one of the first species to show damage in the form of premature browning, defoliation and death of bark.

Although birch is susceptible to damage by fire, which is a frequent occurrence on heathland where birches often predominate, saplings usually recover producing vigorous basal shoots and the exposed soil surface for 2–3 years after a fire is ideal for natural regeneration.

Sheep, cattle, deer, and rabbits will all browse birch seedlings and saplings. Seedlings also suffer periodic browsing by squirrels, voles and wood mice. Where browsing pressure is high, trees become stunted and remain in their juvenile state, and natural regeneration may be eliminated. Heavy browsing pressure is the main reason for poor regeneration in many upland birch woods.

Birches are sometimes defoliated by the sawfly *Croesus septentrionalis.*

The leaf rust *Melampsoridium betulinum* is very common but only causes significant damage to seedlings and young natural regeneration. Witches brooms are caused by *Taphrina betulina*; infected twigs are rendered more susceptible to frost.

Cherry leaf roll virus has been isolated from Silver birch and causes bushiness and small leaves on affected branches. It may also be the cause of the figuring in wood known as 'flamy birch' (Cooper, 1979). Birch wood is not durable and the bracket fungus *Piptoporus betulinus* is common on standing trees. Birch is frequently attacked by Honey fungus *Armillaria* spp.

Growth

Once established, birch grows very rapidly for the first 20 years. On good sites trees can attain 10 m in 10 years and yield classes as high as 12. However, most birch woodland is not as high yielding and many stands, especially in Scotland, only achieve Yield Class 4–6. The species is not long-lived and most trees die at around 60 to 80 years of age, though much greater ages may be attained if growth has been slow. Maximum mean annual increment culminates between 40 and 50 years. The maximum height attained rarely exceeds 20 m.

Downy birch is generally slower growing than Silver birch.

When growing in pure stands birch is very intolerant of between-tree competition. In dense stands self-thinning occurs, mortality rates are high, lower branches are quickly suppressed and die, and by about 40 years of age the number of branches per tree is relatively constant at about 50 (Ovington and Madgewick, 1959). Even if thinning is commenced soon after canopy closure, birch is generally unresponsive.

Utilization

Birch wood varies from almost white to pale fawn in colour, is of moderate density, is easily worked but is rather featureless.

Birch is a good firewood and pulpwood, and posts are easily pressure treated with preservatives for use in fencing.

Much birch is used in turnery, e.g. brush backs, even though markets for cotton-reels and bobbins have very largely disappeared.

Only small quantities of birch are sawn. In Finland it is a very important species for plywood veneers but in Britain this market has never developed because there are insufficient logs of suitable quality.

Special silvicultural considerations for birches

The improvement of birch

As a forest tree birch has many advantages: rapid growth, self pruning, ability to grow on a wide range of sites including relatively infertile ones, easy natural regeneration, and production of a general purpose white hardwood. There are many reasons why birch has not been more widely used in British forestry but among them is its poor form (Figure 20.4) with respect to stem straightness, stem circularity and branching habit. Some of these characters are heritable, i.e. can be passed from one generation to the next, therefore appropriate selection and breeding may produce trees of better quality.

Because birch sets fertile seed at a relatively young age the possibility of carrying through a tree breeding programme is rather more attractive than for other broadleaved species. Such improvement work with the aim of increasing production of veneer quality material is currently in hand (Brown and Kennedy, 1981; Lines and Brown, 1982). Birch is relatively easily propagated from cuttings and another avenue of improvement is to develop clones in which desirable characters are passed on.

Birch as a soil improver

For many years it has been claimed that the litter produced by leaves and twigs beneath birch woodland develops a mull humus which leads to an accompanying rise in pH, exchangeable calcium, rate of nitrification and numbers of earthworms. On acid, especially heathy sites, these effects improve soil conditions particularly because birch roots appear able to penetrate the hard ironpan that often occurs in the B2 horizon on such sites. However, on the most acid soils the earthworm species which help to produce a mull humus cannot survive. Gardiner (1968) reviewed this role of birch as a soil improver and concluded that the case for birch, both as a nurse and soil improving species, is a good one. Several experiments have been laid down, mostly in the 1950s and early 1960s, to verify this benefit but they are still too young to give any conclusive evidence. Studies by Miles and Young (1980), using buried stem fragments and seed of birch, offer some evidence for sequential soil changes as *Calluna* moorland progresses to birchwood.

The use, silviculturally, of this possible benefit is confounded by the fact that on many poor sites such as the acid heaths, control of heather and an addition of phosphate fertiliser are very much quicker and more effective means of ameliorating the site for tree growth.

Conservation

The upland birchwoods of Scotland are an important natural ecotype which is gradually disappearing. Since 1947 the area of these woods has declined by 30 to 40 per cent.

Birch is a frequent minor component of conifer plantations and is thus of conservation value being one of the few native broadleaves able to grow in the uplands.

MAPLES

The maples include one important timber producing tree, sycamore, which constitutes almost 9 per cent of all broadleaved woodland, and one of considerable potential, Norway maple.

Taxonomy and distribution

FAMILY: Aceraceae

GENUS: *Acer* L.

SPECIES: One maple species is native: Field maple *A. campestre* L.

The two main timber producing maples are Norway maple *A. platanoides* L. and sycamore *A. pseudoplatanus* L.

Many species of maple have been introduced into Britain and four are of research interest with possible forest potential:

Oregon or Big leaf maple *A. macrophyllum* Bursh.
Red maple *A. rubrum* L.
Silver maple *A. saccharinum* L.
Sugar maple *A. saccharum* March.

Of these four American maples Oregon maple and Silver maple have grown vigorously as individual trees on a number of sites in Britain. They and Sugar maple are presently included in small-scale species trials.

The distributions of Field maple, Norway maple and sycamore are shown in Figure 20.6 a, b and c.

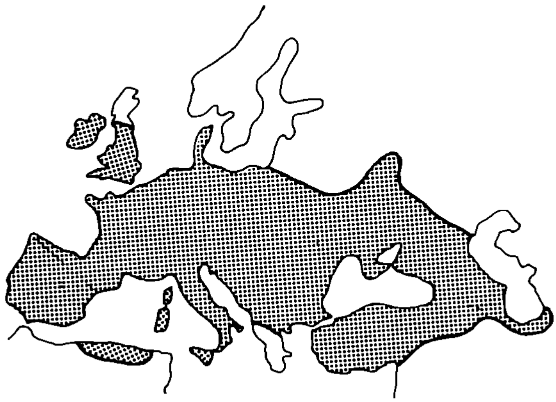


Figure 20.6 (a) Natural distribution of Field maple.

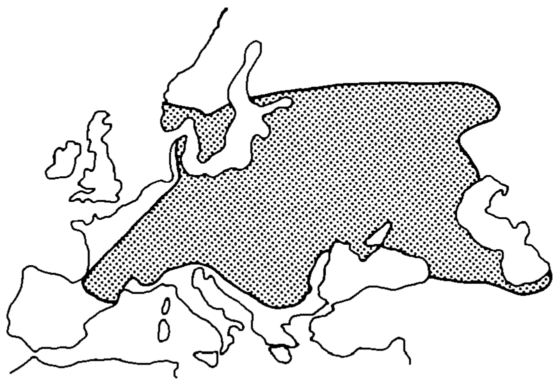


Figure 20.6 (b) Natural distribution of Norway maple.

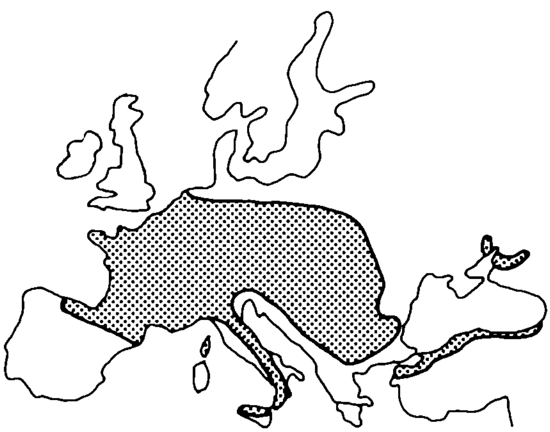


Figure 20.6 (c) Natural distribution of sycamore.

Field maple

The ecology of Field maple has been described by Jones (1944).

Field maple is largely confined to the southern half of Britain where it is often found at the margin of a wood, along boundary banks and occasionally in hedgerows. In mixed woodland it is frequently found in association with ash, hazel and oak.

The best development of Field maple occurs on heavy soils which are often calcareous at depth though not with free lime. At the surface optimum pH is about 6 but the species can be found growing on soils ranging in pH from 5.5–7.5. Field maple sets viable seed in most years though one rarely sees pure natural regeneration of Field maple seedlings. The seed often germinates in the second year after falling to the ground. Field maple coppices strongly and is a frequent component of mixed coppices in southern Britain. From time to time it has been included as a standard tree in coppice with standards.

Field maple grows with moderate vigour for the first 20–25 years in which time it reaches 10–15 m height. It very rarely exceeds 20 m in height and maturity is reached at about 50 years.

Field maple rarely makes timber size trees and its principal use is in turnery, marketry and craft work (in the Middle Ages it was much used for musical instruments). Field maple is a satisfactory firewood and pulpwood. Its timber is similar to that of sycamore although darker in colour.

Field maple is tolerant of clipping and is suitable for hedges and low screens. It is widely found on roadsides where its modest stature and autumn colours are used to best advantage. It is one of the best species for epiphytic lichens and bryophytes and is generally worth conserving in mixed woodland under the main canopy.

Norway maple

Norway maple is a tree of the mountains of central Europe, southern Scandinavia and eastern Europe (Figure 20.6b), but has been planted and become naturalized elsewhere. It grows on better soils throughout its range replacing sycamore in the north. Norway maple often grows by stream sides along with species such as Grey alder and ash but also with Silver fir and sycamore in the alps.

Although introduced into Britain over 300 years ago, Norway maple has not been planted extensively as a forest tree, though it is much used in streets, parks and gardens. Like sycamore it regenerates freely.

The soil preferences, tolerance of shade, and growth of Norway maple very closely resemble those of sycamore, namely moist, deep, free rooting soils of high base status. Norway maple is probably a little less demanding than sycamore regarding soil fertility and appears also to tolerate rather drier soils. On sheltered fertile sites it will often grow faster than sycamore, at least for the first 40–50 years. Norway maple is not as tolerant of exposure as sycamore.

Norway maple grows best on deep soils over chalk and limestone but tolerates shallow soils over these rocks and, like Italian alder, is a species meriting wider consideration for chalk downland planting.

Norway maple is frost hardy but less resistant than sycamore. The bark is highly attractive to squirrels which must be controlled as for beech plantations (page 173).

Norway maple grows rapidly for 30 or 40 years by which time it reaches 18–22 m height and achieves stem diameters of 30–40 cm. It is not as long-lived as sycamore and trees older than 100 years are rare.

In most respects the wood of Norway maple resembles that of sycamore though it is rather harder. Thinnings of Norway maple are suitable for turnery, but otherwise may be considered as a substitute for sycamore as a general purpose hardwood.

Sycamore

The sycamore is well known in Britain as a woodland tree and is much used for shelter and amenity plantings. Its timber, when the tree is properly grown, is one of the most valuable and is available in large dimensions. The date of introduction is uncertain but it was already well known by the 16th century in the north of England and Scotland. In most parts of the country the species is naturalized. Reviews of sycamore will be found in Bolton (1949), Jones (1944) and Stern (1982).

Sites and silviculture

Sycamore occurs throughout Britain from sea level to over 500 m. It stands exposure to wind and salt spray better than almost any other large broadleaved tree, and is a familiar component of upland shelterbelts (Figure 20.7) and planting around exposed farm buildings (Figure 10.4). It is a tolerant tree and has been one of the most successful species for use in densely populated industrial areas, particularly in northern Britain. Sycamore thrives on a wide range of soils except those which are very dry and infertile, and heavy clays with gleying near the surface. It grows best on deep well drained soils over chalk and limestone and acid brown earths in the pH range 5.5–7.5 and of at least moderate depth. It is a moderately exacting species, but less demanding

Figure 20.7 Sycamore in a shelterbelt in Britain's most northerly plantation at Kergord, Shetland Islands. (*A1020*)

than ash. It does not grow well on infertile sandy soils or those low in phosphate. It grows better than most species on calcareous soils with free lime to the surface, and on chalk rendzinas, being resistant to lime-induced chlorosis.

