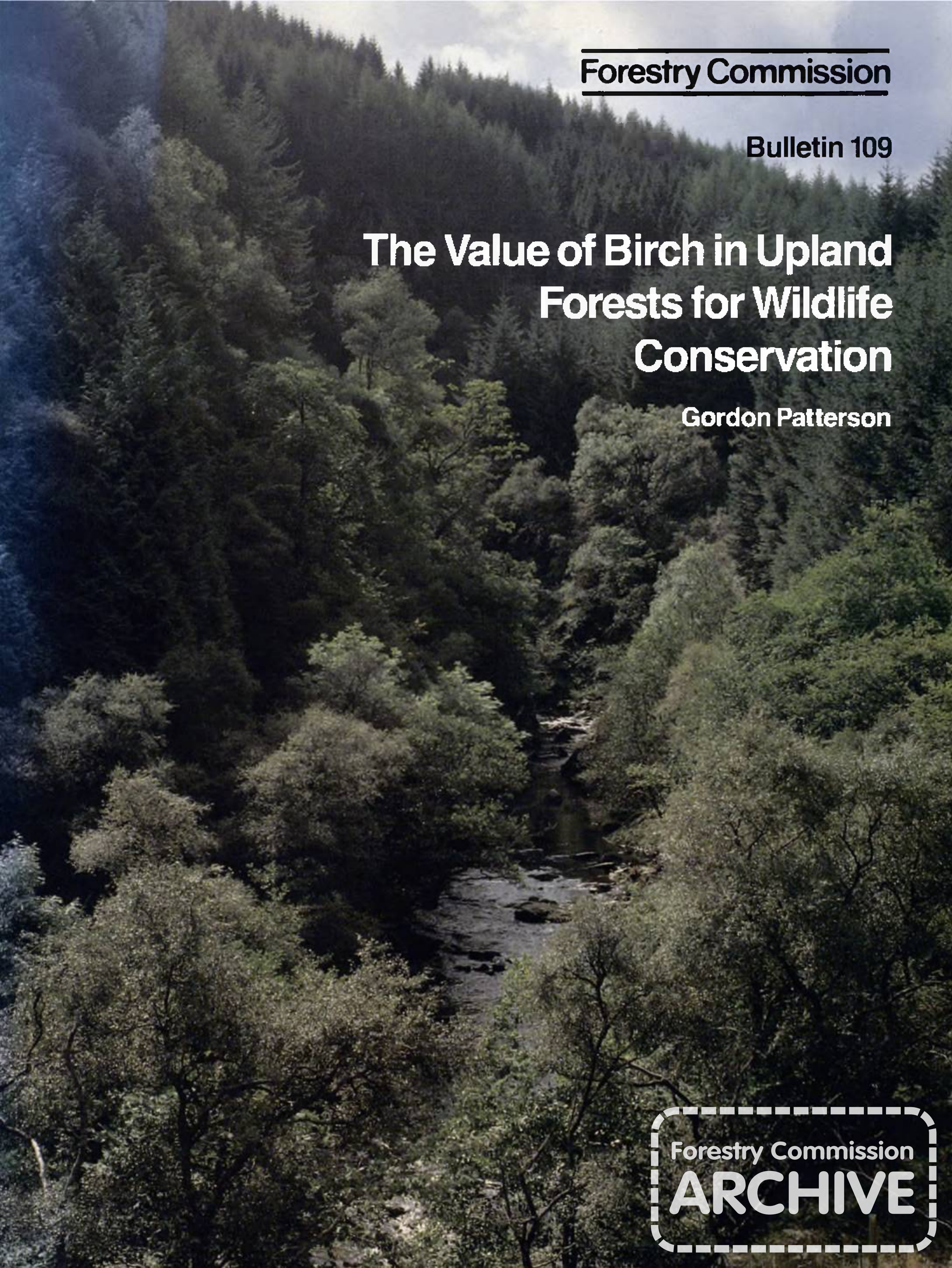
Forestry Commission

Bulletin 109

The Value of Birch in Upland Forests for Wildlife Conservation

Gordon Patterson



FORESTRY COMMISSION BULLETIN 109

The Value of Birch in Upland Forests for Wildlife Conservation

Gordon S. Patterson
Forest Ecologist, Wildlife and Conservation Research Branch
Northern Research Station, Roslin, Midlothian EH25 9SY

LONDON: HMSO

ISBN 0 11 710316 0
FDC 907 : 176.1 : 151 : (410)

KEYWORDS: Birch, Forests,
Wildlife conservation, Uplands

Enquiries relating to this publication
should be addressed to:
The Technical Publications Officer,
The Forestry Authority, Forest Research Station,
Alice Holt Lodge, Wrecclesham,
Farnham, Surrey, GU10 4LH.

Front cover: Semi-natural woodland dominated by
downy birch (*Betula pubescens*, ssp. *pubescens*)
alongside the River Add in Kilmichael Forest, Argyll.

Contents

The Value of Birch in Upland Forests for Wildlife Conservation

Summary

Broadleaved trees and shrubs are frequently scarce in upland forests in Britain, and national policy is to increase the proportion of broadleaves because of their value as wildlife habitat. Birches (*Betula pubescens* Ehrh. and *Betula pendula* Roth.) are between them adapted to succeed on a wide range of soils and are the commonest native trees of infertile regions.

The value of birches for wildlife is high for most taxonomic groups. Birch woodland is capable of increasing the fertility of some mineral soils; it supports a large number of specialist and generalist phytophagous insects and a wide variety of woodland plants, birds and mammals. When mixed into conifer stands, birch is likely to increase their diversity considerably, especially for insects and birds.

Ways of increasing birch cover in upland forest are suggested, with emphasis upon improvements at the end of the first rotation for existing forests, which were established mainly on bare pasture or moorland. The best strategy for increasing the biodiversity of woodland species associated with birch, while also encouraging the uncommon and less mobile species associated with long-established semi-natural woodland, is to establish birch in the following locations:

- linked to existing semi-natural woodlands;
- in patches and clumps on rides, roadsides and streamsides to form a loosely connected network;
- in clumps within conifer plantations, mainly towards the edges of compartments;
- as a temporary intimate mixture in conifer plantations which is largely shaded out after canopy-closure.

The establishment of clumps of birch along edges during the first rotation to act as seed sources for colonising felled ground is likely to be an effective method of increasing birch cover in the second rotation.

Although birches are recommended as major broadleaved species to diversify wildlife on infertile soils in upland areas, other native trees and shrubs should also be used, according to the site, especially within or close to established semi-natural woodland.

Importance du bouleau dans la protection de l'environnement des forêts en altitude

Résumé

Les arbres et arbustes feuillus sont fréquemment rares dans les forêts britanniques en altitude, et la politique nationale est d'augmenter la proportion de ces arbres en raison de leur importance pour la flore et la faune. Les bouleaux (*Betula pubescens* Ehrh. et *Betula pendula* Roth.) sont adaptés à une grande variété de sols, et sont les arbres indigénes les plus communs des régions infertiles du Royaume-Uni.

Les bouleaux sont tres importants pour la faune et la flore de la plupart des groupes taxonomiques. Les forêts de bouleaux sont capables d'augmenter la fertilité de certains sols minéraux, et elles abritent un grand nombre d'insectes phytophages, spécialisés ou non, ainsi qu'une grande variété de plantes, oiseaux et mammiferes forestiers. Lorsque mélangé avec les conifères, le bouleau a de grandes chances de considérablement augenter la diversité de la faune et de la flore de cet habitat, et notamment la variété d'insects et d'oiseaux.

Des manières d'augmenter le peuplement de bouleaux dans les forêts en altitude sont suggérées, notamment grâce à des améliorations apportées à la fin de la première rotation pour les forêts existantes établies principalement sue des pâturages ou des landes. La meilleure stratégie pour augmenter la biodiversité des espèces forestieres associées au bouleau, tout en encourageèant les especes plus rares et moins mobiles associées aux foràts semi-naturelles bien établies, est de planter des bouleaux dans les endroits suivants:

- à la périphérie de forêts semi-naturelles;
- en groupes et bouquets sur les chemins forestiers, et au bord des routes et des cours d'eau afin de former un réseau lâche;
- en bouquets a l'intérieur des plantations de conifères, principalement à la périphérie des parcelles;
- de façon temporaire comme mélange intime dans les plantations de conifères. La plupart de ce peuplement est appelé a disparaître à la suite de la formation du manteau forestier.

L'établissement de bouquets de bouleaux à la périphérie des plantations lors de la première rotation, de manière à ce que ses graines colonisent les clairières formées par l'abattage des arbres, est une manière efficace d'augmenter le peuplement de bouleaux dans la seconde rotation.

Bien que les bouleaux soient la principale espèce feuillue recommandèe pour la diversification de la faune et de la flore des terres infertiles en altitude, d'autres arbres et arbustes indigènes devraient également être plantés en fonction du site, notamment à l'intérieur ou à la périphérie des forêts semi-naturelles bien établies.

Die Bedeutung für den Naturschutz von Birke in Hügellandwäldern

Zusammenfassung

Laubbäume und -sträucher sind in Hügellandwäldern in GB oft selten zu finden, und es ist die Absicht des Staates den Anteil des Laubbäume zu erhöhen, da sie als Lebensraum wertvoll sind. Birken (Betula pubescens Ehrh. und Betula pendula Roth.) sind sehr geeignet, um in einem weiten Spektrum von Böden erfolgreich zu sein. Sie sind die weitverbreiteste einheimische Baumart in unfruchtbaren Gegenden.

Für die meisten Ordnungen der Tierwelt ist die Birke von großer Bedeutung. Birkenwald ist fähig, die Fruchtbarkeit mancher Mineral-böden zu erhöhen, er unterstützt eine große Anzahl von allgemeinen und spezialisierten, pflanzenfressenden Insekten und eine Vielfalt von Forstpflanzen, Vögeln und Säugetieren. Birke, gemischt mit Nadelholzständen, erhöht deren Artenvielfalt wahrscheinlich erheblich, besonders die von Insekten und Vögeln.

Es werden Verfahren zur Vergrößerung der Birkendecke in Hügel-landwäldern vorgeschlagen, mit besonderem Nachdruck auf Verbesserungen am Ende der ersten Umlaufszeit von existierenden Wäldern, welche vor allem aug Weide- oder Moorland angelegt wurden. Zur Erhöhung der Artenvielfalt des Waldlebens, daß mit Birke verbunden ist, und gleichzeitig zur Unterstützung seltener und weniger mobiler Arten die von lang etablierten, seminatürlichen Waldgebieten abhängen, ist es die beste Strategie, Birke in den folgenden Lagen aufzuforsten:

- verbunden mit bestehenden, seminatürlichen Waldgebieten;
- in Flecken und Gruppen entlang Schneisen, Straßenrändern und Flußufern um ein locker verbundenes Netz zu bilden;
- in Gruppen innerhalb von Nadelholzpflanzungen, vor allem an den Rändern der Abteilungen;
- als vorübergehende Beimischung in Nadelholzpflanzungen, die nach Kronenschluß größtenteils beschattet wird.

Birkengruppen die während der ersten Umlaufszeit an den Rändern gepflanzt wurden, dienen als Samenquellen zur Kolonisierung des Fällortes und sind daher effektive in der Vergrößerung der Birken-decke in der zweiten Umlaufszeit.

Obwohl Birken als Hauptlaubbaumart zur Erhöhung der Artenvielfalt auf unfruchtbaren Böden in Hügelländern vorgeschlagen werden, sollten andere heimische Bäume und Sträucher der Lage entsprechend auch benutzt werden, vor allem innerhalb oder in der Nähe von etablierten, seminatürlichen Waldgebieten.

Chapter 1

Introduction

Increasing the proportion of broadleaved trees and shrubs is one of the major ways of improving the value of upland conifer forests for wildlife, because of their value as habitat for a wide range of plants and animals. In many upland forests the cover of broadleaved trees is very low and efforts are being made to increase it, primarily for environmental benefits rather than timber production, as part of the national policy for broadleaved woodland (Forestry Commission, 1985). However in infertile areas with harsh climates, few broadleaved species can thrive except in local pockets of sheltered, fertile ground (Low, 1986). The native birches, downy birch (*Betula pubescens* Ehrh.) and silver birch (*Betula pendula* Roth.), however, are notable for their tolerance of poor conditions (Table 1.1). Between them they are adapted to all but the most exposed or waterlogged sites and they are capable of rapidly colonising areas once a seed source is established (Low, 1986). This Bulletin focuses on the potential value and use of birch for wildlife conservation and enhancement in upland forests.

Methods of establishing birch and other broadleaves in upland sites have been described by Low (1986) and Evans (1988), and Brown (1983) and Harding (1981) have reviewed the biology and autecology of birches. This Bulletin summarises current knowledge of the value of birch to various wildlife groups and suggests ways in which it can be used to increase the wildlife value of upland forests.

It is not intended that birches should be regarded as necessarily better than other trees and given special status. In most situations, encouraging a variety of species is likely to be the most appropriate approach. However their qualities of wide site tolerance, high colonising ability and widespread distribution, as well as their native status, make birches worthy of a detailed scrutiny of their wildlife value, particularly at a time when interest is increasing in the silviculture, genetic improvement and utilisation of birch in upland forests (Lorrain-Smith and Worrell, 1991).

Table 1.1 Native broadleaved trees and shrubs with pronounced tolerance of exposure or infertile soils in upland forests (adapted from Low, 1986).

Species	*Tolerance of exposure*	*Tolerance of infertile soils*	
		Acid peats	*Others*
Common alder *Alnus glutinosa* L. Gaertn.	▲	○	▲
Aspen *Populus tremula* L.	●	○	▲
Downy birch *Betula pubescens* Ehrh.	●	●	●
Silver birch *Betula pendula* Roth.	▲	▲	▲
Blackthorn *Prunus spinosa* L.	●	○	▲
Hawthorn *Crataegus monogyna* Jacq.	●	○	▲
Rowan *Sorbus aucuparia* L.	●	●	●
Sallows *Salix aurita* L *Salix caprea* L. *Salix cinerea* L.	●	●	▲
Whitebeam *Sorbus aria* L.	●	▲	▲

Key
● High tolerance
▲ Moderate tolerance
○ Low tolerance

Chapter 2

Birch Woodland

Three species of birch are native to the British Isles (Figure 2.1). *Betula pendula* and *Betula pubescens* are common and widely distributed, while the dwarf birch, *Betula nana*, is only locally common and is largely confined to the northern and central Highlands of Scotland, at moderate and high elevations (McVean and Ratcliffe, 1962).

