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National Vegetation Classification – Ten years' experience using the woodland section

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1.1 Ten years of experience of the woodland section of the British National Vegetation Classification

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Summary

The woodland section of the National Vegetation Classification (NVC) has been widely used since its publication in 1991 for the description of semi-natural woodland, in developing prescriptions for the composition of new woodland, and to provide links between UK woods and those in the rest of Europe. Better collation of results from surveys across the country is however needed. Criticisms of the classification have been that it ignores many important variations in the tree and shrub layers and in the woodland structure. These variations can be accommodated as cross-cutting divisions within the NVC framework. While the NVC woodland communities, for the most part, reflect environmental variations, there is increasing evidence that some differences are caused by changes in the level of grazing. The stability of the classes may need to be reviewed in the light of climate change if there are major shifts in species distributions and, hence, in the composition of woodland communities.

Introduction

The National Vegetation Classification project was set up in 1975 by the Nature Conservancy Council to produce a classification of British semi-natural vegetation along phytosociological lines (Rodwell 1991). The classification was based in part on new survey work carried out in the mid to late seventies, but also used existing data where this was suitable. Other classification systems have been developed for British woodland – for example Birse and Robertson (1976), Bunce (1982), Rackham (1980), Peterken (1993), Tansley (1939) – but the National Vegetation Classification (NVC) was the most extensive in terms of the number of plots that went into it (over 2500) and the range of the country covered.

The first full draft of the woodland section was provided to the Nature Conservancy Council in 1986. Woodland surveys using the classification were carried out in various parts of Britain over the next five years (Cooke 1992; Cooke and Kirby 1994). The full woodland classification was published in 1991, followed by some short summary descriptions and a guide to its use (Rodwell 1991; Kirby *et al* 1991; Whitbread and Kirby 1992).

The classification continues to be used by the British nature conservation agencies (English Nature, Countryside Council for Wales and Scottish Natural Heritage - successors to the Nature Conservancy Council) as the main tool for describing the vegetation of Sites of Special Scientific Interest and for other survey work. The NVC has also been widely adopted by other departments (such as the Forestry Commission, eg Ray (2003)) and non-governmental conservation bodies, by ecological consultants, and is included in the curriculum of many university and college courses (Pilkington 2003).

Ten years on from the publication, and fifteen years from its first widespread use within the conservation agencies, it is appropriate to review some of the main developments in the use and understanding of this woodland classification.

Developments in the use of over the last ten years

The main use of the classification has been in the description of semi-natural woodland, although the progress in this has varied from country to country. Coverage is more extensive in Wales (Castle & Mileto 2003; Latham 2003) and Scotland, than in England; Northern Ireland was not included in the original NVC surveys but the classification has started to be used there. Account must be taken however of the scarcity of certain key species in Ireland, for example *Mercurialis perennis,* compared to in Britain.

A register of known occurrences of NVC communities has been developed (Hall 1996, 1997). It now holds over 12,000 entries, more than four times those used to create the original classification and distribution maps, and has considerably improved our knowledge of the distribution of some of the woodland types. The upland ash community (W9) and western alder woods (W7) for example have both been shown to occur more widely in south Wales and the west country than in Rodwell (1991).

Links have been made between the National Vegetation Classification communities and the broad woodland types used in the Forestry Commission native woodland guides (Forestry Commission 1994). NVC types have also been used to help in the definition of the priority woodland types identified under the UK Biodiversity Action Plan (Hall and Kirby 1998).

There has been increasing interest in the use of NVC in plantations, both those of native broadleaved species and of introduced conifers (eg Ferris *et al* 2000; Hutchby 2003; Wallace 2003; Wilson 2003). The degree to which recognizable woodland assemblages survive in these stands has been one of the factors used to guide the setting of priorities for restoration of native broadleaves to plantations on ancient woodland sites under the woodland Habitat Action Plans (eg Hutchby *et al* 2000).

Rodwell and Patterson (1994) used the NVC as a template for developing guidance on the creation of new native woodland and Francis and Dixie (1996) took this further with suggestions for ground flora seed mixtures appropriate for different communities. A predictive approach has been developed to indicate the likely distribution of woodland types from soil and climate data (Gray and Stone in press; Ray 2003).

The increased interest in different types of indicator values (such as those of Grime *et al* 1988; Ellenberg 1988) have provided another way of looking at the assemblages of species grouped into the different NVC communities (Pyatt 2003).

One justification for developing the NVC was the desire to have a system that would be more closely aligned to the classifications widely used on the continent. This became more critical with the adoption of the European Union Habitats and Species Directive and the development of the Natura 2000 series of sites across Europe (European Community 1992). Links have been made between NVC and the CORINE and EUNIS classifications (Commission of the European Communities 1991), which have made it easier to put our woodland types into a European perspective (Rodwell *et al* 2000; Rodwell and Dring 2002; Rodwell 2003).

Areas for further consideration

The register of NVC records by Hall (1997) is patchy: there are still few records for some counties and many ten-kilometre squares. More effort is needed to capture the data that is available eg with county wildlife trusts and to stimulate surveys in under-recorded (or under reported in NVC terms) areas, for example Warwickshire and the Isle of Wight. This is an example of the more general issue of collating biological records that is being addressed in part through the development of the National Biodiversity Network.

The relatively coarse nature of the NVC communities means that some surveyors argue the need to define new types to represent the variations that they find in particular woods. There are also gaps in the coverage of the ecological range of variation covered in the classification and some of these may encompass types that are significant on a European scale (Rodwell *et al* 2000). There is therefore a need to set up a system for describing and validating new types (Strachan and Jackson 2003).

Do we have the right tools available to support the take-up and critical use of the NVC; have we made the system as accessible as it might be to beginners? The published key (Rodwell 1991) has been improved on the basis of experience in various training courses and combined with Whitbread and Kirby’s (1992) short descriptions of the main woodland communities in a recent JNCC report (Hall, Kirby and Whitbread 2001) to assist field recognition of the types.

The computer keys to NVC types - MATCH (Malloch 1990) and TABLEFIT (Hill 1989, 1991) - have been widely used, but are a mixed blessing. They do provide a consistent way of classifying data, but they do not necessarily give the ‘correct answer’ all the time – correct in this case meaning the answer that would be given by an experienced ecologist looking at the same data (Palmer 1992). The presence of one or two anomalous species (or the absence of a key species) may lead to the best overall ecological fit being second or third choice on the list. Too much significance may be placed on the order in which communities or sub-communities are listed based on differences of only a few percent in the coefficient. The relatively low matching scores (often less than 50% for woodland samples) are sometimes seen as meaning that the sample is very atypical, whereas it may simply be a consequence of comparing a limited species list (from for example five plots from one site) with the much longer list in the NVC table derived from tens of samples spread across many sites.

The NVC works at the stand level, but often conservation and woodland management are applied at the site or landscape level. There will be circumstances where it may be appropriate to classify whole woods and landscapes in terms of the similarities of their NVC mix - for example Chiltern beechwoods as catenas of the beechwood communities (W12, W14) and associated ash (W8) and oak (W10) stands - rather than trying to separate out the individual types.

Is NVC too ground flora biased?

The ground flora and tree and shrub layer were treated together within the National Vegetation Classification, rather than being considered separately. The results have therefore been criticized because they do not discriminate between the different types of ash, field maple and hazel woods described in eastern England by Rackham (1980) and Peterken (1993). Similarly, while beech woodland is separated off as three separate communities, equally distinctive hornbeam and lime stands are lost within the W8 (ash-field maple- dog's mercury) and W10 (oak-bracken-bramble) communities. A countercriticism might be made that some of the divisions within their classifications failed to distinguish significant variations in the ground flora. For example Peterken's Upland sessile oak-birch type could include stands with a predominantly grassy ground flora, stands dominated by just *Vaccinium myrtillus*, or dense moss carpets (NVC communities W11, W16b, and W17 respectively).

Variations in canopy composition are however important both from a practical conservation and woodland management point of view. These distinctive mixtures identified by Rackham (1980) and Peterken (1983) can be superimposed on the NVC: eg by describing stands as 'a lime-dominated version of W10a' or 'an elm-dominated version of W8b'. In the longer term sufficient additional quadrat data may be accumulated to justify separating some of these variants as communities or sub-communities in their own right.

Zoologists, particularly entomologists, have also criticized the use of NVC as a tool for describing woodland because it does not distinguish structural variations. A stand classified as NVC type W8 might exist as ash high forest with a high proportion of mature trees and little understorey, or as predominantly hazel-field maple coppice, with a dense understorey and only a few young trees in the canopy. The composition and abundance of the invertebrates and birds in particular would probably be far more influenced by the differences in these structures than by whether the stand was classified as W8 rather than W9. This criticism is not unique to NVC but applies to all other vegetation classifications that have been used in the past: it emphasizes the importance of seeing vegetation composition (as summarized by its classification) as only one component in the description of a stand. We also need to know the stand structure and its history (whether it is ancient or recent) in order to make a proper evaluation of its ecological or nature conservation significance. What the NVC provides however is a common framework within which these other approaches to woodland classification can be nested.

How stable are the NVC woodland classes?

If woodland is cleared to become grassland or if a heath is invaded by trees to become a woodland then its NVC type changes albeit this may take several years to become stable. However to what extent does vegetation within woodland change over time, either in response to management, to internal stand dynamics or to widespread external influences such as climate change or atmospheric pollution. Are the NVC classes themselves stable?

The samples used to construct the NVC were mainly from mature, closed canopy stands. There will not necessarily be a close match between such and the vegetation found in rides or in large gaps, such as is created by felling. In these the vegetation may be closer to ruderal, grassland or scrub communities. Even once the canopy has closed young stands may still show lower resemblances to the standard NVC tables than older ones, because some of the open ground species may still be present.

Another concern at present is increasing numbers of deer in lowland Britain and their impact on the ground flora (Kirby 2001), since the balance between different vegetation types can be affected by the level of grazing (Goldberg & Kirby 2003). Grazed variants of some sub-communities may be needed to reflect the general increase in grasses, notably *Brachypodium sylvaticum*, and the reductions in bramble *Rubus fruticosus*, in some lowland woods.

Changes climate or soil nutrient status (through atmospheric deposition) may also have differential effects on particular species. Depending on how widespread and pervasive these changes prove to be, so we may find that the assemblages as characterized by NVC that were typical of woods 20 years ago are no longer appropriate.

Conclusions

The NVC has proved reasonably robust as a tool for describing woodland vegetation over the last ten years -its widespread use is testimony to that. However it must not, as its originators themselves stressed, be regarded as something fixed for all time. There are ways in which its use can be improved and the classification itself may need to evolve.

In particular we need to:

- be more systematic in the capturing of survey data to fill geographic gaps;
- develop ways to identify and fill consistently the ecological gaps (new types);
- improve our understanding of how woodland type changes over time, both at the individual stand level and with respect to the types themselves;
- be considering at what stage we may need to do a major reworking of the classification.

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1.2 An overview of the woodland NVC in Wales and its applications

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Summary

This paper describes the state of woodland National Vegetation Classification (NVC) survey in Wales and some of its applications to nature conservation. Since 1985, some 11,500 ha (15% of the total area) of semi-natural broadleaved woodland at over 800 sites have been surveyed with the NVC. This information has been collated and is held within a database linked to a Geographic Information System. Seventeen woodland communities and 50 sub-communities have been recorded. The overall NVC composition of Welsh woodland is briefly described, and examples of updated distribution maps are given for two communities. The paper considers the application of the NVC dataset to the selection of protected sites, the UK Government's Habitat Action Plans, and for wider analyses of environmental change.

Introduction

Since the introduction of the National Vegetation Classification (NVC) in the 1980s and publication in Rodwell (1991), many surveys have been carried in Wales. These have ranged from one-off surveys by individuals to large scale and systematic surveys carried out under contract for the Countryside Council for Wales (CCW) (e.g. Castle and Mileto 1998). As much of this information as possible has been drawn together by CCW, and is now held within a computer database. The dataset contains many more records than used for the original distribution maps (Rodwell 1991), and should give a more complete understanding of woodland plant communities in Wales. It can also be used to give estimates of the total areas of different woodland types, providing support to various nature conservation programmes.

The scope of the NVC surveys

NVC information has been collated from 802 woodland sites in Wales with a total area of around 11,500 ha. This is some 15% of the total semi-natural broadleaved woodland cover, based on figures from CCW's Phase 1 survey (Blackstock *et al* in prep). Surveys have varied considerably in methodology and scale. For the majority however, full NVC maps were produced and areas of communities measured from these by the surveyors. For others, mapping was only partial, and areas of communities have had to be estimated. In a few instances, quadrats recorded in non-NVC surveys (Day 1985) were translated to NVC and included. Areas mapped as mosaics or transitions between communities were divided by proportion into their constituent communities. These account for a small proportion of the total area and are unlikely to bias the total dataset in a significant way. Records are held in a computer database with fields for areas of each community and sub-community, along with information on site location, name, surveyor, reliability, date of survey and protected status. This is linked to a Geographic Information System (GIS) (MapInfo Professional Version 6.0), allowing spatial and geographic analyses to be carried out. More details of the surveys are available in Latham 2001.

The NVC records have come from throughout Wales (Figure 1), and give a reasonably consistent coverage across “Areas of Search” (areas based on old counties and used as selection areas for Sites of Special Scientific Interest (SSSIs)). However, there are some apparent concentrations and gaps. For example Carmarthenshire in southwestern Wales has numerous records (from Castle and Mileto 1994, 1995), whilst Pembrokeshire (in the far south-west) has relatively few. The focus in Carmarthenshire was initially to provide information for an area with little woodland survey (Humphrey 1994), but subsequently to allow analysis of the representation of NVC communities within SSSIs in an example Area of Search (Latham 1998). Figures for total broadleaved woodland cover have recently become available from the CCW Phase 1 survey (Blackstock *et al* in prep.) and show the actual variation of survey intensity across Wales (Table 1.) The survey effort in Carmarthenshire is offset by the fact that the Area of Search has the highest proportion of broadleaved woodland cover in Wales (5.4% of the land area, *cf* the national average of 3.8%) and consequently its NVC coverage is not as outstanding as it first appears. Most Areas of Search have NVC coverage of between 10% and 20%, and the lowest is 8%. In summary, the current NVC coverage, although somewhat variable, provides a reasonable dataset from which to draw broad conclusions about the overall plant community composition of Welsh woodlands and the distribution of NVC communities and sub-communities.

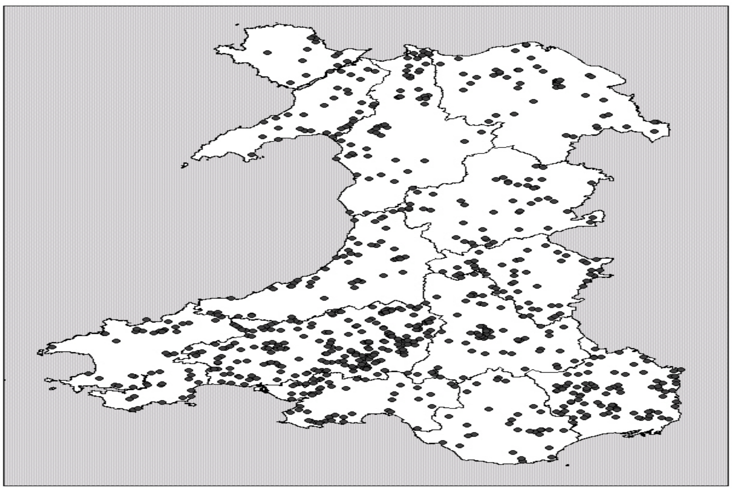

Figure 1. The location of woodland NVC records in Wales shown against the boundaries of Areas of Search for SSSI selection

Table 1. Summaries of the area of semi-natural broadleaved woodland and its coverage by NVC survey in Wales. Areas of Search are selection areas for SSSIs, based on old counties; Phase 1 figures are provisional, and may change slightly as the dataset is refined.

Area of Search	Semi-natural woodland area from Phase 1 (ha)	Cover of semi-natural woodland in Area of Search (%)	Area of semi-natural woodland surveyed with NVC (ha)	Proportion of semi-natural woodlands surveyed with NVC by county (%)
West Gwynedd	4080	2.3	718	17.6
East Gwynedd	8243	3.8	1197	14.5
Clwyd	7272	2.9	776	10.7
Montgomeryshire	7941	3.9	635	8.0
Ceredigion	5645	3.1	944	16.7
Radnor	4711	3.9	596	12.6
Carmarthenshire	11687	5.4	2195	18.8
Pembrokeshire	6585	4.1	637	9.7
Gwent	7128	5.0	1503	21.1
Mid & South Glamorgan	6390	4.4	526	8.2
West Glamorgan	4739	4.1	775	16.3
Brecknock	6722	3.8	1030	15.3
Wales	81143	3.8	11532	14.2

Survey results

The relative proportion of NVC communities by area is shown in Figure 2. All woodland communities except W18 and all sub-communities except W6c and W15d have been recorded. Most communities have a wider geographic distribution than shown in Rodwell (1991), and W3, W13, W14 and W16 were previously unrecorded. Oak wood types account for most of the area, with W10, W11 and W17 representing oak woods across a cline of progressively more acidic and upland conditions. Ash woodland communities (W8 and W9) are also well represented, making up a quarter of the total area surveyed. The NVC has several pairs of communities (W8/W9, W10/W11, and W16/W17) that are counterparts for "lowland" conditions typical of southeastern Britain, and "upland" conditions of northwestern Britain. Geographically, Wales is on the interface between lowland and upland conditions, and all these communities are represented; W10 and W11 notably have quite even abundance. This has practical implications for classification, because many woodland stands in Wales are likely to be transitional between upland and lowland types, and surveyors may vary in how they place them within this spectrum of variation.

Beech wood communities account for a small percentage of the total area surveyed. As beech is only native in the southeast of Wales, this relative rarity is not surprising. However, planted beech woods outwith the native range of the species may well be referable to beech NVC types, but because they have been perceived as "un-natural" may have been avoided in surveys. Wet woodlands too account for a relatively small percentage. W1 to W6 are most likely to occur outside true woodland situations – and especially ancient woodland - and therefore also avoided in surveys. Unfortunately, they are also likely to have been ignored by surveys of herbaceous wetlands! (Wheeler *et al*. 2001). W7 is more often associated with "dry land" woodlands, and has been widely recorded in Wales.

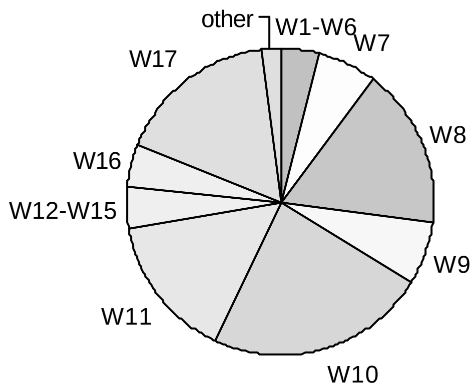

Figure 2. The relative area of NVC communities recorded in Welsh woodlands in a 11,500 ha sample (15% of semi-natural broadleaved woodland).

Only about 2% of the woodland area was unclassifiable with the NVC. In many cases these were secondary stands without a properly developed woodland ground flora, or those that had been severely disturbed. Castle & Mileto (2003) describe difficulties in classification in more detail.

It is beyond of the scope of this paper to describe new results for each NVC community, but further details are available in Latham (2001). See also Hall (1998) and Hall *et al*. (2001) for recent distribution maps.

Applications of woodland NVC in Wales

The NVC is now the standard classification used in woodland conservation assessment. It is the basis for selection of SSSIs (Nature Conservancy Council 1989), and is widely used for general site descriptions and as a basis for management plans. The new Welsh NVC dataset aids these functions, and has a range of wider applications.

Analyses of community distribution and relationships

The NVC dataset should improve understanding of the distribution and environmental relationships of NVC communities in Wales. As well as being intrinsically interesting, this sort of information can be usefully applied to nature conservation programmes. Two examples are given here. Figure 3 shows the geographic distribution and size variation of records of the sub-communities of W7 in Wales, and indicates regional differences not obvious in earlier maps (Rodwell 1991). W7a has an obvious cluster of larger stands in southwestern Wales, W7b has a more central distribution, whilst W7c has a concentration of large records in the southeast centred on the Brecon Beacons; all sub-communities have large representatives in North Wales. This pattern can be partially explained from the community descriptions in Rodwell (1991). W7a is described as a community of low-lying, young river systems with damp but often free-draining and rather eutrophic soils under high rainfall. These conditions are arguably met well in southwest Wales, where W7a can be seen as a characteristic community. W7b is often found on seepages, flushes and slumps associated with waterlogged streamsides and strong topography, conditions typical of valley sides in more central Wales. The distribution of W7c however, is less easy to explain, although as the most terrestrialized of the three sub-communities it may be expected to be commonest in the lower rainfall, eastern parts of Wales. Floristically it can approach, or be indeterminable from W8c, which has a very similar distribution in southeastern Wales (Latham 2001). Further investigation into these communities, their ecological requirements and protected status would be very useful.

Figure 3. The distribution of the sub-communities of W7 in Wales. Records are shown graduated by stand area, but are not to scale between sub-communities.

The second example (Figure 4) is W17 – the most upland and acidic of the oak woodland communities and especially important for rare Atlantic bryophytes. In this case, the maps reflect the original distributions of the sub-communities (Rodwell 1991) quite closely. W17a is the richest bryologically, and has the most records and largest areas in Snowdonia, with a scatter of smaller examples through the west of mid-Wales. W17b and W17c have fewer moisture-demanding lower-plant species and are much more widely distributed. As expected, the distribution of W17a loosely reflects areas of the highest rainfall, but initial analyses show that the coincidence is not perfect, with records in some relatively low rainfall sites in the west. Clearly other factors need to be considered to adequately explain the distribution of W17a. These may include, for example, moisture deficit, annual temperature variation, rock type, and possibly the effects of aerial pollution.

A better understanding of the environmental requirements of communities will be important for exploring the possible impacts of different climate-change scenarios, and hence in developing long-term woodland conservation strategies. Wales is interesting in this respect, with its transitions between British “upland” and “lowland” conditions, often over small distances. This may mean that changes in communities in Wales can be more easily detected than elsewhere in Britain.

Areas of Habitat Action Plan types

Reliable estimates of the abundance and distribution of Habitat Action Plan (HAP) types are needed to implement the UK Government’s Habitat Action Plans for woodland (e.g. UK Biodiversity Group 1998). Conveniently, the HAP types have been defined in terms of the NVC (Hall and Kirby 1998), so it is relatively straightforward to estimate the relative proportion of each HAP type from the relative areas of appropriate NVC communities. The total area of woodland derived from Phase 1 survey can be multiplied by these proportions to estimate the total area of each HAP type. Estimates for the whole of Wales are shown in Table 2. Similar estimates have been made for each of 15 Local Biodiversity Action Groups areas across Wales (Latham in press). These estimates can be used to guide targets for restoration and expansion, based on the proportional increase suggested in the published plans. Similar results have been valuable in providing context for the recording, reporting and prescription of management for woodlands within Tir Gofal, the Welsh agri-environment scheme.

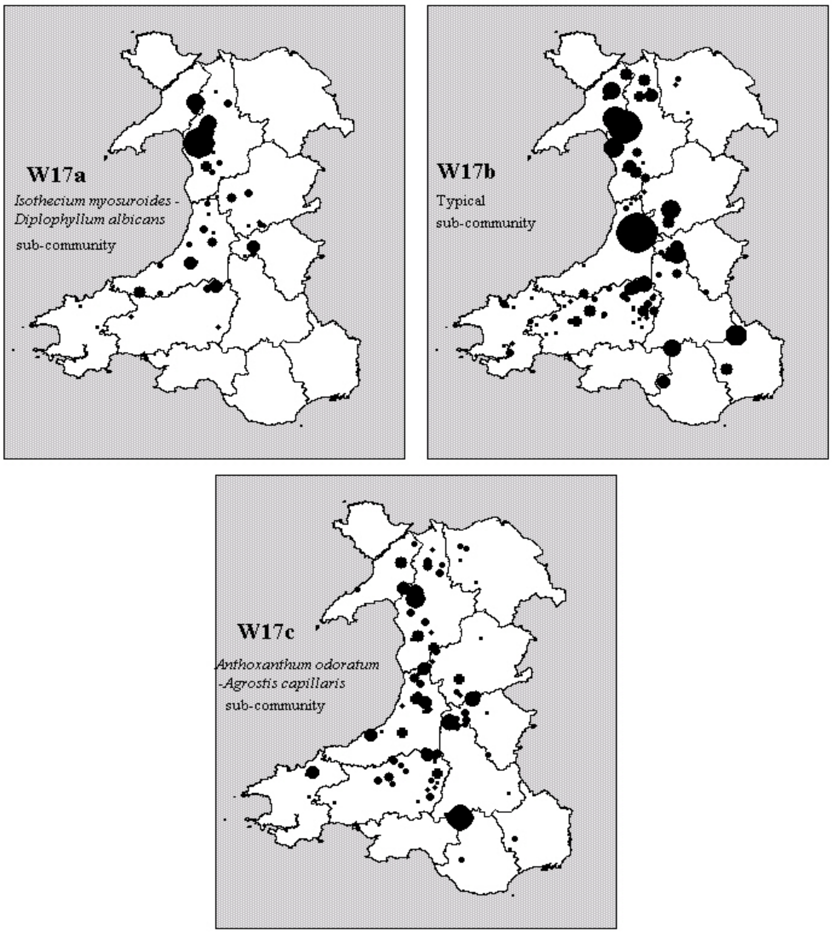

Figure 4. The distribution of the sub-communities of W17 in Wales. Records are shown graduated by stand area.

Table 2. Estimates of the total areas of Habitat Action Plan woodland types in Wales, based on NVC surveys. These figures have also been broken down to local Biodiversity Action Group Areas, see Latham (in press).

Habitat Action Plan woodland type	Total area recorded from NVC surveys throughout Wales	HAP type as a % of total area surveyed	Estimate of total area of HAP type in Wales (rounded to nearest 1,000 ha)
Upland oakwood	5493	47.9	39,000
Upland mixed ashwood	2318	20.2	17,000
Lowland beech and yew woodland	519	4.5	4,000
Wet woodland	1185	10.3	9,000
Lowland mixed deciduous woodland	1722	15.0	12,000

Selection of SACs

The countryside agencies have recently been charged with selecting sites as Special Areas of Conservation (SACs) to meet European Union requirements (Council Directive 92/43/EEC). The NVC dataset for Wales has helped to identify the possible sites. For example, the type *Tilio-Acerion* ravine forests is recognised as being equivalent to NVC types W8d-g, and W9 on steep and rocky situations, especially on limestone (working definition used by the Woodland Lead Coordination Network for the JNCC). As a first stage in selection, a GIS analysis was used to highlight stands of these communities located on outcropping limestone. This identified the largest individual sites, as well as geographic clusters of sites that together could form a SAC.

Discussion

The woodland NVC information collected in Wales over the last 15 years has proved invaluable in a range of conservation initiatives. Although no systematic survey has ever been attempted, a convincing geographical coverage has been achieved, and the relative abundance of the major communities can be established with some confidence. There is still room for improvement in representation, and some areas have quite weak coverage. A pragmatic target may be NVC coverage of at least 15% in each Area of Search in Wales. More survey seems likely, both through SSSI notification programmes, and by bodies such as Forestry Commission, who are increasingly using NVC in site description and management planning.

Most NVC surveys have concentrated on the perceived “best” sites, whether existing or potential SSSIs, or ancient semi-natural woodland. This may well have introduced some bias into these all-Wales results, and assessment of community representation inside and outside SSSIs, and between ancient semi-natural and secondary woodland is needed. This issue opens a question of the purpose of surveys: where once they were intended to identify prime sites, the emphasis has shifted towards using surveys to give an overview of the total resource. This reflects a broad trend in nature conservation away from site-based to wider-countryside strategies.

Modelling techniques are becoming available to predict the distribution of NVC communities at site or regional scales (Pyatt 1995). These complement traditional survey, as they can predict NVC community compositions over large areas more rapidly than is possible by field-work, whilst existing NVC data can help to calibrate the methods and to assess their reliability. Such methods have yet to be widely used in Wales, but offer enormous and exciting potential for the future.

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1.3 Woodland NVC and conservation management in Sussex

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Summary

NVC types serve as a shorthand for descriptions and may allow predictions to be made about future management options. This idea is assessed using data from W8 and W10 woodland in Sussex in the context of teaching the NVC to aspiring consultants and conservation managers.

Introduction

A classification system can be thought of as a series of boxes into which examples fit. The boxes then serve as shorthand for descriptions. For this to work there shouldn't be too many boxes. However, given the continuum and complexity of plant communities there will be a balance between goodness of fit and number of boxes. If we have a large number of boxes the fit will be better, but the likelihood that users from different parts of the country will understand the shorthand is diminished. Also, just as we expect the classification of plant species to reflect evolutionary relationships, we expect our community classification to reflect the underlying ecology. If we have the system right, a comparison of data collected from a particular wood with standard data should highlight important differences which make ecological sense and enable predictions to be made about the effect of different management options. These ideas are assessed here within the context of teaching field biology to aspiring consultants and conservation managers. First the general differences between data for Sussex woods and the standard picture are reviewed and then a more detailed discussion is given showing how particular differences identified for one woodland stand can be related to management issues.

Methods

In the Certificate in Field Biology students use the standard NVC method (Rodwell, 1991) to collect data from a woodland stand with little understorey (in Nap Wood) where it is relatively easy to put out 50m by 50m quadrats. They then collect data from a contrasting wood (either Glovers Wood or Blackbrook Wood) using the minimum quadrat method (Kirby *et al* 1991). Individual students then extend what they have learnt to woods of their own choice and here quadrat size for canopy and understorey may be reduced to 20m by 20m to facilitate sampling of small areas.

In class the pH of the soil at 5-10cm depth was determined in the field for each 4m x 4m ground flora quadrat using a Whatman pH meter. For project work a Rapitest soil test kit was also used and other students took samples back to the lab for pH determinations using a Whatman pH meter.

Data from five Sussex examples of W8 *Fraxinus excelsior –Acer campestre –Mercurialis perennis* woodland (Rodwell 1991) and five Sussex examples of W10 *Quercus robur – Pteridium aquilinum – Rubus fruticosus* woodland (Rodwell 1991) were collected for comparison with standard NVC data (Rodwell 1991). Data were set out in floristic tables so that it was easy to see how well the Sussex woods fit the general picture for these woodland types and to highlight special floristic features which could be linked to particular ecological or management conditions in the different woods.

Study sites

Glovers Wood (TQ 2240), described by Marren (1992) as a fine example of a Wealden wood, lies close to Gatwick airport (and is technically just over the border into Surrey). Bands of Paludina limestone underlie the predominately clay soil and contribute to the diversity of plants within the wood. The compartment sampled was on a level site and consisted of 70% old hornbeam (*Carpinus betulus)* coppice which was overgrown (almost certainly last coppiced during the 1940s) with 20% ash *(Fraxinus excelsior)* and several large Wild Service *(Sorbus torminalis)* trees.

Lank Hook Wood (TQ 632311), near Wadhurst in the High Weald of Sussex, has a typical clay soil and extends round a south-facing slope from south-east to south west at 135m above sea level. This small wood, of less than 4 hectares, is again predominately old, overgrown hornbeam coppice with ash and some field maple *(Acer campestre).*

Blackbrook Wood (TQ 3417), a 43 hectare block of diverse and somewhat fragmented woodland, lies to the south-east of Ditchling Common in Mid Sussex on Wealden clay. The eastern areas of woodland, including Sample Areas 1 and 2, are underlaid with bands of Paludina limestone giving a higher soil pH than that in the larger block of woodland to the west which includes Sample Area 3.

Bollens Bush (TQ 432019), a small 10 hectare area of recent woodland, lies on a north-easterly facing slope at the edge of the chalk downs to the north-west of Newhaven. The soil, which overlies chalk, is variable with sandstone outcrops and areas of clay.

Nap Wood (TQ 5833), described by Marren (1992) as a well-preserved wood typical of the High Weald, lies on a spur of Tunbridge Wells sandstone near Marks Cross in East Sussex. The compartment sampled lies at the top of a north-facing slope where a very shallow, acidic soil overlies the parent sandstone bedrock.

Forge Wood (TQ294390), a small (9 hectare) wood on the out-skirts of Crawley in West Sussex, is north-facing and lies on poorly-drained Wealden clay interspersed with sandstone. The compartment sampled runs along the south-west boundary and extends as a shaw along the edge of the adjacent field.

Views Wood (TQ4822), a 41 hectare sweet chestnut *(Castanea sativa)* coppice wood on the boundary between the parishes of Uckfield and Buxted, lies on the Hastings Beds with a free-draining sandy soil. Two compartments of overgrown *Castanea* coppice were sampled.

Results

Table 1 compares the floristic data from the five Sussex examples of W8 *Fraxinus excelsior–Acer campestre–Mercurialis perennis* woodland (Rodwell 1991) with the standard NVC data (Rodwell 1991) for W8a and W8b.
Table 2 compares the floristic data from the five Sussex examples of W10 *Quercus robur– Pteridium aquilinum–Rubus fruticosus* woodland (Rodwell 1991) with the standard NVC data (Rodwell 1991) for W10a and W10b.
These tables include only species present in the Sussex woods.

Table 1. Floristic table comparing the Sussex woods with standard W8 data

	Glovers	**LankHook**	**Bbrook 1**	**Bbrook 2**	**Bollens**	**Std W8a**	**Std W8b**
CANOPY CONSTANTS							
Fraxinus excelsior	V (5-8)	IV (4-5)	V (5-9)	V (6-10)	V (5-6)	IV (1-10)	IV (1-7)
Acer campestre	II (4-8)	I (4)		III (1-5)		II (1-7)	I (2-5)
Salix caprea		II (5)				I (2-7)	I (1-3)
Betula pubescens	II (2-4)	I (4)				I (3-6)	
Malus sylvestris				I (1)		I (1-3)	
Prunus avium	I (6)					I (1)	
Alnus glutinosa		I (1)					I (1-4)
SE PREFERENTIALS							
Quercus robur	III (1-7)	III (4)	V (4-7)	IV (3-6)	II (1)	IV (1-10)	III (1-8)
Carpinus betulus	V (4-9)	V (9)	V (4-8)			II (1-10)	II (5-7)
Betula pendula	III (1-5)					II (1-10)	I (1-5)
Ulmus spp	I (1)					I (4-10)	
Castanea sativa					I (1)	I (3-4)	I (6)
Sorbus torminalis	I (5)					I (1-3)	
NW PREFERENTIALS							
Acer pseudoplatanus					IV (2-4)	I (2-5)	II (1-10)
SHRUB CONSTANTS							
Corylus avellana	IV (1-5)			II (1-4)	II (3-5)	V (2-10)	IV (1-9)
Crataegus monogyna	V (1-3)		IV (1-2)	III (1-3)	V (4-6)	III (1-7)	IV (1-5)
Acer campestre	II (2-4)	I (1)		III (2-4)		II (1-6)	I (3)
Fraxinus excelsior sapling		I (1)			IV (2-5)	II (1-8)	II (1-3)
Sambucus nigra		I (1)	I (1)	V (2-4)	IV (1-5)	I (1-5)	II (1-7)
Cornus sanguinea				I (1)		II (2-8)	I (3)
Prunus spinosa				V (1-6)	I (4)	I (1-8)	I (1-4)
Euonymus europaeus				V (3-6)		I (2-3)	
SE PREFERENTIALS							
Crataegus laevigata	IV (1-5)	II (1-2)		V (1-6)		I (3-6)	I (3)
Carpinus betulus	II (1-2)	I (3)				I (2-10)	I (3-10)
NW PREFERENTIALS							
Acer pseudoplatanus sapling		I (1)				I (1-4)	II (1-5)
Ilex aquifolium	V (1-3)	I (1)			I (1)	I (3-4)	I (6)
GROUND FLORA CONSTANTS							
Mercurialis perennis	II (1-2)	III (5-6)	IV (6-8)	IV (3-7)		IV (1-10)	III (1-10)
Eurhynchium praelongum	III (1-3)			I (3)	IV (4-8)	IV (1-9)	IV (1-7)
Rubus fruticosus agg	V (2-5)	III (1-7)	III (2-4)	IV (2-3)	V (5-8)	IV (1-10)	III (2-8)
PREFS SUBCOMMUNITY a							
Poa trivialis	I (1)			IV (1)	III (3-5)	III (1-9)	II (1-8)
Glechoma hederacea			II (4-7)	IV (3-5)	IV (1-3)	III (2-8)	II (1-4)
Primula vulgaris				I (1)		III (1-4)	II (3-5)
Viola riviniana/reichenbachiana	III (4-7)		III (4)	IV (2-5)	IV (1-3)	II (2-6)	II (2-5)
Ajuga reptans	I (1)			IV (2-4)		II (1-6)	II (2-3)
PREFS SUBCOMMUNITY b							
Anemone nemorosa	IV (3-5)	II (5)	IV (4-5	I (3)		I (2-6)	V (1-9)
Ranunculus ficaria		I (3)			I (2)	I (1-5)	IV (1-7)
Lamiastrum galeobdolon	III (1-3)			I (2)		I (1-6)	II
Rumex sanguineus				II (1)	II (1-2)	I	II
OTHER SUBCOMMUNITY SPP							
Potentilla sterilis	II (2-4)					I (1-4)	I (1-2)

	Glovers	**LankHook**	**Bbrook 1**	**Bbrook 2**	**Bollens**	**Std W8a**	**Std W8b**
Hedera helix				I (2)	V (3-9)	II	II
Urtica dioica					IV (1-4)	II (1-8)	II (1-4)
Galium aparine		I (1)	IV (3-4)	IV (2-4)	III (1-3)	I (1-7)	II (1-7)
Geranium robertianum		V (1-6)		I (1)		I (1-4)	I (3)
Eurhynchium striatum	V (3-7)			II (1-3)		I (1-6)	I (1-6)
Thamnobryum alopecurum				II (3)	III (5-8)	I (1-8)	I (3-4)
Polystichum aculeatum				I (1)		I (2-4)	
ASSOCIATES							
Hyacinthoides non-scripta	V (3-9)	IV (4-9)	V (5-6)	III (1-9)	V (1-5)	III (2-9)	IV (1-9)
Brachythecium rutabulum	III (2-6)			III (4-5)	III (2-6)	III (1-8)	II (1-8)
Plagiomnium undulatum				I (1)	III (1)	III (2-7)	III (1-6)
Circaea lutetiana	II (3)			II (3)	II (1-2)	III (2-5)	I (1-5)
Geum urbanum				II (1)	II (2-4)	III (1-6)	I (1-4)
Fissidens taxifolius				I (1)		II (1-4)	I (1-3)
Arum maculatum	III (2-4)	III (1-3)		IV (1-3)		II (1-6)	II (1-4)
Atrichum undulatum	V (1-6)	I (4)		II (1-2)		II (2-6)	I (1-4)
Mnium hornum	IV (2-8)	II (1)				II (1-7)	II (1-6)
Fraxinus excelsior seedling	V (3-8)	V (1-3)	III (1)	I (1)		II (1-3)	I (1-3)
Dryopteris felix-mas		II (1-2)		I (1)	III (1-3)	II (1-4)	II (1-4)
Lonicera periclymenum	III (1-4)				I (2)	II (1-6)	II (1-6)
Thuidium tamariscinum	IV (3-5)			II (3)		II (2-7)	I (1)
Carex sylvatica	I (3)			I (1)		II (1-4)	I (4)
Tamus communis				III (1)	III (2-4)	I (2-4)	I (3)
Silene dioica		I (3)		I (1)		I (1-5)	I (1-4)
Lophocolea bidentata s.l.	I (1)					I (1-4)	I (1)
Stachys sylvatica	II (4-6)					I (2-5)	I (1-3)
Dryopteris borreri	I (2)					I (4)	I (1)
Hypnum cupressiforme				I (3)		I (1-4)	
Oxalis acetosella	IV (4-7)					I (1-7)	I (2-3)
Adoxa moschatellina			I (3)	IV (1-2)		I (3)	I (7)
Dryopteris dilatata	II (1)					I (1-4)	I (1-5)
Stellaria holostea			II (2-4)			I (2-3)	I (3-4)
Moehringia trinervia				I (1)		I (1-4)	I (1)
Anthricus sylvestris					I (4)	I (2-3)	I (2)
Crataegus monogyna seedling	I (4)	III (1-2)		III (2-3)		I (1-3)	
Veronica Montana	II (2-4)					I (3-4)	I (1-6)
Ranunculus auricomus				I (1)		I (3)	
Orchis mascula				I (1)		I (2-3)	I (1)
Carpinus betulus seedling	V (3-6)	III (3)	III (1)				
average pH	6.3	6.1	5.7	5.4	5.4	4.5 - 7.0	4.5 - 7.0
Sample size	5	5	5	5	5	128	79