In youth, sycamore is a moderate shade bearer and is often associated with beech, ash and Wild cherry but requires full light after the sapling stage. It may be established as pure plantations but grows well in mixture with larches, Norway spruce, and other broadleaved species including beech. On chalk downland its growth is aided by nursing with alders (Wood and Nimmo, 1962) but in general it is not a broadleaved species which requires nursing.

Sycamore is a species easy to establish but because of its nitrogen and moisture requirements will not grow well in dense grass. Full weed control, as for all broadleaved species, considerably improves early growth – see Figure 3.6.

Sycamore responds well to frequent thinning. Thinning should aim to maintain a deep crown without over-exposing individual trees. If a site is sheltered, almost free growth conditions (page 160) may be applied to enhance stem diameter increment. Thinning should generally start by the time top height is 10 m; on fertile sites it may be begun even sooner. Thinning cycles should be kept short and generally never longer than about 6 years.

Growth and rotation length

Initial growth of sycamore is rapid compared with many broadleaved species and 10–12 m height in 25 years is commonplace. The average yield class of sycamore in Britain is 6 and is higher than other major broadleaved species (Table 2.2). Under conventional thinning regimes a mean diameter of 45 cm is achieved in 50–90 years depending on yield class. However, if heavier thinnings are adopted and free growth conditions maintained around the final crop trees at a stocking of about 150 stems/ha, this minimum diameter can be achieved on moderate to good sites in around 50 years (Stern, 1982). Sycamore is a longer lived tree than other maples and can attain large size in excess of 30 m height and 1.5 m in diameter.

Protection

Sycamore is moderately susceptible to frost damage. It is generally wind firm. Like other thin barked species it may be damaged by sun-scorch on the south side of an exposed trunk.

Sycamore, in common with other maples and beech, is susceptible to bark damage by Grey squirrels. The risk of such damage is frequently put forward as a reason for not planting sycamore but, with modern methods, squirrel numbers can be controlled and damage contained at an acceptable level: the comments in the chapter on beech equally apply (page 173).

There is no insect pest of economic importance.

Sycamore leaves are frequently affected by tar spot caused by the fungus *Rhytisma acerinum* and, although sometimes resulting in premature defoliation, its effects are rarely serious. In recent years sycamore has suffered outbreaks of Sooty bark disease caused by *Cryptostroma corticale*. This imperfect fungus causes wilting of leaves followed by dieback of affected branches. The branchwood is stained and affected trees die within a few years. The disease is mainly confined to warmer, southern parts of Britain and severe outbreaks are associated with hot summers.

Utilization

Sycamore has a fine even textured wood of nearly white or slightly yellowish brown colour. It is normally straight grained but occasional trees may exhibit wavy or curly grain giving the wood an attractive figure. Sycamore wood is moderately dense, diffuse porous and has strength properties resembling those of oak. The wood is hard but not naturally durable, though it takes preservative well.

Sycamore thinnings are readily marketable for pulpwood and firewood, and sometimes for turnery. Sawlogs command high prices and the timber is used for flooring and furniture. Outstanding butts may be marketable for veneer. The exceptional prices paid from time to time for trees with curly grain cannot be relied on and suitable trees are rare.

Special silvicultural considerations for sycamore

Concern is sometimes expressed about the place of sycamore in nature conservation. There are two reasons put forward:

1. that sycamore regeneration can be invasive replacing ash and swamping other species such as beech and oak; and
2. that sycamores support few insect species compared with most native broadleaves.

Sycamore undoubtedly regenerates freely and easily (Figure 20.8), and there are examples of where the species has spread in a wood, e.g. Bedford Purlieus (Peterken, 1981). Natural regeneration is of value to forestry and this ability of sycamore is an advantage except where the site is of special ecological interest.

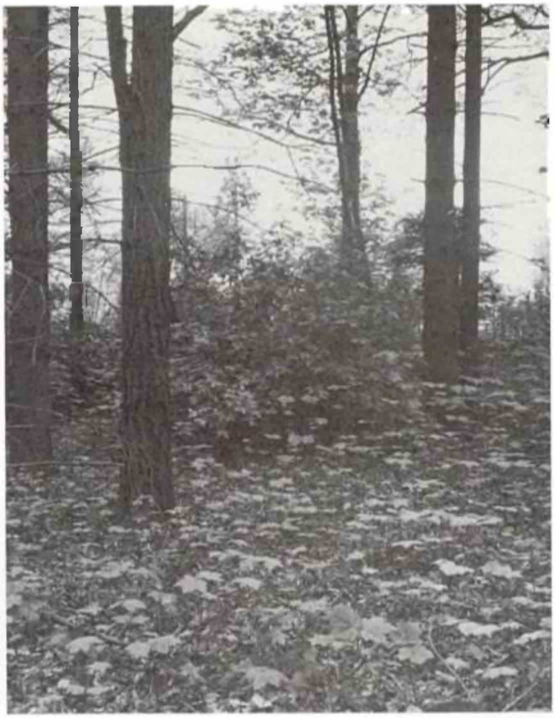


Figure 20.8 Natural regeneration of sycamore springing up at the edge of a mixed conifer plantation. (*B1384*)

The evidence that sycamore provides a poor habitat for insects derives largely from Southwood's (1961) work. He reported that the number of insect species found on sycamore was fewer than on most native broadleaves. However, as pointed out in Chapter 15, the total insect biomass on sycamore is often very high and sycamore, compared with other broadleaved species, has been relatively little investigated and there is little published information at present detailing its insect fauna. Sycamore flowers are rich in nectar and attract many insects, including bees, in May and June.

Jones (1944) gives comprehensive lists of vascular plants and bryophytes associated with sycamore stands and old sycamore trees often have a rich assemblage of epiphytic bryophytes including lichens. The poor reputation of sycamore appears, at least in part, to be due to an absence of published information on the subject. Nevertheless, although sycamore casts fairly heavy shade, if properly thinned the ground flora will be comparable to that under oak and ash, and considerably richer than that under most beech stands.

CHAPTER 21

Poplars and willows

These two large genera in the Salicaceae family include some of the most vigorously growing broadleaved species in British silviculture. Many aspects of the propagation and cultivation of poplars and willows are similar though these differ in many respects from most other broadleaved species.

POPLARS

There are several accounts of poplars and their cultivation (Jobling, 1960, 1963; Peace, 1952; FAO, 1980); these notes are largely based on a recent account by Jobling (1981).

There are about 30 species of poplar. They occur throughout the northern hemisphere in most cold and temperate zones between the subarctic and subtropical regions. Several species, in North America and Europe, have a very extended range and display considerable botanical variation.

The best known poplars in Britain are horticultural cultivars propagated clonally by vegetative means. Some are raised only for screening, shelter and ornament, while others are grown solely to

Figure 21.1 Poplar plantation managed for veneer quality, planted at wide spacing and high pruned. (*D4640*)

produce merchantable wood. A few cultivars are used both for timber production and for landscaping, as well as to protect horticultural and agricultural crops.

Planting has been influenced almost wholly by industrial demands for veneer quality wood. Drastic reductions in requirements by the chip basket and match trades since the late 1960s has led to a marked fall in planting rates during the past decade. The recent emergence of other markets suggest that poplar planting may still be an attractive silvicultural option.

There are about 12 000 ha of poplar plantations (Figure 21.1) which presently yield some 15 000 m^3/year. As the younger stands mature the yield will rise to 90 000 m^3/year in the 1990s (Campbell and Aaron, 1980).

Taxonomy

FAMILY: Salicaceae

GENUS: *Populus*

SPECIES: Two poplars are native: Aspen *P.tremula* L. and Black poplar *P.nigra* L.

Because of the importance of canker resistance only a few poplars are approved for planting and are mostly hybrid Black poplars, varieties of the N W American Black cottonwood *P.trichocarpa* Hook, or hybrids with this species as one of the parents.

Choice of cultivar

Poplars currently approved for grant-aid are as follows:

P. x *canescens*
P. x *euramericana* 'Eugenei'
P. x *euramericana* 'Gelrica'
P. x *euramericana* 'Heidemij'
P. x *euramericana* 'I–78'
P. x *euramericana* 'Robusta'
P. x *euramericana* 'Serotina'
P. tacamahaca x *trichocarpa* 32
P. trichocarpa 'Fritzi Pauley'
P. trichocarpa 'Scott Pauley'

Grey poplar *P.* x *canescens* is a hybrid between White poplar *P.alba* and European aspen *P.tremula*. A large number of hybrids varying in appearance and behaviour are known. A useful and fast-growing component of mixed woodland, Grey poplar is not easily propagated from hardwood cuttings but can be raised from softwood cuttings.

P. x *euramericana* is the name given to all natural and artificial hybrid cultivars derived from Eastern cottonwood *P.deltoides* and Black poplar *P.nigra*. Those listed above should be cultivated at wide spacing. None is suitable for growing in the cooler and wetter parts of Britain. Cultivation of *P.* 'I–78' should be limited to eastern and southern England. For convenience their nomenclature may be shortened to *P.* 'Eugenei', *P.* 'Robusta', etc.

P. tacamahaca x *trichocarpa* 32 is a fastigiate, narrow-crowned, artificially bred tree which can be grown at close spacing for pulpwood or at wide spacing for sawlogs or veneer logs. It is correctly *P. trichocarpa* x *balsamifera* but has been known, incorrectly, as 'TT 32' since its release. *P.* 'Balsam Spire' is an acceptable name awaiting taxonomic approval.

P. trichocarpa 'Fritzi Pauley' is a versatile, canker resistant and fast growing selection from Washington State. It is prone to wind damage – mainly stem snap in the upper crown – and, like most balsam poplars, it produces epicormics after heavy pruning. It has a very fine form and can be used in woodland.

P. trichocarpa 'Scott Pauley', also from Washington State, is slightly less vigorous than 'Fritzi Pauley' and is less resistant to bacterial canker than this cultivar, but it is not damaged by wind and is less prone to grow epicormics after pruning. It has a very fine form.

Sites and silviculture

The ideal site for poplars is a base rich loamy soil in a sheltered situation, with the water table 1 to 1.5 m below the surface in the summer. In practice the timber producing cultivars can be grown successfully on a wider variety of sites and on soil ranging from clays to sands, though on poor soils growth is slow, especially to begin with, and the trees may never reach large dimensions.

Unsuitable soils are those with a high water table, pH values of less than 5.0 and with a depth of 50 cm or less. Some balsam poplars, including *P. trichocarpa*, grow quite well in soils with a pH as low as 4.5 so long as other site factors are favourable. All upland sites and exposed lowland sites should be avoided. Cultivation in the north of England, Wales and Scotland should be limited to the most favourable localities.

Propagation

Cultivars grown for timber are raised from hardwood cuttings 20 to 25 cm long taken from fast-grown one-year-old shoots on stock plants or stools established for the purpose. Cuttings with a diameter of 10 to 20 mm are preferred.

The cuttings are inserted vertically into well cultivated soil so that the top cut end is level with the soil surface. Spacings of about 50 × 50 cm are commonly used except for the fastest growing cultivars which require a spacing of 50 × 100 cm.

In sheltered, fertile nurseries shoot growth from cuttings is normally vigorous and the stems of most plants attain a height in excess of 120 to 150 cm in the first season. Sturdy, well rooted one-year plants taller than 150 cm are usually considered suitable for planting out.

Supply of plants

Under Common Market regulations poplar cuttings and plants used for forestry purposes must be raised from officially approved reproductive sources recorded in the National Register of Basic Material. The conditions controlling the marketing of poplar stocks and of seed and plants of 14 forest tree species within the European Economic Community are explained in Statutory Instruments 1977 No. 891: *The Forest Reproductive Material Regulations 1977.*

During the past few years a National Register of some 50 approved poplar stools beds, of the nine cultivars planted for wood production, has been prepared. A list of these can be obtained from the Silviculture Branch, Forestry Commission Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey, GU10 4LH.

Planting

Rooted stocks are always pit planted. Holes 45 cm across are required to accommodate the roots of well grown, carefully lifted plants. The pits are also 45 cm deep. Deeper planting, to a depth of 80 to 100 cm, may improve the stability of trees later in life. On sites that remain wet for much of the planting season the roots may be placed in relatively shallow pits and covered with a mound of soil built around the base of the stem.

Tractor-driven soil augers are widely used to make planting holes. Problems only arise on heavy, wet clay soils, when the sides of the pit may become polished and inhibit lateral root extension, and on woodland sites where existing root systems are likely to affect the efficiency of the equipment. Soil augers with a diameter of 60 cm have been developed especially for poplar planting.