The downy birch is very variable morphologically and two subspecies have been recognised in the British Isles, ssp. *pubescens* and ssp. *odorata*. Continental European taxonomists have distinguished three subspecies: ssp. *pubescens*, ssp. *carpatica* and ssp. *tortuosa*. Opinions vary on whether ssp. *odorata* is equivalent to either *carpatica* or *tortuosa* (Tuley, 1973; Gardiner, 1984; Brown, 1991).

In the British Isles *Betula pubescens*, ssp. *pubescens* is found at lower elevations than ssp. *odorata* which is a shrubby type common on high ground and in harsher, wetter climates (Brown, 1991). The compact dense crown of the latter may be a genetic adaptation to short growing seasons and exposure (Forbes and Kenworthy, 1973).

Downy birch, especially ssp. *pubescens*, often grows in mixed stands with silver birch, but the former is more abundant on heavier, wetter soils (Gimingham, 1984), while the silver birch prefers slightly warmer sites and drier soils.

Although their optimal site requirements differ, the two species are both very widely distributed throughout the British Isles. However, as Figure 2.1 shows, downy birch tends to be concentrated in the west and silver birch in the east, reflecting broad climatic differences.

In upland areas of northern and western Britain both species are common constituents of most semi-natural woodland types (Table 2.1) with downy birch a more consistently prominent component of the canopy.

On acid peaty gleys and peats, the downy birch is the major, often the only, tree species in semi-natural woods. It is capable of colonising the drying surface of raised mires or the areas of shallower or drained peats on the margins of unflushed blanket mires (Rodwell, 1991). Generally, however, dense and vigorous naturally regenerated stands of birch on acid peats are confined to areas with some degree of flushing, where purple moor grass (*Molinia caerulea*) is abundant.

Conventional afforestation techniques, including drainage, cultivation and fertilising, permit downy birch to be established successfully even on unflushed peats.

Birch is particularly common in Scotland (Table 2.2) where it occupies about 43% of the area of broadleaved woodland over 0.25 ha in size (Forestry Commission, 1982). In a survey of Scottish deciduous woods over 5 ha in size, birch comprised 45% of the tree canopy overall and was present at 89% of sites sampled; in 50% of woods birch occupied at least one-quarter of the canopy (Bunce *et al.*, 1979; Parr, 1981). Because of the area of conifer woodlands, however, the proportion of total woodland cover formed by birch is considerably smaller, especially in Scotland (Table 2.2).

Woods of almost pure birch are particularly common in the Scottish Highlands, partly as a result of human exploitation of other species and partly due to the ability of birch to colonise moorland after fires or periods of heavy grazing. At high altitudes and latitudes and especially on peaty soils, however, birch (mainly *B. pubescens*) sometimes appears to form pure stands naturally. McVean and Ratcliffe (1962)

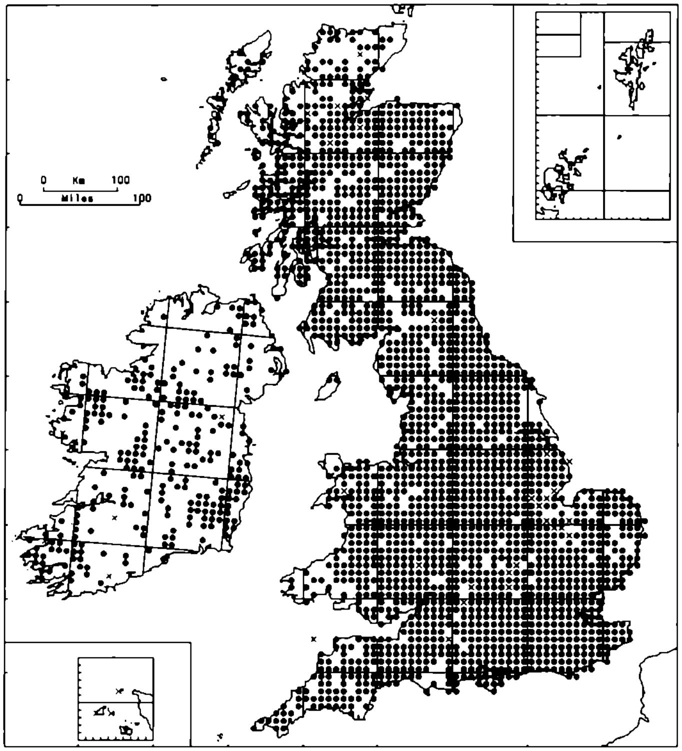
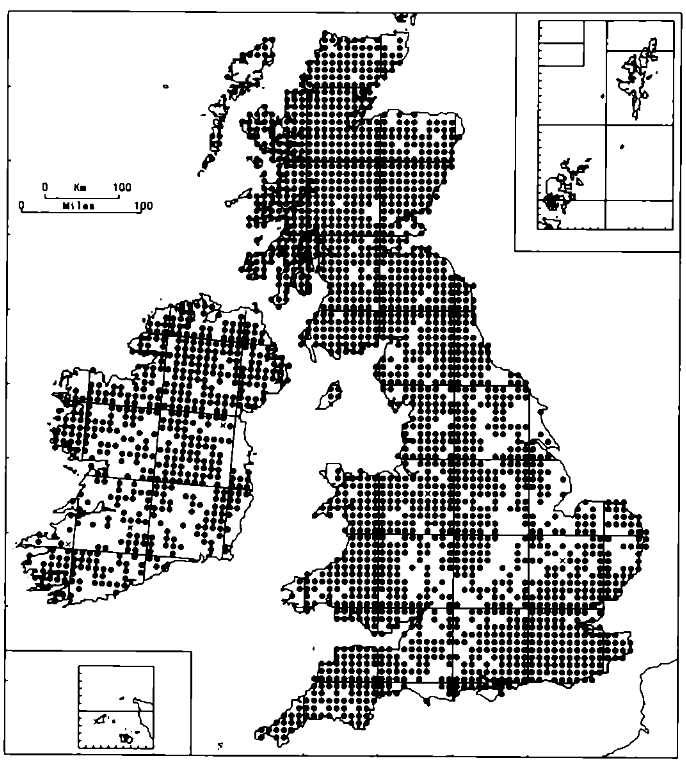


Figure 2.1 Distribution of *Betula* species in the British Isles. Dots represent recorded presence in 10 km squares (from *The Atlas of British Flora*, eds F. H. Perring and S. M. Walters, by permission of the Botanical Society of the British Isles and the Institute of Terrestrial Ecology).

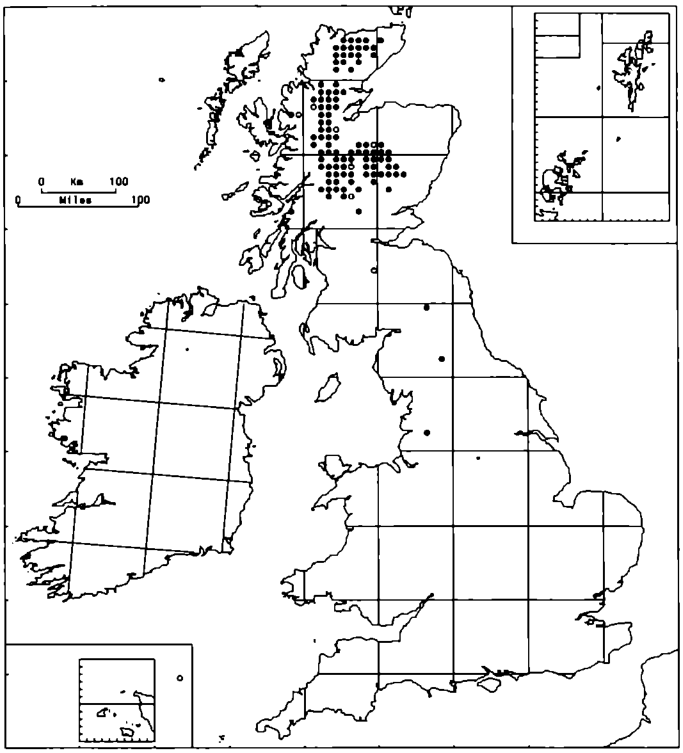
Betula pendula
0920 239

× recorded introductions (GB–29, Ir–5, Ch. Is–3)
● all other records (GB–2030, Ir–254, Ch. Is–1)



Betula pubescens
0920 240

× recorded introductions (GB–4, Ir–3, Ch. Is–1)
● all other records (GB–2026, Ir–555, Ch. Is–1)



Betula nana
0920 238

● 1930 onwards (GB–103, Ir–0, Ch. Is–0)
○ Before 1930 (GB–9, Ir–0, Ch. Is–0)

described such woods as climax birch scrub occurring beyond the presumed climatic limits of pine or oak woodland.

Birch has a high demand for light and rarely regenerates beyond the seedling stage under its own canopy. Competition from mature birch trees may play a part in inhibiting birch regeneration as well as shade (McVean, 1964). Successful regeneration usually occurs on disturbed ground, cushions of moss or in old heather outside the wood or in large glades. Brown (1983) and Miles and Kinnaird (1979) give detailed accounts of the regeneration and reproductive biology of birch.

Birch stands in upland semi-natural woodland (Plate 1) often occur as temporary stages in vegetation successions which frequently appear to be cyclical in nature (Yapp, 1953; McVean and Ratcliffe, 1962; Miles, 1981, 1986). Birch is able to invade disturbed sites rapidly, e.g. after fire, windthrow or clearfelling because of its prolific seed production and its dispersal ability (Plate 2). The relatively short-lived stands which develop in this way cannot regenerate within their own boundaries and eventually give way to longer-lived tree species or to open vegetation. The boundaries and composition of birchwoods may therefore fluctuate widely through time.

On podzolic and brown-earth soils the succession tends to involve oak and bracken or grassland stages. Birch frequently replaces oak which is felled or blown over. Oak may succeed birch by growing through it or invading later after an open grass/bracken phase.

In the Boreal climatic zone of the eastern and central Scottish Highlands, cycles involving birch and Scots pine and heather moorland occur. Fire has played an important part in determining successional changes in this region.

Table 2.1 The main tree and shrub species of upland semi-natural woodlands (adapted from Rodwell, 1991).

Soil types	*Flushed mineral gleys and gleyed brown earths*	*Calcareous brown earths (moist)*	*Acid brown earths (low base status)*	*Podzols, ironpans, pozdolic brown earths*	*Podzols, ironpans peaty ironpans (Scottish Highlands)*	*Acid peats and peaty gleys*	*Fen peats (moderately base-rich)*
National Vegetation Classification Woodland Type[a]	W7 Alder–ash–yellow pimpernel	W9 Ash–rowan–dog's mercury	W11 Sessile oak–downy birch–wood sorrel	W17 Sessile oak–downy birch –moss	W18 Pinewood	W4 Downy birch–purple moor grass (*Molinia*)	W3 Bay willow–bottle sedge
Downy birch (*Betula pubescens*)	○	●	●	●	○	●	○
Silver birch (*B. pendula*)			○[b]	○[b]	○[b]		
Sessile oak (*Quercus petraea*)	○		●	●			
Ash (*Fraxinus excelsior*)	●	●					
Wych elm (*Ulmus glabra*)		○					
Sycamore (*Acer pseudoplatanus*)	○	○					
Common alder (*Alnus glutinosa*)	●	○					
Rowan (*Sorbus aucuparia*)	○	●	○	○			
Scots pine (*Pinus sylvestris*)					●		
Common sallow (*Salix cinerea*)	●	○				●	●
Bay willow (*S. pentandra*)	○					○	●
Hawthorn (*Crataegus monogyna*)	○	○	○				
Hazel (*Corylus avellana*)	○	●	○	○			
Juniper (*Juniperus communis*)					○		

[a] For each soil type, the main woodland type as classified by the National Vegetation Classification (Rodwell, 1991) is included.
[b] Silver birch is locally more abundant than this in the eastern and central Scottish Highlands.

Key ● Present in over 40% of samples; often a major component.
○ Present in under 40% of samples; usually a minor component.

Table 2.2 Area and percentage of woodland occupied by birch[a] in Scotland, England and Wales in the 1980 Census of Trees and Woodlands.

	Broadleaved high forest		*Broadleaved scrub*		*All broadleaved woodland (excluding coppice[b])*		*All woodland (excluding coppice[b])*
	Birch area (000s ha)	*% Birch*	*Birch area* (000s ha)	*% Birch*	*Birch area* (000s ha)	*% Birch*	*% Birch*
Scotland	16.6	21.7	41.7	70.8	58.3	43.0	6.5
England	45.9	10.8	20.4	25.9	66.3	13.1	7.4
Wales	5.6	9.4	1.1	13.7	6.7	9.9	2.8

[a] These are minimum values as they exclude 'mixed broadleaves' which is likely to include a birch component.
[b] Excludes coppice/coppice with standards as no data are available for birch. Excludes cleared woodland.
Source: Forestry Commission (1982).

Chapter 3

Effects of Birch on Soils

Birch has long had a reputation as a soil improver, both in Britain and continental Europe (Gardiner, 1968). Studies of British upland birch stands which had colonised moorland sites with podzolic soils showed that profound changes in soil chemistry and biology often occurred after birch colonisation (Miles, 1981). The humus type changed from mor to mull, earthworms colonised and pH levels and rates of nutrient turnover increased. The increased soil fertility allowed more demanding herbaceous woodland plants to colonise (Figure 3.1).

Many other broadleaved trees and shrubs are probably at least as capable of promoting similar soil fertility changes to those that occur under birch (Miles, 1986) but birches are particularly effective because of their ability to thrive on podzolic soils.

