Forestry Commission

Applying the Ecological Site Classification in the Lowlands

A Case Study of the New Forest Inclosures

Technical Paper 33

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A Case Study of the New Forest Inclosures

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Front cover: A typical New Forest landscape in the west of the forest. Open scrubby heath with mature oak woodland in the distance. (42864)

Back cover: *top:* Dry open heathland grazed by New Forest ponies, against a background of broadleaved woodland. (42865)
middle: River Docker, a typical small meandering New Forest stream.
(ForestLife Photolibrary 102046720)
bottom: Strongly developed, freely drained, podzol soil developed in Becton Sand (Barton Sand) with a thin overlay of Plateau Gravel (Soil Type 1). The Gravel is confined to the upper layers, especially the bleached layer. Beneath the undulating black layer of humus deposition and the dark brown layer of iron oxide deposition the original bedding of the Becton Sand can be clearly seen. (D.G. Pyatt)

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EXECUTIVE SUMMARY

General

1. An Ecological Site Classification (ESC) of the New Forest Inclosures (8500 ha) has been developed to help forest managers with choice of tree species, prediction of timber yield, silvicultural operations, habitat restoration and a number of related matters.
2. The methods developed in the project can be applied to other forests in lowland Britain for similar benefits to their management.
3. For the first time in Britain, site types have been created as combinations of soil types and plant communities of the ground vegetation and defined in terms of their soil moisture and soil nutrient regimes.
4. Choice of tree species for timber production has been put on a sound ecological basis through the use of 'species suitability ratings' in terms of climatic factors, soil moisture and soil nutrient regimes.
5. The restoration of habitats, including native woodland, has similarly been aided through an improved understanding of the ecological potential of the site types.

Objectives

1. The main objective of the work was to provide forest managers with ecological information on sites within the Inclosures that would help them achieve a newly defined set of multi-purpose objectives of management in a sustainable way.
2. A subsidiary objective was to provide a demonstration to managers throughout lowland Britain of the benefits of Ecological Site Classification, as a refinement of traditional forms of forest site classification.
3. The general aims of management for the Inclosures include the restoration of native woodland and non-woodland habitats, conservation of important wildlife habitats, management of public access, growing of quality timber, protection of archaeological sites and enhancement of landscape and amenity values.
4. Among detailed aims for Inclosures are the restoration of heath, grassland and mire habitats from existing plantations, an extension of the wood pasture system, an increase in appropriate biodiversity whilst maintaining existing timber productivity.

Methods

1. The existing survey of soil types throughout the Inclosures has been supplemented by a complete survey of plant communities using a locally devised classification.
2. The 10 soil types are grouped into 2 podzols, 3 ground-water gleys, 3 brown earths and 2 surface-water gleys (clays).
3. The 19 plant communities are grouped into 3 purple moor-grass, 4 bracken, 2 fine grassy, 4 species-rich or bramble, 2 coarse grassy and 4 wet woodland communities.
4. Detailed descriptions of quadrats within most of the plant communities have been used, in combination with ecological indicator values, to estimate the range of soil moisture and soil nutrient regime for each community.
5. Site types have been formed by combining soil types and plant communities as they occur in the Inclosures.
6. After deletion of trivial combinations, over 100 site types were accepted into the classification.
7. Each site type has been defined by one of eight classes of soil moisture regime and one of five classes of soil nutrient regime.
8. Classes of soil moisture and nutrient regime provide the means of amalgamating site types for practical purposes. The great majority of the area of the Inclosures falls into 10 'site groups' on this basis.
9. Each site type has been rated as 'very suitable', 'suitable' or 'unsuitable' for each tree species considered desirable for timber production.

10. Database information on the existing sub-compartments has been linked to the site types so that average yield classes can be calculated for each major tree species on each major site type.
11. This information will allow managers to consider alternative strategies for use of timber species and nature conservation and compare the strategies in terms of overall timber production and the other aims.
12. The work has been facilitated by digitising the mapped soil and vegetation boundaries and handling the data in a Geographical Information System (GIS).