Planting may also be done with sets, that is usually 2-year unrooted shoots which are 2–3 m long. Pits are dug and the base of the set placed in a crow-bar hole in the bottom of the pit. Sets simply pushed into uncultivated soil develop roots slowly or not at all. Short sets, 25 cm long, establish well in ploughed ground.

Young poplars rarely need to be staked.

Weed control

The survival and growth rate of newly planted poplars are seriously reduced by weed competition. A dense grass sward in particular may prevent satisfactory establishment. All weeds around young poplar, to a diameter of at least 1 m, should be rigorously controlled.

Mulches have frequently been used to check weed growth after planting. The more common mulching method is to pile locally cut vegetation around the base of the tree for the first 2–3 years or to use straw or shredded bark especially brought onto the site. Thick, well-maintained mulches at least 15 cm deep and spread to a diameter of 120 cm are the most beneficial.

A second method is to place a sheet of an opaque, durable material such as black polythene around the tree immediately after planting. Old fertiliser bags or roofing felt can be used. The sheet material must be anchored securely.

Herbicides in common use in forestry to control grasses and herbaceous broadleaved weeds readily control ground flora encountered on poplar sites – refer to Figure 3.8 (page 38).

At the wide spacings normally adopted for poplar, agricultural and horticultural cultivators, including tractor drawn equipment, can be employed in plantations to till the soil to obtain weed-free conditions.

Spacing and thinning

Poplars dislike competition both above and below ground and only attain their fastest growth rates and largest dimensions when grown as isolated trees or in small groups or single tree rows. Cultivars in the Black hybrid group *P.* x *euramericana*, by far the most commonly planted poplars, are the most affected by competition. In block plantings their radial increment is likely to be seriously retarded long before canopy closure, and recovery is slow and uncertain if thinning is delayed.

Where the main object is the production of sawlogs and veneer logs, wide spacings are usually adopted at time of planting. The problem of finding remunerative markets for small-sized thinnings and the large differential between pulpwood and veneer log prices have further encouraged wide spacing. In Britain, as elsewhere, spacings have widened with increasing experience of poplar culture and wood marketing.

Since 1970 the maximum planting distance in plantations eligible for grant aid has been 8 × 8 m. At this spacing most trees in the stand may be expected to reach veneer log dimensions before the onset of competition, so obviating the need for a thinning. At spacings appreciably less than this a thinning will certainly be required some years in advance of final felling preferably well before general canopy closure to avoid reductions in rates of radial increment.

Production of veneer quality stems is dependent upon regular pruning at intervals of not more than 2 years. To minimize epicormic growth, pruning should never be excessive. A pruned height of 5 to 6 m can be achieved using pole saws, without recourse to special tools or climbing equipment.

Cultivation at close spacing can only be practised successfully if use is made of selected clones of the more shade tolerant *P. trichocarpa* or of hybrids with *P. trichocarpa* as one of the parents. Forms of this species and some related crosses are much more tolerant of competition than any *P.* x *euramericana* cultivar, and for several years after canopy closure high growth rates can be sustained, and large volumes of wood produced. Such crops are best worked on short rotations. It is uncertain whether thinning in close spaced crops, after some years of closed canopy, will promote rapid crown recovery of the final crop trees or whether veneer quality stems may be produced.

Protection

Climatic damage

Most poplars are hardy to frost damage.

Windthrow is rare but *P. trichocarpa* 'Scott Pauley' suffers much from windsnap even on relatively sheltered sites.

Diseases

Poplar leaf rusts *Melampsora* spp. cause considerable damage to poplars in Europe but in Britain, although their effects can be conspicuous in late summer causing premature defoliation, they appear to do little lasting harm.

Leaf spot diseases caused by species of *Marssonina* can lead to defoliation and loss of growth. So far in Britain it has not been of major importance although one or two locally serious outbreaks have been reported.

Much the most important disease affecting poplars is bacterial canker caused by *Xanthomonas populi*. Susceptible poplars may suffer dieback or even death. The principal control measure is to use canker resistant clones – see under 'Choice of cultivar'.

Poplar mosaic virus has been recorded in Britain and may reduce growth of nursery stock, but appears to have little effect on the growth of older trees.

Pests

There are no serious pests but the following occasionally cause damage:

DEFOLIATORS:

Poplar leaf beetles *Chrysomella populi*, *Phyllodecta* spp.
White Satin moth *Leucona salicis*.

WOOD BORERS:

Hornet moth *Sesia apiformis* occasionally causes basal damage by boring at root collar level; only observed in E. Anglian fens.
Leopard moth *Zeuzera pyrina*.

Growth and yield

In sheltered, fertile nurseries in the southern half of England, stems 1.5 to 2 m long are produced by most of the common cultivars in a single season from 25 cm cuttings. Some cultivars grow 2 to 3 m in one year.

Annual height increments over 3 m are not achieved in the field. Favourably located specimens of *P. trichocarpa* and *P. trichocarpa* x *maximowiczii* crosses achieve height increases of 2 m in the first season after planting, and can continue to grow at this rate until the end of the 12th season to reach 25 m or more, and many attain over 30 m in only 18 years from planting.

P. x *euramericana* cultivars are less vigorous and seldom grow more than 1.5 m in a season even during the first 10 years. The fastest trees reach 30 m in about 25 years.

On fertile sites with a stocking of 200–250 stems/ha, yields of 250 to 300 m^3/ha in 25 years (Yield Class 10–12) are achieved. At lower stockings of 150 to 200 stems/ha (trees 8 m and 7 m apart respectively) yields are 220 to 270 m^3/ha at 25 years (Yield Class 10). On sites of below average quality yields are 200 to 230 m^3/ha at 30 to 35 years (Yield Class 6–8).

When trees in the stand are high pruned to about 6 m, volume to pruned height (veneer quality wood) is more than 80 per cent of total volume. Fast grown trees begin to produce logs of veneer size at 12 to 15 years of age (the minimum top diameter specification for veneer logs is usually 25.4 cm, minimum length 3.05 m).

High yielding pulpwood crops (200–300 m^3/ha) on rotations 12 to 15 years, i.e. yield classes around 20, appear quite feasible (Stern, 1972), the highest yields being obtained with trees planted 2.2 to 4 m apart. Trials indicate that most balsam poplars coppice freely.

Utilization

Wood properties

The wood has a clean white appearance sometimes tinged with grey, brown or pink. It is free from taints, odours or colours hence its popularity for use with food. When subjected to abrasion it bruises rather than splinters, and it smoulders instead of igniting. The strength properties of the wood of the older *P.* x *euramericana* cultivars fall between those of European whitewood and British-grown spruce. Poplar wood superficially resembles coniferous timber and is sometimes regarded as a softwood substitute.

Poplar is not durable and the heartwood is resistant to penetration by preservatives.

Marketing

Thirty years ago about a dozen factories consumed poplar roundwood for rotary peeling into veneers for match and chip basket manufacture. Although some contraction of the industry was soon to occur, several match factories seemed to have long-term if not permanent prospects. Most of the industry's wood requirements had to be imported.

Thus much of the poplar planting in Britain has been undertaken until recently with the expectation that a lasting outlet existed for knot-free logs suitable for veneer. Unfortunately, the demand for poplar roundwood for matches and chip baskets declined in the 1960s, and by the mid-1970s rotary peeling of poplar was confined to one match splint factory which finally ceased splint production in 1978.

Since 1978 alternative markets have been actively sought of which the most promising is for production of vegetable crates (Campbell and Aaron, 1980). Other markets include plywood, as a softwood substitute in building, pallets and wagon flooring, sawn mining timber and industrial uses including wood wool, board products and pulp.

Use of poplar as a very short rotation energy crop is noted in Chapter 8.

WILLOWS

Willows have not been planted extensively like poplars for an industrial raw material, apart from about 2000 ha (nominal) of Cricket bat willow, mainly in E. Anglia (Figure 21.2). There are more species of willow than any other native tree and they occur throughout Great Britain.

Taxonomy and distribution

FAMILY: Salicaceae
GENUS: *Salix* L.
SPECIES: There are 19 native willow species of which five achieve tree size:

White willow *S.alba* L. occurs throughout Britain except NW Scotland, but is commonest in England. There are many varieties of White willow including the Cricket bat willow cv. 'Coerulea'.

Crack willow *S. fragilis* L. occurs throughout Britain as far north as Perthshire and is more common in south Scotland than White willow.

Sallow, Pussy or Goat willow *S. caprea* L. and Grey willow *S. cinerea* L. are large woody shrubs which occur throughout Britain. Sallow is found up to 840 m in Scotland and Grey willow up to 600 m.

Bay willow *S. pentandra* L. is native in north Wales and in the north of the Midlands and is much less common than other willows.

Selected clones of two shrub willows are used in osier growing, Almond-leaved willow *S. triandra* L. and Common osier *S. viminalis* L., details of which are given in Chapter 8 (page 83).

Sites and silviculture

All willows are associated with damp soil conditions, though sallow tolerates drier sites than other species, but the important tree species White willow and Crack willow principally occur beside streams and rivers. Both White and Crack willow have similar site requirements and are often found associated with Common alder, Downy birch, and other willow species.

Silvicultural information for the cultivation of Cricket bat willow can be found in Forestry Commission Bulletin 17 *The cultivation of the Cricket bat willow* (Anon., 1958) and is not specifically repeated here.

Willows grow best on deep alluvial loams or fertile boulder clays of high pH. Proximity to running water, either as a stream or as subsoil water, appears beneficial; waterlogged soil is unsuitable.

Planting stock is produced from unrooted 'sets' or rooted hardwood cuttings. For Cricket bat willow and other riverside plantings sets are usually very long, about 3 m, and inserted into the ground to a depth of about 60 cm. Sets are cut in the autumn or winter for planting in late winter.

Subsequent treatment is similar to that described for poplar except it is important for Cricket bat willow to be absolutely clean and free from knots. This is achieved by removing any branchlets from the original set and by carrying out disbudding in

Figure 21.2 Cricket bat willow in Essex. (*C3226*)

subsequent years on the lower bole. Buds that develop should be rubbed off each year.

Protection

Willows are generally frost hardy.

The bark of young willow is green, tender and sweet and is very attractive to browsing animals, especially horses. It is important to ensure full protection from browsing for any willow that is planted.

Diseases

Willows suffer several diseases of which the most important economically is watermark disease caused by *Erwinia salicis*. Watermark disease stains the wood and makes it more liable to splinter, thus rendering willows grown for cricket bats unsaleable for this purpose. The disease is controlled by ensuring that sets used are entirely free from infection, and by killing the stumps of diseased trees. For more information see Forestry Commission Leaflet 20 *Watermark disease of the Cricket bat willow* (Preece, 1977).

Several rusts of *Melampsora* spp. affect willows including osiers.

Anthracnose caused by *Marssonina salicicola* is widely observed damaging Weeping willow.

Canker and dieback can be caused by Black canker *Glomerella miyabeana*, Willow scab *Fusicladium saliciperdum*, and *Cryptodiaporthe salicina*.

Pests

Willows generally suffer from the same defoliators as poplars though, from time to time, the Large puss moth *Cerura vinula* is seen.

Two Poplar longhorn beetles damage willows: *Saperda populnea* causes twig galls and *S. carcharias* is a wood borer.

The giant willow aphid *Tuberolachnus viminalis* is especially prevalent on *Salix alba*.

Growth and yield

White willow and Crack willow are fast growing erect trees attaining heights of 20–25 m.

Other willow species are also very vigorous and various cultivars and hybrids of them appear capable of yielding up to 12 dry tonnes/ha/year when grown as an energy crop – see page 87.

Cricket bat willow planted at wide spacing (10–12 m apart) reaches utilizable size (greater than 35 cm dhb) in 12–18 years.

Utilization

Willow wood is diffuse porous with fine even texture. The sapwood is mainly white and heartwood pinkish. It is straight grained and relatively light in weight and the wood dries well. The heartwood is not durable and is resistant to uptake of preservative.

Apart from the specialized use of White willow for cricket bats and limited use for artificial limbs, willow is suitable for plywood, veneers for vegetable crates and chip baskets, board products and wood pulp. As a firewood it burns very rapidly.

Role in Britain

About 12 000–14 000 mature trees are felled each year for cricket bats.

There seems little prospect of planting willow for other forest products apart from its possible use as an energy crop. However, willows are easy to raise and establish and are useful for screening or single row windbreaks in the lowlands.

In the past many riverside willows were regularly pollarded but this practice has gradually declined – see page 84.