Oak and beech, however, appear to be somewhat less able than birch to increase soil fertility and promote mull humus on acid soils, due to differences in the chemical composition of their litter. The palatability of oak, beech and conifer leaf litter to *Lumbricus terrestris*, one of the earthworm species which most influences soil development, is less than that of birch, al-

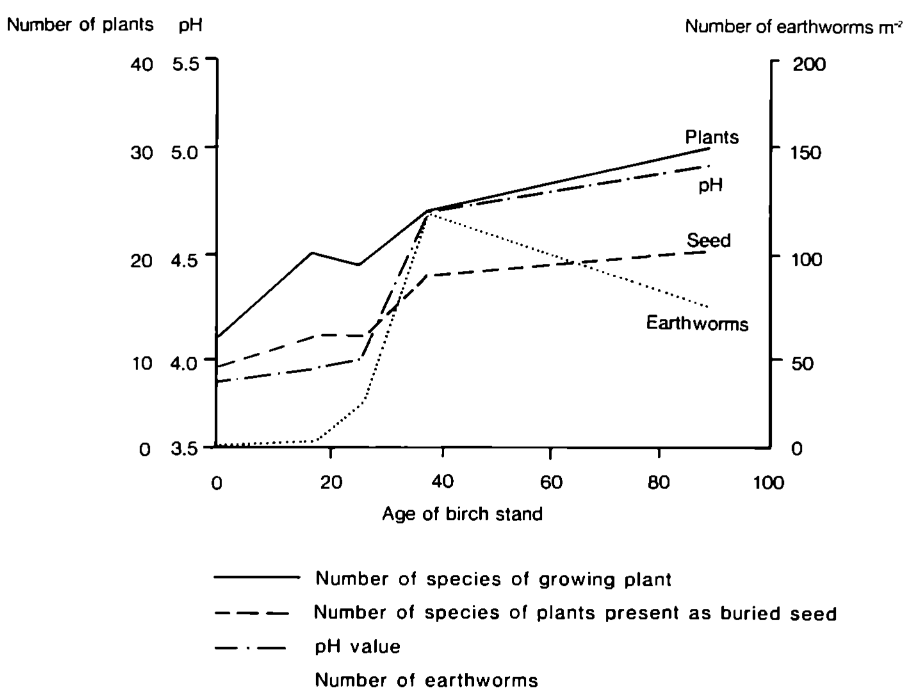


Figure 3.1 Changes in soil and vegetation after birch stands colonised heather moorland on a south-facing hill in Speyside (adapted from Miles, 1981).

though birch in turn is less palatable than elm, alder, ash or sycamore (Satchell and Lowe, 1967).

These changes occurred more readily on the more base-rich soils. Indeed on the most impoverished ironpans and podzols they had not occurred at all after 70 years of birch woodland (Miles, 1981). McVean and Ratcliffe (1962) and Satchell (1980a) also noted no soil changes under birch growing over base-poor parent materials. The changes are summarised in Figures 3.1 and 3.2. The processes involved are not fully understood, but the mechanical mixing of the soil layers by earthworms seems to be very important in reversing podzolisation and promoting a mull humus (Miles, 1986).

It is not clear whether the increase in earthworm abundance is a cause or a result of initial increases in pH and levels of plant nutrients, perhaps mediated by the birch litter and the fine root system (Brown and Harrison, 1983). The development of a herbaceous field layer under birch and the elimination by shading of ericaceous plants which promote a mor humus may also play a part in increasing the rate of mineralisation, raising the pH and stimulating earthworm activity. However on strongly acid soils mor-forming species such as *Vaccinium myrtillus* and *Deschampsia flexuosa* may still dominate the ground flora after the birch closes canopy, thereby maintaining a low pH and discouraging colonisation by soil-mixing earthworms (Satchell, 1980b).

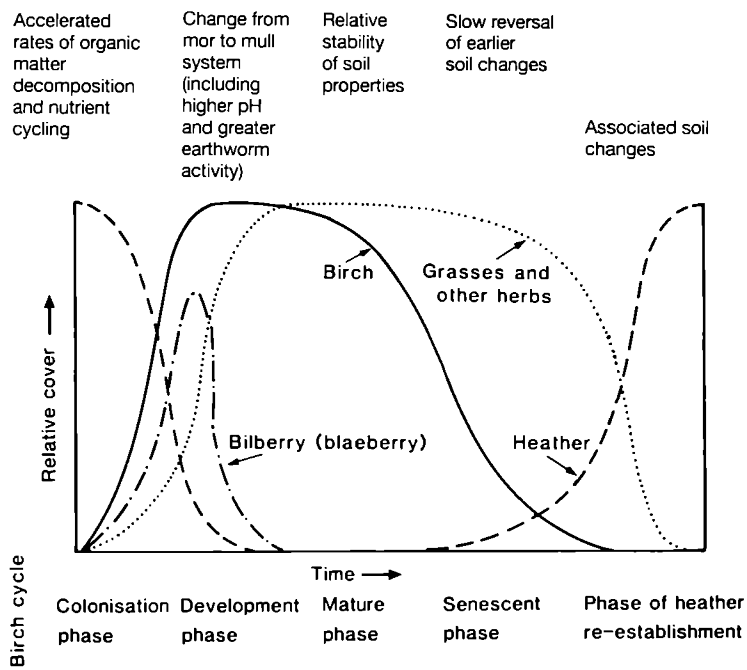


Figure 3.2 Generalised sequence of vegetation changes occurring during the life cycle of a Highland birchwood together with associated trends in labile soil properties (after Miles, 1981).

Birch-conifer mixtures

Gardiner (1968) described a number of studies and observations from continental Europe which attributed increased soil fertility and growth of conifer trees to the presence of birch in mixture with Scots pine or Norway spruce. It is not yet known whether such effects occur in birch-conifer mixtures in Britain.

The size of a birch stand or the proportion of birch in mixture with conifers which is required to increase soil fertility is not known. However birch stands as small as 10 m in diameter may be sufficient (J. Miles, personal communication).

It is likely that any soil changes that occur within mixtures of birch with conifers will be associated with quite small clumps or even individual birch trees because differences in litter quality, root activity and the field layer vegetation may all operate at that scale.

Brown (1992) reported increases in soil fertility and earthworm populations under mixed stands at Gisburn, Lancashire, compared to pure stands. The unit of each species in the mixture was 18 trees. This experiment did not include birch but similar processes are likely to be involved.

The role of earthworms in enhancing soil fertility makes the process of earthworm colonisation important. Colonisation of new habitats is thought to occur at a rate of only a few metres per annum (van Rhee, 1969). The deeper living species of earthworms which can mix the soil effectively, e.g. *Lumbricus terrestris* and *Apporrectodea* spp., are absent or uncommon in coniferous woodland and peaty soils mainly due to their low pH (Robinson *et al.* in press, a). They are most abundant in base-rich soils.

The colonisation by such species of new birchwood habitat which is isolated from existing earthworm populations by unsuitably acidic soils (pH below about 4·7) could therefore be slow and uncertain. Birch stands established close to fertile soils, which support populations of deeper living earthworms, are likely to be colonised more rapidly. Some indirect evidence for this is provided by earthworm populations in forest liming trials. Studies of limed coniferous plots where the pH has been raised to levels which could support the deeper living earthworms show that in several cases colonisation has not yet occurred (Robinson, 1990). However at one site the addition of lime permitted a substantial community of earthworms to develop, including deep-dwelling species, in deep peat soil under Sitka spruce (Robinson *et al.* in press, b).

The cyclical alternation described earlier between birch and other vegetation types is accompanied by fluctuations in soil fertility and in the plant and animal communities. In moorland or native pinewood areas, for example, a senescent birch stand will be replaced by heather or Scots pine, both of which reduce surface pH, develop mor humus and increase podzolisation (Figure 3.2, Plate 3). This natural cyclical process might also have a role in upland plantation forests where birch might help to conserve soil fertility and associated wildlife communities in the long term.

In general the evidence above suggests that the effects of birch woodland on soils are likely to be small on peaty or very infertile mineral soils. However, on podzols of moderate base status and on podzolised brown earths, a process of mull humus formation is likely to occur after canopy closure which has important implications for soil fertility and biological diversity (see Figure 4.1).

Plate 1. *Native pinewood, Loch Beinn a' Mheadhoin, Glen Affric. Birches are found as a component of most semi-natural woodland types in the uplands ranging from native pinewoods to calcareous mixed–deciduous woods.*

Plate 2. *Extensive woods of almost pure birch are common in the Scottish Highlands where birch is more able to adapt to periodic disturbances such as felling, burning and grazing than other trees.*

Plate 3. *A senescent birchwood where the heavily grazed woodland field layer will gradually be recolonised by heather, with consequent podsolisation of the soil as part of a cyclical succession.*

Plate 4. *Chickweed wintergreen, a northern montane plant which is particularly common in birchwoods in northern and eastern Scotland.*

Plate 5. *The redstart is one of the less common birds that nest in upland birchwoods, using cavities in mature and senescent trees.*

Plate 6. *Birch mixed with spruce near the edges of plantation stands and in clumps on the roadsides will diversify the invertebrate and vertebrate fauna.*

Plate 7. *Planted birch by a roadside. Birch groups need to be closer spaced and larger than this if they are to develop a woodland microclimate and plant community.*

Plate 8. *Birch sowing experiment, Forest of Ae, Dumfries and Galloway. Birch establishes from seed on freshly clearfelled ground where the brash layer is sparce or absent.*

Chapter 4
Wildlife Associated with Birch

Ground flora

Birchwoods have a similar ground flora to that of mixed deciduous woods on the same sites and no vascular plant species are entirely confined to birch stands. However some species with a northerly distribution, such as chickweed wintergreen (*Trientalis europaea*, Plate 4) in the eastern and central Scottish Highlands, are more common in birchwoods than other habitats (Kirby, 1984).

The main types of vegetation associated with birch stands are summarised in Table 4.1. As for woodland generally, the dominant influences are those of climate and soil. The fertile brown-earth soils support more species-rich vascular plant communities than the peats, gleys, ironpans and podzols. On acid peaty soils there are few species which are not found on equivalent unwooded moorland areas, whereas a high proportion of woodland species are found on brown earths and podzols.

The influence of climate is reflected in the shift from grass and heath dominated communities in the eastern and central regions to the bryophyte-rich type of the wet woods near the west coast. These include many of the important 'Atlantic' bryophyte species which are rare elsewhere in Europe.

Birchwoods can influence the character of their ground vegetation by altering the fertility of the soil, as described earlier. Figure 4.1 summarises the successional changes which occur on different soil types. The mull forming tendency of birch contrasts with species which tend to develop an acid mor type humus such as heather (*Calluna vulgaris*) or Scots pine (*Pinus sylvestris*) and the spruces.

McVean and Ratcliffe (1962) sampled birch, oak and native Scots pine stands in the Scottish Highlands and described the flora of birch and oak as being similar on comparable soils. However birch and pine stands showed considerable differences in their species-richness (Figure 4.2) and species composition (Table 4.2). The soil parent materials were similar in most cases except some parts of the herb-rich birch stands which were on areas subject to calcareous flushing. Elsewhere the contrasting plant communities appeared to be mainly the result

Table 4.1 Characteristic ground vegetation types in Scottish birchwoods (adapted from Kirby, 1984).

	Soil Type				
	Base-rich brown earths and gleys	Base-poor (acid) brown earths	Podzolic brown earths, podzols, rankers	Peaty podzols and ironpans	Acid peats and peaty gleys
Characteristic ground vegetation	← Herb-rich →	← Grass + bracken	→	→	*Molinia* mire
			← *Vaccinium/Calluna* heath (mainly east)	→	*Molinia caerulea*/ sedges, rushes
		← Bryophyte-rich (mainly west)		→	*Sphagnum* mosses

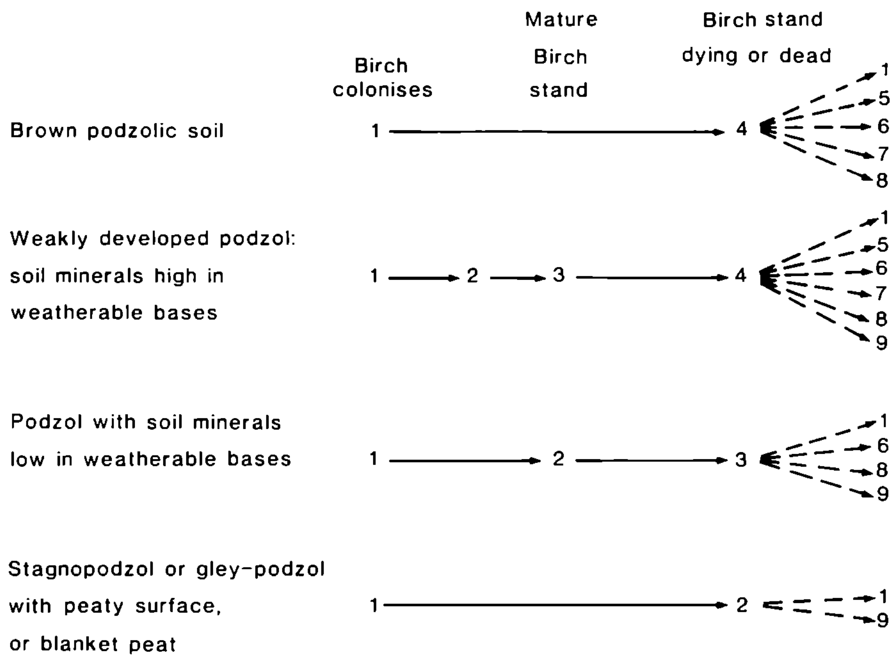


Figure 4.1 Generalised sequences of vegetation change during the life cycle of an upland birchwood on different soil types. Continuous arrows represent observed transitions in the field layer, dashed arrows observed or likely potential transitions with death of the birch stand. 1: *Calluna* heath; 2: *Vaccinium* heath; 3: co-dominant *Deschampsia flexuosa* and *Vaccinium* spp; 4: species-rich grassy field layer; 5: *Agrostis-Festuca* grassland; 6: *Pteridium* stands; 7: *Juniperus communis* scrub; 8: woodland dominated by *Quercus* and other broadleaved spp.; 9: *Pinus sylvestris* woodland (from Miles (1988) in *Ecological Changes in the Uplands*, eds. M. B. Usher and D. B. A. Thompson, pp. 365-380, by permission of Blackwell Scientific Publications Ltd).