Table 2 Floristic table comparing the Sussex woods with standard W10 data

	Nap	Forge	Bbrook3	Views 1	Views 2	std W10a	std W10b
CANOPY CONSTANTS							
Quercus robur	V (1-5)	IV (8-9)	IV (1-9)	V (1)	IV (1-2)	III (2-10)	IV (3-10)
Betula pendula	V (5-7)	IV (1-9)	V (1-7)	V (3-7)	IV (1-3)	III (2-9)	III (2-8)
Fagus sylvatica	III (1-5)				I (1)	I (1-10)	I (3)
Sorbus aucuparia	II (1)			II (1)	II (2)	I (1-5)	I (3)
Ilex aquifolium						I (1-5)	I (2-7)
Alnus glutinosa		III (1-2)		III (2-4)	II (2)	I (1-5)	I (4)
Prunus avium		II (1-5)				I (3)	I (3-5)
Betula pubescens	IV (7-10)					I (4-7)	I (4-7)
Carpinus betulus			IV (2-9)			I (1-9)	I (4-9)
Salix caprea				V (1)	V (1-2)		
CANOPY PREFERENTIALS							
Quercus petraea	II (2)					III (3-10)	
Castanea sativa			I (1-2)	V (3-9)	V (6-8)	I (1-5)	III (3-10)
Pinus sylvestris	II 1-5					II (3-4)	I (4)
Acer pseudoplatanus				IV (2-9)	II (2-4)	II (1-9)	I (5)
Fraxinus excelsior		II (1)	I (5)	I (5)	III (3-5)	I (1-6)	II (2-7)
Quercus hybrids						I (1-8)	
UNDERSTOREY							
Corylus avellana		V (2-9)	IV (4-8)	V (2-5)	V (1-3)	III (1-9)	III (2-9)
Crataegus monogyna	I (1)	IV (1-8)		II (2)	IV (2)	II (1-6)	I (3-7)
Ilex aquifolium		II (1-2)	I (1-2)	III (1-2)	V (1-3)	II (1-6)	I (2)
Carpinus betulus sapling		I (3)				I (8)	I (3-5)
Viburnum opulus					II (1-2)	I (1-4)	I (2-3)
Fagus sylvatica sapling	II (1)					II (1-5)	
Rhododendron ponticum	II (2-3)			V (2-4)	I (2)	I (1-8)	
Sorbus aucuparia	II (1)			II (1)	I (2)	I (1-4)	
Betula pendula sapling	II (1-2)	II (1)		V (2-3)	I (2)	I (2-3)	
Malus sylvestris				I (1)	I (1)	I (1-2)	
Quercus robur sapling	II 2-3	II (1)		III (1-2)	III (1-3)	I (2-3)	
Castanea sativa				III (1-2)	II (1-2)	I (1-3)	II (3-9)
Acer pseudoplatanus sapling				IV (2)	III (1-2)	II (1-7)	I (2-4)
Fraxinus excelsior sapling					III (1-2)	I (1-5)	I (3)
Sambucus nigra		IV (1-8)		III (1)	IV (1-2)	I (2-3)	I (2-3)
Prunus laurocerasus		II (2-3)		III (1)	IV (1-3)		
PREFS SUBCOMMUNITY a							
Rubus fruticosus agg	I (1)	V (1-5)	IV (4-5)	III (3)	IV (2-3)	V (3-10)	IV (2-9)
Pteridium aquilinum	V (6-9)	V (2-8)	II (3)	I (3)	III (2-3)	IV (1-9)	III (2-7)
Lonicera periclymenum	I (2)		III 1-3	III (2-3)	IV (2-3)	III (2-8)	IV (3-7)
PREFS SUBCOMMUNITY b							
Anemone nemorosa			II (3-4)	V (2-9)	V (5-7)	I (1-2)	IV (3-8)
Atrichum undulatum	I (3)				I (2)	I (1-4)	II (2-7)
Lamiastrum galeobdolon					V (3-5)	I (1-5)	II (2-5)
OTHER SUBCOMMUNITIES							
Hedera helix				II (2-8)	I (1)	II (2)	II (2-8)
Oxalis acetosella		II (2-3)		IV (3-4)		I (1-4)	I (2-3)
Dryopteris dilatata		II (1)				II (1-7)	I (2-5)
Eurhynchium praelongum	II (1-2)					II (1-7)	II (3-5)
Mnium hornum	I (1-2)					II (1-5)	II (1-6)

	Nap	**Forge**	**Bbrook3**	**Views 1**	**Views 2**	**std W10a**	**std W10b**
Viola riviniana			I (4)		I (4)	I (1-3)	I (2)
Thuidium tamariscinum	II (3-4)					I (1-8)	I (5)
Stellaria holostea					I (1)	I (1-5)	I (2-4)
Brachythecium rutabulum	III (1-3)			I (2)	I (1-3)	I (1-3)	I (3-5)
Pseudoscleropodium purum	I (3)					I (1)	
ASSOCIATES							
Hyacinthoides non-scripta	II (2-5)	V (8-10)	V (2-8)	V (3-9)	V (6-9)	III (3-9)	IV (4-10)
Acer pseudoplatanus seedling				IV (1-3)	III (2-3)	II (1-9)	I (3)
Dryopteris felix-mas			I (2)			II (1-5)	I (2-6)
Conopodium majus					II (2)	I (1-4)	I (1-4)
Silene dioica		III (1-3)			II (1-3)	I (3)	I (3)
Fraxinus excelsior seedling			I (1)			I (1-3)	I (3)
Teuchrium scorodonium			I (3)			I (1-5)	I (2)
Urtica dioica					I (1)	I (2-3)	I (4)
Dicranella heteromalla	I (3)					I (1-4)	I (2-3)
Hypnum cupressiforme	V (2-4)			III (2)	II (2)	I (1-4)	I (2-3)
Glechoma hederacea				V (3-6)		I (2-3)	I (2-3)
Quercus robur seedling	I (1-3)		I (2)			I (3-4)	I (3)
Circaea lutetiana			I (1)	V (1-4)		I (1-4)	I (2)
Adjuga reptans			I (5)	II (5-6)		I (1-3)	I (2)
Stachys sylvatica					IV (3-4)		I (3-4)
Sorbus aucuparia seedling	I (2-3)			I (1)	I (1)	I (1-2)	
Lophocolea bidentata s.l.	II (1-2)					I (1-3)	
Fagus sylvatica seedling	II (1)					I (1-4)	
Ilex aquifolium seedling	I (1)			I (3)		I (1-4)	
Mercurialis perennis					I (4)	I (2-4)	
Galium aparine		III (1-7)			II (2)	I (2)	
Dicranum scoparium	IV (2-3)					I (3)	
Narcissus pseudonarcissus		I (1)					I (3)
average pH	3.9	4.5	5	5.4	5.4	4.0 - 5.5	4.0 -5.5
sample size	5	5	5	5	5	51	22

Discussion

W8 *Fraxinus excelsior-Acer campestre-Mercurialis perennis* woodland

Classification of the Sussex Woodlands sampled

In these Sussex woods the canopy constant, *Fraxinus excelsior* (ash), is consistently very frequent with *Acer campestre* (field maple) also present in three out of the five samples, and *Betula pendula* (silver birch) is absent from all except Glovers Wood (Table 1). The SE Preferential, *Quercus robur* (pedunculate oak), is frequent in all except Bollens Bush, which as its name suggests has only recently become woodland. Bollens Bush is also different in having a high frequency of the NW Preferential, *Acer pseudoplatanus* (sycamore), which again can be attributed to its recent woodland status. So far these Sussex woods fit the general picture, but the frequency of the SE Preferential *Carpinus betulus* (hornbeam) differs dramatically from the general picture. This species is either absent from a Sussex wood or occurs at a very high frequency and since it casts a deep shade (Rodwell 1991) the effect of these two extremes on the vegetation below is profound.

The most important Under-Storey Constant, *Corylus avellana* (hazel), is generally low in the Sussex woods, but Rodwell (1991) suggests that the high community values can be attributed to management practices which favoured hazel coppice. In the coppice woodlands in this Sussex sample (Glovers, Lank Hook and Blackbrook Area 1) hornbeam was selected rather than hazel, resulting in low values for hazel. *Crataegus monogyna* (common hawthorn), and/or the SE Preferential species *Crataegus laevigata* (midland hawthorn), are generally high in the Sussex woods, the latter which is particularly associated with ancient woodland, reflecting the long-standing wooded nature of the Wealden landscape. Of the NW preferential species only *Ilex aquifolium* (holly) occurs and only the high frequency in Glovers Wood is exceptional and even here the abundance is very low (Domin 1-3).

The Ground Flora Constants, *Rubus fruticosus* (bramble) and *Mercurialis perennis* (dog's mercury) agree well except for the surprising absence of *Mercurialis perennis* from Bollens Bush presumably due to its recent woodland status. The moss *Eurhynchium praelongum* has a low frequency in the Wealden woods in the Sussex sample, perhaps because other mosses are more common, but it attains high frequency and cover in Bollens Bush on the Downs.

Subcommunity designation is straight forward for Blackbrook Wood Area 2 which has the preferential species for the W8a sub-community. The frequency of *Hyacinthoides non-scripta* (bluebell) in all the other Sussex woods suggests W8b, but *Anemone nemorosa* (wood anemone), which characterises the W8b sub-community, occurs at a high frequency in only Glovers Wood and Area 1 of Blackbrook Wood. Differences between the subcommunities in the SE are related to the waterlogging of the soil (Kirby *et al*, 1994) with bluebell dominating at intermediate levels of soil dampness between the a and b subcommunities.

W8 *Fraxinus excelsior-Acer campestre-Mercurialis perennis* woodland

Management issues

Both Area 1 and Area 2 of Blackbrook Wood have a canopy with constant and frequently abundant *Fraxinus excelsior*, and frequent, but less abundant *Quercus robur*. However, there is a significant difference in the amount of *Carpinus betulus* which has a much greater frequency in Area 1 than the standard frequency of II, but is completely absent from Area 2. The under-storey shrubs also differ from the standard picture, but in the reverse direction with *Sambucus nigra* (elder), *Prunus spinosa* (blackthorn), *Euonymus europaeus* (spindle) and *Crataegus laevigata* all occurring at a much higher frequency in Area 2 than in the standard data and apart from one specimen of *Sambucus* present in one quadrat, these shrubs are absent from Area 2. This makes ecological sense since the *Carpinus* in Area 1 consists of large and over-grown coppice stools which were probably last coppiced during the 1940s and now cast a deep shade, restricting the growth of shrubs. In Area 2, the absence of *Carpinus* means that the canopy, consisting predominately of *Fraxinus* with some *Quercus robur*, casts a much lighter shade allowing the development of a very dense shrub layer. This in turn has affected the spring vernal species, *Anemone nemorosa* and *Hyacinthoides non-scripta*, which in Area 1 form a carpet beneath the *Carpinus*, producing their leaves and flowering before the canopy darkens overhead. In contrast these species form only isolated patches in Area 2 presumably because the dense shrub layer cuts down the light much earlier in the year.

In Bollens Bush where *Carpinus* is also absent, there is again a dense under-storey, but here the most frequent shrub species are those associated with woodland which has recently regenerated on an open site, such as *Sambucus nigra*, *Crataegus monogyna* and *Fraxinus* saplings, rather than the species associated with ancient woodland, such as *Crataegus laevigata* and *Euonymus europaeus*, found in Blackbrook Wood.

There may be another similarity to Bollens Bush. It is strange that there is no hornbeam coppice in Area 2 which is plainly an area of ancient woodland containing at least 23 ancient woodland indicator species including several fine specimens of wild service *(Sorbus torminalis)* occurring around the periphery and along the public footpath. The answer may lie in an area of *Aesculus hippocastanum* (horse chestnut) coppice, lying between and adjacent to both Area 1 and 2, (which has given the name The Plantation to this part of Blackbrook Wood). The clearing and subsequent planting of the horse chestnut coppice was carefully done with many ancient woodland indicator species still present in this area and it may be that Area 2 was also intended to be planted with horse chestnut necessitating the removal of the hornbeams.

Should coppicing be re-introduced into hornbeam woods in Sussex which were last coppiced 50 or 60 years ago? Ted Green (2000) has suggested that it is dangerous to coppice a stool outside its original coppicing cycle, and hornbeam in particular is sometimes a reluctant producer of coppice re-growth, so there is no guarantee that the hornbeam would coppice successfully after this length of time. In addition deer are increasing in number in lowland Britain and pose a major problem to coppice regrowth on sites where coppice management has been recently re-introduced (Putman and Moore, 1998). The ‘doing nothing’ option is supported by the NVC data from Glovers Wood, Lank Hook Wood and Blackbrook Wood which suggest that the display of wood anemones and bluebells, of prime importance in these amenity woods, is greater under the overgrown hornbeam coppice than is to be expected in this sort of woodland and all three woods showed evidence of hornbeam regeneration in the frequency of hornbeam seedlings present in ground flora quadrats (Table 1).

W10 *Quercus robur-Pteridium aquilinum-Rubus fruticosus* woodland

Classification of the Sussex woodlands sampled

Nap Wood and Forge Wood are W10a woodlands lacking *Anemone nemorosa*, and with *Pteridium aquilinum* (bracken) constant and usually very abundant (Table 2). Views Wood on the other hand shows the typical association of *Anemone nemorosa* with *Castanea* coppice (Rodwell 1991). Blackbrook Wood has nearly constant *Carpinus betulus*, but interestingly the wood has remained mixed with *Quercus robur* and *Betula pendula* as co-dominants in the canopy rather than being reduced, as is frequently the case (Rodwell 1991), to occasional standards by the rigorous selection of the *Carpinus*. In fact in all the Sussex woods sampled, *Quercus robur* is constant or more constant than in the standard subcommunity and *Betula pendula* is consistently more constant, although in Views Wood the standards are well distributed rather than abundant resulting in high frequency values, but low abundance values. Rodwell (1991) suggests that in the 1940s post-coppice clearing was sometimes neglected leading to the subsequent increased abundance of *Betula pendula* in the canopy, since this species is the most frequent and successful invader of the canopy gaps thus created and this would appear to be the case here. Oak was planted into many Sussex woods in the mid 1800s.

All the Sussex woodlands are bluebell woods *par excellence* with *Hyacinthoides non-scripta* constant and abundant, except in Nap Wood where the area sampled was at the top of the slope on a very shallow, acidic soil. Lower down the slope, the bluebell cover becomes continuous as the depth of the soil overlying the sandstone bedrock increases. In the standard data *Hyacinthoides* is not constant, although Rodwell (1991) suggests that this is due to the presence within the standard data of samples from modified plantations and overgrown coppice where the absence of light has prevented the survival of the bluebell cover. The Sussex data suggest that where edaphic factors promote the growth of bluebells, low light intensities become less critical and indeed there are examples from the Weald of Sussex (personal observations) where bluebells continue to survive under conifers planted into ancient woodland. In Views Wood, where *Anemone nemorosa* is also constant, one or other of these two species dominates in quadrats from Area 1, but bluebell dominates in the majority of quadrats from Area 2. Where edaphic conditions favour both species, bluebell will dominate (Pigott 1982), so the wood anemone in these quadrats is showing up the wetter patches of ground where bluebell loses its competitive advantage.

Apart from *Quercus robur* and *Betula pendula* W10a and W10b contain many tree species with a frequency of I in the standard table (Rodwell 1991) which are absent from the Sussex sample. On the other hand, each of the Sussex woods have certain species which stand out in table 2 with particularly high frequencies. Thus Nap Wood has a frequency of IV for *Betula pendula* and this species is overall about twice as abundant in this wood as *Betula pubescens* (downy birch) which is the canopy constant for the community. This is a regional difference since *Betula pubescens* is also the most abundant species of birch on the very similar sandstone of Ashdown Forest (Sussex Botanical Recording Society 1996). Both Forge Wood and Views Wood contain more frequent *Alnus glutinosa* (alder) and Views Wood contains *Salix caprea* (goat willow), not present at all in the standard table, at a frequency of V.

Differences in the under-storey element are also highlighted by the comparison. For example *Corylus avellana* generally has a higher frequency in the Sussex woods sampled (IV or V instead of III in the standard data), but is completely absent from the area of Nap Wood studied. The abundance is low in Views Wood, though, suggesting that it is not competing well with the shade of the over-grown *Castanea* coppice. As well as light, *Corylus* likes damp, neutral or moderately acid soils (Clapham, Tutin & Warburg 1962), so it will do well on most of the wealden soils, but it is not surprising that it is absent from the very acid, leached soil in the part of Nap Wood studied. These extreme soil conditions also almost totally excluded the ground flora community constants *Rubus fruticosus* and *Lonicera periclymenum,* although the dense litter and deep shade of the vigorous bracken (Rodwell 1991) coupled with browsing by deer may also have contributed to the low amounts of these species. In contrast two heathland mosses (Watson, 1981) *Hypnum cupressiforme and Dicranum scoparium,* present as low frequency associates in the standard data, here attain constant status.

W10 *Quercus robur-Pteridium aquilinum-Rubus fruticosus* woodland

Management issues

Rhododendron ponticum, which was extensively planted into woods as game cover (Rodwell 1991), is a particular problem in many Sussex woods on the more acid soils. This is illustrated by the data from Views Wood (Table 2) from two stands lying adjacent to an area of woodland thick with *Rhododendron.* Within the areas sampled the *Rhododendron* has been cut and the stumps treated, resulting in low abundance values. In the NVC system *Rhododendron* is associated with the 10a subcommunity, not the *Anemone nemorosa* subcommunity as here, but in the Sussex weald the acid soils which encourage the growth of *Rhododendron* (Rodwell 1991) predominate. The under-storey of Views Wood (and Forge Wood, Table 2) also contains another game cover shrub, *Prunus laurocerasus* (laurel), which causes a similar management problem in many Sussex woods and is absent from the standard data. The high constancy values of *Acer pseudoplatanus* (sycamore) both in the canopy and as saplings in the under-storey in Area 1 in Views Wood suggest that there have been gaps in the canopy in the past (Rodwell 1991) and this is supported by the presence of sapling *Betula pendula* as a constant compared with the low frequency value of I in the standard data and *Quercus robur* saplings at a frequency of III.

Coppicing is being re-introduced in Views Wood by the Woodland Trust as being appropriate for both amenity and conservation management. The NVC data suggest that care will have to be taken not only to control the rhododendron and laurel, but also sycamore may become a problem if the coppice is cut on a short rotation allowing extensive gaps in the canopy to exist. The sycamore will be easier to control if the *Castanea* is allowed to form a closed canopy for a large part of the rotation cycle since sycamore in the understorey is slow growing and rarely fruits (Nisbet 1905). Alternatively, if a short coppice cycle was introduced this might lead to an increase in the currently low abundance (Domin 2-5 and 1-3) of hazel, favouring dormouse conservation.

Conclusions

The system works well for the Sussex woods sampled allowing NVC types, qualified by special floristic features, to serve as shorthand for vegetation descriptions. These special floristic features are highlighted by a comparison of data from particular woods with Rodwell’s standard data (1991) and can be related to general ecology including past management. This provides a rational basis for planning future management.

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2. NVC use in plantations

2.1 Vegetation of plantation Sitka spruce – development of new 'forest noda'

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Introduction

The vegetation of sitka spruce (*Picea sitchensis)* plantations in Britain was not formally placed within the classification of British Plant Communities (Rodwell 1991 *et. seq.*) but described generally in terms of the impoverishment caused to the pre-planted vegetation. This has involved the loss of species through under-planting of broadleaved woodland (Kirby 1988) and the convergence of vegetation communities of mire, heath and grassland towards fewer, often species poor, variants of recognized communities (Sykes *et al* 1989., Wallace *et al* 1992).

The development of a flora having affinities with native broadleaved woodland was noted in mature first rotation plantations on previously unwooded sites in Wales (Hill and Jones 1978) and the Borders (Good *et al* 1990) and in second rotation spruce stands also in the Borders (Wallace and Good 1995; Wallace 1998). However, the stands only fitted loosely to units of the NVC, lacking many species characteristic of such woodland associations whilst supporting other species in greater amounts; bryophytes tended to be more prevalent than expected whilst grasses and herbs were sparse (Wallace 1998); convergence to W17b and W10e seemed most frequent.

Continental studies of plantation forests have shown ground flora development to be closely related to soil conditions and the age and number of rotations of the plantation (Koie 1938, Hauff *et al* 1950, Ellenberg 1988). Tuxen (1950) introduced the term 'Forstgesellschaft' (planted forest community) for communities which arise when pure conifer plantations occupy areas where the species would not normally be a principal component of the native broadleaved woodland. Many German plantations have been placed in the *Picea-Vaccinium* forest type of the boreal zone (Sjors 1965); here *Vaccinium myrtillus* and *Deschampsia flexuosa* are joined by a suite of bryophytes including *Dicranum scoparium, Plagiothecium curvifolium, Pleurozium schreberi* and *Lophocolea cuspidata* (Ellenberg 1988; Rheinheimer 1957).

In northern Britain the direction of woodland development under spruce plantations is likely to be towards communities of the *Dicrano-Pinion* or *Quercion* alliances with *Betulion* woodland on the wettest sites (Rodwell *et al* 2000).

The *Dicrano-Pinion* and *Quercion* share a suite of species which differentiate them from other woodland types but, as Ellenberg (1988) notes, since many of these are species characteristics of the heath and grassland associations from which the woodlands are derived, their expansion in the acidic litter of the forest floor renders separation of true coniferous woodland from oak-birch woodland of the *Quercetalia robori* particularly problematical. The problem of partitioning *Vaccinium*-rich woodland between these two alliances is evident in the early treatment of pine and *Vaccinium* -rich birch stands in northern Scotland and their subsequent translation into units of the NVC. *Vaccinium* – rich birch woodlands, placed by McVean and Ratcliffe (1962) in the *Betuletum Oxaleto-*

Vaccinetum of the *Vaccinio-Piceetea,* are listed in the synonyms for W17 and W11 of the NVC, within the *Quercetalia-Robori-petracaea,* whilst herb-rich birch woodlands described by McVean and Ratcliffe as supporting a flora which '.. comes close to that of broadleaved woodland' are listed in the synonymy for W11 and W9 of the NVC.

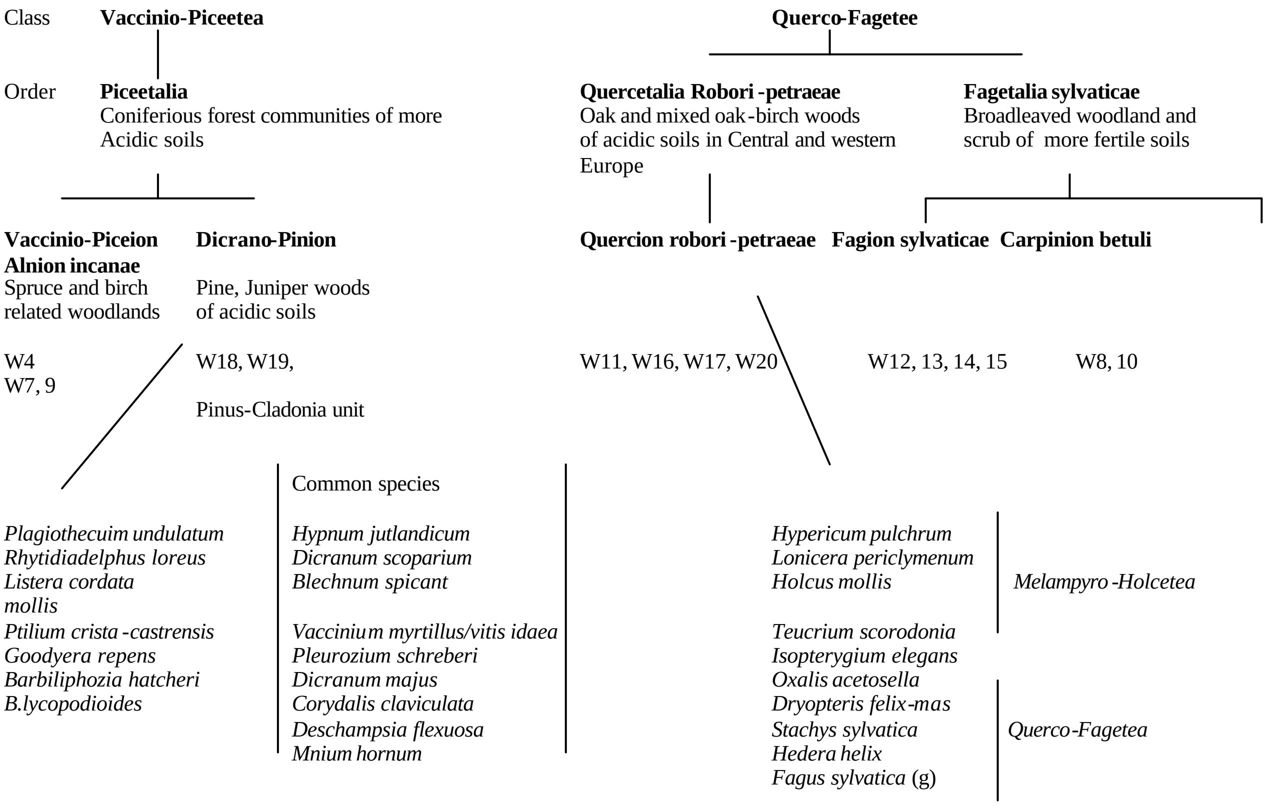

Figure 1. Relationship of NVC communities to European woodland classes including alliance preferential species

The present study, based on surveys of first and second rotation sitka spruce stands in northern Britain, aims to identify the direction of woodland development under spruce and mixtures of spruce and birch, where the natural woodland would be expected to be of either the *Dicrano-Pinion* or the *Quercion*. The influence of site type (especially soils) and canopy composition will be considered as will the influence of previous landuse history.

Methods

Second rotation spruce in the Borders

A survey of second rotation sitka spruce in the Scottish borders was carried out in 1991. The Forestry Commission data base was used to provide listings of sitka spruce compartments in Dumfries and Galloway. Stands were stratified by crop age (1, 4, 9, 14 and 19 years) and soil type (brown earth, podzols, surface water gleys, peaty gleys and deep peats). The sampling unit was a 200m^2 plot following the methodology of Bunce and Shaw (1973) for ground cover estimates. Twinspan analysis was carried out on the 106 plots recorded and endgroups fitted to units of the NVC with the aid of the computer programme SIN (Prosser 1990).

First and second rotation spruce, and spruce/birch mixtures in northern Britain

A more extensive survey of first and second rotation crops was carried out in 1992; the principal objective of the survey being to assess the role of birch in enhancing the ground flora development of sitka spruce plantations. The Forestry Commission data base provided a listing of compartments containing birch (including managed, unmanaged and semi-natural woodland stands). A stratified random sample was taken based on two geographic regions, the Highlands (Tayside, Strathclyde, Central and Highlands) and the Borders (Dumfries and Galloway, Kielder); five soil types (as above) and three crop ages (restocks of 14-20 years and 20-29 years and first rotation stands over 30 years); unmanaged and semi-natural birch stands were paired with crop stands. Plots in the crop were placed in 'pure spruce', spruce/birch mixtures and birch thickets (areas of birch dominance). The recording unit was the $200m^2$ plot; canopy cover was measured using the line intercept method and ground cover values were obtained from the average of five (2 x 2m) quadrats placed at fixed locations within the plot. Soil type was determined from soil profiles using an 80cm metal augur.

An initial Twinspan was performed on the 508 plots; 315 from the Highlands and 193 from the Borders; separate Twinspan analyses were then performed on the second and first rotation managed stands. Endgroups were tested against units of the NVC using the computer programme SIN, and against other noda from continental plantations and birch woodlands.

Comparison of data from other studies in northern Britain

The survey of Kielder Forest, Northumberland, included many stands of first rotation sitka spruce which failed to fit satisfactorily into units of the NVC and these, together with additional stands of mature conifer and mixed conifer/broadleaved stands sampled in the borders, were subject to Twinspan analysis and series of noda arrived at which fitted more or less loosely into units of the NVC (Good *et al* 1990). These noda are re-analysed here by testing them (with SIN) against both the NVC, the noda derived from the 1992 spruce/birch study and other units from European studies of plantation forests.

A further comparison has been made with data for first (44 and 62 years) and second (24 year) rotation spruce stands at Knapdale (source Humphries, Forest Research, Biodiversity Assessment Research Programme). Eight samples were available for each age class.

Results

Second rotation spruce in the Borders

Young crops (<10 years) on mineral soils fitted *Calluna-Vaccinium myrtillus* heath (H12a) whilst those on peaty profiles were closer to the *Scirpus cespitosus-Erica tetralix* wet heath (M15d). With increasing age, and canopy cover, there was a convergence of the flora to a vegetation which shared characteristics of H12, W17b and W11a; the herbs of open habitats were declining whilst bryophytes characteristic of shady woodlands were increasing (Wallace and Good 1995; p.39). Species diversity and goodness of fit to the NVC woodland type W17b peaked at about 18 years; in older crops with greater spruce cover the bryophyte flora became less characteristic of such woodlands whilst sub shrubs and grasses both declined and a suit of species distinctive of plantation spruce achieve constancy (*Dryopteris dilatata, Lopholocea bidentata, Mnium hornum, Thuidium tamariscinum, Lepidozia reptans* and *Eurhynchium praelongum).*

Spruce and spruce/birch mixtures in northern Britain

The principal gradient of the 508 sample Twinspan was soil type; deep peats and peaty gleys of the Highlands were segregated from the predominantly mineral soils of the borders at the first division. Subsequent divisions could be related to canopy cover and composition; open areas and natural woodland with low canopy cover were placed at the extreme ends of both sides of the principal division. These unmanaged areas graded through stands with high spruce cover which often failed to fit units of the NVC to crop stands with higher birch cover which could be placed with greater confidence into NVC sub-communities. Thus, crop stands were spread across the soil gradient, with poor fitting units of peaty substrates segregated from those of more freely drained mineral profiles.

Second rotation stand types

The principal gradient of the Twinspan analysis of the 215 second rotation stands remained soil type whilst canopy composition and past landuse were important in subsequent divisions.

15 endgroups were compared with units of the NVC using both MATCH and SIN. Following assessment of the performance of community preferential and differential species for ‘best fitting’ units the stands were aggregation into four noda considered distinct in terms of their floristic composition (Appendix 1 at the end of this paper). Of the seven species constant to the four noda *Hypnum jutlandicum, Dicranum scoparium* and *Mnium hornum* are common to both *Picea-Vaccinium* and *Quercion* woodlands whilst *Plagiothecium undulatum* is more commonly associated with the former; all seven species are over-represented compared to native oak-birch woodlands (W17 and W11). Nodum A, comprising spruce/birch mixtures in the Highlands has, as preferential species common to both classes, *Deschampsia flexuosa, Blechnum spicant, Pleurozium schreberi* and *Vaccinium myrtillus,* whilst species characteristic of the *Quercion* are generally infrequent or absent. The nodum scores highest for W17b in the Match and Sin analyses and apart from the over-represented constant species does not deviate greatly from the unit as defined in the NVC. Nodum B comprises those stands which characterize the ‘sparse’ ground flora of spruce plantations. The distribution of stands spans both regions and all soil types, indicating a convergence in ground flora in these high spruce cover stands. The seven constants remain but no other species achieves constancy; herb cover is low but bryophyte cover remains moderate. In the most impoverished stands (endgroup 0101) even bryophyte cover falls to an average of 13%, with the mean number of species per quadrat declining to 11; *Dicranum scoparium* is much reduced whilst *Isopterygium elegans* achieves constancy (Appendix 2). On mineral soils (endgroup0100) affinity with W10e is maintained through constant *Dryopteris felix-mas* and frequent *Blechnum* and *Oxalis acetosella.* The highest canopy cover of spruce in the samples studied is 65%: at higher covers light penetration decreases to an extent such that vascular ground cover is virtually eliminated and the litter supports only sparse cover of a few mosses. Under these conditions no true community can develop.

Nodum C is particularly problematical in having characteristics of both W17c and W11a accompanied by a suit of species characteristic of flushed ash/alder woodlands. The unit is restricted to mineral soil profiles of spruce/birch mixtures and birch thickets, largely on formerly wooded sites in the Highlands. Nodum D is more firmly placed in the *Quercion* with ferns and herbs more characteristic of lower altitude oak-birch woodlands, although here again bryophyte species are over-represented and the distinction between W11a and W10e is blurred (Appendix 3a). The geographic distribution of stands of the four noda is shown in Figure 2.

First rotation stand types

Endgroups derived from the analysis of first rotation stands in northern Britain were tested against units of the NVC, continental plantation noda and the four noda derived from the analysis of second rotation spruce/birch.

In all cases the 'fit' to the second rotation noda was closer than to NVC or other plantation woodland noda (Appendix 3b). Of the two spruce-dominated endgroups, one scored equally for Nodum A and W17b and although floristically very similar to the NVC unit the low herb cover (2%) suggests recognition of at least a forest variant of W17b for this unit. The species-poor, spruce-dominated, first rotation stands were remarkably similar to those of their second rotation counterparts (nodum B); the main discrepancy being the lower frequency of *Eurhynchium praelongum* and absence of *Pleurozium schreberi* in the first rotation stands (Appendix 2). In the highlands the 'fit' of spruce/birch mixtures to nodum A was remarkably close, and far outscored that of W17b. The placing of stands on the better drained mineral soils of the borders was less clearcut; the distinctive forest effect was apparent in high scores for the forest noda B and D but *Plagiothecium undulatum* and *Dicranum scoparium* were less frequent and convergence to W10e was suggested. A group of four stands approaches the Pinewood Vaccinium-Calluna association of McVean and Ratcliffe (1962).

Comparison with other studies

Kielder and the Borders

Species diversity in these stands was very low (averaging 7 –13 per releve); *Thuidium tamariscinum* and *Eurhynchium praelongum* were poorly represented whilst *Lepidozia reptans* and *Calypogeia muelleriana* were more prevalent than in the Scottish samples (Good *et al* 1990). However, three groups of thinned and unthinned sitka spruce on peaty gleyed soil profiles at middle altitudes (240-280m) could be accommodated within the species-poor nodum (nodum B) of the second rotation study whilst a forth, comprising stands at higher altitudes on deeper peat profiles, was closer to Nodum A due largely to retention of more elements of the original wet heath vegetation, notably *Vaccinium myrtillus, Molinia caerulea* and *Calluna vulgaris*. Thinned broadleaved / spruce mixtures with a grassy ground cover could be satisfactorily placed within W11a. Thus, it seems that the second rotation noda can accommodate much of the species-poor 'no-fit' vegetation of the Borders forests (Appendix 3c and 4).

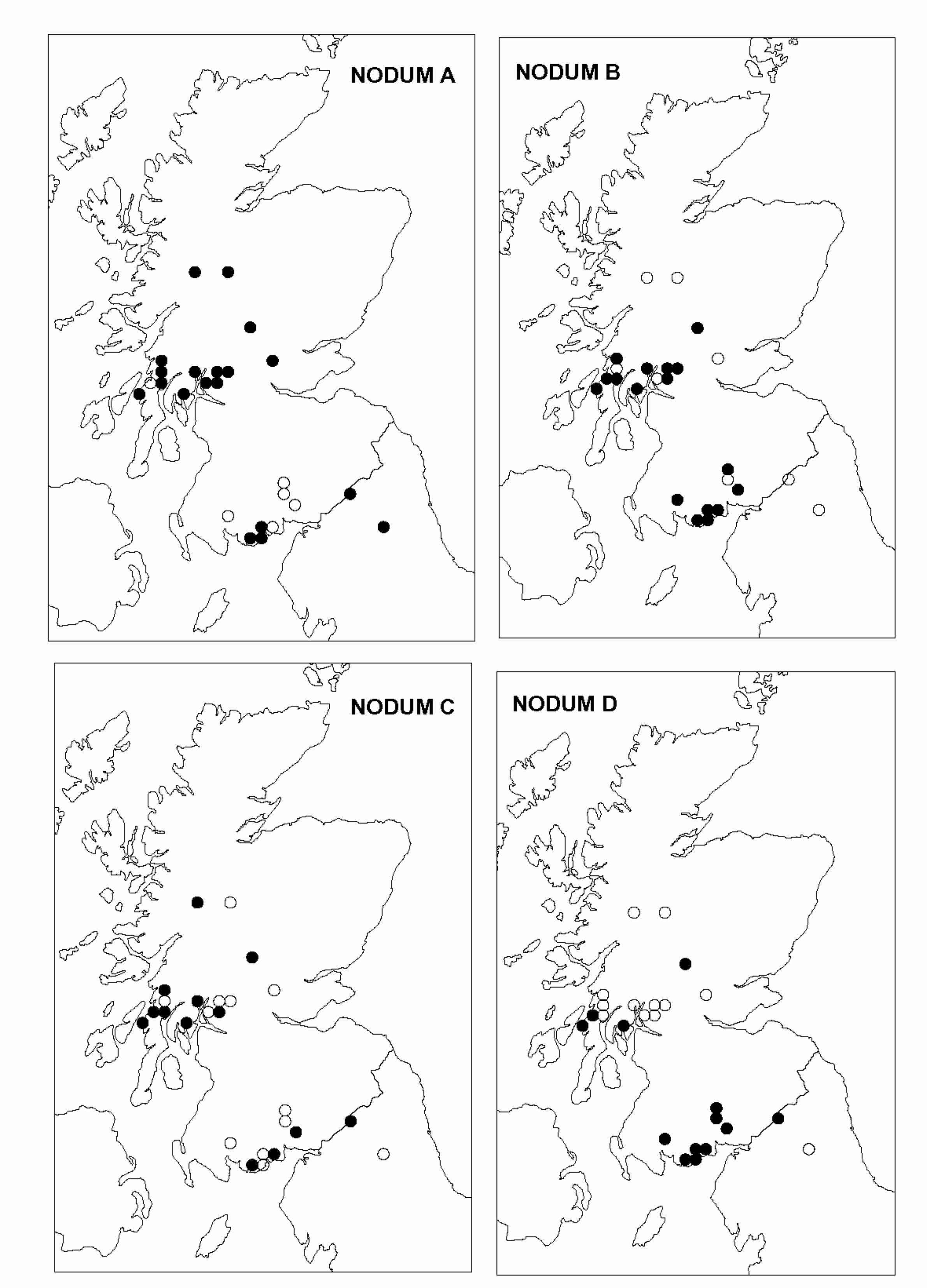

Figure 2.

