
**VOLUME 10 ENVIRONMENTAL
DESIGN AND
MANAGEMENT**

**SECTION 3 LANDSCAPE
MANAGEMENT**

PART 3

HA 115/05

**THE ESTABLISHMENT OF AN
HERBACEOUS PLANT LAYER IN
ROADSIDE WOODLAND**

SUMMARY

This Advice Note provides detailed guidance on the establishment of an herbaceous filled layer in woodland plantations alongside new and existing highways, helping them to achieve full biodiversity potential and adding visual interest for road users.

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The Establishment of an Herbaceous Plant Layer in Roadside Woodland

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The aim of this advice note is to provide sound practical guidance to those involved in the management of roads who wish to improve the species diversity of existing woodland and plantations by developing an appropriate woodland field layer. The herbaceous field layer consists of the communities of flowers, grasses, sedges and ferns that grow below the shrub understorey in open and shaded areas within woodlands.

Advice is given for site selection and testing, plant species choice, provenance and availability and a full description of the techniques required for the successful introduction of woodland herbaceous species into young plantations.

The advice note is intended primarily for use by foresters, landscape managers and ecologists.

1.1 WHY PLANT INTRODUCTION IS NECESSARY

In recent decades, native trees and shrubs have been planted extensively across Britain in an attempt to 'create new woodland'. Whether along road networks or in urban or agricultural landscapes, these young plantations often have few or no links to existing old woodlands. This isolation within modern landscapes greatly reduces the ability of woodland plants and animals to colonise the new areas (Peterken & Game, 1984). As a result, the plantations only acquire woodland characteristics, in terms of conditions and species very slowly, or may never do so.

Herbaceous field layers in woods consist of all the vascular plants growing beneath the trees and shrubs. These plants, known as woodland field layer species, have varying degrees of shade tolerance. As shade develops within new plantations the herbaceous field layers are typically characterised by a few dominant, competitive species, such as brambles (*Rubus fruticosus* agg.), Ivy (*Hedera helix*), Bracken (*Pteridium aquilinum*), Common Nettle (*Urtica dioica*) and coarse grasses, depending on soil type. Beneath dense, unthinned canopies that cast heavy shade, the field layer vegetation is either very sparse or absent.

Comprehensive research across Europe has shown clearly that many herbaceous field layer species associated with old woodlands are unlikely to reach the new plantations even in the long-term. Many woodland plants may take up to 1,000 years for 1km penetration into an adjacent new wood (Honnay *et al.*, 2002). This is due to their very poor dispersal and colonising ability.

If slow-growing herbaceous species are to be included in woodland creation schemes, then their direct introduction into new plantations is necessary (Buckley & Knight, 1989). Cost-effective techniques have been developed for enhancing the plantation field layers by the introduction of native woodland herbaceous species (e.g. Francis & Morton, 2001; Cohn *et al.*, 2000). Natural colonisation of plantations by woodland plants is extremely slow and many

species are unable to colonise isolated plantations. However, a wide variety of woodland species can be successfully established in between 3 to 7 years (Francis, 2000) by direct introduction into suitable sites. Figure 1 shows an enhanced site ten years after the introduction of woodland herbaceous species as seeds and plants. The introduced species, including Bluebell and Red Campion, have established and formed sustainable populations.

1.2 ROADSIDE PLANTATIONS IN THE 'SOFT ESTATE'

The soft estate associated with Britain's Trunk Road Network extends to approximately 45,000ha. It consists of land within the highway boundaries that is not part of the carriageway and that forms a complex linear resource. There is, therefore, considerable potential for the development of woodland and woodland edge habitats within soft estate plantations throughout the UK. There are remnants of semi-natural ancient woodland within the network, e.g. Breach Wood along the M4, but these are limited in area.

Species diversity in roadside plantations is usually low, but there has been a small amount of natural colonisation by woodland plants along the road network. Species such as Primrose (*Primula vulgaris*), Wood Anemone (*Anemone nemorosa*) and Pendulous Sedge (*Carex pendula*) have colonised roadside slopes in some areas. This is generally where there are links to existing semi-natural woodland habitats.



Figure 1. An established field layer ten years after the introduction of woodland herbaceous species

1.3 AREAS TO IMPLEMENT PLANTATION ENHANCEMENT

The enhancement of new plantations by direct introduction of plants, other than the trees and shrubs, is particularly appropriate in lowland Britain. Here, semi-natural woodland cover has been greatly reduced and the landscape is dominated by urban sprawl and intensive agriculture. In these conditions, the natural development of new plantations to woodland is most difficult and woodland creation must be more than just planting trees (Francis, 1995; Cohn *et al.*, 2000).

In some parts of the north and west of Britain conditions are rather different. There are extensive areas of moorland, for example, and wooded landscapes are less characteristic. However, where there is more tree cover new plantations may not be as isolated as in the lowlands. In these conditions, woodland herbaceous species are more able to spread into the new plantations and so direct enhancement of the field layer may not be necessary.

1.4 THE REQUIREMENT FOR ASSOCIATED PLANTATION MANAGEMENT

The general uniformity of many roadside plantations must be changed before woodland herbaceous plant species can be introduced successfully. This can be achieved by appropriate management (refer to the Landscape Management Handbook DMRB Vol 10). The guidance provided within this advice note assumes that the young plantations are regularly maintained with a regime of thinning and/or coppicing. Such management is required to improve structural diversity within the developing sites. This provides the right conditions for a range of plants to be introduced and encourages their establishment. Plant introductions should not be made into sites without this ongoing management.

More recent planting schemes have begun to address the problems of poor species and structural diversity by using different planting patterns, densities and species mixes. As these younger areas are subject to weed control regimes and because light levels are high, they are not sufficiently established to be considered for field layer enhancement.

1.5 THE BENEFITS OF HERBACEOUS PLANT INTRODUCTIONS

Road verges, with their variety of habitats, may represent a considerable ecological resource in the form of a 'green estate'. In theory, these verges may benefit wildlife by providing longitudinal habitat and potential corridors facilitating the movement of genes and wildlife through, what is often, an ecologically starved wider landscape (Angold *et al.*, 1999).

Without direct intervention, however, the roadside plantations will remain species poor and so offer very little in terms of biodiversity to the 'soft estate'. By manipulating the plant community the appearance, use, ecology and woodland nature of the plantations can be enhanced. Two successfully enhanced road embankments are shown in Figures 2 and 3.

Such is the extent of the soft estate that roadside plantations may possibly link into the restoration of forest habitat networks (Peterken, 2000). To achieve this, additional management and direct enhancement techniques to increase species diversity are essential. With the correct management, and if plant introductions are successful, an unexpected benefit in the long-term may be that existing road verge plantations will act as sources of woodland species for adjacent new farm woods (Keith Kirby, pers. comm.).

1.6 RELEVANCE TO REGIONAL BIODIVERSITY ACTION PLANS (BAPS)

The advice is relevant to the aims of BAPs and may be helpful to the Highways Agency, the Welsh Transport Directorate, the Scottish Executive Transport Group and the Northern Ireland Department for Regional Development in the development of their respective BAP objectives for woodland habitats.

Primary objectives of the BAPs are, for example, "to maintain and enhance the nature conservation value of the ancient woodland habitats found on road verges" (HA BAP, 2000). When managing new plantations along roadsides, it is important to recognise that natural colonisation of woodland field layer species is very slow. Action plans can reflect this by identifying plantations that are suitable for field layer enhancement. Successful field layer introductions will directly increase plant species diversity and, in time, may enhance plantation biodiversity.



Figure 2. Sloping road verge plantation with drifts of Primrose (*Primula vulgaris*) growing along the canopy edge



Figure 3. Native Bluebells (*Hyacinthoides non-scripta*) resulting from the direct seeding of a roadside embankment

2.1 GENERAL PROCEDURE

Prior to the introduction of any woodland herbaceous species into a new site there are procedures that should be followed carefully. These can be summarised as:

- **Site selection** to enable the rejection of unsuitable sites and to allow favourable sites to be chosen. This selection process increases the likelihood of successful field layer development by selecting sites that promote plant growth and establishment.
- **Basic site testing** to determine those site characteristics that directly influence the growth of field layer species.
- **Selection, provenance and availability of field layer species** are considered for the chosen new site.
- **Design of a species mixture** that contains a range of woodland edge and shade species. Species are selected to suit soil conditions, natural plant distributions and the mix is tailored to complement local woodland types.
- **Site preparation** to allow selected woodland field layer species to be introduced into the site.
- **Introduction techniques** enabling seed mixtures and/or groups of plants to be introduced successfully into roadside plantations. The introduction of field layer species directly increases plant diversity and accelerates the development of a more naturalistic woodland field layer.

