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Creating New Native Woodlands

John Rodwell
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Front cover: A new native pinewood formed by Scots pine and birch colonising heather moorland on The Crannach, near Ballater, Deeside. (Peter Quelch, by permission of Crannach Management Group)
Insets Chickweed wintergreen, a flower typical of woods like this. (E11023)
A native mixed broadleaved wood planted about thirty years ago in lowland West Yorkshire. (38628)

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Foreword

The proportion of native trees and shrubs planted within woodlands of all kinds has increased dramatically over the last few years and there has also been a growing interest in establishing new woodlands, composed entirely of native trees and shrubs suited to the site. There are probably two principal motivations: firstly the desire to expand the remnants of our semi-natural woods and secondly the more general aim of reversing past losses of native species in the wider countryside. Very encouraging progress has already been made in the Scottish Highlands with New Native Pinewoods created under the Woodland Grant Scheme and this book will help to extend the new native woodland concept to other species associations by providing comprehensive advice on design and management for the main categories of semi-natural woodland in Britain.

This Bulletin combines expertise in woodland ecology and up-to-date silvicultural knowledge. It encourages the selection of the appropriate type of new native woodland for any particular site and gives guidance on the species composition, design and silvicultural methods which should be used in order to secure the development of the woodland ecosystem as a whole. The wide range of possible benefits from these new woods, including wood production, is recognised and the practical advice is tailored accordingly.

I therefore believe that this book will play a very useful role in encouraging the creation of new native woods which will suit particular local environments throughout Britain. This could eventually lead to a reversal of the present situation where the area of semi-natural woodlands is declining.

R. T. Bradley

Head of the Forestry Authority

January 1994

Creating New Native Woodlands

Summary

The use of native trees and shrubs in establishing new woodlands has increased greatly in Britain in recent years because of growing emphasis on obtaining environmental benefits from forests. In addition to planting native trees as part of mixed woods together with introduced species to combine timber production with environmental and social benefits, interest is growing in establishing new woods of a more natural character. These are both as extensions to the surviving remnants of semi-natural woods to safeguard their future and in presently unwooded areas. Advice on design and management of these new native woodlands is provided in this Bulletin.

The guidance is based upon knowledge of the composition of semi-natural woodlands and their relationship to site factors which has been derived from the recent National Vegetation Classification in Britain. The first part of the Bulletin describes the main characteristics of semi-natural woodland composition including trees, shrubs and field layer plants and how they depend upon soil and climate as well as management history. This is followed by guidance on methods of design and early management for new native woods which are likely to encourage communities of trees and shrubs and associated flora and fauna to develop similar to those of semi-natural woods on equivalent sites. The prospects for the development of the full flora and fauna will vary. For example, it will be lower on more disturbed and isolated sites, but much of the character of semi-natural woods can still be encouraged. In some cases introduction of field layer plants might be considered and guidance is given on whether and how this should be done.

Finally, the Bulletin provides a series of design prescriptions for individual woodland types. These are for selecting the appropriate type of new native woodland for a given site using information on the local climate, geology, soil and existing vegetation. Lists of recommended trees and shrubs, divided into major and minor species, are provided for each woodland type with notes on the characteristic structure of the woodland and its pattern in the landscape. There are also lists of the main vascular field layer plants which might be expected to colonise as the new native woodland develops.

Creation de Nouveaux Bois Natifs

Résumé

L'emploi d'arbres et d'arbustes natifs dans la création de nouveaux bois a accrû énormément en Grande Bretagne dans les années récentes à cause du croissant intérêt marqué d'obtenir des bénéfices du milieu forestier. En plus de planter des arbres natifs qui forment part des bois mixtes avec des espèces introduites combinant la production de bois avec des bénéfices pour le milieu et sociaux, il y a un croissant intérêt d'établir des nouveaux bois d'un caractère plus naturel. Ce sont, tous les deux, des extensions aux vestiges survivants des bois seminaturels pour sauvegarder leur futur et dans des terrains actuellement dépourvus d'arbres. Des conseils sur le dessein et la gestion de ces nouveaux bois natifs sont fournis dans ce Bulletin.

L'avis se base sur les connaissances de la composition des bois seminaturels et leur relation avec des facteurs du terrain qui ont été dérivées de la récente Classification Nationale de Végétation de la Grande Bretagne. La première partie du Bulletin décrit les caractéristiques principales de la composition des bois semi-naturels, y inclus arbres, arbustes et plantes-couche de champs et comment ceux-ci dépendent du sol, du climat et de l'histoire de leur gestion. Ceci est suivi par des indications sur des méthodes de dessein et le tôt manège des bois natifs nouveaux qui peuvent probablement encourager le développement de communautés d'arbres et d'arbustes, de flore et de faune sauvage associée, similaires à celles des bois semi-naturels dans des terrains équivalents. Les perspectives de développement intégral de la flore et de la faune variera. Par exemple, il sera inférieur sur des terrains plus remués et isolés, mais une grande partie du caractère des bois semi-naturels peut être tout de même encouragé. Dans certains cas, l'introduction de plantes-couche de champs sera convenable et orientation est donné vis à vis si et comment cela doit être fait.

Finalement, le Bulletin pourvoit une série de formules de dessein pour des genres de bois individuels. Celles-ci aident à choisir le type qui convient au nouveau bois natif pour un terrain donné , utilisant l'information sur le climat local, la géologie, le sol et l'existante végétation. Listes d'arbres et d'arbustes recommandés, divisées en espèces majeur et mineur, sont pourvues pour chaque type de bois, avec notes sur la structure caractéristique du bois et son modèle dans le paysage. Il y a aussi des listes des principales plantes-couche vasculaires champêtres qui pourraient coloniser au fur et à mesure que le bois natif se développe.

Die Schaffung neuer, einheimischer Wälder

Zusammenfassung

Der Gebrauch von einheimischen Baümen und Straüchern hat in Britannien in den letzten Jahren beträchtlich zugenommen, da man zunehmenden Wert darauf legt, von Wäldern umweltliche Nutzen zu erlangen. Neben der Pflanzung von einheimischen Baümen als Bestandteil eines Mischwaldes zusammen mit eingeführten Arten, um Holzproduktion mit umweltlichen und sozialen Vorteilen zu kombinieren, besteht ein zunehmendes Interesse an der Schaffung neuer Wälder mit einem natürlicherem Charakter. Dies gilt sowohl für die Erweiterung der überlebenden Reste von Semi-Ursprungswäldern um deren Zukunft zu sichern, als auch für momentan unbewaldete Gebiete. Ratschläge zur Planung und Pflege dieser neuen, einheimischen Wälder werden in diesem Bulletin gegeben.

Die Anleitung basiert sich auf Kenntnisse, über die Zusammensetzung semi-ursprünglicher Wälder und ihre Beziehung zu Geländefaktoren, die man durch die kürzlich in Britannien vollzogene, nationale Vegetations-Klassifizierung erlangt hat. Der erste Teil des Bulletins beschreibt die Hauptcharakteristiken der Zusammensetzung von Semi-Ursprungswäldern inclusive Baüme, Straücher und Feldpflanzen, und wie sie nicht nur von Boden und Klima, sondern auch vom Pflegewerdegang abhängen. Diesem folgt eine Anleitung zu Methoden der Planung und Anfangspflege neuer einheimischer Wälder, welche wahrscheinlich die Bildung von Gemeinschaften von Baümen, Straüchern und der entsprechenden Flora und Fauna, ähnlich derer von Semi-Ursprungswäldern auf ähnlichem Gelände, fördern. Die Aussichten zur Entwicklung der vollen Flora und Fauna werden unterschiedlich sein. Zum Beispiel werden sie auf gestörterem und isoliertem Gelände geringer sein, aber viel des Charakters eines Semi-Ursprungswaldes kann trotzdem unterstützt werden. In manchen Fällen Könnte man die Einführung von Feldpflanzen erwägen und es wird somit eine Beschreibung gegeben, ob und wie dies getan werden sollte.

Zuletzt liefert das Bulletin eine Reihe von Planungsbeschreibungen für individuelle Waldtypen. Diese dienen zur Wahl des passenden Types für den neuen, einheimischen Wald für das gegebene Gelände, unter Benutzung von Information über lokales Klima, Geologie, Boden und vorhandene Vegetation. Für jeden Waldtyp werden Listen von vorgeschlagenen Baümen und Straüchern, unterteilt in Haupt- und Unterarten, angegeben, mit Erlaüterungen zur charakteristischen Struktur des Waldes und seiner Lage

in der Landschaft. Es enthält auch eine Liste hauptsächlicher Feldpflanzen, welche voraussichtlich den neuen, einheimischen Wald kolonisieren, während er sich entwickelt.

Creando Nuevos Bosques Nativos

Resumen

El uso de árboles y arbustos nativos en el establecimiento de nuevos bosques ha crecido muchísimo en Gran Bretaña en los últimos años a causa del creciente énfasis en la obtención de beneficios medio ambientales forestales. Además de sembrarse árboles nativos como parte de bosques mixtos junto con especies introducidas para combinar una producción maderera con beneficios medio ambientales y sociales, está creciendo el interés en establecer nuevos bosques de un carácter más natural. Estos son ambos como extenciones de los vestigios de bosques seminaturales que sobreviven para resguardar su futuro y en actuales zonas desprovistas de árboles. Este Boletín ofrece asesoramiento sobre el diseño y manejo de estos nuevos bosques naturales nativos.

El asesoramiento está basado en lo que se sabe de la composición de bosques seminaturales y de su relación con factores de localidad que se ha derivado de la reciente Clasificación Nacional de Vegetación en Gran Breta ña. La primera parte del Boletín describe las características principales de la composición de bosques seminaturales, incluyendo árboles, arbustos y plantas cubre campos y como éstos dependen del suelo, del clima y de la historia de su manejo. Luego se indican métodos de diseño y de temprana gestión de nuevos bosques nativos que sean probables de fomentar comunidades de árboles y arbustos, de flora y fauna asociada, similares a los bosques seminaturales en terrenos equivalentes. Las perspectivas de desarrollo total de flora y fauna variará. Por ejemplo, será inferior en areas más removidas y aisladas, pero mucho del carácter de bosques semi-naturales puede aún ser fomentado. En ciertos casos, se considera la introducción de plantas cubre campos y se informa si ésto se debe hacer y cómo.

Finalmente, el Boletín provee una serie de preceptos de diseño para tipos de bosques individuales. Estos son para seleccionar el tipo de nuevo bosque nativo apropiado a tal lugar, utilizando información sobre el clima local, la geología, el suelo y la actual vegetación. Se suministran listas, divididas en mayores y menores especies, de árboles y arbustos recomendados para cada tipo de bosque, con notas sobre la estructura característica del bosque y su aspecto en el paisaje. También hay listas de las principales plantas vasculares cubre-campos que se podría esperar colonizarían a medida que el nuevo bosque nativo se desarrolla.

Chapter 1
Introduction

This Bulletin provides advice to land managers and owners who are interested in establishing new areas of woodland made up of communities of native tree and shrub species which are appropriate to the site.

In recent years the importance of conserving the remnants of Britain's semi-natural woodlands has been widely accepted and translated into policy. Semi-natural woodlands are largely composed of trees and shrubs that are native to the site. They have developed from seedlings or stump regrowth through successive generations from the original trees in the wood which were self-sown (Kirby *et al.*, 1989). They include:

- **primary woods** on sites that have always been wooded;
- **secondary woods** which have colonised bare ground within historical times.

Semi-natural woods, especially the oldest or 'ancient' ones, are the nearest we have to truly natural woodland. They are very valuable wildlife habitats and an important part of our cultural heritage. The current area of ancient semi-natural woodland is thought to be approximately 300 000 hectares (ha) (Kirby *et al.*, 1989).

As a result of concern over the large losses of ancient semi-natural woodland that have occurred since 1945, the Forestry Commission introduced new policies in 1985 and 1989 aimed at conserving the remaining areas of semi-natural woodland, and of broadleaved woodland more generally, and extending them where appropriate (Forestry Commission, 1985a; 1989). Further guidance on the management of semi-natural woods has since been produced (Forestry Commission, in press). These policies have resulted in a great increase in the planting and natural regeneration of native trees in recent years. Broadleaved planting of all types has increased sixfold from 1844 ha in 1985 to 11 145 ha in 1992 (Forestry Commission, 1985b; 1992) and the great majority of this has been with species native to Britain. Of all the proposals for grant-aid for new areas of woodland submitted to the Forestry Authority between June 1991 and November 1992, almost 95% of broadleaved trees proposed for planting were native to Britain.

Native broadleaved trees and shrubs are increasingly being planted and regenerated within extensive coniferous forests for wildlife conservation, amenity, recreation and other environmental benefits. Much of the characteristically smaller woodland recently established on farms and in and around urban areas also consists of native species. Native species are predominant, too, in larger broadleaved plantations in the lowlands where timber production is important. By contrast, thousands of hectares of new native pinewoods are being planted or regenerated in the Scottish Highlands for which wood production is often considered less important than environmental objectives.

All these uses of native species are likely to continue in future as major contributions to forestry for multiple objectives (Forestry Commission, 1991). Indeed, there is considerable interest in the expansion of native woodlands in sensitive areas where more intensively managed forests of exotic species may be considered inappropriate.

Native trees are clearly being planted for a wide range of objectives and situations. Sometimes only a few native species are suitable for the purpose in mind, for example, oak, beech, ash or gean for high quality timber in lowland England (Kerr and Evans, 1993); but often a wide range of native species can be used to provide environmental and amenity benefits. There are frequently opportunities to think in terms of *encouraging whole communities of native trees and shrubs appropriate to the site with the aim of approaching the appearance and ecological integrity of semi-natural woodland.* These new native woods could range from small pockets along streamsides in a forest of exotic conifers to extensive areas of several hundred hectares comprising a mosaic of woodland, heath and mire in the uplands. Lowland areas which are being converted from agricultural use also have potential.

Advice is given on the site selection, design and early management of these new native woodland areas where one of the objectives is to encourage the development of the native trees, shrubs and associated flora and fauna suited to the site. Semi-natural woodland composition and structure is used as a model upon which to base the advice. Semi-natural woodlands vary greatly in their composition due to their long and varied management history. The prescriptions given for new native woodland are therefore deliberately broad and flexible, and can accommodate other objectives, including wood production and utilisation wherever appropriate.

The advice in this Bulletin is based on the premise that achieving a good match to the appropriate semi-natural woodland type for the site in question will not only result in similar tree and shrub communities, but also encourage the associated plants and animals to colonise if they are not already present. The focus is on plant communities and notably vascular plants. Plants are more readily surveyed and monitored than most animals. If the characteristic plant community of the model woodland type develops, the animals are more likely to colonise successfully too.

It is important to emphasise, however, that new native woods must not be regarded as a substitute for existing semi-natural woodland. They will perhaps never attain the full ecological value of ancient semi-natural woods and, of course, new woods cannot replace the cultural and scientific interest of the originals. Advice on the management of semi-natural woodlands can be found in a series of guides from the Forestry Authority (Forestry Commission, in press).

The scope of this Bulletin includes all areas of new native woodland being established, whether by natural colonisation or by planting, on currently unwooded ground outside existing semi-natural woods. However, it is more difficult to use semi-natural woods as models on highly disturbed sites such as arable fields or industrial spoils where the soil or vegetation has been drastically altered from the natural state, and the course of succession is more unpredictable. The advice is therefore targeted principally at sites where semi-natural vegetation persists, although attempts are made to suggest adaptations for disturbed sites.

This Bulletin is based upon the National Vegetation Classification (Rodwell, 1991) which provides a systematic description and classification of woodland and other vegetation types in Britain. It also draws upon a research study carried out for the Forestry Commission of plant communities in planted upland broadleaved woods ranging from 10 to 70 years of age (Rodwell and Cooper, 1990).

The information and advice is arranged in four sections:

- An outline description of the major types of semi-natural woodland in Britain, their characteristic trees, shrubs and associated floras and how they are influenced by climate, soil conditions and management (Chapter 2).
- General guidance on the methods of design and early management of new woods of native trees and shrubs which are likely to encourage a composition similar to semi-natural woodland (Chapter 3).

- The use of the design prescriptions for individual woodland types, with definitions of the terms used (Chapter 4).
- Design prescriptions for new native woods modelled upon the major kinds of semi-natural woodland in Britain. These have two main functions: to assist the reader to choose the appropriate woodland type for a given site and to provide advice on the trees and shrubs to select, their relative abundance and pattern in relation to the site and vegetation (Chapter 5).

Chapter 2

Types of Semi-natural Woodland in Britain

Classifying semi-natural woodlands

The semi-natural woodlands of Britain are very diverse in their trees, shrubs and associated floras. The composition of these woodlands and their structure are determined by climate, soil conditions and biotic influences: chiefly the impact of man through generations of woodland use and, more recently, tree planting. Understanding the patterns of variation, and how they develop in relation to natural environmental factors and silvicultural practice, is essential for the sensitive design of native woodlands.

The National Vegetation Classification

From the diverse wooded landscape of Britain, the National Vegetation Classification (NVC) has described 19 major types of woodland (Rodwell, 1991). Each can be recognised by distinctive mixtures of trees and shrubs, and has a characteristic associated flora of flowering plants and often, too, some ferns, mosses, liverworts and lichens. Each is limited to a particular climatic zone and certain types of soil and represents the kind of climax vegetation that could develop wherever such conditions occurred, if succession everywhere was allowed to take its full course. Although the progress of such succession has often been modified by man, these woodlands still preserve much natural diversity and provide important clues as to the kinds of vegetation we should aim for when creating new woodlands where wildlife conservation and visual amenity are high priorities.

Using the NVC for designing new native woodlands

The NVC can provide a valuable working tool for the forester in the design and management of new woodland. It can:

- Predict the kind of woodland vegetation which we might expect to develop on a site if succession were to proceed unhindered.
- Provide lists of the most ecologically appropriate trees and shrubs to plant in such situations, and give a rough indication of the proportions and patterns that could be used.
- Identify optimal precursors among the variety of plant communities that could already occupy the site, so as to give a head start in the development of an appropriate ground cover.
- Indicate other desirable plants characteristic of the woodland type, whose appearance could be expected and monitored, and perhaps actively encouraged.
- Suggest forms of management of the site, in establishment and subsequent phases, which could aid development of the distinctive complement of woody and herbaceous plants.

Semi-natural woodland descriptions

This chapter describes all the different kinds of semi-natural woodland in Britain that it is practicable to mimic in new native woods. The main features of these woodland types, as we see them at present in our landscape, are

described below under the following groupings:

- Mixed broadleaved and oak-birch woodland of the lowland zone (three types).
- Mixed broadleaved and oak-birch woodland of the upland zone (three types).
- Beech woodland (three types).
- Scots pine and juniper woodlands (two types).
- Wet woodlands with alder, downy birch and willows (four types).

Yew woodland and those types of swampy woodland of lake and river margins which are more difficult to develop are only briefly described because they are not included in the design prescriptions.

In the following account, the woodland types are given their NVC code number and a simplified vernacular name. Table 2.1 gives their full scientific names and relates the woodland types to the categories used in the Forestry Commission's *Management guides for semi-natural woodlands* (Forestry Commission, in press).

Mixed broadleaved and oak-birch woodlands of the lowland zone

In the warmer and drier lowlands of south and east Britain (Figure 2.1), it is possible to recognise three distinct types of mixed broadleaved and oak-birch woodland, each associated with particular soil conditions (Figure 2.2). One type of woodland is characteristic of lime-rich soils that have developed from calcareous bedrocks and drift: shallow, immature rendzinas on steeper slopes and deeper calcareous brown earths with mull humus over gentler terrain. At the opposite extreme, another kind of woodland occurs on the highly acidic soils: rankers, podzolic brown earths, podzols and ironpan soils with mor humus formed from sandstones and sandy superficials. Between these two extremes, a third sort of woodland is found on base-poor brown earths, often with moder humus, that have developed from clay and shale rocks and heavy, lime-poor drift.

At the base-rich extreme, oak (usually *Quercus robur* with *Q. petraea* much more locally) is an important tree in the canopy with small-leaved lime (*Tilia cordata*) and hornbeam (*Carpinus betulus*), although many woodlands have been treated as hazel (*Corylus avellana*) coppice. The most distinctive trees, however, are ash (*Fraxinus excelsior*), various elms (*Ulmus glabra* and the suckering *U. procera* and *U. carpinifolia*) and a range of associates dependent upon the warmer and drier climate of the south-east, i.e. field maple (*Acer campestre*), dogwood (*Cornus sanguinea*), wayfaring tree (*Viburnum lantana*) and purging buckthorn (*Rhamnus catharticus*).

On the more base-poor brown soils, lime, hornbeam and the introduced sweet chestnut (*Castanea sativa*) can be important dominants among the trees, but overall it is oak and the birches (usually *Betula pendula* but with some *B. pubescens*) that are the most frequent members of the canopy. Hazel is again a common dominant in coppiced stands and hawthorn (*Crataegus monogyna* and the rarer *C. laevigata*) remains frequent, but many of the trees and shrubs of more lime-rich soils now fade in importance. This often leaves just holly (*Ilex aquifolium*) and rowan (*Sorbus aucuparia*) as the most common companions in the understorey, with elder (*Sambucus nigra*) on more nutrient-rich soils.

On the most acidic soils, there is a continuing reduction in the contribution from many of these species, leaving just the oaks and birches dominant in the canopy, with sessile oak and downy birch now increasing their role. Holly and rowan are often the only components of the understorey.

Associated with these shifts in the composition of the tree and shrub elements, there are distinct differences in the field and ground layers of the woodlands on the various soil types. On the most base-rich soils, for example, it is herbs such as dog's mercury (*Mercurialis perennis*), wood avens (*Geum urbanum*), enchanter's nightshade (*Circaea lutetiana*),

Table 2.1 Woodland types: classification and nomenclature.

(a) Freely drained soils

Zone	*New native woodland type*	*Equivalent semi-natural woodland type in National Vegetation Classification (NVC)*		*Equivalent semi-natural woodland type in FA management guides (Forestry Commission, in press)*		
Lowland *south and east*	Lowland mixed broadleaved with dog's mercury	W8	*Fraxinus excelsior – Acer compestre – Mercurialis perennis* woodland	3	Lowland mixed broadleaved woods	Westerly examples of W8 are in upland ashwoods (see below)
	Lowland mixed broadleaved with bluebell/wild hyacinth	W10	*Quercus robur – Pteridium aquilinum – Rubus fruticosus* woodland			
	Lowland oak-birch with bilberry/blaeberry	W16	*Quercus* spp. – *Betula* spp. – *Deschampsia flexuosa* woodland	1	Lowland acid beech and oak woods	
	Beech-oak with wavy hair-grass	W15	*Fagus sylvatica – Deschampsia flexuosa* woodland			
	Beech-ash with dog's mercury	W12	*Fagus sylvatica – Mercurialis perennis* woodland	2	Beech-ash woods	
	(Yew woodland)	W13	*Taxus baccata* woodland			
	Beech-oak with bramble	W14	*Fagus sylvatica – Rubus fruticosus* woodland			
Upland *north and west*	Upland mixed broadleaved with dog's mercury	W9	*Fraxinus excelsior – Sorbus aucuparia – Mercurialis perennis* woodland	4	Upland mixed ashwoods	Upland mixed ashwoods also includes W8 sub-communities e–g
	Upland oak-birch with bluebell/wild hyacinth	W11	*Quercus petraea – Betula pubescens – Oxalis acetosella* woodland	5	(Oak-dominated) Upland oakwoods	
	Upland oak-birch with bilberry/blaeberry	W17	*Quercus petraea – Betula pubescens – Dicranum majus* woodland	6	(Birch-dominated) Upland birchwoods	
	Scots pine with heather	W18	*Pinus sylvestris – Hylocomium splendens* woodland	7	Native pinewoods	
	Juniper with wood sorrel	W19	*Juniperus communis – Oxalis acetosella* woodland	6	Upland birchwoods	Associated with birch and pine in mosaics
				7	Native pinewoods	

Table 2.1 Woodland types: classification and nomeclature *(continued)*.