CHAPTER 22

Other broadleaved species

Other species not in previous chapters are included here in alphabetical order of common names. For many species the summary in Table 3.1 or reference elsewhere, such as in Chapter 11 on growing decorative quality hardwoods, obviate the need for further amplification and comments are confined to notes on taxonomy, distribution and possible forest importance. Other species are of very minor significance and receive the briefest of mentions, a few merit fuller consideration such as the Southern beeches and Sweet chestnut.

BOX

FAMILY: Buxaceae

GENUS: *Buxus*

SPECIES: *Buxus sempervirens* L.

A small tree native on chalk and limestone in southern Britain. Slow growing but producing a fine even-textured, creamy white timber much valued in turnery and craft work (Johnston, 1983). If present in a stand, usually well worth retaining.

CHERRIES

FAMILY: Rosaceae

GENUS: *Prunus*

SPECIES: There are two native cherries: Wild cherry or Gean *Prunus avium* L. and Bird cherry *Prunus padus* L.

The distribution of Wild cherry is shown in Figure 22.1. Refer to Table 3.1 and particularly Chapter 11 (page 114) for details of silviculture and ultilization.

ELMS

FAMILY: Ulmaceae

GENUS: *Ulmus*

SPECIES: Only one elm is probably truly native: the Wych elm *U.glabra* Hudson.

Several elms were introduced in pre-Roman times including English elm *U.procera* Salisbury and Smooth-leaved elm *U.carpinifolia* Gleditsch which has two varieties: Cornish elm var. *cornubiensis* and Wheatley elm var. *sarniensis*. Two other elms which have been widely cultivated, the Huntingdon and Dutch elms, are assumed to have arisen from crosses between Wych elm and Smooth-leaved elm: Dutch elm *U.* x *hollandica* Miller var. *hollandica* and Huntingdon elm *U.* x *hollandica* Miller var. *vegeta* Loudon.

Elms are a common tree species in Britain though only English elm and Wych elm tend to occur in woodlands. Other types of elm occur or are planted in hedgerows, roadside spinneys, etc.

Optimum site conditions for elms are noted in Table 3.1 but very little planting of elms has occurred during the last 50 years because of the prevalence of Dutch elm disease. It is an aggressive strain of this disease which has led to the loss of the

Figure 22.1 Natural distribution of Wild cherry.

great bulk of the mature elm population in Britain since the late 1960s (see below). Elm wood is dull brown in colour, cross grained and coarse textured, and has long been used for coffin boards and more recently in solid wood furniture. Elm has also been used in the construction of walls and other sea defences, and important minor uses including weather-boarding, cattle grids, etc. It is also used for general turnery work. Wych elm appears prone to shake and Dutch elm to butt rot.

Dutch elm disease

Dutch elm disease is caused by a fungus *Ceratocystis ulmi* which blocks a tree's conductive tissue causing crown dieback and rapid death. Fungal spores of the disease are spread by elm bark beetles (*Scolytus scolytus, S. multistriatus* and *S.laevis*) in their maturation feeding activity on elm twigs in May. The beetles breed beneath dead elm bark. Full accounts of this disease can be found in Forestry Commission Bulletin 60 *Research on Dutch elm disease in Europe* (ed. Burdekin, 1983).

Much work has been carried out in North America, Holland and Britain to produce disease resistant varieties of elm.

There is some evidence that a virus-like agent is present which causes a reduction in growth and sporulation of *Ceratocystis ulmi*. Also the fungus *Phomopsis oblonga*, particularly in northern and western Britain, is rendering the bark of many elm trees inhospitable for beetle breeding.

Though, and very regrettably, a large proportion of mature elms have been killed by this disease, many of the rootstocks, especially in hedges, remain alive and sprout new shoots. These shoots are relatively unaffected by the disease for 10 to 15 years. By that time the bark on the stems may be thick enough to support breeding populations of elm bark beetles and the disease may then return.

EUCALYPTS

FAMILY: Myrtaceae

GENUS: *Eucalyptus*

SPECIES: The eucalypts are a very large genus comprising more than 500 species, almost all of which are native to Australia. Many species have been introduced into Britain since the 1840s but only about 30 have survived more than one or two winters. Of these, fewer than five species have proved to be sufficiently hardy to grow to large size away from favoured mild localities. Many species are currently of research interest, particularly identification of any very cold-hardy provenances, but most interest concerns seed origins of Cider gum *E. gunnii* Hook f. from central Tasmania and the Snow gums *E.debeuzevillei* Maiden and *E.niphophila* Maiden et Blakely from the mountains and high tablelands of south-eastern Australia.

Several other species are hardy enough to grow well in Britain for many years and these are listed in Forestry Commission Booklet 50 *A key to eucalypts in Britain and Ireland* (Brooker and Evans, 1983).

Silviculture

In Britain eucalypts are observed to grow very vigorously on a wide range of sites. No distinction is yet possible for site preferences of different eucalypt species, but Cider gum appears to grow well on clays, including calcareous soils, as well as on more acid soils including peats which are the principal soil type of its natural habitat in central Tasmania. Cider gum will not tolerate high exposure and on clayey soils may rock in the wind when young, leading to socketing around the root collar.

Eucalypts, especially Cider gum, are readily browsed and must be protected when young. Most eucalypt species in Britain are killed by extreme cold in winter rather than unseasonal frosts. Seed origins of Cider gums and Snow gums currently being used can tolerate minimum temperatures down to at least −16°C.

Fuller details of the propagation and planting of eucalypts in Britain will be found in Evans *et al.*, 1983.

Potential use in Britain

Eucalypts in Britain are amongst the fastest growing trees (Evans, 1980) and have the potential to produce very high yields (Yield Class 15–25) on short rotations (10–15 years). This, combined with their ability to grow on a wide range of sites of varying fertility, indicates some potential as an alternative high yielding broadleaf. The wood of Cider gum is not sawn commercially in Australia and its properties of crossed grain and drying cracks rule out this use. However, along with many eucalypt species in the *Globulinae* group, it is suitable for pulpwood and, of course, firewood. The Snow gums are in the ash group of eucalypts and are likely to produce wood of higher quality of some saw timber potential. Their growth is generally slower than that of Cider gum and they probably require more fertile sites, though they are more tolerant of exposure.

FALSE ACACIA

FAMILY: Leguminosae

GENUS: *Robinia*

SPECIES: *Robinia pseudoacacia* L.

From time to time the planting of this nitrogen-fixing species has been advocated but has not found wide acceptance owing to poor form and preferential browsing by many mammals, especially hares and rabbits. Further details of its cultivation are in Chapter 11, page 115.

HAZEL

FAMILY: Betulaceae

GENUS: *Corylus*

SPECIES: Common hazel *C. avellana* L.

A very widely occurring underwood species and component of hedgerows. Hazel is considered in the chapters on coppice, especially Chapter 8.

Turkish hazel *C.colurna* L. grows to much larger size than Common hazel and, on very limited evidence, appears to be fast growing. The species has not been tried in forest conditions.

HOLLY

FAMILY: Aquifoliaceae

GENUS: *Ilex*

SPECIES: Holly *I. aquifolium* L.

Holly is a very common understorey species in beech and oak woods and is native throughout Britain except in north Scotland. Trees occasionally reach large size (more than 15 m) but are generally slow growing and of poor form.

Holly wood is pale greyish white with a very fine even texture and somewhat irregular grain. It is a good carving and turnery wood.

HORNBEAM

FAMILY: Betulaceae

GENUS: *Carpinus*

SPECIES: Hornbeam *C.betulus* L.

Hornbeam is native to south-east England and parts of Somerset and Monmouth. It is common as a hedgerow tree in south-east England and there are pure woods of hornbeam in Hertfordshire and Essex. It is a frequent component of underwood and there is a considerable area of hornbeam coppice – see Table 7.2.

Hornbeam is a strongly shade-bearing species and casts a dense shade. It grows well on damp clays and thrives on both acid brown earths and soils derived from chalk and limestone.

Hornbeam is very frost hardy and will survive in frost hollows where many other broadleaves succumb. Also it is not often damaged by grey squirrels.

Hornbeam is generally slow growing, but on fertile soils will achieve 20 m in height.

Hornbeam wood is dense, very hard and heavy and is as strong as beech. It dries well and fairly rapidly and clear timber is good for bending and turning. Because of its hardness and toughness it has several specialist uses in the action of keyboard instruments, for turnery, carving, mallet heads and pegs. It is sometimes used for flooring (Johnston, 1983).

Hornbeam is excellent for firewood and charcoal.

Hornbeam is unlikely to be planted. Its principal value is as a component of coppices worked for firewood.

HORSE CHESTNUT

FAMILY: Hippocastanaceae

GENUS: *Aesculus*

SPECIES: Horse chestnut *A.hippocastanum* L.

This very common parkland and garden tree has very little forest potential though it is a useful quick-growing tree in mixed broadleaved woods where it shades out thorn and throws a rich, heavy litter.

Horse chestnut timber is white and not very strong. It is occasionally used for shelving for apples and pears.

LABURNUM

FAMILY: Leguminosae

GENUS: *Laburnum*

SPECIES: Common laburnum *L.anagyroides* Med.

This small tree produces a valuable timber; it is considered in Chapter 11 (see page 115).

LIMES

FAMILY: Acetiliaceae

GENUS: *Tilia*

SPECIES: Both Large-leaved lime *T.platyphyllos* Scop. and Small-leaved lime *T.cordata* Mill. are native (Figure 22.2a and b). Common lime *Tilia* x *europea* L. is a hybrid between Large-leaved and

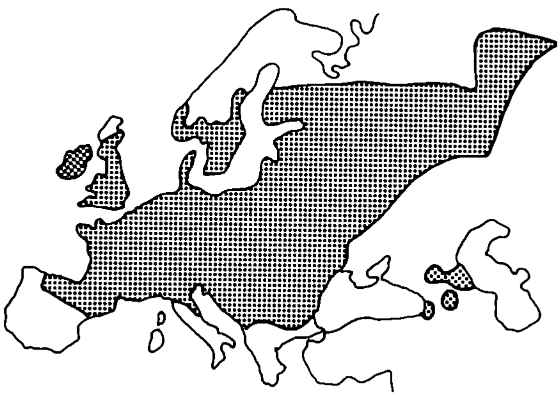


Figure 22.2 (a) Natural distribution of Small-leaved lime.

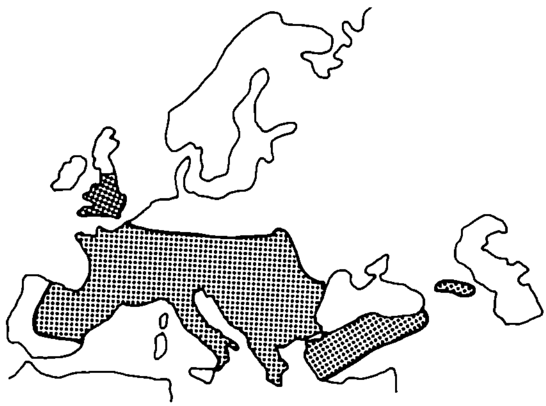


Figure 22.2 (b) Natural distribution of Large-leaved lime.

Small-leaved lime which occurred naturally and was probably introduced into Britain long ago, though it may be native. Most limes in streets and avenues are this Common lime and it is the tallest broadleaved tree in most areas of Great Britain.

Small-leaved lime

Small-leaved lime is native to England and Wales where it sometimes grows in small pure stands but mainly occurs in mixed woodland with ash, hawthorn, Field maple, birch, oaks, Wild cherry and Wych elm. It also occurs with Large-leaved lime in Derbyshire and the Wye Valley.

Small-leaved lime is moderately tolerant of shade and itself casts a heavy shade. It occurs naturally on silty gleys and soils derived from chalk and limestone but succeeds wherever there is good drainage.

Production of viable seed is dependent on warm summers. Small-leaved lime can be propagated from cuttings. The species coppices strongly and is a common component of mixed coppices as well as a few pure coppices – see Table 7.2 and Figures 6.2 and 7.4.

Small-leaved lime grows vigorously as a young tree. The tree commonly reaches a height of 25–30 m with stem diameters of 30–45 cm, in a rotation of 50–70 years.

Small-leaved lime is frost hardy and generally resistant to windthrow. The species appears little damaged by grey squirrels though young seedlings are preferentially browsed by deer.

The wood of Small-leaved lime is diffuse porous, mainly white or yellow in colour. It has a fine texture and uniform grain and is of medium density. It is a useful general purpose hardwood but also finds a market for turnery and, because of ease of working, is favoured for wood carving and model making.

The species is a valued component of mixed broadleaved woodland and is a useful tree in lowland shelterbelts.