Knapdale

The 24 year old second rotation samples fitted poorly to both the forest noda and sub-communities of the NVC; though the floristic composition seems very similar to that of the species-poor forest nodum B. *Eurhynchium, Thuidium and Dryopteris dilatata* were both frequent but, in contrast, *Polytrichum formosum, Rhytidiadelphus loreus* and *Isopterygium elegans* were also constant. The 44 year old first rotation stands were closer to forest nodum B than any NVC unit, with all seven constant species present at constancy III or higher; in the older stands low species diversity and forb cover still suggest nodum B as the best fit despite the higher frequencies of *Dryopteris borreri, Vaccinium myrtillus, Deschampsia flexuosa* and *Oxalis acetosella (Appendix 3d).*

Discussion

Both the sparse grass and herb cover, and the ruderal nature of many of those species which do colonise, restrict the range of NVC woodland units which could be expected in plantation forests. Fully developed stands of both W17c and W11a are rare; being largely restricted to well thinned stands or those with extensive colonization of broadleaved species (Wallace 1998). Conversely, the suit of bryophyte species which characterise the spruce stands do not represent a coherent group indicative of either *Vaccinio-Pinion* or *Quercion robori* woodlands but include species capable of growing in dense shade with rapidly accumulating acidic litter fall. *Hypnum jutlandicum* and *Lophocolea bidentata* have been noted frequently for their success in spruce plantations whilst *Plagiothecum undulatum* is successful in the shade of woodland and under dense *Calluna* on heaths. The colonization of *Eurhynchium praelongum* and *Thuidium tamariscinum* suggests an amealioration of the surface conditions of the wetter peaty substrates whilst the frequency of liverworts, especially in second rotation stands, reflects the increase in dead wood surfaces supplied by tree stumps and the very low light compensation requirements of many of these species (Rheinheimer 1957). Locally these stumps also provide colonization sites for lichens. Some species, notable *Pleurozium schreberi,* appear less able to withstand the increasing litter accumulations; *Dicranum majus* and *Rhytidiadelphus loreus* are both more frequent on formerly wooded sites (Wallace, in prep).

Inclusion of noda from McVean and Ratcliffe and from Dutch plantations in the SIN analysis failed to elucidate further the placing of these stands other than to confirm that, in general, they appeared closer to the units of the *Quercion* than to the *Vaccinio-Pinion*. Only nodum A, lacking many *Quercion* species is suggestive of the link between the two orders (scoring second highest for W18e in the SIN analysis) there has however been little colonization by species distinctive of the *Vaccinio-Pinion*. Further samples from the central highlands might well provide more convincing convergence towards the *Vaccinio-Pinion*. The species-poor unit (B) had some affinities with the Dutch ‘Romp’ (=species-poor) unit, the *Holcus-Dryopteris* in the *Quercion-roboris* whilst nodum D has tendencies towards W10, in the *Carpinion betuli* (Stortelder *et al* 1999).

These results suggest the recognition of a planted forest community for those stands with sparse ground cover, in which herbs are scarce but where there is often an extensive cover of a restricted suite of bryophytes characteristic of shade conditions (Nodum B). The only constant vascular species is *Dryopteris dilatata* though *Blechnum spicant, Oxalis acetosella, Deschampsia flexuosa, Vaccinium myrtillus* and *Dryopteris felix-mas* may be locally frequent. The unit occurs principally on mineral soil profiles and more frequently in the west. The extension of this vegetation onto more humic soil profiles in the highlands is seen in nodum A where, under high spruce cover, the herb cover is low and frequent *Sphagnum* spp. contribute to a distinctive ground cover.

With an increase in the broadleaved element of the canopy stands come closer to defined broadleaved woodland units and may be seen as plantation variants of these in which some species characteristic of the forest noda remain over-represented. The flushed mineral stands seem best placed within a W17c whilst deeper mineral soils of the Borders are tending towards W10e. A species-poor forest nodum distinct from W10e occurs in the deepest shade.

At present all the newly defined units fall within the Quercion-Robori, though some endgroups in nodum A come close to W18e and suggest that with increased sampling in the eastern highlands more convincing examples of the *Vaccinio-Pinion* are likely to be recorded.

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Appendix 1. Synoptic table for second rotation managed stands

Nodum	**A**		**B**		**C**		**D**		**Full**	
Endgroup	1		01		001		0000	+0111		
Betula pubescens (c)	V	8	V	8	V	9	V	9	V	9
Picea sitchensis (c)	V	9	V	9	V	8	IV	10	V	10
Sorbus aucuparia (c)	II	5	I	4	I	5	II	5	I	5
Salix cinerea (s)	I	4			II	5	I	5	I	5
Corylus avellana (s)					I	7			I	7
Alnus glutinosa (c)					I	7			I	7
Salix caprea (c)					I	5			I	5
Acer pseudoplatanus (c)					I	4	I	4	I	4
Larix sp. (c.)							I	5	I	5
Hypnum jutlandicum	V	7	V	7	V	7	V	5	V	7
Dryopteris dilatata	V	4	V	4	V	5	V	6	V	6
Plagiothecium undulatum	V	4	V	5	V	4	V	4	V	5
Lophocolea bidentata	V	4	IV	4	V	4	V	4	V	4
Dicranum scoparium	V	5	IV	4	V	5	IV	4	V	5
Mnium hornum	III	4	V	5	V	4	V	6	IV	6
Thuidium tamariscinum	IV	7	IV	7	V	8	III	5	IV	8
Eurhynchium praelongum	II	4	IV	5	V	6	V	6	IV	6
Deschampsia flexuosa	IV	5	II	4	III	5	III	7	III	7
Blechnum spicant	IV	4	III	4	IV	2	II	2	III	4
Pleurozium schreberi	IV	5	II	5	II	4	I	1	II	5
Vaccinium myrtillus	IV	7	II	5	I	1	II	1	II	5
Molinia caerulea	III	6	I	1	I	4	I	1	II	7
Calluna vulgaris	III	8	I	5	I	5			I	5
Betula pubescens (g)	III	4	I	1	II	1	I	1	I	3
Sphagnum palustre	II	5	I	3	I	5	I	1	I	5
Hypogymnia physodes	II	1	I	1	I	1	I	1	I	1
Cladonia squamosa	II	1	I	1	I	1	I	1	I	1
Sphagnum capillifolium	II	6	I	1	I	3			I	4
Picea sitchensis (g)	II	2	I	2					I	2
Erica cinerea	I	5							I	5
Cladonia chlorophaea	I	1							I	4
Cladonia pyxidata	I	1							I	1
Erica tetralix	I	1							I	1
Sphagnum fimbriatum	I	5							I	5
Cladonia digitata	I	1							I	1
Cladonia macilenta	I	1							I	1
Oxalis acetosella	II	3	III	5	IV	5	IV	5	III	5
Deschampsia cespitosa	II	5	I	4	V	5	IV	9	II	9
Rubus fruticosus agg.	II	4	II	1	III	4	IV	4	III	4
Digitalis purpurea	I	1			III	2	III	2	II	2
Dryopteris filix-mas	II	5	II	4	V	5	III	5	III	5
Luzula pilosa	II	4	II	4	IV	2	II	5	II	5
Plagiochila porelloides			I	1	III	4			I	4
Cirsium palustre					III	4	II	2	I	4
Viola riviniana					III	2	I	1	I	1
Nowellia curvifolia	I	1	I	2	II	2			I	2
Platismatia glauca	I	1			II	1	I	1	I	1
Plagiomnium undulatum			I	1	II	4	I	1	I	4
Ajuga reptans					II	4			I	4
Raunculus repens					II	2			I	2
Primula vulgaris					II	1			I	1
Chrysosplenium oppositifolium					I	3			I	3
Galium palustre					I	1			I	1
Equisetum sylvaticum					I	4			I	4
Hypericum pulchrum					I	1			I	1

Nodum	A		B		C		D		Full	
Agrostis canina					I	4			I	4
Hookera lucens					I	2			I	2
Carex nigra					I	2			I	2
Angelica sylvestris					I	1			I	1
Luzula multiflora					I	1			I	1
Cirriphyllum piliferum					I	1			I	1
Eurhynchium striatum					I	4			I	4
Lysimachia nemorum					I	1			I	1
Rhizomnium punctatum					I	4			I	1
Metzgeria furcata					I	1			I	1
Fraxinus excelsior (g)					I	1			I	1
Holcus lanatus	II	5	I	2	III	4	IV	5	II	5
Athyrium filix-femina	I	2	I	1	II	5	III	4	II	5
Brachythecium rutabulum			I	1	II	4	III	2	I	2
Lonicera periclymenum (g)	I	4	I	4	I	3	II	3	I	4
Cladonia coniocraea	I	1	I	1	I	1	II	1	I	1
Holcus mollis	I	4			I	4	II	7	I	7
Corydalis claviculata			I	1			II	4	I	4
Teucrium scorodonia							I	2	I	2
Stachys sylvatica							I	1	I	1
Fagus sylvatica (g)							I	1	I	1
Agrostis vinealis	IV	6	II	5	IV	5	III	4	III	6
Pseudoscleropodium purum	III	4	II	5	III	4	III	4	III	5
Rhytidiadelphus squarrosus	III	4	II	3	III	4	III	4	III	4
Hypnum cupressiforme	II	8	III	3	III	4	III	4	III	4
Polytrichum formosum	III	5	II	5	III	5	II	2	III	5
Sorbus aucuparia (g)	III	2	II	2	III	4	I	1	III	2
Galium saxatile	III	4	I	3	III	3	II	3	II	3
Dicranum majus	III	6	III	5	II	3	I	1	II	6
Hylocomium splendens	III	7	II	5	III	5	I	1	II	7
Rhytidiadelphus loreus	III	5	II	4	III	5	I	1	II	4
Polytrichum commune	III	6	II	4	III	5	II	5	II	4
Isopterygium elegans	I	1	II	2	I	2	II	4	II	4
Lepidozia reptans	II	3	II	4	II	3	I	1	II	4
Calypogeia muelleriana	II	3	II	2	I	1	I	2	II	3
Pteridium aquilinum	II	7	II	6	I	4	II	5	II	6
Dicranella heteromalla	I	3	II	1	I	2	II	1	II	3
Juncus effusus	II	3			II	4	II	4	I	4
Potentilla erecta	II	2	I	1	II	1	II	2	I	2
Rubus idaeus	I	1	I	1	II	1	II	4	I	4
Isothecium myosuroides	I	2	I	4	II	4	I	4	I	4
Agrostis capillaris	I	4	I	4	II	4	II	4	I	4
Cardamine flexuosa			I	2	II	1	II	4	I	4
Carex binervis	I	4	I	1	I	2	I	1	I	2
Luzula sylvatica	I	5	I	2	I	4			I	5
Sphagnum recurvum	II	7	I	5	II	6	I	4	I	7
Ilex aquifolium (g)	I	1	I	1			I	1	I	1
Viola palustris	I	3			I	2	I	2	I	3
Quercus seedling/sp	I	1	I	1	I	1			I	1
Rhytidiadelphus triquetrus	I	4	I	1	I	4			I	4
Hyacinthoides nonscripta	I	2	I	2	I	4	I	4	I	4
Diplophyllum albicans	I	4	I	4	I	2			I	4
Anthoxanthum odoratum	I	5	I	2	I	2	I	4	I	4
Atrichum undulatum			I	1	I	2	I	2	I	2
Oreopteris limbosperma	I	3			I	3			I	3
Carex echinata	I	2			I	1			I	2
Scapaina gracilis	I	4			I	1			I	4
Scapania nemorosa	I	3			I	1			I	3
Epilobium palustre					I	2	I	1	I	2
Sphagnum subnitens	I	3	I	2					I	3
Rhododendron ponticum			I	1	I	4			I	4

Nodum	**A**		**B**		**C**		**D**		**Full**	
Sphagnum squarrosum			I	5	I	2	I	1	I	5
Pellia sp			I	2			I	1	I	2
Dryopteris borreri	I	5			I	4	I	3	I	5
Carex echinata	I	2			I	1			I	2
Chamerion angustifolium					I	1	I	1		
Hedera helix (g)					I	1	I	4	I	4
Number of samples	59		57		37		34		185	
Mean species per sample	30		21		38		27		28	
Mean crop age (years)	19		21		21		19		20	
Canopy cover (total %)	66		76		69		76		72	
Canopy cover - Birch (% cover)	31		23		37		50		33	
Canopy cover – Sitka Spruce (% cover)	34		54		24		24		36	
Sub shrub cover (%)	10		5		5		1			
Herb cover (%)	21		8		29		36		22	
Bryophyte cover (%)	48		30		51		28		39	
Slope (degrees)	8	(0-27)	11	(0-40)			12	(0-28)		
Altitude (metres)	85	(10-320)	83	(10-230)	88	(5-230)	101	(5-220)	91	(5-320)
% of samples with a history of ancient woodland	16		18		54		15			
% of samples in Highland region	89		61		87		20			
% samples on mineral soils	28		58		77		62			

Appendix 2. Synoptic table for second and first rotation managed stands of the forest nodum (B)

Rotation	2		2		2		1	
Endgroup	0100		1010		0110		001	
Betula pubescens (c)	V	7	V	7	V	8	III	8
Picea sitchensis (c)	V	9	V	9	V	9	V	9
Sorbus aucuparia (c)	I	4					III	4
Hypnum jutlandicum	V	4	V	3	V	6	V	5
Dryopteris dilatata	V	3	IV	4	V	4	IV	4
Plagiothecium undulatum	V	4	III	4	V	5	V	4
Lophocolea bidentata	III	2	IV	2	V	4	IV	4
Dicranum scoparium	IV	2	I	1	V	4	II	2
Mnium hornum	V	4	IV	5	V	4	IV	5
Thuidium tamariscinum	V	6	III	6	IV	6	IV	4
Eurhynchium praelongum	IV	4	IV	4	IV	5	II	4
Deschampsia flexuosa	II	2			IV	4	II	4
Blechnum spicant	IV	2	I	1	III	4	II	3
Pleurozium schreberi	II	4			II	6		
Vaccinium myrtillus	II	3			III	5	II	1
Sphagnum palustre					I	1	II	3
Sphagnum capillifolium	I	1					II	1
Picea sitchensis (g)	I	1					II	4
Oxalis acetosella	V	5	III	4	III	2	II	6
Rubus fruticosus agg.	I	1	I	1	II	1	I	1
Dryopteris filix-mas	IV	4	II	2	I	1	I	2
Luzula pilosa	III	2			III	4	I	1
Teucrium scorodonia							I	1
Hypnum cupressiforme	IV	3	II	1	III	3	II	4
Dicranum majus	IV	4			III	5	I	1
Isopterygium elegans	III	2	IV	2	I	2	III	3
Pseudoscleropodium purum					IV	5		
Agrostis vinealis	II	4	I	1	II	5	I	2
Rhytidiadelphus squarrosus	I	1	I	1	II	3	I	1
Polytrichum formosum	II	5	I	1	III	3		
Sorbus aucuparia (g)	II	1	I	1	III	2	II	1
Galium saxatile	I	1			II	1		
Hylocomium splendens	II	3			II	5	I	1
Rhytidiadelphus loreus	II	4	I	1	III	4		
Polytrichum commune	III	4	I	2	I	1	I	5
Lepidozia reptans	II	3	I	1	III	4	II	2
Calypogeia muelleriana	II	2	II	2	II	2	II	4
Pteridium aquilinum	II	4	II	2	II	6		
Dicranella heteromalla			I	1	III	1	II	2
Isothecium myosuroides	I	2	II	1	I	1	I	4
Ilex aquifolium (g)	II	1			I	1		
Diplophyllum albicans	II	4	I	1			I	1
Number of samples	20		13		24		30	
Mean species per sample	21		11		20		14	
Mean crop age (years)	21		24		20		39	
Canopy cover (total %)	79		80		76		74	
Canopy cover - Birch (% cover)	19		13		32		14	
Canopy cover – Sitka Spruce (% cover)	57		65		48		64	
Herb cover (%)	7		4		10		5	
Bryophyte cover (%)	32		13		35		19	
Altitude (metres)	79		84		84		118	
% of samples with a history of ancient woodland	50		16		20		17	
% of samples in Highland region	95		23		58		37	
% samples on mineral soils	80		54		46		17	

Appendix 3a. SIN scores for the four proposed forest noda; all communities scoring 2.75 or higher included

	A	B	C	D
W11a	2.58	2.97	**2.75**	**2.86**
W17a	3.36	2.85	2.22	1.76
W17b	**4.09**	**3.34**	2.44	1.98
W17c	3.08	3.31	2.46	2.28
W17d	2.88	2.53	2.07	2.05
W18e	3.46	2.54	2.21	1.94
W4a	2.94	2.55	2.26	2.10
W10e	2.38	3.12	2.48	**2.85**

Appendix 3b. Sin scores for first rotation forest endgroups; all units scoring >2.75 included

Endgroup	000	001	01	10
A	**4.13**	3.14	**9.23**	2.60
B	3.89	**7.89**	4.16	**6.39**
C	3.04	3.21	4.87	4.49
D	2.25	4.08	3.12	**5.39**
W11a	1.41	2.74	2.49	3.89
W17a	3.94	3.65	2.04	2.19
W17b	**4.04**	2.82	4.10	2.19
W17d	1.91	2.00	3.28	1.96
W18e	2.71	2.01	3.17	1.96
W10e	1.02	2.37	2.70	**5.23**

Appendix 3c. SIN scores for first rotation unthinned and thinned/mixed stands at Kielder and other border forests (data of Good *et. al* 1990) against the proposed forest noda and the NVC

	KU1	KU2	KU3	KU4	KU5
Second rotation:					
Nodum A	***3.37***	1.57	2.64	3.03	2.37
Nodum B	2.31	***2.20***	***4.87***	***4.79***	2.44
Nodum C	1.76	1.30	2.03	3.89	2.43
Nodum D	1.85	1.79	2.20	3.83	2.65
NVC:					
W11a	1.72	1.83	1.82	1.96	***3.04***
W17a	2.09	1.70	1.81	1.74	1.62
W17b	2.73	1.71	2.18	1.87	1.38
W17c	1.59	1.83	1.61	1.70	1.78
W17d	2.57	1.67	1.39	1.45	1.52
W10e	1.89	1.71	1.83	1.01	2.11

Appendix 3d. SIN scores for sitka spruce crops at Knapdale, southern Scotland (Data of Humphries, unpublished)

Age (years)	24	44	62
Rotation	2	1	1
Second rotation:			
Nodum A	0.95	3.11	2.22
Nodum B	0.94	***3.59***	2.12
Nodum C	0.76	2.02	1.67
Nodum D	0.85	1.99	1.82
NVC:			
W11a	***1.52***	1.44	1.83
W17a	0.84	2.01	1.75
W17b	0.96	2.21	***2.45***
W17c	1.08	2.02	1.76
W17d	0.98	1.45	1.96

Appendix 4. Summary of the floristic composition of the unthinned (KU1 and KU2) and thinned first rotation endgroups from Kielder/Southern Scotland. All constant species in the proposed forest noda together with additional species present at constancy III or higher in the first rotation endgroups included. (Data of Good *et. al*. 1990.)

	KU1		KU2		KU3		KU4		KU5	
Number of samples	51		49		18		15		9	
Hypnum jutlandicum	III	5	II	5	V	5	V	5	III	4
Dryopteris dilatata	II	4	II	3	IV	4	IV	3	V	7
Plagiothecium undulatum	V	8	V	10	V	6	V	7	III	4
Lophocolea bidentata	III	7	II	6	IV	4	III	4	IV	5
Dicranum scoparium	IV	5	II	4	III	3	V	4		
Mnium hornum	I	1	II	3	IV	3	IV	7	V	5
Thuidium tamariscinum			I	4						
Eurhynchium praelongum			II	5	II	3			II	3
Deschampsia flexuosa	IV	6	I	4	I	3	III	5	IV	6
Pleurozium schreberi	IV	5					I	5		
Vaccinium myrtillus	V	4	II	3	II	3	III	4	II	5
Molinia caerulea	III	9	I	1			II	2	II	3
Calluna vulgaris	III	7					I	6	III	2
Betula pubescens (g)					I	2				
Lepidozia reptans			III	4	IV	3				
Calypogeia muelleriana			III	5	III	3	I	2	II	2
Rubus fruticosus									IV	8
Luzula pilosa									IV	4
Gallium saxatile	II	4	I	1					IV	3
Agrostis capillaries			1	1			1	1	IV	4
Holcus mollis									III	8
Carex binervis									III	2
Sphagnum recurvum	III	6	I	9			I	2		
Rhytidiadlphus loreus	III	7	I	4	II	3				
Polytrichum commune	III	4	I	4	II	3	III	4	V	5
Oxalis acetosella			I	2					III	5
Sorbus aucuparia (c)					I	1			III	3
Mean species/sample	14		7		13		13		20	

2.2 Use of the National Vegetation Classification (woodland section) for site assessment in British plantation forests

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Summary

Increased emphasis in British forestry is currently being placed on the sustainability of management practices and the conservation and restoration of biodiversity. All forest operations should thus be supported by an accurate understanding of site ecology. The Ecological Site Classification provides a consistent methodology for the description of forest sites in terms of major ecological variables – climate, soil moisture regime and soil nutrient regime. The species composition of forest ground vegetation is used as a diagnostic field indicator of soil nutrient regime in many parts of the world. A study was undertaken at a range of plantation forests to derive the most effective methods for using ground vegetation for this purpose in Great Britain. The use of the woodland section of the National Vegetation Classification (NVC) was compared with a simpler visual classification of dominant vegetation types under plantations. Use of the NVC was made difficult by the low diversity of the ground vegetation in some plantations. It was reliable for sites of low or high soil fertility, but it failed to discriminate between some more mesic sites naturally associated with oak and beech woodland vegetation. A more precise approach was based on the use of species indicator values to calculate a site "score" for soil fertility, and this method has been adopted for use within the Ecological Site Classification. The site assessments produced can be used to predict ecological suitability for establishment of tree species or for restoration of specific NVC woodland communities. This should aid the ecological planning of new native woodlands on open land and the restoration of PAWS (plantations on ancient woodland sites), both of which are required under the UK Woodland Habitat Action Plans (HAPs).

Introduction

Recent years have seen increasing emphasis placed on the sustainability of forest management practices and on the conservation and restoration of forest biodiversity in Great Britain. These priorities are enshrined in both the UK Forestry Standard (Forestry Commission 1998) and the UK Woodland Assurance Scheme (2000). Particular importance has been attached to the expansion of the area of native species woodland, both by establishment of new native woodland on open land (Rodwell and Patterson, 1994) and by restoration of native woodland in place of plantations on ancient woodland sites (PAWS). Habitat Action Plans (HAPs) for a variety of native woodland types have been published (Department of the Environment 1996).

Ecologically appropriate forest management requires an holistic understanding of site ecology, considering a wider range of site attributes than those relating to productivity. The Forestry Commission has developed an Ecological Site Classification (ESC), which provides a consistent methodology for describing forest sites in terms of major ecological variables, including climate – warmth and wetness, soil moisture regime (SMR) and soil nutrient regime (SNR). This system is intended to inform forest management decisions, particularly species selection, both on bare land and within existing woodlands, including plantations. The ESC is currently being brought into use and is reported in detail by Pyatt and Suarez (1997), Pyatt *et al* (2001) and Wilson *et al* (1998, 2001). A computer decision-support package for the ESC has recently been produced by the Forestry Commission (Ray 2001).

Of the site parameters included within the ESC, soil nutrient regime is the most difficult to reliably assess in the field, as it is, in fact, a complex of individual chemical variables. Most major forest regions in Continental Europe and North America utilise ground vegetation species composition as a diagnostic indicator of SNR, usually taken together with soil type and humus type. However the majority of such systems have used vegetation classifications developed within a natural or semi-natural forest context. The majority of woodland in Great Britain is of recent plantation origin, using tree species which are not native to the site. It has been widely recognised that the ground vegetation assemblages that have developed to date under such plantations differ from those in remnant semi-natural woodlands in having lower species diversity and being dominated by a small number of common plant species that can colonise rapidly (Peterken 1993).

A study was undertaken in a wide range of plantations during 1995 and 1996 to assess the feasibility of using ground vegetation as an indicator of SNR under British forest conditions. The woodland section of the National Vegetation Classification (NVC) (Rodwell, 1991) provided one possible framework for characterising the ground vegetation in plantation forests. However it was developed for use in British semi-natural woodlands with differing vegetation conditions and as such is not readily applicable in many plantations. Hence it was compared with two other approaches to vegetation analysis (a) a simpler visual categorisation of dominant plantation vegetation types and (b) the use of species indicator values to produce a quantified soil nutrient “score” for each site by means of an abundance-weighted averaging approach.

Methods

Soil chemistry and ground vegetation species composition were studied at 70 plantation forest sites throughout Great Britain during the field seasons of 1995 and 1996. The sites were selected in mature plantations of a number of conifer and broadleaf tree species where sufficient ground vegetation had developed for adequate survey. The range of sites included examples of most of the major soil types used for forestry in Great Britain. It was difficult to include young conifer plantations on upland sites where ground vegetation tends to be sparse or absent. Approximately half of the study sites were in plantations which had been established on land that had previously carried semi-natural woodland or wooded scrub – broadly corresponding to the PAWS definition.

The soil type and profile were recorded in a soil pit using the standard Forestry Commission method (Pyatt *et al* 2001). The soil was also sampled volumetrically to a depth of 50 cm using a mechanised coring apparatus at 5 to 9 locations spaced across each site. The stone fraction of the soil was determined by weight. Soil samples were analysed in the laboratory for pH, moisture content, organic matter content, calcium, magnesium, potassium, phosphorus and nitrogen (organic and mineral).

The vascular vegetation species composition at each site was recorded in 5 to 9 2m x 2m quadrat relevees coincident with the soil core sampling points. Field, herb and shrub layers were recorded separately using estimated absolute cover fraction to quantify abundance. The ground vegetation was assigned to the “best fit” NVC woodland community using the constancy tables provided by Rodwell (1991). The application of computer software packages to this “matching” process was attempted, but it did not offer any perceived advantage as compared with the use of constancy tables, given the technology then available. It was generally not possible to take the NVC allocation to sub-community level, due to the low species diversity of the vegetation. Once all sites had been sampled, a simpler categorisation of 10 “visually dominant vegetation types” of plantation forests was devised, and each site then allocated to one of these categories by examining only the few most abundant plant species.

The vegetation species abundance data was also used to produce abundance-weighted soil nutrient indicator values for each site, using the species indicator values provided by Ellenberg (1988). These species indicator values attempt to characterise the ecological preferences of plant species growing under natural competition. The R-values (soil base status) and the N-values (soil nitrogen fertility) were used, each on a scale from 1 to 9. The Ellenberg (1988) values were developed for use in Central Europe, but a set of revised values for use in Britain, based on these, have recently be produced by Hill *et al* (1999, 2000). These can now be used in place of the original Ellenberg (1988) values.

A variety of computer-based multivariate statistical methods were employed to relate the soil chemical analysis results to the species composition of the ground vegetation at each study site. These included Principal Components Analysis (PCA), Canonical Correlation Analysis (COR), Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA). A single major gradient of soil nutrient regime was identified upon which all of the sites could be ordinated. A comparison was then carried out to establish which method(s) of describing the ground vegetation allowed for the most reliable prediction of site position on this gradient.

Fuller details of the scientific methods employed in this work are presented by Wilson (1998) and Wilson *et al* (2001), together with appropriate bibliography.

Results

Use of the National Vegetation Classification

All study sites were allocated to a single “best-fit” NVC woodland community. Table 1 shows the allocation of sites. Examples of NVC woodland communities W4, W7, W8, W10, W11, W14, W16, W17 and W18 were included, which are felt to be the major types occurring within plantations generally. No examples of W1, W2, W3, W5, W6, W9, W12 or W15 were identified within the plantation sites examined – of these only W9 might be expected to play a widespread role in British plantation forests.

Allocation of ground vegetation assemblages to NVC woodland communities using constancy tables varied noticeably in difficulty between the study sites. It was generally straight-forward for infertile upland sites dominated by ericaceous vegetation (W18) and for very fertile lowland sites with abundant calcicole and nitrophile species such as *Mercurialis perennis* and *Urtica dioica* (W8). It was therefore felt that NVC description alone in most plantations would allow the reliable identification of Very Poor and Very Rich sites in the terms of the Ecological Site Classification.

Table 1 Freqency distribution of study sites in terms of NVC community and dominant vegetation type

	W18	W4	W17	W16	W11	W10 W14	W8	
A	7							7
B		1						1
C			4	3				
D		1		6	4	1		12
G					3	3		6
F			1		11	5		17
E					2	5		7
H						6	1	7
I							3	3
J							3	3
	7	2	5	9	20	20	7	70

A similar position applies to the recognition of Rich sites characterised by species-diverse W10 ground vegetation, although this depends to a greater extent on ecological conditions within the plantation. Most examples of this type identified were mature broadleaf or mixed plantations on ancient woodland sites, with ground vegetation approaching the semi-natural condition. It might be more difficult to detect Rich sites where the diversity of the vegetation had been markedly suppressed by heavy canopy shade under conifers. Some poorer W10 assemblages appear to grade into W11 under plantation conditions.

For sites of low to moderate fertility, allocation to the NVC oak-birch woodland communities W11, W16 and W17 was much less straight-forward. This is primarily due to the lower vegetation species diversity encountered within such plantations, and the resulting concentration of cover fraction on a small number of common plant species that are found on the constancy tables for all of these communities. Identification of upland W17 sites with a Poor soil nutrient regime is often possible where these are dominated by *Deschampsia flexuosa.* However separation of Poor and Medium sites dominated by one or more of *Pteridium aquilinum*, *Rubus* spp, *Oxalis acetosella, Dryopteris* spp., *Agrostis spp* and *Holcus* spp. is often not possible based on NVC constancy table analysis alone. Many plantations on these sites have a ground vegetation species list of only a few such ecologically plastic species, and characteristic indicator species for W11, W16 and W17 are frequently entirely absent. In upland plantations, especially in Scotland, the distinction between W11 and W17 sites appears to be very difficult to discern indeed.

Figure 1 shows the ordinated ranges of occurrence of the main NVC woodland communities in terms of SNR, based on the plantation sites studied. The bars show the mean SNR occupied. The gradient of SNR is that defined from Canonical Correspondence Analysis based on combined analysis of the soil chemical and species abundance data. More detailed discussion of this gradient and its derivation is provided by Wilson *et al* (2001). This ordination of NVC woodland communities against SNR in plantations can be compared their with observed site preferences under semi-natural conditions, as discussed by Wilson (2003) in this volume.

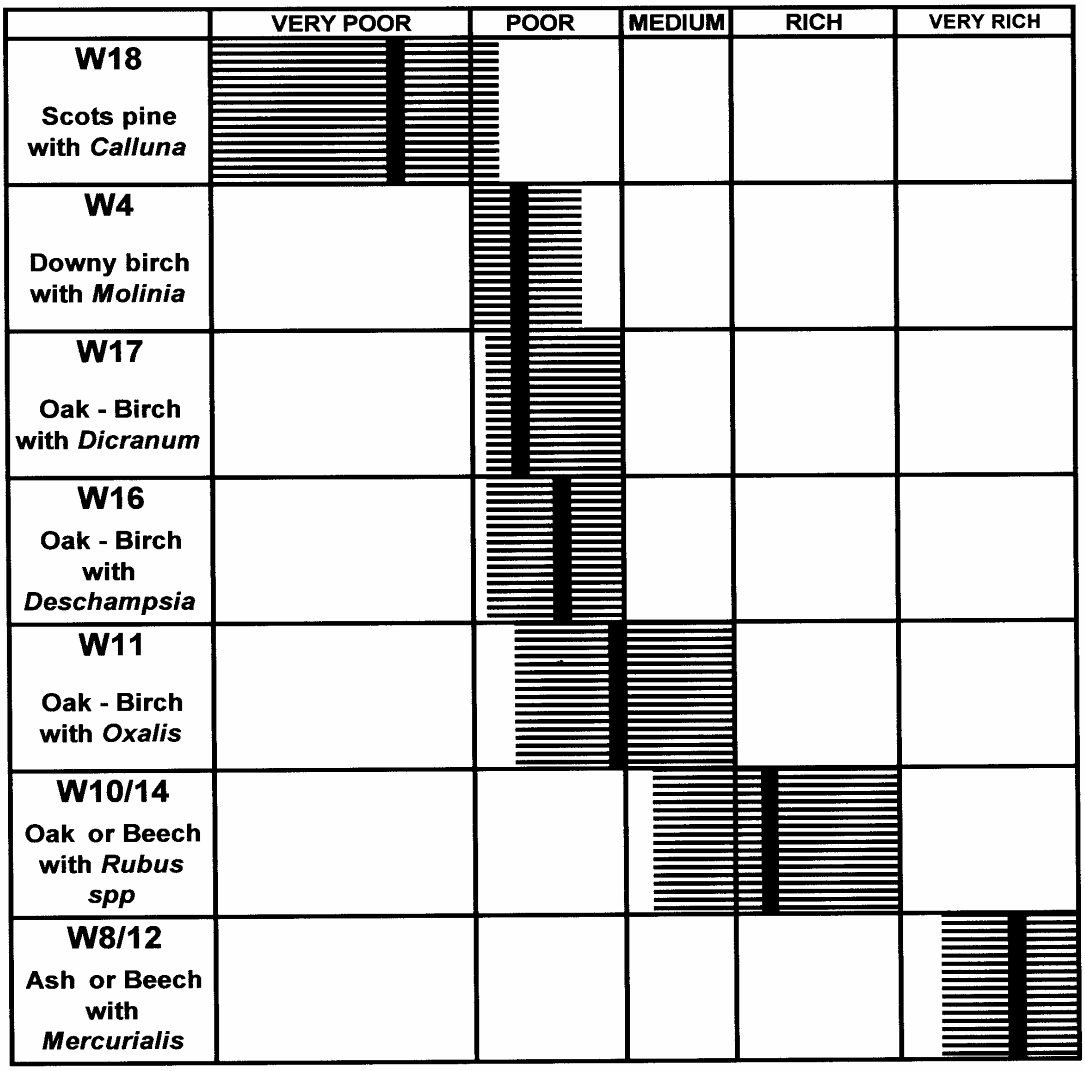

Figure 1. Occurrence of selected NVC woodland communities in relation to soil nutrient regime

Use of visually-dominant vegetation types of plantation forests

An attempt was made to produce from within the current dataset, a scheme of vegetation classification for use in plantations that would be simpler to use than the woodland NVC. A 10 category scheme was produced by subjective means, using the visually dominant ground vegetation species as a guide. These ten categories could also be termed "noda" or "ideal types" of plantation forest ground vegetation. It is likely that further categories would be required to describe plantation vegetation conditions not encountered at any of the sites studied for this work, hence the total number needed remains very uncertain.

Table 2 compares the categories derived with the "corresponding" NVC communities, and attempts to rank these in terms of SNR. It can be seen that there is a very strong relationship between these categories and the woodland NVC, particularly at either end of the soil fertility spectrum. There might, however, be some advantage in using these categories to more readily discriminate between mesic sites dominated by *Pteridium*, *Rubus*, *Oxalis*, *Dryopteris* and *Agrostis/ Holcus* vegetation.

Table 2 Dominant ground vegetation types in British plantation forests and corresponding National Vegetation Classification woodlands

Type	Characteristic species	Corresponding NVC woodlands
A	*Calluna vulgaris, Erica* spp.	W18 Scots pine with *Calluna vulgaris*
B	*Molinia caerulea*	W4 Downy birch with *Molinia caerulea*
C	*Deschampsia flexuosa*	W15 Beech with *Deschampsia flexuosa* W16 Oak - Birch with *Deschampsia flexuosa* W17 Oak - Birch with *Dicranum majus*
D	*Pteridium aquilinum*	W16 Oak - Birch with *Deschampsia flexuosa*
G	*Agrostis* spp./*Holcus* spp.	W11 Oak - Birch with *Oxalis acetosella*
F	*Rubus* spp./*Dryopteris* spp/ *O. acetosella*	W11 Oak - Birch with *Oxalis acetosella*
E	*Rubus fruticosus* (+ *Pteridium aquilinum*)	W10 Oak with *Rubus fruticosus* W14 Beech with *Rubus fruticosus*
H	Species rich ground vegetation	W10 Oak with *Rubus fruticosus*
I	*Mercurialis perennis*	W8 Ash – field maple with *Mercurialis perennis* W12 Beech with *Mercurialis perennis*
J	*Urtica dioica*	W7 Alder with *Urtica dioica* W8 Ash – field maple with *Mercurialis perennis*

Use of soil nutrient indicator values

The multivariate statistical analyses demonstrated that it was possible to produce reliable and accurate assessments of site SNR using a quantitative “score” derived from abundance-weighted averaging of species indicator values for soil factors.

Using the original set of species indicator values (R and N) provided by Ellenberg (1988), a species-environment correlation of r = 0.89 was achieved, with the SNR gradient defined using the output of the Canonical Correspondence Analysis. The site “score” (mR) used is, in fact, simply the abundance-weighted mean of the species Ellenberg R-values (soil base status). It is expected that this method can be further refined for British conditions by use of the revised indicator values, based on those of Ellenberg, produced by Hill *et al* (1999, 2000).

The Canonical Correspondence Analysis also allows the production of a set of species “scores” from within the present dataset. Use of these “scores” allows the species-environment correlation to be increased to r = 0.94. However, reliable species indicator values based on these “scores” are only available for those plant species encountered at several of the study sites – a list of 40-50 species were present on at least 10% of these. These values and their derivation are reported by Pyatt *et al* (2001) and Wilson *et al* (2001). Additional field-work was carried out in upland Scotland during 2001 to increase the number of indicator species for the Very Poor soil nutrient regime, which is very important in plantation forests. Results of this work are currently in preparation.

Groups of the main indicator species for each dass of SNR can be used for “rapid appraisal” of sites, where it is not possible to carry out detailed quadrat vegetation survey.