The following sections describe the procedures of site selection and testing, species selection and mixture design, site preparation and introduction techniques.

2.2 SITE SELECTION

Woodland plantations are rarely 'perfect' for the introduction of field layer species. The conditions recommended in this section form guidelines for site selection, although it is unlikely that all of these criteria will be met by a single site.

The ten criteria for site selection are summarised in Table 1. At least eight of these, including Criteria 2, 4 and 10, should be fulfilled for a site to be selected for field layer enhancement. Each of the selection criteria is described in sections 2.2.1 to 2.2.10.

Table 1. Summary of preferred states for selection of sites suitable for herbaceous field layer introductions

	Site Property	Preferred State
1.	Overall site quality	Site 'patchiness' is important; select sites with a range of conditions; or give appropriate treatment to uniform sites
2.	Light level	15-40% daylight at ground level
3.	Canopy composition	Mixed canopy of native broad-leaves and/or native conifers
4.	Existing ground vegetation	<30% existing ground vegetation
5.	Dominant weed species	<10% Bramble, Ivy or Bracken
6.	Soil characteristics	Humid and moist; not compacted.
7.	Aspect and degree of slope	North, east or west-facing slopes and those less than 1:1.5
8.	Leaf litter	At least 30% cover of leaf litter on the soil surface
9.	Size and links	Minimum area 0.02ha; with a minimum of five sites situated within a 1km stretch of roadside along the same carriageway
10	Adjacent sites	At least 1km from existing ancient semi-natural woodland

2.2.1 OVERALL SITE QUALITY

CRITERIA: Select a site that appears ‘patchy’ with a diversity of internal habitats. Such a site may be characterised by groups of different canopy and understorey species, patches of leaf litter at different depths, varying light conditions, including shady areas and flecks of sunlight, areas of bare soil and mosses.

Most roadside plantations will not present limitations for the growth and establishment of field layer species. As long as trees have established without inherent problems, then field layer species should do likewise. Sites that have proved problematic for tree and/or shrub establishment are not suitable for enhancement with woodland field layer species, as there is little or no canopy to provide shade.

The most important aspect of the roadside sites, as far as field layer enhancement is concerned, is the patchiness, i.e. heterogeneity, of the internal habitat. The more niches that are available for colonisation, whether natural or by species introduction, the more successful the development of a diverse and attractive woodland field layer. It is important to be mindful of the concept of patchiness when selecting a site for enhancement.

2.2.2 LIGHT LEVELS

CRITERIA: Light levels should be between 15-40% at ground level in summer. Light levels must, however, be considered in conjunction with existing vegetation levels within a plantation. The balance of light and vegetation is tested in Section 3.3 below.

Woodland plants occur naturally in a variety of light and shade conditions. Many perform best, i.e. flower and set seed, in open glades, rides and when light is increased after coppicing. They are able, however, to tolerate low light for relatively long periods enabling them to avoid competition from dominant light-demanding species.

For enhancement purposes, plantations need to be relatively shady at ground level. This is most important because shade is a natural method of controlling the germination and establishment of competitive, light-demanding ruderal weed species. It is equally important to have a range of different light and shade levels within a site so that field layer species with varying requirements can find appropriate niches in which to establish.

If light levels are too low, then the growth and establishment of even the most shade-tolerant species can be affected. Introduced field layer species can withstand very low light levels, but only once they are well-established. For the first five years after introduction species need moderate light levels to become suitably established and to form sustainable and persistent populations.

Most of the roadside plantations are very narrow, between 10-40m, so they will be subject to edge effects, i.e. light penetrating the plantation edges, particularly at the base of slopes. The associated problems of high light and colonisation by ruderal weed species are addressed by correct species choice (Section 4.2) and by target sowing (Section 5.5).

2.2.3 CANOPY COMPOSITION

CRITERIA: Sites should be selected with mixed canopies of native broad-leaves and/or conifers. Dense monocultures, particularly of beech and conifers, should be avoided.

Whilst very few roadside plantations reflect woodland types within the NVC (National Vegetation Classification) system, most consist predominantly of native tree and shrub species. Canopies that consist of a range of tree species result in a variety of conditions in terms of light levels, leaf litter *etc.*, thus promoting internal site variation.

2.2.4 EXISTING GROUND VEGETATION

CRITERIA: Sites should be selected with existing vegetation levels of less than 30% (or treated appropriately so that the existing vegetation is less than 30%). **Sites with more than 10% of Bramble, Ivy or Bracken should generally be avoided.** These competitive species are persistent, have a great potential to spread and, unless controlled effectively, will reduce the success of field layer introductions.

Beneath lighter canopies coarse grass species, e.g. Cock’s-foot (*Dactylis glomerata*) and False Oat-grass (*Arrhenatherum elatus*), may persist as tussocks or form a sward. The presence of a grass sward is particularly detrimental to the growth and establishment of woodland field layer species.

If competitive species need to be controlled, non-persistent, translocated herbicides may be used. A single herbicide application can be very effective, particularly if shade levels are rising quickly, to control any plant re-growth.

2.2.5 SOIL CHARACTERISTICS/FERTILITY

CRITERIA: Soils should be humid, moist and not compacted. Soil humidity may be revealed by the presence of bryophytes in the ground flora. Soils that are compacted and/or water-logged for long periods in winter are not recommended.

Although soils in old woodlands are generally low in phosphate, many woodland field layer species grow well at increased soil nutrient levels, as long as competition is controlled. Sites with high fertility may be revealed by the presence of nettles. Subsequent site selection will be determined by the extent of this growth, as recommended in Section 2.2.4.

2.2.6 SITE ASPECT AND GRADIENT

CRITERIA: Flat sites and damp slopes should be selected preferentially. Avoid very dry south-facing slopes. Slopes steeper than 1:1.5 should not be selected. Most slopes are unlikely to be steeper than 1: 2.

Woodland herbaceous species have high moisture requirements for successful germination and also during seedling establishment south-facing slopes and to some extent west-facing slopes are likely to dry out more quickly and this may affect the germination and initial establishment of introduced species. Water deficit and soil erosion also increase with slope steepness.

2.2.7 LEAF LITTER

CRITERIA: Plantations should have at least 30% cover of leaf litter by area on the soil surface prior to field layer introductions. On very fertile sites where litter levels are low, due to rapid incorporation into the soil, introductions should only be made as part of a tree thinning programme.

The accumulation of leaf litter on the soil surface within a plantation is beneficial to the introduction of woodland herbaceous species. The build up of leaves provides microsites for seed germination and provides moisture both for seeds and seedlings. Leaf litter also prevents the growth of many competitive weed seeds that require light to trigger germination. A suitable amount of surface litter is shown in Figure 5.

2.2.8 PLANTATION SIZE

CRITERIA: Field layer introductions should be made into sites with a minimum area of 0.02ha, i.e. minimum dimensions of 5m x 40m. At interchanges or in other areas where dimensions are increased, a minimum width of 10m is recommended.

Established populations of woodland plants can survive in very small sites, such as in relic hedgerows. However, these populations may have reduced vigour and may be unable to withstand the rigours of ongoing management, other disturbance or potentially climate change.

2.2.9 LINKS AND CONNECTIVITY

CRITERIA: Ideally there should be a minimum of five enhanced plantations within any 1km section of road, all along the same carriageway. It is also suggested that, wherever possible, suitable plantations should be enhanced near or adjacent to verge areas where grasslands have already been enhanced with native meadow species.

The connectivity of isolated sites is important to enable species dispersal and to encourage visits by pollinating insects.

To avoid risk of damage from chemical drift, sites that are adjacent to intensive arable farming operations should be separated by a gap of a least 5m, or by a suitable barrier such as a hedge.

2.2.10 PROXIMITY TO EXISTING SENSITIVE SITES

CRITERIA: Species introductions must not be made into sites within a 1km buffer zone of existing ancient semi-natural woodland. This precautionary approach to the sensitivity of semi-natural sites may need to be reviewed in the future. If it is highly desirable to make introductions within 1km of existing semi-natural woodland then extensive local consultations must first be carried out with appropriate Statutory Bodies (Annex C) and Wildlife Trusts.

Plantations located adjacent to or near recent secondary woodland can be enhanced with woodland field layer species. Introductions into plantations near other semi-natural habitats should be carried out only after consultation with site managers or landowners.

Cross-pollination may occur between natural and introduced populations of woodland species if roadside plantations adjacent to semi-natural sites are enhanced. This may not be desirable.



Figure 4. A young plantation suitable for enhancement with woodland field layer species. (This site would be even more suitable if it were enriched with a shrub understorey.)