Table 4.2 Constant species in pinewood and birchwood communities sampled by McVean and Ratcliffe (1962).

Constant ground flora species	***Pinewood***		***Birchwood***	
	Vaccinium/ moss	*Vaccinium/ Calluna*	*Vaccinium-rich*	*Herb-rich*
Calluna vulgaris	C	CD		
Hylocomium splendens	CD	CD	CD	CD
Vaccinium myrtillus	CD	CD	CD	
Vaccinium vitis-idaea	CD	C		
Galium saxatile			C	C
Deschampsia flexuosa		C	C	
Potentilla erecta				C
Anthoxanthum odoratum				CD
Viola riviniana				C
Oxalis acetosella			C	C
Blechnum spicant			C	C
Thuidium tamariscinum			C	
Plagiothecium undulatum		C		
Ptilium crista-castrensis		CD		

C = constant (present in all samples).
D = dominant, in one or more samples, in field or moss layer.

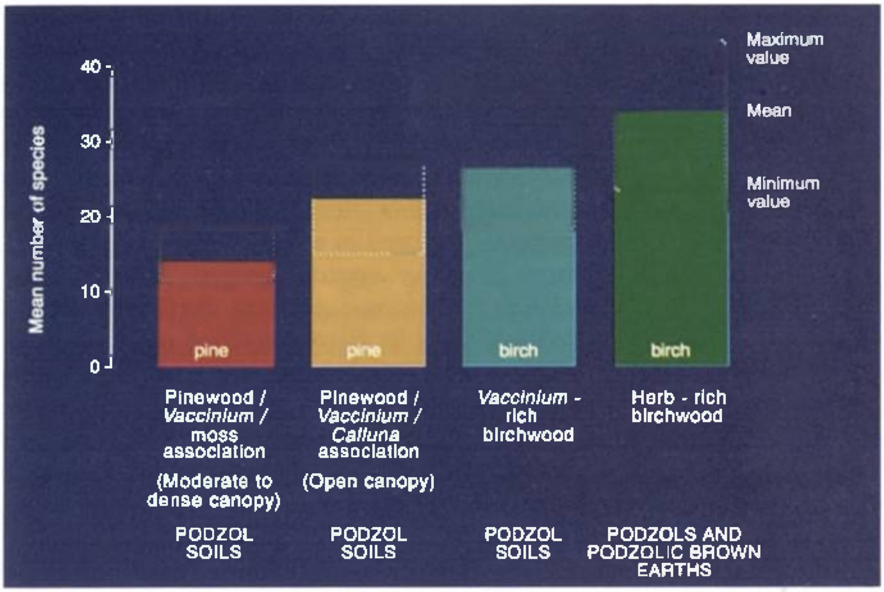


Figure 4.2 Plant species-richness under birch and Scots pine stands on parent materials of intermediate base status in the Scottish Highlands (after McVean and Ratcliffe, 1962).

of the divergent influences of the two tree species upon the soil.

The contrast between birch and Sitka spruce, the main plantation species of the uplands, is stronger still. Under spruce the ground vegetation is frequently eliminated by a combination of dense shade and a deep acid mor humus (Good *et al.*, 1990).

As for other woodlands the vegetation of a birchwood is influenced by many factors in addition to climate and soil. These include size, age, structural complexity, proximity to other semi-natural woodlands and land-use history.

Small woods of recent origin and a single age class which are distant from long-established semi-natural woodland can be expected to have a poorer flora and to be colonised more slowly than large woods adjoining ancient woodland and containing several age classes. In a survey of Highland birchwoods, Fenton (1985) found that woods under 1 ha had a poorer flora than larger woods.

The speed of colonisation by woodland plants is influenced by the proximity of source populations and by soil fertility. On brown earths and podzolic soils colonisation by a range of herbs, grasses and mosses can occur within 30 years (see Figures 3.1 and 3.2).

Many plants commonly found in birch woodland can tolerate the fluctuating boundaries of birch stands, for example, by being able to persist outside woodland on riverbanks, or in moorland or rough pasture. Even some plants classed as characteristic of ancient woodland in lowland England are able to survive outside woods in the uplands and colonise new woodland nearby. Examples are *Lathyrus montanus* and *Viola riviniana* (Miles, 1988). However, there are a number of less mobile and more demanding woodland plants which are closely associated with old woodland sites (Table 4.3). Birch stands established close to such sites are more likely to include these species than more distant stands on similar soils.

What are likely to be the effects upon the ground flora of increasing birch cover in upland forests? On freely drained soils the vegetation under birch is likely to be more species-rich than under pine plantations of a similar age. The differences will be greater still between birch and spruce. Larches have a ground flora which is closer to that of birch than to the flora of evergreen conifers.

The potential differences will be less on peaty soils although vascular plant cover under birch will invariably exceed that under fully stocked

Table 4.3 Examples of vascular plants closely associated with old or former woodland sites in the Scottish Highlands and Islands (adapted from Miles, 1988).

*[a]	*Corylus avellana*	Hazel
*[b]	*Juniperus communis*	Juniper
*[a]	*Phegopteris connectilis*	Beech fern
**	*Carex pallescens*	Pale sedge
*[a]	*Hyacinthoides non-scripta*	Bluebell or wild hyacinth
*[a]	*Luzula pilosa*	Hairy woodrush
*[b]	*Luzula sylvatica*	Greater woodrush
**	*Milium effusum*	Wood millet
**	*Adoxa moschatellina*	Town hall clock
*[a]	*Anemone nemorosa*	Wood anemone
**	*Circaea lutetiana*	Enchanter's nightshade
*[a]	*Conopodium majus*	Earth-nut
**	*Lysimachia nemorum*	Yellow pimpernel
*[b]	*Melampyrum pratense*	Common cow-wheat
*[b]	*Oxalis acetosella*	Wood sorrel
**	*Primula vulgaris*	Primrose
*[b]	*Stellaria graminea*	Lesser stitchwort
*[b]	*Trientalis europea*	Chickweed wintergreen

*Tolerant of base-poor brown earths.[a] or podzols [b] frequent in birchwoods

**Typically found in mixed deciduous woods on base-rich soils.

spruce stands on all soil types. Whether the full potential plant community develops on a given soil type would depend upon several factors including the size, isolation and structure of patches of new birch woodland. Browsing and grazing pressures can also be important in influencing the structure and species-richness of the vegetation.

Linkage with long-established semi-natural woodland, the selection of podzols or brown-earth soils and the establishment of stands large enough to develop woodland conditions, the inclusion of other tree species and a varied structure will all favour the development of a diverse woodland flora in new areas of birch woodland.

Patches of birch within conifer woods may need to be one or two mature tree heights in width (20-40 m), to enable sufficient light penetration for a vigorous field layer to develop. In comparison a woodland field layer may develop in patches of birch as small as 10-20 m wide set in moorland (J. Miles, personal communication).

However, even intimate mixtures of birch with spruce or pine are still likely to have a richer flora than pure conifer stands, especially on fertile soils. No studies have yet been carried out on such birch-conifer mixtures in Britain, but Simmons and Buckley (1992) found a substantially richer flora in Norway spruce–oak mixtures, planted in a 3:3 row mixture, than in pure Norway spruce crops. The bluebell (*Hyacinthoides non-scripta*) did better in the mixture than in pure stands of either species, because the partial shade cast by the spruce reduced competition from bramble (*Rubus fruticosus* agg.) It is possible that distinctive communities may develop in birch–spruce mixtures in a similar way.

Epiphytes

The species of birch which act as host to epiphytes are not consistently recorded and so the collective term 'birch' is used here. This is also true of other wildlife groups. The epiphytes of birch have been reviewed by Coppins (1984). Birch has a poorer lichen flora than some other broadleaved trees (oak, ash, hazel, sycamore, willows) mainly due to its more acid bark. The relatively short lifespan and rapid decay of birch also contribute to the difference.

The communities of macrolichens on Scots pine and birch are similar, but pine lignin is more suitable for lichens and so pine has more species on decaying wood. However there are a number of species which use birch but not pine, mainly crustose lichens inhabiting smooth bark.

In total, 235 species of lichens have been recorded on birch trees, 15% of the British lichen list. Sixty of these are more or less confined to Scotland as birch epiphytes and many others are more prevalent on birch in Scotland than elsewhere in the British Isles. This reflects the northern or montane distribution of lichen species, the long history of abundance of birch in Scotland and generally lower sulphur pollution levels than in England and Wales. There is some evidence of a greater longevity of birch trees on infertile upland sites (Brown, 1983) and this could also favour a greater development of the lichen flora compared to lowland areas.

Coppins (1984) listed 30 mosses and 28 liverworts which have been recorded on birch trees in the British Isles. The majority are most common in the western uplands and these form part of the rich Atlantic bryophyte communities found in deciduous woods close to western coasts. These communities are largely dependent upon the microclimate created by trees and topography rather than upon particular tree species (Ratcliffe, 1968) and many arboreal and terrestrial species are found in birchwoods as well as in mixed deciduous woods.

Birch woodland is therefore poorer than mixed deciduous woods for epiphytes, especially in the southern and eastern uplands. Nevertheless, on soils where oak, ash, elm and hazel will not thrive and especially in western Scotland, birch woodland can considerably enhance the epiphyte communities of upland conifer forests. Locating new birch stands close to rocky gullies and to mixed deciduous woods with a range of age classes including old trees, will increase the probability of colonisation by a range of species.

Fungi

In a review of the macrofungi of British birchwoods, Watling (1984) considered that mosaics of Scots pine and birch in native pine forests were the richest fungal habitat in Scottish woods, but he concluded that knowledge of distributions of fungi in birchwoods was still incomplete. Several species of agarics appear to be restricted to birchwoods but many of the more common birchwood fungi such as *Russula ochroleuca* are also widespread in other woodland types. The wood-rotting fungi of birch trees are also mostly widespread and common and grow on several host trees.

Miles (1985) described a succession of mycorrhizal fungal communities in birch woodland, with marked differences between young and old stands. Alexander and Watling (1987) compared the mycorrhizal macrofungi of birch, Sitka spruce and Scots pine from Scottish records (Table 4.4).

Birch has a slightly greater number of species in common with Sitka spruce than does Scots pine, including the common genera *Amanita*, *Lactarius* and *Russula*. Colonisation of spruce from relict birch woodland was suggested as an explanation by Alexander and Watling (1987). Although sampling of Sitka spruce has not been intensive and species could be under-recorded, it seems that Sitka spruce has a lower variety and abundance of mycorrhizal macrofungi than birch.

The increase of birch woodland in both spruce and pine forest areas is therefore likely to increase the variety of macrofungi in the forest and to enable further colonisation of conifer stands by shared species.

Invertebrate animals

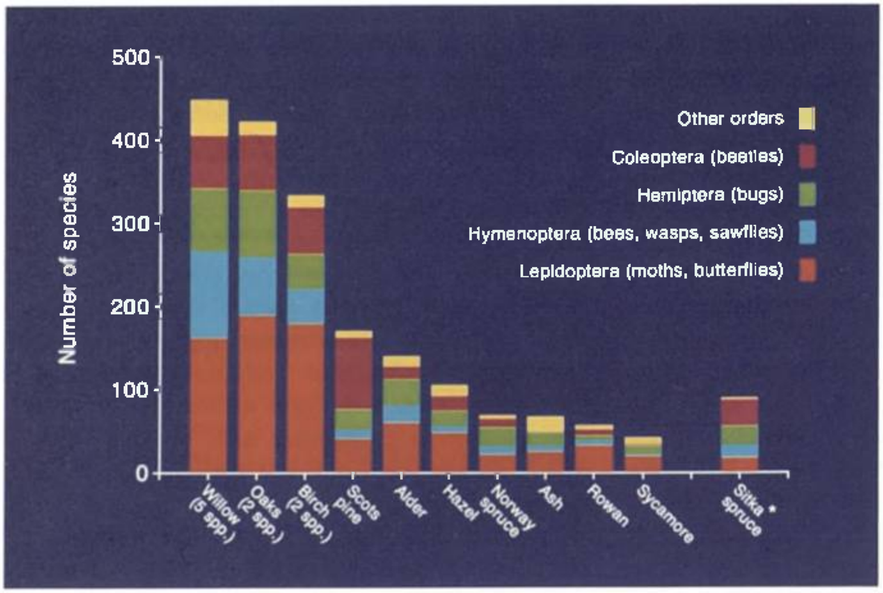
Where the conversion of mor to mull humus occurs under birch stands on freely drained soils, a different and richer soil fauna develops, including earthworms which are very important prey items for many vertebrate animals.

The development of earthworm populations in mull soils greatly increases the biomass of invertebrates in the soil. Coulson (1988) found that an upland brown earth overlying limestone on moorland supported a total dry weight of invertebrates which was ten times greater than that in a peaty podzol and that 92% was composed of earthworms, mostly *Lumbricus* species. Similar degrees of change are apparent during

Table 4.4 Numbers of mycorrhizal macrofungi found with selected tree species in Scotland (adapted from Alexander and Watling, 1987).

Tree species	*Birches*	*Scots pine*	*Sitka spruce*
Number of species of fungi	103	90	84[a]
Species in common with Sitka spruce	29	24	
Index of similarity with Sitka spruce	33%	26%	

[a] Relatively little sampling done, but many appear uncommon under Sitka spruce.



*All species recorded on Sitka spruce are included: none are specific.

Figure 4.3 The number of phytophagous species of insects and mites associated with various trees in Britain (normally or typically associated, excludes generalists). (Adapted from Kennedy and Southwood, *Journal of Animal Ecology* **53,** 455-478, 1984, by permission of Blackwell Scientific Publications Ltd, and Evans, in *Proceedings B: Biological Sciences* **93,** 157-167, 1987, by permission of The Royal Society of Edinburgh.)

succession from moorland to birch woodland on some podzols (see Figure 3.1).

