

## **Priority Habitat Definition Statement Lowland Beech and Yew Woodland - v1.3**

### **1. Introduction**

#### **1.1 HAP woodland criteria**

**Please note:** As outlined by the UK Native Woodland HAPs Definitions Working Group report<sup>14</sup>, woodland must fit into one of the following categories to qualify as being in the current area of broadleaved woodland HAPs.

- Ancient semi-natural woods (semi-natural stands on ancient sites).
- Other semi-natural woods (semi-natural stands on more recent woodland sites).
- Planted woods on ancient woodland sites where the composition is mainly site native species (over 50% of the canopy).
- Other planted woods of mainly native species (over 50% of the canopy is site-native species), where the agreed aim is to manage towards a more semi-natural structure and composition.
- New Native Woodlands created to mimic the natural composition of the woodlands on the site.

To qualify as HAP woodland, a site must have:

- 20% or more canopy cover, or the potential to achieve this in the case of newly planted stands.
- A canopy composed of 50% or more site-native species of trees or shrubs (or will be at canopy closure in the case of younger stands). Site native trees are those which are native to the locality and capable of growing naturally on the site, ie. they can successfully colonise and complete their life cycle. Peterken and Soutar (1989) 'Native trees and shrubs for wildlife'<sup>11</sup> can be used as a guide, but it gives a broad indication only. Local knowledge is more important.

When determining if a site is part of the lowland beech and yew woodland HAP, the above criteria should be met before the description of lowland beech and yew that follows is applied.

#### **1.2 General description of lowland beech and yew woodland**

**Lowland beech and yew woodland spans a variety of distinctive vegetation types reflecting differences in soil and topographical conditions. Calcareous beech and yew forms perhaps 40% of the total amount of this priority habitat, beech woodland on neutral-slightly acidic soils comprised about 45%, and acidic beech the remaining 15%.<sup>1</sup>**

##### ***Calcareous beech and yew woodland***

**The canopy can include mixtures of beech, ash, sycamore (non-native), yew and whitebeam. It may include small amounts of gean, field maple, wych elm, and locally small-leaved and large-leaved limes. Oak is less common than in other beechwoods. Promotion of high quality beech for silviculture has often lead to an artificial**

dominance of beech. Where beech is not absolutely dominant and the soil is shallow, a diverse underwood of yew, holly, whitebeam and other shrubs develops. In a few sites the shrub layer includes native populations of box. On the deeper soils, hazel and hawthorn appear. Sycamore is well-established in many woods. On the steepest and driest slopes, yew forms a dense underwood, but it also forms pure stands on similar sites in the absence of beech. These areas are perhaps the least diverse of all British woodland. Yew is often so dominant that only a scatter of hazel, whitebeam or ash may be present.

Dog's mercury *Mercurialis perennis* often carpets the ground, with sanicle *Sanicula europaea*, ivy *Hedera helix*, wild arum *Arum maculatum*, sweet woodruff *Galium odoratum* and wood avens *Geum urbanum*. On moister examples, primrose *Primula vulgaris*, yellow archangel *Lamium galeobdolon*, and wood anemone *Anemone nemorosa* are common. In yew dominated sites the ground vegetation, if not entirely absent, is rarely more than a thin scatter of dog's mercury, wild arum, violets and wild strawberry *Fragaria vesca*. Characteristic uncommon or rare plants can include box *Buxus sempervirens*, red helleborine *Cephalanthera rubra*, white helleborine *Cephalanthera damasonium*, green hellebore *Helleborus viridis*, narrow-lipped helleborine *Epipactis leptochila*, coralroot bitter-cress *Cardamine bulbifera*, lady orchid *Orchis purpurea*, and bird's nest orchid *Neottia nidus-avis*.<sup>1,6</sup>

#### ***Beech woodland on neutral-slightly acidic soils***

Stands tend to be dominated by beech, but oak *Quercus robur* and sometimes *Quercus petraea* is a common associate. Small amounts of gean, birch and naturalised sycamore may occur. Ash is scarce in contrast to the previous type. Often a shrub layer is lacking, although holly can form a second tier of trees, occasionally with yew.