Discussion and conclusions

This work has confirmed that ground vegetation in plantation forests is strongly indicative of soil quality and, in particular, of soil nutrient regime. Hence it can be used as one tool for site assessment within the Ecological Site Classification. However the ecological conditions within plantations, particularly young stands consisting of shade casting conifer species, affect the composition and diversity of the ground vegetation. This implies that it may not be optimal to apply a system of vegetation description, such as the National Vegetation Classification (woodland section), which has been developed primarily for use in the context of ancient semi-natural woodland. The major difficulty encountered is the absence, within plantations, of many characteristic plant species that are required to differentiate between NVC woodland communities and sub-communities. The evidence collected suggests that an approach based on quantitative indicator species analysis is likely to be the most effective for the purposes of Ecological Site Classification. This has the advantage of using the ecological preferences of all of the species present and their relative abundance to inform soil quality assessments. The use of a qualitative system of dominant vegetation categories or indicator species groups has potential as a supporting or "rapid appraisal" technique, but is inherently less precise.

The National Vegetation Classification is likely to remain a potentially effective system of vegetation description for site assessment in semi-natural contexts, both within woodlands and on open planting land of grassland, heathland and mire types. For this reason it is important to continue to develop our understanding of the site preferences of the various NVC communities involved, by observation of their natural patterns of occurrence (Wilson 2003). Such understanding will support the effective and sustainable restoration of NVC woodland communities both on open land and in place of existing plantations on ancient woodland sites (PAWS).

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3. Interpretation, prediction and modelling with NVC

3.1 Linking the NVC woodlands to the Ecological Site Classification

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Summary

Refining the soil information within the National Vegetation Classification (NVC) could help to explain the habitat inter-relationships between communities. Modified Ellenberg indicator values for plants are used to calculate mean values for three soil factors from the floristic lists of each NVC woodland sub-community, the indicator values being weighted by species frequency. The mean Hill-Ellenberg F value (moisture) is used as a measure of soil moisture regime, the mean R (reaction) and N (nitrogen) values are combined as a measure of soil nutrient regime. Ecological Site Classification (ESC) uses climate, soil moisture regime and soil nutrient regime to characterise site types. Woodland sub-communities displayed on axes of F and R+N are linked to the 'soil quality grid' formed from gradients of moisture and nutrient regimes. The distribution of sub-communities on the soil quality grid reveals their ecological similarities and differences including overlaps and gaps in coverage. Suggestions are made as to the soil conditions where additional communities may be worthy of recognition within lowland, upland and sub-alpine climatic zones.

Introduction

The NVC is not just a classification of British plant communities; the supplementary information presented on climatic and topographic factors and soil types of the *habitats* at both the community and sub-community levels takes it into the realm of a classification of site types (Rodwell 1991). The summary of the NVC woodlands by Whitbread and Kirby (1992) provides a simplified view of the geographical and soil relationships between the main communities. The Ecological Site Classification (ESC) devised for the assessment and management of land for forestry (Pyatt and Suárez 1997; Pyatt *et al* 2001) may provide an appropriate site classification. This paper attempts to link the NVC to ESC to provide more precise information on the soil moisture and nutrient conditions associated with each woodland community.

ESC combines three principal factors: climate, soil moisture regime and soil nutrient regime, although recognising that each of these is multi-factorial. Soil moisture regime is defined by wetness class (or depth to winter water-table) and by soil droughtiness. The definition of soil nutrient regime includes pH, nitrogen and other nutrients (Wilson *et al* 2000). Within each climatic zone the eight classes of soil moisture regime (Very Dry, Moderately Dry, Slightly Dry, Fresh, Moist, Very Moist, Wet, Very Wet) and the six classes of nutrient regime (Very Poor, Poor, Medium, Rich, Very Rich, Carbonate) form a so-called soil quality grid.

Ellenberg indicator values are a subjective scoring system reflecting the site ‘preferences’ shown by plants in their natural habitats, ie when growing (competing) with their associates (Ellenberg 1988; Ellenberg *et al* 1992). Scores (mostly on an integer scale of 1 to 9) are provided for several site factors: light, temperature, continentality, soil moisture, soil reaction (acidity) and soil nitrogen. The values can be applied, with appropriate weighting for abundance or frequency, to the species list of a plant community to estimate the site conditions under which the community is growing. Recently, Hill *et al*. (1999) have adjusted Ellenberg values for the plants that grow in Britain based on actual and summarised vegetation quadrat data from British sources.

This paper uses the Hill-Ellenberg values separately for the three soil factors, F – moisture, R – reaction (acidity), N – nitrogen, to locate the habitats of NVC woodland sub-communities on the soil quality grid of ESC. The sub-communities are then stratified according to ESC climatic zones. This presentation is based on a forthcoming detailed paper (Pyatt, In prep.)

Methods

Weighting the indicator values

Weighted mean values of the three soil factors F, R and N have been calculated for each floristic list. For each factor the Hill-Ellenberg value assigned to each species is weighted according to its frequency class. A species with a frequency of V receives a weight of 5, IV a weight of 4, III a weight of 3, and II a weight of 2. Species with a frequency of I are given a weight of 0.5 in an attempt to lessen the bias introduced by species present in very few samples. The sum of the products (Hill-Ellenberg value x weight) is divided by the sum of the weights to give the mean value for that factor for the sub-community.

Climatic factors

The main climatic gradients influencing the floristic composition of British woodlands can be summarised as warmth (heat energy or temperature), wetness (the balance between precipitation and evaporation) and continentality/oceanicity (the difference between summer and winter temperatures and the length of the growing season). ESC defines seven climatic zones by a combination of accumulated temperature above 5.0 ^{o}C and potential soil moisture deficit (Pyatt *et al* 2001). The data are derived from the recording period 1961-1990. The ESC map of continentality uses an index based on the range of annual temperature.

Results and discussion

Distribution of woodland sub-communities on the ESC soil quality grid

The definitions of soil nutrient regimes in ESC emphasise pH and the supply of NO_3-nitrogen. In British woodland soils derived from most types of lithology these variables are broadly related; there is normally an increase in the availability of nitrogen and a progressive switch from NH_4-N to NO_3-N as pH increases from 3.0 to about 7.0 (Hawkes *et al* 1997; Wilson *et al* 2000). Therefore the R and N values for each sub-community are combined to create a gradient equivalent to soil nutrient regime. This simple trend breaks down when the pH is above about 7.5. These shallow rendzina soils, with finely dispersed calcium carbonate in the topsoil, have much lower availability of nitrogen and some other nutrients and are placed in the Carbonate class of nutrient regime. Many plants tolerant of Carbonate soils have been given smaller Ellenberg N values (albeit with high R values) than plants typical of Very Rich or Rich soils.

Appendix 1 shows the distribution of sub-communities on scales of F and R+N (termed ‘soil nutrients’) using the Hill-Ellenberg values. No attempt has been made to show the Carbonate class of nutrient regime.

For extra clarity on Appendix 1 the woodlands are allocated to five groups based on floristic similarities and soil quality. The method of locating the scales of F and R+N on the ESC soil moisture and nutrient axes is described by Pyatt (In prep.).

Relationships with climate

Rodwell (1991) defined the lowland zone as having a mean annual maximum temperature of 26° C or above, and mean annual precipitation below 1000 mm. The area encompassed by the Warm Dry and Warm Moist zones of ESC is similar to Rodwell and Patterson’s (1994) lowland zone, but is less extensive in the east and more extensive in the west. Their upland zone is equivalent to the Cool Moist, Warm Wet and Cool Wet zones of ESC. Trends in climatic wetness or continentality are often revealed in the number of bryophytes or ferns in the floristic list. The W17 *Quercus-Betula-Dicranum* woodlands are outstanding in their number of bryophytes and, to a lesser extent, ferns. In this respect there is a similarity between the two upland communities W17 and the W18 *Pinus-Hylocomium* woodlands. The other upland woodlands W11 *Quercus-Betula-Oxalis* and W9 *Fraxinus-Sorbus-Mercurialis* are floristically nearer to the lowland W10 *Quercus-Pteridium-Rubus* woodlands
.

Rodwell (1991) treated certain pairs of communities viz. W8/W9, W10/W11, W16/W17 as lowland/upland equivalents in terms of soil conditions. The present method suggests that W8 occurs on Very Rich soils while W9 is more typical of Rich; W10 occurs on Rich but W11 is linked to Medium; W16 and W17 do both occur on Poor to Medium soils. Rodwell (1991) described W18 as the sub-alpine equivalent of W16 and W17, but not only is the W18 soil poorer than W16 or W17 but also all three woodlands lie within the ESC Cool wet (upland) zone rather than in the Sub-alpine.

Communities and the ESC soil quality grid

Whitbread and Kirby (1992) made a primary distinction between ‘wet woodlands’ (W1-W7) and ‘dry woodlands’ (W8-W19) and this is supported by the ordination of Figure 1. The dry woodlands straddle the Fresh to Moist classes of moisture regime where the soils would be freely draining or only slightly impeded. The wet woodlands lie across the Moist to Wet classes, where rooting depth would be restricted by poor aeration above a fluctuating water table.

The fit of F values to the soil moisture scale shown in Appendix 1 seems satisfactory between the classes of Fresh and Very Wet. The method cannot provide much information about moisture classes drier than Fresh, because so few woodland plants have indicator values less than 5. According to ESC, several communities occur in the drier parts of the lowlands where the soil moisture regime is Slightly Dry or even Moderately Dry. Therefore it must be accepted that there is a large range of soil moisture regime within several of the ‘dry’ woodlands.

The W18 *Pinus sylvestris* is the only woodland characteristic of the Very Poor class of soil nutrient regime. The *Quercus-Betula* woodlands, W17 and W11 in the uplands and

W16 in the lowlands, occur across the Poor to Medium classes and overlap in soil quality. The other community often dominated by *Quercus* is the lowland W10 *Quercus-Pteridium-Rubus*. The sub-communities of W10 lie within the Medium to Rich classes and do not overlap even with those of W11. The upland 'mercury woodland' W9 *Fraxinus-Sorbus-Mercurialis* falls within the Rich class whereas the lowland equivalent, W8 *Fraxinus-Acer campestre-Mercurialis,* lies mainly in Very Rich.

Each of the three communities of *Fagus* woodland is equivalent in terms of soil quality to one (or more) of the *Quercus* or *Fraxinus* woodlands. Thus W12 *Fagus-Mercurialis* has a slightly drier moisture regime but a similar nutrient regime to the W8 *Fraxinus* woodland. These *Fagus* woods occur on shallower soils, usually on steeper slopes than the *Fraxinus* woods, at least within the natural range of *Fagus sylvatica* in southern England (Rodwell 1991; Whitbread and Kirby 1992). The *Fagus* equivalent of the lowland *Quercus* wood W10 is the W14 *Fagus-Rubus* woodland. It has no sub-communities, but is located in the middle of the range of the W10 sub-communities. The W15 *Fagus-Deschampsia flexuosa* community has four sub-communities which span Poor to Medium nutrient regimes, overlapping the W11 and W16 *Quercus* woods. In terms of geographical spread, however, the overlap is more with the lowland W16 than with the upland W11.

Although the Carbonate class of nutrient regime is not shown on Figure 1, inspection of mean R and N values suggests that at least one of the sub-communities of *Fagus* woods (W12c) and both of the *Taxus* woods (W13a and W13b) may occur on soils exemplifying this class.

Are NVC sub-communities sufficiently 'pure'?

The use of the composite floristic lists in this work has highlighted the subject of variation within sub-communities. The floristic lists contain a long 'tail' of species with frequency class I. The question arises, 'Are these species truly representative of the sub-community, or do they represent atypical 'inclusions' of other site types and sub-communities?' The long tail is by no means restricted to woodlands, it is present also in sub-communities of grasslands, heaths and some mires. Nevertheless, the large size of woodland quadrats (50 x 50 m) compared with those used for non-woodland vegetation (2 x 2, 4 x 4 or 10 x 10 m) might be responsible for greater heterogeneity of site conditions in woodland sub-communities. The greater structural complexity of woodlands compared to shorter vegetation might create a wider diversity of niches, but this need not necessarily extend the tail of low frequency species, it might simply increase the total number of species in a sub-community.

The question can probably not be answered without examining the individual samples of vegetation in relation to their site conditions.

Distribution of communities in terms of ESC components

According to Appendix 1 there are several apparent overlaps between communities in terms of both soil moisture and nutrient regimes. It must however, be borne in mind that the third, climatic, component of ESC is not shown on Appendix 1. Appendix 2 to 5 show the communities stratified into 'lowland', 'upland' and sub-alpine zones. The area of the soil quality grid 'occupied' by the sub-communities is used as a guide to the size of the rectangle shown, along with the general assumption that all communities will occupy an area equivalent to at least one cell of the grid. In the lowland zone the overlap between *Fagus* and *Quercus/Fraxinus* woodlands is so wide that for clarity they have been shown separately on Appendix 2 and 3. Lowland *Alnus* and *Salix* woodlands are arbitrarily separated for similar reasons.

It is clear that the difference between *Fagus* and *Quercus/Fraxinus* woodlands in the lowlands must be floristic and geographical (perhaps climatic) rather than one of soil quality. Much of the floristic difference is due to the greater shade cast by *Fagus* than *Quercus* or *Fraxinus* (Rodwell 1991). Within each of these broad groups there are no appreciable overlaps, although substantial parts of the soil quality grid are unoccupied. The *Salix* W1 community appears to occupy similar soil quality to the *Alnus* W1, the latter also overlapping with the W5 *Alnus* community.

In the upland zone (Appendix 4) there is a substantial overlap of nutrient regime between the W17 and W11 *Quercus-Betula* communities. While all the W17 sub-communities are clearly associated with the Poor class, some of the W11 sub-communities extend the community from Medium into Poor. There is an overlap between the *Salix* W3 and W7 *Alnus-Fraxinus* communities. In the sub-alpine zone (Figure 5) there is a substantial overlap between the *Juniperus* W19 and the *Salix* W20 communities. In practice, however, the former has a wide extension into the upland zone whereas the latter is so rare that we hardly know its full potential.

According to Appendix 1 the ‘dry woodlands’ of Whitbread and Kirby (1992) occupy a narrow range of soil moisture regime. On Appendix 2 and 3, however, I have suggested the lowland woods have a range of 2 to 3 classes of moisture regime. If this is so, there might be a case for splitting at least the *Quercus-Betula* communities into ‘Fresh’ and ‘Moist’ types.

Other communities with broad ranges of either nutrient or moisture regime or both include W15 *Fagus*, W4 *Betula*, W6 *Alnus* and W2 *Alnus*. Each of these could be considered for splitting, either by allocation of existing sub-communities to different communities or by a more radical re-classification.

Scope for recognising additional communities

There is scope for finding new communities in currently unoccupied parts of the soil quality grid. In the lowland zone (Appendix 2 and 3) there is a large unoccupied area of the grid in the place occupied, in the uplands, by W4 *Betula pubescens* and W7 *Alnus-Fraxinus*, namely the Very Moist and Wet/Poor and Medium. Of course, it may be that W4 and W7 actually extend to the lowlands, so there is no gap other than in my diagram! There is a dearth of woodland sub-communities on Carbonate soil nutrient regime. On the continent of Europe there are several woodland or scrub types here, including some containing *Pinus sylvestris*.

In the upland zone (Appendix 4) there is an unoccupied area of the grid in Very Poor/Very Moist-Wet. This is where one would expect to find ‘bog woodlands’ of *Pinus*. Perhaps also there should be a woodland containing or even dominated by *Pinus* on Very Dry sites of Poor or Medium nutrient regime. Such soils are provided by the more basic igneous and sedimentary rocks.

In the sub-alpine zone (Appendix 5) our native woodland coverage is so depleted that it is perhaps not surprising to see most of the soil quality grid unoccupied. In Very Poor nutrient regime one could hope to see a *Betula nana* community on Wet moisture regime and perhaps upwards extensions of bog *Pinus* woodland on Very Moist and of W18 on

Fresh-Moist. On slightly better ground a sub-alpine equivalent of W4 *Betula pubescens* ought to occupy at least the lower or more sheltered parts of the zone.

Conclusions

Linking the NVC woodlands to the multi-dimensional ESC classification of sites has offered ideas for redefining, including splitting, some existing communities and for adding communities where the coverage of site types seems to be deficient. This has been made more precise by first stratifying the communities into three zones based on ESC climatic factors.

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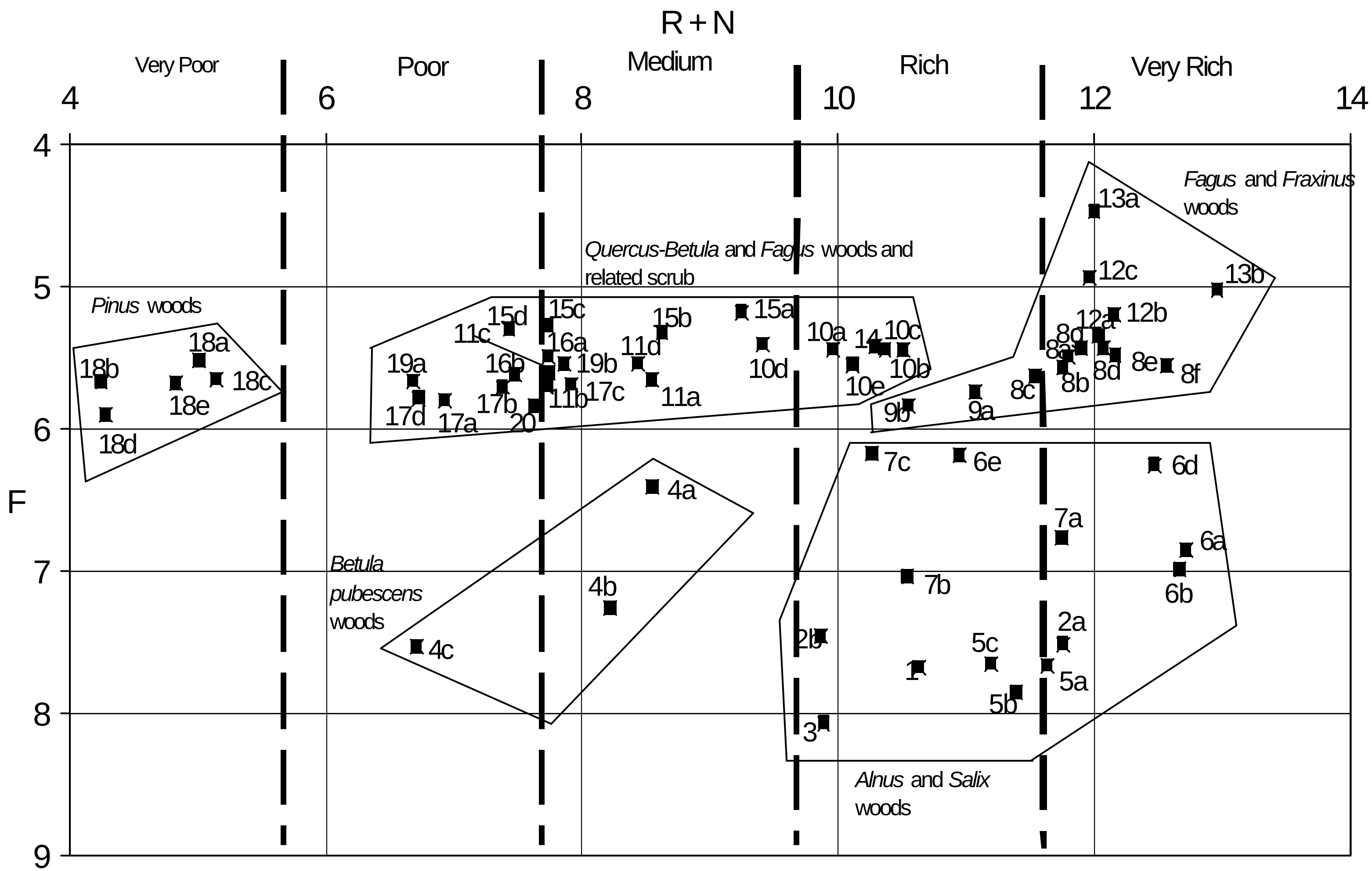
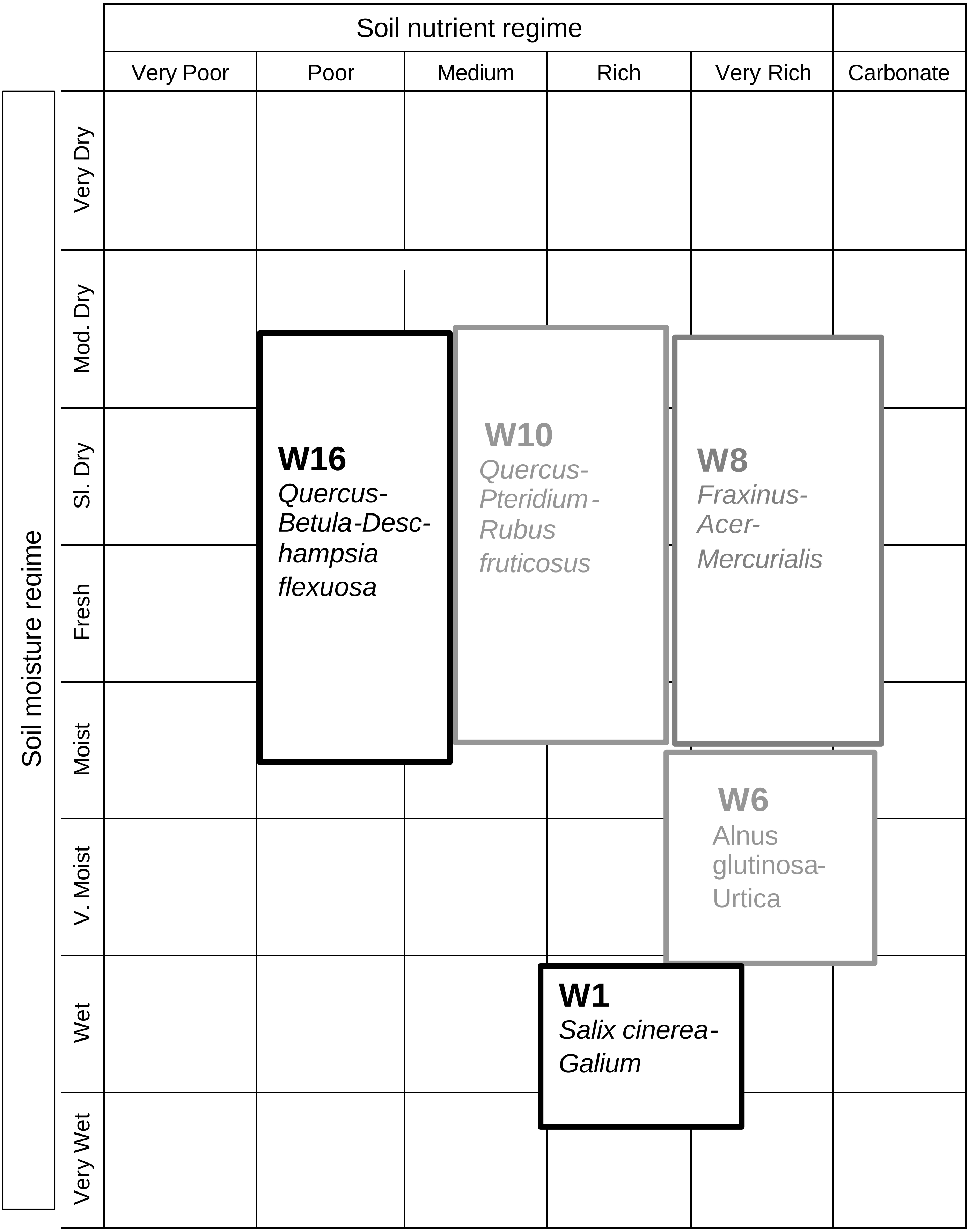
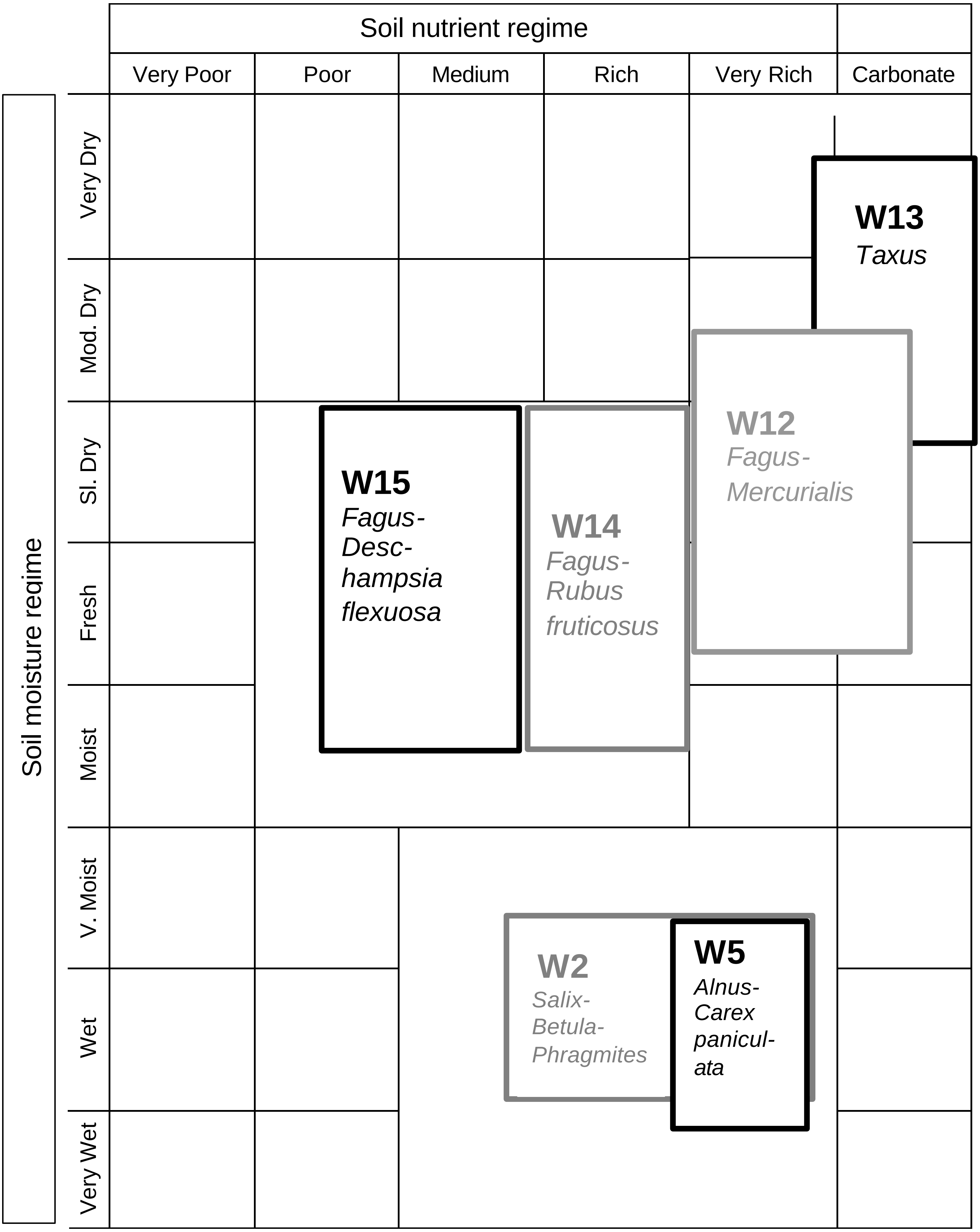


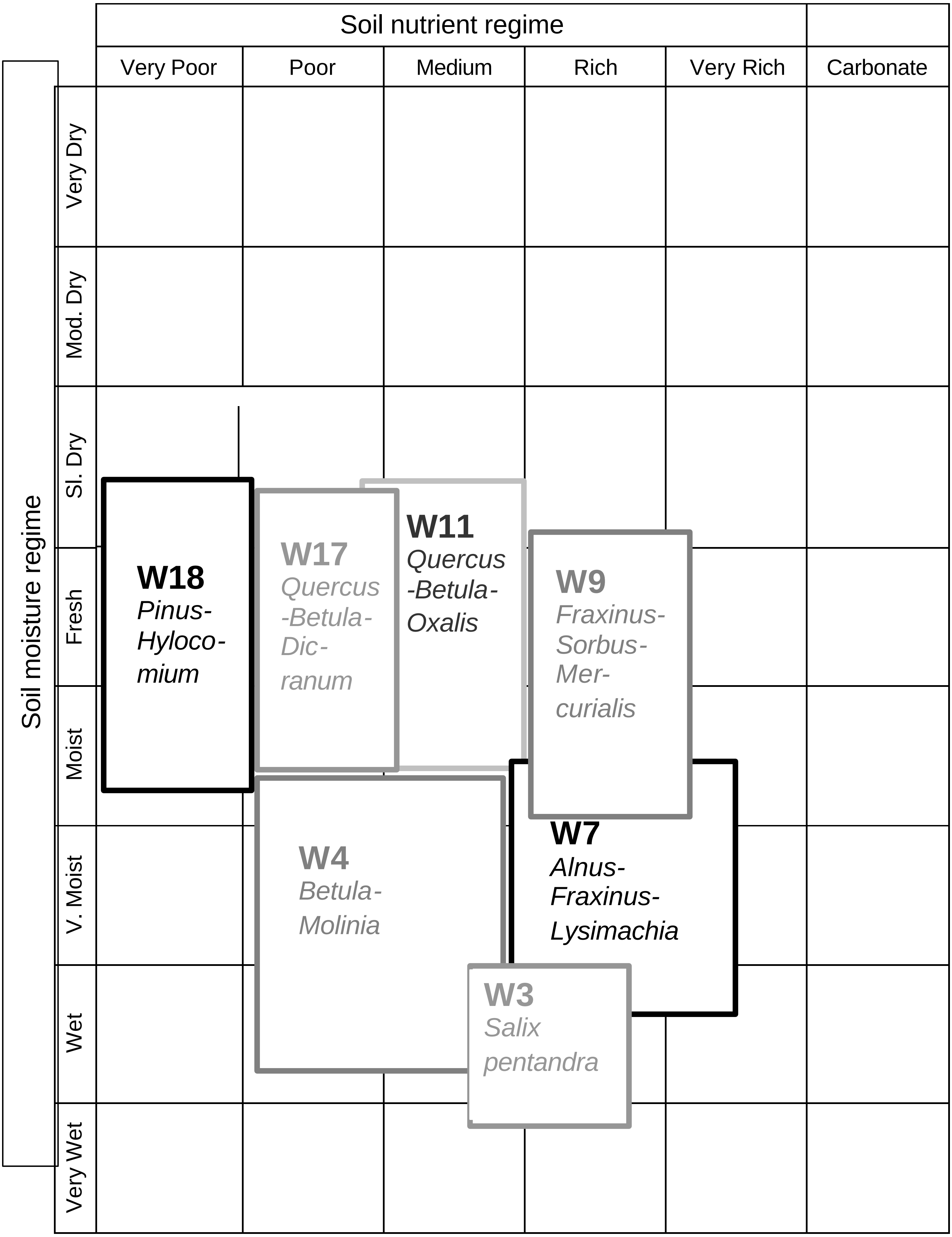
Appendix 1. Ordination of sub-communities of NVC woodlands W1-W20 on scales of Hill-Ellenberg F (soil moisture) and R+N ('soil nutrients'). Class boundaries for ESC nutrient regime are shown by thick broken lines. Class boundaries for ESC moisture regime are at F values of 4.5, 5.5 and so on.



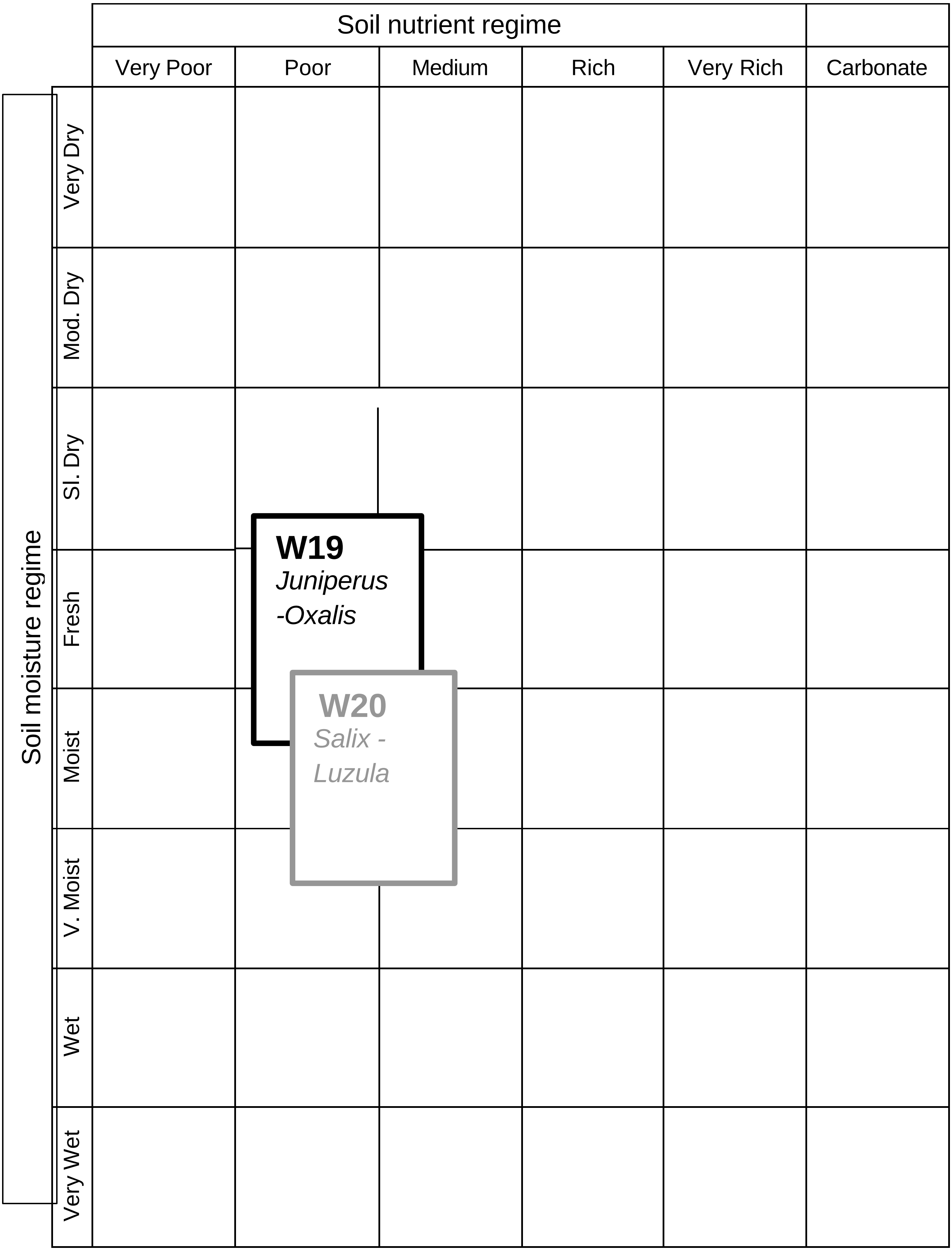
Appendix 2. Very suitable soil quality for NVC *Quercus-Betula*, *Fraxinus* and *Alnus* woodlands in the ESC Warm dry and Warm moist climatic zones (the 'Lowland zone' of Rodwell and Patterson 1994).



Appendix 3. Very suitable soil quality for NVC *Fagus*, *Taxus* and *Alnus* woodlands in the ESC Warm dry and Warm moist climatic zones (the 'Lowland zone' of Rodwell and Patterson 1994).



Appendix 4. Very suitable soil quality for NVC woodlands in the ESC Warm wet, Cool moist and Cool wet climatic zones (the 'Upland zone' of Rodwell and Patterson 1994).



Appendix 5. Very suitable soil quality for NVC scrub woodlands in the ESC Sub-alpine climatic zone (the 'Upland juniper zone' of Rodwell and Patterson 1994).

3.2 Predicting National Vegetation Classification (NVC) woodland suitability using the Ecological Site Classification (ESC) Decision Support System (DSS)

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Summary

The NVC woodland section is used widely by forest managers, and is likely to remain the main classification system of Britain's native and semi-natural woodland communities. New forest policy targets for the expansion and restoration of woodland require the potential of native woodland communities to be assessed on agricultural, moorland and plantation sites. ESC-DSS has been designed as a tool to facilitate sustainable forestry practice by matching tree species and woodland communities to site conditions. This paper describes the procedure using a case study site in the Forest of Dean.

Policy

Government forestry policy, described and expressed in the forestry strategy documents for England (Forestry Commission 1999a), Scotland (Forestry Commission 1999b) and Wales (Forestry Commission 2001) aims to increase the area of sustainably managed woodland in Britain as a resource for timber production, biodiversity conservation, recreation and public amenity.

Since the mid 1990s there has been a steady change in the targeting and uptake of woodland grants with an emphasis on native and broadleaved woodlands. Broadleaved planting has increased by an order of magnitude in 5 years to approximately 10,000 ha per year since 1995, with many new native woodland schemes (Rollinson in press).

Use of NVC in forestry

In comparison to central Europe and North America, forest classification in Britain has been late in development. This may be due to the relatively small proportion of land cover as woodland in Britain (Forestry Commission 1998), the absence of natural forests, and the preoccupation of British ecologists with process and function (Peterken 1993). The National Vegetation Classification (NVC) (Rodwell 1991) has been accepted as the main classification system for semi-natural woodlands by voluntary and statutory organisations, woodland owners and agents (Hall and Kirby 1998). Nineteen woodland communities and 6 scrub communities of native species are recognised.

In planning new native woodland it is convenient to use the NVC (Rodwell 1991) as a model of the range of woodland types and their semi-natural distribution in Britain; the method was outlined by Rodwell and Patterson (1994). The NVC can be difficult to use under certain circumstances, for example, where existing vegetation is heavily modified or non existent (e.g. under conifer stands) or where non-wooded communities predominate (e.g. on managed arable, pasture and moorland sites). On such sites the optimal precursor vegetation, as described by Rodwell and Patterson, may be depleted or absent, making the link between site and an NVC woodland community difficult to ascertain. To help overcome this problem, Rodwell and Patterson (1994) suggest that topography, terrain type, soil and lithology can help with the selection of suitable native woodland communities but the choice is often difficult. The Ecological Site Classification provides an objective method to investigate these influences.

The ESC model

Ecological Site Classification Decision Support System (ESC-DSS) has been designed to predict suitable NVC woodland communities for a given site (Pyatt *et al* 2001, Ray; 2001). It contains a set of climate models which calculate: Accumulated Temperature, Moisture Deficit, Windiness and Continentality (Figure 1) at a resolution of 100x100m (1 ha) from the input site location information. Soil quality, i.e. Soil Moisture Regime (SMR) and Soil Nutrient Regime (SNR), default values are ascribed by ESC-DSS from the selected soil type (Figure 1). When more detailed information such as: soil texture, stoniness and tree rooting depth, humus form and plant indicator species is available for a given site, a more precise estimate of soil quality can be made leading to a better prediction of the NVC woodland community.