The diversity of invertebrate populations living above ground is influenced by the species composition and structure of the vegetation. Some phytophagous insects depend on the presence of a particular plant species. The more abundant and species-rich ground vegetation of birchwoods compared to spruce stands is therefore likely to result in a greater variety of insects, especially where light intensity is sufficient to encourage flowering, which in turn supports nectar feeders.

Data comparing the invertebrates of conifer stands and of birch or other deciduous woods on similar sites are sparse. However, Butterfield and Malvido (1992) sampled soil-surface invertebrates in mixed species and single species plantations in Hamsterley Forest, County Durham. The number of invertebrates caught in pitfall traps in mixed species stands, whether broadleaf–conifer mixtures or mixed conifers, was higher than in conifer monocultures. Patches of birch and other broadleaves within conifer plantations and intimate mixtures of broadleaves and conifers had higher numbers and greater species-richness of carabid beetles than most of the conifer stands sampled. This was related partly to a gradient of soil fertility, which could have existed before the forest was planted, but also to the structure of the field layer vegetation which was sparse under pure spruce and western hemlock canopies.

The presence of birch and other broadleaved trees is therefore likely to enrich the soil-surface invertebrate community in spruce plantations.

The number of insect species that use trees and shrubs for food and shelter is generally much greater than those depending upon field layer vegetation, because of the variety of niches provided by the size and more complex architecture of woody plants (Strong *et al.*, 1984).

Compared with other tree species, the number of insect species which specialise upon birch is very high (Figure 4.3). The insect fauna of birches is surpassed only by that of oaks and willows, although some of the latter group are not upland trees. These lists exclude a large number of generalist species which use a variety of trees or shrubs including birches. They also exclude predators and parasites, so that the number of species actually using birches will be much greater than the 334 counted by Kennedy and Southwood (1984).

The relative importance of birch in the northern uplands is even higher than Figure 4.3 suggests. According to Shaw (1984) this is because:

- Many oak associates are confined to southern England, while birch species tend to have a northerly distribution.
- In Highland Scotland some insect species which use other trees further south are confined to birch, probably because of its historical abundance there.
- Birches are suited to a wider range of upland sites than either willows or oaks, which will be more local in distribution and so less likely to support viable populations of all their potential associates.

Insects associated with young birch trees tend to be efficient colonisers. Some species which specialise on overmature trees however are relatively immobile. They require the continuity of habitat provided by extensive woods containing all age classes of trees. The fly species which feed on the saprophytic fungi growing on dying birch are an example.

The colonisation by insects of isolated small birch clumps at high altitudes may be restricted to the more mobile and common species. Koponen and Iso-Iivari (1978) and Koponen (1984) found that the abundance of insect herbivores on birch species in Alaska and northern Scandinavia was reduced at high altitudes and latitudes, and in clumps which were small in area or stature or were isolated from other woodland. The most exposed sites also had few species.

In those upland conifer forests which currently have few broadleaves, insect colonisation may therefore be more rapid if new areas of the birch are established on moderately sheltered ground and in clumps rather than as scattered individuals. The shelter provided by conifers may also make birch mixed into the plantation areas attractive to insects. However data are lacking for United Kingdom forests.

The abundance of invertebrate populations and their seasonal availability as food items may be more important to predatory higher animals than their species-richness (Peck, 1989). Insectivorous songbirds, for example, will concentrate upon a single abundant species to feed their young, as it is more efficient than searching in a variety of different niches (e.g. Gibbs and Betts, 1963).

Data comparing the abundance and biomass of invertebrates on various tree species are scarce. Hill *et al.* (1990) and Roberts (1990) found a much higher biomass of invertebrates on silver birch coppice than on sweet chestnut (*Castanea sativa*) coppice in Kent. The differences were greatest for the phytophagous Hemiptera (piercing and sucking bugs) of which birch supported an eight times greater biomass. However there were no overall differences in invertebrate biomass between hazel (*Corylus avellana*) and birch. The invertebrate biomass on birch peaked in June, which coincided with a peak demand for food for many insectivorous birds.

Young coppice (*c.*2 m high) of all three species supported a higher invertebrate biomass, despite having a smaller plant biomass than that of older coppice (4–6 m). This may help to explain the higher songbird densities found in young coppice in another study in Southeast England (Fuller *et al.*, 1989). However other authors have not found a clear relationship between tree size or architecture and the biomass or abundance of invertebrates (e.g. Southwood *et al.*, 1982; Lawton, 1983; Koponen, 1984), so that this size effect may not apply to birch of seedling origin in upland forests.

Although most of the biomass on each tree species in Roberts' study was contributed by relatively few species of Hemiptera, Diptera and Arachnida, the ranking order of tree species for biomass was consistent with their ranking for species-richness. This relationship between species-richness and biomass was also reported by Southwood *et al.* (1982), although again only small numbers of tree species were studied. If this relationship were generally the case it would suggest a high ranking for birch in terms of invertebrate abundance.

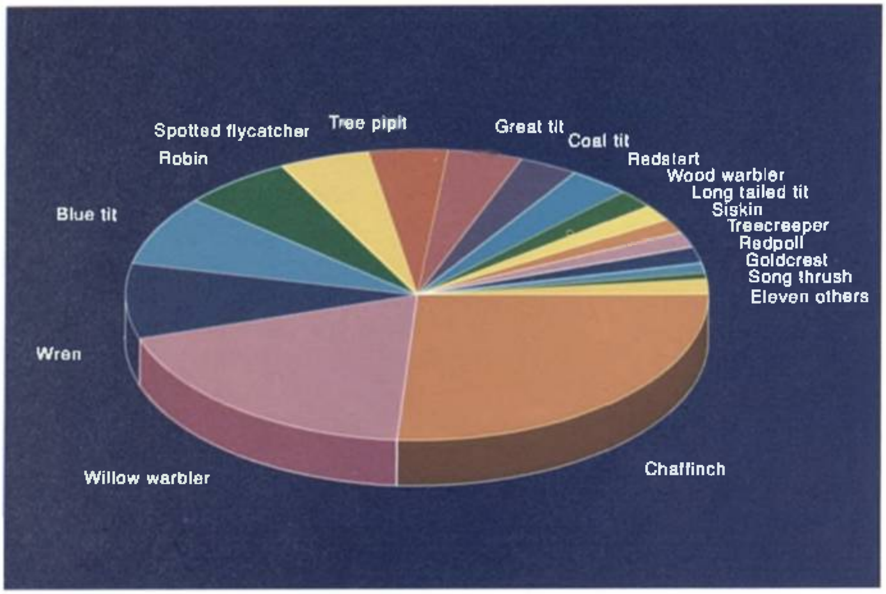


Figure 4.4 Songbird community composition in 36 northern Highland birchwoods. Total mean density of songbirds was 1409 km^{-2} (sampled in the breeding season). (Adapted from Bibby *et al.*, *Bird Study* **36,** 123-133, 1989b, by permission of Blackwell Scientific Publications.)

Peck (personal communication, unpublished data) sampled arthropod populations from tree branches in mixed woodlands in northern England as part of her study of the tree species preferences of common passerine birds (Peck, 1989). The arthropod abundance and biomass varied widely between years and sites so that comparison of absolute values was not practical. However the ranking of tree species did show a fairly consistent pattern. Of the deciduous trees at two study sites sycamore (*Acer pseudoplatanus*) had consistently the highest abundance and biomass and beech (*Fagus sylvatica*) had the lowest. Silver birch had an intermediate ranking along with oak (*Quercus robur*) and European larch (*Larix europaeus*).

One of the study sites, at Hamsterley Forest, County Durham, included several evergreen conifer species. Interestingly, their arthropod biomass and abundances generally compared well with that of birch and most other deciduous trees, except sycamore, although the annual variation was high due to temporary peak populations of insects such as spruce aphids.

Another comparison of invertebrate population on birch and conifers was reported from Finland by Von Haartman (1971). Birch had higher numbers of invertebrates per unit weight of twigs than Scots pine or Norway spruce but this was offset in the case of the spruce by its higher total amount of foliage.

In upland birchwoods large peak populations of defoliating caterpillars are frequent. The commonest defoliators in Scottish birchwoods are the larvae of the geometrid moths *Agriopis aurantiaria* and *Operophtera fagata* (Bevan, 1987).

Although the information on invertebrate abundance is scanty, the overall impression is that birch supports fairly high populations of invertebrates although it may not rank as highly as it does for species-richness.

Birds

Very few bird species are restricted to any single tree species but distinct preferences exist for some birds between broadleaved and evergreen coniferous trees, and broadleaved specialists outnumber conifer specialists. Woodland structure, geography and soil fertility are very important in determining bird com-

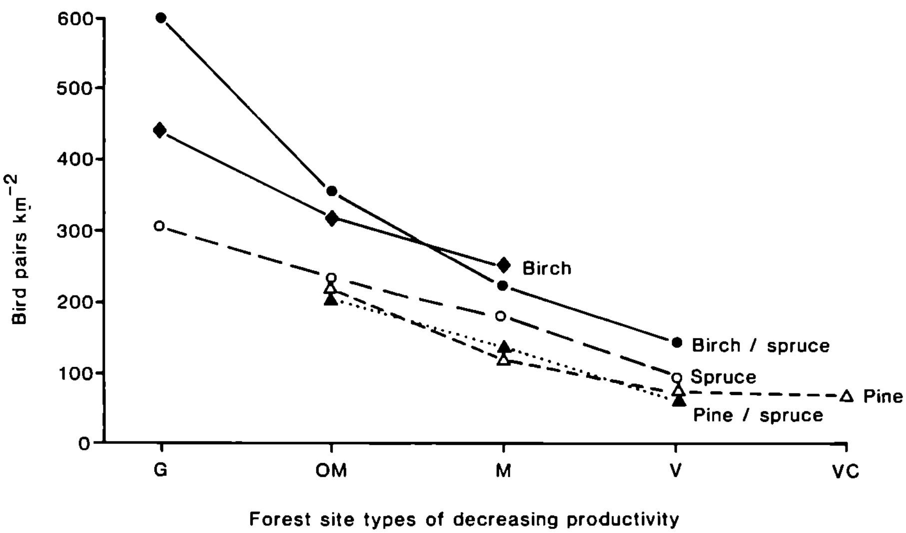


Figure 4.5 Densities of breeding birds in Finnish forests in relation to forest site type and dominant tree species. G: grass-herb; OM: *Oxalis-Myrtillus*; M: *Myrtillus*; V: *Vaccinium*; C: *Calluna* (modified from Von Haartman, 1971).

munities and those factors make comparisons based on tree species difficult. However, a number of studies have demonstrated that broadleaves generally have more species and higher bird densities than conifers, and that mixed conifer–broadleaved stands can be better than either in these respects (Petty and Avery, 1990).

On good soils, birch ages fast and dies relatively early compared to other broadleaves, and because it rots quickly, it provides a good substrate for primary cavity excavators such as the great spotted woodpecker, willow tit, and crested tit.

Natural holes and those made by woodpeckers also provide nest sites for redstarts (Plate 5), spotted and pied flycatchers, blue, great and coal tits, and starlings. Birch produces abundant seed crops which attract redpolls and siskins and many other species during July to September, a time when other seed is scarce (Newton, 1972; S. J. Petty, personal communication). Insectivorous birds were observed to use birch foliage throughout the spring and summer in mixed stands to feed on caterpillars and aphids (Peck, 1989).

The birds of upland birchwoods in Britain have been studied quite extensively (Yapp, 1962, 1974; Williamson, 1969; Simms, 1971; Bibby *et al.*, 1989). A characteristic community has been found, with willow warbler, chaffinch, robin and tree pipit the most numerous species. These birchwoods are somewhat different from upland oakwoods, where the willow warbler is less dominant, and blue and great tits, redstarts, wood warblers and pied flycatchers tend to be more numerous.

Bird populations depend considerably upon woodland structure and birchwoods which have a component of other trees and shrubs such as hazel are richer than those subject to heavy grazing with no understorey and a single age-class. The latter are frequent in the Scottish Highlands, and in these even-aged birch monocultures the bird community is fairly poor with three or four species dominating (Figure 4.4). Geography is also important in determining the potential communities and fewer woodland species are found in northern and western areas (Fuller, 1982; Petty and Avery, 1990).

When birch woodland is compared to conifer plantations the data suggest that birch and birch-conifer mixtures support higher densities and more species than spruce and especially pine plantations, although very few comparisons have been made in the same locality and in the same year. Moss (1978) compared birch–Scots pine mixtures with pure stands of Scots pine and spruce in Dumfries and Galloway region (Table 4.5). The birch–pine mixtures had higher densities and species-richness than pure pine or spruce. This may have been partly the result of a more varied structure, but it was probably not due to greater soil fertility, as the mixed stands were on peatland. Moss estimated that the bird biomass differences were even greater than those of density, because the birch–pine included some larger birds such as thrushes which were absent in the pure conifer stands. Most of the extra species of the birch–pine stand were present in small numbers, however, which is consistent with other surveys of birchwoods (Figures 4.4 and 4.5).

Williamson (1969) compared a birch woodland, including a minor component of other broadleaves, with semi-natural pinewoods in Wester Ross, using the same territory-mapping technique as Moss. He found the birchwood to be much richer than the pine, despite the varied structure of the latter. French *et al.* (1986), however, studied 16 woods of various types in Deeside, Grampian Region and found that pure birch was the poorest type for songbirds. This was probably partly due to differences in structure and other factors, which were confounded with species differences. Mixed conifer–broadleaved stands (including birch) had the highest densities, numbers of species and species diversity in this study.

Birch–spruce mixtures are becoming common on restocking sites where birch establishes readily from seed and sometimes threatens to smother the spruce in the early stages. No studies have been reported on bird communities of such mixtures in Britain. However, Bibby *et al.* (1989) studied spruce and other conifer stands containing mixed broadleaves, mainly oak coppice remnants, in North Wales. They showed that the broadleaves in small numbers attracted several additional species.