Bramble *Rubus fruticosus* forms a characteristic ground layer, particularly when the canopy is broken or loses vigour. Other common ground flora associates include bluebell *Hyacinthoides non-scripta*, wood sorrel *Oxalis acetosella*, male fern *Dryopteris filix-mas*, tufted hair-grass *Deschampsia cespitosa*, creeping soft-grass *Holcus mollis* and wood spurge *Euphorbia amygdaloides*. Violet helleborine *Epipactis purpurata* is a rare plant found in this community.<sup>1,6</sup>

#### ***Acidic beech woodland***

Oak is the common canopy associate of acidic beech. Holly is the main understorey species, notably in woods which have been heavily grazed, and less often yew. Rowan and alder buckthorn are also characteristic but hazel and hawthorn tend to be rare.

The ground vegetation may be sparse and extremely poor in some areas, sometimes reduced to little more than tufts of *Leucobryum* and other mosses scattered amongst persistent drifts of leaves. In other example, wavy hairgrass *Deschampsia flexuosa*, bracken or bilberry *Vaccinium myrtillus* is abundant, and in richer examples wood-sorrel *Oxalis acetosella*, cow-wheat *Melampyrum pratense*, butcher's broom *Ruscus aculeatus*, hard-fern *Blechnum spicant* and buckler fern (*Dryopteris*) are common.<sup>1,5</sup>

### **1.3 Summary of existing information**

#### **1.3.1 Information sources**

The UK Native Woodland Habitat Action Plans – Report of the Definitions Working Group (unpublished) provided general guidance on defining the native woodland HAPs.

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Four key documents were identified as the main sources of for defining lowland beech and yew woodland, and in many cases they are quoted from directly in this statement:

- BAP Lowland Beech and Yew Woodland Habitat Action Plan
- JNCC Report No. 288 - The Relationship between Biodiversity Action Plan Priority and Broad Woodland Habitat Types, and other woodland classifications.
- Forestry Authority Forestry Practice Guide 1 - Lowland Acid Beech and Oak Woods (part)
- Forestry Authority Forestry Practice Guide 2 - Lowland Beech - Ash Woods

These and other documents used to develop this definition statement are listed in **Appendix 1**.

### **1.3.2 Existing inventories**

National-scale woodland inventories do exist, principally the National Inventory of Woodland and Trees (Forestry Commission) and Ancient Woodland Inventory (English Nature), however these do not spatially represent the distribution of woodland priority habitat types.

### **1.4 Key issues with mapping and discriminating from other habitats**

- Please refer to Section 1.1 as a guide to woodland that qualifies as belonging to one of the woodland HAPs. Based on this guidance, any planted woodland that is not on an ancient woodland site, where management is not know, should be included in the “maybe” rather than “definitely” or “definitely not” categories.
- The minimum mappable unit (MMU) for this habitat is 0.25ha, and the minimum width is 15m. Please refer to Section 11 for further details.
- Areas of open ground within woods (e.g. glades, rides) should only be included as part of the woodland resource if they do not qualify to be mapped as a polygon belonging to one of the other priority habitats and are not greater than 0.25 ha in area. (Note that they will however usually be included as part of the “woodland” for management scheme purposes).
- Scrub of 0.25ha or over and 20% or greater cover should be included as part of the appropriate woodland HAP.
- According to the HAP Definitions Working Group Report <sup>14</sup>, woods should be formally confined to the native zones for this habitat. As the beech zone appears to be moving, LB&Y woods outside the accepted zone should be recorded, but under the category “close to but not currently meeting the definition” and with an explanatory note that “this wood is outside the current accepted zone”.
- Include regenerating areas that lack beech as lowland beech and yew if they occur as mosaic with mature beech woodland and show sign of former beech crop.
- The bulk of the range of upland mixed ashwoods is beyond the accepted native range of beech (although both occur in the Wye Valley). Beech has, however, often been planted and subsequently regenerated on sites where upland mixed ashwoods might be expected at least as far north as the Appin area of Argyll. Some such long-established beech stands may key out as W12 (less often W14) beech woodland <sup>8</sup>. These stands

should be included in the lowland beech and yew inventory (mapped as “close to but not currently meeting the definition”) rather than in the upland mixed ashwoods inventory.