Large-leaved lime

There is now clear evidence that Large-leaved lime is native; it occurs naturally on limestone soils in the Wye Valley, Derbyshire and South Yorkshire. Large-leaved lime is rarer than Small-leaved lime and where the species occur together they hybridize.

The silviculture of Large-leaved lime is similar to that for Small-leaved lime.

PLANES

FAMILY: Platanaceae

GENUS: *Platanus*

SPECIES: There are no native plane trees in Britain but London plane *Platanus* x *hispanica* Muenchh. is a common tree which has been much planted in the past because of its reputation for tolerance of smoke pollution. It is a hybrid between oriental plane *P.orientalis* and the American plane *P.occidentalis*. The oriental plane was a fairly early introduction into Britain but has not been considered for forestry use.

There are a number of trial forest plots of London plane but in plantation it does not appear to exhibit the vigour associated with open-grown trees in parkland or streets. London plane produces an attractive wood of medium density which has a decorative lace-like figure when cut radially, and is sometimes used for veneer or inlay work, turnery and carving.

The species possibly merits further trial in forest plantings, but clearly its main value will be as an urban tree in places where there is adequate space to accommodate its very large mature stature.

ROWAN

FAMILY: Rosaceae

GENUS: *Sorbus*

SPECIES: Rowan or Mountain ash *S.aucuparia* L., is native in all parts of Britain though is less common in East Anglia. It is a notable feature of the landscape in Wester Ross and Sutherland.

Rowan is found at higher altitudes than almost any other broadleaved species and reaches nearly 1000 m altitude in Scotland.

Rowan is a light demanding pioneer which cannot tolerate shade, though it sometimes forms an understorey in old Scots pine woods.

Rowan grows best on light textured brown earths and more fertile peat but does not tolerate waterlogged conditions.

The species fruits regularly. Seed is widely dispersed by birds and natural regeneration is common. It coppices strongly. Young rowan trees grow fairly quickly but the species rarely exceeds 15 m in height.

Rowan is exceptionally hardy and can withstand droughts. It is very tolerant of wind and makes a useful component of upland shelterbelts. It is readily browsed by deer.

Although rowan has a dense hard timber which is good for turnery and carving and makes a good firewood, it is unlikely ever to become a timber tree. Its principal use is as one of the few broadleaves suitable for planting in the uplands both for shelter and for amenity.

For other species of *Sorbus* see Whitebeams.

SOUTHERN BEECH

FAMILY: Fagaceae

GENUS: *Nothofagus*

SPECIES: There are some 40 species of Southern beech all of which occur naturally only in the southern hemisphere. Two species are of considerable forest potential in Britain: *N.obliqua* (Mirbel) Blume and *N. procera* (Poepp & Endl.) Oerst. Several other Southern beeches are of research interest, notably *N. dombeyi*, *N. antarctica* and *N. pumilio*. A recent account of Southern beeches in Britain will be found in Forestry Commission Forest Record 122 *Nothofagus in Britain* (Tuley, 1980).

Natural distribution

Figure 22.3 shows the distribution of the South American species of *Nothofagus*. Almost all occur in Chile though *N. antarctica*, *N. obliqua* and *N. procera* all occur on the western edge of Argentina.

Sites and silviculture

The two Southern beeches *N. obliqua* and *N. procera* have been planted extensively in trials throughout Britain, mainly since the 1950s. From these trials it appears that *N. procera* is the better choice for the milder more maritime conditions of western Britain and that *N. obliqua* is able to survive drier conditions, though it has not succeeded well in East Anglia. Soil preferences for Southern beeches are unclear but both species have grown well on soils ranging from deep sands to fairly heavy clays. There is some evidence that they do not thrive on shallow soils over chalk or on acid peats. Southern beeches do not stand exposure well and are generally unsuitable for planting above 300 m altitude unless the site is well sheltered. In general, many sites considered only marginal for oak and certainly not good enough for ash will often support a moderately vigorous crop of Southern beech.

Establishment of Southern beech does not differ significantly from other broadleaves. Like beech, Southern beeches show good natural pruning.

Both Southern beeches set fertile seed and have produced natural regeneration under stands in Britain. Both species coppice vigorously.

Protection

Southern beeches are not specially susceptible to unseasonable frosts but are damaged by severe cold in winter. This damage is, at the present time, the principal reason why they are not planted more extensively in Britain. Variation in tolerance to winter cold is being investigated in relation to provenance (see Figure 4.1) and there is good reason to suppose that some seed origins of both Southern beeches will be able to survive all but the most severe of winters in Britain. Where Southern beeches are planted frost hollows should be avoided and middle lower slope positions selected.

Damage to Southern beeches from winter cold is not always expressed in the year in which the extreme temperatures occur. Damage takes two forms.

1. Death of buds and shoots in the crown – these fail to break in late spring.
2. Death of bark – usually occurring in patches which subsequently flake off or appear as splits and lesions on the stem (Figure 4.2).

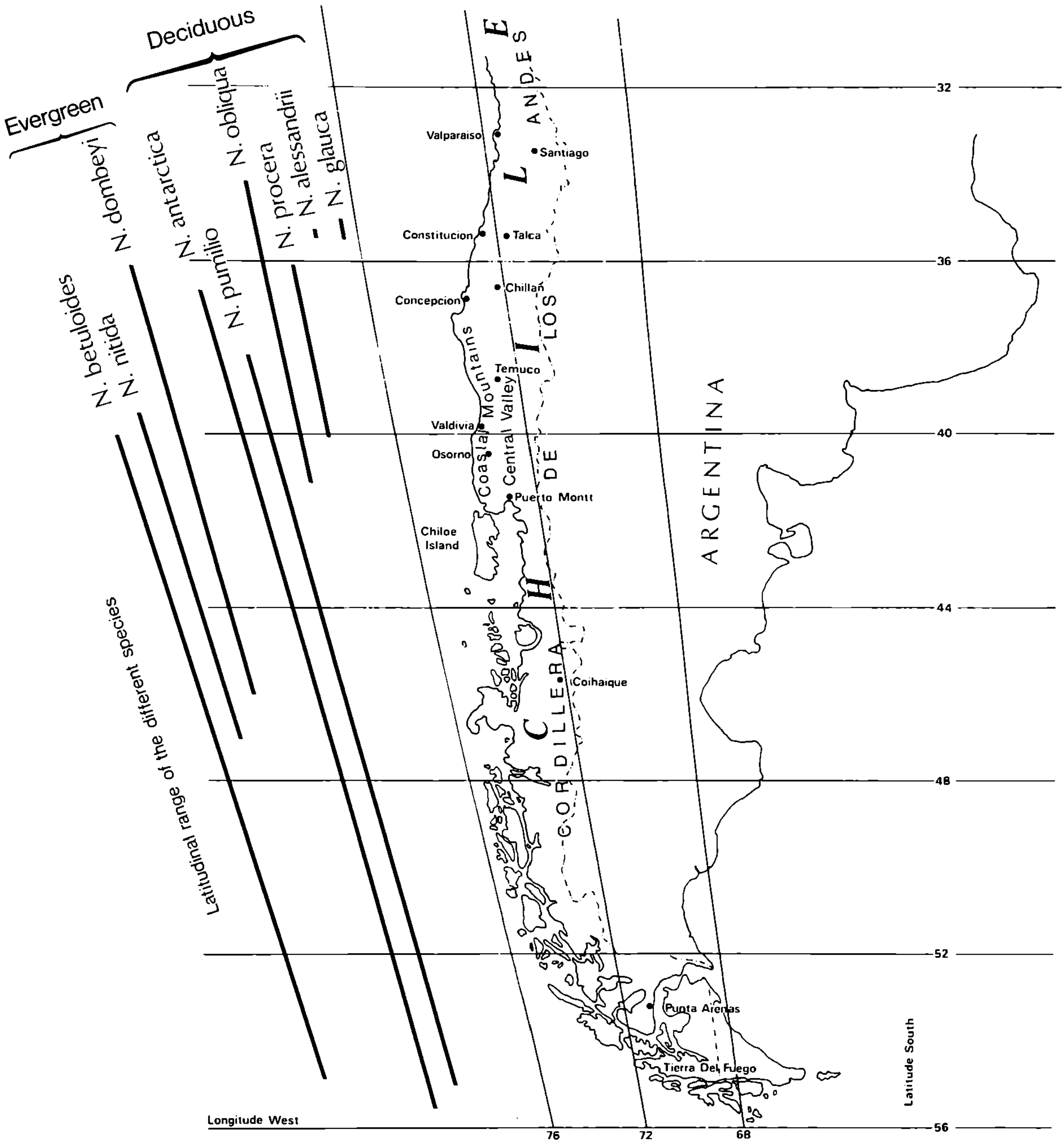


Figure 22.3 Latitudinal range of Southern beeches native to southern South America (from Tuley, 1980).

Damage to bark frequently does not appear until a year or two after the extreme cold.

Squirrel damage of Southern beeches appears infrequent though it has been observed to occur.

Growth and yield

Southern beeches are amongst the fastest growing broadleaved species in Britain (Figure 1.1). On most sites they will substantially outperform native broadleaves. Yield classes as high as 20 have been recorded and nearly all stands fall in the range of 10 to 18 (Christie *et al.*, 1974). However, not only are high yield classes achieved but the age of maximum mean annual increment occurs relatively early, between 27 years and 45 years of age.

Southern beeches have the capacity to grow large sized timber on rotations of 40–50 years (Figure 22.4).

Utilization

The wood of both Southern beech species is moderately dense and fairly strong and is used in Chile for furniture, cabinet work, veneers, flooring, interior and exterior finishes, etc.

Figure 22.4 Well grown Southern beech (*Nothofagus procera*) in Exeter Forest, age 48 years. (*A10620*)

Tests on timber produced from Southern beech plantations in Britain reveal the wood to be generally inferior to Common beech but, nevertheless satisfactory as a general purpose hardwood. It is also suitable for turnery and wood pulp. One defect which has arisen is end splitting of planks as they dry out after sawing. This appears similar to fractures resulting from growth stresses commonly observed in fast-growing eucalypts. The problem is not insuperable but Southern beeches may require a modified form of conversion.

Ecology and conservation

Because of the considerable promise Southern beeches afford as potential forest tree species in Britain, attention has been given to their conservation value. Studies investigating the flora associated with stands of both *N. obliqua* and *N. procera* in southern England have shown remarkable similarities to that under native oak woodland (Wigston, 1980). Also it has become apparent that both Southern beeches have acquired an extensive and varied insect fauna since their introduction into Britain (Welch, 1980).

Although Southern beeches are exotic species the above evidence does suggest that plantations of the species can be rich habitats leading to more diverse wildlife than frequently found, for example, in native beech woodland.

Potential

Southern beeches are amongst the most promising broadleaved species for more extensive use in Britain. Research into cold hardiness variation within provenances offers the prospect that this one disadvantage can be greatly reduced in importance.

SWEET CHESTNUT

FAMILY: Fagaceae

GENUS: *Castanea*

SPECIES: Sweet or Spanish chestnut *C. sativa* Mill.

Sweet chestnut was probably introduced by the Romans and is now abundant on the lighter soils of southern and eastern England. Figure 22.5 shows the natural distribution of Sweet chestnut. The species is naturalized in southern Britain and Rackham (1980) regards it as an 'honorary native' on the grounds that it is a historic member of our flora and enters into the natural vegetation.

Figure 22.5 (left) Natural distribution of Sweet chestnut.

Sweet chestnut is the most important commercial coppice crop presently worked and details of its silviculture have been described in Chapter 7. However, Sweet chestnut timber is a valued wood commanding high prices when free of defect. Thus the species is a desirable component of mixed broadleaved woodland and merits consideration for planting on acid soils ranging from clay with flints through to deep sands.

Although Sweet chestnut is a long-lived tree it is generally grown for timber on rotations of 50–70 years. The wood closely resembles oak in colour and texture but lacks oak's broad rays. Usually the timber is straight grained (Figure 22.6), but that from old trees is apt to contain shakes and have spiral grain. Sweet chestnut suffers from ring and star shakes (see Figures 17.5a and b) especially the former. Shake mostly occurs in older trees (over 80 years) growing on light soils liable to dry out. The problem of shake is an important limitation to growing Sweet chestnut for timber in eastern Britain. It is rare for all trees in a stand to be affected

Figure 22.6 (below)
Fine stem of mature Sweet chestnut. (*B8671*)

but the problem is difficult to predict. It is not a problem with coppice.

Sweet chestnut fruits in most years and after warm summers the nuts develop well and are edible. They also provide food for many sporting animals.

THORNS

FAMILY: Rosaceae

GENUS: *Crataegus*

SPECIES: There are two native thorns: hawthorn *C. monogyna* Jacq. and Midland thorn *C. oxyacanthoides* Thuillier.