(b) Wet soils

Zone	*new native woodland type*	*Semi-natural woodland type in National Vegetation Classification (NVC)*		*Equivalent semi-natural woodland type in FA management guides (Forestry Commission, in press)*
Mainly south	(Sallow with marsh bedstraw)	W1	*Salix cinerea – Galium palustre* woodland	8 Wet woodlands
Mainly south	Alder with common reed	W2	*Salix cinerea – Betula pubescens – Phragmites australis* woodland	
North	(Sallow with bottle sedge)	W3	*Salix pentandra – Carex rostrata* woodland	
Widespread (mainly north and west)	Birch with purple moor-grass	W4	*Betula pubescens – Molinia caerulea* woodland	
Mainly southern	(Alder woodland with tussock sedge)	W5	*Alnus glutinosa – Carex paniculata* woodland	
Mainly southern	Alder with stinging nettle	W6	*Alnus glutinosa – Urtica dioica* woodland	
Mainly upland (north and west)	Alder-ash with yellow pimpernel	W7	*Alnus glutinosa – Fraxinus excelsior – Lysimachia nemorum* woodland	

Note: New native woodland types in parentheses are described in the text, but no design prescriptions are given.

Figure 2.1 The lowland zone of Britain.

Lowland mixed broadleaved woodland with dog's mercury	Lowland mixed broadleaved woodland with bluebell/wild hyacinth	Lowland oak-birch woodland with bilberry/ blaeberry
Rendzinas and calcareous brown earths →	*Base-poor brown earths* →	*Rankers, podzolic and ironpan soils*

Figure 2.2 Mixed broadleaved and oak-birch woodlands of the lowland zone.

sanicle (*Sanicula europaea*), early dog violet (*Viola reichenbachiana*), lords and ladies (*Arum maculatum*) and wood false brome (*Brachypodium sylvaticum*) that give a distinctive character to the field layer. Or, on more clayey calcareous soils, derived from lime-rich shales or heavy drift, there can be an abundance of bluebell or wild hyacinth (*Hyacinthoides non-scripta*), wood anemone (*Anemone nemorosa*), primrose (*Primula vulgaris*) and, in parts of East Anglia, oxlip (*P. elatior*), ground ivy (*Glechoma hederacea*) and yellow archangel (*Lamiastrum galeobdolon*) (Plates 1 and 2). It is various mixtures of these plants, together with lime-loving mosses and liverworts of bare soil and exposed rock surfaces, that help give the **lowland mixed broadleaved woodland with dog's mercury** (numbered **W8** in the NVC scheme) its distinctive character.

On more base-poor brown soils, most of the strongly lime-demanding species among these field and ground layer plants disappear leaving bluebell as the most common spring dominant among the herbs (Plates 3 and 4). By mid-summer, however, the woodlands here often have a dense cover of bracken (*Pteridium aquilinum*) or thick tangles of bramble (*Rubus fruticosus*) and honeysuckle (*Lonicera periclymenum*) where the soils are a little more moist. Other characteristic associates of this **lowland mixed broadleaved woodland with bluebell/wild hyacinth (W10)** are red campion (*Silene dioica*), greater stitchwort (*Stellaria holostea*), wood sage (*Teucrium scorodonia*) and foxglove (*Digitalis purpurea*).

With the move on to the most acidic soils, only bracken from among these plants remains at all common in the **lowland oak-birch woodland with bilberry/blaeberry (W16).** The most common herbs are usually wavy hair-grass (*Deschampsia flexuosa*), tormentil (*Potentilla erecta*), heath bedstraw (*Galium saxatile*) and common cow-wheat (*Melampyrum pratense*). Where grazing is absent though, bilberry or blaeberry (*Vaccinium myrtillus*) can become very abundant with heather (*Calluna vulgaris*) in less shady places (Plate 5).

Although soil differences control much of the variation among these mixed broadleaved

and oak-birch woodlands, silvicultural treatments have also had a great impact on their composition and structure. Such treatments have not always reinforced the patterns of tree and shrub occurrence which are related to natural environmental factors: sometimes treatments have worked against that grain, obscuring such variation.

Thus, the removal or planting of trees for timber, or the selective coppicing of different underwood crops can produce a great diversity of tree and shrub cover in what is still essentially the same kind of woodland. The **lowland mixed broadleaved woodland with dog's mercury (W8),** for example, which has been a major source of wood and timber for centuries on the base-rich soils of lowland Britain, can be found as coppice of hazel, field maple or ash, or various combinations of these, with or without varying numbers of standards, usually common oak, sometimes ash, occasionally field maple; with large-coppice underwood of small-leaved lime or hornbeam or mixtures of the two, again with or without standards; with invasive suckering elms; as semi-natural high forest; and in older plantations, particularly of pedunculate oak or ash.

Conversely, identical silvicultural treatments applied to different kinds of woodland can result in stands which look very much alike in their tree and shrub cover and where, with dense shading, there may be little obvious difference in the sparse field and ground layers. The **lowland mixed broadleaved woodland with bluebell (W10),** for example, is also often found with the same woody cover of hazel, lime or hornbeam coppice as is seen in the **dog's mercury woodland (W8)** where these crops have been favoured on more base-poor brown earths.

Mixed broadleaved and oak-birch woodlands of the upland zone

A similar range of mixed broadleaved and oak-birch woodlands occurs in the uplands of Britain, but with some important differences which reflect the climatic contrasts of the north and west of the country and distinctive traditions of woodland use (Figures 2.3 and 2.4).

Figure 2.3 The upland zone of Britain.

Among the woodlands on base-rich soils in the north-west, for example, the effect of the cooler, cloudier and shorter summers of the region is well seen in the disappearance of various woody and herbaceous plants characteristic of the south-east. In the **upland mixed broadleaved woodland with dog's mercury (W9),** then, small-leaved lime, hornbeam, field maple, dogwood, wayfaring tree, purging buckthorn, lords and ladies, early dog violet and yellow archangel are all characteristically absent (Plate 6). Other species, by contrast, favouring the more montane climate, increase in frequency: bird cherry (*Prunus padus*), stone bramble (*Rubus saxatilis*), marsh hawk's-beard (*Crepis paludosa*), wood crane's-bill (*Geranium sylvaticum*), globeflower (*Trollius europaeus*) and melancholy thistle (*Cir-*

sium helenioides). And, with the more moist soils and higher humidity, there is often an abundance of ferns, notably hart's tongue (*Phyllitis scolopendrium*) and shield ferns (*Polystichum* spp.), and a much greater cover and diversity among the mosses and liverworts (Plate 7).

Upland mixed broadleaved woodland with dog's mercury		Upland oak-birch woodland with bluebell/wild hyacinth		Upland oak-birch woodland with bilberry/ blaeberry
Rendzinas and calcareous brown earths	→	*Base-poor brown earths*	→	*Rankers, podzolic and ironpan soils*

Figure 2.4 Mixed broadleaved and oak-birch woodlands of the upland zone.

Losses and gains in temperature-sensitive plants can also be seen on more base-poor soils in the north and west, where an **upland mixed broadleaved woodland with bluebell/wild hyacinth (W11)** is characteristic. Compared with its south-eastern counterpart, lime and hornbeam, together with yellow archangel and wood spurge (*Euphorbia amygdaloides*), are typically absent here while chickweed wintergreen (*Trientalis europaea*) is a distinctive addition among the herbs.

Increased humidity again encourages a rich fern flora, with broad buckler fern (*Dryopteris dilatata*) and its relatives becoming prominent, and abundant bryophytes. Higher precipitation towards the north and west also increases the tendency for the soils to become leached. Interactions between humidity and soil conditions play an important part in the increasing switch in these woodlands from pedunculate oak and silver birch to sessile oak and downy birch, but leaching also encourages the spread of lime-avoiding herbs like tormentil, heath bedstraw and wavy hair-grass into the bluebell woodland of the north-west, something not seen in the lowlands.

A further distinctive feature of the upland bluebell woodland is that stands are often grazed, being open to stock from the unenclosed hill land. Grasses such as creeping soft-grass (*Holcus mollis*), sweet vernal grass (*Anthoxanthum odoratum*) and common bent (*Agrostis capillaris*) are thus very common, while palatable plants (including the distinctive bluebell) can be much reduced in abundance (Plates 8 and 9).

Combinations of climatic and management effects have also left their mark on the **upland oak-birch woodlands with bilberry/blaeberry (W17)** which characterise the very acidic soils of the north and west. Sessile oak and downy birch, together with holly and rowan, are the distinctive species of the canopy here while among the heathy field layer there can be an extraordinary richness of mosses and liverworts, especially where woods develop over very rocky terrain in humid and sunless ravines (Plates 10, 11 and 12).

Beech woodlands

Within the south-east lowlands of Britain, it is possible to distinguish a more restricted climatic zone within which beech (*Fagus sylvatica*) is a natural dominant in a variety of woodland types (Figure 2.5). Beech became abundant as a forest tree after the Post-Glacial period in the warmest and driest parts of the country, south of a line from the Wash, across to south Wales and down to Dorset. What stopped its advance there is something of a puzzle: planted beech grows well and regenerates even in the north of Scotland, but its natural spread may have been dependent upon some combination of congenial climate and human activity like the clearance of existing forest and agricultural neglect.

Within this zone, beech can become a woodland dominant on virtually the complete range of free-draining mineral soils and we can recognise three kinds of beech woodland in Britain analogous to our lowland mixed broadleaved and oak-birch types. A **beech-ash woodland with dog's mercury (W12)** is characteristic of shallow rendzinas (Plate 13),

Figure 2.5 The zone of semi-natural beech woodlands.

a **beech-oak woodland with bramble (W14)** occurs typically on base-poor brown earths (Plate 14) and a **beech-oak woodland with wavy hair-grass (W15)** is found on acid rankers and podzols (Figure 2.6).

Beech-ash woodland with dog's mercury	Beech-oak woodland with bramble	Beech-oak woodland with wavy hair-grass
Rendzinas →	*Base-poor brown earths* →	*Rankers and podzols*

Figure 2.6 Soil variation and types of semi-natural beech woodland.

Each of these woodlands shows some distinctive floristic features in its field layer compared with its mixed broadleaf and oak-birch counterpart. In the calcicolous beech woodland, for example, sanicle, wall lettuce (*Mycelis muralis*), woodruff (*Galium odoratum*) and a number of orchids can be represented and, in the brambly beech woodland, wood millet (*Milium effusum*) is particularly characteristic. Often, however, the dense shade which beech casts and the fierce competition for water and minerals which its extensive root mat exerts greatly impoverish the associated herbaceous floras. In fact, in mature stands, it can be hard to tell the different kinds of beech woodland apart, so sparse are the characteristic field layer plants which survive. This convergence is accentuated by the tendency for shade-tolerant woody associates like holly and yew (*Taxus baccata*) to become abundant in all three types of beech woodland as a second tier to the canopy.

Each of the lowland mixed broadleaved and oak-birch woodlands can act as a forerunner to the beech-dominated counterpart but whether our beech woodlands themselves represent the inevitable climax forest over this part of southern Britain is unclear. Where soil conditions are such as to be equally favourable to woodlands with and without beech, there may be some natural cyclical replacement through time, one type giving way to the other.

Even within the natural range of beech, the woodlands that it dominates have often originated by planting or been greatly affected by silviculture, as beech is widely grown and harvested for its valuable timber. In the Chilterns, in particular, many stands show signs of former management under a selection system, though more recently clearfell or shelterwood regimes have predominated there and replanting often involved conifer nurses until the mid 1970s. Beech has also been widely planted beyond its natural range, and can dominate there in impoverished versions of its semi-natural woodland types.

Yew is a distinctive associate in all three kinds of beech woodland but, especially on

very warm and sunny south-facing slopes with rendzina soils, it can pre-empt beech in the process of invasion and become dominant in **yew woodland (W13).** More open stands can have plants like dog's mercury and stinging nettle, but the intense shade and very inhospitable soil conditions often make this one of the most species-poor of our woodland types in Britain. Yew is certainly worth planting as an element in various other kinds of woodland, but the interest of pure stands is usually in their great age and the individual contorted character of the trees, factors which make the use of the tree on anything but a small scale an unattractive prospect. This woodland type is therefore not included in the Design Prescriptions.

Scots pine and juniper woodlands

Scots pine (*Pinus sylvestris*) has been very widely planted as an ornament or substitute on mixed broadleaved and oak-birch woodland sites throughout Britain, and within the natural range of beech. In the Highlands of Scotland, however, it is possible to distinguish a zone where the tree has a natural role as the dominant in a **Scots pine woodland with heather (W18)** (Figure 2.7).

Figure 2.7 The zone of semi-natural pine woodland (native pinewoods).

This woodland type occurs predominantly on impoverished, highly acidic podzolised soils, sometimes with an ironpan and peaty top, and it has a similar complement of field layer plants to the **upland oak-birch woodland with bilberry/blaeberry (W17),** with some additional associates reflecting the often harsh montane climate. Heather, blaeberry and wavy hair-grass remain very common (Plate 15), but they are frequently joined here by cowberry (*Vaccinium vitis-idea*) and crowberry (*Empetrum nigrum*) and there can be striking rarities like lesser twayblade (*Listera cordata*), creeping lady's-tresses (*Goodyera repens*), twinflower (*Linnaea borealis*) and various wintergreens (*Pyrola* spp., *Orthilia secunda* and *Moneses uniflora*). The mixture of lime-avoiding bryophytes, which often form a luxuriant carpet over the ground, is also enriched by some distinctive species, notably the attractive moss *Ptilium crista-castrensis*, particularly in those scattered stands of this kind of woodland which occur in the more humid western Highlands.

There is little doubt that the more natural stands of Scots pine woodland represent fragments of a once much more extensive forest, providing an unbroken link with the landscape of the Post-Glacial period in the cooler parts of northern Scotland. Evidence also suggests that, in the past, the canopies of our native pine woodland were more varied than at the present time, with birch and juniper occurring often as integral elements of the wood cover. These days, even among the more extensive tracts of woodland in the eastern Highlands, we see a greater separation in the roles these species play, each tending to dominate different woodland types. It is also important to

remember that even the more varied stands of Scots pine woodland are just one element, albeit the most important, in the landscape of the 'Caledonian pine forest' defined in its broad sense. In that majestic scene, quite apart from stretches of oak-birch and juniper woodlands, there can also be birch-sallow woodland with purple moor-grass, sallow woodland with bottle sedge and alder-ash flushes with yellow pimpernel (see below).

Only in a very few places in the Scottish Highlands can **juniper woodland with wood sorrel (W19)** be seen as a convincing altitudinal replacement for sub-montane forest, as in the low-alpine zone of Scandinavian mountains. For the most part, this vegetation persists in northern Britain (Figure 2.8) as a scrubby forerunner to woodland in the upland fringes, which does not, for one reason or another, progress to the climax of the succession. More often, in the past, juniper scrub was an integral part of the development of Scots pine woodland, and it still occurs in close association with this vegetation on very acidic and impoverished soils, sharing much of the same field layer flora and ground carpet of mosses.

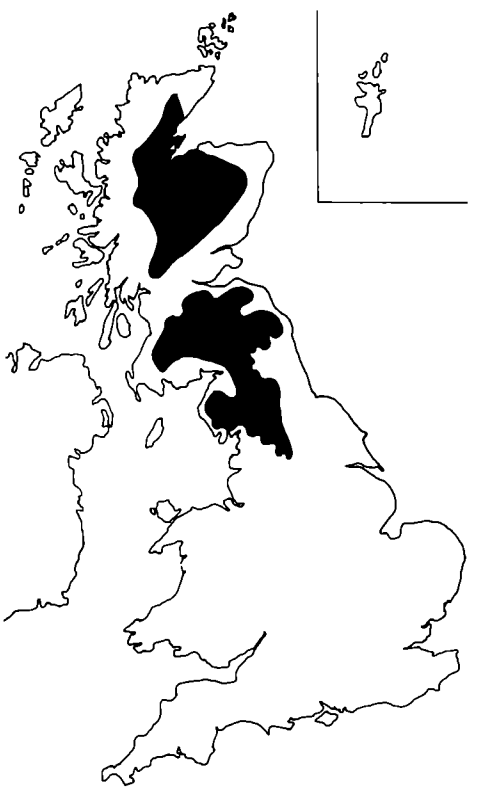


Figure 2.8 The zone of juniper woodland in the uplands.

Often, though, juniper woodland is found on better soils than this: circumneutral mull brown earths, sometimes quite nutrient rich. Then the associated flora is very similar to that in the **upland mixed broadleaved woodland with bluebell/wild hyacinth**, typical of mesotrophic brown soils throughout north-western Britain, with plants like common dog violet, wood sorrel, tormentil and heath bedstraw, occurring among a grassy ground of red and sheep's fescue, creeping soft-grass and sweet vernal grass. Outlying stands of this kind of woodland occur in the Lake District, the north Pennines, Northumberland and the southern uplands of Scotland, but the centre of the range is in the east-central Highlands of Scotland where wood anemone is a striking replacement for the more oceanic bluebell in this woodland, and other plants like chickweed wintergreen (*Trientalis europaea*) and hairy wood-rush (*Luzula pilosa*) reflect the boreal character of the climate (Plate 16). Where dense clumps of old juniper bushes give protection from grazing, tall herbaceous dicotyledons and ferns can also become luxurious.

Wet woodlands with alder, downy birch and willows

We can recognise a number of wetter woodland types in Britain characterised by the dominance in the canopy of alder (*Alnus glutinosa*), downy birch (only rarely silver birch in these more moist situations) and various willows, sallows and osiers (*Salix* spp.). In the early stages of colonisation around open waters and on wet ground there is often a strong element of chance in the mixtures of woody species invading, but, with time, the canopy composition stabilises. Then, with increasing terrestrialisation and deepening shade, the distinctive field and ground layers develop. In maturing woodlands of these

kinds, differences in species composition are usually related to variations in the wetness of the ground, the base-richness of the soils and waters, and the amount of nutrients in the system. Often the combination of conditions favoured by a particular woodland type is found in a distinctive kind of mire or flush, and the distribution of the woodlands is frequently related to the pattern of occurrence of such sites within regions of broadly suitable climate (Figures 2.9 and 2.10).

Figure 2.9 The main zones of wet woodlands on fen peat.

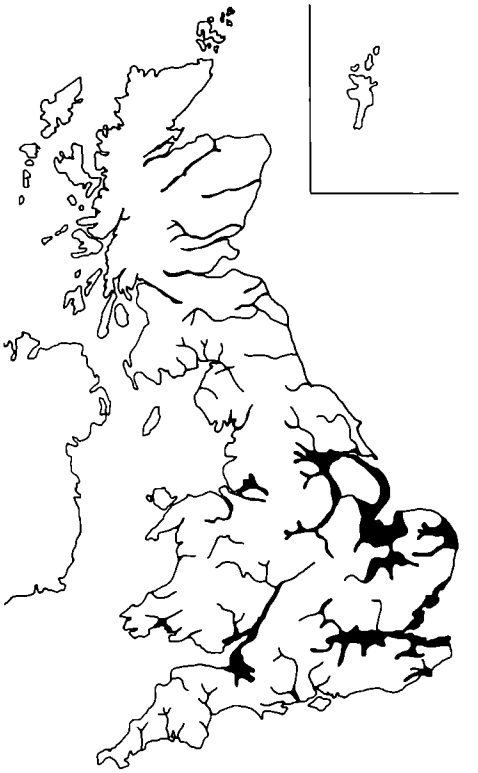


Figure 2.10 The main zones of wet woodlands on alluvium.

Two types of wet woodland can develop early in the primary colonisation of swampy vegetation around standing or sluggish open waters. In more base-rich and eutrophic systems, where fen peats accumulate in floodplains, basins and valley fens, **alder woodland with tussock sedge (W5)** is characteristic. Here, alder and grey sallow (*Salix cinerea*) are the most common invaders of sedge swamp with the great tussock sedge (*Carex paniculata*), lesser pond sedge (*C. acutiformis*) and tufted sedge (*C. elata*) and a rich flora of tall fen herbs and ferns (Plate 18). More local, and largely confined to northern Britain, where suitable swamps are open to invasion around basin mires with more base-poor and nutrient-poor waters, is the **sallow woodland with bottle sedge (W3).** Alder has often not reached these isolated sites and the most frequent colonising trees are grey sallow and the northern bay willow (*Salix pentandra*), with bottle sedge (*Carex rostrata*) accompanied, in what are often floating rafts of field layer vegetation, by associates characteristic of poor fens (Plate 19).

Where the influence of base-rich and quite eutrophic waters remains strong in lowland fens (Plate 20), but where the peat surface is raised above the limit of winter flooding, **alder woodland with common reed (W2)** develops. The commonest colonisers in such situa-

tions, in the primary successions developing in floodplains, basins and valley fens, or where mowing-marsh has been abandoned, are grey sallow, downy birch and alder. The field layer inherited from the tall-herb fen usually has much common reed (*Phragmites australis*) with plants like meadowsweet (*Filipendula ulmaria*), hemp agrimony (*Eupatorium cannabinum*), wild angelica (*Angelica sylvestris*), marsh thistle (*Cirsium palustre*) and, more locally, yellow loosestrife (*Lysimachia vulgaris*) and purple loosestrife (*Lythrum salicaria*) (Plate 15). Then, as these become sparse with the drying of the ground, bramble and broad buckler fern can appear with a patchy carpet of rough meadow grass, while ash, guelder rose and hawthorn grow up among the canopy.

In still more nutrient-rich systems, where fen peats have been drained and disturbed, or the waters enriched with nutrients, or where rich alluvium accumulates in mature river valleys or around silting water bodies, **alder woodland with stinging nettle (W6)** is characteristic. Along with alder, grey sallow is a common invader here, but various other *Salix* spp. can also attain prominence, like the osier (*S. viminalis*), purple willow (*S. purpurea*) or almond willow (*S. triandra*) or, on wet river terraces, the crack willow (*S. fragilis*). More species-rich stands can have remnants of a fen flora, but characteristically it is plants like stinging nettle (*Urtica dioica*), great willowherb (*Epilobium hirsutum*), bitter-sweet (*Solanum dulcamara*) and goose-grass (*Galium aparine*) that form an often patchy and tangled field layer in this kind of woodland.

Even in floodplain fens it is possible to find more acidophilous areas of woodland which have developed where the peat surface is out of reach of the influence of the base-rich ground waters. In such situations, downy birch tends to be the leading woody invader and bog mosses (*Sphagnum* spp.) form patchy carpets among the reed, with calcifuge herbs also making an appearance. However, damp acidophilous birch woods are much more commonly found where true bog peats, in basin and raised mires and on the fringes of blanket mires, are invaded by trees as the ground dries and is freed from grazing. In the **birch woodland with purple moor-grass (W4),** downy birch, often with a little grey sallow, forms a generally open and rather decrepit canopy, with a field layer of purple moor-grass (*Molinia caerulea*) and a variety of *Sphagna.* Fragments of the original bog or wet heath flora often persist in this sort of woodland, and there can be a patchy prominence of grasses, sedges and rushes (Plate 17).

Such woodland can extend into lowland valley bogs and into the water tracks and hillslope flushes of the upland fringes, where peaty gleys are kept very wet by seepage of base- and nutrient-poor waters. However, in more base-rich flushes on valley sides in the wetter parts of southern Britain, and more widely in the north and west, where surface-water gleys show some local nutrient-enrichment, the **alder-ash woodland with yellow pimpernel (W7)** is characteristic. Downy birch and grey sallow can remain frequent here, but alder is generally the leading tree along with some ash. Yellow pimpernel (*Lysimachia nemorum*), creeping buttercup (*Ranunculus repens*), meadowsweet (*Filipendula ulmaria*), opposite-leaved golden saxifrage (*Chrysosplenium oppositifolium*) and lady fern (*Athyrium filix-femina*) are typical herbs, together with bulky dominants like soft rush (*Juncus effusus*), tufted hair-grass (*Deschampsia cespitosa*), pendulous sedge (*Carex pendula*), remote sedge (*C. remota*) and smooth-stalked sedge (*C. laevigata*) (Plates 21 and 22).