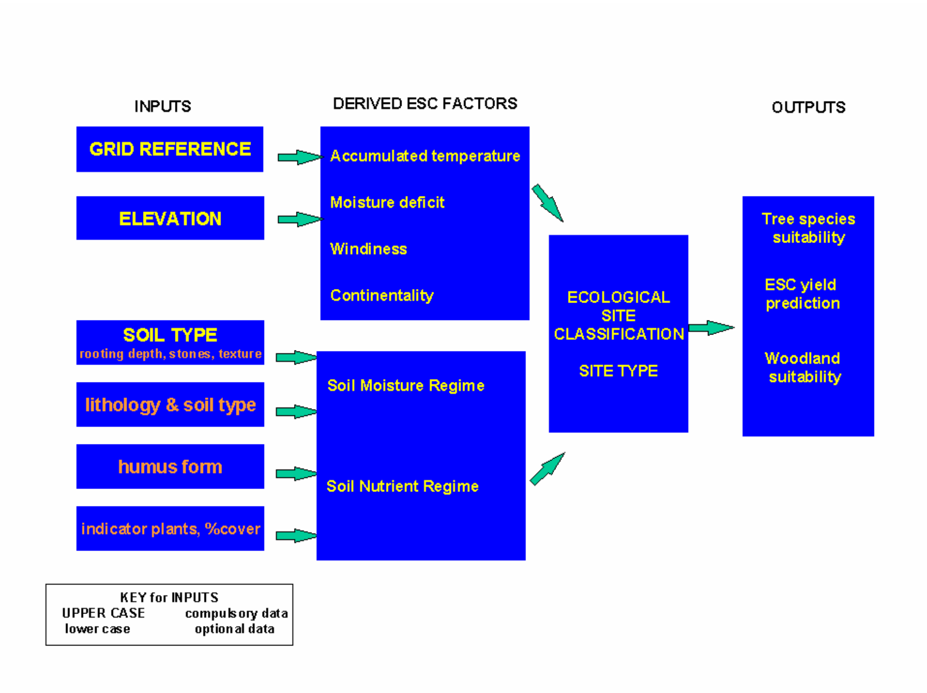

Figure 1. Flow of information through ESC-DSS

ESC-DSS makes links between climate factors and the distribution and range of woodland communities described by Rodwell (1991) while referring to the climatic preference of the main tree species associated with each community (Pyatt *et al* 2001). The soil quality link between ESC and the NVC has been made through use of the moisture (F value), reaction (R value) and nitrogen (N value) defined by Ellenberg (1988), and modified for British conditions by Hill *et al* (1999), for species of vascular plant in the sub-community floristic list of Rodwell (1991). This allows an ordination of NVC sub-communities on the ESC soil quality grid, as described in more detail in this report (Pyatt 2001).

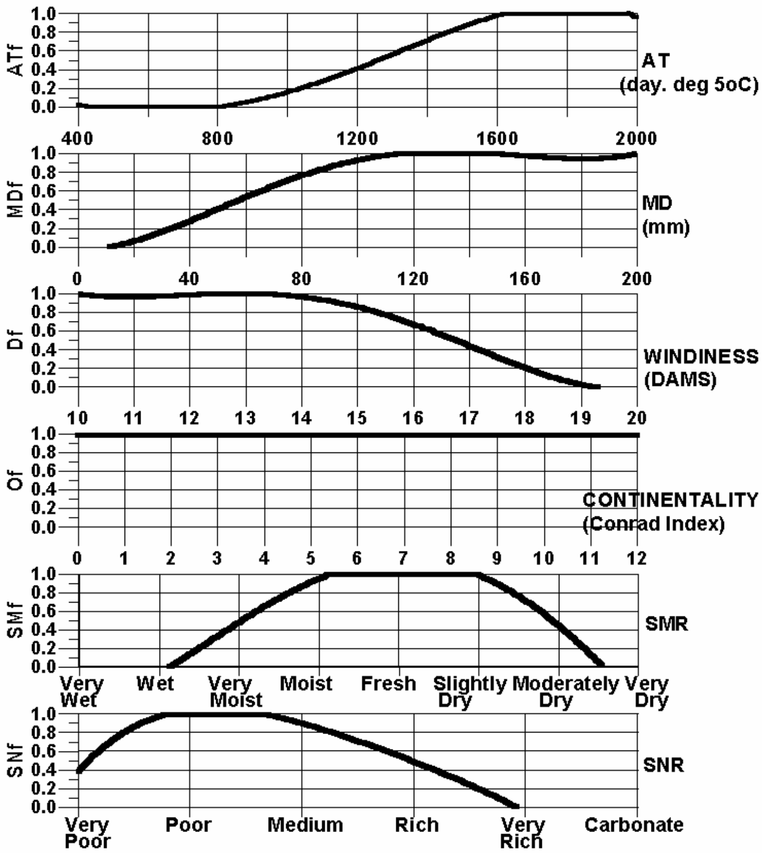

Figure 2 Continuous functions relating suitability of W16 (oak, birch, wavy hair-grass woodland) to the 6 ESC factors

The SMR of a site is calculated using one of two methods depending on whether the soil is deemed a wet type or a dry type. For a wet soil the SMR is directly related to the depth of the winter water table, and for a dry soil the available water capacity of the soil is calculated and related to the climatic droughtiness/wetness (Moisture Deficit), see Pyatt *et al* (2001) for details.

ESC-DSS uses 2 plant indicator species models to assess the SNR based on the work of Hill *et al* (1999) and Wilson *et al* (2001) and described in more detail by Pyatt *et al* (2001). If the mean cover percentage of plants with Wilson numbers falls below 60% then the Hill-Ellenberg model is used to calculate SNR, otherwise the Wilson model is used.

Figure 2 shows the suitability variation of the 6 ESC factors for *Quercus* spp. - *Betula* spp. *Deschampsia flexuosa* woodland (W16 oak, birch with wavy hair-grass). The 'y' value shows the suitability score from zero (unsuitable) to 1 (suitable), and the suitability score is derived in the equation describing the shape of the curve, with the 'x' values for the site in question. In practice, a threshold score of 0.7 or more is used to designate a suitable classification. ESC-DSS finds the smallest ‘y’ value from the six factors and assigns that to be the limiting factor for the site. ESC makes an assumption that suitable factors cannot compensate for unsuitable factors. Thus a site with a suitable climate and a suitable soil moisture regime cannot compensate for an unsuitable soil nutrient regime, and such a site would be assessed as unsuitable.

Demonstration site and ESC analysis

As an example Table 1 shows site details for a 10 ha sub-compartment on an elevated ridge of the Pennant sandstone within the Forest of Dean. The sub-compartment currently contains Scots pine, Corsican pine, European larch yield class and birch.

Table 1. Forest of Dean demonstration site information

Site Name	MTC
Grid Reference	SO 597106
Elevation	190 m
Geology	Pennant sandstone
Soil type (FC Classification)	1z - Podzolic brown earth
Slope	10^0 easterly aspect
Rooting depth	80 cm
Stoniness	1%
Soil Texture	Sandy-loam
Humus Form	Moder like mull

The ESC-DSS derives climatic data for the site (Table 2). The site is relatively warm and is quite dry for an elevation of nearly 200m in western England. The windiness score shows a sheltered site which also has an average continentality score.

Table 2. Climatic and soil quality data calculated in ESC for the Forest of Dean MTC demonstration site

ESC Climate Factor	
Accumulated Temperature (day.degree over 5^o)	1579
Moisture Deficit (mm)	139
Windiness (DAMS)	10
Continentality (Conrad Index)	8
Soil Moisture Regime	Slightly Dry
Soil Nutrient Regime	Poor

In ESC-DSS the soil type, texture, stoniness and rooting depth were used to calculate the SMR as Slightly Dry. The field layer plant indicator species recorded (Table 3) are comprised of plants indicating Very Poor SNR (e.g. *Vaccinium myrtillus*, *Calluna vulgaris*), Poor SNR (e.g. *Blechnum spicant*, *Deschampsia flexuosa*, *Agrostis capillaris*) and Medium SNR (*Holcus mollis*, *Rubus fruticosus*), and when weighted by their cover proportion showed a Poor SNR for the site.

Using the climate data and soil quality data in Table 2 ESC-DSS identified that a *Quercus* spp. - *Betula* spp. *Deschampsia flexuosa* woodland (W16 oak, birch with wavy hair-grass) community was best suited to the site (Figure 3). The analysis methodology is transparent, and can be assessed by reading the suitability score for each of the ESC factors for the site in Figure 2, e.g. Accumulated Temperature of 1579 gives a suitability value of approximately 0.95 on the 'y' scale of the AT function of Figure 2, the other 5 factors (Table 2) indicate a suitability score of 1 in Figure 2. Thus AT with a suitability score of 0.95 is limiting the overall suitability of W16 on this site, but not by much. This result can be compared with the suitability of the other NVC communities in Figure 3.

Table 3. Plant indicator species at the Forest of Dean site

	Quadrat - % cover									
Indicator species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Deschampsia flexuosa	65	5	30		30		60	70		40
Agrostis capillaris	15						5	10		
Vaccinium myrtillus	5					65		30	2	
Rubus fruticosus	10	20	60	50	20	20	15	15	60	30
Pteridium aquilinum	5	25	25	50	80	1	10	25		20
Dryopteris dilitata			5			5			10	2
Blechnum spicant			1					2		
Calluna vulgaris							2			
Holcus mollis									10	

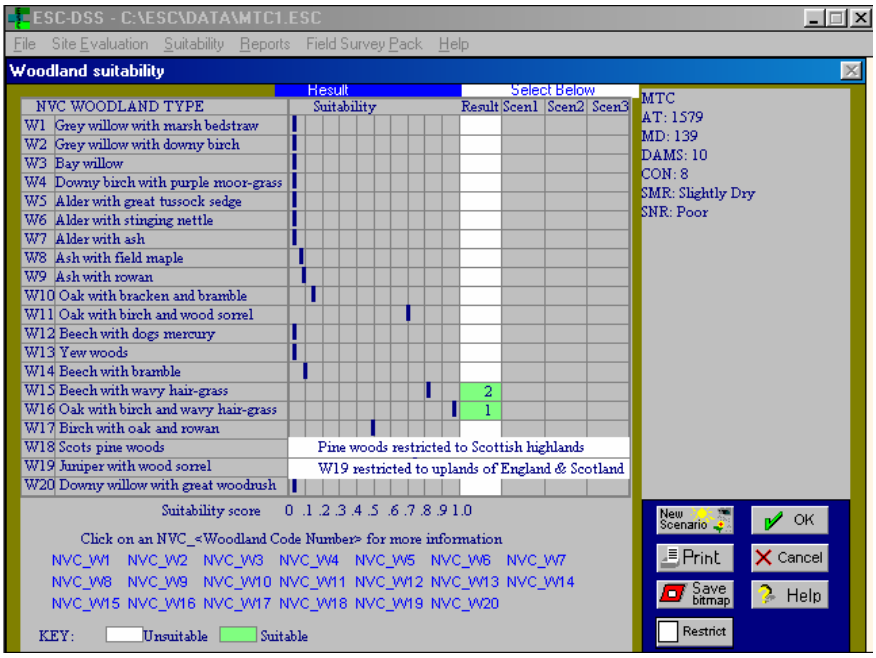

Figure 3. Output analysis of NVC woodland community suitability from ESC-DSS for a site in the Forest of Dean

Conclusions

ESC provides a means of predicting NVC from a range of site information of varying precision. It extends the use of the NVC to plantation, pasture and moorland areas. It informs the user of the relative suitability of all NVC types, offering the possibility of restoration and expansion management towards a 'suitable' woodland type.

Future developments will incorporate the NVC open ground communities and the extension of ESC on to a GIS.

ESC-DSS is available from Woodland Ecology Branch, Forest Research, Northern Research Station, Roslin, EH25 9SY, and is priced £100.

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3.3 Using the National Vegetation Classification (NVC) in woodland survey - 6000ha on.

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Summary

This paper presents a personal view of the practicalities of using NVC in woodland survey based on extensive experience in the field. Primarily it reviews some of the difficulties which can arise during field sampling and assigning NVC communities and identifies some potentially significant factors inherent in the woodland NVC which may be overlooked.

Difficulties in assigning community/sub-community in certain stands are recognised, particularly recently managed stands, transitional stands, stands of closely related communities/sub-communities and where a single species is overwhelmingly dominant to the exclusion of other species.

Additionally, some stands are poorly described by the NVC perhaps because they are restricted in distribution or are uncommon.

Our observations suggest that a certain amount of care is appropriate in the interpretation and use of the results of woodland NVC survey. Particular caution is required where NVC survey is being used, or considered, as a monitoring tool.

Introduction

Between 1993 and 2000, the authors undertook NVC survey of at least 5000 ha semi-natural woodland in Wales and over 1000 ha semi-natural woodland in west and south-west England (Castle & Mileto 1994, 1995, 1998, 1999). The vast majority of the woodland surveyed was semi-natural, often ancient, and primarily in protected sites.

This paper presents a personal, somewhat anecdotal, view of the practicalities of using NVC in woodland survey based on our experience in the field. It reviews some of the difficulties which can arise during field sampling and assigning NVC communities and identifies some potentially significant factors inherent in the woodland NVC which may be overlooked.

These observations may aid other NVC practitioners, promote discussion and be of value in any future development of the woodland NVC.

General observations based on practical experience in using NVC

The effect of sample location on sample data

NVC methodology requires identification of homogenous stands within which a sample will be representative of the stand as a whole. However, since vegetation is variable over small distances, it is often difficult to define a homogenous stand and rarely is it possible to select a 4x4m field layer sample which is typical of the whole. In practice, the tendency may be for an experienced surveyor to identify stands which appear to correspond to published descriptions of NVC communities/sub-communities and to position samples in locations which are most characteristic of the NVC community/sub-community rather than of the stand itself. Whilst this aids classification of the stand (samples being close to an NVC community/sub-community), deviations from the 'standard' NVC type may be under-recorded as a result. Thus, quadrat data can suggest that stands are more typical of the published NVC types than is actually the case and are unlikely to present a complete picture of a stand. Detailed stand descriptions and target notes are necessary to indicate major variations from the typical NVC community/sub-community.

This source of potential bias may become significant if NVC quadrat data are subsequently used as sources of information for other projects. For example, sample data have been used to assess species diversity and rarity in wet woodland stands (Wheeler *et al* 2001). However, since woodland NVC quadrats are likely to have been placed in areas of moderate to dense canopy, with areas of open canopy and glade under-sampled, it is likely that the quadrat data do not fully reflect species diversity and will not record species which are present but which favour more open situations within woodland (Latham, pers. comm.).

Any future refinement of the NVC using data from samples which have been located as described above might result in a bias towards re-enforcing the existing classification rather than presenting a more accurate view of the broad variation within British woodland.

Sampling within stands as opposed to sampling between stands

NVC survey methodology often suggests the sampling of at least five quadrats within each stand (as recommended in Kirby, Saunders and Whitbread 1991) to allow a summary table to be drawn up for the stand. Whilst sampling of a number of quadrats allows for a better overall impression of the stand from the sample data alone (variations within the "homogenous" stand becoming apparent), due to regional/local floristics, the resulting table is not necessarily directly comparable with the published NVC summary tables since these were based on data from stands scattered throughout the country.

At any single site (or in a particular region) there will be locally common species which give a frequency of V (recorded in 81-100% of samples) in a summary table derived solely from samples from that stand or stands in the locality. However, in a national context, these species may occur very infrequently and thus be shown on the published tables as a frequency of I (recorded in no more than 20% of samples).

Similarly, a species which is generally frequent in a community in a national context (perhaps a constant) may be absent in any one region and thus may be missing from a summary table derived from a single stand or region.

Table 1 shows a number of significant differences in species frequency between a summary table resulting from 12 samples in W8 stands in the Lower Wye SSSI (three sub-communities represented) and those of the published W8 NVC table resulting from 429 samples throughout Britain (note only species illustrating a significant variation in frequency between the two summary tables are shown in table 1).

Table 1

Species	**Frequency/cover in 12 Lower Wye W8 samples**	**Frequency/cover in published W8 NVC table**
Acer campestre (canopy)	not in samples	II (1-8)
Betula pendula (canopy)	III (1-4)	I (1-10)
Tilia cordata (canopy)	IV (4-9)	I (1-10)
Cornus sanguinea *(shrub layer)*	not in samples	II (1-8)
Taxus baccata (shrub layer)	III (1-5)	I (1-4)
Ulmus glabra (shrub layer)	III (1-7)	I (1-6)
Lamiastrum galeobdolon	III (2-3)	I (1-6)
Hedera helix	V (3-9)	III (1-10)
Thamnobryum alopecurum	IV (4-8)	I (1-8)
Phyllitis scolopendrium	IV (1-6)	I (1-8)
Ctenidium molluscum	IV (2-6)	I (1-7)
Plagiomnium undulatum	not in samples	III (1-7)
Circaea lutetiana	not in samples	III (1-7)
Fraxinus excelsior seedlings	IV (2-5)	II (1-4)
Polystichum setiferum	IV (1-5)	I (1-8)
Sorbus spp. (shrub layer)	II (1-3)	not in samples

Timing of survey

Woodland NVC survey is usually restricted to the period May to September and the vast majority of stands can be assigned to community level throughout this period. Indeed, it is usually possible to assign most stands to community level throughout the year although any quadrat data taken outside the May-September period should be viewed with care since they will not be complete in terms of species composition and will be very different with regard to species cover estimates.

However, some woodland sub-communities can only be identified during a more restricted period. For example W8 and W10 sub-communities which are characterised by vernal species (W8b, W8e, W8f and W10b in particular) can only be identified in spring/early summer. Outside this period it is possible to miss these sub-communities completely. Therefore where these sub-communities are suspected, survey should always be undertaken in May/June. Conversely, it may be difficult to identify W17c early in the season (before the field layer cover of grasses has fully developed); the stand sometimes appearing closer to W17b whilst grasses remain sparse.

Scale of survey

Within woodland it is generally appropriate to map stands of 0.25ha and larger, this being the recommended size of sample for the canopy layer (50mx50m). In some instances smaller stands can be mapped or target noted but very small areas will represent a patch of only a few trees and it could be argued that such areas do not represent distinct stands but a small-scale variation within a larger stand. The authors consider 0.1ha to be the minimum area which could be described as a homogenous stand.

Areas of 0.25 ha can be shown on maps at 1:10 000 scale (appearing 5 mm x 5 mm) and areas of 0.1 ha can be shown on maps at 1:5 000 scale (appearing 6 mm x 6 mm). Therefore mapping at a scale greater than 1:5000 will not generally add detail to a woodland NVC survey (and will often result in very large maps which are difficult to use).

Effects of recent management

Where woodland has been recently coppiced, felled or heavily thinned there is often little or no canopy and thus the managed area is not strictly speaking wooded. The resulting vegetation, frequently dominated by abundant bramble, is often better described by the NVC underscrub communities (W24 and W25). However, in most cases, enough of the characteristic woodland field and ground layers remain, along with shrub/tree regeneration, to enable the woodland community from which it has been derived (and to which it is likely to return) to be identified. It may not be possible to assign a community where it is not clear whether the future canopy will be dominated by ash/oak or beech (and could thus be W8/W10 or W12/14). Also, on occasion, recently felled areas comprise such dense bramble regrowth that survey has proved impossible!

Grazing (or lack of grazing) can also significantly affect the appearance of various woodland communities/sub-communities. Such effects are sometimes well described by the NVC. However, grazing sometimes results in stands which appear to be poorly described by the NVC. This is particularly noticeable in grazed stands of W8/W9 where grazing can result in a grassy sward reminiscent of W11, though with a species composition still closer to W8/9.

Transitions

Transitions are common since vegetation communities almost always grade into one another over a broad transitional zone rather than a sharply defined boundary. Transitional stands also occur where a stand (or whole woodland) is intermediate between two communities. However, such transitions are typically avoided during sampling and boundaries between communities are usually mapped as distinct lines rather than zones. The exact positioning of community boundaries on maps can be somewhat arbitrary within the transition zone.

Although transitions may be target noted, they are generally ignored in subsequent analysis of the site; extent of communities/sub-communities being calculated according to the mapped areas of each.

Common transitions noted by the authors include the following:

- W8/W10: Areas with locally frequent calcicolous species often occur within W10 stands, often at site margins or around areas of flushing. Such areas are often insufficiently extensive to be considered distinct W8 stands. Equally, in some W8 stands there are areas, sometimes relatively extensive, in which calcicolous species are uncharacteristically sparse or absent.
- W10a/W10e: Many W10 stands in Wales appear transitional between these two sub-communities, being fairly typical of W10a but with a scattering of W10e preferentials (particularly *Holcus mollis, Oxalis acetosella, Dryopteris dilatata, Acer pseudoplatanus and Athyrium filix-femina*) at very low covers. The difficulty in separating these two sub-communities is of particular relevance to the Biodiversity Action Plan process, with W10a generally being regarded as lowland mixed deciduous woodland while W10e is regarded as upland oakwood (Hall & Kirby 1998).
- W11/W17: Perhaps the commonest transitions in Wales are between the W11 and W17 communities, with intermediate areas frequently occurring between adjacent stands of the two communities, in particular between the W11a and W17c sub-

communities. These sub-communities are floristically similar in terms of vascular plants, being divided primarily on bryophyte cover and bryophyte species composition.

- W8a-b/d-e: Some W8 stands in south-east Wales and the Wye valley appear to comprise two sub-communities "superimposed" on each other. The stands support field layer species typical of W8a (eg: *Primula vulgaris* and *Glechoma hederacea*) or W8b (eg: *Anemone nemorosa*) which are not normally found in W8d or W8e but also species typical of W8d/e (eg: *Hedera helix and Phyllitis scolopendrium*) which are not normally found in W8a or b.
- W7a/b/c: Stands of W7 which support several preferential or constant species from all three sub-communities appear to be particularly common amongst stands of W7.

Stands which appear to be poorly described by the NVC

Several stands have been encountered by the authors which appear not to conform to any communities/sub-communities described by the NVC or are difficult to assign. In some instances, these appear to be particularly unusual stands and may represent a unique scenario - no classification system could be expected to describe every situation. However, in several instances similar stands have been encountered which vary significantly from any communities or sub-communities described by the NVC and these may represent gaps in the current classification which might be addressed in the future. Examples of such stands include:

- Stands supporting a field layer dominated by *Luzula sylvatica* - this species can be abundant/dominant in a variety of stand types (often in steep valley woodland) which would otherwise appear closest to a number of different NVC communities, in particular W10, W14, W16 and W17 (occasionally W8). Such stands appear relatively frequent in Wales and western England although they may be uncommon in a national context.
- Stands dominated by *Fagus sylvatica* but which support a field layer comprising carpets of *Allium ursinum* appear to have been poorly sampled in the published data but are presumably closest to W12a.
- Stands dominated by *Fagus sylvatica* but which support a field layer rich in Atlantic bryophytes (ie: stands close to W17 but where the canopy is dominated by *Fagus*). These do not appear to have been sampled in the published data but are presumably a form of W15 (W15c?). Although beech can be dominant in "upland" stands there are no beech dominated analogues for W9, W11 and W17 (W12, W14 and W15 representing beech-dominated analogues of the lowland communities W8, W10 and W16 respectively).
- Stands relatively frequent in and around the Brecon Beacons, north Gwent and south Brecknock which support abundant *Fraxinus excelsior*, often with some *Alnus glutinosa* and abundant *Deschampsia cespitosa* but with few other species characteristic of either W8 or W7, though calcicoles are sometimes present at low covers. Such stands are close to both W7c and W8c, perhaps closer to the former in wetter situations but more commonly appearing closer to W8c. However, these Welsh stands appear to occupy distinctly different situations to the sampled stands of W8c which were typically (coppiced) stands on the heavy clay soils of southern and eastern England. These stands may therefore represent a W8 sub-community distinct to this area.

- *Fraxinus* dominated stands, often in ravines on a calcicolous substrate, with abundant ferns but where *Polystichum setiferum* and/or *Phyllitis scolopendrium* account for a significant proportion of the fern cover. Such stands have the general appearance of W9 due to the high cover of ferns but *Polystichum*, although mentioned as occurring at low frequency in W9, does not appear on the W9 summary table presumably since it occurred in less than 5% of the samples (ie: 4 samples or fewer) and *Phyllitis* is not a dryopterid fern typical of W9. These stands therefore appear closer to W8e since *Phyllitis* is a W8e preferential species and *Polystichum setiferum* is cited in the description of W8e as often contributing to the lush appearance of this sub-community and is recorded up to cover 8 (up to 75%). However, it is possible that these stands represent under-sampled variations of W9.
- Many, if not most, of the stands of W11 in Wales clearly fit the community but generally lack key preferential species for any of the four W11 sub-communities. It is possible that the majority of Welsh W11 stands are somewhat transitional between W11a and W17 and/or represent a distinct W11 sub-community.
- *Quercus* hybrids were apparently not recorded in the canopies of samples used to prepare the W16 data table (though hybrids were recorded in the shrub layer). However the majority of W16b stands encountered in Wales appear to be dominated by hybrids rather than *Quercus petraea*.

'Difficult stands'

Some stands are, by their nature, difficult to assign to community level, let alone sub-community. These include:

- stands lacking field layer/ground layer vegetation, either due to heavy grazing and/or due to a dense canopy which is often the case in *Fagus sylvatica* or conifer dominated stands.
- stands supporting single species carpets to the local exclusion of other field layer species, notably *Luzula sylvatica* (carpets of which can occur in a number of communities - see above), *Mercurialis perennis* (carpets of which can occur in either W9 and W8 and tend to obscure sub-community variations in the latter) or *Hedera helix* (carpets of which can commonly occur in either W8 or W10).

The significance of surveyor interpretation in NVC survey

Due to the continuous variation in vegetation and the uniqueness of every stand, identifying homogenous stands and locating samples is often subjective. Assigning NVC communities/sub-communities is also somewhat subjective. Some communities/sub-communities are particularly close to one another (being points on a continuum) and one surveyor may assign a stand to one community/sub-community whilst another might assign the same stand to a closely related community or sub-community. Examples of communities/sub-communities which can be particularly difficult to separate include W11a or b/W17c, W8d/W8e and W13/W8/W12c where *Taxus baccata* is abundant.

In some situations surveyors could assign a single stand to different community/sub-community without either being obviously right or wrong. During the survey of some 6000ha in Wales, the Welsh borders and the west of England, the authors devised simple 'cut-off' rules in an attempt to ensure consistency when assigning stands which were borderline between two communities/sub-communities (these are cited in detail in Castle & Mileto, 1998).

Once mapped, measured and described in a report, the community/sub-community composition of a site is generally viewed as 'set in stone' and the possibility of an alternative interpretation is not generally considered even where this is discussed in a target note or the text (cf: transitional zones/stands above). Inclusion of quadrat data in any survey report allows subsequent review of the assigning of communities/sub-communities.

Use of NVC surveys as a monitoring tool

NVC is being used, or considered, as a monitoring tool at many sites, particularly nature reserves. However, repeated NVC survey may be of limited value within woodland habitat.

The value of NVC as a monitoring tool

If the purpose of monitoring is to record the status of features considered to be of importance/value, NVC will only be a valuable monitoring tool where the NVC communities/sub-communities themselves, or a key characteristic of them (such as bryophyte diversity in W17) are an important feature of the site.

NVC cannot be used to specifically monitor species diversity or species populations (though samples may provide some data on diversity, cover and frequency of plant species). NVC cannot be used to record status of rare plant species (which if they are uncommon are unlikely to be present in samples) and clearly cannot be used to monitor fauna species.

Interpretation of apparent vegetation changes as a result of NVC re-survey

As discussed above, two competent surveyors may assign a single stand to different communities/sub-communities where the stand is close to both, or is intermediate or transitional between them. Where re-survey involves a different surveyor to the previous survey, a stand may be assigned to a different community/sub-community due to a different interpretation of the stand rather than due to significant vegetational changes. Thus the resulting report/map may imply that significant changes in vegetation have occurred where in fact changes are due to an observer effect.

Quadrat data and target notes/stand descriptions can allow subsequent independent and more objective review of actual changes in vegetation.

Similarly, two surveyors may draw different boundaries to communities, particularly where there is a broad transition between them (resulting in apparent changes to community areas). It may be difficult to identify whether such changes in boundaries are due simply to surveyor interpretation or to actual vegetation changes, particularly since samples are rarely taken in transitional stands.

Potential for significant vegetation changes which would not affect NVC communities/sub-communities

The above section discusses how repeat NVC surveys might suggest that significant changes in vegetation have occurred even where actual vegetation changes are not significant.

Conversely, it is possible that significant changes at a woodland site, including modification of vegetation composition, can occur without affecting the NVC community/sub-community. It is considered likely to be quite unusual for management to result in a change from one community to another, though removal of grazing in some Welsh woods appears to have resulted in a change from W11/W17 communities to the W10 community as bramble has developed and shaded out species more typical of the former communities. However, in general, woodland NVC communities tend to be a result more of geology, soils, hydrology and climate than management.

At Coedydd Aber NNR detailed quadrats either side of a 20-year old fence line, one side of which is heavily grazed and the other of which is ungrazed, have shown that despite a considerable difference in structure and to a certain extent species composition (there being copious ash regeneration in the ungrazed area) the NVC sub-community remains unchanged - W7b (Latham & Blackstock 1998).

Forestry treatments can significantly alter the canopy composition of a stand (either through replanting or favouring a specific species) without altering the NVC type since the field layer is key to the assignment of an NVC community/sub-community, not the canopy.

Conclusions

In terms of methodology, we consider:

- provision of both sample data (including mapped locations of quadrats) and stand descriptions/target notes to be vital elements of NVC survey (in addition to community/sub-community mapping) to enable more accurate subsequent interpretation/review of the results of survey;
- survey should be restricted to the period May to September with certain communities surveyed to sub-community level during a more restricted period (for example May/June for W8). Limitations of data and assigned communities/sub-communities resulting from survey outside these periods must be taken into account if they are to be used;
- mapping to a scale of greater than 1:5000 is unnecessary for woodland NVC survey where the minimum area of woodland which can be recognised as a distinct stand may be some 0.1ha.

In terms of subsequent use of the results of woodland NVC survey:

- quadrat data alone may not present a complete picture of a stand;
- there may be limitations to the use of sample data collected for the purposes of NVC survey for other projects including further revision of the NVC;

- summary tables constructed from sample data from a single stand or a single region may appear significantly different from the published (national) NVC tables due to local floristics;
- the use of NVC as a monitoring tool should be considered on a site by site basis since it may not be the optimal method for monitoring important features at many sites.
- The partly subjective nature of assigning NVC communities/sub-communities needs to be recognised, particularly during re-survey where alternative interpretations by different surveyors are most likely to arise. The review of the more objective quadrat data may be an important part of interpreting repeat surveys.

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Appendix

Comments relating to *British Plant Communities Volume 1 Woodlands and Scrub* (ed. J.S. Rodwell, 1991).

The following minor comments are recorded here since they may be of value should the woodland and scrub NVC be revised and republished in the future. We have concentrated only on issues which potentially effect the use of this reference (ie: simple spelling typos etc. are not considered here).

Index errors

Several species are indexed as occurring in a particular community but do not appear in the relevant data table; for example *Fagus sylvatica* seedlings in W4, *Mnium hornum*, *Rhizomnium punctatum* and *Juncus effusus* in W6, *Asplenium ruta-muraria*, *A. trichomanes* and *Carex pendula* in W8 and *Dicranum scoparium* in W17.

In other cases a community has been omitted from the index of species; for example, W6 for *Allium ursinum*, W11 for *Rhytidiadelphus triquetrus*, W12 for *Taxus baccata* and *Viola* spp and W17 for *Sphagnum quinquefarium*..

Occasionally, species have been omitted from the index altogether, eg: *Petasites hybridus* (found in W6).

Descriptions based on a very small number of samples

Sometimes species are mentioned in the community/sub-community descriptions but do not appear in the data table, presumably because the species occurred in fewer than 5% of samples. In these cases the text is referring to a very small number of samples (in some instances only one) and might thus be describing an atypical situation. For example, the description of W7a states “in other cases … *Allium ursinum* may provide a distinctive vernal cover” and “In other places *Impatiens glandulifera* has become prominent in this kind of woodland.” *Allium* and *Impatiens* do not appear in the W7 data table and therefore they presumably occur in fewer than 5% of W7a samples of which there were only 23 - ie: these descriptions are derived from single samples.

As a result, care may be needed where descriptions are derived from very few stands/samples.

Mathematical inconsistencies

There are some mathematical inconsistencies within the data tables, presumably as a result of typographical errors; for example in W4c, *Salix cinerea* is recorded up to cover 9 (76-90%) in the table, and yet the maximum shrub cover for this sub-community is given as 15%; in W9 *Arrhenatherum elatius* and *Agrostis capillaris* each occur at frequencies II and III in sub-communities W9a and W9b respectively but are shown at frequency I for the community overall; in W9 at least 4 species occur at greater covers in a sub-community than in the summary for the community overall and in W17 *Pseudoscleropodium purum* is recorded up to cover 9 in W17c but only up to cover 4 in the summary for the community as a whole. Note that these errors can be deduced from the available information - there could potentially be other errors which cannot be identified from the published information alone.

Difficulties in using the text and tables

Sub-communities are referred to in the text by their full titles only rather than using the NVC notation (a letter for each sub-community) which can make cross-referencing with the tables (which use letters only in the column headings) more difficult than might be the case if both names and letters were used in the text.

It is sometimes difficult to interpret the species groupings in the tables at a glance (ie: canopy/shrub/field layer; community constants, sub-community preferential species etc.). Labelling of tables in the future might facilitate use of the tables.

4. Review and development of the NVC

4.1 Review and development of the National Vegetation Classification: stability and change

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Summary

Following completion of the original National Vegetation Classification (NVC) project, a review has been undertaken for JNCC of coverage of the NVC. This has identified a number of likely gaps in the classification. Those relevant to woodland and scrub are highlighted. A process for incorporating new variation into the NVC is proposed.

Introduction

The National Vegetation Classification (NVC) was commissioned in 1975 by the Nature Conservancy Council to provide a comprehensive and systematic catalogue and description of the plant communities of Great Britain. The original specification for the work is now complete with the publication of the fifth volume of *British Plant Communities* (Rodwell 2000). The principal objective of the NVC was to provide a way of classifying vegetation into types that can be identified in the field and mapped on the ground. A strong and consistent base of classification is an important tool in nature conservation. It is vital to be able to identify and record ecological communities of interest that are under threat so that they can be related to a legal framework to ensure their protection. Vegetation classification provides a language through which data can be communicated at a national and international level.

The Joint Nature Conservation Committee, the forum through which the three country nature conservation agencies (the Countryside Council for Wales, English Nature, and Scottish Natural Heritage) deliver their statutory responsibilities for Great Britain as a whole and internationally, has the responsibility for maintaining the NVC and developing it use as a standard for the description of vegetation. On of the main reasons the NVC has developed such importance as a standard in Britain is because it has been officially adopted to implement key aspects of national or international legislation. Important examples are:

- the selection of biological SSSIs for terrestrial habitats, which is based largely upon the National Vegetation Classification (NVC); and

- the interpretation of Annex I of the EC Habitats Directive, which in the UK relies heavily upon the NVC.

Not only has the NVC been accepted as standard by the nature conservation and countryside organisations, but also by forestry, agriculture and water agencies, local authorities, non-government organisations, major industries and universities. For example, it has been recommended as a standard methodology for use in environmental assessments and statements by the Institute of Environmental Assessors (IEA 1995). It has been widely welcomed as providing a much-needed common language, in which the character and value of the vegetation of Britain can be understood.

The review of coverage of the NVC

The original aim of the NVC was to cover all natural, semi-natural and major artificial habitats in Great Britain (but not Northern Ireland), covering virtually all terrestrial plant communities, and those of brackish and fresh waters, except where no vascular plants were the dominants. Only short-term leys were specifically excluded, and though care was taken to sample more pristine and long-established kinds of vegetation, no undue attention was given to assemblages of rare plants or to especially rich and varied sites.

The NVC has now been in use since the mid eighties and this increasing body of experience of the NVC, and comparison with European phytosociological classification systems, has revealed that there are types of vegetation which have yet to be described. These types have not been described either because they are previously unsampled or under-sampled vegetation types, or as a result of gaps in the geographical and habitat coverage of the samples used for analysis. The NVC types required to fill these gaps may be either new NVC communities or new sub-communities. Some of the new types may already have existing samples which require analysis, or may have samples which need to be supplemented with further field work before analysis. Others may have no substantial data collected for them at all in the UK, or may not have been sampled in an NVC compatible manner. Therefore the JNCC commissioned a review to establish in detail the current situation regarding the coverage of the NVC. The review was undertaken by the Unit of Vegetation Science, Lancaster University by a team lead by John Rodwell (Rodwell *et al* 2000).

Review methodology

Along with the personal experience of the review team, three principal methods were used to identify new variation and community types in the review. These were:

1. A review of the wider European scene

The team reviewed phytosociological entities described in the rest of Europe, and in particular in the Atlantic biogeographical region, and assessed whether they are likely to occur in the UK, and the degree to which they are adequately described. Use was made of the *Phytosociological conspectus of British plant communities* (in Rodwell 2000), which organises the NVC vegetation types into the hierarchical frame of alliances, orders and classes currently being prepared by the European Vegetation Survey. This greatly assisted the review as it enabled those alliances which were considered to be ill-covered by the NVC to be highlighted.

2. A review of NVC surveys

The team was also asked to review major NVC surveys, particularly those which have aimed to describe the national resource of a particular habitat, and evaluate any gaps in NVC descriptions which they have identified.

3. A review of comments from a representative sample of users of the NVC

In addition to the above, comments were sought from a representative sample of users of the NVC about gaps in coverage of the NVC and these were evaluated.

Findings of the review

The results of the review have been presented within the framework of the Phytosociological Conspectus. Throughout the conspectus commentary is provided where new variation or gaps have been identified. This commentary describes in indicative terms the floristics of the type, the broad ecological requirements and where they are known to, or may, occur in Britain. In addition some indication of the work required to complete a floristic table and full NVC description of the type is given, in particular, whether there is an existing data set of samples, and how much further field work may be required.

The review identified a wide range of new variation and gaps in the NVC. In phytosociological terms, the biggest weaknesses and most numerous gaps are among the freshwater aquatic vegetation of moving and standing waters, shallow or fluctuating pools, and water-margins and springs. A further substantial group of new communities comprises weedy vegetation or rank vegetation of clearings, woodland fringes and riverbanks and shoals. In habitat terms, they tend to be:

- transitional or marginal situations like woodland fringes or hedge-bottoms;
- fragmentary habitats like rock outcrops and scree crevices;
- ephemeral situations such as seasonally-flooded hollows and temporary pools; and
- more remote, inaccessible or awkward situations like cliff ledges, snow-beds and open waters.

The weaknesses in coverage and the gaps identified in this review were, to an extent, not unexpected, given the particular methodology adopted by the NVC, with its focus on homogeneous stands and the limited resources available for survey (5 staff for 3 field seasons, plus some external contributors).

At community level, woodland and scrub vegetation was considered to be relatively well covered. Lichen-rich Scot's pine woodland and lowland elder-willow scrub were identified as the major omissions among semi-natural vegetation, with categories for *Rhododendron ponticum* scrub and conifer plantations (Wallace 2003) also suggested.