- Except for lowland wood pasture and parkland, woodland priority habitats are mutually exclusive of each other and there should be no overlap between polygons belonging different woodland priority habitats. Please refer to Section 9 for further details.
- Please refer to Section 4 for resolution of classification types that may be allocated to this habitat as well as to other woodland priority habitats.
- In distinguishing this habitat from other non-woodland habitats, any site of over 0.25ha with 20% or greater canopy cover will be a woodland rather than a non-woodland habitat. For further rules on dealing with relationships with non-woodland habitats, see Section 9.

## **2. Physiographical description**

### **2.1 Structural/physical components**

W12 is especially characteristic of the steeper drift-free faces of the escarpments of the Chalk and the Oolite in the South-East. Stands of W13 are typically associated with moderate to very steep limestone slopes.<sup>12</sup>

### **2.2 Applicability of aerial photos and other remote sensing technologies**

Dependant on factors such as the time of year the photographs were taken, their scale, and the experience of the interpreter, it is possible to distinguish broadleaved from coniferous species from aerial photographs, and sometimes certain individual species types. It is however unlikely that aerial photography alone would provide enough information to identify individual woodland priority habitat types.

Unknown as to the value of using airborne remote sensing instrumentation such as ‘LIDAR’ (Light Detection and Ranging), and ‘CASI’ (Compact Airborne Spectrographic Imagery). May have some use for distinguishing woodland types at a fairly crude scale.

## **3. Altitudinal limits**

No specific upper or lower limits.

## 4. Habitat classification

(based on JNCC Report 288<sup>8</sup>, with additions)

CLASSIFICATION and version date	CODE	(HIS CODE)	DESCRIPTION	RELATIONSHIP*	COMMENTS
<b>BAP priority habitat (1995)</b>		<b>WB331</b>	<b>Lowland beech and yew woodland</b>		
<b>BAP broad habitat (1998)</b>		WB0	Broadleaved, mixed and yew woodland	>	
<b>Phase 1 (1990)</b>	A1.1.1 A1.1.2 A1.3.1 A1.3.2 A2.1 A3.1 A3.3 A4.1 A4.3		Broadleaved semi-natural woodland Broadleaved plantation woodland Mixed semi-natural woodland Mixed plantation woodland Dense/continuous scrub Broadleaved parkland/scattered trees Mixed parkland/scattered trees Recently-felled broadleaved woodland Recently-felled mixed woodland	# # # # # # # # #	A4.1 and A4.3 are only relevant if the intention is to keep the site as woodland.
<b>NVC (1991)</b>	W12 W14 W15 W13		<i>Fagus sylvatica</i> – <i>Mercurialis perennis</i> <i>Fagus sylvatica</i> – <i>Rubus fruticosus</i> <i>Fagus sylvatica</i> – <i>Deschampsia flexuosa</i> <i>Taxus baccata</i>	< <	Beech woodland comprises W12, W14 and W15 according to soil conditions. These all occur in the native and the planted range of beech. Yew woodland is W13. When W13 occurs on carboniferous and magnesian limestones and in mosaic with upland mixed ash stands, it should be allocated to that habitat.  NB. Within W12, W14 and W15, regeneration patches where beech is currently scarce usually fall into W8, W10 and W16 respectively. These should still be included as the priority habitat.
<b>Forestry Commission guide types (1994)</b>	1 2		Lowland acid beech and oak woods Lowland beech-ash woods	# <	Beech-dominated stands whose management is considered under Guide type 1 are included in the lowland beech and yew priority habitat type. Lowland woods on acid soils which lack beech and are dominated by oak, hornbeam, lime etc. are considered as part of the lowland mixed deciduous woodland habitat type.  Guide type 2 falls entirely within this type.
<b>Peterken stand types (date?)</b>	8A 8B 8C  8D 8E		Acid sessile oak-beech woods Acid pedunculate oak-beech woods Calcareous pedunculate oak-ash-beech woods Acid pedunculate oak-ash-beech woods Sessile oak-ash-beech woods	< < < < <	There is good correspondence between Stand Group 8 (which includes beech on both calcareous and acid soils) and this priority habitat. There is no stand equivalent for yew woodland. Strictly speaking, the Peterken Stand Type classification only applies to ancient semi-natural woodlands and should not be used in plantations. It is, therefore, restricted to stands of beech growing in the accepted native range.  8A and 8B may also be associated with other woodland types such as upland oak where beech is invading the stands. These should be included in the lowland beech and yew inventory only if they occur with other Peterken stand types associated with this habitat.
<b>EUNIS (date?)</b>	G1.62 G3.971		Atlantic acidophilous [ <i>Fagus</i> ] forests Atlantic [ <i>Taxus baccata</i> ] woods	< <	