Results

1. The site types of the Inclosures are placed within the topographic, climatic and geological setting for the Forest.
2. The topography is linked to the underlying geological strata and in turn to the soil types.
3. Although geology is not directly used in the site classification, the distribution and nature of the soil types is related to the lithology of the strata.
4. The New Forest falls within the Warm Dry climatic zone of Britain as defined by Ecological Site Classification.
5. The climate sets limits on the range of habitats that occur within the Inclosures, on the range of timber producing species that can be grown and on their rates of growth.
6. The climatic factor most limiting to tree growth rate is summer moisture supply.
7. Windiness appears to restrict the maximum height reached by trees to about 40 m through either breakage of the top or physiological effects (dehydration).
8. The variation in climate within the Inclosures is insufficient to justify sub-dividing the site classification by climatic sub-zones.
9. Maps are presented of climate factors, elevation, geology, soil types, plant communities, soil moisture regimes, soil nutrient regimes.
10. Important soil limitations include a generally low level of fertility and a predominance of shallow winter water tables.
11. The most extensive soil types are heavy clays with attendant risks of compaction by heavy machinery, especially in winter.
12. A strategy of using productive conifers on sites that are very suitable for them could reduce the area required to maintain present levels of timber production.
13. The species most tolerant of Wet clayey sites is pedunculate oak, even though the soil nutrient regime is generally only suitable and therefore growth rates are low.
14. Areas of clay soils with better than average profile drainage have been identified in the site classification and are suitable for species that are higher yielding than pedunculate oak, including Douglas fir, Corsican pine and beech.
15. The most productive species for well drained brown earth sites are Douglas fir and Corsican pine.
16. Corsican pine is ecologically better suited than Douglas fir to Moist and Very Moist sites and Poor sites.
17. For good growth and stability beech requires well drained brown earth sites.
18. Sessile oak is less tolerant of Wet sites than pedunculate oak and may be more tolerant of Slightly Dry sites but its yield is similarly low.
19. Some of the potentially most productive site types for conifers (mainly the brown earths with Medium soil nutrient regime) have plant communities of high amenity value when growing beneath broadleaved species.
20. The ability of a tree species to regenerate naturally on a site type depends more on the condition of the seedbed and the subsequent regrowth of weeds than to the potential of the site for long-term growth of that species. The most likely problems of weed growth occur on Moist or Wet, Medium or Rich site types.
21. Restoration of dry heath habitats from woodland is more successful or rapid on podzol sites than on brown earths; restoration of wet heath or mire from woodland is more successful or rapid on ground-water gley sites than on clays.

22. The National Vegetation Classification of native woodlands is difficult to apply in the plantations of the Inclosures probably because the plant communities are degraded by a history of grazing and shade.
23. The principal 'site groups' within the Inclosures are ecologically appropriate for W16 (oak–birch with bilberry), W15 (beech–oak with wavy hair-grass), W10 (mixed broadleaved with bluebell), W14 (beech–oak with bramble) and W4 (downy birch with purple moor-grass). The wet woodlands within the Inclosures are important for conservation but are already under appropriate management.

Implications for other forests

1. ESC can offer managers of other lowland forests similar benefits through improved understanding of the variety of site types and their potential for silvicultural, wildlife conservation and other uses.
2. Forests that are smaller or less complex than the New Forest could carry out a simpler form of site survey to achieve these benefits.
3. Creating site types by combining soil types and plant communities and rating them in terms of soil moisture and soil nutrient regime is ecologically effective. It also facilitates the amalgamation of site types into a much smaller number of site groups for practical purposes.
4. ESC provides an ecological rationale for species choice and links site type to expected yield class through the use of 'species suitability ratings' based on the best available knowledge.
5. The range of site conditions in lowland Britain is wider than in the New Forest and includes site types not considered in this survey.
6. In upland forests the relative importance of climate in the site classification will be greater than in the New Forest.
7. GIS is essential to get the full benefits from ESC.