Figure 5. Patchy soil surface in young plantation woodland with bare earth, leaf litter and moss

3.1 GENERAL

Once a site has been selected for field layer enhancement, site testing can take place. Ideally, the site should be fully surveyed to provide a record of the existing flora and fauna on the site and any current conservation value, soil type and characteristics, general topography and aspect, local climate and adjacent habitat types. When resources do not allow such a complete site survey, a minimum of site testing is essential prior to the introduction of woodland field layer species.

Additional information about site surveys can be referenced in the Wildflower Handbook (DMRB Volume 0, Section 3, Part 1).

3.2 SOIL CHARACTERISTICS

3.2.1 SOIL REACTION: PH

The pH must be measured to ascertain whether the soil is acid (pH 3.0-5.0), neutral (pH 5.5-6.5) or alkaline/base-rich (pH 7.0-9.0).

3.2.2 TEXTURAL CLASS: CLAY/SAND/LOAM

The textural quality of soil is important, as it is responsible for determining factors such as drainage and water-holding capacity. The percentages of clay/sand/loam in the soil sample should be identified.

3.2.3 MOISTURE AND HUMIDITY

Site hydrology and soil textural properties determine soil moisture and drainage. Other factors suggest whether a site is generally moist and humid. The presence of a bryophyte, i.e. mossy, layer on the soil surface indicates that a site is relatively humid.

3.3 LIGHT AND VEGETATION LEVELS

The relationship between light and vegetation levels at a proposed enhancement site is fundamental (refer to Section 2.2.2). Ideally, a full site survey will determine the levels of light and vegetation cover. Alternatively, the pictures in Figure 6 can be used to assess levels of light and plant growth. This assessment should take place in summer when trees are in full leaf and may be done visually or by using a light meter. A site can be chosen if levels of existing ground vegetation and light are similar to those shown in Sites 1 or 2 (refer to Figure 6). Other sites with very low light levels or high existing ground cover must be rejected.

3.4 LOCATION

Site location must be checked using Ordnance Survey maps and then related to the Forestry Commission local seed zones (Annex A). Each selected site should be given a seed zone number to be used for field layer species selection (refer to Section 4.2).

3.5 LOCAL WOODLAND TYPE AND SPECIES DISTRIBUTIONS

Ideally, the NVC type of the nearest semi-natural woodlands on the same soil type should be ascertained. This information and records of woodland species distributions will be available from the local records centre, county recorder or Wildlife Trust. If these records are not available it may be necessary for a suitably experienced botanist to undertake a survey.

Knowledge of the local woodland type will help when selecting herbaceous species for introduction. Information concerning local species distributions should ensure that only those herbaceous field layer species appropriate to the area are introduced into the road verge plantations.

If a site is either very suitable for or already supports a population of protected species, e.g. Great Crested Newts, then it should be rejected. Sites in the vicinity of an established population of a protected species should also not be chosen.



Site 1



Site 2



Site 5



Site 6



Site 3



Site 4

Figure 6. Suite of young plantations indicating different amounts of daylight at ground level and existing ground vegetation.

Sites 1 and 2 are suitable for selection as existing vegetation is limited or patchy and leaf litter has accumulated.

Site 3, although weed-free with plenty of leaf litter, is too shady and needs thinning to increase light levels prior to field layer introduction.

Sites 4, 5 and 6 all have too much existing vegetation, although they show large variations in light levels. **Site 4** is dominated by grasses and Creeping Thistle, **Site 5** by brambles and **Site 6** by Ivy.

4.1 SPECIES PROVENANCE

In practice, the success of any introduction project is governed by suitable provenance. Seeds and plants contain genetic material conferring adaptations to a particular geographic location and climate type, for instance. These adaptations may be especially important as climate change progresses. Local variability within plant populations, which is quite considerable in some cases, must also be reflected by species provenance.

Provenance should, ideally, be **as local as is practically possible**. This is often governed by the size of a project, as small amounts of local seed may be readily available, but commercial quantities for large-scale introductions, such as along roadsides, may not. If provenance is too tightly constrained, then many projects will be obstructed. Material for seed and plant introductions should, at least, be regionally sourced.

If field layer introductions take place near or adjacent to a sensitive site, such as beside existing semi-natural woodland, **then provenance is more critical**. In this case, material must be sourced locally, if not from the adjacent woodland itself.

PROCEDURE: Provenance of seed and plant material for introduction into roadside woodlands is addressed by the following guidelines:

- i. The involvement of local bodies, such as Wildlife Trusts, is important from the outset of any enhancement project.
- ii. For sensitive sites, i.e. those adjacent to existing semi-natural woodland especially those that are designated, and for small-scale introductions, local seed should be collected and bulked-up, wherever possible. The appropriate permissions from land owners must be sought prior to making any local collections of seed or plant material. Small, vulnerable populations of woodland species should not be depleted by collections made for enhancement purposes.
- iii. Wildlife Trusts or other local conservation bodies can be responsible for seed and/or plant collection from the local site.
- iv. For larger, less sensitive sites, the Forestry Commission seed zones (Annex A) serve as areas for species provenance. Material from sources within these zones can either be collected and 'bulked-up' commercially or suitable regionally sourced material can be obtained from a reputable supplier. (Refer to Section 4.3) Commercial bulking-up requires a minimum three year lead-in time for slow-growing woodland species.

4.2 SPECIES SELECTION

A lowland woodland, e.g. a W8 Ash-Maple woodland, may support more than 100 herbaceous species in the field layer. These include forbs, grasses, sedges, rushes and ferns. In contrast, sites characterised by dense shade, e.g. southern beechwoods, may only have 10 to 15 species in the field layer. The characteristic variability of natural field layers is governed by soil type and geographic locality. When making species introductions into new woodlands it is only practical to introduce a representative mixture of these field layer species.

Species mixtures can be designed to reflect those in local woodlands, but selections must be made primarily to suit both the region and soil type of the receptor plantation, i.e. the site to be enhanced. Species selections should be made with restraint for those species with a distinct ecology, e.g. Herb Paris (*Paris quadrifolia*), as many have specific requirements that are unlikely to be met by the artificial and/or young soils within roadside plantations.

A good species mixture is one that is well-balanced and includes a wide range of growth forms, plant heights and structures, flowering times and colours. Different life forms, i.e. annual, biennial and perennial species, should be represented, with the emphasis on long-lived perennial species. Species mixtures should include forbs, grasses, sedges and ferns, as appropriate to site type and location.

Species selection is, necessarily, governed by regional availability. This is addressed in Section 4.3.

PROCEDURE: Master lists of native field layer species appropriate to Forestry Commission local seed zones and to different soil types and conditions are given for England and Wales in Table A and for Scotland and Northern Ireland in Table B (Annex B). As Northern Ireland is out of the Forestry Commission's jurisdiction, it is not included in the seed zones (Annex A). However, the natural distribution of woodland plants throughout Northern Ireland allows the province to be treated as a single seed zone.

A total of 66 woodland field layer species, comprising 50 forbs, 12 grasses, sedges and rushes, and 4 ferns, are available for the enhancement of road verge plantations throughout the United Kingdom. The lists were compiled in conjunction with the New Atlas of the British and Irish Flora (Preston *et al.*, 2002) and British Plant Communities Woodlands and scrub (Rodwell, 1991), with reference to Hill *et al.* (1999), Francis & Dixie (1996), Francis (1993) and Stace (1997) to guide and inform species selection.

To use the lists, a manager must first test soil type and conditions and check site location (refer to Chapter 3). These site details are then used to select an initial species list from the master lists. For example, if a site has moist, neutral soils and is situated in F.C. Zone 204, then species fulfilling those criteria are chosen.

Worked examples of initial lists for four contrasting zones and soil types are given in Table C (Annex C). The initial site list is then tailored by determining local distributions of field layer species in woodlands on similar soil types. The local Wildlife Trust, Biological Records Centre or County Recorder can help with this. A few field layer species may have to be omitted from the list if they are not found locally. Finally, some species may also be omitted from the list at this stage if they are not available from suitable, local sources.

This procedure results in a **regional group of framework herbaceous species** that represent woodland field layers in nearby locations on similar soil types. These framework species mixtures contain approximately 15-20 species of common, widespread woodland species. Where appropriate, the species mixtures contain some common ancient woodland species, but species with very limited distributions and specific soil requirements are not included. Each list should contain a range of suitable woodland edge and core species to sow and plant within the selected road verge plantation.

4.3 SPECIES AVAILABILITY

A good range of woodland edge, ride, bank, ditch and hedgerow species are currently available for sale as seeds and/or plants. Additionally, a limited number of relatively common ancient woodland field layer species are available, particularly from those suppliers who specialise in plants rather than seeds. Figure 7 shows a tray of Wild Strawberry plug plants available at a native plant nursery.