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Palaeartic (date?)	?				
CORINE (1991)	41.13 41.12 42.A71		Neutrophilous beech forests Atlantic Acidophilous beech forests British yew forests	< < <	42.A71 may also correspond to upland mixed ashwoods. It should be included with upland mixed ashwood if in mosaic with other ashwood CORINE types.
Habitats Directive Annex 1 (1997)	42.A71 to 42.A73 41.13 41.12	WB3313  WB3312 WB3311	' <i>Taxus baccata</i> woods'  ' <i>Asperulo-Fagetum</i> beech forests' 'Beech forest with <i>Ilex</i> and <i>Taxus</i> , rich in epiphytes'	< < <	42.A71 to 42.A73 may occur locally as small groves with upland mixed ashwoods. In these situations it should be included in the upland mixed ashwoods inventory.
Habitats Directive Annex 1 (date?)	91J0 9130 9120	WB3313 WB3312 WB3311	' <i>Taxus baccata</i> woods of the British Isles' ' <i>Asperulo-Fagetum</i> beech forests' Atlantic acidophilous beech forests with <i>Ilex</i> and sometimes also <i>Taxus</i> in the shrublayer ( <i>Quercion robori-petraeae</i> or <i>Ilici-Fagenion</i> )	< < <	91J0 may occur locally as small groves with upland mixed ashwoods. In these situations it should be included in the upland mixed ashwoods inventory.

\* relationship of classification type to priority habitat:  
= equal, < narrower, > wider, # overlap, ? not determined

## 5. Species composition

Section 1.2 gives a description of the combinations of tree, shrub and ground flora species that can be used to identify this habitat.

A list of priority species associated with this habitat, from 'Biodiversity - Making the Links'<sup>3</sup>, is included as **Appendix 2**.

## 6. Geographical restrictions

### 6.1 Geographical coverage and restrictions in the UK

In the UK beech is considered native only in southern England and south-east Wales. The priority habitat mainly includes lowland beech and yew woodlands within their native range, but long-established planted beech woods outside the native range are included where they have acquired a high nature conservation value<sup>1</sup>. A number of stands outside the native range (e.g. in the Wyre Forest, Dendles Wood in Devon and Felbrigg Park in Norfolk) are also taken to be native outliers. The northernmost site of native beech known to Rackham is Mallygill Wood near Durham and the westernmost is Coed Deri-Newydd above Caerphilly; both have ancient coppice stools.<sup>8</sup>

#### Calcareous beech and yew woodland

Occurs on the limestone and chalk outcrops in southern Britain e.g. chalk scarps of the Northern and South Downs, the Chilterns and the Cotswolds.<sup>1</sup>

#### Beech woodland on neutral-slightly acidic soils

This type is common, but not confined to, the High and Low Weald, the Chilterns plateau, the New Forest, the Cotswolds and the Wye Valley.<sup>1</sup>

### **Acidic beech woodland**

The western edge of the range of acidic beech is ill-defined and beech clearance from and spread into western oakwoods occur in almost equal measure. Typical sites are found in the High Weald (on Greensand), Hampshire and London basins, the Chilterns plateau and at a few sites in East Anglia. <sup>1</sup>

A map showing the beech zone and core distribution of this woodland type, from JNCC Report 288 <sup>8</sup>, is attached as **Appendix 3**.