Chapter 1

Introduction

This case study concerns the application of the Ecological Site Classification (ESC) to the Inclosures of the New Forest. These extend to some 8500 ha and consist largely of woodland managed for multiple benefits. The Inclosures form about half of the total woodland area and represent about 31% of the area within the boundary or 'perambulation' of the Forest. This Technical Paper presents the results of a survey of the Inclosures designed to provide managers with a classification of site types based on their ecological potential, as an aid to more effective management for silvicultural and conservation objectives. The classification is supported with information on soil conditions, climate and ground vegetation, including an attempt to relate the timber yield of the major tree species to the site types. The survey has benefitted from the recent introduction of a geographical information system (GIS) both in providing precise quantitative data and a variety of maps.

The reader who is familiar with ESC (Pyatt *et al.*, 2001) and who is mainly interested in the practical results of the survey could move directly to Chapters 11, 12 and 13. Someone who is coming to the subject for the first time will find in Chapter 2 a general review of the classification methods as applied nationally. Chapters 3 to 7 provide background information on the environment of the New Forest Inclosures. The novel methodological work of the survey is detailed in Chapters 8 to 10.

The New Forest was chosen as a demonstration area for the introduction of ESC in forest management because it is one of the largest and most complex forests in lowland Britain. It was opportune because a new phase of management of the Inclosures was about to be implemented through a series of design plans. We hope that the methods and results of the survey carried out in the New Forest will lead the way into a new era of forest planning throughout lowland Britain based firmly on ecological principles and knowledge. Managers of smaller and less complex forests will not need to go to such lengths as we have done to map their site types and acquire ecological data to characterise them, but the same principles should apply everywhere.

The uses to which this ecological information can be put are many and varied and for each Inclosure will depend on the objectives of management. The management of an individual Inclosure is set within a strategic plan for the Inclosures, and within the overall management of the woodlands and of the whole Forest (MAFF, 1999). The general and possible detailed aims for the Inclosures are given in Appendix 1.

Purpose of ecological site classification in the New Forest

ESC is intended to provide a sound basis for the sustainable management of multi-purpose forests. In its present stage of development as a national system, ESC supplies information and methodology to assist two major tasks of management: choice of species for timber production (Chapter 11) and choice of native woodland for conservation purposes (Chapter 12). At a forest scale, with more detailed site information, it can provide help with a range of silvicultural matters such as ground preparation for planting, drainage, weed growth, fertilisers, windthrow hazard, soil compaction hazard, long-term retentions, habitat restoration and potential biodiversity (Chapter 13).

ESC sets out to determine the ecological potential of a site from climatic and soil factors. It then supplies advice on how timber production and native woodlands are linked to site potential. As far as timber production is concerned, there will usually be a range of alternative 'crops' that can be grown, each of which will be ecologically adapted to the site. ESC may be able to rank these alternatives in terms of their ecological suitability as well as their potential timber yield and these will be two of the considerations for the forest manager. The manager will always have a number of different objectives and various constraints on his actions, such as which kinds of timber are most valuable and the desire to balance the quantity of supply of any product to the likely future size of the market.

As far as conservation is concerned, there will usually also be more than one choice of action. More than one type of native woodland may be ecologically suited, or there may be the choice between woodland and non-woodland vegetation.

Last but not least, the manager is constrained by the present nature of the vegetation, its composition, age, health and so on. The present condition may be close or very far from the desired future condition; it may be fairly easy or it may be extremely difficult or may take many years before the needed improvements can be effected.

Whatever support ESC can provide to these management decisions it is important that the information be available for the whole area. Only with complete coverage can the manager deal with questions on, for example, the balance between timber production and conservation, the balance between broadleaves and conifers, and what scale of operation best suits particular objectives. The manager needs to know not only the total areas of different site types, but also where the main site types are predominantly located and what is their pattern in the landscape. It is clear that the introduction of a GIS will be a great help to the manager in handling all this information. More importantly it will also make it possible to examine the potential impact of the different choices of action on timber production, conservation and other values.