Von Haartman (1971) summarised a series of studies in Finland which showed greater densities of birds in birch and birch–Norway spruce stands compared to pure Norway spruce or Scots pine. The differences and total densities were greater in the more fertile sites, where birch–Norway spruce mixtures held considerably more birds than all pure stands (Figure 4.5).

The birch–Sitka spruce and birch–Douglas fir mixtures now developing on British restocking sites may have different effects upon birds, but the balance of evidence is that a significant increase in songbird densities and species-richness is likely to occur in mixed stands compared to pure conifer stands. Evidence concerning the effects of various proportions and patterns of mixture is still scarce although several relevant studies have been done (French *et al.*, 1986; Currie, 1989; Bibby *et al.*, 1989; Peck, 1989). On balance a small proportion of broadleaves dis-

Table 4.5 Comparison of songbird communities of birch–pine and pure conifer stands in Dumfries and Galloway (adapted from Moss, 1978).

	Birch–pine mixture[a] *(2)*	*Sitka spruce or Norway spruce*[b] *(5)*	*Scots pine*[c] *(2)*	*Japanese Larch*[d] *(1)*
Songbird density pairs km^{-2}	463–935 (mean 685)	351–598 (mean 497)	208–340 (mean 274)	448
No. of species	15–18 (mean 16.5)	4–9 (mean 7.4)	6–8 (7)	9

Notes:
For each stand type the number of stands is given in parentheses.
[a] Natural scrub aged about 30 years on former peat moss. The plot with higher densities had a denser cover of birch.
[b] Aged 22–47. No understorey vegetation.
[c] Aged 40, 43. Understorey of *Calluna*, grass and bramble.
[d] Aged 27. Some spruce and Scots pine within the larch stand.

persed in small clumps of 100 m^2 or as individual trees may be the most effective way of increasing the density and species-richness of birds in the lowlands and southern uplands and the more fertile sites, especially in localities with sizeable amounts of broadleaved woodland.

In Scotland, especially in the northwest Highlands, the smaller pool of potential colonists and often small amounts of well-established broadleaved woodland within or close to conifer forests may mean that scattered trees are less effective in increasing densities or attracting new species (Petty and Avery, 1990). In these areas the use of clumps at least 25 m wide, with some patches exceeding 1 ha, as suggested by French *et al.*, would probably be more effective, especially in conjunction with the establishment of a network of linear woodland along rides, roads and streamsides and some larger areas of woodland centred on existing semi-natural remnants.

The proportion of birch in a conifer crop which would be required to achieve richer bird communities may also vary regionally. Peck (1989) calculated that extra bird species were attracted to compartments in Hamsterley Forest, Durham, which had extra tree species, even when they comprised 5% or less of the canopy. Bird species used different tree species preferentially, thereby avoiding competition. Bibby *et al.* (1989) also found that a small proportion of broadleaves could have a significant effect in plantations in North Wales. French *et al.* (1986) working on Deeside, Grampian Region suggested that maximum bird densities would be obtained when the minor component (either broadleaf in conifers or vice versa) had at least 20% canopy cover, but the evidence for this was uncertain.

The increased soil fertility often developed under birch stands is likely to contribute to an increase in the songbird populations where birch is added to upland conifer plantations. The importance of site fertility to birds is indicated in Figure 4.5 where bird densities were greater for all tree species on the more fertile 'grass/herb' type sites in Finnish forests.

Newton *et al.* (1986) found that sparrowhawk breeding densities in the Scottish uplands were greater on more fertile land and that the differences reflected the densities of their songbird prey species. Raptors such as tawny owls and buzzards are likely to benefit from a higher population of small mammals in birchwoods and other types of deciduous woodland, compared to coniferous woodland (described below).

Mammals

Most small mammals are favoured by well-developed field and shrub layers in deciduous woodland and at woodland edges which provide cover and a variety of food sources (Mayle and Gurnell, 1991). The predators of these animals, including fox, stoat and weasel, also benefit from cover as well as from the increased populations of their prey.

Soils with mull humus support abundant earthworm populations, which are important for shrews, moles and badgers. Hedgehogs also eat considerable quantities of earthworms. Kruuk (1981) found that the home range size of badgers depended upon distances between populations of *Lumbricus* species of earthworms and that these were most available to badgers in short grassland and broadleaved woodland. Earthworms comprised 50% of the badger's diet. The soil-improving effects of birch are therefore important to these mammals.

The increased soil fertility under birch may also benefit mammals by allowing additional food plants to colonise, such as the earth-nut (*Conopodium majus*), whose tubers are a significant food source for badgers (Kruuk, 1981). Berry and nut-bearing plants such as the blaeberry (*Vaccinium myrtillus*), bramble (*Rubus fruticosus* agg.), raspberry (*Rubus idaeus*) and hazel (*Corylus avellana*) also increase. The fungi of birchwoods are also a significant potential resource, e.g. for mice, although data comparing birch with conifers or other broadleaved species in terms of the biomass available are lacking.

The variety of abundance of invertebrates in the field and shrub layers as well as those descending from the tree canopy will also benefit the shrews, hedgehogs and woodmice.

Bats select deciduous woodland patches in forests for feeding, especially where they are associated with glades or edges (Mayle and Gurnell, 1991). The abundant Lepidopteran fauna of birch make it a valuable food source for bats.

In forests with red squirrels, substantial amounts of oak or beech may encourage grey squirrels to invade and eventually displace the red squirrels, if the trees mast regularly. In this respect birch and other light-seeded trees are to be preferred (Gurnell and Pepper, 1991).

Deer also benefit from the combination of cover and forage in deciduous woodland. However, they are likely to limit the spread of birch and other deciduous trees and shrubs as well as woodland herbs, even when present at densities which are too low to cause significant damage to spruce or pine crops.

Birches are not as palatable to deer as most other broadleaves but are preferred to spruce and Scots pine (Mitchell *et al.*, 1977). Mitchell *et al.* (1982) found that in an experimental area in Wester Ross containing red and roe deer the order of preference was willows and rowan. alder, birch and finally Scots pine. However where other broadleaves are not present or where deer densities are high, birch is browsed more heavily and deer may therefore restrict birch colonisation if few parent trees are present. In Kielder Forest, for example, where mature broadleaves are scarce, young birches are common within the fenced restocks but absent outside the fence (Good *et al.*, 1990).

The deer densities which result in reduced plant diversity or reduced cover of deciduous trees will depend on the site quality as well as species of deer and other herbivores present. A number of studies however suggest that these effects may become significant at densities of 10–20 deer km^{-2} (Holloway, 1967; Kraus, 1985; Tilghman, 1989; P. R. Ratcliffe, personal communication). Many upland forests currently harbour such numbers and densities of red deer alone are often 5–15 km^{-2} (Ratcliffe, 1987).

By inhibiting the development of birch and other broadleaves and the associated woodland herbs, high deer populations may check the whole process of mull humus formation and maintain soils of reduced fertility (Mitchell *et al.*, 1977).

Summary of birch: wildlife associations

Table 4.6 summarises the value of birch for the various groups described in this chapter.

Table 4.6 Summary of the value of birch as wildlife habitat in upland forests.

Soil and flora	
Aspect	*Main features of birch*
Soil	■ Increases fertility on podzolic soils, except on base-poor parent materials and ironpans. Converts mor to mull humus; increases availability of plant nutrients and pH. Reverses podzolisation by mixing of soil layers by earthworms. ■ Changes are slight on acid peaty soils. ■ Cyclical changes are likely if birch is succeeded by heather moorland or conifers as in boreal forests. ■ Soil effects may occur under small groups of birch and in intimate mixtures with conifers, but little data is available.
Ground vegetation	■ Similar to that of mixed deciduous woodland on similar sites. ■ On mineral soils, the vegetation is more vigorous and species-rich than that of pine or spruce stands. Grasses and other herbs are more strongly represented under birch. Differences are smaller on peaty soils. ■ Birch–conifer mixtures may show moderate gains in species and cover compared to pure conifers, especially where birch is in clumps of at least 20 m diameter. ■ Soil type, isolation, structure, size, and grazing and browsing pressures are vital factors determining the flora of birch woodland.

Table 4.6 Summary of the value of birch as wildlife habitat in upland forests (continued).

Soil and flora	
Aspect	*Main features of birch*
Epiphytes	■ Birch is poorer for lichens than trees with less acidic bark such as the oaks, ash, elms, sycamore and hazel but 15% of the British lichen flora has been recorded on birch. ■ Birch is more valuable for epiphytes in northern and western Scotland than in other areas.
Fungi	■ The birch fungal flora is larger than and distinct from that of Scots pine, Sitka spruce and Norway spruce, and so can add diversity to conifer forests. ■ Birch in mixture with Sitka spruce is likely to enable colonisation of the spruce by some species of fungi. ■ Only a few species are birch specialists. ■ A succession of different mycorrhizal species occurs between young and old stands.

Fauna	
Aspect	*Main features of birch*
Invertebrates	■ Earthworm populations and the biomass of soil fauna rise and fall in accordance with cyclical changes in fertility as a birch stand develops. ■ The diversity and abundance of the field layer invertebrates are likely to respond to that of ground flora. ■ Birch trees support a very high number of arboreal insect species particularly in Scotland. ■ The biomass of arboreal insects is also fairly high, which is important for vertebrate predators. ■ The variety and abundance of the insect population living on birch trees are likely to depend upon the size, isolation and vigour of birch stands, and the climate. Smaller populations are likely in exposed, infertile sites.
Birds	■ Birch is of considerable value to insectivores, hole-nesters, seed-eaters and field-layer species. ■ Pure birchwoods have only a moderately diverse bird community compared to that of mixed deciduous woods. Geography, woodland structure and soil fertility are all important factors. Grazing animals often simplify the woodland structure by inhibiting regeneration and a shrub layer in upland birchwoods. ■ Pure birch probably supports higher populations and more species of birds than pure pine or spruce stands of similar structure, but birch–conifer mixtures are likely to be richer than pure stands of either type. ■ The proportion and pattern of birch in mixture with pine or spruce required to benefit birds most effectively is likely to vary regionally, and according to site fertility and the amount of deciduous woodland nearby. ■ The potential gains in species from adding birch to conifer forests are less in the northern and western uplands because they are outside the range of some species.
Mammals	■ The optimal habitat of most mammals is deciduous woodland and its associated glades and edges. ■ Birch woodland is generally a good habitat especially on mineral soils because of: • a vigorous field layer including palatable herbs and fruit-bearing plants; • high earthworm populations; • diverse and abundant invertebrate populations. ■ These features will be most pronounced on fertile soils and where a shrub layer exists. ■ An increase in birch cover within coniferous woodland will benefit most mammal species. ■ Adding birch to conifer forests will also improve the habitat quality for deer. However deer densities of about 10–20 km^{-2} may restrict the spread of birch where seed sources are scarce and may retard the colonisation of birch stands by associated plants and animals. ■ Birch is less palatable to deer than most other broadleaved tree species. ■ Red squirrel populations are unlikely to be affected by increasing the amount of birch in conifer forests whereas an increase in oak or beech may reduce red squirrel numbers by encouraging grey squirrels.

Chapter 5

Encouraging Birch in Upland Forests

In the uplands on infertile soils, where few other deciduous trees do well, birch is suited to a wide range of sites and is widely beneficial to wildlife. Therefore the improvement of upland forests for wildlife should include an increase in the amount of birch, especially in the Scottish Highlands and on the more infertile and exposed sites, where it is clearly the most appropriate tree for a broad spectrum of wildlife. Other tree and shrub species appropriate to the site should also be used, however, especially if the aim is to encourage woodland communities akin to those of semi-natural woodland.

Woodland managers need to know how and where birch cover should be increased for best results. Table 5.1 compares four possible ways of increasing birch cover in forests and suggests

Table 5.1 Relative wildlife benefits[a] expected from adding birch to an upland forest in different locations.

	Location of additional birch[b]			
			Mixed into conifer plantation	
	Linked to existing semi-natural woodlands	*Patches on rides, roadsides, streamsides and in glades*	*Clumps for full rotation*	*Intimate mix until canopy closure*
Soil fauna	●	▲	▲	○
Ground vegetation	●	▲	▲	○
Epiphytes	●	▲	○	-
Fungi	●	●	▲	○
Invertebrates above ground	●	●	▲	○
Birds	●	●	●	▲
Mammals	●	●	▲	○

[a] Wildlife benefit is taken here to be increased species diversity and increased populations for a wide range of species within a group without regard for conservation value of individual species.
[b] Assumes that the total amounts of birch and conifer are similar and that the same amount is added in each case.

Key to wildlife benefits
● High
▲ Medium
○ Low
- Negligible

the relative wildlife benefits which might be expected for each. It assumes that the manager's general objective is to increase the diversity and abundance of a broad range of taxonomic groups within a forest block. Under this assumption emphasis is not placed on one species rather than others. Here the gains from birch in rides, roads, etc. would be high, especially for invertebrates, birds and mammals.

Patches of birch and other native species interspersed with unwooded ground along these linear features will create a high proportion of edge habitats, which will increase the diversity and abundance of most wildlife groups (Ratcliffe, 1991). The more mobile taxa are most likely to benefit from this approach, at least in the short-term (several decades).

If conserving or enhancing uncommon woodland species is the main wildlife objective the linkage of additional areas of birch to existing semi-natural woodland would become the best single option.

However, a combination of some or all of the four methods may be the best answer for most forest areas with the emphasis varying according to the local objectives.

Linking new birch to existing semi-natural woodland

The theoretical advantages of linkage are twofold:

1. The likelihood of colonisation by a wide range of wildlife, including rare and immobile species, is increased. Ancient and long-established woods are particularly valuable as refugia for such species.
2. By enlarging the existing wood, populations of uncommon species may become more viable and extra species which require large home ranges may be attracted, for example the badger. These enlarged woods may then act as source areas for the colonisation of new birch woodland areas elsewhere in the forest.