Rare woodland species with limited distributions are not generally available from reputable suppliers. Sources of some species, in particular Bluebell (*Hyacinthoides non-scripta*), shall only be obtained from commercial sources who hold the appropriate licences for collection.

It should be noted that the lead time might be a minimum of three years to supply woodland species, either as seeds or plants, in quantity. Lead times for bulbs or rhizomes of suitable provenance may be in excess of five years. When ordering plants, timing is very important to ensure that stock is in suitable condition at planting time, *i.e.* not 'soft', but sufficiently mature and hardened off. For best plant quality and practice, the lead time for a proposed March planting is the previous June, whereas an autumn planting requires plants to be ordered by the previous January.

PROCEDURE: At the outset of a project, a recommended supplier should be contacted to ascertain species availability within a specific area, e.g. a Forestry Commission local seed zone. When planning the project, allow suitable lead times for ordering stock. Most failures result in species being introduced at incorrect times after placing late orders.

Most of the woodland field layer species in the master lists (Tables A and B, Annex C) are currently available from commercial sources. These include woodland edge, core and common ancient woodland species.

Only source bulbs and rhizomes from suppliers with the appropriate licences. Illegal bulb collection does take place and any material used in roadside enhancement schemes must be collected legally.



Figure 7. Tray of Wild Strawberry (*Fragaria vesca*) plug plants at a native plant nursery

5.1 DEVELOPMENT OF TECHNIQUES

Practical techniques for the enhancement of roadside plantations with native herbaceous species have been developed for use in shady plantations with established canopies and are tried and tested. Very little quantitative and/or long-term research has been carried out in light, open plantations and the techniques involved and long-term management required are not recommended for use along road verges.

The recommended techniques are dependent on correct and careful site selection procedures (refer to Chapter 2). If appropriate sites are selected for enhancement, then introduction methods are complementary to normal forestry practices and do not require any special treatments. In determining the proposed techniques, practicality has been a foremost consideration.

5.2 SITE PREPARATION

If sites have been chosen in accordance with the recommended site selection procedures (refer to Chapter 2), further site preparation is unnecessary. Patchiness at ground level is very important for the survival and growth of a range of field layer species. Usually site conditions within developing plantations are suitably variable to introduce species as plants and seeds. It is recognised, however, that it may be difficult to find the perfect site within a certain area and so a minimal level of site preparation may be required, e.g. by removal of existing vegetation as in 5.2.3.

5.2.1 SITE MANAGEMENT: CREATING THE CONDITIONS

The success of any native field layer enhancement scheme is entirely dependent upon the site conditions at introduction time and for a few years thereafter. In mature semi-natural woodlands, field layer species distributions are maintained and governed by a wide variety of factors, including differences in soil structure and type, variation in the light climate, disturbance and woodland structure. This variability, or site heterogeneity, is of similar importance to introduced herbaceous species within a young woodland plantation.

It is particularly important to create diversity within small woods, in order to obtain a range of ecological niches. Some habitat qualities, such as the accumulation of a dead wood resource, only evolve as a woodland ages, but structural diversity can be manipulated in the short to medium term by thinning, coppicing and/or shrub planting. New planting schemes should accommodate differences in space, shade, size and form to create woodland diversity.

To promote habitat variability and thus increase biodiversity, roadside plantations must be managed for maximum structural diversity and sustainability. The proposed management of the roadside plantations for wildlife conservation and field layer enhancement, in particular, is by Continuous Cover Forestry (CCF). This management system avoids clear felling large areas and requires only minor changes when individual trees or groups of trees are removed from time to time. In this way, woodland conditions are maintained and greater structural diversity is promoted, both of which are beneficial for woodland herbaceous species. While woodland cover is continuous, once the system is under way, at no time is the canopy so dense that it shades out all of the field layer species.

After the initial creation of the woodland, natural regeneration or planting of new trees begins relatively early under CCF. Simultaneously, some of the larger trees, as well as a few of the smaller ones, are removed at regular intervals. As a result, the overall density of trees is never quite as great as in the middle stages of the life of an even-aged plantation.

The maintenance of continuous cover and promotion of internal structural diversity allows a range of herbaceous plants to be introduced into a variety of niches within the plantations. Patchiness within the developing habitat reduces uniformity and this is very important to encourage plant establishment and persistence. During this phase, light levels within plantations can be altered by forming temporary glades or spaces to encourage herbaceous establishment. Groups of shrubs and small trees may be coppiced over a four to seven year cycle to allow fluctuations in light levels. This approach provides the establishing herbaceous species with light for a short period, but shade quickly returns, so that the growth of invasive and competitive weed species is reduced.

5.2.2 MICROSITES

Some roadside plantations, due to a uniformity of structure and canopy species, for example, lack variability at the soil surface. There may be a blanket cover of one species of leaf litter at an even depth, or very little accumulated litter, no bare earth or a blanket of mosses. With the proposed management regime (Section 5.2.1) that promotes internal site diversity, conditions should, in time, become more variable.

METHODS: Additional microsites are created by raking over about 50% of the soil surface. This action creates new areas of exposed ground, pushes leaf litter and moss into patches and reduces uniformity. Raking should be carried out within the site away from the edges. This avoids the disturbance of any ruderal weed seeds in the soil seed bank in areas of high light.

5.2.3 EXISTING VEGETATION

The selection of a site with less than 30% cover of existing vegetation is recommended in Chapter 2. The presence of certain competitive, shade-tolerant weed species must be addressed, however, even if cover values are low, i.e. between 5-30%.

Some species, including Bramble, Ivy, Bracken, Common Nettle, Creeping Thistle (*Cirsium arvense*), docks (*Rumex* spp.) and any sward forming grasses, have the potential to spread within the site and become dominant. Although they are all natural components of the woodland flora, these aggressive competitors can be detrimental to the spread and persistence of other woodland field layer species.

METHODS: Competitive weed species must be controlled prior to the introduction of any woodland field layer species. Plants should be spot treated with a suitable non-persistent, translocated herbicide, when they are in full growth. If necessary, a second application can be given. This treatment should be applied in mid-summer during the growing season before introductions are made.

5.2.4 PRESENCE OF WOOD CHIP MULCH

Wood chip or bark mulches gradually increase soil organic matter and help to reduce the germination of light-demanding weed seeds.

METHODS: Where thinnings are chipped on site, the resulting mulch must be spread out to a maximum depth of 15cm and then given between 3 to 5 years to mature prior to making field layer introductions. Alternatively, the wood chips can be left in piles rather than being used as mulch.

On sites where there is already wood chip mulch, introductions can be made as long as nutrient-demanding species, such as nettles and docks, are not present.

Wood chip mulch must not be spread over the introduced field layer species during the establishment phase as seedlings and young plants of many species are unable to grow up through mulch layers. After a suitable establishment period, approximately five years, thinnings can be chipped on site and spread to a depth of no more than 10cm over the introduced field layer species. Figure 8 shows established introduced species, including Primrose, spreading into wood chip mulch.



Figure 8. Established Primroses and Greater Stitchwort growing in wood chip mulch. The mulch is spread out after thinning operations.

5.3 HERBACEOUS FIELD LAYER SPECIES MIXTURES

Woodland herbaceous species should be introduced into new areas as part of well-balanced and robust mixtures. Mixtures should be simple and practical and should contain between 15-20 woodland species. To create well-balanced mixtures, both ecologically and visually, species with a range of flowering times, colours, heights and structures and growth forms are selected. The use of mixtures enables different species to establish within different ecological niches.

METHODS: The procedure for species selection for a particular site and locality is given in Section 4.2. The resulting mixture of between 15-20 woodland field layer species should contain a balance of woodland edge and core species.

5.4 INTRODUCTION MATERIAL

Many of the widespread woodland species in the framework species mixtures can be introduced very successfully as seeds. However, a few woodland species that are particularly characterised by their vegetative spread and reproduction are best introduced as plants to reflect natural strategies. Further, these predominantly vegetative species produce so few, viable seeds that they will rarely be available to introduce as seeds.

METHODS: For introduction purposes there are three main groups of woodland field layer species that distinguish the main regenerative strategies of woodland edge and shade-tolerant species:

1. **woodland edge species** that can be introduced as **seeds**;
2. **shade-tolerant species** with high seed production and low vegetative ability that can be introduced as **seeds**;
3. **shade-tolerant species** with a predominantly vegetative strategy that can be introduced as **plants**.

In schemes where an immediate effect and quick results are required, any species can be introduced as a plant, bulb, corm or rhizome. This approach is very expensive, as both material and labour costs are increased, and is only recommended instead of using a combination of seeds and plants in special circumstances.