ESC site types created by combining soil types and plant communities

A soil survey of the Inclosures was carried out in 1962–63. Ten soil types were identified and mapped at the 1:10 000 scale. The soil types are essentially a pedological classification subdivided by variations in texture and profile drainage class. While they provide a good estimate of soil moisture regime, they are much less successful at predicting soil nutrient regime. A preliminary examination of the Forest in spring 1997 showed that most of the soil types would vary in soil nutrient regime by two or three classes. This variation could only be estimated practically from the ground vegetation. It was decided to carry out as complete a survey as possible of the ground vegetation of the Forest with soil nutrient regime in mind. A local classification was developed for this purpose in preference to mapping plant communities according to the National Vegetation Classification (NVC). Soil types and plant communities were then combined in a novel way to create site types based on soil moisture and nutrient regimes.

Chapter 2

Ecological site classification

ESC has been developed by Forest Research since 1992 and released initially through publications (Pyatt and Suárez, 1997; Pyatt *et al.*, 2001) and then as a computerised Decision Support System (Ray, 2001). However, this chapter supplies an adequate background to ESC without these other publications. The reader interested specifically in site classification in the New Forest should note that this Technical Paper presents a fully worked out site classification for the Inclosures, making it unnecessary for the user to have to work through each step of the process. Detailed data and maps are available from Forest Enterprise, New Forest District (address on title page).

For forest management to be successful, not only the existing condition of each stand but also the ecological potential of the site must be taken into account. Ecological site classification aims to assess the ecological potential of a site in terms of climatic and soil factors, using the existing vegetation as a key indicator. The assumption is also made that there exist *site types* that can be mapped as areas of relative uniformity of ecological conditions, typically larger than a quarter of a hectare.

Climate

The climatic potential of a site is assessed in terms of four factors: accumulated temperature, moisture deficit, continentality and windiness. Accumulated temperature is calculated as the degree-days above 5 °C accumulated monthly throughout the year. It measures the length and intensity of the growing season. Moisture deficit is calculated by accumulating the monthly amounts by which evaporation exceeds rainfall and taking the peak value for the year (mm). It is a measure of summer droughtiness. Seven climatic zones are defined using a combination of accumulated temperature and moisture deficit (White *et al.*, 2000). Continentality is calculated as an index (Conrad, 1946) that is largely determined by the annual range of monthly mean temperature. It measures the degree to which the ocean affects the climate. Windiness expresses the duration and strength of the wind throughout the year. It is calculated using a formula derived from studying the rate of attrition of tatter flags in relation to their location and the topographical conditions (Quine and White, 1994). Values for each of the four factors have been calculated for the New Forest and are discussed further in Chapter 4.

Soil quality

The ecological potential of the soil is assessed in terms of two factors, soil moisture regime and soil nutrient regime. Both are continuous gradients but for convenience are divided into a number of classes. The grid formed from these two axes is called the 'soil quality grid'. A site type is defined as a portion of the soil quality grid *within a specified climatic range.*

Soil moisture regime expresses the availability of moisture and oxygen for root growth and function. There are eight classes from Very Dry to Very Wet. The classes from Very Wet to Fresh are defined by the depth of the water table, either using Wetness Class or simply the mean depth in the winter as in Table 1. Classes from Fresh to Very Dry are defined in terms of their 'droughtiness' by taking into account available water capacity and moisture deficit as in Table 2.

Table 1 A comparison of soil moisture regime and wetness class[1]

Soil moisture class	Wetness class	Duration of wet states[2]	Winter water table[4]
Very Dry–Slightly Dry	I	The soil profile is not wet within 70 cm depth for more than 30 days in most[3] years	>100
Fresh	II	The soil profile is wet within 70 cm depth for 30–90 days in most years	80–100
Moist	III	The soil profile is wet within 70 cm depth for 90–180 days in most years	60–80
Very Moist	IV	The soil profile is wet within 70 cm depth for more than 180 days, but not wet within 40 cm depth for more than 180 days in most years	40–60
Wet	V	The soil profile is wet within 40 cm depth for more than 180 days, and is usually wet within 70 cm for more than 335 days in most years	20–40
Very Wet	VI	The soil profile is wet within 40 cm depth for more than 335 days in most years	<20

1 After Hodgson (1974) or Robson and Thomasson (1977).
2 The number of days specified is not necessarily a continuous period.
3 'In most years' is defined as more than 15 out of 30 years.
4 Approximate mean depth (cm) of the water table between October and March inclusive.