Hawthorn is abundant throughout Britain up to elevations of 500 m while Midland thorn is largely confined to heavy soils in southern England. Hawthorn is of very little economic value in forestry though, of course, it is a frequent component of hedges. Hawthorn is often found in poor quality woodland and at the edge of a wood. Owing to its thorns it is moderately resistant to browsing and it is frequently observed that natural regeneration of other broadleaved species, particularly oak, can become established in a thicket of hawthorn where outside its protection the regeneration is browsed off and killed.

WALNUTS

FAMILY: Juglandaceae

GENUS: *Juglans*

SPECIES: Two walnut species have been cultivated in Britain: Common walnut *J. regia* L. and Black or American walnut *J. nigra* L., but neither is native – see Figures 22.7 a and b.

The silviculture of these prized timber species is described in Chapter 11 (see page 111).

WHITEBEAMS AND WILD SERVICE TREE

FAMILY: Rosaceae

GENUS: *Sorbus*

SPECIES: Whitebeam *S. aria* (L.) Crantz, Swedish whitebeam *S. intermedia* (Ehrh.) Pers. and Wild service tree *S. torminalis* (L.) Crantz. The Whitebeam and Wild service tree are native to Britain though mostly restricted to the south. The Swedish whitebeam was introduced long ago and is frequent in towns and parks.

Whitebeam grows naturally in association with ash, beech, Field maple, hawthorn and Wych elm, and Wild service tree may also be found with rowan, cherry and oaks. Both species are light demanding pioneers though Wild service tree can endure some shade. Whitebeam is an early colonizer in scrub on chalk but often survives the transition to woodland to form an occasional upper canopy tree.

Whitebeam occurs mostly on soils derived from chalk and limestone. Wild service tree is frequently found on clays.

Both species fruit and coppice strongly. Wild service tree also suckers freely.

Neither species is of importance as a timber producer though both are attractive additions to mixed broadleaved woodland. The presence of the Wild service tree is a useful indicator of an ancient woodland site.

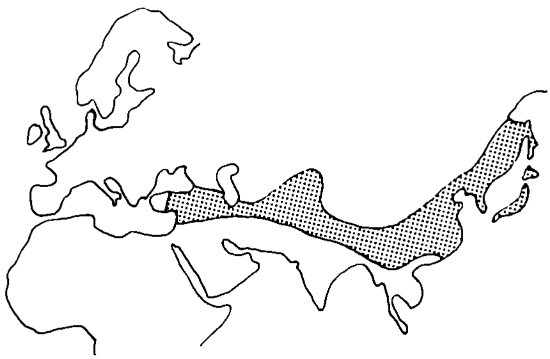


Figure 22.7 (a) Natural distribution of Common walnut.

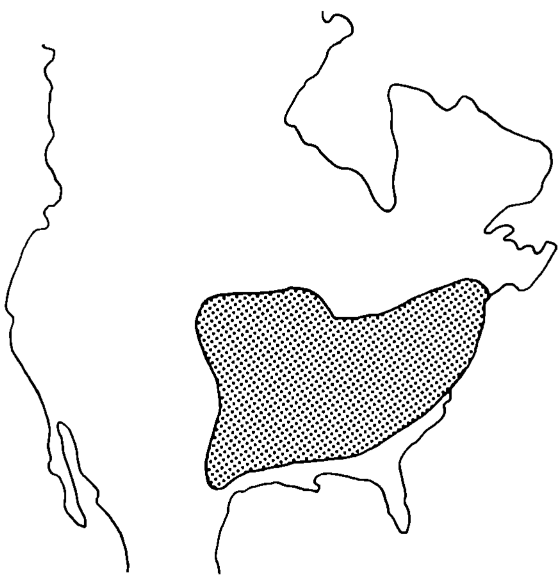


Figure 22.7 (b) Natural distribution of Black Walnut.

Glossary

Scientific names and authorities of English names used in text

ALDER	
Common	*Alnus glutinosa* (L.) Gaertn.
Grey	*Alnus incana* (L) Moench.
Italian	*Alnus cordata* Desf.
Red	*Alnus rubra* Bong.
ASH	*Fraxinus excelsior* L.
ASPEN	*Populus tremula* L.
BEECH	
Common	*Fagus sylvatica* L.
BIRCH	
Downy	*Betula pubescens* Ehrh.
Silver	*Betula pendula* Roth.
CHERRY	
Bird	*Prunus padus* L.
Wild (Gean)	*Prunus avium* L.
ELM	
Commelin	*Ulmus* x *hollandica* Mill. 'Commelin'
Cornish	*Ulmus carpinifolia* Gleditsch. var. *cornubiensis* (Weston) Rehd.
Dutch	*Ulmus* x *hollandica* Mill.
English	*Ulmus procera* Salis.
Huntingdon	*Ulmus* x *hollandica* Mill. 'Vegeta'
Smooth-leaved	*Ulmus carpinifolia* Gleditsch.
Wheatley	*Ulmus carpinifolia* Gleditsch. var. *sarniensis* (Loud.) Rehd.
Wych	*Ulmus glabra* Huds.
EUCALYPTS	*Eucalyptus*
FALSE ACACIA	*Robinia pseudoacacia* L.
HAWTHORN	*Crataegus monogyna* Jacq.
HAZEL	
Common	*Corylus avellana* L.
HOLLY	*Ilex aquifolium* L.
HORNBEAM	*Carpinus betulus* L.
HORSE CHESTNUT	*Aesculus hippocastanum* L.
LABURNUM	*Laburnum anagyroides* Med.
LIME	
Common	*Tilia* x *europaea* L.
Large-leaved	*Tilia platyphyllos* Scop.
Small-leaved	*Tilia cordata* Mill.
MAPLE	
Field	*Acer campestre* L.
Norway	*Acer platanoides* L.
Red	*Acer rubrum* L.
Silver	*Acer saccharinum* L.
Sugar	*Acer saccharum* Marsh.
OAK	
Cork	*Quercus suber* L.
Holm	*Quercus ilex* L.
Hungarian	*Quercus frainetto* Ten.
Pedunculate	*Quercus robur* L.
Pin	*Quercus palustris* Muenchh.
Red	*Quercus rubra* du Roi
Scarlet	*Quercus coccinea* Muenchh.
Sessile	*Quercus petraea* (Mattuschka)
Turkey	*Quercus cerris* L.
PLANE	
London	*Platanus* x *hispanica* Muenchh.
Oriental	*Platanus orientalis* L.

POPLAR
- 'Balsam Spire' — *P. trichocarpa* x *balsamifera*
- Black — *Populus nigra* L.
- Black Cottonwood — *Populus trichocarpa* Hook
- Grey — *Populus canescens* (Ait.) Sm.
- Lombardy — *Populus nigra* L. 'Italica'
- 'Robusta' — *Populus* x *euramericana* (Dode) Guinier 'Robusta'
- 'Serotina' — *Populus* x *euramericana* (Dode) Guinier 'Serotina'
- White — *Populus alba* L.

ROWAN — *Sorbus aucuparia* L.

SOUTHERN BEECH
- Roble — *Nothofagus obliqua* (Mirb.) Bl.
- Raoul — *Nothofagus procera* (Poepp. & Endl.) Oerst.

SWEET CHESTNUT — *Castanea sativa* Mill.

SYCAMORE — *Acer pseudoplatanus* L.

TULIP TREE — *Liriodendron tulipifera* L.

WALNUT
- Black — *Juglans nigra* L.
- Common — *Juglans regia* L.

WHITEBEAM — *Sorbus aria* (L.) Crantz
- Swedish — *Sorbus intermedia* (Ehrh.) Pers.

WILD PEAR — *Pyrus communis* L.

WILD SERVICE TREE — *Sorbus torminalis* (L.) Crantz

WILLOW
- Bay — *Salix pentandra* L.
- Crack — *Salix fragilis* L.
- Cricket bat — *Salix alba* 'Coerulea'
- Sallow — *Salix caprea* L.
- White — *Salix alba* L.

WING-NUT
- Caucasian — *Pterocarya fraxinifolia* (Lamb) Spech.
- Hybrid — *Pterocarya* x *rehderana* Schneid.

References

ALDOUS, J. R. (1981). Beech in Wessex – a perspective on present health and silviculture. *Forestry* **54** (2), 197–210.

ALLABY, M. (1983). *The changing uplands.* Countryside Commission CCP 153.

ANDERSON, M. A. (1979). The development of plant habitats under exotic crops. In, *Ecology and design in amenity land management*, eds. Wright, S. E. and Buckley G. P., Wye College, University of London.

ANDERSON, M. A. (1983). *The effects of tree species on vegetation and nutrient supply in lowland Britain.* Arboriculture Research Note 44/83/SSS. DOE Arboricultural and Information Service, Forestry Commission.

ANDERSON, M. L. (1950). *The selection of tree species* – an ecological basis of site classification for conditions found in Great Britain and Ireland. Oliver and Boyd, Edinburgh.

ANON. (1956). *Utilisation of hazel coppice.* Forestry Commission Bulletin 27. HMSO, London.

ANON. (1971). *A plan for the Chilterns.* Chilterns Standing Conference. (78pp.).

ARNOLD, G. W. (1983). The influence of ditch and hedgerow structure, length of hedgerows, and area of woodland and garden on bird numbers on farmland. *Journal of Applied Ecology* **20**, 731–750.

BEGLEY, C. D. (1955). *Growth and yield of Sweet chestnut coppice.* Forestry Commission Forest Record 30. HMSO, London.

BEGLEY, C. D. and COATES, A. E. (1961). Estimating yield of hardwood coppice for pulpwood growing. *Forestry Commission Report on Forest Research 1959/60*, 189–196. HMSO, London.

BINNS, W. O. and CROWTHER, R. E. (1983). Land reclamation for trees and woods. Conference Proceedings, *Reclamation 83*, 23–28. Industrial Seminar Ltd.

BINNS, W. O. and FOURT, D. F. (1980). Surface workings and trees. Proceedings of the Forestry Commission/Arboricultural Association seminar *Research for practical arboriculture*, Preston. Forestry Commission Occasional Paper 10, 60–75.

BINNS, W. O., INSLEY, H. and GARDINER, J. B. H. (1983). *Nutrition of broadleaved amenity trees. 1. Foliar sampling and analysis for determining nutrient status.* Arboriculture Research Note 50/83/SSS. DOE Arboricultural Advisory and Information Service, Forestry Commission.

BLACK, R. E. (1963). Chestnut coppice with particular reference to layering. *Quarterly Journal of Forestry* **57**, 311–319.

BOLTON, LORD (1949). The growth and treatment of sycamore in Britain. *Quarterly Journal of Forestry* **43**, 161–167.

BOND, R. G. (1956). Evidence for fixation of nitrogen by root nodules of alder under field conditions. *New Phytologist* **55** (2), 147–153.

BOURNE, R. (1942). A note on beech regeneration in southern England. *Quarterly Journal of Forestry* **36**, 42–49.

BROOKER, M. I. H. and EVANS, J. (1983). *A key to eucalypts in Britain and Ireland with notes on growing eucalypts in Britain.* Forestry Commission Booklet 50. HMSO, London.

BROWN, I. R. (1983). *Management of birch woodland in Scotland.* Countryside Commission for Scotland.

BROWN, I. R. and KENNEDY, D. (1981). *The improvement of birch for forestry and amenity.* Arboriculture Research Note 33/81/EXT. DOE Arboricultural Advisory and Information Service, Forestry Commission.

BROWN, J. M. B. (unpublished). *Silvicultural data from war fellings. Ring shake and star shake in oak crops.* Forestry Commission unpublished report, December 1945.

BROWN, J. M. B. (1953). *Studies on British beechwoods.* Forestry Commission Bulletin 20. HMSO, London.

BROWN, J. M. B. (1955). Shelter and early growth of beech. *Quarterly Journal of Forestry* **49** (3), 1–8.

BROWN, J. M. B. (1960). Ecological aspects of regeneration in British beechwoods. *Bulletin de l'Institut Agronomique et des Stations de Recherches de Gembloux*, Hors Série, Vol. I, 75–92.

BURDEKIN, D. A. (1982). Protection problems in broadleaved woodlands. In, *Broadleaves in Britain : future management and research*, eds. Malcolm, D. C., Evans, J. and Edwards, P. N., 47–52. Institute of Chartered Foresters, Edinburgh.

CAMPBELL, D. A. and AARON, J. A. (1980). New markets for poplar. *Forestry and British Timber* **9** (6), 24–25.