When planning new areas of birch woodland in this way, the nature conservation value of the semi-natural woodland areas must be recognised. This implies a preference for natural regeneration. Where planting is done, local genotypes and all the tree and shrub species that are present in the existing wood should be used. Allowance for future fluctuation of the boundaries of the wood should be made by leaving open areas around the margins.

The desirable size of the enlarged woodland will depend on local circumstances including site fertility. A minimum of 5–10 ha may be required to support diverse communities and allow scope for future manipulation of the wood by management, or by events such as storms, without the less mobile wildlife being lost.

Birch in rides, roadsides, streamsides and glades

A network of intermittent patches of birch and other broadleaved species established along rides, roadsides, streamsides and glades would allow colonisation by woodland and woodland edge species throughout the forest along these 'corridors' and provide a base from which they might colonise the plantations.

Linkage of this network to the enlarged semi-natural woodlands described above would also facilitate colonisation by the less mobile species, including the important earthworm fauna. Small patches (10–20 m wide) of deciduous woodland within rides, roads and streamsides will develop a large amount of edge habitat, which will encourage species diversity within most groups, as described earlier. However in order to develop deciduous woodland conditions and communities more fully, some patches should be at least 40 m in width. Birch should be a major component of these new patches of broadleaved woodland especially on infertile soils. Inevitably, conifer regeneration from adjacent plantations will mix with the broadleaves. Provided conifers are kept as a minor component, around 10–20%, this mixture would probably be beneficial or neutral in its effects upon the diversity and abundance of the wildlife (Plate 6).

The natural fluctuations of the boundaries of birch woodland patches must be allowed for.

Wide rides, roadsides and streamsides give more scope for this as well as admitting sufficient light to meet the needs of shade-intolerant plants in open areas. A width at least equal to the expected top height of the adjacent plantation would be required to allow adequate light for a narrow strip of broadleaved woodland to thrive within rides, etc. throughout the rotation. Variable width, with some parts 60 m or more wide, is better than a fixed width because it gives scope for some larger patches of broadleaved woodland.

Periodic felling may be required to control the balance of woodland cover and open areas. This should not be harmful to the wildlife provided long stretches are not cleared at once, and some patches of mature birch are left for fungi, insects and birds.

Birch within plantations

Birch regenerates on clearfelled sites and will increasingly invade restocks as the seed source in adjacent rides, roads and streamsides expands. Table 5.1 indicates that birch in mixture with conifers has considerable value especially where it is present in clumps which persist through the whole rotation of the conifer. Sarvas (1948) found that most birch seed reaches the ground within 50 m of the parent tree, but greater distances have been measured in windy conditions where maximum distances of 550 m for downy birch and 700 m for silver birch have been recorded in a wind speed of 15 m s^{-1} (Harding, 1981).

Wallace and Patterson (in preparation) found that the numbers of young birch within second rotation Sitka spruce plantations in Scotland fell below 500 ha^{-1} for saplings < 2 m high when the distance to the nearest seed source exceeded about 300 m for downy birch and about 150 m for silver birch. For larger saplings over 2 m high the number fell below 200 ha^{-1} at about 50 m distance for both species, although small numbers were found up to 500 m distant from potential seed sources.

This is consistent with other reports of occasional seedlings 500 m–1 km from seed source (Brown, 1983; J. Miles, personal communication). These studies suggest that birch is likely to colonise conifer stands most strongly within 50–100 m of seed sources growing in the rides, roadsides and streamsides. Clumps of birch in this outer zone are more likely to be colonised by woodland plants and many of the less mobile invertebrates, including earthworms, than those nearer to the centre of large compartments. There is also a probability of clumps near to edges being more useful than internal ones to birds and mammals whose territories or home ranges are centred on the linear features and glades. For these reasons, the development of birch in plantations may be better concentrated in the outer 50–100 m.

Patches of birch within conifer plantations should ideally exceed about 20 m in width to allow in enough light to support moderately vigorous field layer vegetation throughout the rotation. The required size will depend upon the aspect, the thinning regime and the conifer species; wider birch groups would be needed in unthinned Sitka spruce on north facing slopes than in thinned Scots pine on southern aspects.

The evidence for birds described in Chapter 4 suggests that the ideal patch size may vary regionally, with larger clumps being more necessary in northern Scotland than in Wales, where scattered trees seem to have a greater effect for a given total amount of deciduous cover (French *et al.*, 1986; Bibby *et al.*, 1989a).

The addition of birch to conifer stands in an intimate mixture is likely to have a generally smaller enriching effect than the addition of clumps of birch with the same total area (Table 5.1). The ground and epiphyte floras, and the invertebrate and mammal faunas may benefit relatively little because the field layer vegetation and the birch trees themselves will be inhibited by shading from the conifers. However, much will depend upon the effects of the mixture upon soil fertility, and the scale at which these effects may operate; topics about which little is currently known.

Arboreal insects and insectivorous songbirds are two groups which are still likely to gain considerably from birch being added to conifers in intimate mixtures, although only temporarily if the birch does not survive for the whole rotation.

The wildlife enrichment obtained from intimate mixtures where birch does not persist much beyond canopy closure is likely to be greater where a patchwork of stands of different ages is developed, so that species could more easily move from one temporary site to another, including the birch itself. The stands which contain these temporary admixtures of birch, namely those less than 15–20 years old, will eventually occupy some 25–40% of the plantation area of the forest when all ages are equally represented. The proportion would depend upon rotation length and yield class (Ratcliffe and Petty, 1986). Thus even temporary mixtures can make a valuable contribution to enriching the forest wildlife.

The costs in terms of timber revenue foregone will be greater for clumped mixtures which last through the whole rotation than for intimate mixtures where the birch is shaded out after the conifer species closes canopy. This difference in costs should be set against the likely overall advantage of clumped mixtures for wildlife in deciding which approach to favour.

In practical terms groups of birch within plantations of conifers might be best concentrated on stable sites with mineral soils where thinning is a realistic prospect. Thinning of the birch clumps would be desirable to develop a field and shrub layer.

On peaty soils where the potential for a woodland flora and fauna is more limited and thinning is less likely, the less costly option of an intimate self-thinning mixture may be a better prospect, with larger clumps of birch woodland being largely confined to the non-plantation areas.

The proportion of birch in mixed stands required to produce substantial wildlife benefits is uncertain. The limited evidence available for songbirds suggests that 5–10% broadleaves will bring substantial benefits and that an increase in broadleaved cover beyond 20% may yield little extra abundance or diversity. At present 10% seems to be a reasonable overall figure but much will depend on local circumstances and objectives.

Methods of increasing birch cover

For the purpose of wildlife conservation, natural regeneration is preferable to planting because it produces a more irregular structure and a closer match of tree species to the site. It also conserves the local gene pool.

Birch germinates best on bare humus or mineral soil (Sarvas, 1948; Kinnaird, 1974; Harding, 1981; Brown, 1983) in well-lit conditions. It establishes poorly in a grassy field layer but quite well in open heather. Recently felled sites provide a good seedbed where the litter layer is thin and brash is sparse or absent (Plate 8).

In some cases seed sources are lacking, however, notably in first rotation thicket and pole stage spruce plantations which were established on bare moorland. Wallace and Patterson (in preparation) found that above 200 m altitude 67% of sample sites within second rotation Sitka spruce plantations had no seed source within 500 m. This scarcity was apparently mainly due to the removal of birch under previous land use rather than any limitations of the site. One way of overcoming this is to plant clumps of parent trees on rides, roadsides and streamsides, where they can act as seed sources to colonise felled ground at the end of the rotation.

Care should be taken to use trees of the appropriate birch species for the site and also to select a suitable provenance, preferably a source from the same region and a similar elevation and climate. Planting should be done at least 10–15 years before clearfelling of adjacent stands, so that the trees are producing seed in time. A spacing of 150–300 m between clumps should result in intermittent patches of birch saplings colonising the plantation area after clearfelling. Sowing birch seed on clearfelled or cultivated soil is another option provided seed can be collected at low cost (Brown, 1983; Patterson, in press).

Birch regeneration that develops on the edges of felled compartments can be incorporated partly into widened rides, roadsides and streamsides and partly into the restocked conifer crops.

Effects of deer

Current population levels of deer in many upland areas will reduce the rate of natural colonisation of birch and other broadleaved trees and shrubs especially from small parent populations, and may also restrict the spread of woodland plants and communities.

Reduction of deer numbers as well as the establishment of additional seed sources, and perhaps the temporary fencing of selected areas may be needed to overcome these problems. Where deer numbers are not reduced sufficiently to allow mixed broadleaved woodland to develop, birch and alder may be the only broadleaves which can spread extensively outside fenced areas.

Conclusions

- Birches (*Betula pendula* and *B. pubescens*) are widespread pioneer species capable of colonising all but the most exposed and waterlogged of upland soils. They are of considerable value to most wildlife groups and can improve soil fertility on many podzolised soils. Birches are particularly valuable for their rich insect fauna.
- The conservation value of birch relative to other deciduous trees is greater in the northern uplands, especially in northern and western Scotland, than it is further south. Birches are the most common trees of semi-natural woods in Scotland and many species of insects with northerly distributions are confined to birch as a host tree.
- An increased amount of birch in upland forests would bring widespread benefits to wildlife. It should be encouraged to form a loosely linked network of woodland patches along rides, roads and streamsides and in adjacent conifer stands. This network should be linked to existing semi-natural woodland to aid the colonisation of associated species.
- Other tree and shrub species which are suited to the site should always be encouraged alongside birch. However, on the poorest soils, birches (notably *Betula pubescens*) are suited to be the major deciduous tree species established for wildlife enhancement.

ACKNOWLEDGEMENTS

The author would like to thank Dr John Miles for helpful comments on the draft manuscript, Dr Phil Ratcliffe for his encouragement at various stages, the typing staff at Northern Research Station, and Glenn Brearley for taking the photographs for Plates 2, 3, 6, 7, 8 and front cover. Other photographs were obtained from the Forestry Commission Headquarters photographic library.

REFERENCES

ALEXANDER, I. and WATLING, R. (1987). Macrofungi of Sitka spruce in Scotland. In *Symposium: Sitka spruce*, eds D. M. Henderson and R. Faulkner. *Proceedings of the Royal Society of Edinburgh (Section B)* **93,** 107–115.

BEVAN, D. (1987). *Forest insects. A guide to insects feeding on trees in Britain.* Forestry Commission Handbook 1. HMSO, London.

BIBBY, C. J., ASTON, N. and BELLAMY, P. E. (1989a). Effects of broadleaved trees on birds of upland conifer plantations in north Wales. *Biological Conservation* **49,** 12–29.

BIBBY, C. J., BAIN, C. G. and BURGES, D. J. (1989b). Bird communities of the Highland birchwoods. *Bird study* **36,** 123–133.

BROWN, A. H. F. (1992). Functioning of mixed-species stands at Gisburn in NW England. In *The ecology of mixed species stands of trees,* eds M. G. R. Cannell, D. C. Malcolm and P. A. Robertson. British Ecological Society Special Publication No. 11, Blackwell Scientific Publications, Oxford, 125–150.

BROWN, A. H. F. and HARRISON, A. F. (1983). Effects of tree mixtures on earthworm populations and nitrogen and phosphorous status in Norway spruce stands. In *New trends in soil biology*, eds P. Lebrun *et al.* Dieu-Bruhart, Louvain-la-Neuvre, Belgium, 101–108.

BROWN, I. R. (1983). *Management of birch woodland in Scotland.* Countryside Commission for Scotland, Perth.

BROWN, I. R. (1991). The current state of knowledge about birch in Britain. In *The commercial potential of birch in Scotland,* eds R. Lorrain-Smith and R. Worrell. Forest Industry Committee of Great Britain, London, 35–42.

BUNCE, R. G. H., MUNRO, R. C. and PARR, T. W. (1979). Deciduous woodland survey of Scotland. Unpublished report of NCC/NERC Contract No. F3/03/75. Nature Conservancy Council, Peterborough.

BUTTERFIELD, J. and MALVIDO, J. B. (1992). Effect of mixed-species tree planting on the distribution of soil invertebrates. In *The ecology of mixed species stands of trees*, eds M. G. R. Cannell, D. C. Malcolm and P. A. Robertson. British Ecological Society Special Publication No. 11, Blackwell Scientific Publications, Oxford, 255–265.

COPPINS, B. J. (1984). Epiphytes of birch. In *Symposium: birches*, eds D. M. Henderson and D. Mann. *Proceedings of the Royal Society of Edinburgh (Section B)* **85,** 115–124.

COULSON, J. C. (1988). The structure and importance of invertebrate communities on peatland and moorlands and effects of environmental and management changes. In *Ecological changes in the uplands*, eds M. B. Usher and D. B. A. Thompson. British Ecological Society Special Publication No. 7. Blackwell Scientific Publications, Oxford, 365–380.

CURRIE, F. A. (1989). *Effects of broadleaved trees on birds of conifer plantations in north Wales—report of joint RSPB/FC study, 1984.* Research Information Note 157. Forestry Commission, Edinburgh.

EVANS, H. F. (1987). Sitka spruce insects: past, present and future. In *Symposium: Sitka spruce*, eds D. M. Henderson and R. Faulkner. *Proceedings of the Royal Society of Edinburgh (Section B)* **93,** 157–167.

EVANS, J. (1988). *Natural regeneration of broadleaves.* Forestry Commission Bulletin 78. HMSO, London.

FENTON, J. (1985). The state of Highland birchwoods. The report of the Scottish Wildlife Trust's 1984 survey of birchwoods in Highland Region. Unpublished report to the Scottish Wildlife Trust, Edinburgh

FORBES, J. C. and KENWORTHY, J. B. (1973). Distribution of two species of birch forming stands on Deeside, Aberdeenshire. *Transactions of the Botanical Society of Edinburgh* **42,** 101–110.

FORESTRY COMMISSION (1982). *Census of trees and woodlands 1979–82.* Forestry Commission, Edinburgh.

FORESTRY COMMISSION (1985). *Guidelines for the management of broadleaved woodland.* Forestry Commission, Edinburgh.