Table D (Annex B) gives introduction methods and rates for the 66 woodland field layer species recommended for enhancement into road verge plantations.

A few of the field layer species appear in more than one column. Some of these species, such as Bluebell, have two distinct methods of introduction. Others, including Sweet Woodruff and Primrose, establish slowly from seed that is usually expensive. For these species the introduction of a few plants can be a more economical option and allows quicker establishment. Figure 9 shows a planted Primrose with young seedlings growing around it.



Figure 9. An established planted Primrose (*Primula vulgaris*) with seedlings growing around it.

5.5 SEEDS

Most of the woodland edge species and some woodland core species can be successfully introduced as seeds. This method is the easiest and most cost-effective method of introducing native herbaceous species into young plantations.

Sowing rate

Rates for species introduction vary depending on site conditions. Relatively low sowing rates can be used at ideal sites, but even in such situations seed predation can be considerable between sowing time and germination. Many woodland species have low germination rates and prolonged seedling stages, during which many individuals are lost to herbivores and environmental stresses.

Sowing time

Many woodland herbaceous species have seeds that require frost action or chilling to break dormancy and it is merely a requirement that seed is sown before frosts finish. Most species do not germinate in autumn, and, if sown too early, may be subject to predation during the winter. Waterlogged soils may also reduce subsequent germination rates and reduce the success of small seedlings.

Seed storage

After purchase, seeds should be kept dry and stored in paper bags in a cool, dark place.

Where and how to introduce seeds

As a general rule, a seed mixture can be broadcast throughout a site. As long as the seed mixture has been well designed, species that require higher light levels will germinate at site edges or in gaps and glades, whilst shade-tolerant species will germinate beneath litter layers in shady areas.

It is recommended that sowing takes place in target areas where conditions for growth and establishment are most suitable. This approach makes the best use of limited quantities of expensive seed. Target areas may include patches of leaf litter, low weed competition and high shade levels. For example, up to 10% of a site may be targeted selecting the most favourable areas for seeding. This creates core areas of introduced species that can spread out into the site as the conditions for plant growth become more suitable.

Shady areas at the top of slopes may also be targeted when sowing. The seed of woodland species introduced at the top of banks is dispersed downhill by gravity and/or rainfall, so enhancing the potential for spread.

METHODS

1. Rates for field layer species introduction are given in Table D (Annex B). The rates are 5kg per ha (0.5g per m²) for seed mixtures of woodland edge species and 10kg per ha (1.0g per m²) for seeds of each additional shade-tolerant woodland species.
2. It is recommended that the species to be introduced as seeds are sown in late winter/early spring before the last frosts. Exact sowing time is determined by region and may be much later in some areas than others, depending on local weather conditions.
3. Between purchase and sowing, seeds should be stored in a cool, dry and dark place in sealed, labelled containers.
4. At sowing time, seeds of all species are mixed together in a suitable container, e.g. a plastic bucket, so that they can be introduced as a mixture. To keep weights manageable, it is suggested that mixtures are made up for a maximum area of 0.5ha. It is normally possible for seed mixtures to be supplied in this way.

5. Seeds can be broadcast throughout a site, or targeted into areas within the plantations where conditions for growth and establishment are most suitable. It is usually unnecessary to mark out sites, but the sower should be aware of site dimensions so that seed is spread relatively evenly over the entire area.
6. Handfuls of seed are scattered directly onto the soil surface in front of the sower. Leaf litter on the soil surface may be gently scuffed up by the sower as sowing takes place. This will help to incorporate some of the seed into the litter.

5.6 PLANTS

Some of the woodland herbaceous species are best introduced as plants. These include species such as Bugle (*Ajuga reptans*) and Enchanter's Nightshade (*Circaea lutetiana*), that are characterised by their vegetative growth, such as the production of runners and stolons (creeping stems). Many of these species produce few seeds of low viability and will not be available to purchase as seeds.

Planting rate

The introduction rates depend on the plant's capacity for spread. Some species spread very quickly by sending out runners, whereas others grow slowly and reproduce by seed.

Planting time

For plants, introduction time is dependent on the availability of soil moisture. This will normally be during late autumn and winter. Plants should not be introduced into frozen soil or those that are likely to be waterlogged during the winter, as this reduces establishment success. Spring plantings should take place once the soil has warmed up, but whilst it is still sufficiently moist so that no artificial watering is necessary.

Plant storage

Plants of woodland herbaceous species may be supplied as plugs, typically in 4-5cm modules, or in pots up to 0.3litre (7cm diameter). It is most cost-effective, and often more successful, to introduce higher densities of smaller plants than fewer large ones.

Woodland species are not supplied as seedlings, but as young plants or rooted cuttings. Ideally, delivery should be timed to coincide with planting to avoid the requirement for storage. As long as the stock is supplied whilst semi-dormant (i.e. not in full, active growth) during late autumn and winter, then plants will survive the winter period, as long as they are not subjected to cold winds and/or frosts.

Where and how to introduce plants

The introduction of plants into a receptor site should mimic the species mosaics that are found in semi-natural woodlands. As with seed mixtures, groups of plants can be targeted into the most suitable areas for their survival and establishment creating core areas as a source of species for the future.

METHODS

1. For plants, rates of 4 plants per m² are suitable for the introduction of each species with vegetative spread, whereas slow-growing species are introduced at a rate of 9 plants per m².
2. Plants can be introduced into roadside plantations between the beginning of October until the end of March. Planting should take place in dull weather, ideally just before rain is expected. Planting must not take place into frozen, water-logged or compacted ground.
3. Plants should be supplied between October and March, to minimise care between supply and planting. Trays of plants should be removed from carrying crates and placed individually, i.e. not stacked, on flat soil in a shady and sheltered outdoor position. Plants should not be subjected to cold winds and/or frosts. Plants will need watering if there is no rain for more than two weeks.
4. Plants should be introduced as single species groups. These patches may be positioned throughout the site or targeted into the most suitable areas for survival and establishment.
5. Plug and pot-grown plants should be watered thoroughly prior to planting. Once removed from their containers or pots, plants should be placed into suitably sized holes made with a trowel or dibber. Soil around the roots should then be firmed in gently.

5.7 BULBS

A few of the woodland herbaceous species are characterised by having bulbs, corms or rhizomes. These species are listed in Table D, Annex B. Most of these species do also produce seeds, but often have low germination rates, a long seedling phase and only mature slowly.

The use of bulbs is recommended on high profile sites where immediate impact is required from the introduced herbaceous layer. However, bulbs must be sourced very carefully from reputable suppliers and will increase both material and labour costs of an introduction project. Figure 10 shows an established sward of introduced Bluebells that may be obtained as bulbs.

METHODS

1. Bulbs should be planted in the autumn, generally in October and November.
2. Species with bulbs, corms or rhizomes are introduced at a rate of 9 per m².
3. The introduction of bulbs into a receptor site should mimic the species mosaics that are found in semi-natural woodlands. As with seed mixtures, groups of bulbs can be targeted into the most suitable areas for their survival and establishment creating core areas as a source of species for the future.
4. Bulbs should be introduced as single species groups.
5. Bulbs should be planted at a depth of approximately four times the diameter of the bulb, or as specified by the supplier.

5.8 SUBSEQUENT MANAGEMENT

With careful site selection and preparation, management to promote site variability, appropriate species choice, and correct timing of introductions, no aftercare should be necessary for the introduced plants and seeds. With cyclical woodland management, outlined in the Landscape Management Handbook, the field layer species should flourish post introduction.

The most usual problem during the establishment of introduced field layer species is presented by competition from other shade-tolerant weed species. If sites are suitably shaded and the existing vegetation levels are low at introduction time, then the field layer species should not be subjected to high competition levels during their establishment phase. Spread of invasive species may occur, however, at sites selected with, or adjacent to, patches of Bramble, Ivy or Bracken. These competitive species may spread into the introduction areas despite initial management and may require further control.

METHODS: It is recommended that sites with, or adjacent to, patches of competitive, shade-tolerant weed species, especially Bramble, Ivy or Bracken, are regularly monitored after introductions have been made. Any significant spread of these aggressive competitors should be checked by appropriate spot treatments of non-persistent herbicides.

5.9 RECORDING SPECIES INTRODUCTIONS

Any introductions of native British species into new sites should be recorded, both in terms of species provenance and the receptor site. Records are particularly important when introduction mixtures contain local ancient woodland indicator species.