Table 2 Using moisture deficit and available water capacity to assess the soil moisture class of freely draining soils

Available water capacity (mm)	Moisture deficit (mm) < 20	20–60	60–90	90–120	120–140	140–160	160–180	180–200	> 200
<50	SD	SD	MD	MD–VD	VD	VD	VD	VD	VD
50–100	F	SD	SD–MD	MD	VD	VD	VD	VD	VD
100–150	F	F	F–SD	SD	MD	MD	VD	VD	VD
150–200	F	F	F	F	F–SD	SD	SD–MD	MD	MD
>200	F	F	F	F	F	F	SD	SD	SD–MD

VD = Very Dry, MD = Moderately Dry, SD = Slightly Dry, F= Fresh.

For a particular site the class of soil moisture regime can be assessed or predicted in various ways. Soil type itself gives a rough indication of the class of soil moisture regime (Figure 1 see colour section). This diagram is much simplified and does not indicate the overlap that occurs between soil types on both axes.

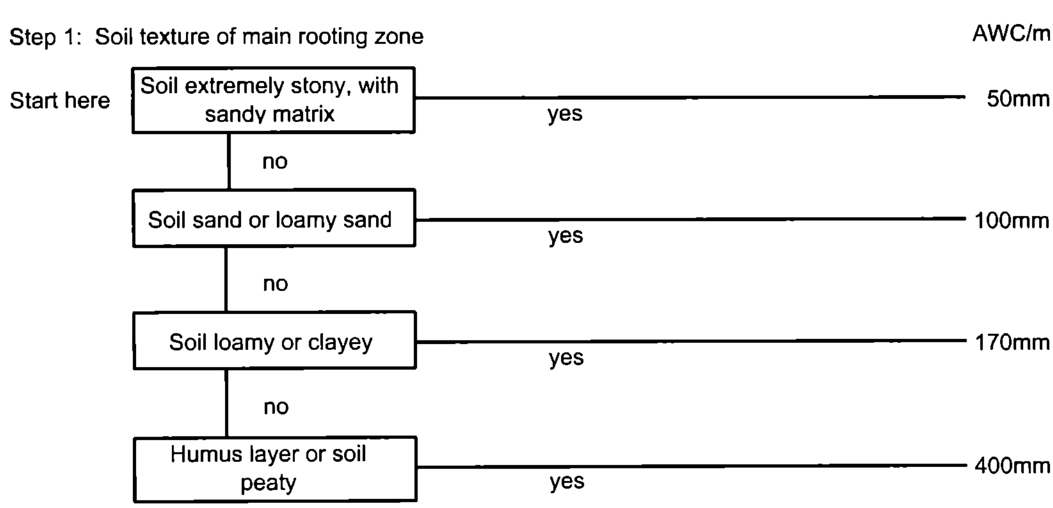
A more reliable estimate of the class of soil moisture regime entails a consideration of several soil, topographic and climatic variables. Soil wetness class can be assessed by examining the soil profile for gley symptoms (Chapter 6) or by directly observing the depth of the water table, particularly in winter. In freely draining soils the most important soil properties are the texture, stoniness and organic matter content, which affect the available water capacity of the soil. Stony or sandy soils have a smaller available water capacity than humose, loamy or clayey textured soils. Available water capacity is estimated using Figure 2. On slopes soils may receive lateral flow of water from higher ground, thereby reducing the period of summer drought that affects the soils at the top of the slope. The amount and distribution of rainfall and evaporation also affect soil moisture regime and their combined effect is predicted by the moisture deficit.