CANNELL, M. L. R. (1982). Short rotation coppice. In, *Broadleaves in Britain: future management and research*, eds. Malcolm, D. C., Evans, J. and Edwards, P. N., 150–160. Institute of Chartered Foresters, Edinburgh.

CHARD, J. S. R. (1949). The walnut. *Journal of the Forestry Commission* **20**, 164–165.

CHRISTIE, J. M., MILLER, A. C. and BRUMM, L. E. (1974). *Nothofagus yield tables.* Forestry Commission Research and Development Paper 106. Forestry Commission, Edinburgh.

COOPER, J. I. (1979). *Virus diseases of trees and shrubs.* Institute of Terrestrial Ecology, Cambridge.

COUNTRYSIDE COMMISSION (1983). *Small woods on farms.* Countryside Commission Report CCP 143.

COUSENS, J. E. (1965). The status of Pedunculate and Sessile oak in Britain. *Watsonia* **6** (3), 161–176.

CROWE, S. (1978). *The landscape of forests and woods.* Forestry Commission Booklet 44. HMSO, London.

CROWTHER, R. E. and EVANS, J. (1984). *Coppice.* Forestry Commission Leaflet 83. HMSO, London.

CROWTHER, R. E. and PATCH, D. (1980). *Coppice.* DOE Arboriculture Research Note 21/80/SILS. DOE Arboricultural Advisory and Information Service, Forestry Commission.

DARRAH, G. V., DODDS, J. W., JOBLING, J. and PENISTAN, M. J. (1968). Woodland elms in Wessex. *Forestry* **41** (2), 131–151.

DAVIES, R. J. (1984). The importance of weed control and the use of tree shelters for establishing broadleaved trees on grass-dominated sites in England. In, Proceedings ECE/FAO/ILO Seminar *Techniques and machines for the rehabilitation of low-productivity forest.* Turkey, May 1984.

DAWSON, F. H. and HASLAM, S. M. (1983). The management of river vegetation with particular reference to shading effects of marginal vegetation. *Landscape Planning* **10**, 147–169.

DOWNING, P. and FITTON, M. (1981). *Small woods – the Dartington Study.* Conference on farm woods – management, conservation and financial resources. National Agriculture Centre, Stoneleigh, February 1981.

EELES, H. S. (1949). Coppice management. *Quarterly Journal of Forestry* **43**, 115–118.

EVANS, J. (1980). Prospects for eucalypts as forest trees in Great Britain. *Forestry* **53** (2), 129–143.

EVANS, J. (1982a). Silviculture of oak and beech in northern France: observations and current trends. *Quarterly Journal of Forestry* **76**, 75–82.

EVANS, J. (1982b). Free growth and control of epicormics. In, *Broadleaves in Britain : future management and research*, eds. Malcolm, D. C., Evans, J. and Edwards, P. N., 183–190. Institute of Chartered Foresters, Edinburgh.

EVANS, J. (1982c). Epicormic branches and their control, with a report of current research. *Proceedings of the Third Meeting, National Hardwoods Programme*, Oxford, 5–11. (Also in *Revue Forestière Française* **35** (5), 369–375. 1983).

EVANS J., HAYDON, L. and LAZZERI, M. (1983). Propagating and planting eucalypts in Britain. *Arboricultural Journal* 7(2), 137–147.

FAIRBROTHER, N. (1974). *The nature of landscape design.* Architectural Press, London.

FAIRLEY, C. (1955). Walnut for gun stocks. *Wood* (Oct. 1955), 400–401.

F.A.O. (1980). *Poplars and willows in wood production and land use.* FAO Forestry Series 10. F.A.O., Rome (328 pp.)

FINDLAY, D. C., COLBORNE, G. J. N., COPE, D. W., HARROD, D. R., HOGAN, D. V. and STAINES, S. J. (1984). *Soils and their use in south-west England.* Soil Survey Bulletin.

FLETCHER, J. (1983). *Quercus petraea* and *Q. robur.* The implications in N.W. Europe of differences in growth pattern and wood features. *Proceedings Fourth Meeting, National Hardwoods Programme*, Oxford, 19–23.

FORD, E. D., and NEWBOULD, P. J. (1970). Stand structure and dry weight production through the Sweet chestnut (*Castanea sativa* Mill.) coppice cycle. *Journal of Ecology* **58**, 275–296.

FORD, E. D. and NEWBOULD, P. J. (1977). The biomass and production of ground vegetation and its relation to tree cover through a deciduous woodland cycle. *Journal of Ecology* **65**, 201–212.

FORESTRY COMMISSION (1983/4). *Forestry Commission census of woodlands and trees, 1979–82.* County, conservancy and national reports. Forestry Commission, Edinburgh.

FORESTRY COMMISSION (1984). *Managing farm woodlands.* Unpriced leaflet. Forestry Commission, Edinburgh.

FRASER, A. I. (1982). The role of deciduous woodland in the economy of rural communities. *Arboricultural Journal* **6**, 37–47.

GAME CONSERVANCY (1981). *Woodland and pheasants.* Game Conservancy Booklet 15.

GARDINER, A. S. (1968). *The reputation of birch for soil improvement – a literature review.* Forestry Commission Research and Development Paper 67. Forestry Commission, Edinburgh.

GARDINER, A. S. (1974). The Sessile oak: anomalies of the binomial *Quercus petraea. Transactions of the Botanical Society Edinburgh* **42**, 261–263.

GLENN, E. M. (1947). Growing walnuts in England. *Report East Malling Research Station 1946*, 160–164.

GOODIER, R. and BALL, M. E. (1974). The management of upland broadleaved woodlands for nature and landscape conservation. In, *The management of broadleaved woodlands*. Supplement to *Forestry.* Oxford University Press 1974, 59–71.

GORDON, A. G., (1964). The nutrition and growth of ash (*Fraxinus excelsior* L.) in natural stands in the English Lake District as related to edaphic site factors. *Journal of Ecology* **52**, 169–187.

GORDON, A. G. and ROWE, D. C. F. (1982). *Seed manual for ornamental trees and shrubs.* Forestry Commission Bulletin 59. HMSO, London.

GRADWELL, G. R. (1974). The effect of defoliation on tree growth. In, *The British oak: its history and natural history*, eds. Morris, M. G. and Perring, F. H., 182–193. Published for the Botanical Society of the British Isles by E. W. Classey.

GREIG, B. J. W. and STROUTS, R. G. (1983). *Honey fungus.* Arboricultural Leaflet 2 (2nd edition). HMSO, London.

GROOS, R. (1953). Oak stands from coppice allowed to grow on as high forest – a study of increment and yield. *Allgemeine Forst und Jadzeitung* **124** (7), 189–208.

HARKNESS, C. E. (1983). Mapping changes in the extent and nature of woodlands in National Parks in England and Wales. *Arboricultural Journal* **7**, 309–319.

HARRIS, L. G. (1956). Relative growth of coppice from a varying number of shoots per stool. *Quarterly Journal of Forestry* **50**, 244.

HART, C. E. (1967). *Practical forestry for the agent and surveyor.* Estates Gazette Ltd. (438 pp.).

HILEY, W. E. (1967). *Woodland management*, 2nd edition (revised). Faber and Faber, London.

HELLIWELL, D. R. (1981). Silviculture of ash (*Fraxinus excelsior* L.) in Wessex. *Quarterly Journal of Forestry* **75**, 103–108.

REFERENCES

HILL, M. O. (1983). *Plants in woodlands.* Institute of Terrestrial Ecology, Bangor.

INSLEY, H. (1982). *The effects of stock type, handling and sward control on amenity tree establishment.* Ph.D. Thesis, University of London. (468 pp., unpublished).

JARVIS, M. G., ALLEN, R. H., FORDHAM, S. J., HAZELDEN, J., MOFFAT, A. J. and STURDY, R. G. (1984). *Soils and their use in south-east England.* Soil Survey Bulletin.

JARVIS, R. A., BENDELOW, V.C., BRADLEY, R. I., CAROLL, D.M., FURNESS, R. R., KILGOUR, I. and KING, S. J. (1984). *Soils and their use in northern England.* Soil Survey Bulletin.

JOBLING, J. (1960). *Establishment methods for poplar.* Forestry Commission Forest Record 43. HMSO, London.

JOBLING, J. (1963). *Poplar cultivation.* Forestry Commission Leaflet 27. HMSO, London.

JOBLING, J. (1981). *Poplar cultivation.* Research Information Note 64/81/SILS. Forestry Commission.

JOBLING, J. and PEARCE, M. L. (1977). *Free growth of oak.* Forestry Commission Forest Record 113. HMSO, London.

JOBLING, J. and STEVENS, F. R. W. (1980). *Establishment of trees on regraded colliery and spoil heaps.* Forestry Commission Occasional Paper 7. Forestry Commission, Edinburgh.

JOHNSTON, D. R. (1956). An enumeration of the mature oak in the Forest of Bere. *Forestry* **39**, 154–168.

JOHNSTON, D. R. (1983). *The wood handbook for craftsmen.* Batsford, London. (168 pp.).

JOHNSTON, D. R., GRAYSON, A. J. and BRADLEY, R. T. (1966). *Forest planning.* Faber and Faber.

JONES, E. W. (1944). Biological flora of the British Isles – *Acer* L. *Journal of Ecology* **32**, 215–252.

JONES, E. W. (1959). Biological flora of the British Isles. *Quercus L. Journal of Ecology* **47**, 169–222.

JUKES, M. R. (1984). *The knopper gall.* Arboriculture Research Note 55/84/ENT. DOE Arboricultural Advisory and Information Service, Forestry Commission.

LANE, P. B. (1984). *Chemical weeding – hand-held direct applicators.* Arboriculture Research Note 53/84/WS. DOE Arboricultural Advisory and Information Service, Forestry Commission.

LINDSEY, J. M. (1976). The history of oak coppice in Scotland. *Scottish Forestry* **29**, 87–93.

LINES, R. (1984). Species and seed origin trials in the industrial Pennines. *Quarterly Journal of Forestry* **78**(1), 9–23.

LINES, R. and BROWN, J. R. (1982). Broadleaves for the uplands. In, *Broadleaves in Britain : future management and research*, eds. Malcolm, D. C., Evans, J. and Edwards, P. N., 141–149. Institute of Chartered Foresters, Edinburgh.

LONSDALE, D. (1983). *A definition of the best pruning position.* Arboriculture Research Note 48/83/PATH. DOE Arboricultural Advisory and Information Service, Forestry Commission.

LONSDALE, D. and PRATT, J. E. (1981). Some aspects of the growth of beech trees and the incidence of beech bark disease on chalk soils. *Forestry* **54**(2), 183–195.

LUST, N. and MOHAMMADY, H. (1973). Regeneration of coppice. *Sylva Gandavensis* 39. (28 pp.).

MACDONALD, A. (1967). Trial plantations established by the Forestry Commission on the island of Hoy, Orkney. *Scottish Forestry* **21**(3), 163–172.

MANN, D. and HENDERSON, D. M. (1984). *The birch symposium.* Royal Society of Edinburgh.

MASON, C. (1982). Letter to *Natural World* **5**, 34.

McCAVISH, W. J. and INSLEY, H. (1983). *Herbicides for sward control among broadleaved amenity trees.* Arboriculture Research Note 27/83/SILS (revised by J. S. P. Sale). DOE Arboricultural Advisory and Information Service, Forestry Commission.

McVEAN, D. N. (1953). Biological flora of the British Isles. *Alnus glutinosa* (L.) Gaertn. *Journal of Ecology* **41**, 447–466.

McVEAN, D. N. (1955–59). Ecology of *Alnus glutinosa* (L.) Gaertn.

i. Fruit formation. (1955). *Ecology* **43**, 40–60.
ii. Seed distribution and germination. (1955). *Ecology* **43**, 61–71.
iii. Seedling establishment. (1956). *Ecology* **44**, 195–218.
iv. Root system. (1956). *Ecology* **44**, 219–225.
v. Notes on some British alder populations. (1956). *Ecology* **44**, 321–330.
vi. Post-glacial history. (1956). *Ecology* **44**, 331–333.
vii. Establishment of alder by direct seeding on shallow blanket bog. (1959). *Ecology* **47**, 615–618.

MILES, J. and YOUNG W. F. (1980). The effects on heathland and moorland soils in Scotland and northern England following colonization by birch (*Betula* spp.). *Bulletin d'Ecologie* **11**, 233–242.

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD (1982). *Farming and the countryside.* ADAS Booklet 2384.

MITCHELL, A. F. (1973). *Replacement of elm in the countryside.* Forestry Commission Leaflet 57. HMSO, London.