METHODS: Any information regarding species introduction should be lodged with County Recorders or with local record centres and also on the appropriate Highway Authority environmental database. Species provenance, locations of donor and receptor sites, species lists, rates and times of introduction should be recorded. Whenever possible, any records of the subsequent monitoring of plant survival and spread should also be made.



Figure 10. Bluebells establish slowly and relatively cheaply from seed or can be introduced as bulbs. Using bulbs is more expensive and great care must be taken with provenance.



Pendulous Sedge from seed



Yellow Archangel from plug plants



Red Campion from seed



Bugle from plug plants

Figure 11. Established woodland herbaceous species introduced into young plantations using different methods

6. ENQUIRIES

All technical enquiries or comments on this Advice Note should be sent in writing as appropriate to:

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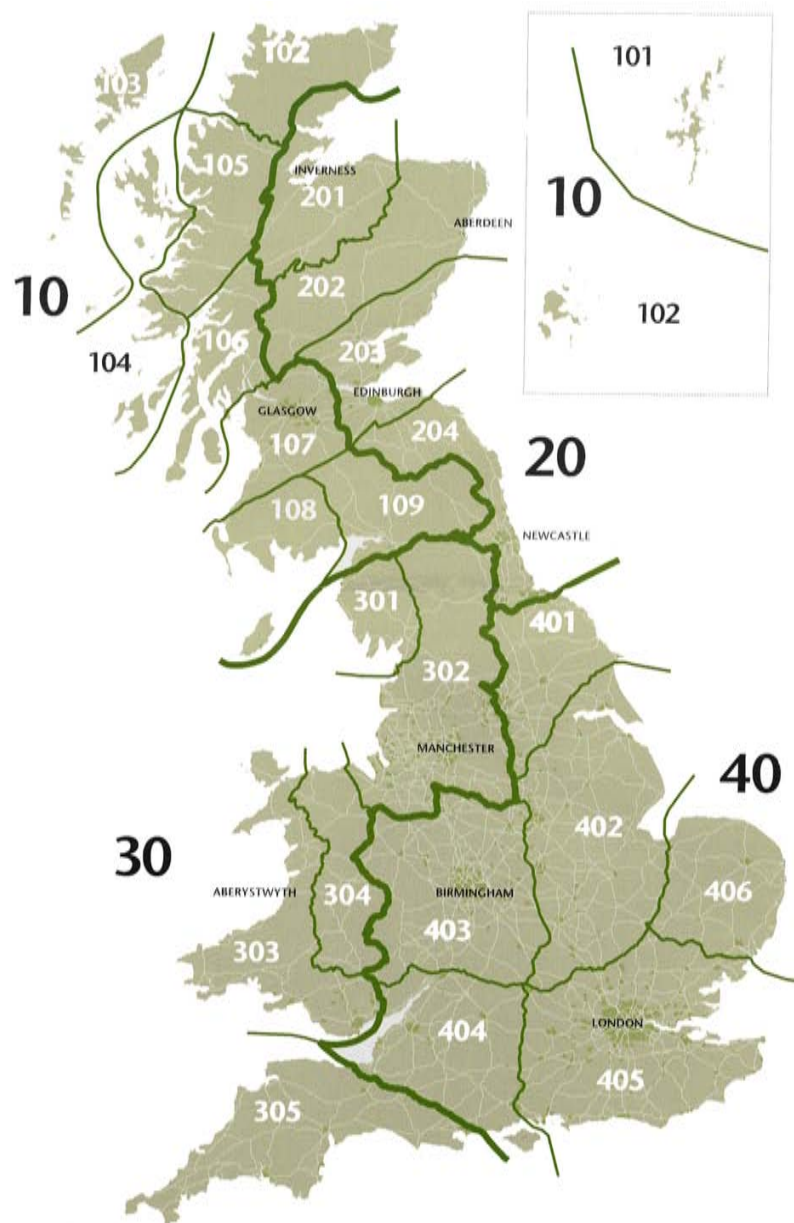


Fig.1. Forestry Commission local seed zones for England, Wales and Scotland.

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ANNEX B WOODLAND FIELD LAYER SPECIES FOR THE ENHANCEMENT OF ROAD VERGE PLANTATION VOLUME 10 SECTION 3 PART 3 HA 115/05

Table A. Native woodland field layer species appropriate to Forestry Commission's numbered seed zones in England and Wales.
(Soils: **M**: moist sites; **D**: light, dry soils; **H**: heavy soils; **A**: acid; **N**: neutral; **B**: alkaline)

SPECIES		Seed Zone No.														Soils					
		ENGLAND												WALES		M	D	H	A	N	B
Common name	Latin name	109	204	301	302	305	401	402	403	404	405	406	303	304							
Betony	<i>Stachys officinalis</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Bilberry	<i>Vaccinium myrtillus</i>	*	*	*	*	*			*	*	*		*	*	*	*	*	*	*	*	
Bluebell	<i>Hyacinthoides non-scripta</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Bugle	<i>Ajuga reptans</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Common Figwort	<i>Scrophularia nodosa</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Common Valerian	<i>Valeriana officinalis</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Common Violet	<i>Viola riviniana</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Devil's-bit Scabious	<i>Succisa pratensis</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Dog's Mercury	<i>Mercurialis perennis</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Enchanter's nightshade	<i>Circaea lutetiana</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Foxglove	<i>Digitalis purpurea</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Germander Speedwell	<i>Veronica chamaedrys</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Greater Stitchwort	<i>Stellaria holostea</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Ground-ivy	<i>Glechoma hederacea</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Hairy St. John's-wort	<i>Hypericum hirsutum</i>	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Heath Bedstraw	<i>Galium saxatile</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Hedge Bedstraw	<i>Galium mollugo</i>			*	*	*	*	*	*	*	*	*			*	*			*	*	
Hedge Garlic	<i>Alliaria petiolata</i>		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Hedge Woundwort	<i>Stachys sylvatica</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Herb-robert	<i>Geranium robertianum</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Lesser Celandine	<i>Ranunculus ficaria</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Lords-and-Ladies	<i>Arum maculatum</i>			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Meadow-sweet	<i>Filipendula ulmaria</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Nettle-leaved Bellflower	<i>Campanula trachelium</i>							*	*	*	*	*			*	*			*	*	
Pignut	<i>Conopodium majus</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Primrose	<i>Primula vulgaris</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Ragged-robin	<i>Lychnis flos-cuculi</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Ramsons	<i>Allium ursinum</i>		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Red Champion	<i>Silene dioica</i>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Sanicle	<i>Sanicula europaea</i>		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	

ANNEX B WOODLAND FIELD LAYER SPECIES FOR THE ENHANCEMENT OF ROAD VERGE PLANTATION VOLUME 10 SECTION 3
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SPECIES		Seed Zone No.												Soils							
		ENGLAND											WALES	M	D	H	A	N	B		
Common name	Latin name	109	204	301	302	305	401	402	403	404	405	406	303	304							
Selfheal	<i>Prunella vulgaris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sweet Violet	<i>Viola odorata</i>					.	.	.	.	.	.	.			.		.		.	.
Sweet Woodruff	<i>Galium odoratum</i>	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.		.	.
Tormentil	<i>Potentilla erecta</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.
Tufted Vetch	<i>Vicia cracca</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.
Upright Hedge-parsley	<i>Torilis japonica</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.			.	.
Wild Angelica	<i>Angelica sylvestris</i>	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.		.	.
Wild Daffodil	<i>Narcissus pseudo-narcissus</i>			.		.								.	.		.		.	.
Wild Strawberry	<i>Fragaria vesca</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.
Wood Anemone	<i>Anemone nemorosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood Avens	<i>Geum urbanum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.
Wood Sage	<i>Teucrium scorodonia</i>	.	.	.	.	.	.		.	.	.	.	.	.	.	.		.	.
Wood Spurge	<i>Euphorbia amygdaloides</i>					.			.	.	.				.		.	.	.
Yellow Pimpernel	<i>Lysimachia nemorum</i>	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.
False Brome	<i>Brachypodium sylvaticum</i>	
Giant Fescue	<i>Festuca gigantea</i>	
Great Wood-rush	<i>Luzula sylvatica</i>	.	.	.	.	.							.	.	.	.			.	.
Hairy-brome	<i>Bromopsis ramosa</i>	
Hairy Wood-rush	<i>Luzula pilosa</i>
Pendulous Sedge	<i>Carex pendula</i>			
Rough Meadow-grass	<i>Poa trivialis</i>
Sweet Vernal-grass	<i>Anthoxanthum odoratum</i>
Wavy Hair-grass	<i>Deschampsia flexuosa</i>
Wood Melick	<i>Melica uniflora</i>		
Wood Millet	<i>Milium effusum</i>				
Wood Sedge	<i>Carex sylvatica</i>
Broad Buckler-fern	<i>Dryopteris dilatata</i>
Hard-fern	<i>Blechnum spicant</i>
Lady Fern	<i>Athyrium filix-femina</i>
Male-fern	<i>Dryopteris filix-mas</i>