Soils in which the water table lies within reach of the roots have greater resistance to summer drought than freely draining soils where the water table lies out of reach of roots. It is difficult to estimate the contribution of the water table to alleviating droughtiness, but if the water table at any time in June–August of an average summer lies within the secondary rooting zone it would be safe to assume that the soil is not drier than Fresh. The effect on soil moisture regime of position on slope should not need to be taken into account separately from the effect on water table, but an adjustment can be made for the combined effects of slope gradient and aspect (Pyatt *et al.*, 2001). Gradients over 10 degrees are rare in the New Forest, so such adjustments can for most purposes be ignored.

Soil nutrient regime expresses the availability of nutrients for plant growth. Recent research in Britain (Wilson *et al.*, 1998) has shown that the most important components of soil nutrient regime in woodlands are pH and the availability of nitrate-nitrogen, but the availability of calcium, magnesium, potassium and phosphorus is also involved. There are five classes from Very Poor to Very Rich with increasing pH and availability of nutrients, and a sixth, Carbonate, class where very high pH reduces the availability of some nutrients. The main characteristics of the six classes are given in Table 3.

Layered soils: For a soil with two very different layers, e.g. a layer of peat over mineral, separate calculations should be made for each layer and summed. (In many cases the two layers will conveniently form the main and secondary rooting zones.)

Step 1: Soil texture of main rooting zone



Step 2: Depth of main rooting zone

Multiply the AWC/m by the depth of the main rooting zone in metres, e.g. if the depth is 70 cm multiply by 0.7.
(The main rooting zone is that part of the soil that is likely to be uplifted with the root system if the tree is windthrown.)

Step 3: Stoniness of main rooting zone

Soils that are extremely stony (AWC 50 mm/m depth) need no further adjustment.
For other soils reduce the AWC obtained so far by the volumetric proportion of stones.
For example, if there are 15% stones, multiply value by 0.85.
(It is easy to over-estimate the volumetric proportion of stones. Even the extremely stony fluvioglacial gravels with most stones in contact with each other have a maximum of 60% stones by volume, provided the matrix fills the interstices.)

Step 4: Secondary rooting zone

Repeat steps 1–3, for the secondary rooting zone, but finally multiply its contribution to AWC by 0.5.
(The secondary rooting zone may have very few roots (e.g. <1/dm^2) but can be a major source of moisture during droughts. If in doubt about depth, err on the generous side.)

Step 5: Add the contributions from the main and secondary rooting zones.

Figure 2 Estimating the available water capacity of the soil.

Table 3 Some chemical properties of soil nutrient classes in relation to silviculture

	Soil nutrient regime					
	Very Poor	**Poor**	**Medium**	**Rich**	**Very Rich**	**Carbonate**
pH (H_2O) in upper 25 cm depth	3.0–4.0	3.0–4.0	3.0–5.0	3.0–5.5	4.5–7.5	7.5–8.5
P availability	low	moderate to high	usually high	high	very high	low to moderate
P fertiliser requirement*	1. likely 2. possible	1. likely except for pines 2. unlikely	unlikely except for basic igneous and some shale lithologies	unlikely	none	uncertain
N availability	very low, mainly NH_4 with a little NO_3	low, mainly NH4 with some NO_3	moderate, both NH_4 and NO_3	moderate to high, both NH_4 and NO_3	very high, mainly NO_3	moderate, mainly NO_3
N fertiliser requirement*	1 & 2. likely for species other than pines and larches	1 & 2. possible for species other than pines and larches	unlikely	none	none	uncertain
Other nutrient problems	K often deficient on peats	none likely	none likely	none likely	none likely	N,P,K and micro-nutrients (Fe, Mn) can be unavailable

* 1. For woodland establishment on bare land. 2. Restocking existing woodlands.

The class of soil nutrient regime is identified using a combination of soil type and lithology of the parent material, the humus form and the species composition of the non-tree vegetation. The approximate relationship between soil type, humus form and soil nutrient regime is shown in Figure 1. A more precise assessment is obtained from the species composition of the ground, field and shrub layers of the vegetation. Wilson (1998) derived nutrient indicator values for over 50 of the commonest woodland plants. The weighted mean indicator value derived from the most abundant species present gives a reliable prediction of soil nutrient class. Ellenberg *et al.* (1992) provided separate indicator values for soil moisture and nutrients for over 1000 plants in Central Europe, many of which grow in British woodlands. Recently, Hill *et al.* (1999) calibrated Ellenberg's values for British plants. The indicator plants shown on Table 4 have been placed on the soil quality grid in classes based on their Wilson and Hill-Ellenberg values (Pyatt *et al.*, 2001).