Woodland fringe vegetation ('saum' in German) was also highlighted as being under-represented in the NVC. Of particular interest are the rather patchy mixtures of taller herbs on calcareous substrates on the sunny margins of scrub woodland, with such typical species as agrimony *Agrimonia eupatoria*, marjoram *Origanum vulgare*, perforate St John's-wort *Hypericum perforatum* and bloody crane's-bill *Geranium sanguineum*. Several new communities corresponding to associations within the Class *Trifolio-Geranietea sanguinei* are suggested.

Within certain vegetation types that are already described in *British Plant Communities*, Extensive further sampling since the NVC has revealed considerable variation but which is not adequately covered by the range of existing sub-communities. In other cases, new variation that appears to be intermediate between two communities already defined in the NVC could well be considered as a sub-community of one or the other.

The review identified several woodland types to which this applies. For example, stands of oak-birch woodland (including W10 *Quercus-Pteridium-Rubus*, W11 *Quercus-Betula-Oxalis*, W16 *Quercus-Betula-Deschampsia* and W17 *Quercus-Betula-Dicranum* types) can have field layers so overwhelmingly dominated by either great wood-rush *Luzula sylvatica* or bracken *Pteridium aquilinum* that they cannot readily be included in any existing sub-communities. In the Scottish uplands, eared willow *Salix aurita* is a distinctive local dominant in shrubby canopies of vegetation similar to W4 *Betula-Molinia* and W7 *Alnus-Fraxinus-Lysimachia* woodlands, for which new sub-communities ought perhaps to be recognised.

What next?

The findings of the review have been discussed by an inter-agency working group consisting of staff from the country agencies, set up especially to consider the future development of the NVC. It was recommended by that group that the results of the review should be published and that the support unit should seek further comments on the findings.

The group acknowledged that due to resource constraints, future development of the NVC will be undertaken on a priority basis and that the individual conservation agencies and JNCC will have their own priorities for description of new types. The group also recognised that other organisations may wish to describe new variation and again will have different priorities for future work.

The group also acknowledged that, although for some of the new variation there were no known samples and for other variation additional sampling would be required to ensure adequate coverage, some of this newly-described or recognised variation has already been well covered by survey work and the outstanding task is to formally characterise new communities and sub-communities. This survey work has not only been undertaken by the conservation agencies both in-house and through contracted surveys, but also a large number of other government agencies, non-government organisations and research institutes.

During the course of the original NVC project, many other botanists, phytosociologists and other researchers willingly supplied their data and ideas. In fact some sources, particularly post-graduate theses, had already amassed very comprehensive sets of samples of certain kinds of vegetation or from particular areas and these, with permission, were often incorporated into the project directly.

It is therefore proposed that a code or protocol should be developed which circumscribes rules for describing new variation in the NVC. This would allow anyone with an interest in vegetation to described new communities and sub-communities and would provide a process by which this work could be formally accepted into the NVC scheme. In this way, users of the NVC and scientific researchers would be able to have an input into the future development of the classification, and a mechanism would be provided for the dissemination of new information on the character of British plant communities.

It is recognised that classification systems need a built-in formal mechanism for review and update. If review systems are not formalised different users are tempted to produce their own reviews, eventually causing divergence to the point where different versions are mutually incompatible. This can be avoided if a statutory organisation is responsible for defining the classification and accrediting reviews. This has long been recognised in taxonomic classifications, but as yet has rarely filtered through into ecological and land-use classifications, which have more recent origins.

The code will provide minimum standards for the description of new communities or sub-communities and a process for their validation and publication. An expert committee will be given authority to validate the descriptions of new types and ensure that the standards of the code are met. The code will be drafted by JNCC support unit and country agency specialists, and others will be invited to participate. The support unit will also undertake to consult on the code before it is finalised. The JNCC will be responsible for establishing and chairing an expert committee who will oversee the implementation of the code.

Provisional ideas on the content of the code

It is proposed that the code will cover:

- how descriptions of new variation should be published
- how consultation on suggested new types will be managed
- how information should be submitted to the expert committee
- the format for the description of new communities
- recommendations on minimum standards for number of samples/relevés required to describe a new type
- recommendations on minimum standards for parameterisation
- other agreed criteria for assessment
- protocols for access to data
- how new NVC types will be coded and published
- copyright and ownership of data and the resulting description

The expert committee will base the assessment of new variation on scientific criteria and not on political implications for their scarcity. They will be responsible for ensuring that the division of new types maintains a similar level of ecological variation across the board and that local variation is not over-described in the national scheme.

The development of the code is specifically for the description of new variation that can be recognised as discrete gaps and it is proposed that in most circumstances, the expert committee will not consider the redefinition of existing units. This is considered necessary to ensure that the classification maintains stability, and that historical data holdings which have been collected over the last 15 years or so are not invalidated.

Acknowledgements

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4.2 British Woodlands in a European perspective

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Summary

Any user of the NVC woodland classification is automatically part of a European discourse because the NVC approach to the survey and description of woodlands is completely compatible with the phytosociological methods traditional in many other parts of the Continent. This paper provides an update on woodland classification across Europe, illustrates the benefits of a wider European perspective for understanding the character, value and potential of British woodlands and highlights some of the types of woodland we should and could have in the UK.

A common language for describing European woodlands

From the start, it was envisaged that the NVC should be compatible with approaches used elsewhere in Europe to describe and classify vegetation types (Rodwell 1991). In many countries on the Continent, including some eastern parts of Europe, it is phytosociology which, for some decades, has provided the most widely used methodology for sampling vegetation in the field and for developing hierarchical classifications of the plant communities characterised from these data. Pioneered by Braun-Blanquet (1928) and Tüxen (1937), the phytosociological approach has accumulated vast quantities of data and an extensive literature about the vegetation of Europe and provides a robust common language for understanding similarities and differences in the character of plant communities. In recent decades, a new spirit of cooperation among phytosociologists has produced a European Vegetation Survey network (EVS) which is committed to common scientific standards and the development of a unified classification of vegetation types (Mucina *et al* 1993b; Rodwell *et al* 1998). Among European plant communities, woodlands have long attracted attention from phytosociologists and have been the subject of some classic studies. For those interested in the wider European significance of British woodlands, this approach offers three particular benefits.

The NVC sample and phytosociological relevés

The NVC methodology for sampling vegetation in the field involves recording floristic lists of all vascular plants, bryophytes and macrolichens from representative plots in stands of vegetation judged by the eye to be homogeneous (Rodwell 2001). The NVC sample is thus more or less the same as what phytosociologists call a relevé (Westhofff & van der Maarel 1978). As a record of woodland vegetation, this kind of sample aims to provide a more complete indication of species composition than approaches which concentrate on the trees and shrubs (Rackham 1980; Peterken 1981) or on the herbaceous element of the vegetation (Bunce 1982). In fact, compared with many woodland relevés from elsewhere in Europe, the NVC sample is somewhat more generous in the size of its canopy/understorey sample (50x50m) so as to try to represent a more representative range of trees and shrubs. A proposal for a standard European relevé (Mucina *et al.* 1999) will mean that wherever woodlands are sampled such discrepancies will be avoidable. Even now, NVC users should have no difficulty in making sense of and using woodland relevés collected in other European countries.

Just how many such woodland relevés there are across Europe is uncertain: at a conservative estimate, the total number of relevés recorded from all vegetation types is well over 1½ million (Rodwell 1995). Quite how these may be accessed is another problem. Many woodland relevés are published in the scientific literature and research reports, often in tables of samples relating to particular woodland types, and key references for some of these sources up to the date of its publication are included in the first volume of *British Plant Communities* (Rodwell 1991). However, many data are not published and, though individual workers will often share relevés, national databases are relatively few and data management software varied. Recently, the EVS has promoted the development of a European software network using a Dutch program TURBOVEG (Hennekens 1995). This is now established in 28 countries and makes it possible to mail vegetation data and the results of analyses electronically.

NVC communities and phytosociological associations

The brief for the NVC contract also stipulated that the project should provide standardised accounts of plant communities which were on roughly the same scale as Braun-Blanquet associations, the basic unit of vegetation description in phytosociology that is characterised from relevés. With woodlands, therefore, the NVC user can be confident that a community like the W7 *Fraxinus-Alnus-Lysimachia* woodland is more or less commensurate with a woodland association like the *Carici remotae-Fraxinetum* Koch 1926, first described from Germany.

This kind of latinised name for an association, indicating the author of the first relevé and the date of publication of the vegetation description, are part of the formalities of phytosociology governed by the *Code of Phytosociological Nomenclature* (Barkmann *et al* 1986; Weber *et al* 2000). The NVC did not adopt this convention, although the Synonymy and Affinities sections of the descriptions in *British Plant Communities* attempt to indicate the relationships between our own woodland types and their counterparts elsewhere in Europe. Although many accounts of vegetation from other countries are, of course, in their vernacular languages, floristic tables of species with their frequency scores often accompany the published descriptions and enable a direct comparison to be made with the species composition of British woodlands. For the kind of wet woodlands mentioned above, for example, even a glance at the floristic tables in an account of the *Carici remotae-Fraxinetum* from what was then Czechoslovakia (Neuhäuslova-Novotna 1977), proves very revealing about the similarities and differences between that woodland type there and in this country.

The phytosociological literature contains numerous such accounts of woodlands from many different parts of Europe though much of this material is widely dispersed in journals and research publications. Surprisingly, though Britain came late to phytosociology, we were the first country to publish a national vegetation classification with a systematic account of our woodlands more or less in this style. Austria (Mucina *et al* 1993a) and The Netherlands (Schaminee *et al* 1995) have since followed, and there is a complete account of the woodlands of Italy (Pignatti 1998). Masterly ecological overviews of the vegetation of south-eastern Europe (Horvat *et al* 1974), central Europe (Ellenberg 1988) and the north (Dierßen 1996) also provide brief phytosociological accounts of woodland types over broad geographical regions.

The NVC classification and phytosociological hierarchies

One further feature of phytosociology is that the associations are grouped into hierarchical arrangements of alliances, orders and classes, of increasingly broad floristic character (Barkmann *et al* 1986). The NVC did not use this approach but rather grouped together the plant communities into more informal categories familiar to British users. However, the Affinities section of each description in *British Plant Communities* attempts to relate the community to its nearest phytosociological alliance: in the case of the *Fraxinus-Alnus-Lysimachia* woodland, for example (and the *Carici remotae-Fraxinetum),* this is the Alno-Ulmion, an alliance of ash and alder woodlands of flushed and impeded lime-rich soils. These broader groupings are very useful for understanding ecological relationships across Europe.

With the completion of the NVC, it has been possible to bring together the hierarchical relationships of our vegetation types into a single overview and this Phytosociological Conspectus has been included in the final volume of *British Plant Communities* (Rodwell 2000). In fact, the detailed framework of classes, orders and alliances of vegetation represented across Europe into which British woodlands might be fitted is still incomplete as new vegetation types continue to be described. Over past decades, diverse proposals for structuring the phytosociological hierarchy have been put forward, uncoordinated and often contentious. Recently, the EVS has proposed a more stable classification down to the level of alliances (Mucina *et al* in press). In Britain, our woodlands (and scrub) can be seen as representing 6 of these classes, 10 orders and 19 alliances, one useful index of the proportion of woodland diversity represented here. The overview of alliances has also been related in a crosswalk to the EUNIS and CORINE habitat classifications that underlie the Habitats Directive (Rodwell *et al* 1998), which promises to make interpretation of Annex 1 habitats less laborious.

A European perspective on the character of British woodlands

The value of this wider European phytosociological perspective for understanding the character of British woodlands - their floristic composition in relation to similar types elsewhere and their relationship to climatic and terrain factors across the Continent - can be illustrated using three examples taken from a recent report to English Nature (Rodwell & Dring 2001): mesophilous beech woods, heathy pine forests and the ash-elm ravine forests.

Mesophilous beech woodlands

Woodlands dominated by beech, alone or with other trees, comprise the major forest types across much of central Europe. They are particularly important in the lowland and foothill landscapes to the north of the Atlantic and Continental biogeographic zones but continue to make a prominent contribution at higher altitudes in the warmer south, where cooler temperatures in the mountains of the Alpine and Mediterranean zones sustain a beech zone above other deciduous or evergreen broadleaf forest.

British woodlands of a more mesophilous character such as are included in the W12 *Fagus-Mercurialis* and W14 *Fagus-Rubus* communities share many floristic features with beech forests that occur extensively on drought-free, mesotrophic brown earths all across

Europe: eastwards through Belgium and Germany into Poland, Austria and Czechia, southwards through France into the Pyrenees and through Switzerland into the mountains of Italy, Illyria and the northern Balkans. Beech remains the major tree in these woodlands throughout this range with such herbs as *Galium odoratum, Viola reichenbachiana, Dryopteris filix-mas, Oxalis acetosella, Anemone nemorosa, Geranium robertianum, Mycelis muralis, Sanicula europaea, Milium effusum* and *Brachypodium sylvaticum*. A conservative phytsociological view has placed all these woodlands within the alliance Asperulo-Fagion (or Galio odorati-Fagion) (Tüxen 1955).

A recent review by Dierschke (1997) has distinguished a number of geographical groupings within this complex series of woodland types (Figure 1) where the British examples can be seen as belonging among the central and north European associations that are additional characterised by the occurrence in the canopy of *Quercus robur, C. petraea, Carpinus betulus, Fraxinus excelsior* and *Acer pseudoplatanus* and, in the field layer, *Mercurialis perennis, Circaea lutetiana, Lamiastrum galeobdolon* and *Euphorbia amygdaloides*. These kinds of mesophilous beechwoods extend through France and Belgium into Denmark, south-west Norway, Germany, Poland and Czechia. Most similar of all to the UK W12 woodlands are the beech forests of north-west France where *Ilex aquifolium* also becomes a frequent subordinate canopy element, *Tamus communis* an occasional liana, *Daphne laureola* and *Ruscus aculeatus* distinctive small bushes and *Hyacinthoides non-scripta* a striking vernal herb. Associations which have been named Endymio-Fagetum Noirfalise & Sougnez (1963) and Rusco-Fagetum Durin *et al* (1967) present a very familiar appearance to British eyes.

Heathy pine woodlands

Though geographically isolated from the rest of Europe, the native pine woodlands of Scotland are an integral part of a complex spectrum of variation among *Pinus sylvestris* woodlands that extends right across northern Europe (Rodwell & Cooper 1994). In broad terms, our W18 *Pinus-Hylocomium* woodland belongs among the heathy pinewoods of the alliance Dicrano-Pinion Matuskiewicz 1962, sharing a group of sub-shrubs, herbs and cryptogams with central and north European associations that stretch eastwards through Fennoscandia, Germany and into Poland and European Russia (*Calluna vulgaris, Vaccinium myrtillus, Deschampsia flexuosa, Dicranum scoparium, Hylocomium splendens, Pleurozium schreberi* and *Cladonia rangiferina*), though not *Picea abies* which occurred in this country during the post-Glacial period but beyond whose present western limit Scotland now lies.

Our own examples of this kind of woodland are closest to the pinewoods of Scandinavia in their combination of species which reflect the generally Boreal (or northern Continental) climate of this part of Europe - *Listera cordata, Goodyera repens, Pyrola minor, P. media, P. rotundifolia, Moneses uniflora* and *Orthilia secunda* - together with indicators of the increased oceanicity which prevails along the Atlantic seaboard - bryophytes such as *Sphagnum quinquefarium, Scapania gracilis, Diplophyllum albicans* and *Anastrepta orcadensis* (Aune 1977; Dierßen 1996; Fremstad 1997). Interestingly, in moving eastwards through the pinewoods of Norway into Sweden there is a similar shift in the balance between these two floristic elements as can be seen in Scottish stands. The most similar associations to ours among this range of pinewoods are the Bazzanio-Pinetum Aune 1977 and the Barbilophozio-Pinetum Aune 1977. With the increasingly Continental climate to the east, Scandinavian pine-spruce woodland gives way to steppe pinewoods.

Pinus reaches its competitive peak on the impoverished acid sands that are so extensive across the north European plain but, with the shift southwards, oak can become quite frequent in the canopy. On somewhat better soils with the shift towards a more oceanic climate, the balance in dominance moves definitively against pine until the tree is reduced to an occasional by the combined shading of oak and beech.

Ash-elm ravine woodlands

One striking kind of situation in which beech and the oaks can all be out-competed by fast-growing trees like *Fraxinus excelsior, Acer pseudoplatanus, A. platanoides, Ulmus glabra* and *Tilia cordata* is on the nutrient-rich soils that accumulate in the humid micro-climate of shady slopes and ravines. Here, with downwash and percolation of ground water, the soils can be deep and moist, though they are usually free-draining and have a brisk turnover of nutrients. Typically, such situations are associated with base-rich (though not always calcareous) rocks and they occur widely in the steep-sided immature river valleys of the foothills, sub-montane and high mountain belts right across Europe.

Woodlands of this type have been grouped together in a distinctive alliance, the Tilio-Acerion Klika 1933. Further characteristic features are the occurrence of *Sambucus nigra* among the shrubs, luxuriant nitrophilous herbs like *Urtica dioica, Aegopodium podagraria* and *Impatiens noli-tangere* in the field layer, moisture-loving vernal plants like *Allium ursinum*, ferns such as *Phyllitis scolopendrium, Polystichum aculeatum, P. setiferum* and *Gymnocarpium robertianum* and bulky mosses which thrive on the bare ground exposed by the rapid breakdown of herbage and litter at the end of the growing season. The terrain is typically complex and rocky with a patchy cover of soil.

It is clear that, on general floristic and ecological grounds, many of the north-western stands of W8 *Fraxinus-Acer-Mercurialis* woodland (sub-communities e-g) and W9 *Fraxinus-Sorbus-Mercurialis* woodland are the British representatives of this alliance, despite the fact that, with us, neither *Acer pseudoplatanus* nor *A. platanoides* is native and *Tilia cordata* reaches its limit just where suitable sites are becoming more common. An early phytosociological account of some British woodlands by Klötzli (1970), a paper that still well repays reading, recognised this broad affinity.

A large number of associations has been characterised within the Tilio-Acerion and, not surprisingly, the most similar to our own have been described from Ireland (the Corylo-Fraxinetum Braun-Blanquet & Tüxen 1952) southern Norway and Sweden (e.g. the Ulmo-Tilietum Kielland-Lund apud Seibert 1969: Diekmann 1994; Dierßen 1996; Lawesson 1999). Down through Germany, Austria, Switzerland and France, many associations show generic similarities with British Tilio-Acerion woodlands, though there is a tendency for montane types to be dominated by *Acer platanoides* and those at lower altitudes to have more prominent lime. More particularly, *Tilia platyphyllos* emerges as the lime more confined to the Tilio-Acerion ravine forests whereas *T. cordata* is also widely distributed through mixed broadleaf forest. At warmer latitudes further south in Europe, and particularly in sunny ravines at lower altitudes, there is a tendency for species of the downy oak (*Quercus pubescens*) forests to appear in these woodlands. The Tilio-Acerion reaches its southern limit in humid north-facing ravines of the Apennines (Pignatti 1998).

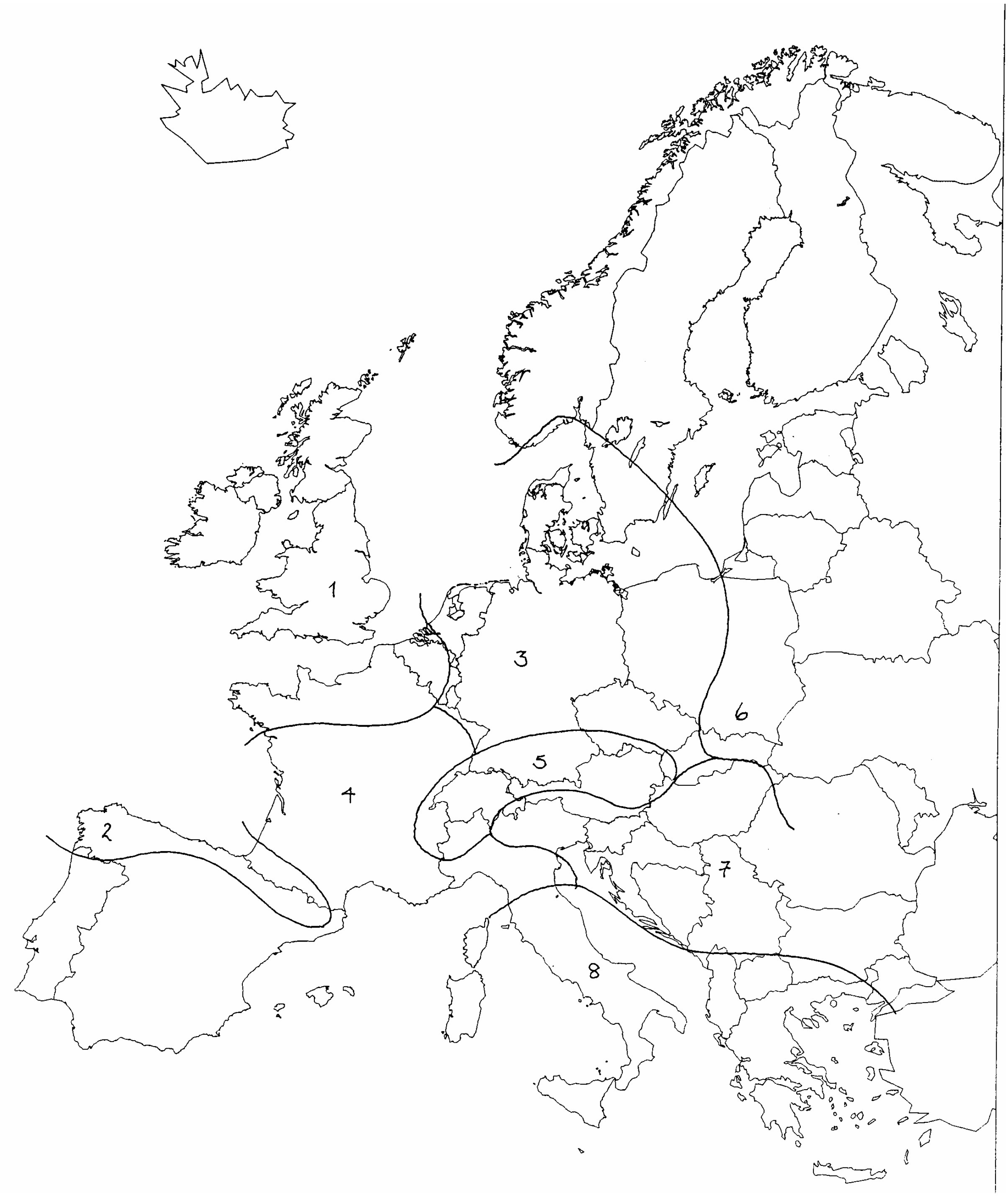

Figure 1. Major geographical types of mesic European beech forest

1 Northern Atlantic type, 2 Spanish/Pyrenean type, 3 Central European type, 4 Continental French type, 5 Alpine Sub-Montane type, 6 Carpathian type, 7 SE European type, 8 Italo-Balkan type (after Dierschke 1997)

A European perspective on the conservation value of British woodlands

Interpreting the Habitats Directive

The benefits of a wider European perspective on the character of British woodlands are crucial for interpreting their conservation significance in relation to the Habitats Directive. It might be supposed that there was some coherence and clarity in defining the Annex 1 habitats across the extent of the EU but it is clear from the *Manual of Interpretation* (CEC 1994), that their 'sub-types, regional varieties and correspondence with other classification systems' have usually been identified in only rudimentary fashion, with information from certain countries providing more detail and interpretation than for others. It has usually been left to the Member States to wrestle with the precise meaning of the habitats and is obvious that political expediency has sometimes over-ridden an informed ecological understanding. The above accounts in fact provide us with a much clearer basis for interpreting the Annex 1 habitats 9130 Asperulo-Fagion, 91C0 Caledonian pine forest and 9180 Tilio-Acerion ravine woodland.

Evaluating capture of designated woodlands within Natura 2000

The Natura 2000 network aims to capture a proportion of the examples of each of the Annex 1 Habitats within each Member State. The end result will be a complex algorithm of the extent and significance of the Habitats within the States and across Europe as a whole and of political resolve to make the proposals work. With woodlands, as with other Habitats, it is not easy to obtain accurate information throughout the EU about the extent of the various associations and alliances that could be included within each Habitat or the number, location and size of Candidate Special Areas of Conservation that have been put forward. Germany, for example, has been slow to declare its cSACs and the political process of negotiating the adequacy of coverage from country to country is still in train.

However, using such information as was available, Rodwell & Dring (2001) provided an overview as at August 2000 of the numbers and areas of woodland cSACs for the Annex 1 Habitats throughout the EU (Appendices 1 and 2) and comments about the adequacy of their coverage within the designation network in the UK. This information was able to inform the latest round of discussions on coverage and, for many woodland types, the numbers of UK cSACs was increased. Figure 2 shows the cSAC map for 9130 Asperulo-Fagion which should be compared with the geographical zones of mesophilous beech woods recognised by Dierschke (Figure 1). It can be seen that, in terms of the number of cSACs, the UK contribution to this woodland Habitat in the Atlantic zone is still relatively modest compared with that of northern France where the most similar analogues are to be found, though the disparity is not so great when the area of the cSACs is considered.

Identifying omissions from networks of protection

We can also use this wider perspective to highlight inconsistencies in our perceptions of the conservation value of woodlands and identify gaps in the network of protection afforded by UK designated sites and Natura 2000. Comparison of a phytosociological overview of European woodland types (Rodwell & Dring 2001, Mucina in press) with the Habitats Directive also enables us to identify communities that are absent altogether from

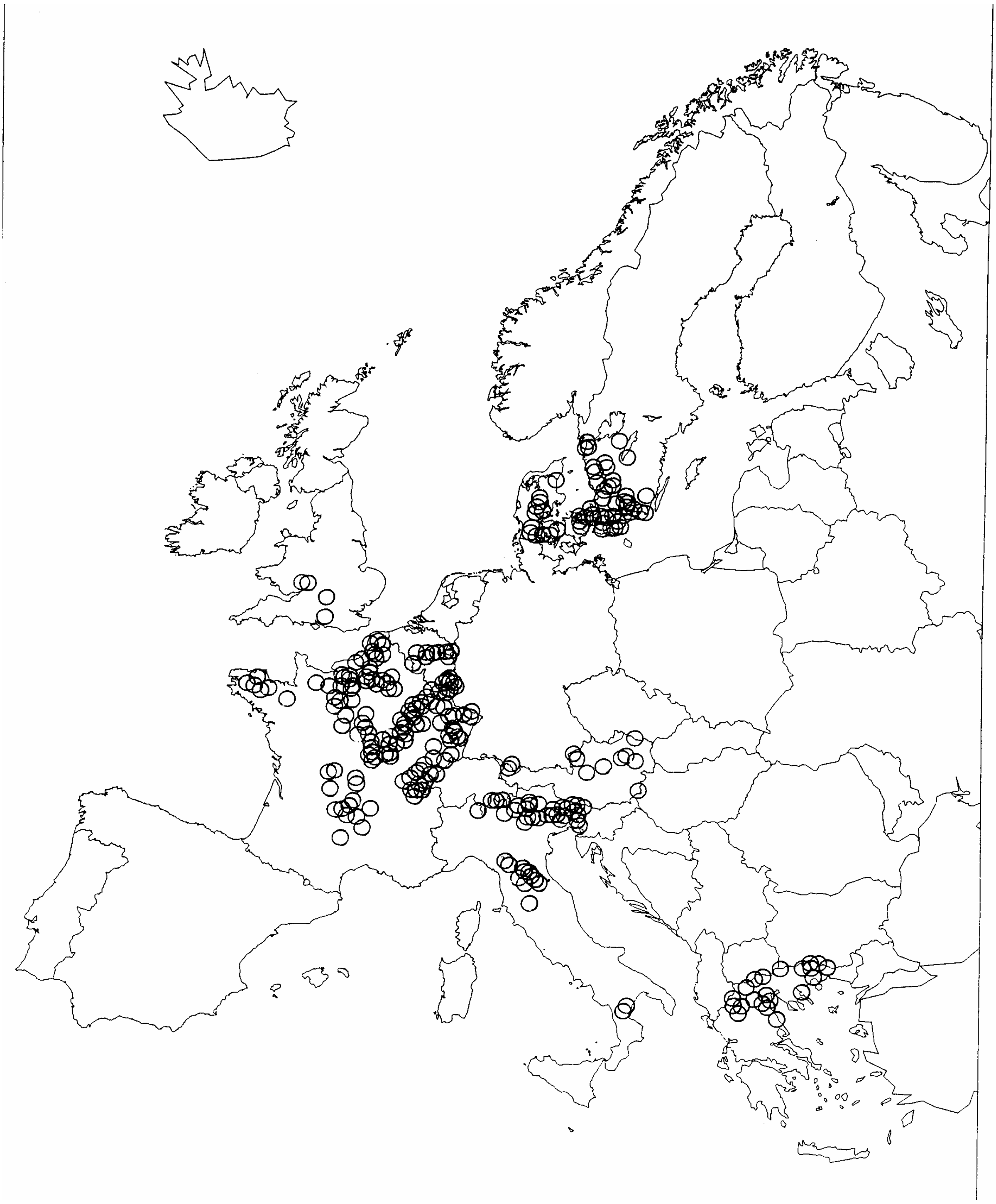

Figure 2. Distribution of cSACs for 9130 Asperulo-Fagatum as at 1 January 2000

the EU framework for wildlife protection. One of the most obvious omissions are the kinds of mixed broadleaf woodlands with a springtime carpet of *Hyacinthoides non-scripta* which in Britain we include in the more south-easterly W8 *Fraxinus-Acer-Mercurialis* and W10 *Quercus-Pteridium-Rubus* woodlands. These are essentially Oceanic representatives of the Carpinion woodlands which occur on better-quality brown earths in the European lowlands where the dominance of beech is challenged by oak and hornbeam. More Continental and Sub-Atlantic types of these woodlands are covered in the Annex 1 habitat 9160 Stellario-Carpinetum, an association which is scarcely recognisable in the UK, yet these very striking bluebell woodlands, characteristic of the Atlantic regions of Britain, northern France and Belgium, are accorded no conservation value at European level.

A European perspective on the woodlands we might restore

Mapping the potential extent of woodlands in Europe

A different kind of wider perspective is cast upon British woodlands by the European interest in 'potential natural vegetation'. This term is not common currency among ecologists and conservationists in the UK, though the idea is familiar enough in the notion of 'climax vegetation'. By potential natural vegetation is meant the kinds of plant communities that would eventually prevail in any place under existing environmental conditions if man's interventions were to disappear and if succession had time to reach stable end-points. Over most of Europe, the potential natural vegetation would be forest of various kinds.

It is not always easy to predict the pattern of potential natural vegetation using an understanding of the relationships between existing plant communities and the climatic and soil conditions which govern their composition and distribution, but it is an approach which had demonstrated benefits for several decades elsewhere in Europe. In order to harmonise the mapping of potential natural vegetation and to produce an overview of patterns across the whole Continent, a collaborative programme involving 31 countries from Iceland to Russia as far as the Urals, and including the UK, was initiated in 1975, and has just borne fruit in the publication of the full-colour *Map of the Natural Vegetation of Europe* at a scale of 1:2.5 million (Bohn *et al* 2001). A common legend characterises the mapping units and relates these, and the various vegetation types which have replaced them with human intervention, to phytosociological associations.

32 mapping units are represented in the UK, of which 16 are woodlands, the remainder being bogs and coastal and mountain vegetation occurring where tree cover cannot be sustained and where these other communities are climatic or edaphic climaxes (Rodwell in press). Figure 3 shows an example of the European extent of mapping units which help give us a wider perspective on our woodlands. It gives the potential extent of the kinds of heathy boreal pinewoods described above as including our own W18 *Pinus-Hylocomium* woodland.

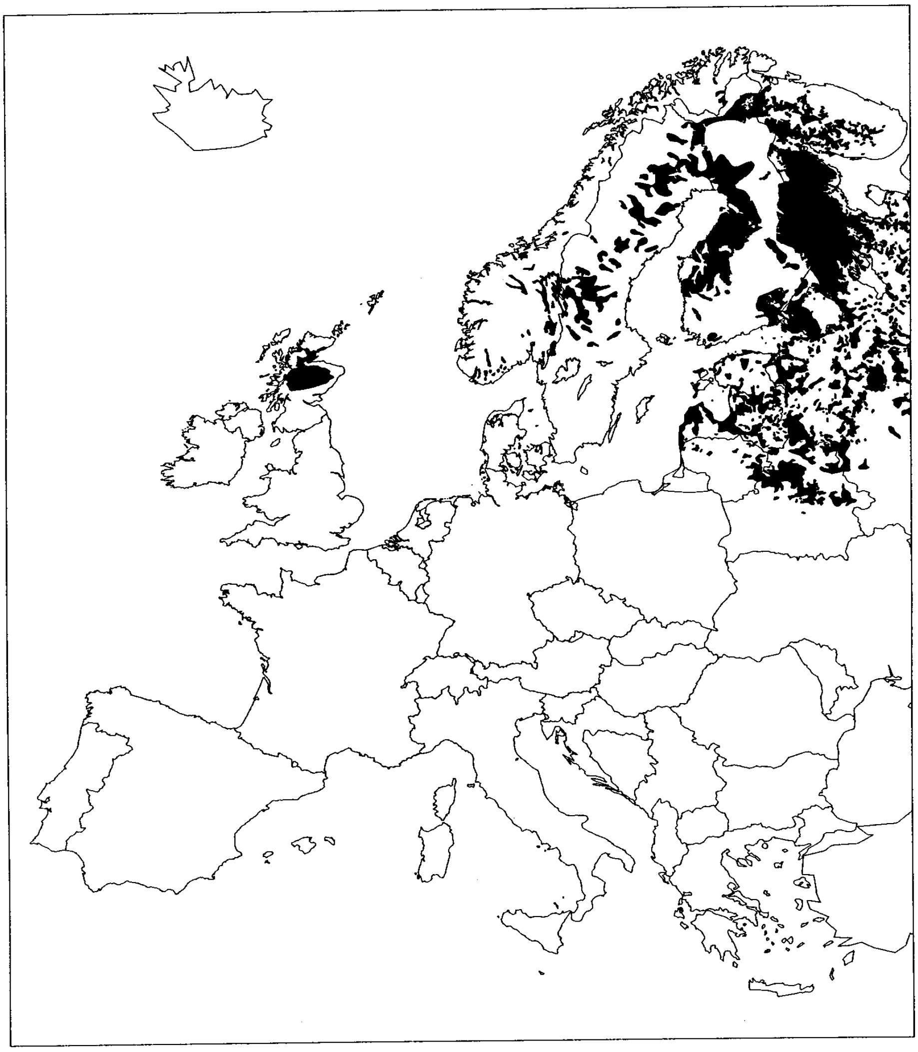

Figure 3 Potential extent of boreal and hemi-boreal pinewoods

Shortfall in potential woodland cover and targets for restoration

Planting ecologically appropriate trees and shrubs in areas designated as suitable by such potential vegetation mapping is the kind of notion that underlies *Creating New Native Woodlands*, a handbook applying the NVC to woodland restoration that has been produced by the Forestry Commission (Rodwell & Patterson 1994). Targeting such woodlands is often part of campaigns for landscape restoration but it is also possible to use the European Vegetation Map to provide elements of an ecological strategy.

For example, we can compare the proportions of the land surface that would be occupied by particular woodland types if human influence were to be minimised with the actual proportions of these woodlands that are represented in the network of designated sites. One especially startling result of such a comparison is that, under such more natural conditions, over 3% of the country would be covered by alluvial flood plain forest of the W6 *Alnus-Urtica* type (probably a considerable under-estimate because of the coarse scale of the mapping) whereas very little of this actually survives and almost none is given statutory protection within the SSSI network. Even with the additional force of the Habitats Directive, where such vegetation falls within the Annex 1 91E0 Residual Alluvial Forest habitat, little of the potential of this interesting kind of woodland remains sustainable. Clearly it is a priority for restoration.

Acknowledgements

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Appendix 1. Numbers of woodland cSACs in EU Member States as at 1 January 2000

sites	**zone**	**5130**	**9120**	**9130**	**9160**	**9180**	**9190**	**91A0**	**91C0**	**91D0**	**91E0**	**91J0**
AT	alp	3		12	1	17				9	33	
AT	con	6		10	6	18				6	33	
BE	atl	1	1	7	13		14			11	26	
BE	con	3		1	4	8	1			4	12	
DE	Alp			6		5				2	5	
DK	atl	6	1	2			8				1	
DK	con	9	5	23	3	1	5			11	11	
ES	atl		44			9					94	
ES	med	1	14			10					66	
ES	pyr					8					5	
FI	bor					6	2			659	59	
FR	alp	15	1	10		14				5	9	
FR	atl	86	46	51	22	35	30	2		23	142	
FR	con	50	41	85	42	90	14			58	154	
FR	med	16	6	2		12					18	
FR	pyr	1		1		1				1		
GR	med	9	7	23		2					20	
IE	atl	5						3		4	3	
IT	alp	4		56	8	59				24	49	
IT	con	90		10	30	15	4				129	
IT	med	68	3	9	1	42	6				54	
LU	con		1	26	17	16				5	22	
NL	atl	5		2	4	2	4			12	14	
PT	atl										3	
PT	med										9	
SE	bor	27		19	49	42	18			266	100	
SE	con	50		36	43	22	36			28	45	
UK	atl	8	5	4	2	10	4	10	10	4	6	7
Total		463	175	395	245	444	146	15	10	1132	1122	7

Key to Sites:
AT - Austria, BE - Belgium, DE – Germany, DK – Denmark, ES – Spain, FI – Finland, FR – France, GR – Greece, IE – Ireland, IT – Italy, LU – Luxemburg, NL – Netherlands, PT – Portugal, SE – Sweden, UK – United Kingdom.

%	zone	5130	9120	9130	9160	9180	9190	91A0	91C0	91D0	91E0	91J0
AT	alp	0.6		3.0	0.4	3.8				0.8	2.9	
AT	con	1.3		2.5	2.4	4.1				0.5	2.9	
BE	atl	0.2	0.6	1.8	5.3		9.6			1.0	2.3	
BE	con	0.6		0.3	1.6	1.8	0.7			0.4	1.1	
DE	alp			1.5		1.1				0.2	0.4	
DK	atl	1.3	0.6	0.5			5.5				0.1	
DK	con	1.9	2.9	5.8	1.2	0.2	3.4			1.0	1.0	
ES	atl		25.1			2.0					8.4	
ES	med	0.2	8.0			2.3					5.9	
ES	pyr					1.8					0.4	
FI	bor					1.4	1.4			58.2	5.3	
FR	alp	3.2	0.6	2.5		3.2				0.4	0.8	
FR	atl	18.6	26.3	12.9	9.0	7.9	20.5	13.3		2.0	12.7	
FR	con	10.8	23.4	21.5	17.1	20.3	9.6			5.1	13.7	
FR	med	3.5	3.4	0.5		2.7					1.6	
FR	pyr	0.2		0.3		0.2				0.1		
GR	med	1.9	4.0	5.8		0.5					1.8	
IE	atl	1.1						20.0		0.4	0.3	
IT	alp	0.9		14.2	3.3	13.3				2.1	4.4	
IT	con	19.4		2.5	12.2	3.4	2.7				11.5	
IT	med	14.7	1.7	2.3	0.4	9.5	4.1				4.8	
LU	con		0.6	6.6	6.9	3.6				0.4	2.0	
NL	atl	1.1		0.5	1.6	0.5	2.7			1.1	1.2	
PT	atl										0.3	
PT	med										0.8	
SE	bor	5.8		4.8	20.0	9.5	12.3			23.5	8.9	
SE	con	10.8		9.1	17.6	5.0	24.7			2.5	4.0	
UK	atl	1.7	2.9	1.0	0.8	2.3	2.7	66.7	100.0	0.4	0.5	100.0

Key to Sites:
AT - Austria, BE - Belgium, DE – Germany, DK – Denmark, ES – Spain, FI – Finland, FR – France, GR – Greece, IE – Ireland, IT – Italy, LU – Luxemburg, NL – Netherlands, PT – Portugal, SE – Sweden, UK – United Kingdom.