ANNEX B WOODLAND FIELD LAYER SPECIES FOR THE ENHANCEMENT OF ROAD VERGE PLANTATION VOLUME 10 SECTION 3 PART 3 HA 115/05

Table B. Native woodland field layer species appropriate to Northern Ireland and to the Forestry Commission's numbered seed zones in Scotland.
(Soils: **M**: moist sites; **D**: light, dry soils; **H**: heavy soils; **A**: acid; **N**: neutral; **B**: alkaline)

SPECIES		Seed Zone Number						Soils						
		SCOTLAND						NORTHERN IRELAND						
Common name	Latin name	101-104	105	106	109	107/108/203/204	201/202		M	D	H	A	N	B
Common name	Latin name													
Bell Heather	<i>Erica cinerea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Bilberry	<i>Vaccinium myrtillus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Bluebell	<i>Hyacinthoides non-scripta</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Bugle	<i>Ajuga reptans</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Common Cow-wheat	<i>Melampyrum pratense</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Common Figwort	<i>Scrophularia nodosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Common Valerian	<i>Valeriana officinalis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Common Violet	<i>Viola riviniana</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Cowberry	<i>Vaccinium vitis-idaea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Devil's-bit Scabious	<i>Succisa pratensis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Dog's Mercury	<i>Mercurialis perennis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Enchanter's nightshade	<i>Circaea lutetiana</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Foxglove	<i>Digitalis purpurea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Germander Speedwell	<i>Veronica chamaedrys</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Greater Stitchwort	<i>Stellaria holostea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Ground-ivy	<i>Glechoma hederacea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Hairy St. John's-wort	<i>Hypericum hirsutum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Heath Bedstraw	<i>Galium saxatile</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Heather	<i>Calluna vulgaris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Hedge Garlic	<i>Alliaria petiolata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Hedge Woundwort	<i>Stachys sylvatica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Herb-robert	<i>Geranium robertianum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Lesser Celandine	<i>Ranunculus ficaria</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Lords-and-Ladies	<i>Arum maculatum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Meadow-sweet	<i>Filipendula ulmaria</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Pignut	<i>Conopodium majus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Primrose	<i>Primula vulgaris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Ragged-robin	<i>Lychnis flos-cuculi</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Ramsons	<i>Allium ursinum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.

ANNEX B WOODLAND FIELD LAYER SPECIES FOR THE ENHANCEMENT OF ROAD VERGE PLANTATION VOLUME 10 SECTION 3
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SPECIES		Seed Zone Number						Soils						
		SCOTLAND						NORTHERN IRELAND						
Common name	Latin name	101-104	105	106	109	107/108/203/204	201/202		M	D	H	A	N	B
Red Campion	<i>Silene dioica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Sanicle	<i>Sanicula europaea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Selfheal	<i>Prunella vulgaris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Sweet Woodruff	<i>Galium odoratum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Tormentil	<i>Potentilla erecta</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Tufted Vetch	<i>Vicia cracca</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Upright Hedge-parsley	<i>Torilis japonica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Water Avens	<i>Geum rivale</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wild Angelica	<i>Angelica sylvestris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wild Strawberry	<i>Fragaria vesca</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood Anemone	<i>Anemone nemorosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood Avens	<i>Geum urbanum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood Sage	<i>Teucrium scorodonia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood Sorrel	<i>Oxalis acetosella</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Yellow Pimpernel	<i>Lysimachia nemorum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
False Brome	<i>Brachypodium sylvaticum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Giant Fescue	<i>Festuca gigantea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Great Wood-rush	<i>Luzula sylvatica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Hairy-brome	<i>Bromopsis ramosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Hairy Wood-rush	<i>Luzula pilosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Pendulous Sedge	<i>Carex pendula</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Rough Meadow-grass	<i>Poa trivialis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Sweet Vernal-grass	<i>Anthoxanthum odoratum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wavy Hair-grass	<i>Deschampsia flexuosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood Melick	<i>Melica uniflora</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood Millet	<i>Milium effusum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood Sedge	<i>Carex sylvatica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Broad Buckler-fern	<i>Dryopteris dilatata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Hard-fern	<i>Blechnum spicant</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Lady Fern	<i>Athyrium filix-femina</i>	.	.	.	.	.	.	.	.	.	.	.	.	.
Male-fern	<i>Dryopteris filix-mas</i>	.	.	.	.	.	.	.	.	.	.	.	.	.

ANNEX B WOODLAND FIELD LAYER SPECIES FOR THE ENHANCEMENT OF ROAD VERGE PLANTATION VOLUME 10 SECTION 3 PART 3 HA 115/05

Table C. Initial field layer species lists for introduction into three contrasting plantation site types along road verges in England.

F.C. ZONE: 406 SOIL: Light, dry and neutral (East Anglia)		F.C. ZONE: 304 SOIL: Moist and acid (East Wales)		F.C. ZONE: 405 SOIL: Heavy and base-rich (South-east England)		F.C. ZONE: 202 SOIL: Light, dry and acid (North-east Scotland)	
FORBS	GRASSES, SEDGES & RUSHES	FORBS	GRASSES, SEDGES & RUSHES	FORBS	GRASSES, SEDGES & RUSHES	FORBS	GRASSES, SEDGES & RUSHES
Bluebell	False Brome	Betony	Great Wood-rush	Bluebell	False Brome	Bell Heather	Great Wood-rush
Common Violet	Rough Meadow-grass	Bilberry	Hairy Wood-rush	Common Figwort	Hairy-brome	Bilberry	Hairy Wood-rush
Devil's-bit Scabious	Sweet Vernal-grass	Bluebell	Rough Meadow-grass	Common Violet	Pendulous Sedge	Bluebell	Rough Meadow-grass
Foxglove	Wood Melick	Bugle	Sweet Vernal-grass	Dog's Mercury	Rough Meadow-grass	Common Cow-wheat	Sweet Vernal-grass
Germander Speedwell	Wood Millet	Common Valerian	Wavy Hair-grass	Enchanter's-nightshade		Cowberry	Wavy Hair-grass
Greater Stitchwort		Devil's-bit Scabious	Wood Sedge	Germander Speedwell		Devil's-bit Scabious	Wood Millet
Hairy St John's-wort		Foxglove		Ground-ivy		Foxglove	
Hedge Bedstraw	FERNS	Greater Stitchwort	FERNS	Hedge Garlic	FERNS	Greater Stitchwort	FERNS
Herb-robert	Broad Buckler-fern	Heath Bedstraw	Broad Buckler-fern	Hedge Woundwort	(none)	Heath Bedstraw	Broad Buckler-fern
Pignut	Male-fern	Pignut	Hard-fern	Lesser Celandine		Heather	Hard-fern
Primrose		Tormentil	Male-fern	Lords-and-Ladies		Pignut	Male-fern
Red Campion		Wood Anemone		Meadow-sweet		Tormentil	
Selfheal		Yellow Pimpernel		Nettle-leaved Bellflower		Wood Anemone	
Tufted Vetch				Primrose		Wood Sage	
Upright Hedge-parsley				Ramsons			
Wild Strawberry				Red Campion			
Wood Avens				Sanicle			
Wood Sage				Selfheal			
				Sweet Violet			
				Sweet Woodruff			
				Tufted Vetch			
				Wild Angelica			
				Wood Anemone			
				Wood Avens			
TOTAL SPP. NO: 25		TOTAL SPP. NO: 22		TOTAL SPP. NO: 28		TOTAL SPP. NO: 23	

Note: These initial species lists are then tailored to reflect local species distributions and availability of suitable seed/plant material.

ANNEX B WOODLAND FIELD LAYER SPECIES FOR THE ENHANCEMENT OF ROAD VERGE PLANTATION VOLUME 10 SECTION 3
PART 3 HA 115/05

Table D. Introduction methods and rates for woodland field layer species used in road verge enhancement schemes.