## **6.2 Climate requirements**

The current climatic limits for beech are well beyond its accepted past-natural range. It would certainly have spread naturally to other areas of the British Isles had forest fragmentation not impeded its progress. Hence difficulties arise with regard to areas where beech occurs only at a low density; where it may be naturally invading stands: and where it exists as plantations outside its presumed native geographical/ecological range. Under climate change scenarios we may need to accept spread of some beech beyond its current range if this woodland type is to survive at all. Conversely, regeneration phases within beech woods often lack beech, and are dominated by either oak or ash. <sup>8</sup>

These considerations make it difficult to set hard criteria for inclusion of stands within this Priority Habitat, but important factors include the maturity of the beech, and its abundance/cover. Regeneration patches should normally be included within this type unless they are very extensive and there appears little likelihood of their eventual return to beech woodland. <sup>8</sup>

## **7. Geology and soils**

Beech can grow on both acidic and calcareous soils, although its association with yew tends to be most abundant on the calcareous sites. <sup>1</sup>

### **Calcareous beech and yew woodland**

Associated with freely-drained calcareous soils and the limestone and chalk outcrops in southern Britain. <sup>1,6</sup>

### **Beech woodland on neutral-slightly acidic soils**

This type is found on heavier, calcareous soils (pH 7 to 4). e.g. clays and clay loams. Such soils are generally base-poor. The boundary with other beech types is often defined by pH, drainage and soil texture, thus it is common to find this type grading into one of the others. <sup>1,6</sup>

### **Acidic beech woodland**

Acidic beech stands are usually found on light sandy and sometimes gravelly soils that are well drained. Acidic soils, pH3.5 to 4.5. Infertile, base-poor. <sup>1</sup>

## **8. Hydrology**

Calcareous beech and yew and acidic beech woodland are associated with well-drained sites. Beech woodland on neutral-slightly acidic soils often occurs where drainage is poor. Very heavy or water-logged soils are however avoided. <sup>1</sup>

## 9. Relationship with other habitats

	<b>Lowland beech and yew woodland</b>
<b>Ancient and/or species rich hedgerows</b>	Separate by width and area protocols. Hedgerows by definition must be under a width of 5m by definition. Strips of woodland below a width of 5m will be mapped as a linear feature and will therefore not contribute to the area of the woodland HAP.
<b>Lowland mixed deciduous woodland</b>	Separate by NVC and other vegetation criteria.
<b>Lowland wood-pasture and parkland</b>	Allowable overlap – sites can be recorded as part of both HAPs.
<b>Maritime cliffs and slopes</b>	Allowable overlap. Area may be mapped as part of both inventories.
<b>Upland birchwoods</b>	Separate by NVC and other vegetation criteria.
<b>Upland mixed ashwoods</b>	Separate by NVC and other vegetation criteria, and see note in Section 1.4.
<b>Upland oakwood</b>	Separate by NVC and other vegetation criteria. Where Upland oakwood is in close association with beech a cut off of 50% canopy cover should be used. If beech >50 % then map in beech inventory (do not also map in oak). If beech <50 % then map as Upland oak and attribute beech as appropriate in additional habitat features comment. If proportions are unclear then use <i>Pridet</i> field to record as “probably” or “within but not mappable”
<b>Wet woodland</b>	Separate by NVC and other vegetation criteria.

## 10. Management

Lowland beech and yew woodlands have been managed historically as coppice, coppice with standards, wood-pasture, high forest and minimum intervention. Although beech produces weak coppice shoots, such woods can be found, for example in the Cotswolds and further west. Beech responds better to treatment as wood-pasture, and fine examples can be found at Epping Forest and Burnham Beeches. The commonest management type is high forest, which is found throughout the native and planted range. <sup>1,8</sup>

## 11. Size of mappable units

**Minimum mappable unit (MMU): 0.25 ha**

**Minimum width: 15 m**

The UK Native Woodland HAPs Definitions Working Group report <sup>14</sup> states that although all national inventory and reporting should distinguish between woods over and under 2ha, smaller units should be distinguished if possible. Experience from mapping work (SERC, EN Wetland Inventory Project) has show that is not significantly more time consuming to map small blocks of woodland. (Areas below 2ha may however be treated as part of the surrounding woodland type for management planning purposes).