Finally, among these wetter woods, we can distinguish a **sallow woodland with marsh bedstraw (W1),** where grey sallow is often the only woody plant over mixtures of soft rush, common marsh bedstraw (*Galium palustre*), water mint (*Mentha aquatica*) and a variety of other water margin herbs. This can be found on waterlogged mineral soils of moderate base-status throughout the country, as in wet neglected pasture, for example, but it is especially well developed in more sheltered situations around the west coast, in cliff-top flushes and around dune slacks.

Chapter 3

Methods of Creating Native Woodlands

For those wishing to establish new woodlands of native species where the composition and structure of tree, shrub and field layers eventually approach those of semi-natural woods, this section sets out general advice on location, design and early management. The guidance given is broad and qualitative so that it applies to most of the woodland types. Moreover experience of creating and monitoring woodlands in these ways is very limited in Britain, so precise quantitative advice is not yet possible on many aspects.

Woodland design

When a new native woodland is planned, thought must be given to a number of aspects of design, including:

- location
- design at the landscape scale
- use of natural colonisation
- species choice for planting
- planting patterns
- the planting of sensitive species.

Location

As with all new woodlands, careful consideration must be given to where new native woods are located. Although the new woodlands should eventually develop into valuable wildlife habitats, placing them on open ground which currently has a high nature conservation value could result in a net loss of value to society. Avoiding the rare lowland heaths of southern England is one example.

Wetland habitats such as fens or raised mires may also be adversely affected by woodland established on adjacent land. Sometimes, however, the value of open semi-natural habitats might be conserved or enhanced by the sensitive establishment of new native woodland over part of the area. On moorland, for example, the conversion of some rank bracken (*Pteridium aquilinum*) or purple moor-grass (*Molinia caerulea*) areas to native woodland might often be regarded as beneficial to nature conservation as well as to the scenic value of the landscape.

Where new native woods are established on more disturbed sites, such as improved pastures or arable fields, i.e. semi-natural habitats have already been lost, a net gain for nature conservation will often result even though the prospects of developing an ecosystem like that of old semi-natural woodland may be poor, except in the very long term.

However, each case must be treated on its merits and, where there is doubt, advice should be sought on the current status and value of the proposed site from the appropriate national conservation agency.

Design at the landscape scale

In cases where establishing some area of new native woodland is judged to be desirable, its size and situation should be influenced by the character of the landscape of the whole locality and the distribution of existing tracts of woodland and other semi-natural vegetation, as well as by the pattern of topography and soils.

Proximity to potential colonising sources of plants and animals is important, especially in the dry arable lowlands, where woodland species are often slow colonisers confined to existing woods and hedgerows.

In the more moist west and north, notably in semi-natural landscapes in the uplands, colonisation is likely to be less restricted as many woodland species are also found in patches of moorland, grassland or wetland habitats, and even on roadside verges.

Even in the uplands, however, siting new native woods adjacent to semi-natural woodland on similar soils will normally be the most favourable location to encourage colonisation. Riparian areas by streams should also be considered because they are frequently refuges for the native flora and fauna which have been depleted in the wider catchment by more intensive land uses. Dispersal and colonisation are also assisted by running water and some species such as alder are adapted to water-borne dispersal.

The size and shape of a new native wood may also affect the development of the field layer and consequently the woodland fauna. Small stands, especially narrow belts with a high proportion of well-lit woodland edge, are unlikely to develop a complete woodland flora. In the eastern lowlands of England, new woodlands may need to be at least 2 ha and perhaps over 5 ha to enable them to support the more slowly colonising and exacting woodland plants (Hooper, 1977; Usher *et al.*, 1992). However, the size required is likely to depend also on the proximity of colonising sources and on shape and no precise threshold can be defined.

The design of size, shape and location can be assisted by landscape design guidelines (Forestry Commission, 1991). It is important to realise, however, that there are often good ecological reasons for choosing distinctive patterns of woodland types for a particular locality. Very commonly, for example, **mixed broadleaved woodland with bluebell (W10)** is found on gentler slopes below rocky ground with **oak-birch woodland with bilberry/blaeberry (W16)** where base-poor brown earths pass to podzolised rankers. At the junction of the two, where groundwater emerges in a flush as it meets impermeable shales, there is often a stand of **alder-ash woodland with yellow pimpernel (W7)**. Such patterns can be mimicked when planting trees and shrubs over similar slopes (Figure 3.1). Characteristic patterns in relation to landform and geology are described in more detail for individual woodland types in the design prescriptions. Ecologically informed design of this type can be used to create a mosaic of woodland types suited to the varying landform and soils.

The design of new native woodlands should also include open areas. These should be sited first in habitats naturally less suited to woodland such as wetland, crags, screes, shallow soils and exposed ridges. These habitats are usually of intrinsic value for nature conservation and will contribute to the structural diversity and amenity value of a woodland (Figure 3.2). Some further open ground in places which are capable of becoming wooded can be of great value for a variety of purposes such as nature conservation, amenity, recreation, deer management and field sports. This more artificial open ground can be designed to include the range of soil or vegetation types present or any notable habitats which are to be conserved. Interconnected open areas flowing irregularly through the woodland can provide important dispersal and colonisation networks for animals, and perhaps plants (Forestry Commission, 1990), although the degree to which these are used by different species is not yet known.

Open areas may also be used around the edge of new native woodland along with variable tree spacing to integrate a woodland more naturally into the landscape in terms of vegetation pattern and scenic appearance (Figure 3.3). The edge zone or ecotone which is thereby created is a distinctive habitat in itself, intermediate in character between woodland and open ground and often attractive to birds and insects.

The amount of open ground within any new native woodland should not follow any fixed formula but depend upon the character of the ground and the particular mixture of objectives which have been agreed. An indication of any characteristic pattern of tree spacing and open areas is given in the Design Prescriptions for individual woodland types.

Open areas can also be used within schemes which are partially planted to allow for future natural colonisation, as described below. This can be used to reduce the possible drawbacks of the large-scale establishment of a new native woodland, over a short timescale, that is, a limited structural diversity and a tendency to use more intensive methods of cultivation and planting instead of natural colonisation. Thus, the more sensitive or fragile parts of the site might be left for natural colonisation to occur gradually, thereby spreading the age structure of the wood.

Using natural colonisation

Natural colonisation of unwooded sites is theoretically preferable to planting for the creation of new native woodlands because it should result in a more natural matching of trees and shrubs to the local conditions and consequently a more irregular structure and natural appearance. Natural colonisation is also more likely to conserve local genetic distinctiveness and diversity than planting.

In many cases, however, seed sources for some or all of the characteristic trees and shrubs desired for a site may not be present nearby and planting may be necessary, for some species at least. The birch species, rowan and many willows can readily colonise more distant sites where conditions are suitable and may dominate a new woodland in the early stage. To some extent, this is a natural pioneer phase and these trees may help to create conditions more suitable for slower colonisers such as oaks or beech to establish themselves later. However, a high density of early colonisers may restrict opportunities for others, especially where their seed sources are scarce. A balance must be struck, according to local circumstances and management objectives, between planting and encouraging natural colonisation (with or without management) to allow for future infiltration by missing species.

Much will depend on the establishment timescale which is envisaged and the proportions of particular species, e.g. timber-yielding trees, which are desired. Where planting is used, some space should be left on all the soil types present to allow for the possibility of natural regeneration and colonisation in future. These open areas should be substantial: sometimes as much as half the site in total, and normally at least 20%. Some of this ground will not become wooded and will contribute to the long-term open habitats of the woodland.

Species choice for planting

Where natural regeneration is thought likely to be inadequate and on sites isolated from seed-parents, planting will be necessary to establish new woods with the full complement of appropriate trees and shrubs.

The planting recommendations in this Bulletin are based on the natural distribution patterns of native trees and shrubs on different soils throughout Britain. Past planting has often obscured these patterns but, in new native woodland, such patterns can be re-established. This is of much greater ecological value than trying to maximise diversity as such in any site or locality, which would lead to greater similarity between woods and lower diversity at a regional and national scale.

Therefore, when creating new native woods, the trees and shrubs listed should not be planted outside their natural ranges and, even within their ranges, care should be taken to respect local patterns of distribution. This is important even with such common trees as the two oak species which show different natural distribution patterns across the country as a whole and in particular regions. Where the species can be distinguished, care should always be taken to maintain the relative proportions of pedunculate oak (*Quercus robur*) and sessile oak (*Q. petraea*). In particular, the former, which has been much favoured in the past, should not be planted in areas where apparently pure populations of sessile oak are to be seen in nearby semi-natural woodlands. Among the lists of recommended trees and shrubs, an indication is given where a species is especially characteristic of part of its overall range, or likely to show patchy abundance.

While species composition and structure are the most important aspects of design, con-

sideration should also be given to the genetic origin of the planting stock (Kinloch *et al.*, 1986; Worrell, 1992). This is especially important in the vicinity of long-established semi-natural woodlands, where local sources should be used. Elsewhere, planting stock should at least be of British origin and ideally from similar site types within the native range of the species.

Even with a widespread tree such as common hawthorn (*Crataegus monogyna*), the use of imported material from elsewhere in Europe can result in eccentric flowering times quite out of keeping with the British landscape and ill-coordinated with the emergence of many dependent insects. And, with a species such as juniper, which shows a great diversity of growth form from place to place, some of it probably genetically controlled (McVean, 1992), care should be taken not to introduce specimens that will develop a locally atypical appearance, or an unsuitable growth form for the particular environment.

Under EEC regulations, the seed or cuttings of some species must be collected from a registered source if seed or young plants are to be sold. Of our native species, the oaks, beech, Scots pine, black poplar, and aspen are covered by these regulations. The EEC criteria for registration are based on timber quality, which can restrict the potential for collecting from local sources in some areas. However relaxations of the EEC criteria are possible in some circumstances, e.g. for Scots pine in native pinewoods. Advice should be sought from the Forestry Authority where there is doubt.

Certain rarer trees and shrubs are not generally recommended in this Bulletin for planting in new native woodlands, even though they occur in distinctive kinds of semi-natural woodland. This is because their distribution patterns are of intrinsic importance and they could be altered by planting. If any planting of these species is undertaken, it should be recorded and monitored and special care taken to use local stock (Soutar and Peterken, 1989). These species and their characteristic woodland types are:

Small-leaved lime (*Tilia cordata*) in woodland types W8 and W10

Large-leaved lime (*Tilia platyphyllos*) in W8

Wild service tree (*Sorbus torminalis*) in W8

Midland hawthorn (*Crataegus laevigata*) in W8 and W10

Rare whitebeams of the *Sorbus aria* group, including *Sorbus rupicola, S. lancastriensis, S. devoniensis*, in W9

Box (*Buxus sempervirens*) in W12

Wild pear (*Pyrus communis*) in W8.

Because of their complex genetics and uncertain vulnerability to Dutch elm disease, all elms other than wych elm (*Ulmus glabra*) have also been omitted from the lists for planting. Sea buckthorn (*Hippophae rhamnoides*), a native shrub which is valued for planting on sandy soils in areas subject to salt-laden winds, has also been omitted because of its very aggressive character.

All these species should be welcomed as natural colonisers of new native woodlands where they do occur with the possible exception of the sea buckthorn in situations where it is liable to spread rapidly.

All exotic trees and shrubs have been excluded from the design prescriptions, including long naturalised species like sycamore (*Acer pseudoplatanus*), sweet chestnut (*Castanea sativa*) and European larch (*Larix decidua*). These species and other exotics will frequently colonise new native woodlands to some extent and decisions will need to be made about whether to rigorously remove, control or ignore them. Sycamore, for example, is a ready and prolific invader of moist, but free-draining, and nutrient-rich soils throughout Britain and can establish itself with some abundance in mixed broadleaf and wet woodlands of a variety of types (particularly W6, W7, W8, W9, W10 and W11). Sweet chestnut has become abundant in a much more restricted zone in the warmer parts of south-east Britain, but is especially tolerant of strongly waterlogged soils and has often been selected for use as a coppice crop in mixed broadleaf woodlands on heavy clays

(mostly types of W10). Larch can invade mixed broadleaf woodlands, too, but together with various species of spruce and pine, including *Pinus sylvestris* planted outside its native zone, it will also colonise more acidic and nutrient poor soils, naturalising in oak-birch woodlands (W11, W16, W17).

Decisions about whether to remove or control these species will be influenced by the likelihood of rapid invasion and dominance by the trees in question, their value for conservation and other purposes and the mix of objectives in the establishment of particular new native woodlands.

Two other species, which should be rigorously removed as soon as they appear, are rhododendron (*Rhododendron ponticum*), which has become very prominent among some mixed broadleaf (W10 and W11) and particularly oak-birch woodlands (W16 and W17), and Japanese knotweed (*Reynoutria japonica*), which invades damp riverine and mixed broadleaf woodlands (W6, W7, W8, W10). These plants are very aggressive invaders, quickly overwhelming the native field layers and hindering regeneration of native trees and shrubs.

Planting patterns

Semi-natural woodlands show a great variety of structure and species-composition even within a single woodland type, resulting from a combination of natural site factors and management history. This allows considerable scope for imaginative variation in the design of new native woodlands in terms of the proportions of trees and shrubs and the structure, both horizontally over the ground (woodland structure) and vertically in the layering of canopy and understorey (stand structure).

Some woodland types show great variations in the structure of existing stands, for example, the **lowland mixed broadleaved woodland with dog's mercury (W8)** while others are more simple and consistent such as the **birch woodland with purple moor-grass (W4)**. Especially distinctive patterns are indicated in the design prescriptions and planting in new native woods should be designed to develop a composition and structure appropriate to the woodland types which it is intended to encourage. The best guarantee of success is to match sensitively the species choice and planting pattern to the natural character of the site: notably the landform, soil and existing vegetation.

There is no point in precisely designing the detail of future canopy structure, because nature will inevitably alter the details. A robust but varied pattern which gives each species a good chance of contributing to the mature woodland structure in the right places and without relying heavily upon future stand management will generally be best. Repetitive formula-driven patterns should be avoided as they will prevent a natural appearance and reduce the variety of potential niches for wildlife.

A combination of planted clumps and open areas should be used. Subject always to the overriding dictates of the site characteristics, there are six main variables which can be used to develop a planting pattern.

- Species composition of clumps
- Clump size and location
- Spacing of trees and shrubs in adjacent clumps
- Spacing of trees and shrubs within clumps
- Size of gaps between clumps
- Size and location of larger open areas

Experience with intimate mixtures has shown that it is often difficult to maintain all the species used. Growth rates are frequently badly matched and slower growing species are eliminated. Thus, particularly where future tending operations such as respacing and thinnings are not envisaged, the use of intimate species mixtures, i.e. within clumps, should be carefully restricted. It is best to use two or three well-matched species at most (Figure 3.4). Table 3.1 lists some combinations of broadleaved trees which have been found to be suitable.

The chances of maintaining an intimate mixture after canopy closure can be improved by using small clumps with gaps between adjacent clumps to allow sidelight. However, the eventual canopy structure may then be

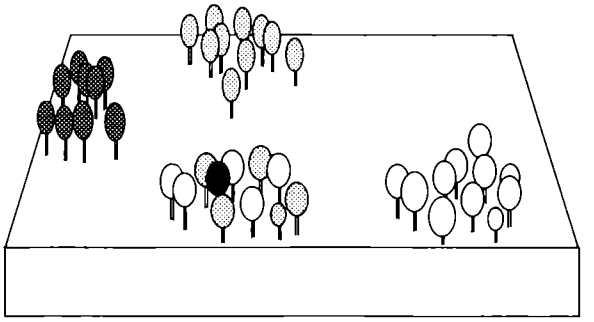


Figure 3.4 Using pure clumps or clumps with two or three well-matched species to develop mixed woodlands.

only slightly different from that produced by using small clumps of a single species. Intimate mixtures within clumps could therefore be avoided except where they serve a specific purpose, such as softening species or woodland type boundaries. Great variety can be obtained by altering the other variables, and using single species clumps ranging in size from single isolated trees to larger stands of 50 m or more in width (Figure 3.5). Clumps of slow-growing trees or shrubs should be large enough to prevent excessive shading by adjacent groups of taller trees (Figure 3.6). Gaps between adjacent clumps can be varied from about 7 m (which will eventually close over in most cases) to 20 m or more (Figure 3.7). Gap-widths equivalent to the height of the mature canopy will stay well lit, favouring plant and animal species of woodland margins and open ground but perhaps hindering colonisation by shade-tolerant woodland herbs. These would be more quickly favoured by smaller gaps of 10 m or so.

Table 3.1 Examples of successful mixtures of native timber trees (adapted from Evans 1984).

Intimate even aged mixtures	Ash with alder
	Beech with gean
	Oak with alder
	Oak with ash
	Oak with gean
Nursing mixtures for shelter and frost protection	Birch nursing oak[a]
	Birch nursing beech[a]

[a] Oak or beech can be planted at the same time or after birch, depending on birch density and degree of protection required.

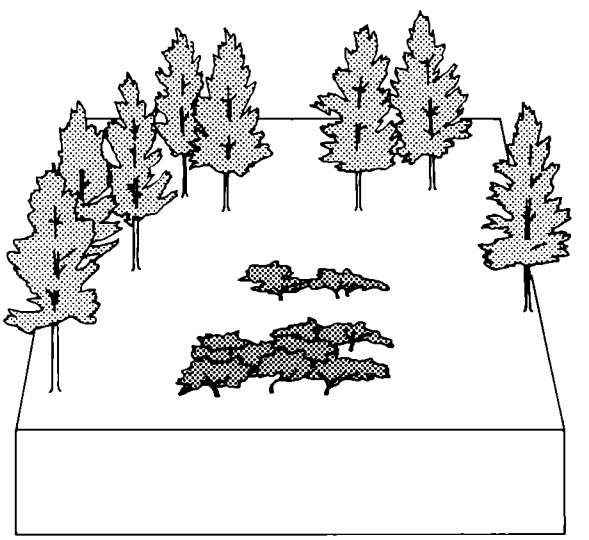


Figure 3.6 Allowing enough room around shrubs to prevent excessive shading by adjacent trees.

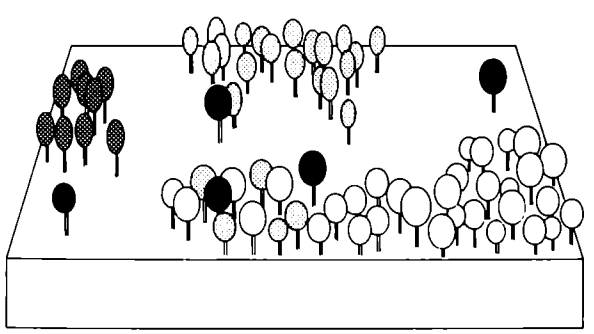


Figure 3.5 Using varied clump size to increase diversity in new native woodlands.

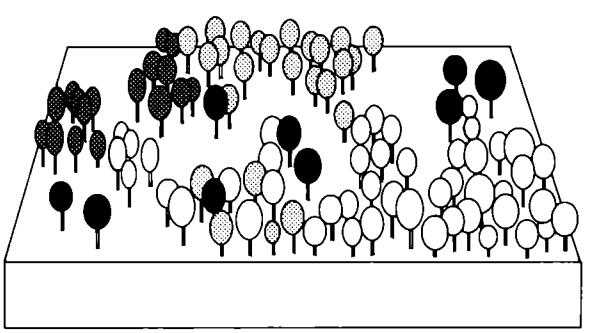


Figure 3.7 Using varied spacing between clumps to increase diversity in new native woodlands.

Larger open areas greater than about 25 m across can be used to provide glades and accommodate valuable habitats as well as to allow for future colonisation and regeneration of trees. Spacing within clumps or in adjacent clumps can also be varied to avoid the appearance of rows and grids and to provide a range of light and other conditions which should favour wildlife diversity (Figure 3.8). Close spacings of 2 m or less should be used where timber quality is important and also to accelerate canopy closure to provide earlier opportunities for specialist woodland plants and animals to colonise. Spacings of 3–5 m will result in slower canopy closure and a bushier form of tree or shrub. The simpler tactic is to vary spacing in adjacent clumps rather than within a single clump, but the latter method will be valuable on irregular sites.

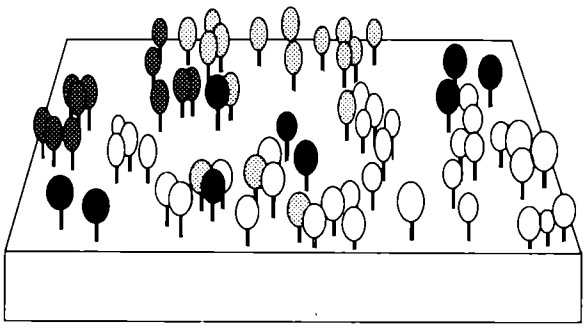


Figure 3.8 Using varied spacing within clumps to increase diversity in new native woodlands.

All of these guidelines should be used flexibly and the pattern should be dictated primarily by the character of the site.

Planting sensitive species

Some trees and shrubs which are found in old semi-natural woods are rather sensitive to conditions which may be found in newly established woodlands such as exposure, frost and strong weed competition. These species tend to colonise later in natural successions and are adapted to moderate shade and shelter and to well-developed woodland soils. Beech, hornbeam, holly and yew are examples.

Delaying the planting of these species until other trees are established to provide suitable conditions, or to await natural colonisation, are possible tactics. However, delayed planting has not had a happy history, as the younger trees tend to be overlooked in subsequent management and become browsed by rabbits and deer which colonise the adjacent thickets.

The most practical solution for sensitive species where prospects of adequate natural colonisation are poor is generally therefore to plant them at the start, but to take special care to restrict them to the most suitable parts of the site and to favour them in subsequent tending operations.

Management practices

A number of management practices can have a marked influence on the development of the communities of plants in any new woodland and uniform standards of silvicultural treatments work against the emergence of diversity in composition and structure. Among lowland broadleaved plantations in Britain, for example, disturbance and uniformly dense shade have tended to favour a convergence of many potentially varied woodland types to a gloomy, species-poor and rank variant of **lowland mixed broadleaf woodland with bluebell (W10),** often without bluebells! (Anderson, 1979; Rodwell, 1991). Some sensitive variation of practice is therefore necessary, together with an awareness of the impact of different operations upon the developing woodland types. Knowledge of the precise effects of various management practices and their persistence is insufficient for detailed recommendations to be given, but enough is known about their broad influences (Tables 3.2 and 3.3) to say that the scale, frequency and intensity of disturbance in general should be low, especially on wet or fertile soils.

Ground preparation

Cultivation and drainage may be desirable to assist establishment for a variety of reasons (Hibberd, 1991). These include providing a

Table 3.2 The influence of design and early management upon the development of field layer plant communities in new native woodlands.

Factor	General effects	Effects on species composition in various types of planted woods sampled by Rodwell and Cooper (1990)				
		Oak-birch woodland with bilberry/ blaeberry (W16, W17)	*Oak-birch woodland with bluebell/wild hyacinth (W10, W11)*	*Alder-ash woodland with yellow pimpernel (W7)*	*Upland mixed broadleaved woodland with dog's mercury (W9)*	*Birch woodland with purple moor-grass (W4)*
Ploughing and drainage	Long-term patterning along ridges + furrows + drains. Loss of microsite variety Drying and nutrient-mineralisation cause initial loss of wetland plants and spread of common 'weedy' species	*Vaccinium myrtillus* and *Deschampsia flexuosa* dominate on ridges. Very little in furrows due to deep litter layer	*Deschampsia flexuosa* on ridges, *Holcus mollis* in furrows. Bramble, raspberry and bracken tend to spread	*Juncus effusus* and *Deschampsia caespitosa* spread on gleyed soils and reduce diversity. Nettle, goosegrass and other 'weedy' herbs spread on drier soils	(Often too steep to cultivate) Loss of moisture loving herbs, spread of *Brachypodium sylvaticum*	Loss of mire species and dominance by *Deschampsia flexuosa,* ericaceous species, *Molinia caerulea,* or rushes
Fertiliser	Nutrient-enrichment encourages invasive weedy species	Transition to W10, W11 may occur but leaching in wet areas may offset this	Bramble is encouraged as are soft grasses	Not likely to be needed. Will favour nettles and other demanding 'weeds'	Increase of nutrient demanding species (e.g. nettle, goosegrass)	Combined with cultivation and drainage, fertiliser reinforces the dominance of *Molinia* and losses of small herbs and remnant mire plants
Dense uniform canopy	Reduces diversity and vigour of field layer, especially on wetter soils and on acid infertile soils, where a vernal flora is largely absent	Loss of ericaceous species which may be difficult to regain later	Vernal flora, e.g. bluebell, can still colonise, but sparsely. Ivy spreads in mild western areas	This type has a naturally open canopy. Dense shading will prevent the colonisation of many typical herbs, e.g. *Filipendula ulmaria*	Many species can survive moderate shade (e.g. dog's mercury and ramsons) but ivy can spread and create a species-poor version of the type	Naturally has an open canopy. Dense shade eliminates ericaceous and some mire species and leads towards W16, W17 types

Table 3.3 Field layer plants favoured by disturbance. Examples of species which commonly showed greater than expected abundance, compared to semi-natural woods in a survey of upland broadleaved plantations (adapted from Rodwell and Cooper, 1990).