Table 4 Indicator plants for the assessment of soil moisture and nutrient regimes in British woodlands (based on Wilson, 1998 and Hill *et al.*, 1999)

Soil moisture regime	Soil nutrient regime[1]				
	Very Poor	**Poor**	**Medium**	**Rich**	**Very Rich**
Slightly Dry			wood sage		burdock
Fresh	cowberry, bell-heather	wavy hair-grass, common bent, bracken, common violet, great woodrush, slender St John's wort, sheep's sorrel, sheep's fescue	raspberry, holly, greater stitchwort, cow-wheat, chickweed, broom, gorse, common mouse-ear	bluebell (wild hyacinth), hazel, ivy, hawthorn, false-brome, rosebay willowherb, germander speedwell, wood sedge, pignut, primrose, cocksfoot, red fescue, yarrow	elder, yellow archangel, wood spurge, common hemp-nettle, spear thistle, white clover, false oat-grass, hogweed
Moist	bilberry (blaeberry), heather, crowberry, green-ribbed sedge	wood sorrel, scaly male-fern, hard fern, heath bedstraw, heath woodrush	bramble, creeping soft-grass, broad buckler-fern, wood anemone, foxglove, honeysuckle, yorkshire fog, sweet vernal-grass	tufted hair-grass, male-fern, herb robert	dog's mercury, goosegrass (cleavers), ramsons, stinging nettle, hedge woundwort, ground ivy, wood avens, enchanter's nightshade, lesser celandine, red campion, wood speedwell, common horsetail, creeping thistle, rough meadow-grass
Very Moist	mat-grass, tormentil, heath rush	compact rush, devil's bit scabious	lady-fern, yellow pimpernel, creeping buttercup, soft rush	bugle	
Wet	purple moor-grass, cotton-grass (hare's-tail), cross-leaved heath, deer-grass, lousewort	sharp-flowered rush	marsh thistle	wood horsetail, common valerian, meadow-sweet, wild angelica	
Very Wet	common cotton-grass, bog myrtle			golden saxifrage, marsh marigold,	

[1] There are no common indicator plants for the Carbonate class. Shade-tolerant species are underlined.

A full assessment of an individual site or of a *site type* using ecological site classification therefore requires four climatic factors and two soil factors to be taken into account. In the New Forest, as elsewhere, the climate sets the limits on the kind of ecosystems that can develop, but the variability of climate in this area is small. It is the soil moisture and nutrient supply that cause most of the variability in ecological potential between sites in the New Forest.

Species suitability

Sites are judged as to their suitability for the growth of different timber producing species using 'species suitability ratings'. For each species the range of each climatic and soil factor throughout Britain has been assigned to one of three suitability classes. *Very suitable* implies that the climatic or soil variable is ideal or close to ideal for the species and that rapid growth and the production of good quality timber are to be expected. Suitable implies that the climatic or soil variable is capable of sustaining a satisfactory growth rate and timber quality. *Unsuitable* conditions are incapable of sustaining either satisfactory growth rates or timber quality and the species is not recommended for planting.

The suitability ratings have been drawn up based on a combination of experience, a study of the literature and limited validation from sub-compartment databases and sample plots. A list of the relevant literature was given by Pyatt and Suárez (1997). The overall suitability of a site for a species is obtained by combining the suitabilities for each factor. The lowest rating of any factor determines the outcome of the combination. Suitability ratings for six major and three lesser timber producing species in the New Forest are given in Figures 3 to 8. An explanation of why some other species have been left off the list is given in Chapter 12.