## 12. Regional differences

None described as yet.

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## Appendix 1

### Information Sources

- <sup>1</sup> Anon. (1998). UK Biodiversity group: Tranche 2 Action Plans. Volume II – terrestrial and freshwater habitats.
- <sup>2</sup> Castle, G. and Mileto, R. (Eco Tech)(1999). UKBAP Native Woods Inventory and Reporting: A needs assessment and review of current resources and future opportunities (undertaken on behalf of the Forestry Commission). Unpublished.
- <sup>3</sup> English Nature (1999) Biodiversity : making the links. English Nature
- <sup>4</sup> Forestry Commission Native Woodland Habitat Action Plans Information Note (draft). Unpublished.
- <sup>5</sup> Forestry Practice Guide 1 – Lowland acid beech and oak woods. Forestry Authority, Edinburgh
- <sup>6</sup> Forestry Practice Guide 2 – Lowland beech-ash woods. Forestry Authority, Edinburgh.
- <sup>7</sup> Gibson, C.W.D. (1998). Harmonisation of Habitat Classifications. JNCC Report, No. 279.
- <sup>8</sup> Hall, J.E. and Kirby, K.J. (1998). The relationship between Biodiversity Action Plan Priority and Broad Woodland Habitat Types, and other woodland classifications. JNCC Report, No. 288.
- <sup>9</sup> Jackson, D.L. (2000). Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other habitat classifications. JNCC Report, No. 307.
- <sup>10</sup> NCC (1990). Handbook for Phase 1 habitat survey: a technique for environmental audit field manual NCC, Peterborough
- <sup>11</sup> Peterken, P. and Soutar, R. (1989). Native Trees and Shrubs for Wildlife. In Forestry Commission (1990) Forest Nature Conservation Guidelines, HMSO.
- <sup>12</sup> Rodwell, J.S.(ed) (1991). British Plant Communities. Vol. 1: Woodlands and scrub. Cambridge University Press, Cambridge
- <sup>13</sup> SERC (2001) The Integrated Habitat System.
- <sup>14</sup> UK Native Woodland Habitat Action Plans – Report of the Definitions Working Group (unpublished)
- <sup>15</sup> Whitbread, A.M. and Kirby, K.J (1992). Summary of National Vegetation Classification woodland descriptions. UK Nature Conservation 4 JNCC

## Appendix 2

### BAP priority species associated with lowland beech and yew woodland

(From "Biodiversity - Making the Links" <sup>3</sup> - 28 June 2000 version)

The presence of these species does not indicate that the habitat is definitely lowland beech and yew woodland. These species are included as additional information only.