Sample group	A	B	D	F	E	C	G[a]
Equivalent semi-natural woodland NVC type	*Upland oak-birch woodland with bilberry/blaeberry (W17)*	*Lowland oak-birch woodland with bilberry/blaeberry (W16)*	*Upland oak-birch woodland with bluebell/wild hyacinth (W11)*	*Lowland mixed broadleaved woodland with bluebell/wild hyacinth (W10)*	*Alder woodland with yellow pimpernel (W7)*	*Birch woodland with purple moorgrass (W9)*	*Upland mixed broadleaved woodland with dog's mercury (W9)*
Yorkshire fog *Holcus lanatus*			•	•	•	•	
Rough meadow grass *Poa trivialis*		•	•		•	•	
Bramble *Rubus fruticosus* agg.			•		•		
Soft rush *Juncus effusus*			•			•	
Tormentil *Potentilla erecta*			•		•	•	
Broad buckler-fern *Dryopteris dilatata*	•			•			

• Sample groups in which the species was more abundant than expected.

[a] All samples in this group were on previously wooded sites.

well-aerated, weed-free planting position, leading away excess surface water or lowering the water table and disrupting subsurface barriers to tree root penetration such as iron and clay pans and indurated layers. However, because deep and extensive forms of cultivation, notably ploughing, disrupt the natural profile of the soil, increase nutrient levels at the surface and reduce the variation in physical conditions, they tend to restrict the range of microsites available and may hamper the development of the full range of desired plants and animals in the new native woods.

Drainage can be an especially drastic change leading to the destruction of existing flushes and bogs and wasting the opportunity of using these to encourage wetter woodlands. Where these types are desired, all mechanical cultivation and drainage is best avoided, the sites being left unplanted for natural colonisation or provided with aerated planting positions by hand-turfing. Even on somewhat less wet but still heavy soils, as around flush margins or over plateaux and hollows with clays, manual turfing is ideally preferable to using tractor-mounted equipment, at least until knowledge of their impacts is improved. If tractors are used, mounding with a continuous-acting mounder is generally preferable to excavator mounding or ploughing, as it has less disturbance and drainage effect.

The disturbance, nutrient enrichment, and compaction produced by using tractor equipment on heavy mineral gleys can also favour the spread of some troublesome aggressive plants, such as tufted hair-grass which in young **mercury woods** or around **alder-ash flush woods** can be a vigorous competitor to young trees and shrubs. Rushes, too, especially soft rush, can become abundant in such situations. On drier soils, brambles may spread with cultivation and overwhelm the developing field layer in young **bluebell woods**, and wood false-brome becomes unusually abundant in cultivated **mercury woods** on free-draining base-rich soils. Bracken is a common dominant on cultivated and newly planted ground with free-draining acid soils where **upland bilberry/blaeberry woods** are being sought.

The production of regular ridges and furrows in ploughing also lends a highly artificial relief to the ground which can be reflected in long-persistent patterning among the developing woodland flora. In **upland bluebell/wild hyacinth woods**, for example, ridges are often picked out by the dominance of wavy hair-grass, and furrows by creeping soft-grass; the former shedding, the latter accumulating litter. On more base-poor soils, blaeberry often joins wavy hair-grass on the ridges, the troughs tending to be so choked with decaying organic matter as to exclude any herbaceous plants or bryophytes. Wet birch woods on ploughed peat may have wavy hair-grass or purple moor-grass on the ridges with bog-mosses restricted to the hollows.

The degree and persistence of these cultivation and drainage effects in relation to site type and cultivation method is not well known at present and so it is better to err on the side of caution. Generally the effects upon composition of the field layer are likely to be greater and more persistent with ploughing and ditching than scarifying or mounding and effects may be more persistent on wet sites and on fertile soils, especially those in low rainfall areas.

On freely-draining podzolic soils in the uplands the rate of leaching of nutrients may make the enrichment effect of cultivation relatively short-lived, but the patterning of ploughing could still persist for many decades. Superficial patch scarification on these soils may have relatively little effect on the long-term development of the flora and fauna and should be the preferred method.

Fertilisers

Cultivation often has the effect of enriching the nutrient status of the soil by enhancing aeration and the rate of oxidation of organic matter. Application of fertiliser further enhances the growth of more nutrient-demanding plants, such as purple moor-grass on peat, rosebay willowherb on more base-poor soils, bramble on somewhat better quality brown earths and stinging nettle and goosegrass on moist clayey soils and loams.

Each of these is a natural element of various woodland types, but overwhelming dominance of each results in marked impoverishment of the respective field layers. Colonisation by less competitive woodland plants may be delayed and the persistence of these effects may be considerable.

In order to minimise such problems, fertilisers should be confined to sites where they are essential for establishment and even then only applied around the individual trees and shrubs, so as to avoid widespread enrichment. Special care should also be taken near streams and flushes to avoid exporting nutrient enrichment into drainage systems. The careful selection of appropriate tree and shrub species, as recommended in the prescriptions in Chapter 5 should minimise the need for fertiliser.

Narrow woods in arable landscapes are vulnerable to fertiliser enrichment from spray drift or in drainage water from adjacent land and this should be taken into account at the design stage.

Herbicides

Herbicides may often be preferable to cultivation in suppressing weeds and hastening tree growth especially on fertile brown earths. They should be applied as selectively as possible, however, avoiding desired plants or uncommon species. One-metre spot applications around the planted trees are normally preferable to band or overall treatments, except where the aim is to eradicate bracken or pernicious exotics such as rhododendron. Another use of herbicide is to eliminate rank weedy field layers in disturbed farm, urban or reclamation sites, both to hasten tree growth and to provide opportunities for woodland plants to invade or to be introduced (see page 30). Techniques for herbicide application should follow those in Forestry Commission Fieldbook 8 (Williamson and Lane, 1989).

Grazing

Grazing and browsing by large herbivores are natural features of many woodland ecosystems, although the type and the number of grazing animals are now very different from those in the truly natural woodland of prehistoric times. However, grazing should be carefully considered in the management of both existing semi-natural and new native woods.

Mature semi-natural woods, notably in the uplands, are frequently subject to high grazing and browsing intensities mainly from sheep and deer. This often prevents tree regeneration and reduces the diversity of the field layer. However, *low* grazing pressures can be beneficial in maintaining diversity by preventing competitive exclusion of smaller plants, such as distinctive bryophytes in western oak-birch woods, and by creating niches for colonisation and regeneration.

Grazing needs to be considered from the outset when planning new native woods. To allow establishment of the trees and shrubs, total exclusion by fencing is the simplest and safest option. Where trees and shrubs are being planted, grazing can be removed for the vulnerable period, anything from 5 to 20 years or more depending upon the site. Total removal of grazing, however, can lead to the loss of smaller grasses and herbs which were maintained in the close-cropped turf, as they become smothered by dominants like bramble, bracken or tussock grasses. This may lead to a loss of conservation value in open areas within the new native woodland and a loss of potential colonists for the wooded parts, since heathland and rough grassland often harbour woodland herbs such as wood anemone, dog violet and primrose. In these mainly upland situations, maintaining low-intensity grazing or reintroducing it quickly should be considered *where it is practical.*

Where natural colonisation by trees and shrubs is expected to be the main method of establishing new native woods, permanent exclusion of grazing animals may also not always be the best solution, as it may lead to reduced opportunities for the germination of trees and shrubs. Grazing often produces conditions suitable for germination of trees and shrubs but the seedlings are then frequently browsed back to the level of the field layer

until grazing pressure is reduced. Grazing could be considered as a means of encouraging gradual colonisation of a new native woodland site by continuing with a light grazing regime over several years and then perhaps removing animals completely for a time to allow establishment of the seedlings.

Other woodlands such as **mercury woods** and **alder-ash flush woods** would probably develop better without any grazing because so many of their characteristic field layer plants are highly palatable.

Grazing could also be used as a form of 'ground preparation' for natural colonisation, e.g. by using a high intensity regime for a short period before a good seed year. These approaches could be suited to areas near existing semi-natural woodland as an alternative to cultivation. It must be stressed, however, that manipulating grazing in these ways is not well tested. Local advice should be taken as each site will be different.

Deer are a potential threat to the development of new native woodland. They tend to browse selectively on woody species and palatable herbs and even at relatively low total densities such as 5–10 km^{-2} they may restrict colonisation by trees, shrubs and field layer plants (P.R. Ratcliffe, personal communication). Deer should therefore be excluded or controlled at low densities for longer than the establishment period of the trees to encourage the full plant community to develop.

Encouraging natural colonisation

Reference has already been made to the theoretical desirability of using natural colonisation where seed sources and site conditions are suitable, and especially for new native stands near to existing semi-natural woodlands. A judgement will be needed about the distance from seed sources over which it is acceptable to rely upon natural colonisation. This will depend on many factors and should be decided on a site-by-site basis. The timescale which is acceptable for establishment will be important. In practice, this will often be the lifetime of a fence, around 15–20 years. If this is so, then new woods further than about 100 m from seed sources may be unsuitable especially for heavy-seeded trees. However, local examples of enclosures should be examined to judge how successful colonisation is likely to be. Species such as rowan, hawthorn, birch and sallows can sometimes colonise more distant areas quite abundantly, but high stocking densities should not be expected.

The site conditions can be manipulated to encourage natural colonisation by means of cultivation and perhaps by control of grazing as described earlier. Light patch-scarification or mounding are the preferred methods of cultivation to avoid excessive disturbance and still produce a seedbed. They should be timed for late summer to precede seedfall. Herbicides may be needed to eliminate dense bracken which normally prevents any colonisation by trees or shrubs.

It may often be best to observe the existing colonisation pattern for a few years before undertaking ground preparation, to be sure whether it is necessary or not.

Altering early canopy structure and composition

There may be a variety of reasons for removing trees or shrubs after they have established, such as:

- Removing unwanted species, notably invasive exotics such as rhododendron or Sitka spruce.
- Reducing the cover of prolific colonisers in favour of less common desired species or to maintain designated open habitats.
- Reducing canopy cover to create suitable light conditions for the characteristic field layer to develop.

In general, it is desirable to avoid drastic interventions which cause abrupt changes in light regimes. The need to alter canopy cover for the benefit of the field layer can be avoided by designing the planting pattern as described earlier to produce a range of light conditions right through to maturity. However, there will be some situations, notably on disturbed sites

with strong weed growth, where initial dense planting with few gaps is preferred, to shade out weeds for example, and gaps and wider spacings will then need to be created after canopy closure. Ultimately, of course, thinning and felling of parts of the wood may be intended for wood production and these are dealt with in detail in *Forestry practice* (Hibberd, 1991) and *Growing broadleaves for timber* (Kerr and Evans, 1993). Wherever trees or shrubs are removed, care should be taken to avoid compaction and other disturbances of the soil which can have undesirable effects (see page 25). For example, on heavy mineral gley soils, the sudden creation of a large gap in a closed canopy, if combined with soil disturbance, can favour the rapid spread of the tufted hair-grass (*Deschampsia cespitosa*), smothering other species with its dense tussocks, perhaps for decades (Davy, 1980).

Where timber production is not an objective of canopy restructuring, soil disturbance can be avoided by felling to waste. Another alternative to consider is thinning by using stem injection of herbicides to kill standing trees *in situ*. Although the effects on the flora have not yet been tested experimentally, it may be better than felling for the gradual development of the field layer as it avoids creating piles of brash which encourage brambles and coarse grasses.

Disturbed sites

On some sites, vegetation, the soil or even the shape of the whole landscape have been so altered by human activity that it can be difficult to predict the kinds of woodland that it might be appropriate to encourage, and sometimes difficult to establish the desired trees and shrubs. Yet, with some thought, it is possible to apply the same basic approach to improved pasture and arable farmland, in derelict sites and areas affected by mineral workings or landfill. Clearfelled areas formerly occupied by densely shading plantations are also briefly considered below.

In general, however, on all kinds of disturbed site, the time required to approximate to the desired semi-natural woodland flora is likely to be longer and the outcome more uncertain than for more natural sites. This is particularly true for reclamation sites and arable farmland, where the model woodland field layers may never fully develop by natural colonisation, and plants more typical of field margins and edges will remain for long periods of time.

Farmland

Grant assistance is available to encourage the establishment of woodland on farms, especially on improved pastures and arable land. This reflects the current policy of diversifying land use and reducing surpluses of agricultural products. Where wildlife conservation is a major objective of such projects, the encouragement of native woodland communities can be considered as an option (Table 3.4). However, particularly with arable land, or fields that have been resown as leys, the soil and vegetation will have been greatly altered from their natural state and native herbaceous plants may have been almost completely eliminated.

Unfortunately, because such farmland has often been much improved by fertilisers, the high nutrient status of the soils can be a real hindrance to the development of the appropriate woodland flora, by encouraging vigorous growth of tall and rank plants like stinging nettle (*Urtica dioica*), rosebay (*Epilobium angustifolium*), Yorkshire fog (*Holcus lanatus*) and docks (*Rumex* spp.) at the expense of desired species. Arable soils may be especially rich in seed of potential weeds and unusually high alkalinity of the soils may also inhibit colonisation by appropriate plants. Fertiliser should rarely be required for tree and shrub growth on such sites but, even where none is used, it may take decades for fertility to decline sufficiently to allow woodland herbs to colonise.

It may be necessary to space trees and shrubs regularly in rows to allow for machine access for weeding, although the rows can be made irregular and given a less artificial appearance by gentle curves and gaps. Sup-

Table 3.4 Target new native woodland types for former arable and improved pastureland (adapted from Williamson, 1992).

	Soil types						
	Fen peats pH 4–7	*Brown earths and fen peats pH 4–7*	*Non-calcareous clay pH <7*	*Calcareous clays pH ≥7*	*Alluvial soils pH 4–7*	*Shallow soils over chalk and limestone pH ≥7*	*Acidic sands and podzols pH <4*
Drainage	Good	Good	Poor (winter waterlogging possible)		Poor (high water table)	Good	Good
Fertility	High	High	Medium-high	Medium-high	High	Medium	Low
Special problems of establishment	None	None	Cracking in dry weather. Severe on southern sites, less severe in north and west		Seasonal flooding	Rooting depth restrictions Lime-induced chlorosis	Ironpan on podzols Water deficits
Target woodland type NVC number							
South and east	W2 W6	W8, W10 W14, W15 W16	W8, W10	W8	W6 (W2) (W10)	W8 W12	W10 W15 W16
North and west	(W12) (W6)	W9, W11 W19 (W10)[a]	W7 W9	W7 W9	W7 (W6)[a]	W9	W11 W17 W18 W19

( ) Occasional, minor type.

[a] Although normally restricted to south and east, it may develop in north and west due to high initial soil fertility; likely to be a species-poor variant.

pression of weeds by strip or spot application of herbicides may be needed close to the trees for several years and vigorous weed populations can be expected between rows until the canopy closes. Sowing native grasses with or without wild flowers can reduce weed problems on arable sites and provide some of the species desired in the target woodland type. Close spacing and fewer gaps between groups may be more appropriate than for more natural sites because this will hasten weed suppression. The canopy can then be gradually opened up to create suitable conditions for woodland flora, taking care not to stimulate fresh weed growth (see page 28). Detailed advice on establishment methods for planted farm woodland is available in *Establishing farm woodlands* (Williamson, 1992).

Natural colonisation by trees and shrubs may be slow on rich ex-arable sites, but seedlings of hawthorn and oak are quite often present in less improved pastures and these can get away readily after the withdrawal of grazing. Other species can invade from nearby hedges or existing woodland, and an imaginative and economic approach may be to leave some areas adjacent to such established seed sources unplanted from the start. Proximity of new plantings to older woodland can also facilitate colonisation by desired herbaceous plants. Isolated plantings, set in a lowland landscape or arable or improved pasture, also need to be large enough to avoid a preponderance of rank, weedy edge vegetation beneath: Usher *et al.* (1992) suggested at least 2 ha as a minimum for attracting the less mobile woodland flora. Long, narrow plantations, though perhaps useful as shelter or as corridors allowing migration of plants and movement of animals, are more likely to retain a high proportion of marginal herbs and underscrub.

Reclamation sites

Woodland is often chosen for revegetating land which has been reclaimed after mineral extraction, landfill refuse disposal or urban dereliction. Sites of this kind typically have an artificial landscape with highly disturbed soils that present a range of problems for trees, shrub and field layer plants. These include shortage of topsoil, subsoil-compaction and poor structure, waterlogging in hollows and excessive drainage, high levels of exposure and sometimes erosion on slopes. Nutrient deficiencies are typical, especially of nitrogen. Heavy metals or other substances can also occur at toxic levels.

A range of treatments are required to alleviate these problems sufficiently to grow trees successfully, including landscaping the ground, cultivation, replacing subsoil and topsoil and fertilising with sewage sludge or mineral fertilisers. These are described fully in Forestry Commission Bulletin 110 (Moffat and McNeill, 1994). However, reclaimed sites can remain very difficult locations for the establishment of native woodlands to mimic semi-natural communities because of their gross disturbance and artificial unbalanced ecosystems. They are generally suited to pioneer tree species which can cope with poor nutrition and other stresses. Only where good quality soil has been replaced will there be a chance to plant more demanding species such as ash, oak or gean from the start.

Alders are particularly good pioneer trees for reclaimed sites because they increase the nitrogen levels in the soil. Nitrogen is 'fixed' in root nodules by soil micro-organisms called *Frankia* and taken up by the alder roots. Alder leaf litter is nitrogen rich. Alders can be used in mixtures with other trees such as ash to improve their growth (Moffat *et al.*, 1989). The native common alder (*Alnus glutinosa*) could be used as a pioneer on most reclaimed sites where native woodland is desired except the most freely drained or waterlogged soils.

Other native pioneers which have been successfully planted on reclaimed land, and which often colonize naturally, are rowan, birches and willows, notably goat willow. On infertile sites with little or no topsoil, the best method to develop some form of native woodland is to plant pioneer trees and shrubs or wait for them to colonise gradually. Common alder should be a large component, probably at least 20–30%, and preferably in small drifts between other species. After about 20 years,

Plate 1 *Lowland mixed broadleaved woodland with dog's mercury (W8), in Hayley Wood, Cambridgeshire. A rich display of dog's mercury, wood anemone and oxlip associated with coppice with standards management.*

(M.C.F. PROCTOR)

Plate 2 *Ground flora of a W8 woodland in the western upland fringes showing ramsons, wood anemone, pignut, dog's mercury and barren strawberry. Coed Gorswen, North Wales.* (04-91)

Plate 3 *Lowland mixed broadleaved woodland with bluebell/wild hyacinth (W10). Fifehead Magdalen, Dorset.*

(M.C.F. PROCTOR)

Plate 4 *Ground flora of W10 woodland including bramble, bluebell/wild hyacinth, broad buckler fern and bracken.* (J. RODWELL)

Plate 5 *Lowland oak-birch woodland with bilberry / blaeberry (W16). Ground vegetation dominated by wavy hair-grass due to grazing pressure. Birches, oak and holly form the canopy.*

(J. RODWELL)

Plate 6 *Upland mixed broadleaved woodland with dog's mercury (W9). Old hazel coppice over a rich flora including flowering ramsons and bluebell / wild hyacinth in Argyll.*

(M.C.F. PROCTOR

Plate 7 *Details of the flora in a W9 woodland, including dog's mercury, enchanter's nightshade, wood avens, wood false-brome, ramsons and wood speedwell.* (06–91)

Plate 8 *Upland oak-birch woodland with bluebell/wild hyacinth (W11), dominated here by silver birch with no shrub layer and a ground flora influenced by grazing, consisting mainly of grasses and bracken. Rannoch, Tayside Region.*

(M.C.F. PROCTOR)

Plate 9 *Upland oak-birch woodland with bilberry/blaeberry (W17) at Shieldaig, Wester Ross, showing twisted, moss covered downy birch, hummocks of blaeberry, mosses and liverworts on a steep bouldery slope.*

(M.C.F. PROCTOR)

Plate 10 *A more mixed patch of W11 woodland with mature oaks, hazel and birch in the shrub layer and wood sorrel, creeping soft-grass and bracken in the field layer.*

(E7399)

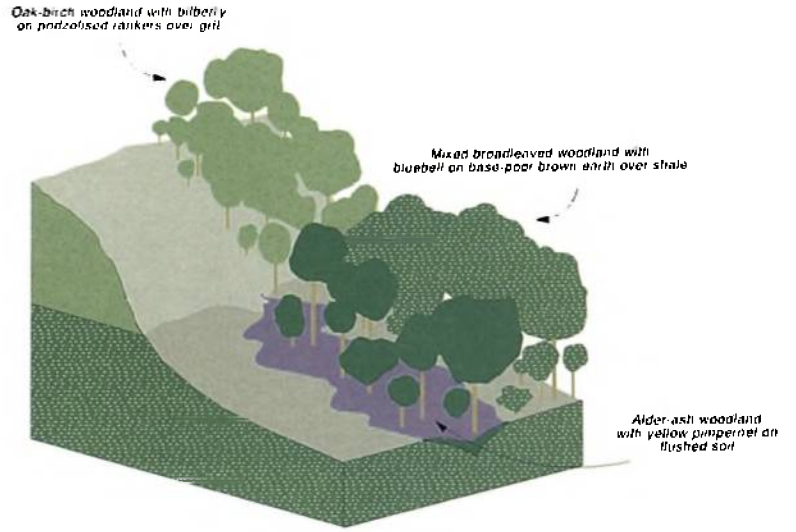


Figure 3.1 *Using geological and soil differences to develop mosaics in new native woodlands.*

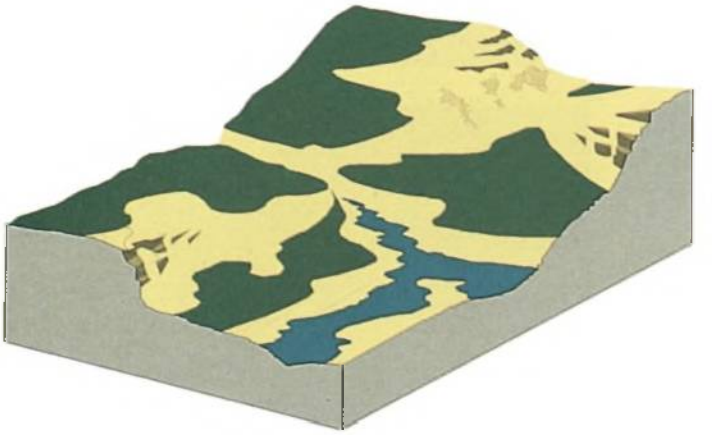


Figure 3.2 *Leaving open ground around crags and mires to increase diversity in new native woodlands.*

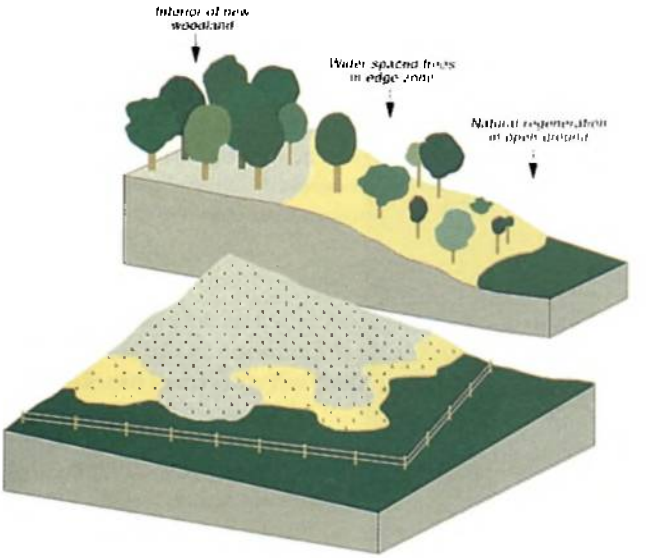


Figure 3.3 *Using variable spacings and unplanted ground at margins for a natural appearance and habitat diversity.*