Edge/marginal species	Woodland core species			
SEED MIXTURE: 5kg ha⁻¹	SEED: 10kg ha⁻¹ each sp.	PLANTS: 4plants m⁻²	PLANTS: 9plants m⁻²	BULBS/RHIZOMES: 9 m⁻²
(=0.5g m ⁻² for the mixture)	(=1 g m ⁻² for each spp)			
Bell Heather	Bluebell	Bell Heather	Bilberry	Bluebell
Betony	Lords-and-Ladies	Bugle	Common Valerian	Lesser Celandine
Common Cow-wheat	Pignut	Enchanter's-nightshade	Common Violet	Ramsons
Common Figwort	Primrose	Germander Speedwell	Cowberry	Wild Daffodil
Devil's-bit Scabious	Ramsons	Greater Stitchwort	Dog's Mercury	Wood Anemone
Foxglove	Sweet Woodruff	Ground-ivy	Lords-and-Ladies	
Greater Stitchwort	Tufted Vetch	Heather	Primrose	
Hairy St John's-wort		Sweet Woodruff	Sanicle	
Heath Bedstraw		Wood Spurge	Sweet Violet	
Heather		Yellow Pimpernel	Wild Strawberry	
Hedge Bedstraw			Wood Sorrel	
Hedge Garlic				
Hedge Woundwort				
Herb-robert				
Meadow-sweet				
Nettle-leaved Bellflower				
Ragged-robin				
Red Campion				
Selfheal				
Tormentil				
Upright Hedge Parsley				
Water Avens				
Wild Angelica				
Wood Avens				
Wood Sage				

ANNEX B WOODLAND FIELD LAYER SPECIES FOR THE ENHANCEMENT OF ROAD VERGE PLANTATION VOLUME 10 SECTION 3
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Edge/marginal species	Woodland core species			
SEED MIXTURE: 5kg ha ⁻¹ (=0.5g m ⁻² for the mixture)	SEED: 10kg ha ⁻¹ each sp. (=1 g m ⁻² for each spp)	PLANTS: 4plants m ⁻²	PLANTS: 9plants m ⁻²	BULBS/RHIZOMES: 9 m ⁻²
GRASSES, SEDGES & RUSHES			FERNS	
False Brome		Giant Fescue	Broad Buckler-fern	
Great Wood-rush		Hairy Brome	Hard-fern	
Hairy Wood-rush		Wood Millet	Lady Fern	
Pendulous Sedge		Wood Sedge	Male-fern	
Rough Meadow-grass				
Sweet Vernal-grass				
Wavy Hair-grass				
Wood Melick				

STATUTORY BODIES

English Nature Northminster House, Peterborough PE1 1UA

Countryside Council for Wales Maes-y-Fyynnnon, Penrhosgarnedd, Bangor, Gwynedd LL57 2DW

Scottish Natural Heritage 12 Hope Terrace, Edinburgh EH9 2AS

Department of the Environment, Northern Ireland Calvert House, 23 Castle Place, Belfast BT1 1FY

Forestry Authority (England) Great Eastern House, Tennison Road, Cambridge CB1 2DU

Forestry Authority (Scotland) Portcullis House, 21 India Street, Glasgow G2 4PL

Forestry Authority (Wales) North Road, Aberystwyth, Dyfed SY23 2EF

Forestry Service (Northern Ireland) Department of Agriculture, Dundonald House, Upper Newtownards Road, Belfast BT4 3SB

OTHER ORGANISATIONS

Biological Records Centre c/o Institute of Terrestrial Ecology, Monk's Wood, Abbot's Ripton, Cambridgeshire PE17 2LS

Botanical Society of the British Isles c/o Department of Botany, Natural History Museum, Cromwell Road, London SW7 5BD

Plantlife 14 Rolleston Street, Salisbury, Wiltshire SP1 1DX

Flora locale 1Denford Manor, Hungerford, Berkshire RG17 0UN

The Woodland Trust Autumn Park, Dysart Road, Grantham, Lincolnshire NG31 6LL

The Wildlife Trusts The Kiln, Waterside, Mather Road, Newark, Nottinghamshire NG24 1WT

SUPPLIERS OF BRITISH NATIVE PLANTS

Lists of suitable suppliers can be found from these organisations:

Flora locale www.floralocale.org

Flora for Fauna, c/o Natural History Museum www.nhm.ac.uk/science/projects/fff/supplies

BAP: Biodiversity Action Plan

biodiversity: the range of plants and animals living in an area to which they are native. The higher the biodiversity, the more species of plants and animals a habitat supports.

bryophyte: a moss or liverwort.

bulked-up: growing a large number of plants from a single or few original individuals.

ecological niche: the exact requirements within a habitat, e.g. a woodland, needed for a particular plant or animal to grow and breed successfully.

herbaceous field layer: the flowering plants – herbs and grasses – and ferns growing below trees and shrubs in a woodland.

invertebrate: literally 'animal without a backbone'; includes groups such as insects, spiders, slugs and snails.

microsite: a very small place.

microtopography: very small structural details. Usually refers to differences within the soil surface.

NVC: National Vegetation Classification. A comprehensive description of all types of British vegetation using a standardised system.

plugs: plants grown in very small containers

provenance: origin of a plant, location or place that it came from.

receptor site: place that is to receive introduced plant species.

ruderal weeds: plants that are adapted to living in disturbed conditions.

semi-natural: a relative term used to describe communities that have a natural aspect or origin, but that are under human influence through current or past management (e.g. coppicing or mowing).

shrub understorey: the layer beneath the tree canopy in a woodland. It consists of small trees and shrubs and provides shelter and nesting sites for birds and animals.

site heterogeneity: variability within a site.

site patchiness: the range of conditions or variations found within a site.

species diversity: the number of different plants and animals within any one place.

species mosaic: distinct groups or patches of one type of plant growing amongst different plants. As opposed to an intimate mixture where individuals of many different types of plants grow together.

stolons: spreading stems that grow horizontally at ground level and which root into soil to form new plants.

translocated herbicides: chemicals which, from a foliar application, move systemically throughout a targeted plant killing both shoots and roots.

woodland field layer species: component vascular plants of the herbaceous woodland field layer, including wild flowers, grasses, sedges and ferns.

Angold, P.G., Underhill, J.E. & Sangwine, A. (1999) A method to assess the extent of road avoidance by wildlife on road verges in deciduous woodland habitat in the UK. In: Proceedings of Fifth International Conference on Roads and Wildlife, Missoula, Montana, USA 1999. Publication No. 005390

Buckley, G.P. & Knight, D.G. (1989) The feasibility of woodland reconstruction. In *Biological Habitat Reconstruction*, G.P. Buckley (ed), 171-188. Belhaven Press, London.

Cohn, E.V.J., Trueman, I.C. & Packham, J.R. (2000) More than just trees. *Aspects of Applied Biology*, **58**, 93-100.

Francis, J.L. (1993) The introduction of woodland field layer species into secondary woodlands. *PhD thesis*, University of London.

Francis, J.L. (1995) The enhancement of young plantations and new woodlands. *Land Contamination & Reclamation*, **32**, 93-95.

Francis, J.L. & Dixie, G. (1996) Planting mixes based on the National Vegetation Classification System. Pubs: High Value Horticulture, Dorset.

Francis, J.L. (2001) The woodland field layer introduction trials, Report 2000. *Ecological Studies in Milton Keynes* **127**.

Francis, J.L. & Morton, A.J. (2001) Enhancement of amenity woodland field layers in Milton Keynes. *British Wildlife* **12 (4)**, 244-251.

Herbert, R., Samuel, S. & Patterson, G. (1999) Using local stock for planting native trees and shrubs. Forestry Commission Practice Note 8. Forestry Commission, Edinburgh.

Highways Agency: Biodiversity Action Plan. Appendix 1.

Highways Agency. (2005) Wildflower Handbook HA67105. Vol. 10, Sect. 4 DMRB

Hill, M.O. Mountford, J.O., Roy, D.B. & Bunce, R.G.H. (1999) Ellenberg's indicator values for British plants. ECOFACT Vol. 2. DETR.

Honnay, O., Verheyen, K., Butaye, J., Jacquemyn, H., Bossuyt, B. & Hermy, M. (2002) Possible effects of habitat fragmentation and climate change on the range of forest plant species. *Ecology Letters* **5**, 252-530.

Moffat, C. (2003) Invertebrate communities in enhanced secondary woodlands. *PhD thesis*, University of London.

Peterken, G.F. & Game, M. (1984) Historical factors affecting the number and distribution of vascular plant species in the woodlands of central Lincolnshire. *J.Ecol.*, **72**, 155-182.

Peterken, G.F. (2000) Rebuilding networks of forest habitats in lowland England. *Landscape Research* **25(3)**, 291-303.

Preston, C.D., Pearman, D.A. & Dines, T.D. (2002) New Atlas of the British and Irish Flora. Oxford University Press, Oxford.

Rodwell, J.S. (1991) *British Plant Communities. Vol.1 Woodland and scrub*. Cambridge University Press, Cambridge.

Stace, C.A. (1997) *New flora of the British Isles*. First Edition. Cambridge University Press, Cambridge.

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