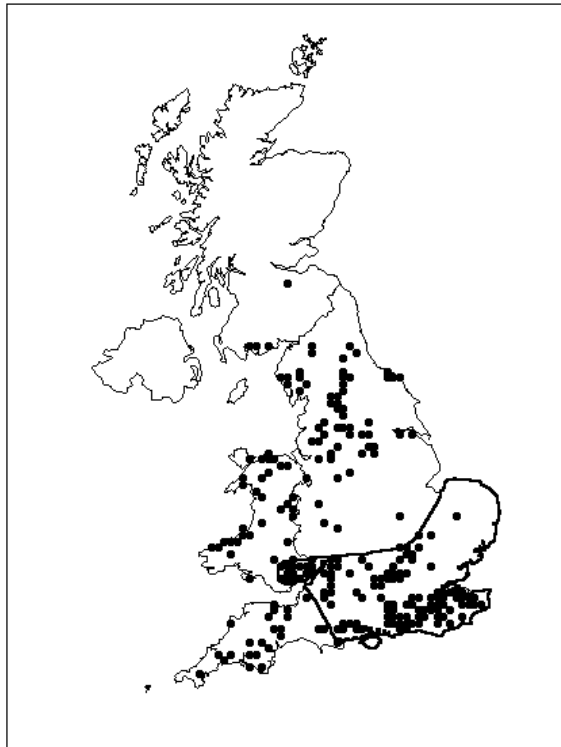
Scientific name	Common name	Taxon	Priority list	Importance of habitat to the species *
<i>Boletus satanas</i>	Devil's bolete	Fungi	SAP	P
<i>Hericeum erinaceum</i>	a hedgehog fungus	Fungi	SAP	P
<i>Hydnoid fungi</i> (14 spp)	tooth fungi	Fungi	SAP	P
<i>Trisateles emortualis</i>	Olive crescent	Moth	SS	P
<i>Boletus regius</i>	Royal bolete	Fungi	SAP	S
<i>Lucanus cervus</i>	Stag beetle	Beetle	SAP	S
<i>Muscicapa striata</i>	Spotted flycatcher	Bird	SAP	S
<i>Myotis bechsteini</i>	Bechstein's bat	Mammal	SAP	S
<i>Myotis myotis</i>	Greater mouse-eared bat	Mammal	SAP	S
<i>Pipistrellus pipistrellus</i>	Pipistrelle bat	Mammal	SAP	S
<i>Rhinolophus hipposideros</i>	Lesser horseshoe bat	Mammal	SAP	S
<i>Turdus philomelos</i>	Song thrush	Bird	SAP	S
<i>Barbastella barbastellus</i>	Barbastelle bat	Mammal	SAP	x
<i>Enterographa elaborata</i>	a lichen	Lichen	SAP	x
<i>Formica rufa</i>	Southern wood ant	Ant	SS	x
<i>Formicoxenus nitidulus</i>	Shining guest ant	Ant	SS	x
<i>Hydrelia sylvata</i>	Waved carpet	Moth	SAP	x
<i>Minoa murinata</i>	Drap looper	Moth	SS	x
<i>Triturus cristatus</i>	Great crested newt	Amphibian	SAP	x
<i>Xestia rhomboidea</i>	Square-spotted clay	Moth	SAP	x
<i>Zygodon forsteri</i>	Knothole moss	Moss	SAP	x

\* (P) primary, (S) secondary or (x) less

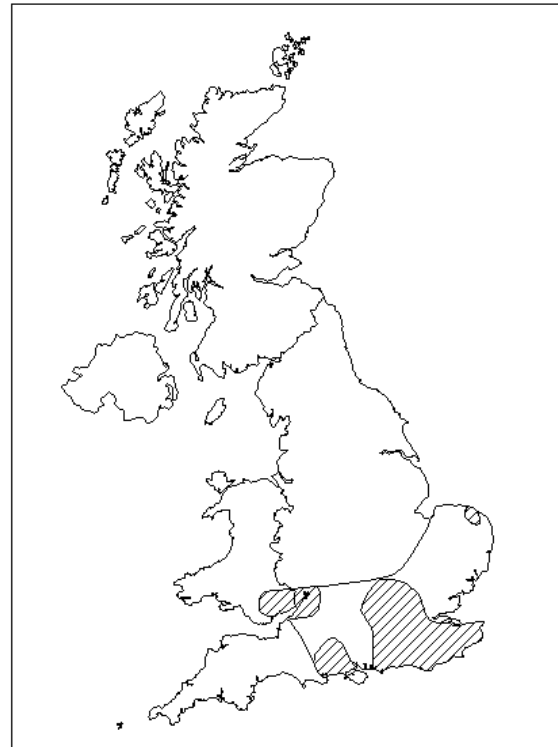


### Appendix 3 - Beech zone and core distribution of lowland beech and yew woodland From JNCC Research Report 288 <sup>8</sup>

Map 1: The Distribution of Lowland Beech and Yew Woodland in Britain



NVC beech communities  
(bold line represents beech zone)



Beech Zone (based on Forestry Authority 1994a)  
Hatched areas represent the core distribution  
of beech, based on Rackham (1997)