Plate 11 *An old pollarded oak with holly sapling and wavy hair-grass and bilberry in the field layer in an example of W17 woodland.*

(J. RODWELL)

Plate 12 *Oak seedlings in profusion among bilberry, wavy hair-grass, hard fern and mosses in a typical W17 woodland floor in Maentwrog, North Wales.* (06–91)

Plate 13 *Beech-ash woodland with dog's mercury (W12) in Wye and Avon. Bluebells and dog's mercury dominate the vigorous field layer in a well-lit open stand of beech.*

(015/0/93/5)

Plate 14 *Mature beech woodland often has no ground vegetation and the woodland type can be hard to determine except by examining the marginal vegetation and the soil. This New Forest stand is probably of the beech-oak woodland with bramble (W14) type because of the presence of bracken and soft grasses at the edges of the stand. Any bramble would be rapidly removed by browsing deer and ponies.* (ENV,HQ)

Plate 15 *Scots pine woodland with heather (W18) at Abernethy Forest, Badenoch and Strathspey, with an open varied structure and wide age range of pine and scattered juniper bushes. The field layer is heather and blaeberry; broadleaves are absent partly due to deer browsing.* [8276]

Plate 16 *Juniper woodland with wood sorrel (W19) at Creag Fiaclach, Cairngorms, one of the few examples left of a natural tree-line at altitude in Britain. Juniper replaces Scots pine as the latter dies out in the harsh conditions upslope.* (M.C.F.PROCTOR)

Plate 17 *Birch woodland with purple moor-grass (W4) at Middle Fen, Malham, Yorkshire, showing the open canopy of downy birch carpets of* Sphagnum *and* Polytrichum *mosses between clumps of purple moor-grass.* (M.C.F.PROCTOR)

Plate 18 *Alder woodland with tussock sedge (W5) at Penn Hill, Sidbury. Large clumps of the great tussock sedge dominate the field layer on base-rich fen soil.* (M.C.F.PROCTOR)

Plate 19 *Sallow woodland with bottle sedge (W3) at Malham Tarn, Yorkshire. Here marsh marigold and valerian are prominent in the flora.* (M.C.F.PROCTOR)

Plate 20 *Alder woodland with common reed (W2) at Catfield Great Fen.* (M.C.F. PROCTOR)

Plate 21 *Alder-ash woodland with yellow pimpernel (W7), formerly coppiced with a rich flora on a wet flushed area by a small stream channel.* (J. RODWELL)

Plate 22 *W7 flora among newly coppiced alder in an ancient semi-natural woodland area in the Forest of Ae, Nithsdale. Meadowsweet, marsh thistle, soft rush and marsh hawk's-beard are prominent.* (07–91)

(a)

(b)

Plate 23 (a), (b) *This 34-year-old stand of sessile oak near Lockerbie, Nithsdale was planted on grazed heathland dominated by heather which has since disappeared. Now the field layer is largely composed of bramble, broad buckler fern, bracken, wavy hair-grass, blaeberry and heath bedstraw, several mosses and liverworts, a mixture characteristic of acidophilous oak-birch woodlands (W16 and W17). The pattern of the ploughing can still be seen (a) in the concentration of mosses and wavy hair-grass on ridges and thick leaf litter in trenches. The abundance of fern and bramble may partly result from ploughing and fertilising (see Tables 3.2 and 3.3).*

more demanding trees and shrubs could be introduced in matrix with alder, which might need to be coppiced to allow their establishment. On sites with adequate topsoil, more demanding trees like ash may be planted as a minor element from the start.

Grasses and legumes have been sown successfully on infertile sites to stabilise the ground and develop biologically active topsoil (Moffat and Roberts, 1990; Moffat *et al.*, 1989). This should hasten successional change in broad terms and eventually encourage trees and shrubs to colonise.

Native trees and shrubs which have been found to be suitable for infertile reclamation sites are shown in Table 3.5 with an indication of the relevant woodland communities which they might help establish. The prospects for a good approximation to the semi-natural woodland types are, however, very uncertain and long-term. The field layer plant community on such disturbed sites is

Table 3.5 Native trees and shrubs found suitable for reclamation sites[a] (adapted from Wilson, 1985; Hibberd 1989; Moffat and McNeill, 1994).

Species	*Soil and site conditions*					
	Mainly coarse/sandy texture		*Mainly fine/clay texture*		*Calcareous spoils*	*Exposure and air pollution*
	Dry	*Moist*	*Acid pH < 6*	*Neutral/alkaline pH > 6*		
Silver birch	••	•	•			E, P
Downy birch	•	••	••	•		E, P
Rowan	••	•	•	•	•	E, P
Goat willow	•	•	•	••		P
Common alder		••	••	••		E, P
Hawthorn		•	•	•	•	E, P
Scots pine	••					E
Crack willow		•	•	•	•	P
Black poplar		(•)	•	••	(•)	P
Whitebeam	•	(•)	•	•	•	E, P
Gean					(•)	P
Ash				•	•	
Sessile oak	(•)	(•)	(•)			E, P
Pedunculate oak		(•)	•	•	•	E, P
Field maple				•	•	E, P
	Closest potential NVC woodland types					
Upland	W17 (W18) (W11)	W11 convex site W7 concave site (W4) concave site	W7 W4 (W11)	W7 W9 (W6)	W7 W9	
Lowland	W16 (W10) W15 (W14)	W10 W4 concave site W5 concave site	W2 W4 W6 (W10) (W14)	W6 W8	W8 W12 (W13)	

[a] Assumes little or no topsoil is present.

Key •• Highly suitable
• Suitable
( ) Occasional; marginal
E Suitable for exposed sites
P Suitable for air pollution

likely to develop into a great variety of temporary mixtures due to the chance colonisation and disturbed nature of the sites. These could persist for many decades, thereby excluding woodland species. As for arable farmland sites, planting at close spacing with few gaps is likely to speed up the onset of conditions for woodland herbs to colonise by excluding weeds. Thinning or respacing would then be necessary to maintain suitable light levels for woodland plants.

Felled plantations

Plantations of densely shading trees such as Sitka spruce (*Picea sitchensis*) or beech (*Fagus sylvatica*) can completely eliminate the field and ground layers of vegetation, especially where they have not been thinned. After felling, the vegetation which develops naturally is influenced by local climatic and soil conditions, but early colonisers often come from seed stored in the soil from before canopy-closure of the previous tree stand and from neighbouring vegetation, especially plants with wind-dispersed seed. Harvesting practices, particularly the extent of disturbance and treatment of felling debris, are also influential. Especially on base-poor, upland soils, where conifer planting has been concentrated, clearfells are often dominated by mixtures of rosebay, grasses and rushes, with heather and bracken, foxglove (*Digitalis purpurea*) and, on somewhat better ground, bramble. Regeneration of the planted tree species and colonisation by birches and willows often occurs also.

Managers may sometimes wish to convert such clearfelled sites to native woodlands which are modelled upon semi-natural woodland types. This may be done to increase the general wildlife and amenity value of plantation forests or specifically to extend small semi-natural woodland remnants, for example along streamsides.

The broad approach of this Bulletin can be applied to these situations even though the site has been recently wooded. Climate, geology, landform and soils can be used as normal to select an appropriate model woodland type, although some allowances may need to be made for the changes to soils caused by previous tree growth and silviculture, such as irreversible drying on ploughed and drained deep peats. The current vegetation will not give so reliable a guide as in semi-natural sites but some of the precursors and some of desired invaders listed in the design prescriptions may be present.

The establishment of the new native wood on felled ground should follow the general guidance for less disturbed sites but there are some peculiar factors to consider.

- Regeneration and colonisation by trees and shrubs will sometimes occur profusely on felled ground shortly after felling. These may include exotic species, such as Sitka spruce or larches, as well as native trees which are part of the desired community. Birches are notable examples of native colonisers.
- Felling residues, notably tree branches and needles (brash) play an important part in the early vegetation succession.
- Harvesting machinery used in the clearfelling can cause site disturbances which have effects like those of cultivation machinery (see page 25).

Regeneration of unwanted species can be very expensive to remove. Care in planning the felling operation (avoiding good seed years for unwanted species or felling before seed ripens) should help to reduce the problem.

The way in which brash is managed can influence the early development of vegetation including tree seedlings. Piles of brash slow down revegetation of the site and species such as heather which germinate from dormant buried seed when exposed to the light will not develop in thicker brash and litter. Birch can colonise freshly felled ground where the litter is disturbed and brash is light but cannot readily invade the grassy field layer which then develops within 2-3 years.

From what is currently known of the influence of brash upon the succession of vegetation on felling sites, the best general policy is probably to ensure that much of the site,

preferably over half, has little or no brash left on it in order to encourage a diversity of colonisers.

Where wet woodland types are desired it may be valuable to restore wetland conditions, e.g. by blocking drains, except perhaps where irreversible drying of peat has occurred. However this suggestion requires testing by research and monitoring.

Conversion of single-species broadleaved plantation stands towards native woodland communities may occasionally be attempted, e.g. when dense beech or sycamore stands are felled. Similar factors to those in conifer plantations are involved. However, the brash has less of a smothering effect (although it can provide a template for brambles to spread) and often a field layer of native woodland plants will already exist before felling.

Coppice regrowth and mixed natural regeneration of broadleaved trees and shrubs may give more opportunities to convert the wood towards the desired type without much planting than for conifers. On stable sites, there will be opportunities for gradual conversion by heavy thinning which may reduce the risk of existing woodland species being smothered by a burst of 'weedy' growth as often happens after clearfelling.

Introducing field layer plants

As indicated earlier, it may take a very long time for many woodland plants characteristic of semi-natural woodlands to colonise new native woods, especially isolated stands in disturbed arable or urban landscapes. The work of Hooper (1977), Peterken and Game (1984) and Usher *et al.* (1992) in lowland eastern England, for example, indicated that some ancient woodland plants such as dog's mercury (*Mercurialis perennis*), primrose (*Primula vulgaris*), bluebell (*Hyacinthoides non-scripta*), sanicle (*Sanicula europaea*) and the grass wood melick (*Melica uniflora*), were slow to colonise secondary woods. Most woods under 100 years old contained only a few such species and it took around 250 years for most of them to appear. Small woods have fewer such species at a given age.

However, the prospects for colonisation of ancient woodand species vary regionally according to soil, climate and their existing abundance in the landscape as described earlier. Generally, colonisation is likely to be faster in the northern and western woodland types and those woods established on and close to semi-natural habitats. Woodland plants can often survive in the open in these areas which they cannot do on arable or improved pasture land in the lowlands.

In any area the prospects for colonisation by specialist woodland plants can be improved by the design and early management measures described earlier, notably:

- Location on suitable precursor vegetation.
- Location of new woods near to existing woodlands, especially old semi-natural woods or hedgerows.
- Avoiding very narrow and small woods (>2 ha in a compact shape is preferable).
- Avoiding highly disturbed or enriched soils.
- Avoiding intensive management practices, e.g. ploughing and drainage, especially on wet or fertile site.
- Developing moderate to strong shading over linked areas to enable spread of shade-bearing species.

Even so, there may be situations where the prospect of colonisation is still thought to be too slow and uncertain and where introducing field layer plants may be thought desirable to speed up the development of the target woodland type.

Introducing such species to new woodlands is still relatively untested. Although a number of projects have recently been monitored over a short period (e.g. Buckley and Knight,1989; Francis *et al.*, 1992), the long-term success and cost-effectiveness of various methods,

namely sowing, planting and the transfer of soil containing buried seeds, bulbs and roots, is not yet known.

At present it seems that planting container-grown stock is probably a more reliable method than sowing for the more shade-tolerant woodland herbs, which tend to rely on vegetative reproduction, while sowing can be effective for a number of common woodland-edge plants like red campion (*Silene dioica*) and hedge bedstraw (*Galium mollugo*). The latter are adapted to take advantage of periodic disturbance which stimulates the germination of seed stored in the soil.

However, the cost of quickly establishing enough woodland plants to make a rapid visual impact is high. For example, at approximately 30–50 p per plant, an area of 100 m^2 planted densely at 0.5 m spacing with, say, primroses would cost £120–£200 to plant at 1993 prices. This does not include any herbicide treatments which might be needed to eliminate competition by other plants. Planting or sowing at lower densities, merely seeking to establish a colonising source, would certainly be less expensive but the future success of the species would be less certain.

Introductions should therefore be treated with considerable caution at present. Where they are contemplated, success is likely to be greater for a given level of expenditure, if:

- Planting or sowing is concentrated in patches which provide more protection from competition by existing species and easier relocation for monitoring and subsequent tending if required.
- Introductions are timed for the onset of canopy closure when competitive light-demanding field layer plants will be eliminated or weakened. Light levels of 10–15% of open conditions are most suitable for shade-bearing woodland species (Buckley and Knight, 1989). Alternatively, introductions can be made after canopy opening.

After planting or sowing, subsequent tending may be needed to control canopy shading and competition from other field layer plants including invasive shade-tolerant species such as common nettle (*Urtica dioica*) and bramble (*Rubus fruticosus*). Disturbance from harvesting machinery or repeated trampling by the public should be avoided in the vicinity of introduced plants.

As for trees and shrubs, rare species should generally be avoided at present for introduction to new native woods; their requirements and current distribution are often poorly known and they are likely to be harder to establish successfully than more common species.

Genetic conservation and adaptation does not seem to have received much consideration so far when wild flowers are sold as seed or plants. Local adaptation may be at least as great as it is for trees and shrubs. Planting stock is mostly produced from seed collected in southern England and may not be well adapted to conditions further north.

In summary, given the current state of knowledge, it is generally appropriate to consider the possibility of using introductions in the future to speed up colonisation of the desired woodland flora, but not to rely upon introduction as a simple substitute for natural colonisation. The emphasis should be on design and management which favours natural colonisation, as described earlier in this chapter and the previous one.

Chapter 4

How to Use the Design Prescriptions

Specific design advice is given for new native woodlands modelled upon all the major types of semi-natural woodland that occur in Britain, and which it is practicable to mimic. Yew woodland and the three wettest types of the alder-downy birch-willow woods have been omitted. The following sections will help the reader to select those kinds of woodland appropriate for a particular site and define the terms used in the Design Prescriptions.

Native woodland zones

The distribution patterns of our major types of semi-natural woodland effectively define a small number of broad zones for establishing new native woodlands (Figure 4.1). For the most part, these zones reflect gross climatic differences, such as the pattern of temperature and rainfall across the country. With some wetter woodlands, however, it is more sensible to map the distribution of suitable ground conditions within the optimal climatic zone. The user should locate him/herself in a zone and note the range of semi-natural woodlands appropriate to that region.

The boundaries of the zones as shown on the maps are not precise and rigid. They are meant as a guide only. It is possible to find some semi-natural woods outside their normal zones where the local climate or soil is particularly suitable. For sites located near to the edges of the zones on the maps local semi-natural woodlands can be used to help to decide what is appropriate as well as the evaluation of *local* climate, soil, geology, terrain and precursor vegetation.

Soil types

Clearly, not all the semi-natural woodlands characteristic of a planting zone will occur on all kinds of soil represented in the region. The particular sites available for planting are also likely to have a limited range of soils occurring in them. Table 4.1 summarises the range of soil types which can support each of the different kinds of semi-natural woodland, using standard terminology (Pyatt, 1982).

The soil types present at the site should be identified and the kind or kinds of woodland which might suitably be encouraged upon them in that region. Further details of soil conditions given within the guidelines should help confirm the selection.

Geology, terrain and site types

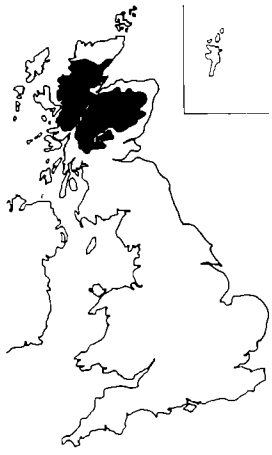
The prescriptions also list the broad categories of bedrock and superficial deposits with which the soil types and their woodlands are associated in the different zones. The general kinds of terrain and site types within which the different semi-natural woodlands are characteristically found are also briefly described.

Recommended trees and shrubs

Trees and shrubs are listed which are particularly characteristic of the semi-natural mixtures developed under the specified climatic and soil conditions. Some of these might already be present on a site as a result of natural colonisation and not all of the species listed need be planted in every new woodland of each type. Nor should the species always be

Upland
north and west

Upland zone



Scots pine zone

Juniper zone

Lowland
south and east

Lowland zone

Beech zone

Wet woods on fen peats

Wet woods on alluvium

Figure 4.1 Zones for new native woodlands.

Table 4.1 Soil types[a] appropriate for new native woodlands

	Calcareous/base-rich		*Acid/base-poor*
(a) Freely or imperfectly drained mineral soils			
Northern and western upland areas (cooler and wetter)		**Juniper with wood sorrel W19** Brown earths 1, 1u, 1z and (1b) Podzol 3 Intergrades to ironpans 4b	**Scots pine with heather W18** Podzolised brown earth 1z Podzols 3, 3p, 3pg, 3m, 3s, 3ms (Ironpans 4, 4z, 4p, 4pg, 4zp) Podzolic peaty gley 6z Podzolic surface water gley 7z Podzolic ranker 13p
	Upland mixed broadleaves with dog's mercury W9 Calcareous brown earth 12b Argillic brown earth 12t Basic brown earth 1b Calcareous ground-water gley 5k Calcareous surface-water gley 7k	**Upland oak-birch with bluebell/wild hyacinth W11** Brown earths 1, 1u, 1z Brown surface-water gley 7b	**Upland oak-birch with bilberry/ blaeberry W17** Podzols 3s, 3ms Podzolic ranker 13z Podzolic ironpan 4z
Southern and eastern lowland areas (drier and warmer)	**Lowland mixed broadleaves with dog's mercury W8** Basic brown earth 1b (1bg) Calcareous and basic ground water gleys 5k, 5b Surface-water gleys 7b, 7i, 7k Calcareous soils 12a, 12b, 12tg	**Lowland oak-birch with bluebell/wild hyacinth W10** Brown earth 1 Ground-water gley 5 Brown surface-water gley 7b	**Lowland oak-birch with bilberry/blaeberry W16** Podzolised brown earth 1z Podzol 3, 3m, 3s, 3ms Podzolic ranker 13z
	Beech-ash with dog's mercury W12 Calcareous soils 12b, 12t, 12bg, 12ab	**Beech-oak with bramble W14** Brown earth 1 (Brown ground-water gley 5)	**Beech-oak with wavy hair-grass W15** Podzolic brown earth 1z Podzol 3
(b) Wet and peaty soils			
Northern and western uplands		**Alder-ash with yellow pimpernel W7** Ground-water gley 5, 5f Surface-water gley 7, 7i, 7f, 7h, 7b	
Azonal			**Birch with purple moor-grass W4** *Molinia* bog 9a, b, c, d, e *Sphagnum* bog 10a, 10b[b] Peaty gleys 6, 6b Flushed bogs 8b, 8c
Southern and eastern lowlands	**Alder with common reed W2** Ground-water gley 5f (5k) Surface-water gley 7f, 7h (7k) Flushed basin bog 8a, 8d	**Alder with stinging nettle W6** Ground-water gley 5f Surface-water gley 7f, 7h Flushed basin bog 8a, 8d	

[a] Soil types follow the Forestry Commission classification (Pyatt, 1982).
[b] This site type will rarely be appropriate for planting because of its high conservation value.

planted in the same proportions. Major trees and shrubs are those which could make up a more consistent element of such mixtures (present in over half the sites) and which, on any particular site, can be used in abundance, collectively making up over half the eventual crown cover (Figure 4.2). Minor trees and shrubs are those which could figure less frequently among the mixtures (in fewer than half the sites being planted) and which should usually be used more sparsely on particular sites (total eventual crown cover less than 50%).

Large and small circles distinguish these categories in Figures 4.3 and 4.4 which list all the trees and shrubs in the different semi-natural woodlands. Where it is appropriate to concentrate planting of a particular tree or shrub within part of a planting zone, or to sometimes use a tree or shrub with local abundance, this is noted in the design prescriptions and marked in Figures 4.3 and 4.4 by the use of open circles.

Optimal precursor vegetation

Even a single site available for planting could clearly already support a variety of herbaceous vegetation types characteristic of the particular climate and soil conditions. Some of these might well contain plants which are also typical of the semi-natural woodland the site could carry. The design prescriptions list optimal mixtures of herbaceous species which should be favoured for planting with the specified trees and shrubs where there is some choice of precursors. However, it should always be remembered that such existing vegetation may have great conservation and amenity value in its own right: rich assemblages of colourful herbs on flushed ground, for example, would give a head start in developing the flora of certain types of wet woodland, but are probably highly prized already. Some decision then has to be made about whether to sacrifice such existing character for the sake of the potential attraction of the eventual woodland cover.

If these optimal plants are not present, a likely situation where woodland is being established on improved pasture, former arable land or reclaimed industrial land, the desired woodland flora may still be able to develop but is likely to take longer.

Desired invaders

Many semi-natural woodlands contain plants which were often absent from the existing herbaceous vegetation invaded by the trees and shrubs, but which colonised after the development of woody cover, sometimes very slowly. The design prescriptions list species of this kind as desired invaders, the appearance of which will help build the full complement of the appropriate woodland flora. In some situations, it might be possible to seed or plant certain woodland herbs, but the success of developing herbaceous communities from seed mixtures or transplants is uncertain, as described earlier. Moreover, such introductions should always be undertaken thoughtfully, and should not encourage species which are absent locally from semi-natural woods.

Woodland structure and pattern

The guidelines give an outline of the range of structure found within the different woodland types, to provide an indication of the variety of mixtures and patterns of trees and shrubs that could be aimed for in planting. A note is also given of the ways in which each of the woodland types can be found in close spatial association with other woodlands and different herbaceous vegetation, so as to inform the landscape design of whole sites.