Appendix 2. Areas of woodland cSACs in EU Member States as at 1 January 2000

KM²	**zone**	**5130**	**9120**	**9130**	**9160**	**9180**	**9190**	**91A0**	**91C0**	**91D0**	**91E0**	**91J0**
AT	alp	7.30		311.68		136.92				0.36	50.43	
AT	con	0.12		89.63	33.46	95.76				32.79	168.70	
BE	atl	0.00	0.91	4.78	18.40		19.33			2.63	23.79	
BE	con	1.33		0.29	1.65	2.14	0.01			0.48	0.93	
DE	alp			0.00		2.08				0.00	0.00	
DK	atl	6.92	0.03	2.24			5.58				0.15	
DK	con	8.99	1.36	32.03	3.84	0.09	10.27			15.06	3.03	
ES	atl		898.83			6.77					96.96	
ES	med	0.00	292.94			14.41					157.84	
ES	pyr					5.87					0.04	
FI	bor					0.13	0.05			1476.72	179.97	
FR	alp	27.22	1.32	34.56		34.13				1.54	6.63	
FR	atl	75.78	68.32	99.43	33.44	18.41	63.39	1.26		9.86	231.55	
FR	con	34.69	51.15	148.60	198.58	68.20	16.74			19.18	169.43	
FR	med	41.21	16.03	4.75		7.77					27.36	
FR	pyr	0.71		3.95		0.30				1.06		
GR	med	49.94	24.00	235.28		3.53					49.66	
IE	atl	8.22						4.49		0.69	1.06	
IT	alp	3.72		306.01	8.84	112.43				11.66	59.67	
IT	con	89.28		59.58	31.52	18.76	5.39				61.58	
IT	med	66.35	17.99	31.60	1.48	41.33	23.00				34.57	
LU	con			68.43	4.36	2.35					1.52	
NL	atl	9.90		0.87	4.20	0.65	44.55			76.91	21.53	
PT	atl										31.03	
PT	med										83.91	
SE	bor	8.56		1.09	12.14	8.80	2.80			98.01	18.91	
SE	con	14.13		6.98	10.78	1.08	6.31			6.76	4.35	
UK	atl	23.96	38.56	14.17	3.73	20.41	33.94	49.54	154.87	32.31	10.50	5.56
Total		478.33	1411.44	1455.98	366.41	602.32	232.25	55.29	154.87	1786.02	1495.11	5.56

Key to Sites:
AT - Austria, BE - Belgium, DE – Germany, DK – Denmark, ES – Spain, FI – Finland, FR – France, GR – Greece, IE – Ireland, IT – Italy, LU – Luxemburg, NL – Netherlands, PT – Portugal, SE – Sweden, UK – United Kingdom.

Relating the natural occurrence of NVC woodland communities to ecological site factors: evidence from extensive field observation in Scotland and Wales

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Summary

Emphasis is currently being placed on the conservation and restoration of native woodland habitats in Britain, using the National Vegetation Classification as a planning framework. It is therefore essential to have an accurate understanding of the ecological site requirements of the individual NVC communities. This will ensure that the appropriate native tree species are selected for establishment on particular sites. One source of evidence for these requirements is the natural pattern of occurrence of woodland communities, in relation to ecological site factors. This paper reports information collected both from inspection of many semi-natural woodlands in Scotland and Wales and from review of existing NVC woodland survey reports for these areas. The Ecological Site Classification is used as the basis for description of the climatic and soil conditions at the sites. The analyses presented should provide useful information for those planning new native woodland establishment and associated future research work.

Background

Much effort is currently being directed to the restoration and expansion of native woodland habitats in Britain, especially in the light of the UK Habitat Action Plans [HAPs]. The woodland section of the National Vegetation Classification (Rodwell 1991) is normally used as the basis for selecting the target woodland communities for establishment (Rodwell & Patterson 1994). However there is a relatively poorly developed understanding of the ecological site requirements of these communities, which may lead to the selection of inappropriate species mixtures for some site types. Some evidence for their site requirements can be deduced from their natural pattern of occurrence in relation major site factors.

Methods

A study was made of the present-natural distribution of certain widespread NVC woodland communities in Scotland and Wales in relation to site climate (warmth and wetness), soil moisture regime (SMR) and soil nutrient regime (SNR) defined in the terms of the Forestry Commission Ecological Site Classification (ESC) (Pyatt *et al*, 2001; Wilson *et al* 2001). The majority of semi-natural woodlands in Scotland and Wales were inspected as part of native tree seed source inventory projects, and the results of previous NVC surveys at these locations were collated – coverage of NVC survey in Wales is more complete at present than in Scotland. The ESC Decision-Support System (Ray 2001) was used to produce ecological assessments of the sites. Climatic assessments employed positional and elevational data, while soil assessments were based on the Soil Survey of England and Wales and the Soil Survey of Scotland respectively. It was unfortunately not feasible to base soil assessments on detailed examination of soil profiles and ground vegetation for such a large number of woodland sites. Frequency distribution analyses were then prepared, relating the occurrence of individual NVC woodland communities to ecological site factors. The NVC communities included were W4,W7,W8,W9,W10,W11,W16 (Wales only),W17 and W18 (Scotland only). The species lists for these communities are set out by Rodwell (1991). A similar analysis was carried out for individual native tree species and will be reported when similar coverage of England has been completed in 2003.

Results

The results of the frequency distribution analyses are presented in the figures. Each NVC woodland community demonstrates a "tolerance profile" to each individual site factor with most communities having rather wide tolerance. There is considerable overlap between these tolerance ranges against single factors, suggesting that the ecological niche for each NVC community may be defined by combinations of these factors and by unassessed variables, for example photo-period and site aspect. All woodland communities present in both countries experience, on average, warmer and drier conditions in Wales than in Scotland. The climatic tolerance of W18 (Scots pine) appears to be quite distinct. Previous understanding of soil requirements for the different woodland types was broadly confirmed, but with much weaker evidence than would be expected for W8 and W9 ash woodlands preferring more fertile soils and W7 alder woodland preferring wetter soils. This is almost certainly due to the use of the small-scale national soil survey maps, which are not really suitable for detecting atypical microsites within upland native woodland complexes. Were better soil information available (based on profile examinations) it is fully expected that these patterns would emerge more clearly. Also, rather few sites were examined in Scotland and Wales where the typical soil nutrient regime would be Rich or Very Rich, but it is already clear that the position for England will be quite different in that respect, which is likely to provide for a more rounded distribution analysis.

Implications and requirements for further work

This work has provided information about the ecological tolerances of NVC woodland communities that should be of value in the planning and establishment of new native woodlands. The work is currently being extended to include woodlands throughout England. It would also be highly desirable to carry out more detailed soil studies at selected semi-natural woodlands to refine our understanding of the site requirements of ash, elm and alder dominated communities which tend to occupy atypical site types within native woodland complexes in the uplands. It must also be recognised that there is adaptive genetic variation within native tree populations which may account for the wide tolerances displayed by many species and communities. This variation could be investigated by means of systematic provenance trials.

Acknowledgements

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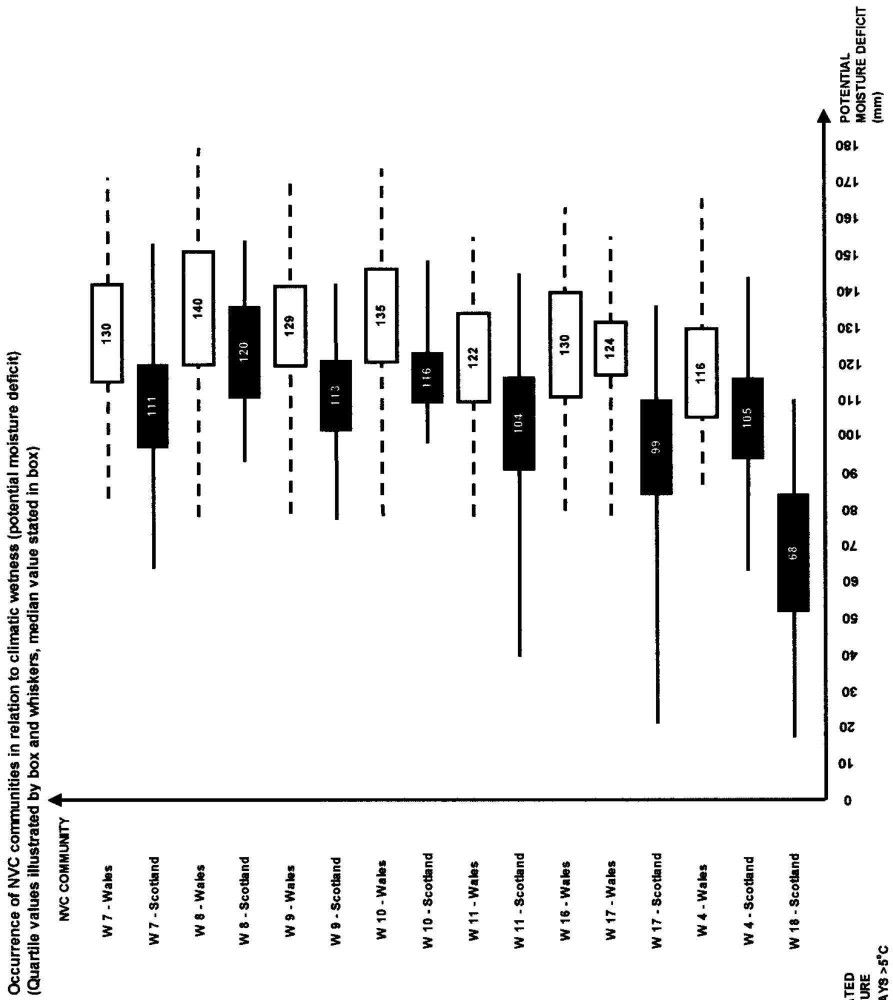
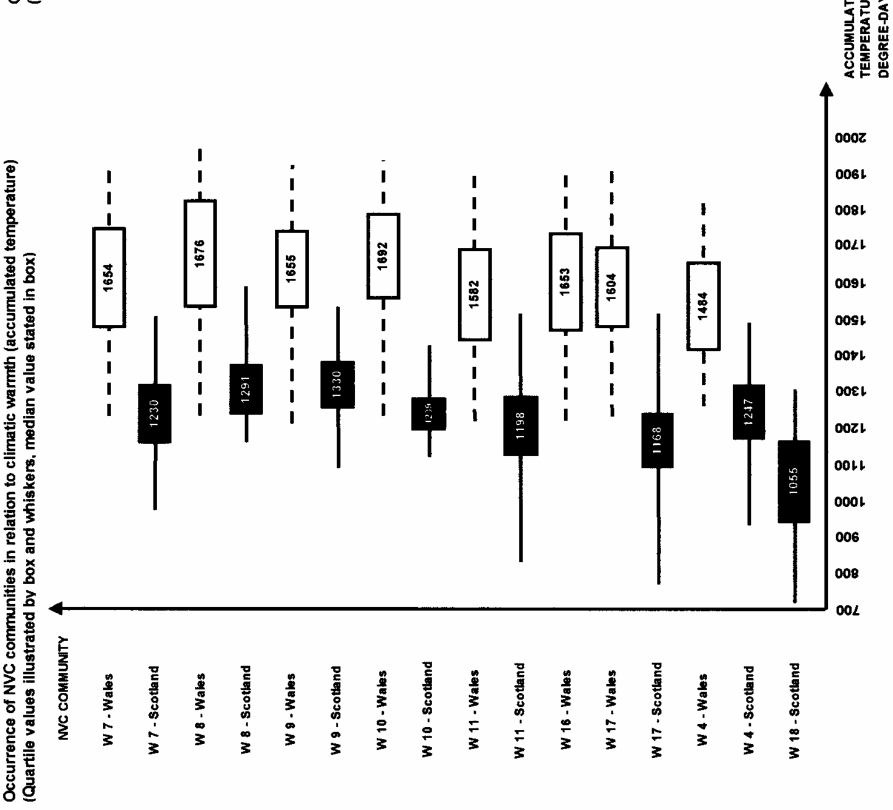
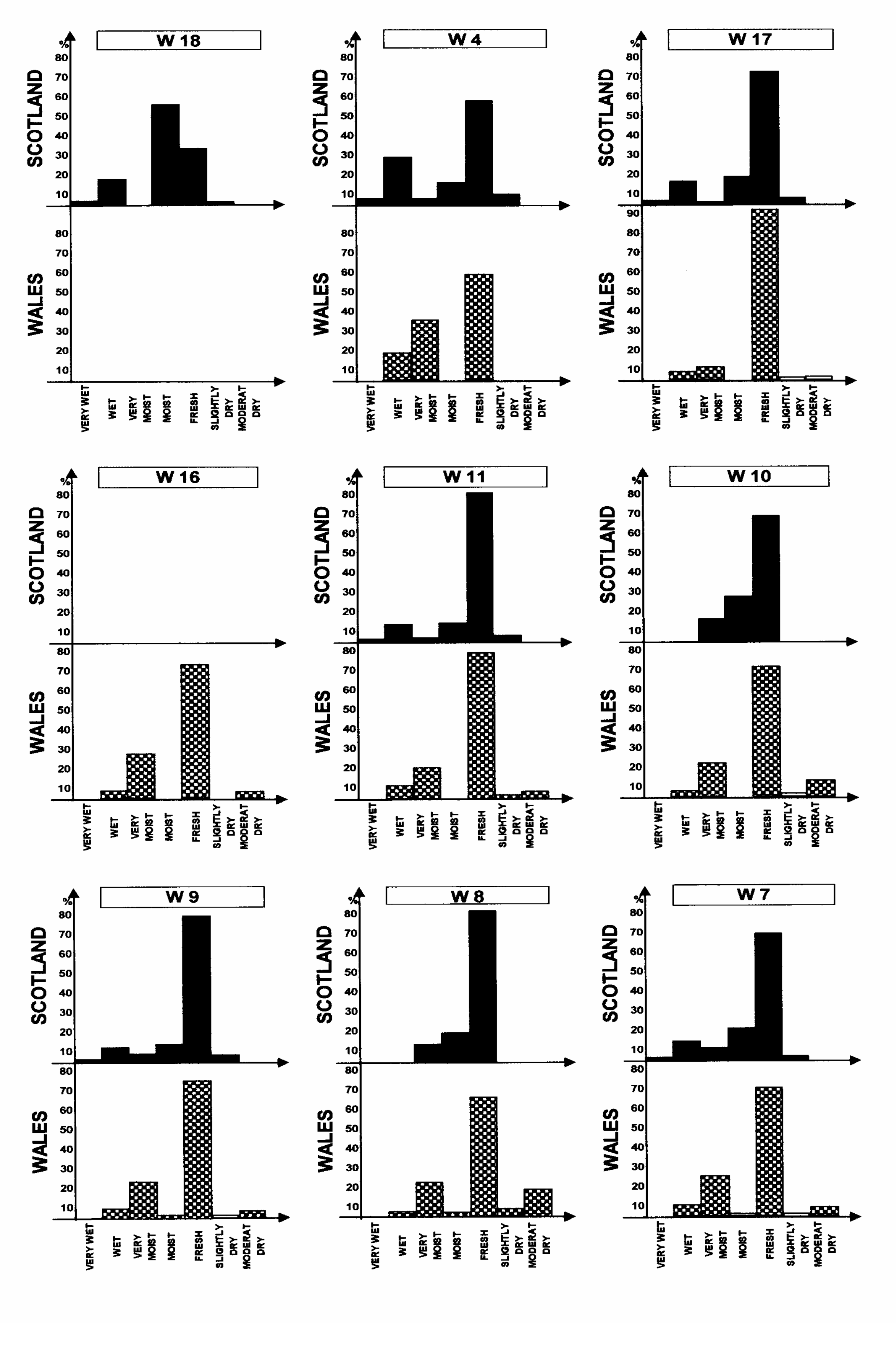
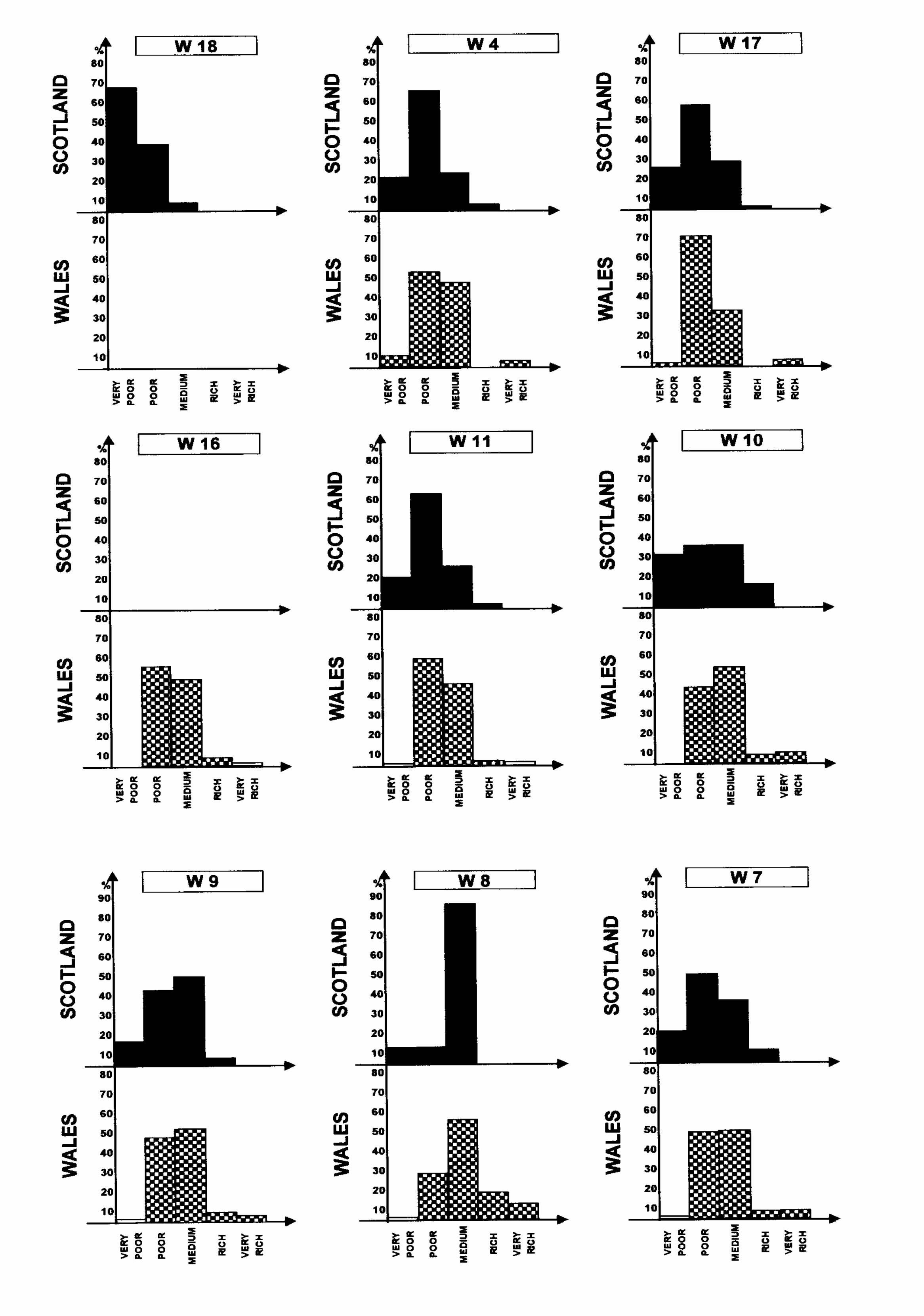

Occurrence of NVC communities in relation to climatic wetness (potential moisture deficit)
(Quartile values illustrated by box and whiskers, median value stated in box)
NVC COMMUNITY
W 7 - Wales
W 7 - Scotland
W 8 - Wales
W 8 - Scotland
W 9 - Wales
W 9 - Scotland
W 10 - Wales
W 10 - Scotland
W 11 - Wales
W 11 - Scotland
W 16 - Wales
W 17 - Wales
W 17 - Scotland
W 4 - Wales
W 4 - Scotland
W 18 - Scotland
POTENTIAL MOISTURE DEFICIT (mm)


Occurrence of NVC communities in relation to climatic warmth (accumulated temperature)
(Quartile values illustrated by box and whiskers, median value stated in box)
NVC COMMUNITY
W 7 - Wales
W 7 - Scotland
W 8 - Wales
W 8 - Scotland
W 9 - Wales
W 9 - Scotland
W 10 - Wales
W 10 - Scotland
W 11 - Wales
W 11 - Scotland
W 16 - Wales
W 17 - Wales
W 17 - Scotland
W 4 - Wales
W 4 - Scotland
W 18 - Scotland
ACCUMULATED TEMPERATURE DEGREE-DAYS >5°C

Occurrence of NVC communities in relation to soil moisture regime. (Pecentile occurrence of sites for eac community shown).



Occurrence of NVC communities in relation to soil nutrient regime (Percentile occurence of sites for each community).



Forest Enterprise (FE) Ancient & Native Woodland Project - using the NVC in lowland plantations

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Background

Forest Enterprise' (FE) Ancient & Native Woodland Project began during the spring of 1999, largely in response to pressure from the UK Woodland Assurance Scheme (UKWAS) to restore Planted Ancient Woodland Sites (PAWS) to native woodland.

Woodlands are dynamic and have been in a constant state of change over the millennia. Man has influenced the character of these woods for a very long time, and they have been intensively managed since at least medieval times (Rackham 1980). This begs the question 'what should we restore these woodlands to?' The FE Ancient & Native Woodland Ecological Survey sets out to establish what type of woodlands are most ecologically suited to the geology and soils which underpin FE woodlands in England. The survey also produces data on the current condition of these woodlands (i.e. how much effort and/or time is needed for restoration to be achieved). It is important to note that the ecological survey does not hold all the answers alone, and much of the value in this project is the availability of the data within GIS (Geographic Information System) where it can be combined and manipulated with other existing datasets.

The main aims of this project were therefore to establish what types of semi-natural woodland FE land had the potential to support, and also how long and what degree of effort would be needed for restoration to occur. Not all woodland is equal in ecological importance or ease of restoration, and the data collected by this project enables ecologically informed decisions and prioritisation to be made at both the local and national level. The preparation of strategies to deliver Planted Ancient Woodland Sites restoration across Forest Enterprise England is thus based on an understanding of each woods individual ecology as well as setting it in the context of both its surrounding landscape and the FE England Estate.

The project was piloted in South East England Forest District, where 22,000 ha of woodland are spread over 11 counties. The sheer size of the Forest Enterprise estate means that any survey method has to be relatively quick and cheap. Interpretation of data over such a large area also necessitates that it is kept as simple as possible.

Why we chose to use NVC

We decided to use the NVC (Rodwell 1991) because it provides a very good description of what sort of woodland can be expected to exist on a particular site. With the exception of the beech communities, the NVC types are dictated largely by climate, and a site's underlying geology and soils as opposed to its management history. As such it is a very useful tool for indicating what **sort** of semi-natural woodland a plantation site is both derived from and has the potential to support.

Rodwell & Patterson (1994) describe how the NVC can be used to predict what type of woodland would arise on a site if there were no intervention with succession. Once this prediction has been made, the NVC provides lists that outline the species and proportions of trees and shrubs most ecologically suited to a woodland type.

We used the NVC as a rather basic ecological site classification tool. The Ecological Site Classification (ESC) (Pyatt & Suarez 1997) was not used because time was limited to carry out a full ESC survey on the area involved for this project. The approach taken of NVC mapping, although rough and ready, was perfectly adequate for the level of information needed to guide restoration to native woodland.

The FE woods were mapped to community level only, mainly because this gave all the information required, but also because in many plantations the ground flora is so suppressed that it is not possible to get down to sub-community level. However in South-east England it was felt useful to record W12 down to sub-community level (W12a *Mercurialis perennis* sub-community, W12b *Sanicula europaea*, sub-community and W12c *Taxus baccata* sub-community). This is because W12 b and W12c occur on very different site types to that of W12a and all three have very different silvicultural implications. It was felt that silvicultural management and planning decision implications could be very different for these different woodland types. In Northants FD, the wetter sub-community of W8 (W8c *Deschampsia cespitosa* sub-community) was recorded in order to separate out the wetter clays for the same reasons as above, but also because of implication for tree recruitment on clearfells.

Difficulties of mapping NVC in plantation stands

The planted trees could not be used to decide to which NVC community a plantation stand belonged. It was therefore the unplanted understorey and ground flora which guided judgment on the NVC type of a site. However, the understorey has often been almost completely removed by thinning operations, and the ground flora suppressed by the dense shade created by conifers. The degree of suppression varied considerably depending on the species and age of a crop.

Forest ride edges are increasingly being managed in such a way that retention of native trees and shrubs is encouraged, the extra light also allows a ground flora to exist. However, great care needs to be taken here as the soils are often quite disturbed, and sometimes include foreign material such as gravels, concrete etc. which change the chemical composition of the soils. For example, field maple is common on banks created out of ditch spoil. Ordinarily, the common occurrence of field maple would indicate W8/W12 woods, however, on ride-side banks it is common in W10/14 woods and sometimes even W15/16 woods.

Clearfelled stands present further difficulties in judging NVC types. The absence of trees means that these sites are not technically (or in many ways ecologically) woodlands! The lack of shade and often disturbed soils on these sites leave many woodland plants unable to compete with more vigorous light-demanding species. It is obviously not easy to use a vegetation classification based on the presence and abundance of woodland plants on sites that possess few woodland species.

It is not just conifers that have been inappropriately planted on ancient woodland sites; very often non-site native broadleaved trees have also been planted. For example in South East England there are extensive plantations of beech on sites that, although geographically within the native range of beech, are not on soils typically within the ecological range of beech. Where it was felt that beech was not site-native the mixed broadleaved/oak NVC equivalent was given to a site, as apposed to the beech NVC type. South East England alone has 5,500 ha of beech plantations, most of which is on sites where it is a very recent arrival. Reversing this is a big restoration decision!

Survey method

The survey was carried out by walking across each sub-compartment on the site and marking onto a 1:10 000 FC stock map where any NVC boundaries occurred.

The NVC type of a woodland was established by visually judging the plant communities present, taking particular notice of any patches where expression was not being suppressed by non-native trees. In very dark and dense conifer stands, a method of informed and educated guesswork and extrapolation was employed!

The result was a broad-brush sketch of the NVC communities present within FE woodland. The locations of the boundaries between communities were often only approximate as many were located in dark plantation stands with poorly developed understoreys and ground vegetation. However, where sufficient natural vegetation was present, the classification and the boundaries of stands are reasonably accurate, sufficiently so for the purposes to which this data is being applied.

The condition of plantation stands within each wood was identified using the Semi-natural Classification developed in FE South East England (Hutchby *et al* 1999), which allocates woodland stands into one of four semi-natural classes.

Semi-natural Classification

It is difficult to develop any meaningful ‘scale’ of semi-naturalness as the concept is a multi-dimensional continuum. According to Peterken (1996) the definition of semi-natural falls between the totally artificial (0% naturalness) and the completely natural (100% naturalness). Since there are no completely natural woodlands (i.e. woods totally unaltered by man) present in Britain, and all woods possess at least some wildlife, all real woods can be said to be semi-natural to some degree; however, the term semi-natural is usually taken to be the opposite of a plantation. Peterken (1996) goes on to suggest that separate descriptions should be made on the various components that make up a woodland’s ‘naturalness’ such as woodland composition and woodland structure. This reflects the multidimensional nature of the term semi-natural.

The term semi-natural is a complicated and subjective term to quantify. In order to simplify its use in the field, four classes of ‘semi-naturalness’ were developed based on a woodlands composition and structure. These classes have been devised to describe the ‘semi-naturalness’ of stands within FE woodlands and, by implication, the ease with which they could be restored to native woodland.

Semi-natural classes

1 = SEMI-NATURAL WOODLAND
Includes native coppice woodland and high forest or site-native plantation with relatively high percentage of native self-sown or coppice understorey.

2 = SEMI-NATURAL WOODLAND (Reasserting)
Plantation/ex-plantation with more than 50% site-native species.
Includes coppice regeneration and/or strong natural regeneration.

3 = PLANTATION - with 20-50% native trees
Includes plantations planted alongside existing native trees and/or plantations with intruding native species.

4 = PLANTATION - less than 20% reasserting native species.
Includes plantations of beech, and non-native broadleaves.

Discussion

PAWS restoration strategy based on NVC data can ensure that a range of different woodland types is restored, and that rare woodland types are suitably prioritised. It also contributes to Habitat Action Plan (HAP) targets being reliably met. Semi-natural Class data tells us how long, and what degree of effort is involved for each site. It would seem more sensible to prioritise the restoration of stands with a semi-natural class of 2 (reasserting native woodland) than a pure plantation for several reasons; reasserting native woodland is more likely to currently contain a greater wildlife interest, it is likely to be quicker to restore since many native trees are already present, and it will usually involve a lot less effort and therefore cost (which enables more woods to be restored per unit budget).

It is the combination of data on the ‘semi-naturalness’ of a stand with its NVC type, which will enable FE to produce ecologically sensible strategies for delivering the effective restoration of PAWS. The power of GIS in facilitating the exploration of a wide range of restoration options and scenarios is seen as crucial to the success of this project.

Conclusion

In South East England, only a certain percentage of PAWS will be restored, however it is planned that the sites which are to be restored should represent a range of different woodland types as well as taking special account of rarer ones. NVC data is being used here to help prioritise which woodlands should be restored.

In Northants FD 100% of the PAWS are going to be restored. Here, NVC data is giving guidance to the foresters as to what sort of woodland they should be trying to restore.

National strategy on the restoration of PAWS in FE England will emerge over 2001/2002. It will be firmly based on the foundation of ecological knowledge that has been collected by this project.

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Some maritime scrub noda from West Wales

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Maritime cliff top scrub and underscrub releves described from south west England, and especially from Cornwall (Malloch 1970 and 1971) have been included within recognized communities of the NVC.

This cliff scrub nodum has been partitioned between:

Prunus spinosa facies	W22 a c	*Prunus spinosa-Rubus fruticosus* scrub
Ulex europaeus facies	W23 c	*Ulex europaeus-Rubus fruticosus* scrub *Teucrium scorodonia*
Ligustrum vulgare facies		?

Data collected from coastal situations in Pembrokeshire and on the Llyn Peninsula, whilst fitting broadly within the envelopes defining NVC scrub and underscrub communities, contain groups of differential species which reflect the situation whereby coastal scrubs are frequently found interposed between maritime grassland and heath communities.

Should noda similar to those presented be found more widely around the British coastline then a case might be made for the erection of maritime sub-communities within the existing scrub and underscrub units.

Maritime W22a	Close to type but generally on damper profiles and characterized by the scarcity of the W10 ground flora elements of typical stands.
Maritime W22c	More distinctive and characterized by having as differentials the southern Atlantic species *Rubus peregrina* and *Tamus communis* together with other species which suggest its affinities with the *Brachypodium sylvaticum* sub-community of *Crataegus-Hedera* scrub (W21c).
Maritime W23c	The presence of 'W25 species' demonstrate the transitional nature of these coastal stands which commonly occur between MC9 maritime swards and W25 scrub on more acidic profiles. *Ulex gallii, Serratula, Calluna, Erica cinerea* and *Silene maritima* reflect the often close proximity to maritime and coastal heaths.
Maritime W25a	Often found as a transition between MC12 and W22a on the less exposed coastal slopes over moderately deep brown earth profiles. Distinguished from the typical sub-community by the high frequency of species associated, in a coastal context, with MC8-12 maritime swards.
Maritime W25b	The stands also display the high representation of MC9 and MC12 species similar to that seen in the W25a examples but tend to occur on more base-poor and/or more exposed coastal situation.
Maritime W25b (*Calluna*)	A more extreme form found on acidic profiles and having a suite of *Calluno-Ulicetalia* speices; often forms a transition to coastal *Calluna-Ulex gallii* heath.
Ligustrum nodum	Essentially a maritime form of W21 in which hawthorn canopy is replaced by privet, the stands are also distinguished by the high frequency of *Rumex acetosa*.

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W22: *Prunus spinosa-Rubus fruticosus* scrub, a) *Hedera helix-Silene dioica* s.c. c) *Dactylis glomerata* s.c.

	W22a NVC	W22a Maritime	W22c Maritime	W22c NVC
Prunus spinosa (s)	V	V	V	V
Rubus fruticosus agg.	IV	III	III	II
Ulex europaeus (s)	II	III	II	II
Lonicera periclymenum (s)	II	.	III	I
Hedera helix (g)	III	IV	III	I
Silene dioica	III	V	III	II
Hyacinthoides nonscripta	II	III	II	.
Stellaria media	II	.	.	.
Poa trivialis	II	.	.	.
Holcus mollis	II	.	.	.
Moehringia trinervia	II	.	.	.
Plagiomnium undulatum	II	.	.	.
Dactylis glomerata	.	I	III	V
Brachypodium sylvaticum	.	.	V	II
Festuca rubra	.	.	II	II
Rumex acetosa	I	III	II	II
Agrostis capillaris	I	I	.	II
Holcus lanatus	I	II	II	II
Plantago lanceolata	.	.	II	II
Silene vulgaris maritima	.	.	.	II
Armeria maritima	.	.	I	I
Geranium robertianum	.	II	I	I
Fissidens taxifolius	.	II	.	.
Eupatorium cannabinum	.	II	II	.
Heracleum sphondylium	.	I	.	.
Viola riviniana	I	I	III	I
Teucrium scorodonia	I	.	IV	I
Rubia peregrina	.	.	II	.
Tamus communis	.	.	III	.
Glechoma hederacea	.	.	II	.
Pteridium aquilinum	III	IV	IV	III
Galium aparine	III	III	II	II
Eurhynchium praelongum	II	II	II	.
Urtica dioica	II	II	.	.
Brachythecium rutabulum	II	I	I	.
Digitalis purpurea	I	.	I	I
Phyllitis scolopendrium	I	I	I	I
Dryopteris filix-mas	I	II	.	.
Carex flacca	.	.	I	.
Number of samples	22	6	7	19
Species per sample	12	12	13	10

W23c; *Ulex europaeus-Rubus fruticosus* scrub, *Teucrium scorodonia* sub-community

	NVC	Maritime	Ulex facies (Malloch)
Ulex europaeus (s)	V	V	V
Rubus fruticosus agg.	V	IV	IV
Teucrium scorodonia	V	V	III
Hedera helix (g)	II	III	III
Brachypodium sylvaticum	II	I	II
Agrostis capillaris	I	II	.
Pteridium aquilinum	III	IV	IV
Festuca rubra	II	II	II
Hypochoeris radicata	I	I	.
Rumex acetosa	I	I	II
Achillea millefolium	I	I	III
Silene dioica	I	I	II
Digitalis purpurea	I	II	III
Arrhenatherum elatius	I	III	.
Potentilla erecta	.	II	.
Serratula tinctoria	.	II	.
Ulex gallii	.	II	.
Dactylis glomerata	II	IV	III
Anthoxanthum odoratum	I	II	III
Viola riviniana	.	III	II
Prunus spinosa (s)	.	I	III
Hyacinthoides nonscripta	.	I	II
Urtica dioica	.	I	I
Calluna vulgaris	.	I	II
Erica cinerea	.	II	II
Holcus lanatus	.	I	I
Lotus corniculatus	.	I	I
Linaria vulgaris	.	I	I
Silene vulgaris maritima	.	I	I
Species / sample	9	11	10
Number of samples	9	19	7

Ligustrum nodum

Ligustrum vulgare	V	4 -10
Rubus fruticosus agg.	IV	3 - 5
Pteridium aquilinum	III	3 - 9
Hedera helix	V	4 - 8
Brachypodium sylvaticum	V	1 - 2
Rumex acetosa	IV	1 - 3
Galium aparine	III	3 - 5
Silene dioica	II	1 - 3
Urtica dioica	II	2
Solanum dulcimara	II	1 - 2
Ilex aquifolium (g)	I	3
Hyacinthoides non-scripta	I	3
Mercurialis perennis	I	4
Arum maculatum	I	2
Eupatorium cannabinum	I	2
Silene maritima	I	2
Teucrium scorodonia	I	2
Agrostis capillaris	I	2

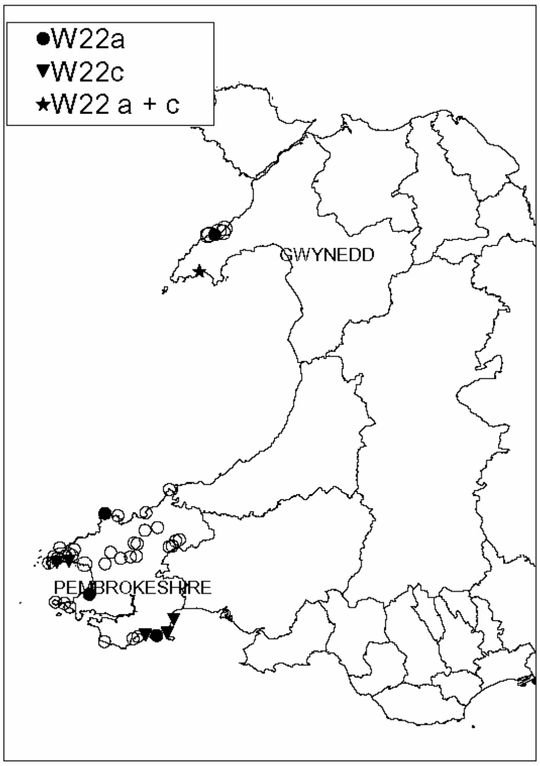
Also I at 1: *Elymus repens, Arrhenatherum elatius, Dactylis glomerata, Festuca rubra, Vicia cracca, Cirsium vulgare, Stachys sylvatica.*