FRENCH, D. D., JENKINS, D. and CONROY, J. W. M. (1986). Guidelines for managing woods in Aberdeenshire for songbirds. In *Trees and wildlife in the Scottish uplands*, ed. D. Jenkins. Symposium No. 17. Institute of Terrestrial Ecology, Abbot's Ripton, 129–143.

FULLER, R. J. (1982). *Bird habitats in Britain.* T. A. D. Poyser, London.

FULLER, R. J., STUTTARD, P. and RAY, C. M. (1989). The distribution of breeding songbirds within mixed coppice woodland in Kent, England, in relation to vegetation age and structure. *Ann. Zool. Fennici* **26,** 265– 275.

GARDINER, A. A. (1984). Taxonomy of intraspecific variation in *Betula pubescens* Ehrh., with particular reference to the Scottish Highlands. In *Symposium: birches*, eds D. M. Henderson and B. Mann. *Proceedings of the Royal Society of Edinburgh (Section B)* **85,** 13–26.

GARDINER, A. S. (1968). *The reputation of birch for soil improvement.* Research and Development Paper 67. Forestry Commission, London.

GIBBS, J. A. and BETTS, M. M. (1963). Food and food supply of nestling tits in Breckland pine. *Journal of Animal Ecology* **32,** 489–533.

GIMINGHAM, C. H. (1984). Ecological aspects of birch. In *Symposium: birches*, eds D. M. Henderson and D. Mann. *Proceedings of the Royal Society of Edinburgh (Section B)* **85,** 65–72.

GOOD, J. E. G., WILLIAMS, T. G., WALLACE, H. L., BUSE, A. and NORRIS, D. A. (1990). Nature Conservation in Upland Conifer Forests. Unpublished report to the Nature Conservancy Council and the Forestry Commission, FC Reference No. Y29P1. Institute of Terrestrial Ecology, Bangor.

GURNELL, J. and PEPPER, H. W. (1991). *Conserving the red squirrel.* Research Information Note 205. Forestry Commission, Edinburgh.

HARDING, J. S. (1981). Regeneration of birch. In *Regeneration of oak and beech: a literature review (with an addendum on birch)*, eds A. J. Newbold and F. B. Goldsmith. Discussion paper on conservation No. 33, 83–112, Ecology and Conservation Unit, University College, London.

HILL, D., ROBERTS, P. J. and STORK, N. (1990). Densities and biomass of invertebrates in stands of rotationally managed coppice woodland. *Biological Conservation* **51,** 167–176.

HOLLOWAY, C. W. (1967). Effect of red deer and other animals on natural regeneration of Scots pine. Unpublished PhD thesis. University of Aberdeen.

KENNEDY, C. E. J. and SOUTHWOOD, T. R. E. (1984). The number of species of insects associated with British trees: a re-analysis. *Journal of Animal Ecology* **53,** 455–478.

KINNAIRD, J. W. (1974). Effect of site conditions on the regeneration of birch (*Betula pendula* Roth. and *B. pubescens* Ehrh.). *Journal of Ecology* **62,** 467–472.

KIRBY, K. J. (1984). Scottish birchwoods and their conservation—a review. *Transactions of the Botanical Society of Edinburgh* **44,** 205–218.

KAPONEN, S. (1984). Abundance of herbivorous insects on dwarf birch near the treeline in Alaska. *Reports, Kevo Subarctic Research Station* **19,** 19–24.

KAPONEN, S. and ISO-IIVARI, L. (1978). Herbivorous insects of the mountain birch (*Betula pubescens*, sub-species *tortuosa*) in eastern Finnmark (Norway) and northern Lapland (Finland). *Norwegian Journal of Entomology* **25,** 157–163.

KRAUS, P. (1985). Vegetation impact, bark stripping intensity and body weight as indicators of relative red deer density. 17th Congress of the International Union of game Biologists, Brussels, 16-21 September 1985, 969–978.

KRUUK, H. (1981). Badger populations and their food. In *Institute of Terrestrial Ecology, Annual Report 1980.* Institute of Terrestrial Ecology, Cambridge.

LORRAIN-SMITH, R. and WORRELL, R., eds. (1991). *The commercial potential of birch in Scotland.* The Forest Industry Committee of Great Britain, London.

LOW, A. J. (1986). *Use of broadleaved species in upland forests.* Forestry Commission Leaflet 88. HMSO, London.

McVEAN, D. N. (1964). Woodland and scrub. In *The vegetation of Scotland*, ed. J. H. Burnett. Oliver and Boyd, Edinburgh.

McVEAN, D. N. and RATCLIFFE, D. A. (1962). *Plant communities of the Scottish Highlands.* Monographs of the Nature Conservancy No. 1. HMSO, London.

MAYLE, B. A. and GURNELL, J. (1991). Edge management and small mammals. In *Edge management in woodlands*, ed. R. Ferris-Kaan. Occasional Paper 28. Forestry Commission, Edinburgh, 42–48.

MILES, J. (1981). *Effect of birch on moorlands.* Institute of Terrestrial Ecology, Cambridge.

MILES, J. (1985). Soil in the ecosystem. In *Ecological interactions in soil. Plants, microbes and animals*, eds A. H. Fitter, D. Atkinson, D. J. Read, M. B. Usher. British Ecological Society Special Publication No. 4. Blackwell Scientific Publications, Oxford, 407–427.

MILES, J. (1986). What are the effects of trees on soils? In *Trees and wildlife in the Scottish uplands*, ed. D. Jenkins. Symposium No. 17. Institute of Terrestrial Ecology, Abbot's Ripton.

MILES, J. (1988). Vegetation and soil changes in the uplands. In *Ecological change in the uplands*, eds M. B. Usher and D. B. A. Thompson. British Ecological Society Special Publication No. 7. Blackwell Scientific Publications, Oxford, 365–380.

MILES, J. and KINNAIRD, J. W. (1979). The establishment and regeneration of birch, juniper and Scots pine in the Scottish Highlands. *Scottish Forestry* **33**, 102–119.

MITCHELL, B., STAINES, B. W. and WELCH, D. (1977). *Ecology of red deer—A research review relevant to their management in Scotland.* Institute of Terrestrial Ecology, Banchory.

MITCHELL, B., McGOWAN, D. and WILLCOX, N. A. (1982). Effects of deer in a woodland restoration enclosure. *Scottish Forestry* **36,** 102–112.

MOSS, D. (1978). Songbird populations in forestry plantations. *Quarterly Journal of Forestry* **72,** 5–14.

NEWTON I. (1972). *Finches.* Collins, London.

NEWTON, I. and MOSS, D. (1977). Breeding birds of Scottish pinewoods. In *Native pinewoods of Scotland.* Proceedings of the Aviemore Symposium, eds R. G. H. Bunce and J. N. R. Jeffers. Institute of Terrestrial Ecology, Cambridge, 26–34.

NEWTON, I., WYLLIE, I. and MEARNS, R. (1986). Spacing of sparrowhawks in relation to food supply. *Journal of Animal Ecology* **55,** 361–370.

PARR, T. W. (1981). Scottish deciduous woodland: a cause for concern. In *Forest and woodland ecology*, eds F. T. Last and A. S. Gardiner. Symposium No. 8. Institute of Terrestrial Ecology, Abbot's Ripton, 12–15.

PATTERSON, G. S. (in press). *The establishment of birch from seed on upland clearfelled sites.* Forestry Commission Research Information Note.

PECK, K. (1989). Tree species preference shown by foraging birds in forest plantations in Northern England. *Biological Conservation* **48,** 41–57.

PERRING, F. H. and WALTERS, S. M., eds (1990). *Atlas of the British flora.* Botanical Society of the British Isles, Peterborough.

PETTY, S. J. and AVERY, M. (1990). *Forest bird communities.* Forestry Commission Occasional Paper 26. Forestry Commission, Edinburgh.

RATCLIFFE, D. A. (1968). An ecological account of Atlantic bryophytes in the British Isles. *New Phytologist* **67,** 365–440.

RATCLIFFE, P. R. (1987). *The management of red deer in upland forests.* Forestry Commission Bulletin 71. HMSO, London.

RATCLIFFE, P. R. (1991). Edge habitats: an introduction. In *Edge management in wood-*

lands, ed. R. Ferris-Kaan. Occasional Paper 28. Forestry Commission, Edinburgh.

RATCLIFFE, P. R. and PETTY, S. J. (1986). The management of commercial forests for wildlife. In *Trees and wildlife in the Scottish uplands*, ed. D. Jenkins. Symposium No. 17. Institute of Terrestrial Ecology, Abbot's Ripton.

RHEE, J. A. van (1969). Development of earthworm populations in polder soils. *Pedobiologica* **9,** 133–140.

ROBERTS, P. J. (1990). Invertebrates in coppiced woodland: A study of numbers, biomass and species richness at Church Wood, Kent, and the implications for nature conservation. Unpublished MSc Thesis, University of Kent.

ROBINSON, C. H. (1990). The effects of introduction of earthworms in deep peat soils under Sitka spruce (*Picea sitchensis* (Bong.) Carr.) on nutrient turnover and tree growth. PhD Thesis, University of Lancaster.

ROBINSON, C. H., INESON, P., PIEARCE, T. G. and ROWLAND, A. P. (in press, a). Nitrogen mobilisation by earthworms in limed peat soils under *Picea sitchensis*. *Journal of Applied Ecology*.

ROBINSON, C. H., PIEARCE, T. G., INESON, P., DICKSON, D. and NYS, C. (in press, b). Earthworm populations of limed coniferous soils: field observations and implications for forest management. *Forest Ecology and Management*.

RODWELL, J. (1991). *British plant communities*, vol. 1: *Woodland and scrub*. Cambridge University Press, Cambridge.

SARVAS, R. (1948). A research on the regeneration of birch in south Finland. *Communicationes Instituti Forestales Fenniae* **35,** 1–91.

SATCHELL, J. E. (1980a). Soil and vegetation changes in experimental birch plots on a *Calluna* podsol. *Soil Biology and Biochemistry* **12,** 303–310.

SATCHELL, J. E. (1980b). Potential of the Silpho Moor experimental birch plots as a habitat for *Lumbricus terrestris*. *Soil Biology and Biochemistry* **12,** 317–323.

SATCHELL, J. E. and LOWE, D. G. (1967). Selection of leaf-litter by *Lumbricus terrestris*. In *Progress in soil biology*, eds O. Graff and J. E. Satchell. North Holland Publishing Co., Amsterdam, 102–119.

SHAW, M. R. (1984). Insects associated with birch. In *Symposium: birches*, eds D. M. Henderson and O. Mann. *Proceedings of the Royal Society of Edinburgh (Section B)* **85,** 169–182.

SIMMONS, E. and BUCKLEY, P. (1992). The ground vegetation under planted mixtures of trees. In *The ecology of mixed species stands of trees*, eds M. G. R. Cannell, D. C. Malcolm and P. A. Robertson. British Ecological Society Special Publication No. 11. Blackwell Scientific Publications, Oxford, 211–231.

SIMMS, E. (1971). *Woodland birds*. Collins, London.

SOUTHWOOD, T. R. E., MORAN, V. C. and KENNEDY, C. E. J. (1982). The richness, abundance and biomass of the arthropod community on trees. *Journal of Animal Ecology* **51,** 635–649.

STRONG, D. R., LAWTON, J. H. and SOUTHWOOD, T. R. E. (1984). *Insects on plants. Community patterns and mechanisms*. Blackwell Scientific Publications, Oxford.

TILGHMAN, N. G. (1989). The impacts of white-tailed deer on forest regeneration in north-west Pennsylvania. *Journal of Wildlife Management* **53,** 524–432.

TULEY, G. (1973). A taxonomic history of the British birch tree. *Transactions of the Botanical Society of Edinburgh* **42,** 31–41.

VAN RHEE (1969). See Rhee, van.

VON HAARTMAN, L. (1971). Population dynamics. In *Avian biology*, vol. 1, eds D. S. Farner and J. R. King. Academic Press, London, 395–459.

WALLACE, H. L. and PATTERSON, G. S. (in preparation). The status of birch *Betula pubescens* Ehrh. and *Betula pendula* Roth. in Sitka spruce restocks: evidence from some Scottish forests.

WATLING, R. (1984). Macrofungi of birchwoods. In *Symposium: birches*, eds D. M. Henderson and O. Mann. *Proceedings of the Royal Society of Edinburgh (Section B)* **85,** 129–140.

WILLIAMSON, K. (1969). Bird communities in woodland habitats in Wester Ross, Scotland.

Quarterly Journal of Forestry **63,** 305–328.

YAPP, W. B. (1953). The high-level woodlands of the English Lake District. *Northwestern Naturalist* **24,** 190–207, 370-383.

YAPP, W. B. (1962). *Birds and woods.* Oxford University Press, London.

YAPP, W. B. (1974). Birds of the northwest Highland birchwoods. *Scottish Birds* **8,** 16–31.

Printed in the United Kingdom for HMSO
Dd.0294460 C33 5/93

Forestry Commission Bulletin 109 The Value of Birch in Upland Forests for Wildlife Conservation HMSO

HMSO

HMSO publications are available from:

HMSO Publications Centre
(Mail, fax and telephone orders only)
PO Box 276, London, SW8 5DT
Telephone orders 071-873 9090
General enquiries 071-873 0011
(queuing system in operation for both numbers)
Fax orders 071-873 8200

HMSO Bookshops
49 High Holborn, London, WC1V 6HB
(counter service only)
071-873 0011 Fax 071-873 8200
258 Broad Street, Birmingham, B1 2HE
021-643 3740 Fax 021-643 6510
Southey House, 33 Wine Street, Bristol, BS1 2BQ
0272 264306 Fax 0272 294515
9-21 Princess Street, Manchester, M60 8AS
061-834 7201 Fax 061-833 0634
16 Arthur Street, Belfast, BT1 4GD
0232 238451 Fax 0232 235401
71 Lothian Road, Edinburgh, EH3 9AZ
031-228 4181 Fax 031-229 2734

HMSO's Accredited Agents
(see Yellow Pages)

and through good booksellers

£5.95 net

ISBN 0-11-710316-0

9 780117 103160