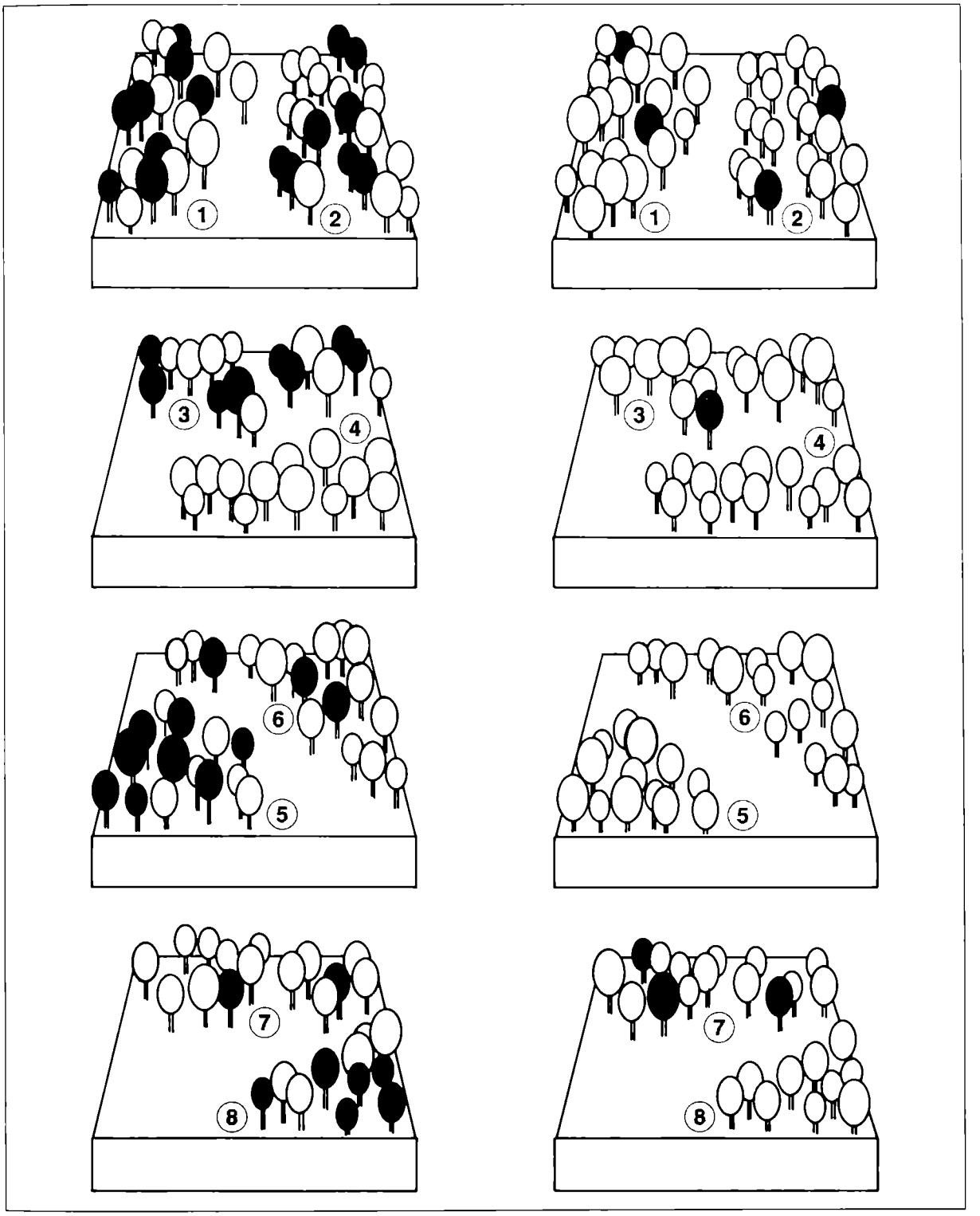


Figure 4.2 Frequency and abundance of major (left) and minor (right) trees and shrubs among a set of eight plantings.

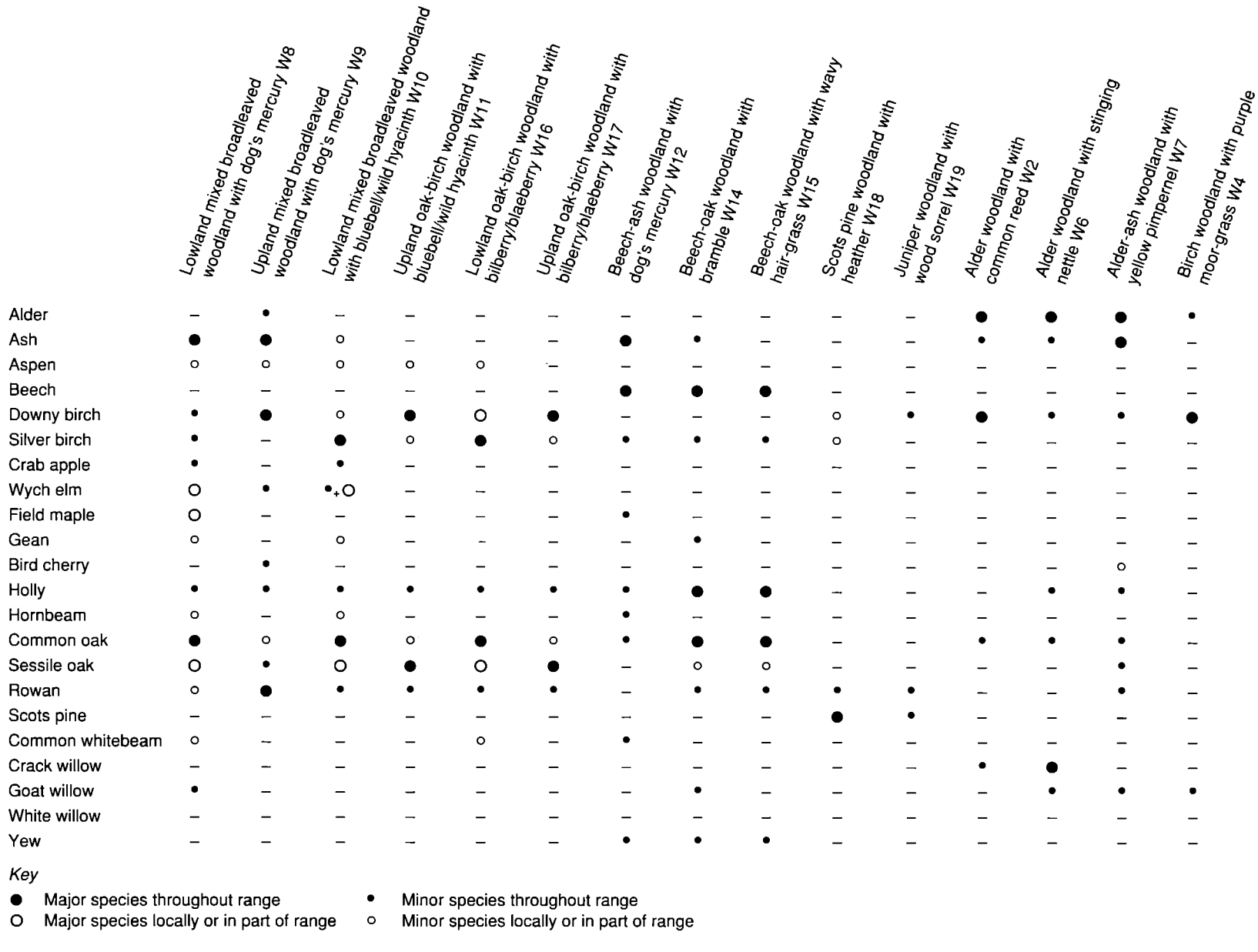


Figure 4.3 Major and minor tree species for new native woodland types.

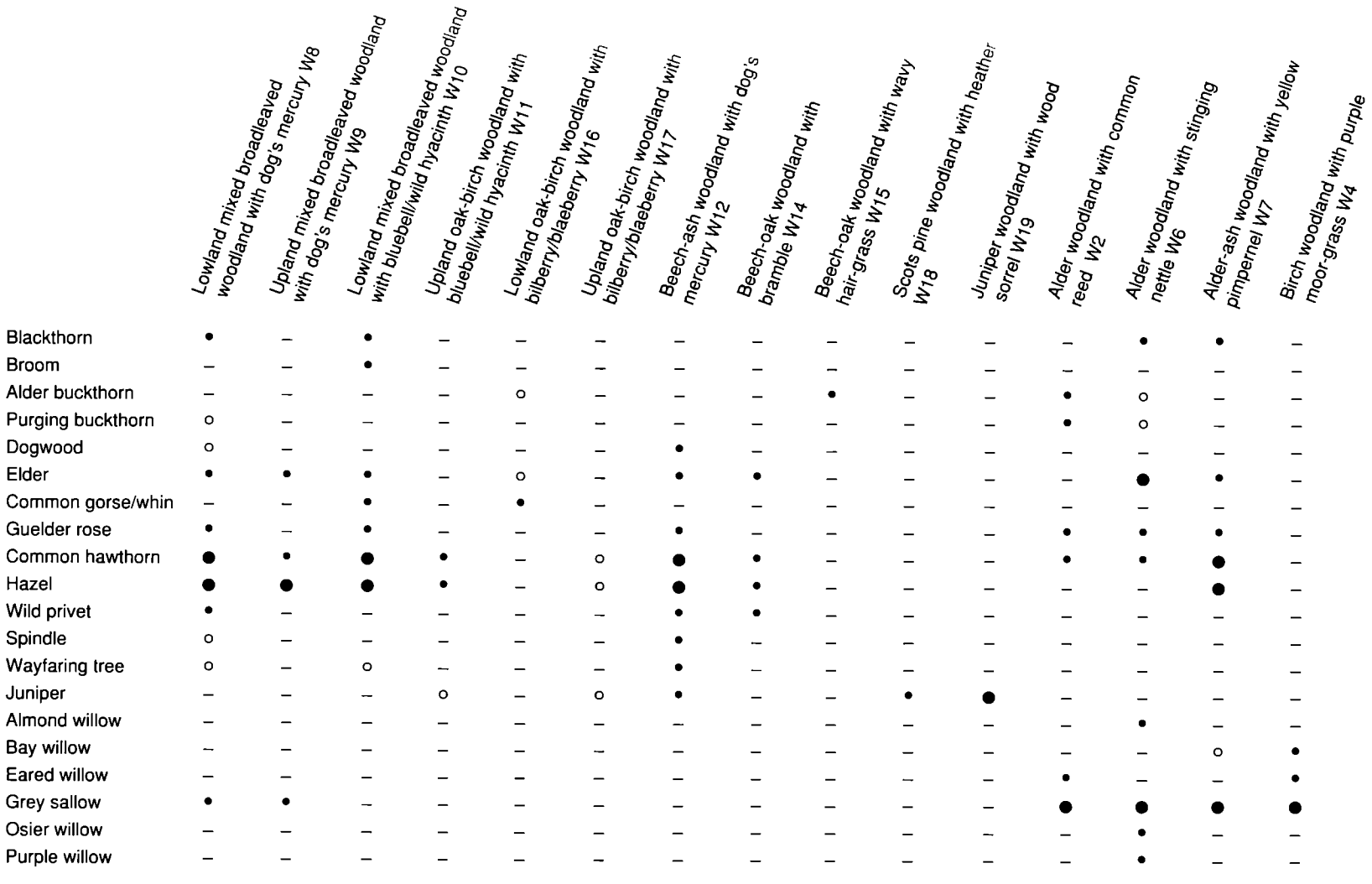


Figure 4.4 Major and minor shrub species for new native woodland types.

Chapter 5
Design Prescriptions

Lowland mixed broadleaved woodland with dog's mercury NVC woodland W8

Zone
Throughout the warmer and drier lowlands of southern and eastern Britain.

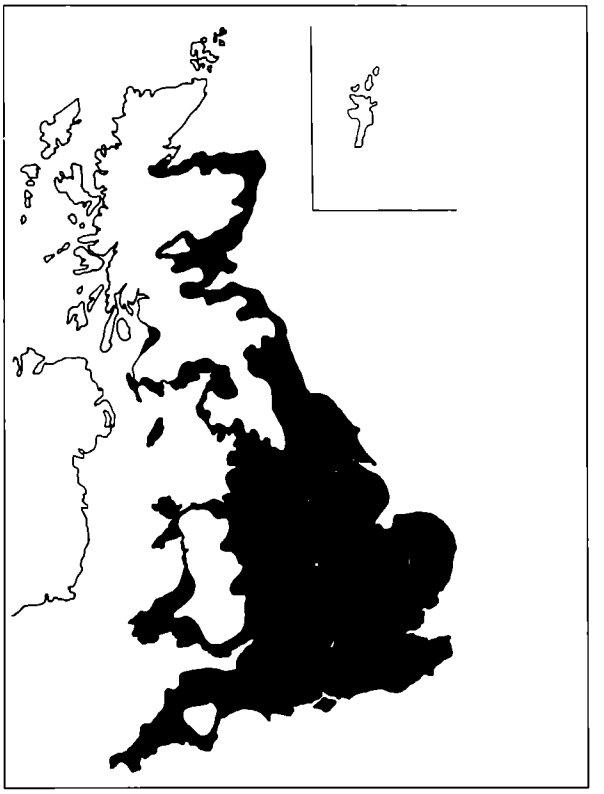
Soil types
Rendzinas, brown calcareous earths, basic brown earths and base-rich ground-water gleys.

Geology
Sedimentary limestones, calcareous shales and clays and heavy lime-rich superficial deposits like boulder clay.

Terrain and site types
Gently undulating basins, vales and low plateaux across central and eastern England, and limestone scarps, particularly towards the north and west, with more steeply sloping and often rocky ground.

Major recommended trees
Ash
Pedunculate oak
Sessile oak (patchily throughout and to the north-west of the zone)
Wych elm (to the north-west of the zone)
Field maple (England and Wales only)

Minor recommended trees
Downy birch
Silver birch
Holly
Crab apple
Rowan
Aspen
Grey sallow
Gean (locally)
Common whitebeam (locally)
Hornbeam (to the south and east)



Major recommended shrubs
Hazel
Hawthorn

Minor recommended shrubs
Blackthorn
Elder
Guelder rose
Goat willow
Wild privet
Dogwood (England and Wales only)
Spindle (England and Wales only)
Wayfaring tree (England and Wales only)
Purging buckthorn (England and Wales only)

Optimal precursor vegetation

Damp rank grasslands with
- Tufted hair-grass (*Deschampsia cespitosa*)
- Yorkshire fog (*Holcus lanatus*)
- False oat-grass (*Arrhenatherum elatius*)
- Cock's-foot (*Dactylis glomerata*)
- Creeping bent (*Agrostis stolonifera*)
- Rough meadow grass (*Poa trivialis*)
- Hogweed (*Heracleum sphondylium*)
- Stinging nettle (*Urtica dioica*)
- Creeping thistle (*Cirsium arvense*)
- Spear thistle (*Cirsium vulgare*)

Dry rank grasslands with
- False oat-grass (*Arrhenatherum elatius*)
- Wild parsnip (*Pastinaca sativa*)
- Upright brome (*Bromus erectus*)
- Tor grass (*Brachypodium pinnatum*)
- False brome (*Brachypodium sylvaticum*)
- Marjoram (*Origanum vulgare*)
- Perforate St John's-wort (*Hypericum perforatum*)
- Agrimony (*Agrimonia eupatoria*)
- Wood sage (*Teucrium scorodonia*)
- Herb robert (*Geranium robertianum*)

Underscrub with some of the above plants and
- Bramble (*Rubus fruticosus*)
- Ivy (*Hedera helix*)
- Ground ivy (*Glechoma hederacea*)

Desired invaders

Dog's mercury (*Mercurialis perennis*)
Bluebell (*Hyacinthoides non-scripta*)
Wood anemone (*Anemone nemorosa*)
Primrose (*Primula vulgaris*)
Early dog violet (*Viola reichenbachiana*)
Common dog violet (*Viola riviniana*)
Ground ivy (*Glechoma hederacea*)
Lesser celandine (*Ranunculus ficaria*)
Yellow archangel (*Lamiastrum galeobdolon*)
Wood avens (*Geum urbanum*)
Enchanter's nightshade (*Circaea lutetiana*)
Wood sedge (*Carex sylvatica*)
Lords and ladies (*Arum maculatum*)
Ramsons (*Allium ursinum*)

Woodland structure and pattern

This is one of our most diverse woodland types with a great variety of composition and structure among the trees and shrubs of semi-natural stands, especially to the south and east of England and Wales. Design options are therefore numerous, and additional variety can be encouraged around open areas and along margins where light-demanding shrubs like dogwood, purging buckthorn and privet can be concentrated. The colourful herbaceous flora characteristic here, and especially well seen after coppicing, establishes only slowly, but damper rides and clearings can develop diverse tall-herb vegetation fairly quickly provided taller grasses can be held in check. Where sites include more base-poor brown earths, planting across the soil boundary can be designed to point up a shift to the **lowland bluebell wood** (W10).

Lowland mixed broadleaved woodland with bluebell/ wild hyacinth

NVC woodland W10

Zone
Throughout the warmer and drier lowlands of southern and eastern Britain.

Soil types
Typical brown earths, moderately acidic brown earths and base-poor ground-water gleys.

Geology
Non-calcareous sedimentary shales and clays, granites and lime-poor superficial deposits like clay-with-flints, more ill-draining sands and gravels and old alluvium.

Terrain and site types
Gently undulating basins, vales and low plateaux across central and eastern England, and valley bottoms and gently sloping valley sides, particularly towards the north and west.

Major recommended trees
Pedunculate oak
Sessile oak (locally and to the north-west of the zone)
Silver birch

Minor recommended trees
Holly
Rowan
Crab apple
Downy birch
Aspen (locally)
Gean (locally)
Hornbeam (to the south and east)
Ash (to the north-west)
Wych elm (to the north-west)

Major recommended shrubs
Hazel
Hawthorn

Minor recommended shrubs
Blackthorn
Elder

Guelder rose
Wayfaring tree (England and Wales only)
Common gorse/whin (in more open places)
Broom (in more open places)

Optimal precursor vegetation
Rank grassland with
- False oat-grass (*Arrhenatherum elatius*)
- Yorkshire fog (*Holcus lanatus*)
- Cock's-foot (*Dactylis glomerata*)
- Creeping soft-grass (*Holcus mollis*)
- Hogweed (*Heracleum sphondylium*)
- Stinging nettle (*Urtica dioica*)
- Rosebay willowherb (*Epilobium angustifolium*)
- Creeping thistle (*Cirsium arvense*)
- Spear thistle (*Cirsium vulgare*)

Underscrub with some of the above plants and
- Bramble (*Rubus fruticosus*)
- Common gorse (*Ulex europaeus*)
- Broom (*Cytisus scoparius*)
- Bracken (*Pteridium aquilinum*)
- Foxglove (*Digitalis purpurea*)
- Red campion (*Silene dioica*)
- Wood sage (*Teucrium scorodonia*)
- Ivy (*Hedera helix*)

Desired invaders

Bluebell (*Hyacinthoides non-scripta*)
Wood anemone (*Anemone nemorosa*)
Honeysuckle (*Lonicera periclymenum*)
Hairy wood-rush (*Luzula pilosa*)
Male fern (*Dryopteris filix-mas*)
Yellow archangel (*Lamiastrum galeobdolon*, England and Wales)
Broad buckler fern (*Dryopteris dilatata*, to north-west)
Common dog violet (*Viola riviniana*, to north-west)

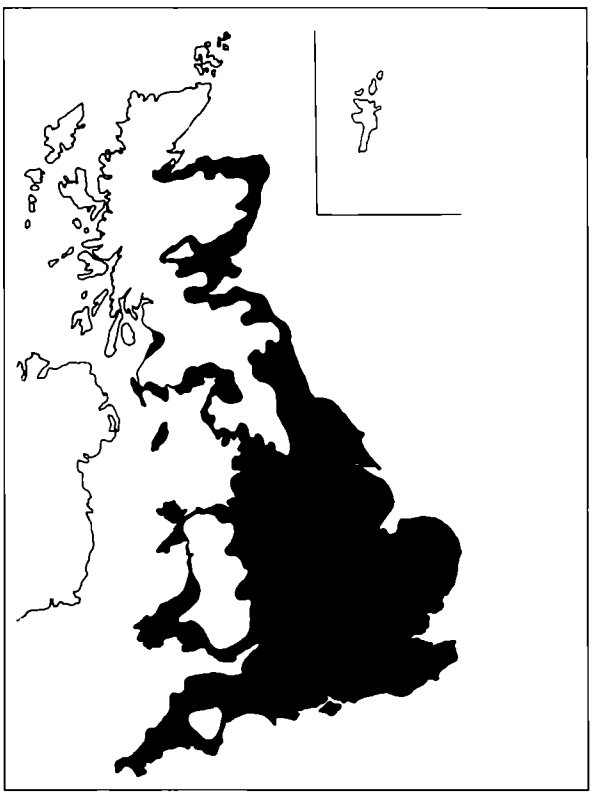
Woodland structure and pattern

Semi-natural stands of this kind of woodland tend to be less diverse in their trees and shrubs than those of the **lowland dog's mercury woodland,** but there is still ample opportunity for variety among the minor trees and shrubs. This should be used to help differentiate more south-easterly planting sites from those towards the upland fringes. Open areas and margins can also be distinguished by encouraging gorse and broom. Associated herbaceous vegetation is often rather species-poor and bramble or, on drier soils, bracken, can be a problem, or where there has been disturbance and soil enrichment, nettle or rosebay. Geological and soil transitions to more lime-rich substrates should be marked by a switch to the richer mixtures of trees and shrubs typical of the **lowland mercury wood.** Flushed areas should be planted with **alder-ash-yellow pimpernel woodland (W7).**

Lowland oak-birch woodland with bilberry/blaeberry

NVC woodland W16

Zone
Throughout the warmer and drier lowlands of southern and eastern Britain.



Soil types
Acid sands, rankers, acidic brown earths and podzols.

Geology
Sedimentary sandstones, grits and sands and gravels, and pervious lime-poor superficial deposits such as sandy drift, aeolian sands and fluvioglacial sands and gravels.

Terrain and site types
Dip slopes and plateaux, and free-draining basins and terraces, localised over suitable deposits in eastern and southern England, and extending on to valley sides and scarps towards the north and west.

Major recommended trees
Pedunculate oak
Sessile oak (locally and towards the north and west of the zone)
Silver birch
Downy birch (locally)

Minor recommended trees
Holly
Rowan
Aspen (locally)
Common whitebeam (locally)

Recommended shrubs
Elder (locally)
Alder buckthorn (locally)
Common gorse/whin (in more open places)

Optimal precursor vegetation
Grasslands and heaths with
- Heather (*Calluna vulgaris*)
- Bell-heather (*Erica cinerea*)
- Dwarf gorse (*Ulex minor*)
- Western gorse (*Ulex gallii*)
- Bilberry/blaeberry (*Vaccinium myrtillus*)
- Wavy hair-grass (*Deschampsia flexuosa*)
- Common bent (*Agrostis capillaris*)
- Bristle bent (*Agrostis curtisii*)
- Red fescue (*Festuca rubra*)
- Sheep's fescue (*Festuca ovina*)
- Tormentil (*Potentilla erecta*)
- Heath bedstraw (*Galium saxatile*)

Underscrub or fern stands with some of the above and
- Common gorse/whin (*Ulex europaeus*)
- Broom (*Cytisus scoparius*)
- Bracken (*Pteridium aquilinum*)
- Broad buckler fern (*Dryopteris dilatata*)

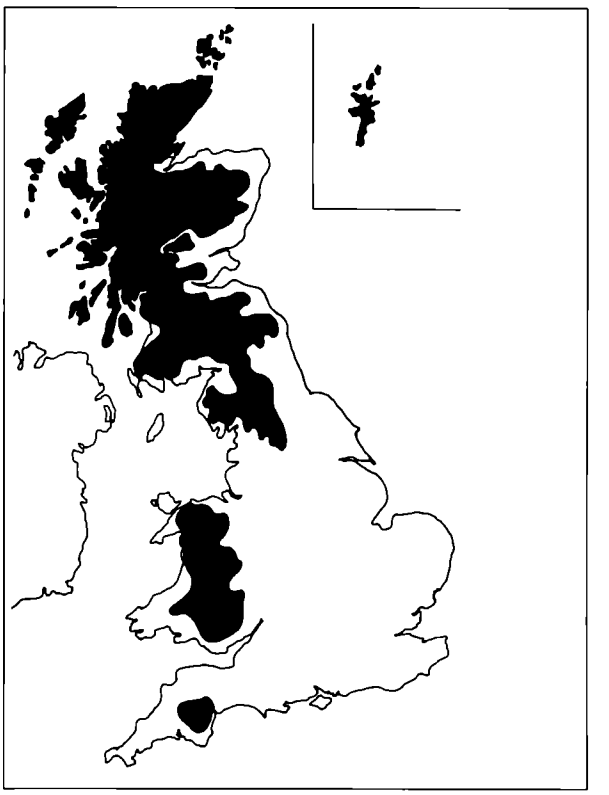
Desired invaders
No herbs other than those listed but, particularly towards the north and west, semi-natural woodlands of this kind can develop a rich bryophyte flora.

Woodland structure and pattern
Even in the warmer south-east, the impoverished base-poor soils characteristic here offer little encouragement for diversification in plantings and, if dense young birch gets an extensive hold, the prospects for short-term interest are poor. However, there is some opportunity for local variety among minor trees and shrubs and more open plantings will help establish somewhat richer heathy field layers. This is also one of the situations where modest disturbance of the ground can be beneficial in allowing the establishment of common gorse scrub. Any patches of less acidic soils or of wetter ground should allow more diverse plantings of **lowland bluebell** or **flush and mire woodlands.**

Upland mixed broadleaved woodland with dog's mercury

NVC woodland W9

Zone
Throughout the cooler and wetter uplands of northern and western Britain.