MITCHELL, A. F. (1981). *The native and exotic trees in Britain.* Arboriculture Research Note 29/81/SILS. DOE Arboricultural Advisory and Information Service, Forestry Commission.

MORRIS, M. G. and PERRING, F. H. (eds.) (1974). *The British oak : its history and natural history.* Published for the Botanical Society of the British Isles by E. W. Classey, Faringdon, Berks. B.S.B.I. Conference Reports No. 14. (376 pp.).

NEUSTEIN, S. A. (1964) A review of pilot and trial plantations established by the Forestry Commission in Shetland. *Scottish Forestry* **18**(3), 199–211.

NEWBOLD, A. J. and GOLDSMITH, F. B. (1981). *The regeneration of oak and beech.* Discussion Papers in Conservation 33. University College, London.

NEWTON, I. and MOSS, D. (1981). Factors affecting the breeding of sparrow-hawks and the occurrence of their song-bird prey in woodlands. In, *Forest and woodland ecology*, eds. Last, F.T. and Gardiner, A. S. Institute of Terrestrial Ecology.

NICHOLLS, P. H. *Spatial analysis of forest growth.* Forestry Commission Occasional Paper 12. Forestry Commission, Edinburgh.

OSWALD, H. (1981). Main results from oak sample plots of the National Centre for Forest Research. *Revue Forestière Français* **33** (Numéro spécial), 65–85.

OVINGTON, J. D. and MADGWICK, H. A. I. (1959). The growth and composition of natural stands of birch. I. Dry matter production. *Plant and Soil* **10**, 271–283.

PATCH, D. and LINES, R. (1981). *Winter shelter for agricultural stock.* Arboriculture Research Note 35/81/SILS. DOE Arboricultural Advisory and Information Service, Forestry Commission.

PATCH, D., BINNS, W. O. and FOURT, D. F. (1984). *Nutrition of broadleaved amenity trees. II – Fertilisers.* Research Information Note 58/84/SSS. Forestry Commission.

PAWSEY, R. G. (1984). *Ash dieback survey: summer 1983.* Arboriculture Research Note 51/84/EXT. Arboricultural Advisory and Information Service, Forestry Commission.

PEACE, T. R. (1952). *Poplars.* Forestry Commission Bulletin **19.** HMSO, London.

PEACE, T. R. (1962). *The pathology of trees and shrubs.* Clarendon Press, Oxford.

PEARSON, W. (1948). Treatment of oak coppice areas. *Journal of the Forestry Commission* **19,** 54–55.

PENISTAN, M. J. (1974). The silviculture of beech woodland. In, *The management of broadleaved woodlands.* Supplement to *Forestry,* Oxford University Press (1974), 71–78.

PETERKEN, G. F. (1977). General management principles for nature conservation in British woodlands. *Forestry* **50**(1), 27–48.

PETERKEN, G. F. (1981). *Woodland conservation and management.* Chapman and Hall.

PHILIP, M. S. (1978). Birch – a report of the work of the Silviculture Group 1976–77. *Scottish Forestry* **32,** 26–36.

PHILLIPS, J. B. (1971). Effect of cutting techniques on coppice regrowth. *Quarterly Journal of Forestry* **65**(3), 220–223.

PIDDINGTON, H. R. (1981). *Land management for shooting and fishing.* University of Cambridge, Department of Land Economy, Occasional Paper 13.

POORE, A. (1982). Coppice management in East Anglian Woodlands and its application in urban fringe nature conservation. *Arboricultural Journal* **6,** 81–94.

PYATT, G. (1982). *Soil classification.* Research Information Note 68/82/SSN. Forestry Commission.

RACKHAM, O. (1967). The history and effects of coppicing as a woodland practice. *Proceedings, Monks Wood Experiment Station Symposium* 3, 82–93.

RACKHAM, O. (1976). *Trees and woodland in the British landscape.* J. M. Dent and Sons Ltd.

RACKHAM, O. (1980). *Ancient woodlands.* Edward Arnold.

RATCLIFFE, P. R. (in preparation). *The use of glades for deer management.* Forestry Commission Leaflet. HMSO, London.

R.I.C.S. (1982). *Forestry and land use.* The Royal Institution of Chartered Surveyors.

ROBERTS, T. (1929). The growing and conversion of chestnut in West Sussex. *Quarterly Journal of Forestry* **23,** 220–229.

ROLLINSON, T. J. D. (1984). Thinning control. Forestry Commission Booklet (revision of Booklet 32, in preparation). HMSO, London.

ROWE, J. J. (1980). *Grey squirrel control.* Forestry Commission Leaflet 56. HMSO, London.

ROWE, J. J. (1983). Squirrel management. *Mammal Review* **13,** 173–181.

RUDEFORTH, C. C., HARTNUP, R., LEA, J. W., THOMPSON, T. R. E. and WRIGHT, P. S. (1984). *Soils and their use in Wales.* Soil Survey Bulletin.

SALE, J. S. P., TABBUSH, P. M. and LANE P. B. (1983). *The use of herbicides in the forest – 1983.* Forestry Commission Booklet 51. Forestry Commission, Edinburgh.

SEYMOUR, W. (1974). The value of broadleaved woodland to the lowland farmer. In, *The management of broadleaved woodlands.* Supplement to *Forestry,* Oxford University Press (1974), 47–53.

SHAW, M. W. (1968). Factors affecting the natural regeneration of Sessile oak (*Quercus petraea*) in North Wales. *Journal of Ecology* **56,** I. 565–583; II. 647–660.

SHAW, M. W. (1974). The reproductive characteristics of oak. In, *The British oak: its history and natural history,* eds. Morris, M. G. and Perring, F. H., 160–181. Published for the Botanical Society of the British Isles by E. W. Classey.

SIMPSON, L. M. (1974). The extent and composition of existing broadleaved woodland in Britain. In, *The management of broadleaved woodlands.* Supplement to *Forestry,* Oxford University Press (1974), 7–18.

SMALL, D. (1982). Reproduction of even-aged high forest oak – with special reference to the New Forest Statutory Inclosures. In, *Broadleaves in Britain: future management and research,* eds. Malcolm D. C., Evans J. and Edwards, P. N., 65–71. Institute of Chartered Foresters, Edinburgh.

SMITH, M. (1983). The vanishing Welsh wildwoods. *Wildlife* (June 1983), 208–212.

SOUTHWOOD, T. R. E. (1961). The number of species of insects associated with various tree species. *Journal of Animal Ecology* **30,** 1–8.

STEELE, R. C. and PETERKEN, G. F. (1982). Management objectives for broadleaved woodland – conservation. In, *Broadleaves in Britain: future management and research,* eds. Malcolm, D. C., Evans, J. and Edwards, P. N., 91–103. Institute of Chartered Foresters, Edinburgh.

STERN, R. C. (1972). Poplar growing at close spacing. *Quarterly Journal of Forestry* **66** (3), 230–235.

STERN, R. C. (1982). The use of sycamore in British forestry. In, *Broadleaves in Britain: future management and research,* eds. Malcolm, D. C., Evans, J. and Edwards, P. N., 83–87. Institute of Chartered Foresters, Edinburgh.

STEWART, G. G. (1961). Experimental introductions of alternative species into pioneer crops on poor sites. *Forestry Commission Report on Forest Research for 1959/60,* 151–166. HMSO, London.

STEWART, G. G. (1962). Kergord plantations, Shetland. *Forestry* **35**(1), 35–56.

STEWART, P. J. (1982). Tudor standards. *Quarterly Journal of Forestry* **76**(3), 188–191.

STOTT, K. (1956). Cultivation and uses of basket willows. *Quarterly Journal of Forestry* **50,** 103–112.

TANSLEY, A. G. (1939). *The British Islands and their vegetation.* Cambridge University Press.

TITTENSOR, R. M. (1970). History of the Loch Lomond oakwoods. *Scottish Forestry* **24,** 100–118.

TOWLER, R. W. (1980). What future for upland amenity woodlands? *Quarterly Journal of Forestry* **74,** 7–20.

TOWLER, R. W. and BARNES, G. C. (1983). What future for broadleaved farm woodlands in East Anglia? *Quarterly Journal of Forestry* **77,** 149–161.

TROUP, R. S. (1952). *Silvicultural systems* (2nd edition revised by E. W. Jones). Clarendon Press, Oxford.

TULEY, G. (1980). *Nothofagus in Britain.* Forestry Commission Forest Record 122. HMSO, London.

REFERENCES

TULEY, G. (1982). Tree shelters increase the early growth of broadleaved trees. In, *Broadleaves in Britain: future management and research*, eds. Malcolm, D C., Evans, J. and Edwards, P. N., 176–182. Institute of Chartered Foresters, Edinburgh.

TULEY, G. (1983). Shelters improve the growth of young trees in the forest. *Quarterly Journal of Forestry* **77**, 77–87.

TULEY, G. (1984). Trees in shelters do need to be weeded. *Aspects of Applied Biology* **5**. Weed control and vegetation management in forests and amenity areas, 315–318.

TULEY, G., and RISBY, P. G. (1984). *Shelters improve the growth of young trees.* Arboriculture Research Note 49/84/SILS. DOE Arboricultural Advisory and Information Service, Forestry Commission.

VARLEY, G. C. and GRADWELL, G. R. (1960). The effects of partial defoliation by caterpillars on the timber production of oak trees in England. *Proceedings of the 11th International Congress of Entomology, Vienna,* **2**, 211–214.

WARDLE, P. A. (1961). Biological flora of the British Isles. *Fraxinus excelsior* L. *Journal of Ecology* **49**, 739–751.

WATERS, W. T. and CHRISTIE, J. M. (1958). *Provisional yield table for oak and beech in Great Britain.* Forestry Commission Forest Record 36. HMSO, London.

WATT, A. S. (1923–5). On the ecology of British beechwoods with special reference to their regeneration. I. The causes of failure of natural regeneration of beech. *Journal of Ecology* **11**, 1–48. II. The development and structure of beech communities on the Sussex Downs. Section I. *Journal of Ecology* **12**, 145–204. Sections II & III *Journal of Ecology* **13**, 27–73.

WATT, A. S. (1931). Preliminary observations on Scottish beechwoods. *Journal of Ecology* **19**, Part 1, 138–157; Part 2, 322–359.

WELCH, R. C. (1980). The insect fauna of *Nothofagus.* In, *Institute of Terrestrial Ecology Annual Report for 1980*, 50–53. Natural Environment Research Council.

WIGSTON, D. L. (1980). *A preliminary investigation of the ecological implications of the introduction of species of Nothofagus Blume into British forestry with particular reference to the ground flora under established canopies of N.obliqua and N.procera.* Woodlands Research Group Report for Nature Conservancy Council, Plymouth Polytechnic. (Unpublished).

WITTERING, W. O. (1974). *Weeding in the forest.* Forestry Commission Bulletin 48. HMSO, London.

WOOD, R. F. and NIMMO, M. (1962). *Chalk downland afforestation.* Forestry Commission Bulletin 34. HMSO, London.

WOOD, R. F., MILLER, A. D. S. and NIMMO, M. (1967). *Experiments on the rehabilitation of uneconomic broadleaved woodlands.* Forestry Commission Research and Development Paper 51. Forestry Commission, Edinburgh.

WORKMAN, J. (1982). Management objectives for broadleaved woodland – landscape, recreation and sport. In, *Broadleaves in Britain: future management and research*, eds. Malcolm, D. C., Evans, J. and Edwards, P. N., 104–110. Institute of Chartered Foresters, Edinburgh.

ZEHETMAYR, J. W. L. (1981). Small woods in Gwent. *Arboricultural Journal* **5**, 301–313.

General Index

(Not every reference to silvicultural operations and practices, site requirements, utilization, and pests and diseases is included here. Additional ones pertaining to individual species will be found in Chapters 11, 17–22 and can mostly be identified from the species index. Entries with such additional references are marked * in this index.)

Tree Species Index

(See other index for general references to silvicultural operations and practices, site requirements, utilization, and pests and diseases.)

Printed in the UK for HMSO Dd 737617 C110 8/84

HER MAJESTY'S STATIONERY OFFICE

Government Bookshops

49 High Holborn, London WC1V 6HB
13a Castle Street, Edinburgh EH2 3AR
Brazennose Street, Manchester M60 8AS
Southey House, Wine Street, Bristol BS1 2BQ
258 Broad Street, Birmingham B1 2HE
80 Chichester Street, Belfast BT1 4JY

Government publications are also available through booksellers

ODC 2 : 176·1 : (410)

ISBN 0 11 710154 0