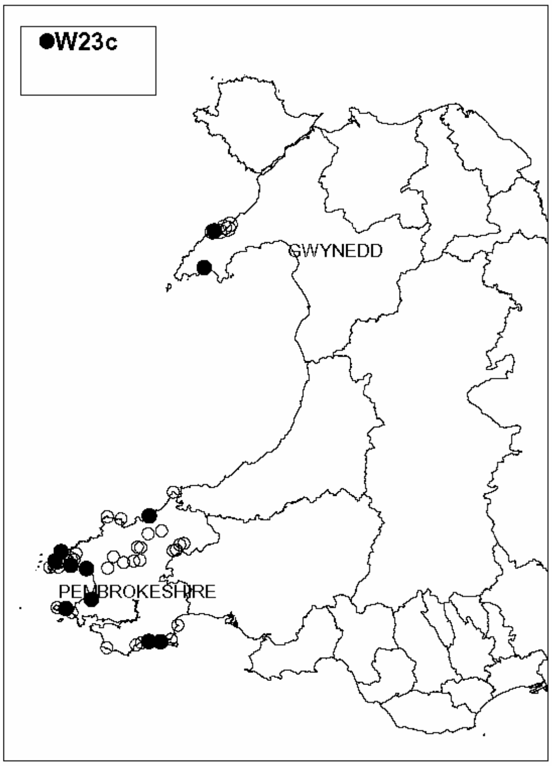
W25a; *Pteridium aquilinum-Rubus fruticosus underscrub, Hyacinthoides nonscripta* sub-community

	NVC	**Maritime**
Pteridium aquilinum	V	V
Rubus fruticosus agg.	III	V
Hyacinthoides nonscripta	IV	IV
Urtica dioica	III	III
Galium aparine	III	III
Eurhynchium praelongum	III	II
Glechoma hederacea	II	II
Dactylis glomerata	II	III
Geranium robertianum	II	II
Holcus mollis	III	I
Dryopteris filix-mas	II	I
Stellaria holostea	II	.
Brachythecium rutabulum	II	.
Conopodium majus	II	.
Arrhenatherum elatius	I	IV
Brachypodium sylvaticum	.	III
Hedera helix (g)	I	III
Heracleum sphondylium	I	III
Teucrium scorodonia	I	III
Cirsium arvense	I	III
Holcus lanatus	II	I
Viola riviniana	II	III
Rumex acetosa	.	III
Silene dioica	II	III
Lonicera periclymenum (g)	I	II
Festuca rubra	I	II
Agrostis capillaris	I	I
Digitalis purpurea	I	I
Poa trivialis	I	I
Species / sample	18	14
Number of samples	32	7

W25b; *Pteridium aquilinum-Rubus fruticosus underscrub; Teucrium scorodonia* sub-community

	NVC	**Maritime**	**Maritime (*Calluna*)**
Crataegus monogyna (s)	I	I	.
Pteridium aquilinum	V	V	III
Rubus fruticosus agg.	IV	IV	III
Teucrium scorodonia	IV	IV	IV
Holcus lanatus	III	III	IV
Agrostis capillaris	II	III	II
Digitalis purpurea	II	I	.
Anthoxanthum odoratum	II	II	.
Galium saxatile	I	I	II
Potentilla erecta	I	I	II
Ulex europaeus (s)	I	.	I
Dactylis glomerata	I	.	II
Arrhenatherum elatius	I	III	I
Serratula tinctoria	.	II	I
Brachypodium sylvaticum	.	II	I
Calluna vulgaris	.	.	V
Silene vulgaris maritima	.	I	III
Hypnum jutlandicum	.	.	III
Erica cinerea	.	I	II
Prunus spinosa (s)	.	I	II
Senecio jacobaea	.	I	II
Solidago virgaurea	.	I	II
Ulex gallii	.	I	I
Urtica dioica	II	II	I
Viola riviniana	II	III	III
Rumex acetosa	II	III	II
Hedera helix (g)	I	I	II
Hyacinthoides nonscripta	I	II	I
Heracleum sphondylium	I	II	.
Glechoma hederacea	I	I	I
Festuca rubra	I	I	II
Silene dioica	II	I	.
Galium aparine	I	I	.
Cirsium arvense	I	I	I
Geranium robertianum	I	I	.
Holcus mollis	I	I	.
Eurhynchium praelongum	I	I	II
Lonicera periclymenum (g)	I	I	II
Species /sample	no data	12	13
Number of samples	22	31	9


●W22a
▼W22c
★W22 a + c
GWYNEDD
PEMBROKESHIRE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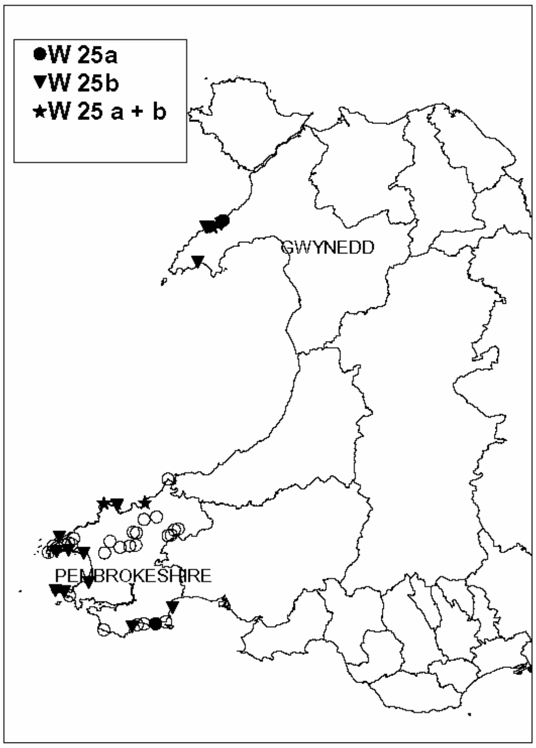
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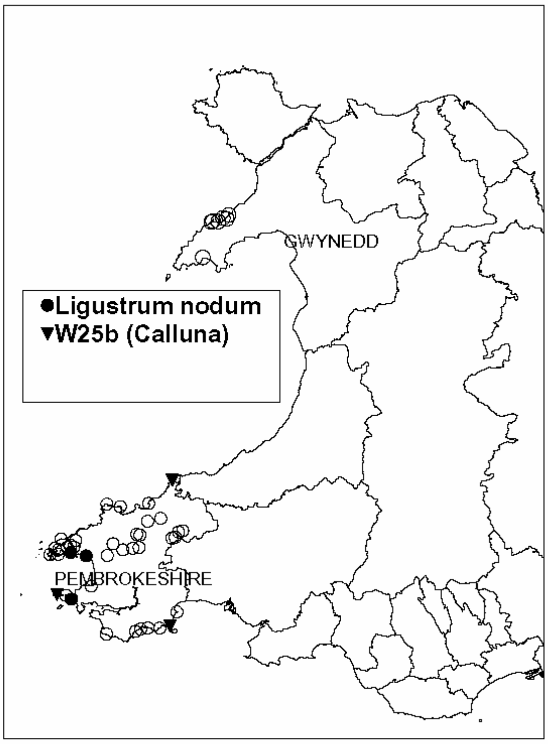
▼W 25b
★W 25 a + b
GWYNEDD
PEMBROKESHIRE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●Ligustrum nodum
▼W25b (Calluna)
PEMBROKESHIRE

Changes in woodland composition over time - does NVC type change?

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Introduction

The main drivers behind the variation in NVC type appear to be environmental - the response of species to wet versus dry soils; acid versus base-rich soils; and the climatic variations from south-east to north-west.

However, management also has some effect in determining NVC type, although less than for other habitats, such as grassland. In addition there may be other changes happening in woodland that could lead to changes in NVC type or the composition of that type over time.

Some data from various long-term monitoring studies illustrate these points.

Sheephouse Wood

Undisturbed stands

This is a clay woodland in Buckinghamshire, dominated by oak in the canopy for the most part. Little change has occurred in the tree and shrub layer over most of the wood over the last 20 years. Random plots (10 x 10 m) were taken at a number of occasions over this period. They show no change in NVC type (W10a oak-bramble-bracken woodland) or in the frequency of the main species.

Recording year	1981	1984	1996	1999	2000
No of plots recorded	8	6	6	6	8
Number of occurrences of:					
Rubus fruticosus	8	6	6	6	8
Lonicera periclymenum	8	6	6	6	7
Carex sylvatica	4	6	3	3	5
Circaea lutetiana	5	4	6	3	4
Deschampsia cespitosa	3	5	2	4	3
Poa trivialis	3	4	3	1	3
Viola riviniana	5	3	1	2	1
Luzula pilosa	5	4	1	1	4
Juncus effusus	5	4	-	-	1

Areas felled in 1988 in Sheephouse Wood

Clear-felled areas within Sheephouse Wood developed a grassy flora and apart from the occurrence of scattered small trees, which are only just beginning to have an effect, show a very different pattern of vegetation, closer to a grassland type (*Holcus lanatus*-*Deschampsia cespitosa* grassland MG9).

Recording year	1988	1989	1996	1999	2000
No of plots recorded	6	6	6	6	6
Number of occurrences of:					
Rubus fruticosus	6	6	6	6	6
Lonicera periclymenum	1	2	6	6	5
Deschampsia cespitosa	2	6	6	6	5
Holcus mollis	2	3	6	6	6
Lotus uliginosus	-	-	5	3	5
Agrostis stolonifera	1	-	3	6	4
Calamagrostis epigejos	-	-	6	6	6

Grazing and exclosure effects

Grazing may also have an effect both directly through its effects on the ground vegetation and indirectly through it leading to changes in the tree and shrub layer.

In Coed Gorswen the woodland has become more shaded since the grazing was excluded and the vegetation has shifted from being closer to W10e or W11a to one more like W10a. A similar effect has been seen in the Forest of Dean. In Monks Wood and Wytham Woods there has been no change in the NVC community, but heavy deer grazing has shifted the abundance of some species and changed the appearance of the stands radically.

Coed Gorswen NNR, North Wales

Coed Gorswen is a mixed oak and ash woodland with areas of alder. It was fenced forty years ago to exclude sheep, and surveyed five years later in 1964, and again in 1999.

Comparison of recently grazed oak plots (1964) with ungrazed plots (1999) and woodland NVC types W10 and W11

Species	W11	**1964**	**1999**	W10
Oxalis acetosella	V	**V**	**I**	II
Agrostis capillaris	IV	**IV**		I
Viola riviniana	IV	**IV**		I
Holcus mollis	IV	**III**	**I**	II
Potentilla erecta	IV	**I**		
Agrostis canina	III	**II**		
Veronica chaemaedrys	III	**II**		I
Brachipodium sylvaticum	I	**III**		I
Melica uniflora			**I**	I
Stellaria hollostea	I	**III**	**I**	I
Deschampsia cespitosa	I	**II**	**I**	I
Hedera helix		**IV**	**IV**	II
Dryopteris dilatata	I	**V**	**V**	II
Lonicera periclymenum	II	**V**	**V**	IV
Rubus fruticosus	I	**V**	**V**	IV

Nagshead Enclosure (Forest of Dean)

Part of this oakwood in Gloucestershire was fenced off from sheep (some deer still go in) about 40 years ago. It has developed a dense understorey of holly and has only a sparse ground flora in comparison to the adjacent sheep and deer-grazed grassy woodland.

Comparison of the flora in sheep-grazed and fenced areas at Nagshead (Gloucestershire) with corresponding values from the NVC tables for W10 and W11 woodland.

Species	W10	Nagshead Fenced (some deer, but no sheep grazing)	Nagshead Grazed	W11
Rubus fruticosus	IV (1-10)	II (2-3)	III (1)	I (1-8)
Hedera helix	II (2-10)	IV (1)	II (1)	-
Lonicera periclymenum	IV (1-8)	I (2)	-	II (1-6)
Hyacinthoides non-scripta	III (1-10)	III (1-5)	III (3-5)	III (1-10)
Holcus mollis	II (1-10)	I (2)	V (1-6)	IV (1-8)
Pteridium aquilinum	IV (1-10)	III (1)	V (6-8)	IV (1-9)
Digitalis purpurea	I (1-6)	II (1-2)	II (1-2)	I (1-7)
Dryopteris dilatata	III (1-8)	I (2)	-	I (1-9)
Oxalis acetosella	*II (1-9)*	I (1)	V (3-5)	V (1-9)
Agrostis capillaris	I (1-9)	-	V (2-5)	IV (1-9)
Deschampsia cespitosa	I (1-9)	-	V (2-3)	I (1-6)
Stellaria holostea	I (1-6)	-	V (2-4)	I (1-6)
Galium saxatile	I (1-7)	-	II (1)	IV (1-6)
Juncus effusus	I (2-4)	-	II (1-3)	-
Deschampsia flexuosa	I (1-9)	-	I (1)	IV (1-8)
Lysimachia nemorum	I (1-3)	-	I (1)	I (1-4)
Urtica dioica	I (1-9)	-	I (1)	-

W10 = *Quercus robur - Rubus fruticosus - Pteridium aquilinum* woodland
W11 = *Quercus petraea - Betula pubescens - Oxalis acetosella* woodland
Data based on five 5x5m samples per treatment at Nagshead.
Roman numerals give frequency of occurrence: I = 1-20%, II = 21-40%, III = 41-60%, IV = 61-80%, V = 81-100%
Arabic numbers give range of cover values (1-10 Domin score) where the species was present.

Monks Wood (Cambridgeshire)

In Monks Wood no significant change in NVC community type has occurred over the wood as a whole, but changes in the abundance of some key species mean that the appearance of the stand has changed. The changes are believed to have been caused by a major increase in deer browsing in the woodland since the mid-eighties.

In 1966 plots were recorded systematically across the wood. In 1996 another independent sample of 36 plots was made. The frequency of eight key species at the two dates and in W8a of the ash-field maple- dogs mercury community are shown below. (Significance of the change was tested by chi-squared). While bramble has not shown a decline in frequency its abundance has decreased and it rarely now forms thickets in the wood.

	1966	1996	Sign.	W8a
Rubus fruticosus	III	III	ns	IV
Mercurialis perennis	III	I	**	IV
Glechoma hederacea	III	V	0	III
Poa trivialis	-	V	**	III
Urtica dioica	I	II	**	II
Brachypodium sylvaticum	I	V	**	II
Hyacinthoides non-scripta	II	II	ns	III
Carex pendula	-	III	**	-

Wytham Woods

Change in frequency and cover of selected species from twenty four 10 x 10 permanent plots are shown below. Again, while no change in NVC type has occurred, the appearance of much of the wood has changed because of the decrease in bramble cover and increase in some grasses.

Recording year	1974	1985	1991	1999
No of occurrences (out of 24 plots)				
Circaea lutetiana	22	17	13	13
Mercurialis perennis	21	21	20	17
Rubus fruticosus	24	24	21	21
Chamerion angustifolium	8	3	2	0
Brachypodium sylvaticum	6	15	20	21
Deschampsia cespitosa	11	12	16	19
Poa trivialis	17	15	22	22
Changes in % cover of				
Rubus fruticosus	41	30	8	5
Mercurialis perennis	32	22	26	18

Improving our knowledge of the distribution of different woodland types

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Introduction

The original NVC for woodlands was created from the analysis of over 2300 survey records from across Great Britain. The classification has been widely used since it became available in 1986 as a result a great deal of information about the occurrence of different woodland types has been gathered, but was largely held by the institutions and individuals who have carried out or commissioned the survey work and was not generally available to other people. That is until 1996 when the JNCC started a project to collate NVC woodland data and from the 2300 original records we now have a database of over 12 300 records for the different woodland communities described in Rodwell's British Plant Communities - Woodland and Scrub (1991).

The Data

From the start of the project it was decided that the spreadsheet to hold the data would be very simple, partly to reduce the time involved in collating the data and also because of the wide variation in detail in each of the surveys due to their differing methodologies. Required data were kept to a minimum so as not to exclude useful data. The minimum information accepted for a record is: grid reference, NVC type, the basis of the identification (quadrat, inspection by eye), name of the recorder and date of the record. There are more fields in the database as shown in figure 1, some of which can be worked out from the grid reference e.g. county and country and others which are useful but not essential e.g. site name and area. The source code refers to a file with more detail about where the individual records have come from.

Figure 2 shows a map of the British Isles with the distribution of NVC records used to produce Rodwell distributions and the records we currently have available. The most obvious difference between the two data sets is that now there is data for a great many more 10 km grid squares however this gives no indication as to the number of records per square and some have very little data. For England and Scotland more than 70% of grid squares have less than 10 records, for Wales this drops to 50%.

Although there are gaps in the GB coverage of data, the number of records per type has greatly improved since the communities were described. The mean number of records per type has increased from 123 to 648 and there are now only 2 communities with less than 50 records of their occurrence compared with 5 in Rodwell (1991).

Date	Site Name	Grid Reference	County	Site Area	NVC Type	NVC Area	Method	Quadrat	Source	Computerised	Confidential	Country
1987	Kings and Bakers Wood and Heaths SSSI	SP920292	Bedfordshire	U	W10a	U	Q	5	2	No	No	E
1987	Kings and Bakers Wood and Heaths SSSI	SP933298	Bedfordshire	U	W10a	U	Q	5	2	No	No	E
1987	Kings and Bakers Wood and Heaths SSSI	SP922291	Bedfordshire	U	W10a	U	Q	5	2	No	No	E
1987	Kings and Bakers Wood and Heaths SSSI	SP927299	Bedfordshire	U	W10a	U	Q	5	2	No	No	E
1987	Kings and Bakers Wood and Heaths SSSI	SP928304	Bedfordshire	U	W8c	U	Q	5	2	No	No	E
1999	Avon Gorge cSAC: Leigh Woods	ST561735	Avon	27.5	W8d	21	Q	4	241	no	no	England
1999	Avon Gorge cSAC: Leigh Woods	ST561735	Avon	27.5	W8e	2	Q	1	241	no	no	England

Figure 1 JNCC NVC database fields and sample data

Source 2 file record:

2. Keith Kirby’s quadrat records, for various sites throughout Great Britain. Held at English Nature, Northminster House.

Distribution changes

Nearly half the community maps produced from the current data are similar to those published in Rodwell (1991). Others show a large expansion in the known range, or a change in the apparent pattern of distribution. There are also many cases (especially for sub-communities) where gaps in the known range have been closed.

The progress that has been made can be illustrated by looking at some of the sub-communities of W8 *Fraxinus excelsior - Acer campestre - Mercurialis perennis*. All of the sub-communities show increases in their distribution from that previously published. Rodwell's maps of W8a (primrose - ground ivy sub-community) and W8c (*Deschampsia cespitosa* sub-community) appeared to indicate south-eastern distributions, with no instance above a line from the Humber to the Severn. Since this time, these sub-communities have been widely recorded throughout England and Wales (figure 3 a and b).

The distribution of W8b (wood anemone sub-community) showed a large hole over Wales and the English midlands, although it was found to the north, south and east of this area. It has since been recorded throughout Wales, but there is still a lack of records for the midlands (figure 3 c). This is the area for which we are most lacking data in general. When further data is acquired it is likely that the distribution will show even more gaps filled in.

Outside of W8, a striking example of expansion in the known range of a type is provided by W4b (figure 3 d). This sub-community was described from nine samples scattered throughout Britain, with no apparent pattern of distribution. Since then many more sites have been found, concentrated in the north and west, with a stronghold in Grampian where it is associated with Caledonian pine forest.

As the database increases in size with more records for sub communities and the geographical gaps in the data are filled it will be possible to confirm and / or clarify the distribution of woodland vegetation types further.

Limitations of the current data-set

There are some limitations, which it is important to be aware of, in order to make the best use of the data. Data is not available for the whole country. A lack of records in any given area does not always mean that there is no woodland there. Although there are relatively few 10 km squares for which we have no data, there are a considerable number for which we have very little, as described above. Figure 4 shows the distribution of ancient woodland (based on the Country Agencies ancient woodland inventories) and in comparison to figure 1 the gaps here are more indicative of a lack of trees that the gaps in the NVC record. It also shows the data coverage there could be just from semi-natural woodland.

In the past surveys tended to target ancient woodland, but were concentrated in certain areas of the country. Nature Conservancy Council surveys covered Wales, northern and southern England; but not central England from Hampshire to Humberside and from the West Midlands across to Suffolk. Most of the other surveys collated in the database are for particular geographical areas, either those that are very well wooded (Wye Valley survey, Borrowdale survey) or National Parks (Yorkshire Dales and North York Moors National Parks).

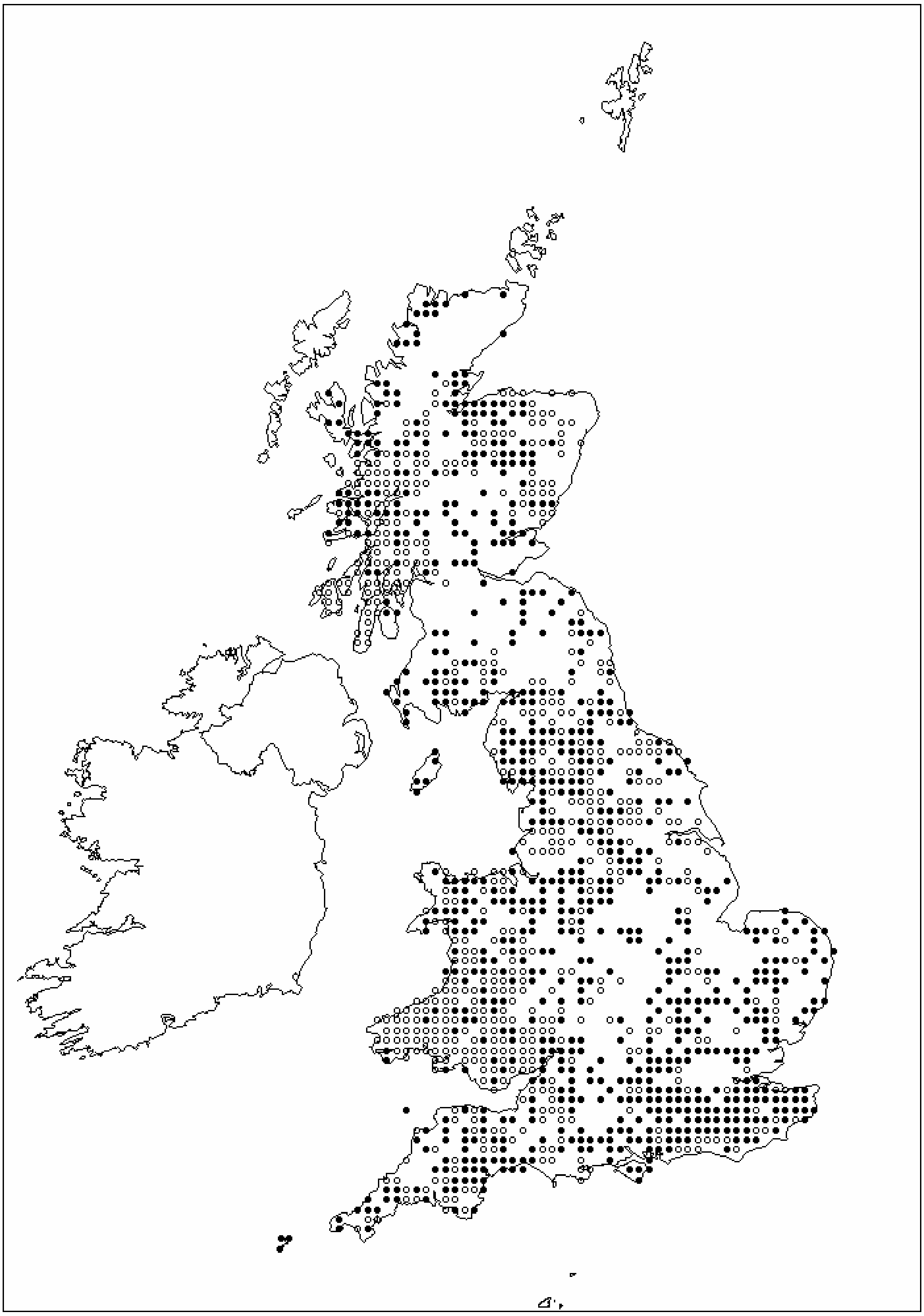

Figure 2 Distribution of original NVC records (•) and new NVC records (❍)

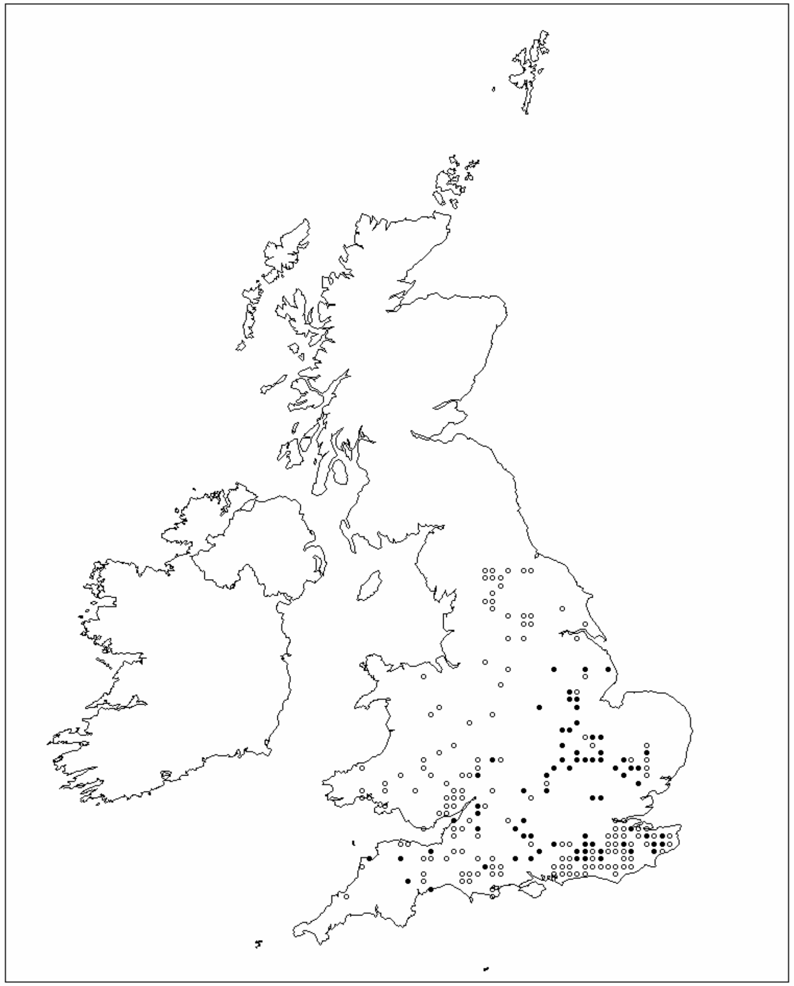

Figure 3a W8a (primrose - ground ivy sub community) original (•) and new NVC records (❍)

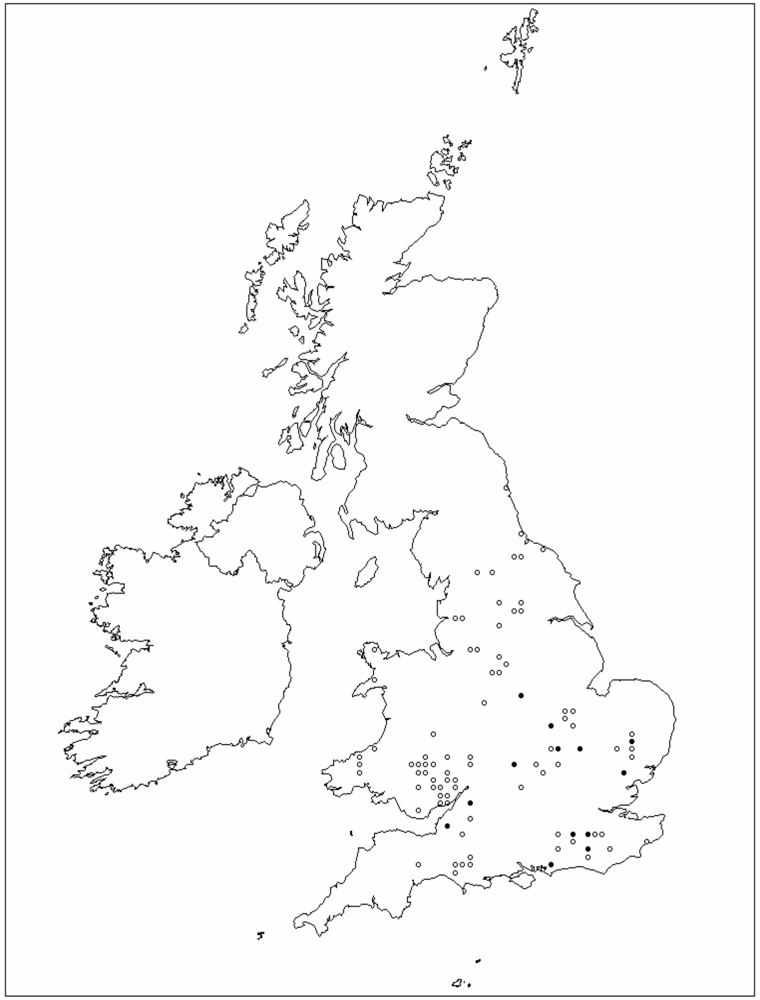

Figure 3b W8c *Deschampsia cespitosa* sub community original (•) and new NVC records (❍)

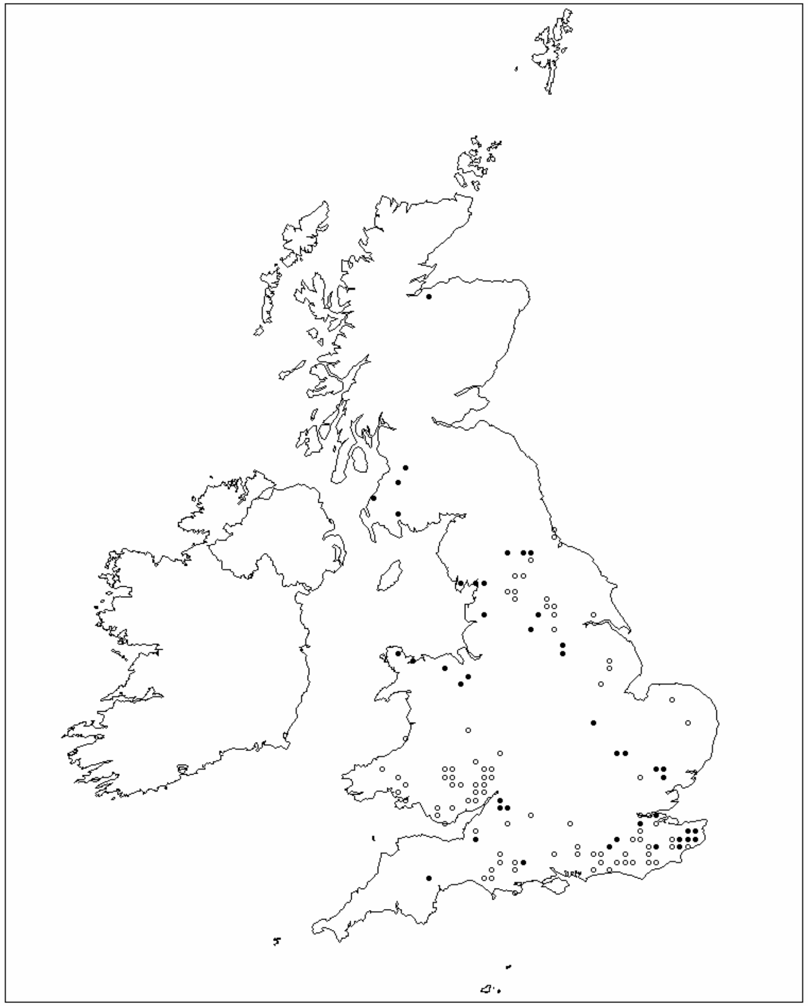

Figure 3c W8b (wood anemone sub community)
original (•) and new NVC records (❍)

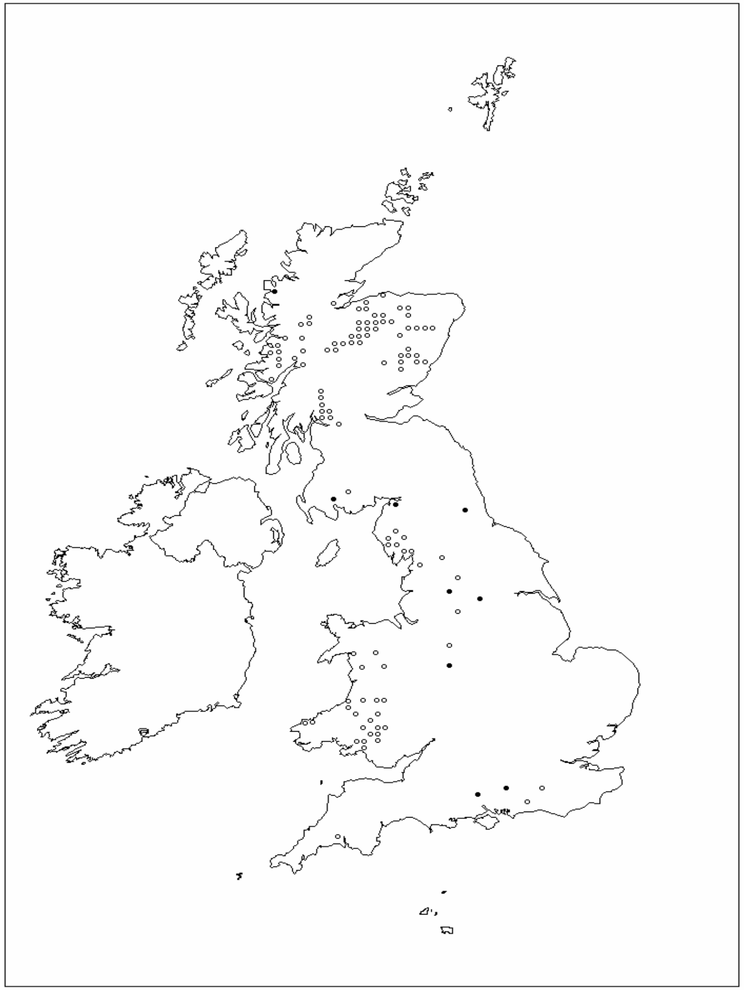

Figure 3d W4b (*Juncus effusus* sub community)
original (•) and new NVC records (❍)

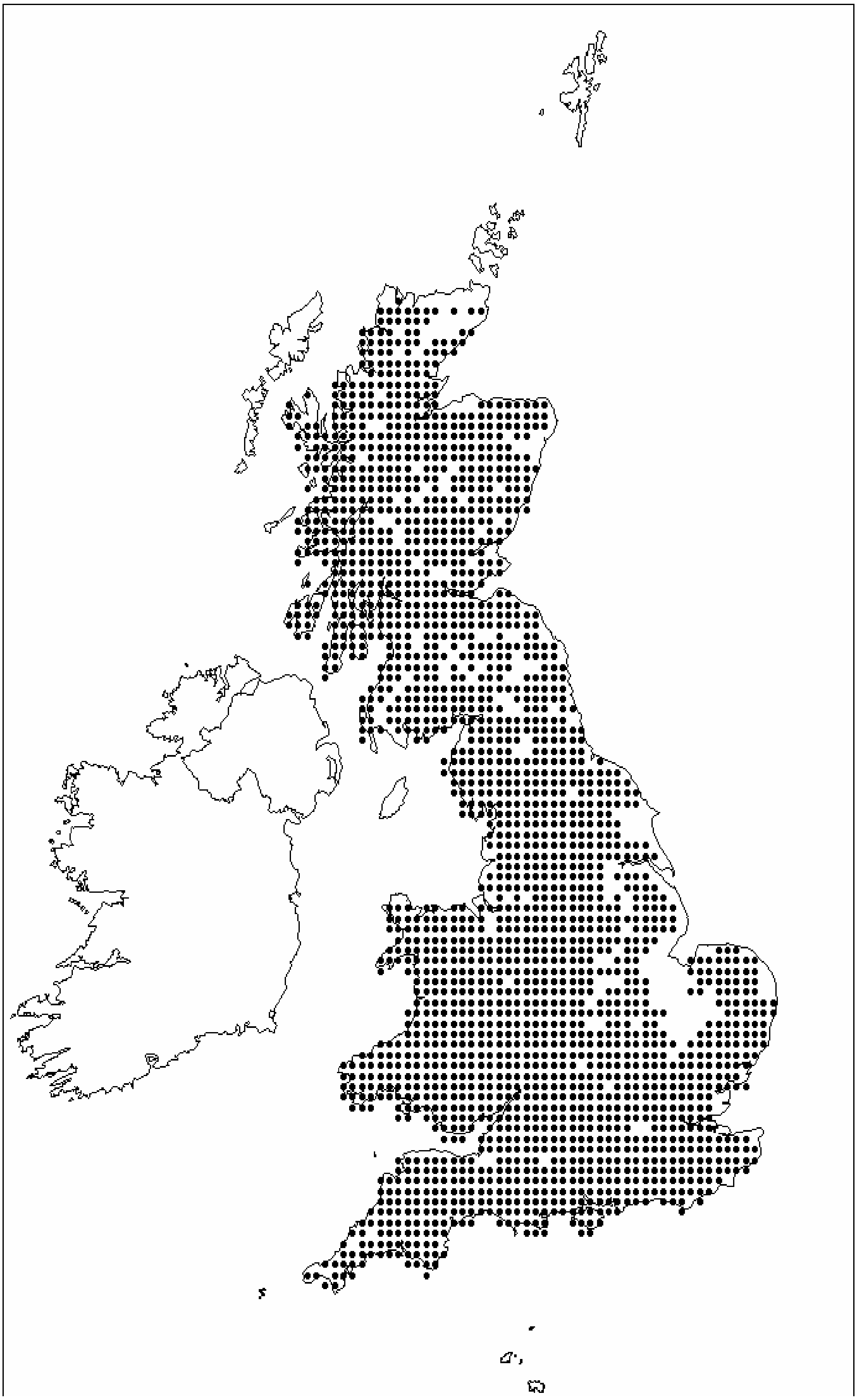

Figure 4 The distribution of ancient woodland in Great Britain

In large areas of the country, most woodland is secondary or plantation, and these have rarely been surveyed. In the Borders region of Scotland, for example, most woodland is recent, and NVC records here are very thin on the ground. Even some areas with very high cover of ancient woodland have not been surveyed using the NVC, often because there is so much woodland there as to make the cost of a representative survey prohibitive (e.g. the New Forest). Other areas had been surveyed using the stand type classification prior to the production of the NVC, and a repeat survey using a different classification has not yet been considered a priority.

Generally speaking, the north, west and southeast of Great Britain has been the best surveyed. The data set (in its present capacity) is, therefore, most useful for looking at communities which there is good reason to suppose are concentrated in these parts of the country. This includes W3 and W7 (northern types of wet woodland), W9, W11 and W17 (northern and western mixed ash and oak woodlands), and W18 (native pine woodland). The general distribution patterns produced for other communities seem to be correct, and are useful for looking at the ranges of such woodland types.

What next

These data are immensely useful and have application beyond describing the known range of a vegetation community. Consequently making the data available via the National Biodiversity Network (NBN) Gateway is a priority. The Gateway is a means of sharing data over the world wide web, at present it is mostly a meta-data source but the potential application is huge.

JNCC are currently considering the future of the database and whether there is a need to restructure it from the simple spreadsheet it started out as. There is value in this as it may allow greater ease of reporting especially regarding the sub communities and the assemblages within sites.

Any donations of data that meet the minimum requirements will be gratefully received.