Soil types
Calcareous brown earths, basic brown earths and base-rich surface-water gleys.

Geology
Sedimentary limestones and calcareous shales, basic igneous and metamorphic rocks, lime-rich boulder clay, head and downwash.

Terrain and site types
Ravine and valley sides and heads, often steep and rocky or choked with drift, and sometimes with modest flushing.

Major recommended trees
Ash
Downy birch
Rowan

Minor recommended trees
Sessile oak
Pedunculate oak (locally)
Wych elm
Alder
Holly and aspen (local)
Bird cherry

Major recommended shrubs
Hazel

Minor recommended shrubs
Hawthorn
Elder
Grey sallow

Optimal precursor vegetation
Damp grasslands and tall-herb vegetation with
- False oat-grass (*Arrhenatherum elatius*)
- Tufted hair-grass (*Deschampsia cespitosa*)
- Cock's-foot (*Dactylis glomerata*)
- Yorkshire fog (*Holcus lanatus*)
- Rough meadow grass (*Poa trivialis*)
- Sweet vernal grass (*Anthoxanthum odoratum*)
- Common bent (*Agrostis capillaris*)
- Meadowsweet (*Filipendula ulmaria*)
- Water avens (*Geum rivale*)
- Germander speedwell (*Veronica chamaedrys*)
- Common sorrel (*Rumex acetosa*)
- Bush vetch (*Vicia sepium*)
- Primrose (*Primula vulgaris*)
- Pignut (*Conopodium majus*)
- Common dog violet (*Viola riviniana*)
- Lady's mantle (*Alchemilla glabra*)
- Hogweed (*Heracleum sphondylium*)

Ferny banks with some of the above plants and
Great wood-rush (*Luzula sylvatica*)
Lady fern (*Athyrium filix-femina*)
Male fern (*Dryopteris filix-mas*)
Scaly male fern (*D. borreri*)
Devil's bit scabious (*Succisa pratensis*)
Wild angelica (*Angelica sylvestris*)

Desired invaders

Dog's mercury (*Mercurialis perennis*)
Bluebell (*Hyacinthoides non-scripta*)
Wood sorrel (*Oxalis acetosella*)
Sanicle (*Sanicula europaea*)
Wood avens (*Geum urbanum*)
Enchanter's nightshade (*Circaea lutetiana*)
Marsh hawk's-beard (*Crepis paludosa*)
Wood crane's-bill (*Geranium sylvaticum*)
Yellow pimpernel (*Lysimachia nemorum*)
Lady fern (*Athyrium filix-femina*)
Male fern (*Dryopteris filix-mas*)
Scaly male fern (*D. borreri*)
Herb robert (*Geranium robertianum*)

Woodland structure and pattern

Although potentially not so diverse in its complement of trees and shrubs as its lowland counterpart, this kind of woodland often shows structural complexity because semi-natural stands are characteristic of irregular, flushed terrain. Difficult sites can therefore provide challenging opportunities for concentrating birch around windswept upper margins and alder in transitions to **alder-ash yellow pimpernel woodland.** More open plantings and unplanted areas should be encouraged, especially on wetter ground as they can develop colourful herbaceous or fern-dominated vegetation.

Upland oak-birch woodland with bluebell/wild hyacinth

NVC woodland W11

Zone
Throughout the cooler and wetter uplands of northern and western Britain.

Soil types
Acidic brown earths and podzolic brown earths.

Geology
Non-calcareous shales and softer lime-poor igneous and metamorphic rocks, lime-poor superficial deposits like boulder clay, fluvioglacial sands and gravels, head and colluvium.

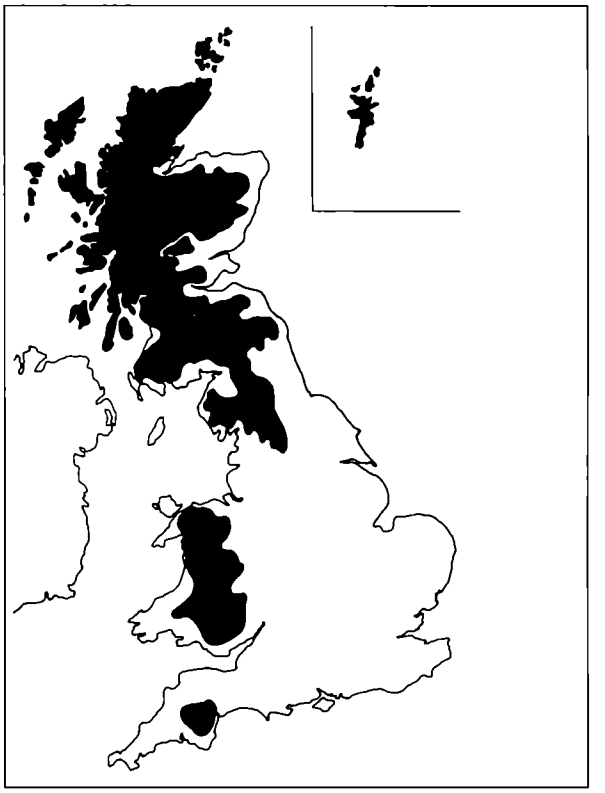
Terrain and site types
Valley sides and hill slopes around the upland fringes and on well-drained terraces of larger rivers.

Major recommended trees
Sessile oak
Downy birch

Minor recommended trees
Silver birch (major in east-central Scotland)
Pedunculate oak (locally)
Rowan
Holly and aspen (local)

Recommended shrubs
Hazel
Hawthorn
Juniper (in more open places)

Optimal precursor vegetation
Grasslands with
- Sheep's fescue (*Festuca ovina*)
- Red fescue (*Festuca rubra*)
- Sweet vernal grass (*Anthoxanthum odoratum*)
- Common bent (*Agrostis capillaris*)
- Yorkshire fog (*Holcus lanatus*)
- Heath bedstraw (*Galium saxatile*)



- Tormentil (*Potentilla erecta*)
- Common dog violet (*Viola riviniana*)
- Field wood-rush (*Luzula campestris*)
- Yarrow (*Achillea millefolium*)

Fern vegetation with some of the above and
- Bracken (*Pteridium aquilinum*)
- Lemon-scented fern (*Thelypteris limbosperma*)
- Hard fern (*Blechnum spicant*)
- Broad buckler fern (*Dryopteris dilatata*)
- Great wood-rush (*Luzula sylvatica*)

Desired invaders
Bluebell (*Hyacinthoides non-scripta*)
Primrose (*Primula vulgaris*)
Pignut (*Conopodium majus*)
Wood sorrel (*Oxalis acetosella*)

Wood sage (*Teucrium scorodonia*)
Creeping soft-grass (*Holcus mollis*)
Wood anemone (*Anemone nemorosa*)
Chickweed wintergreen (*Trientalis europaea*, in east-central Scotland)

Woodland structure and pattern

Semi-natural stands have little diversity among the trees and shrubs, a feature accentuated by the widespread use of the woodlands as oak-coppice with grazing or by the spread of birch following the removal of all good-quality timber. However, more open areas can be given mixtures of rowan, birch, juniper and holly. Open areas will show a strong tendency to become bracken dominated, but where this has an understorey of bluebell there is greater interest. Rocky ground and wetter places promise more diversity in associated herbaceous vegetation, and, in some of the latter, plantings can encourage development of **alder-ash-yellow pimpernel woodland.**

Upland oak-birch woodland with bilberry/blaeberry

NVC woodland W17

Zone
Throughout the cooler and wetter upland fringes of northern and western Britain.

Soil types
Rankers, podzolic brown earths and podzols.

Geology
Sedimentary sandstones and grits, igneous rocks like lime-poor granites and lavas, quartzites and gneisses, and pervious lime-poor superficial deposits like coarse fluvioglacial sands and gravels.

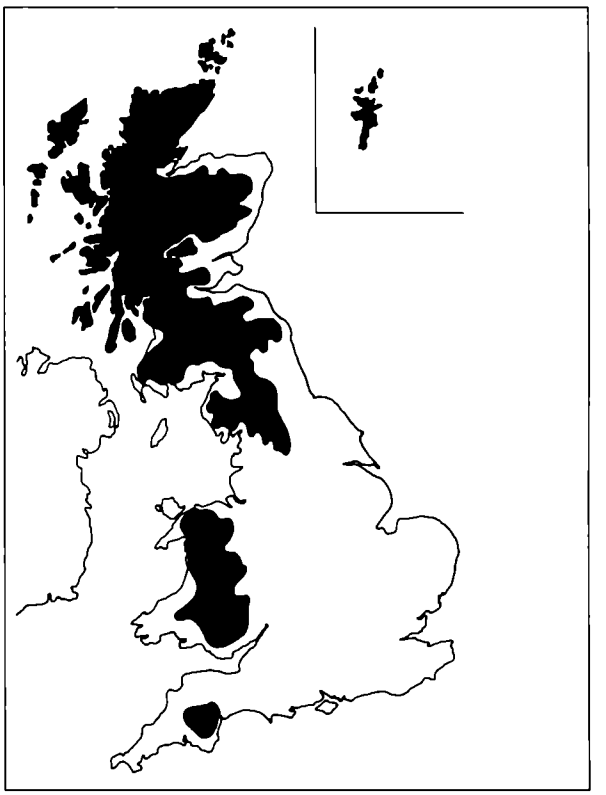
Terrain and site types
Scarps, valley sides and hill slopes, often with rugged terrain, around the upland fringes of the north and west.

Major recommended trees
Sessile oak
Downy birch

Minor recommended trees
Pedunculate oak (with local abundance in east-central Scotland)
Silver birch (with local abundance in east-central Scotland)
Holly
Rowan

Recommended shrubs
Hazel (only on better soils)
Hawthorn (only on better soils)
Juniper (in more open places)

Optimal precursor vegetation
Grasslands and heaths with
- Heather (*Calluna vulgaris*)
- Bilberry/blaeberry (*Vaccinium myrtillus*)
- Bell-heather (*Erica cinerea*)
- Crowberry (*Empetrum nigrum*)
- Cowberry (*Vaccinium vitis-idaea*)
- Wavy hair-grass (*Deschampsia flexuosa*)
- Sheep's fescue (*Festuca ovina*)



- Mat grass (*Nardus stricta*)
- Common bent (*Agrostis capillaris*)
- Sweet vernal grass (*Anthoxanthum odoratum*)
- Heath bedstraw (*Galium saxatile*)
- Tormentil (*Potentilla erecta*)
- Hard fern (*Blechnum spicant*)

Tall-herb and fern vegetation with some of the above and
- Bracken (*Pteridium aquilinum*)
- Broad buckler fern (*Dryopteris dilatata*)
- Great wood-rush (*Luzula sylvatica*)
- Wood sorrel (*Oxalis acetosella*)

Desired invaders
Few herbs other than those listed except in east-central Scotland where the following are

common in semi-natural woodlands of this kind:

Chickweed wintergreen (*Trientalis europaea*)
Hairy wood-rush (*Luzula pilosa*)

Further west, there is an increasingly rich bryophyte flora in woods of this kind, particularly where boulders and crags provide sheltered and shaded niches.

Woodland structure and pattern

Many existing stretches of this kind of woodland show a preponderance of oak in former coppice or of birch where this has spread after clearance. Even in new woodlands there is limited scope with this type for species diversity among trees and shrubs. However, variations in the pattern of the few important trees and shrubs, local concentration of minor components on patches of richer soils and inclusion of unplanted areas will give some variety and opportunity for transitions to heath and fern-rich vegetation. Only on bouldery sites will the full richness of mosses and liverworts develop and, on deeper soils, the spread of bracken is always a threat.

Beech-ash woodland with dog's mercury

NVC woodland W12

Zone
Warmest and driest lowlands of south-east England and south Wales.

Soil type
Rendzinas and brown calcareous earths.

Geology
Chalk, Oolitic and Carboniferous limestones.

Terrain and site types
Scarps and screes, and steeply sloping ground in gaps and on knolls on the limestone hills of south-east Britain.

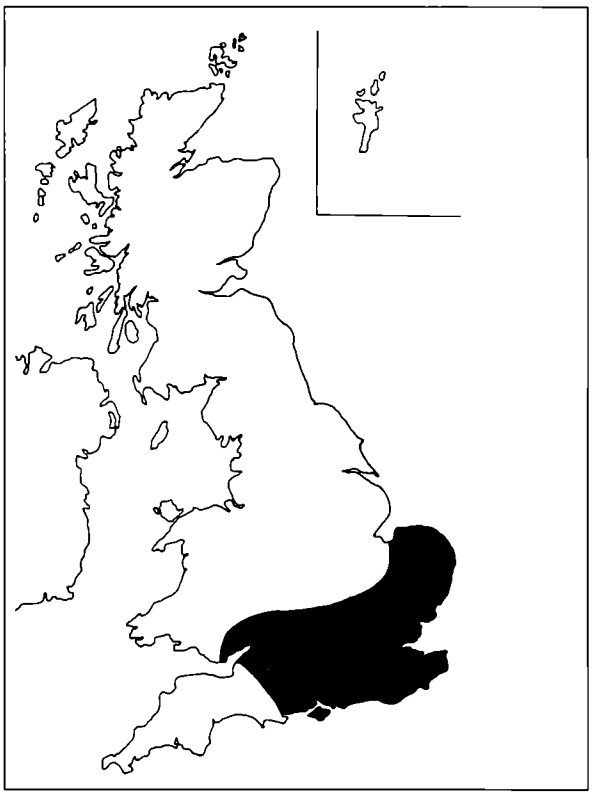
Major recommended trees
Beech
Ash

Minor recommended trees
Pedunculate oak
Common whitebeam
Yew
Silver birch
Field maple
Holly
Hornbeam

Major recommended shrubs
Hazel
Hawthorn

Minor recommended shrubs
Elder
Guelder rose
Wayfaring tree
Spindle
Wild privet
Dogwood (in more open places)
Juniper (in more open places)

Optimal precursors
Dry rank grasslands with
False oat-grass (*Arrhenatherum elatius*)



Tor grass (*Brachypodium pinnatum*)
Upright brome (*Bromus erectus*)
False brome (*Brachypodium sylvaticum*)
Marjoram (*Origanum vulgare*)
Perforate St John's-wort (*Hypericum perforatum*)
Agrimony (*Agrimonia eupatorium*)
Wood sage (*Teucrium scorodonia*)
Herb robert (*Geranium robertianum*)
Stinging nettle (*Urtica dioica*)
Burdock (*Arctium minus*)
Deadly nightshade (*Atropa belladonna*)
Great mullein (*Verbascum thapsus*)
Common figwort (*Scrophularia nodosa*)
Ploughman's spikenard (*Inula conyza*)

Desired invaders
Dog's mercury (*Mercurialis perennis*)
Enchanter's nightshade (*Circaea lutetiana*)

Bluebell (*Hyacinthoides non-scripta*)
Lords and ladies (*Arum maculatum)*
Woodruff (*Galium odoratum*)
Yellow archangel (*Lamiastrum galeobdolon*)
Sanicle (*Sanicula europaea*)
Wall lettuce (*Mycelis muralis*)
Wood melick (*Melica uniflora*)
White helleborine (*Cephalanthera damasonium*)
Broadleaved helleborine (*Epipactis helleborine*)

Woodland structure and pattern

Beech is such a densely shading tree that close planting will always inhibit the development of a richer associated flora. If such diversity is desired, more balanced mixtures of trees and shrubs should be used and more open areas integrated into the plantings. Varied and colourful edges can also be encouraged using ash, birch and the minor shrubs. However, these will quickly spread into gaps and transitions to short, herb-rich swards will only be maintained by grazing or mowing. Shifts, within a site, to less base-rich brown soils should be reflected by planting **beech-oak woodland with bramble (W14).**

Beech-oak woodland with bramble

NVC woodland W14

Zone
Warmest and driest lowlands of south-east England and south Wales.

Soil types
Typical brown earths.

Geology
Non-calcareous sedimentary shales and clays, and lime-poor superficial deposits like clay-with-flints and plateau drift.

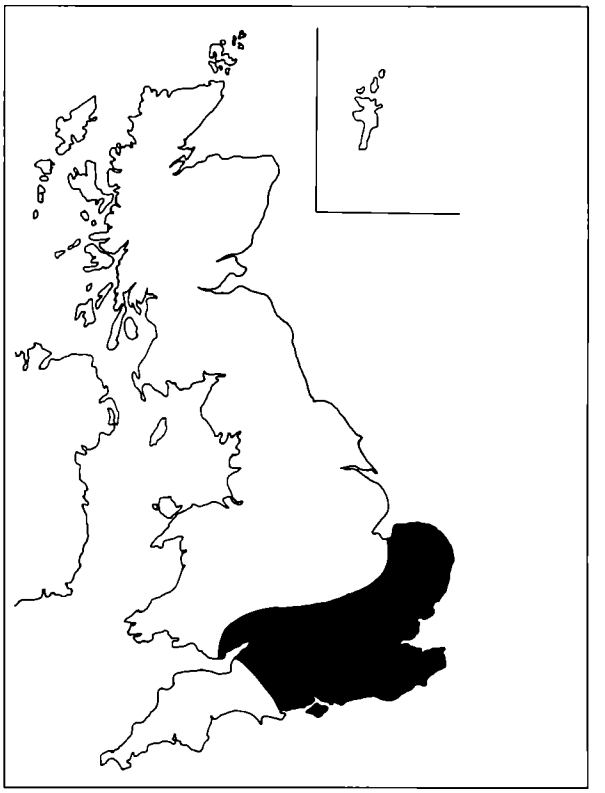
Terrain and site types
Dip slopes and plateaux, often drift-covered, on the low hills of southern Britain.

Major recommended trees
Beech
Pedunculate oak
Holly

Minor recommended trees
Silver birch
Sessile oak (locally)
Yew
Ash
Rowan
Goat willow
Gean

Recommended shrubs
Hazel
Hawthorn
Elder
Wild privet

Optimal precursor vegetation
Rank grassland with
- False oat-grass (*Arrhenatherum elatius*)
- Yorkshire fog (*Holcus lanatus*)
- Cock's-foot (*Dactylis glomerata*)
- Creeping soft-grass (*Holcus mollis*)
- Rosebay willowherb (*Epilobium angustifolium*)



- Hogweed (*Heracleum sphondylium*)
- Creeping thistle (*Cirsium arvense*)
- Spear thistle (*C. vulgare*)
- Stinging nettle (*Urtica dioica*)

Underscrub with some of the above plants and
- Bramble (*Rubus fruticosus*)
- Common gorse/whin (*Ulex europaeus*)
- Broom (*Cytisus scoparius*)
- Bracken (*Pteridium aquilinum*)
- Foxglove (*Digitalis purpurea*)
- Red campion (*Silene dioica*)
- Wood sage (*Teucrium scorodonia*)
- Ivy (*Hedera helix*)

Desired invaders
Wood sorrel (*Oxalis acetosella*)
Wood millet (*Milium effusum*)
Wood melick (*Melica uniflora*)

Woodruff (*Galium odoratum*)
Wood spurge (*Euphorbia amygdaloides*)
Butcher's broom (*Ruscus aculeatus*)

Woodland structure and pattern

Beech can make its best growth of all on the soils characteristic here, so the creation of lofty canopies can be a long-term aim, with the hope of a second tier of holly and yew. Semi-natural stands of such woodland are often bare below and, even with more open spacing, richness among the field layer is never going to be very great. The spread of bramble in such situations may be seen as a problem too, although this plays an important role in maintaining the quality of the soil. Unplanted areas are likely to become rank and weedy or to scrub up with birch and gorse if grazing or mowing are not maintained. Transitions to more acidic soils can be planted with much the same tree mixtures, but will develop a more heathy associated flora.

Beech-oak woodland with wavy hair-grass

NVC woodland W15

Zone
Warmest and driest lowlands of south-east England and south Wales.

Soil types
Acidic brown earths and podzols.

Geology
Sedimentary sandstones, grits and sands and gravels, and coarse textured, pervious and lime-free superficial deposits.

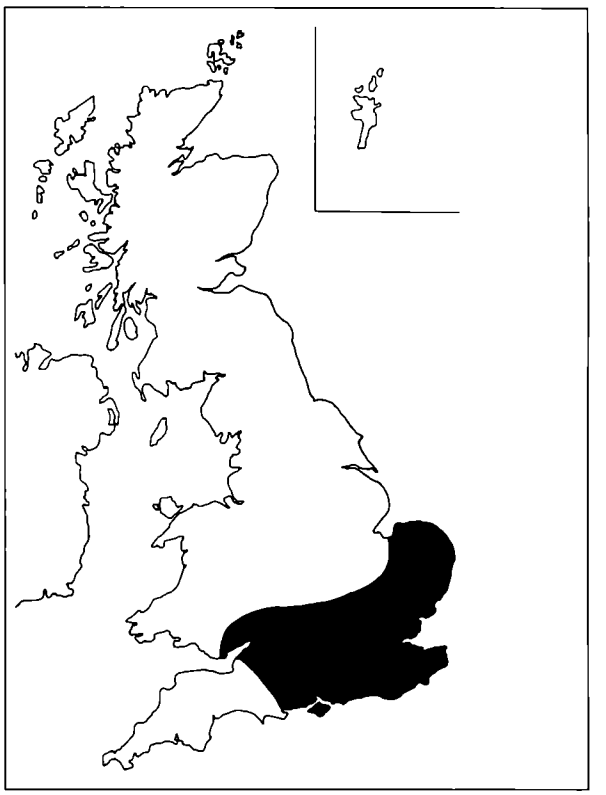
Terrain and site types
Dip slopes and plateaux, often drift-covered, on the low hills of southern Britain, and free-draining basins and terraces between.

Major recommended trees
Beech
Pedunculate oak
Holly

Minor recommended trees
Silver birch
Yew
Rowan
Sessile oak (locally)

Recommended shrubs
Alder buckthorn

Optimal precursor vegetation
Grasslands and heaths with
- Heather (*Calluna vulgaris*)
- Bell-heather (*Erica cinerea*)
- Dwarf gorse (*Ulex minor*)
- Western gorse (*Ulex gallii*)
- Bilberry/blaeberry (*Vaccinium myrtillus*)
- Wavy hair-grass (*Deschampsia caespitosa*)
- Common bent (*Agrostis capillaris*)
- Tormentil (*Potentilla erecta*)
- Heath bedstraw (*Galium saxatile*)
- Sheep's sorrel (*Rumex acetosella*)
- Sheep's fescue (*Festuca ovina*)



Underscrub or fern stands with some of the above and
- Common gorse/whin (*Ulex europaeus*)
- Broom (*Cytisus scoparius*)
- Bracken (*Pteridium aquilinum*)

Woodland structure and pattern
Wide spacing and the inclusion of unplanted areas will not encourage great diversity on these impoverished acidic soils but the associated heathy flora can be visually very attractive where the heathers and gorse have sufficient light to flower. Such a cover of sub-shrubs in more open areas may also hinder the spread of birch and bracken. Colonisation by pine and other conifers may also be a problem.

Scots pine woodland with heather

NVC woodland W18

Zone
Cold and wet uplands of the Grampians and western Highlands.

Soil types
Podzols and peaty podzols, with some podzolic gleys and peaty podzolic gleys, and some podzolic brown earths.

Geology
Pervious, siliceous bedrocks such as sandstones, schists and quartzites and permeable superficial deposits, especially fluvioglacial sands and gravels.

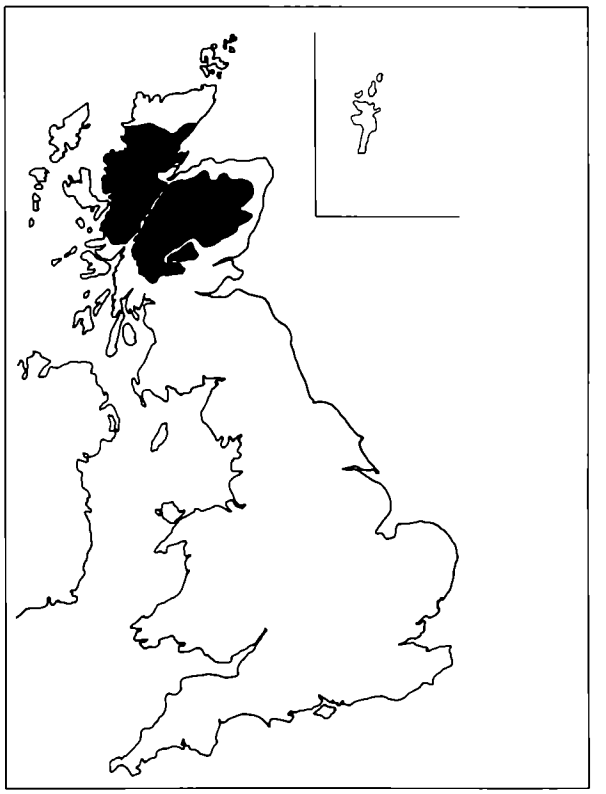
Terrain and site types
Upland plateaux and hill slopes, and particularly the undulating terraces of major river valleys.

Major recommended trees
Scots pine

Minor recommended trees
Silver birch (mainly east-central)
Downy birch (mainly western)
Rowan

Recommended shrubs
Juniper

Optimal precursor vegetation
Heaths with
- Heather (*Calluna vulgaris*)
- Blaeberry (*Vaccinium myrtillus*)
- Cowberry (*V. vitis-idaea*)
- Crowberry (*Empetrum nigrum*)
- Bell-heather (*Erica cinerea*)
- Bearberry (*Arctostaphylos uva-ursi*)
- Wavy hair-grass (*Deschampsia flexuosa*)
- Tormentil (*Potentilla erecta*)
- Heath bedstraw (*Galium saxatile*)
- Common cow-wheat (*Melampyrum pratense*)
- Hard fern (*Blechnum spicant*)



Desired invaders
Lesser twayblade (*Listera cordata*)
Creeping lady's-tresses (*Goodyera repens*)
Wood sorrel (*Oxalis acetosella*)
Hairy wood-rush (*Luzula pilosa*)

Semi-natural stands of this woodland also have extensive carpets of bryophytes, including bog mosses (*Sphagnum* spp.) in boggy hollows and towards the west.

Woodland structure and pattern
Pine forest on the grand scale of the past was a varied tapestry of this kind of woodland with associated stands of oak-birch and juniper and wetter woodland with alder, willows and ash. Where new sites for planting have a diversity of soils, such mosaics should be aimed for with

ample areas left unplanted for the encouragement of heath, tall-herb and grassland vegetation. Even-aged stands of pine of varying size are a natural feature of this woodland which has tended to regenerate after disturbance by wind or fire.

Juniper woodland with wood sorrel

NVC woodland W19

Zone
Locally through the cold and wet uplands of northern England, the southern uplands of Scotland and the eastern Highlands.

Soil types
Typical and acidic brown earths and podzolic brown earths, sometimes moderately mesotrophic and with mull or moder humus, and podzols with mor.

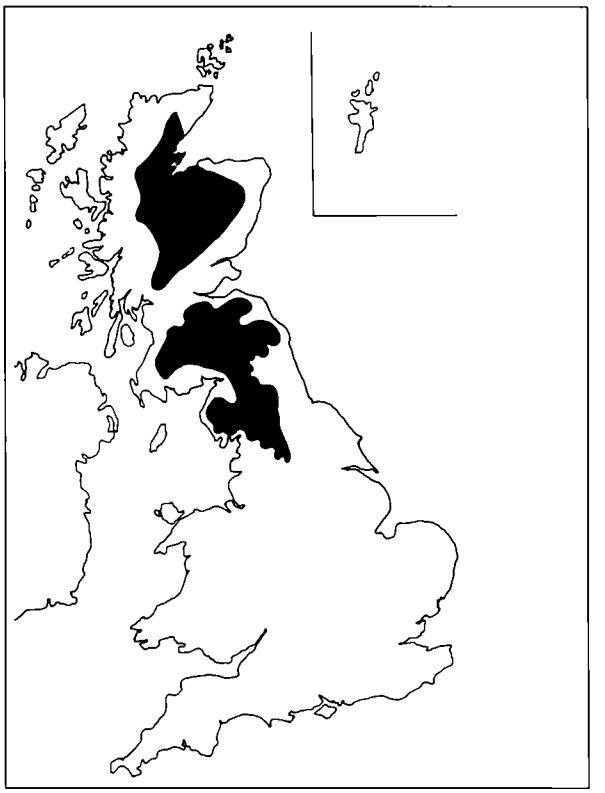
Geology
Sedimentary shales and sandstones, and various igneous and metamorphic rocks like quartzites, gneisses and rhyolites, locally with some lime-enrichment, and also sandy or gravelly superficial deposits.

Terrain and site types
Valley sides and hill slopes in the uplands.

Major recommended trees
Juniper

Minor recommended trees
Downy birch
Scots pine
Rowan

Optimal precursor vegetation
Grasslands with
- Sheep's fescue (*Festuca ovina*)
- Red fescue (*Festuca rubra*)
- Sweet vernal grass (*Anthoxanthum odoratum*)
- Wavy hair-grass (*Deschampsia flexuosa*)
- Common bent (*Agrostis capillaris*)
- Brown bent (*Agrostis canina montana*)
- Heath grass (*Danthonia decumbens*)
- Heath speedwell (*Veronica officinalis*)
- Common dog violet (*Viola riviniana*)
- Alpine lady's mantle (*Alchemilla alpina*)
- Harebell (*Campanula rotundifolia*)
- Field wood-rush (*Luzula campestris*)



- Common bird's-foot trefoil (*Lotus corniculatus*)
- White clover (*Trifolium repens*)
- Ribwort plantain (*Plantago lanceolata*)
- Yarrow (*Achillea millefolium*)

Grasslands and heaths with
- Heather (*Calluna vulgaris*)
- Bilberry/blaeberry (*Vaccinium myrtillus*)
- Cowberry (*V. vitis-idaea*)
- Wavy hair-grass (*Deschampsia flexuosa*)
- Sheep's fescue (*Festuca ovina*)
- Common bent (*Agrostis capillaris*)
- Sweet vernal grass (*Anthoxanthum odoratum*)
- Alpine lady's-mantle (*Alchemilla alpina*)
- Heath bedstraw (*Galium saxatile*)
- Tormentil (*Potentilla erecta*)
- Hard fern (*Blechnum spicant*)

Desired invaders
Wood anemone (*Anemone nemorosa*)
Chickweed wintergreen (*Trientalis europaea*)
Wood sorrel (*Oxalis acetosella*)
Hairy wood-rush (*Luzula pilosa*)
Broad buckler fern (*Dryopteris dilatata*)
Lemon-scented fern (*Thelypteris limbosperma*)
Beech fern (*T. phegopteris*)
Oak fern (*Gymnocarpium dryopteris*)

Many semi-natural stands of this kind of woodland also have patchy carpets of bryophytes in more open places.

Woodland structure and pattern
At all but the highest altitudes in Scotland, juniper woodland of this type is strictly speaking a stage in the succession to pine or oak-birch woodland. Since it has similar soil preferences to these other communities, it offers an alternative option for planting and can be used to bring some patchy diversity to their cover or concentrated in irregular groups in and around open areas and woodland margins. It may attain a semi-permanent status where grazing among the bushes prevents the spread of invading trees, but stock will also limit the development of richer associated floras of tall herbs. Juniper has very diverse growth forms in different areas and local stock should be used for planting to help develop this distinctiveness.

Alder woodland with common reed

Zone
Locally through the warmer and drier lowlands of southern and eastern Britain.

Soil types
Topogenous fen peats and peaty alluvial soils.

Geology
Topogenous fen peats or peaty alluvium over impervious bedrocks or superficial deposits.

Terrain and site types
Floodplain and some basin mires, valley mire terraces and around artificial open waters through the flat or gently undulating lowlands.

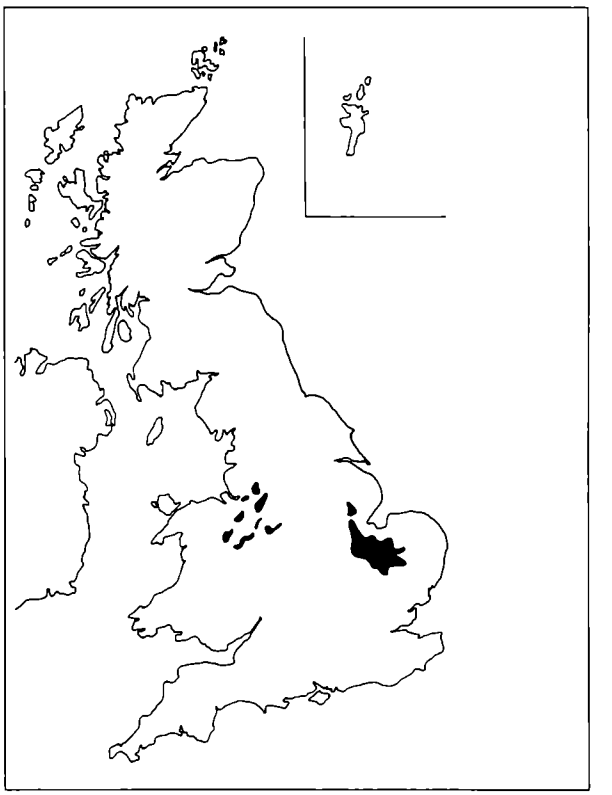
Major recommended trees
Alder
Downy birch

Minor recommended trees
Ash
Pedunculate oak
Crack willow

Major recommended shrubs
Grey sallow

Minor recommended shrubs
Alder buckthorn
Purging buckthorn
Guelder rose
Hawthorn
Eared willow

Optimal precursor vegetation
Tall-herb fen with
- Common reed (*Phragmites australis*)
- Meadowsweet (*Filipendula ulmaria*)
- Wild angelica (*Angelica sylvestris*)
- Agrimony (*Agrimonia eupatorium*)
- Purple loosestrife (*Lythrum salicaria*)
- Yellow loosestrife (*Lysimachia vulgaris*)



- Marsh thistle (*Cirsium palustre*)
- Stinging nettle (*Urtica dioica*)
- Lesser pond-sedge (*Carex acutiformis*)
- Bitter-sweet (*Solanum dulcamara*)
- Yellow iris (*Iris pseudacorus*)
- Water mint (*Mentha aquatica*)

Desired invaders
Bramble (*Rubus fruticosus*)
Broad buckler fern (*Dryopteris dilatata*)
Rough meadow grass (*Poa trivialis*)

Woodland structure and pattern
Younger semi-natural stands of this kind of woodland are characteristically rather different one from another with chance colonisation producing local abundance of either alder, birch or sallow. Irregular patches or mixtures of these species can therefore be

concentrated on wetter ground with more balanced or richer plantings on drier areas. Dense spacing will quickly extinguish richer wetland floras and discourage colonisation. Surrounding slopes can be planted up with the appropriate mixed broadleaved, oak-birch or beech woodland. Unplanted areas are likely to become colonised by trees and shrubs quite quickly if flooding stops or the drier ground is not mown. Disturbance and enrichment of the ground is likely to encourage the spread of nettle.

Alder woodland with stinging nettle

NVC woodland W6

Zone
Locally through the warmer and drier lowland of southern and eastern Britain.

Soil types
Moist alluvial soils and enriched fen peats.

Geology
Young alluvium and disturbed or enriched fen peats.

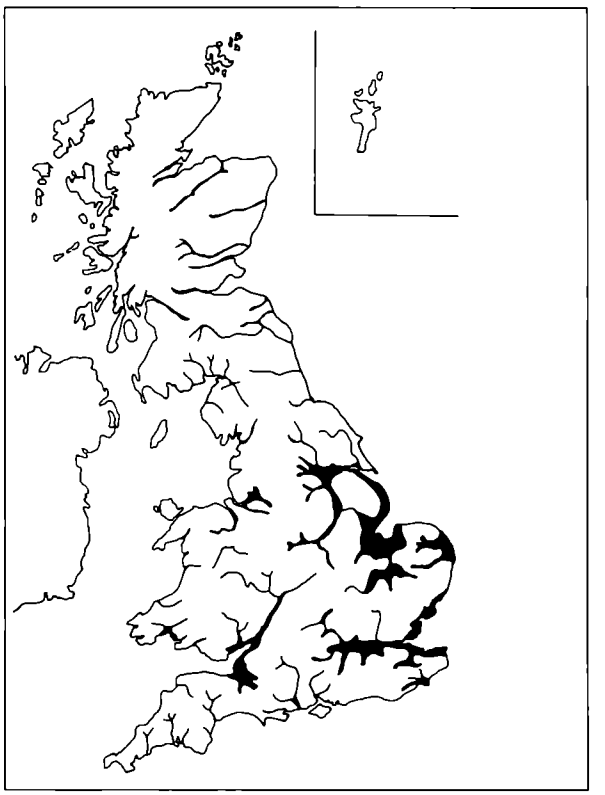
Terrain and site types
Alluvial terraces in more mature river valleys and silting margins of standing open waters, natural and artificial, and in disturbed or eutrophicated floodplain and basin mires.

Major recommended trees
Alder
Crack willow

Minor recommended trees
Downy birch
Ash
Pedunculate oak
Holly
Goat willow

Major recommended shrubs
Grey sallow
Elder

Minor recommended shrubs
Hawthorn
Guelder rose
Blackthorn
Alder buckthorn (locally)
Purging buckthorn (locally)
Almond willow
Osier willow
Purple willow



Optimal precursor vegetation
Tall-herb or grassy fen with
- Common reed (*Phragmites australis*)
- Stinging nettle (*Urtica dioica*)
- Goosegrass (*Galium aparine*)
- Great willowherb (*Epilobium hirsutum*)
- Bitter-sweet (*Filipendula ulmaria*)
- Hemp agrimony (*Eupatorium cannabinum*)
- False oat-grass (*Arrhenatherum elatius*)
- Hogweed (*Heracleum sphondylium*)
- Creeping thistle (*Cirsium arvense*)
- Butterbur (*Petasites hybridus*)
- Hedge bindweed (*Calystegia sepium*)
- Tufted vetch (*Vicia cracca*)

Marginal vegetation with some of the above and some of
- Reed sweet-grass (*Glyceria maxima*)
- Greater pond-sedge (*Carex riparia*)

Lesser pond-sedge (*C. acutiformis*)
Cyperus sedge (*C. pseudocyperus*)
Bulrush (*Typha latifolia*)
Branched bur-reed (*Sparganium erectum*)
Fool's watercress (*Apium nodiflorum*)
Watercress (*Nasturtium officinale*)
Brooklime (*Veronica beccabunga*)
Reed canary-grass (*Phalaris arundinacea*)
Water mint (*Mentha aquatica*)
Water forget-me-not (*Myosotis scorpioides*)
Tufted forget-me-not (*M. laxa cespitosa*)
Water plantain (*Alisma plantago-aquatica*)

Woodland structure and pattern

In younger semi-natural stands, almond, osier and purple willow often predominate and these can be planted in patchy concentrations between and around mixtures of the major trees. Mature stands usually have a tall closed canopy but can develop a decrepit appearance on alluvial flats that are still periodically flooded. Wide spacing and open areas are essential to maintain any kind of richness in the associated flora but there is always a tendency on rich soils of this kind for nettle, goosegrass and great willowherb to predominate. Transitions on drier riverside slopes would naturally be to mixed broadleaved woodland with bluebell or dog's mercury.

Birch woodland with purple moor-grass

NVC woodland W4

Zone
Throughout the wetter regions of Britain and locally in the lowlands where site conditions are suitable.

Soil types
Flushed and unflushed acid peats, and peaty surface-water gleys.

Geology
Peats or over impervious shales and clays, or heavy superficial deposits, where flushed with base-poor waters.

Terrain and site types
Margins of blanket mires, valley bogs and hill-slope and valley-side flushes and the margins of cut-over or drained raised mires.

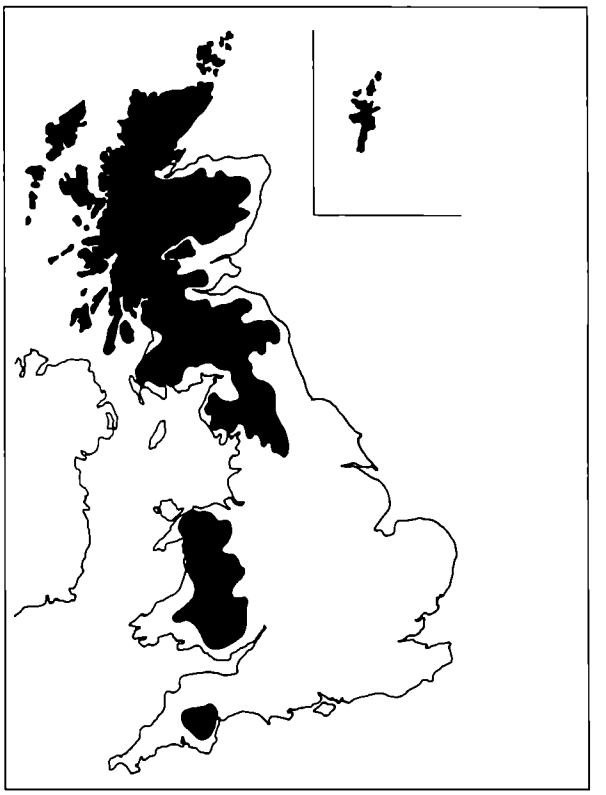
Major recommended trees
Downy birch

Minor recommended trees
Goat willow
Alder

Recommended shrubs
Grey sallow
Eared willow
Bay willow (in northern Britain)

Optimal precursor vegetation
Wet grasslands and rushy pastures with
- Purple moor-grass (*Molinia caerulea*)
- Soft rush (*Juncus effusus*)
- Sharp-flowered rush (*J. acutiflorus*)
- Yorkshire fog (*Holcus lanatus*)
- Brown bent (*Agrostis canina*)
- Common bent (*A. capillaris*)
- Sweet vernal grass (*Anthoxanthum odoratum*)
- Greater bird's-foot trefoil (*Lotus uliginosus*)
- Marsh thistle (*Cirsium palustre*)
- Devil's-bit scabious (*Succisa pratensis*)
- Wild angelica (*Angelica sylvestris*)
- Tormentil (*Potentilla erecta*)

Wet heath, degraded mires and flushes with
- Purple moor-grass (*Molinia caerulea*)
- Cross-leaved heath (*Erica tetralix*)
- Heather (*Calluna vulgaris*)
- Sweet gale (*Myrica gale*)
- Heath rush (*Juncus squarrosus*)
- Mat grass (*Nardus stricta*)
- Deer grass (*Scirpus cespitosus*)
- Star sedge (*Carex echinata*)
- Carnation sedge (*Carex panicea*)
- Sharp-flowered rush (*Juncus acutiflorus*)
- Marsh violet (*Viola palustris*)
- Common cotton-grass (*Eriophorum angustifolium*)



Desired invaders

Tufted hair-grass *(Deschampsia cespitosa)*
Creeping soft-grass (*Holcus mollis*)
Bramble (*Rubus fruticosus*)
Honeysuckle (*Lonicera periclymenum*)
Broad buckler fern (*Dryopteris dilatata)*
Narrow buckler fern (*Drtopteris carthusiana*)
Smooth-stalked sedge (*Carex laevigata*)

Woodland structure and pattern

Semi-natural stands of this sort of woodland usually have a vigorous and dense cover of young birch or an open and decrepit canopy of older trees. Plantings can aim for a little more diversity by varying the abundance of associates and, especially on flushed ground, wider spacing will encourage the development of a richer field layer. Drier sites offer less promise of variety but open areas can have transitions to heath vegetation. A shift on to acid peaty mineral soils on surrounding terrain is common and here **oak-birch woodland with bilberry/blaeberry** would be usual.

Alder-ash woodland with yellow pimpernel

Zone
Throughout the wetter regions of Britain, particularly around the upland fringes of the north and west.

Soil types
Moderately base-rich and mesotrophic surface-water gleys and flushed brown earths, and some ground-water gleys.

Geology
Impervious sedimentary shales and clays, and heavy superficial deposits like boulder clay and clayey head or downwash.

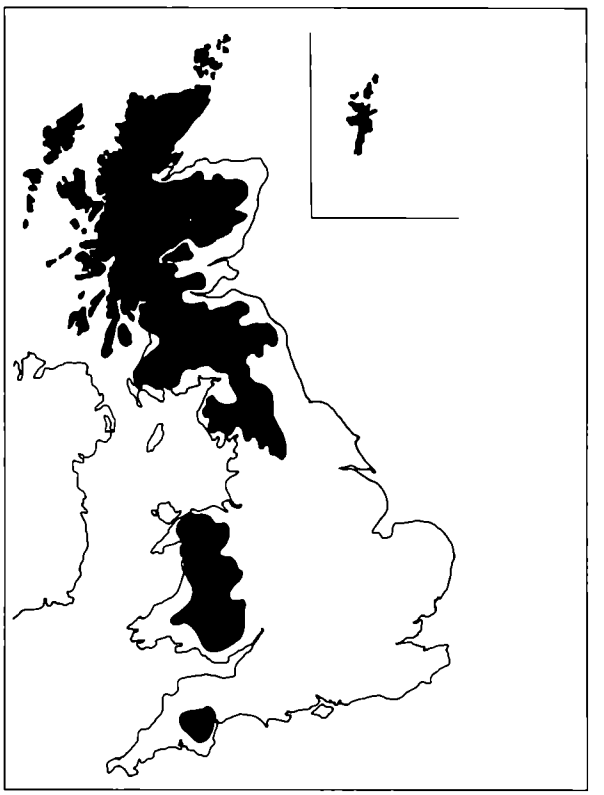
Terrain and site types
Valley sides and hill slopes with flushes and seepage lines, streamsides and older alluvial terraces, and waterlogged brows and plateaux.

Major recommended trees
Alder
Ash

Minor recommended trees
Downy birch
Goat willow
Pedunculate oak
Sessile oak
Rowan
Holly
Bird cherry (in northern Britain)

Major recommended shrubs
Grey sallow
Hazel
Hawthorn

Minor recommended shrubs
Elder
Guelder rose
Blackthorn
Bay willow (towards northern Britain)



Optimal precursor vegetation
Tall-herb fens and rushy pastures with
- Meadowsweet (*Filipendula ulmaria*)
- Soft rush (*Juncus effusus*)
- Sharp-flowered rush (*J. acutiflorus*)
- Tufted hair-grass (*Deschampsia cespitosa*)
- Rough meadow grass (*Poa trivialis*)
- Sweet vernal grass (*Anthoxanthum odoratum*)
- Marsh thistle (*Cirsium palustre*)
- Wild angelica (*Angelica sylvestris*)
- Common valerian (*Valeriana officinalis*)
- Creeping buttercup (*Ranunculus repens*)
- Marsh marigold (*Caltha palustris*)
- Cuckoo flower (*Cardamine pratensis*)
- Common dog violet (*Viola riviniana*)
- Water mint (*Mentha aquatica*)
- Stinging nettle (*Urtica dioica*)

Desired invaders

Creeping soft-grass (*Holcus mollis*)
Wood sorrel (*Oxalis acetosella*)
Yellow pimpernel (*Lysimachia nemorum*)
Opposite-leaved golden saxifrage (*Chrysosplenium oppositifolium*)
Remote sedge (*Carex remota*)
Smooth-stalked sedge (*C. laevigata*)
Pendulous sedge (*C. pendula*)
Lady fern (*Athyrium filix-femina*)
Broad buckler fern (*Dryopteris dilatata*)
Marsh hawk's-beard (*Crepis paludosa,* in northern Britain)

Woodland structure and pattern

Characteristically semi-natural stands of this kind of woodland have a rather open and irregular cover of trees and shrubs, some keeling over where the ground slumps. More widely spaced plantings will also encourage the retention or development of a richer associated flora and, even where there is no grazing, the wetness and instability of the ground will help discourage canopy closure. Stands will often be small, marking out isolated slope flushes, but plantings should not be too closely crowded by the surrounding woodlands. Transitions on such drier slopes will usually be to mixed broadleaved or oak-birch woodlands and, on any alluvium or peat below, to **alder-reed** or **alder-nettle** woodlands.

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