Site conditions that are *very suitable* for the growth of a species are not necessarily those in which the species naturally regenerates successfully, and vice versa. Successful natural regeneration requires that the combination of seed supply, light and seedbed conditions is suitable and this may be provided by sub-optimal conditions for later growth. In particular, growth of weeds either before or soon after seed germination is often critical for seedling establishment, but may provide no long-term hindrance to growth. Seed may germinate well and seedlings may establish on soils that are too nutrient poor for continued growth of the seedlings. Thus decisions as to whether a species or mix of species

Figure 3 Suitability of species by accumulated temperature.

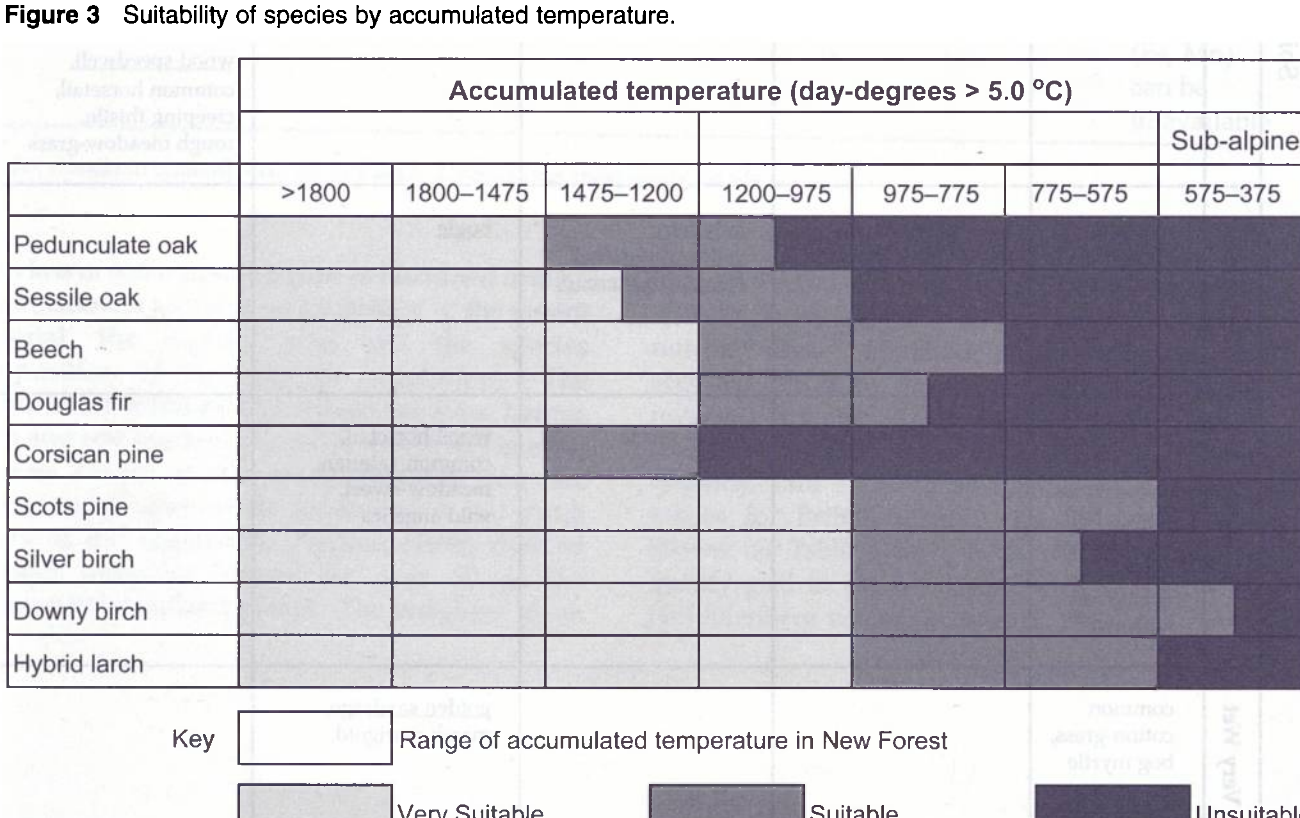


Figure 4 Suitability of species by moisture deficit.

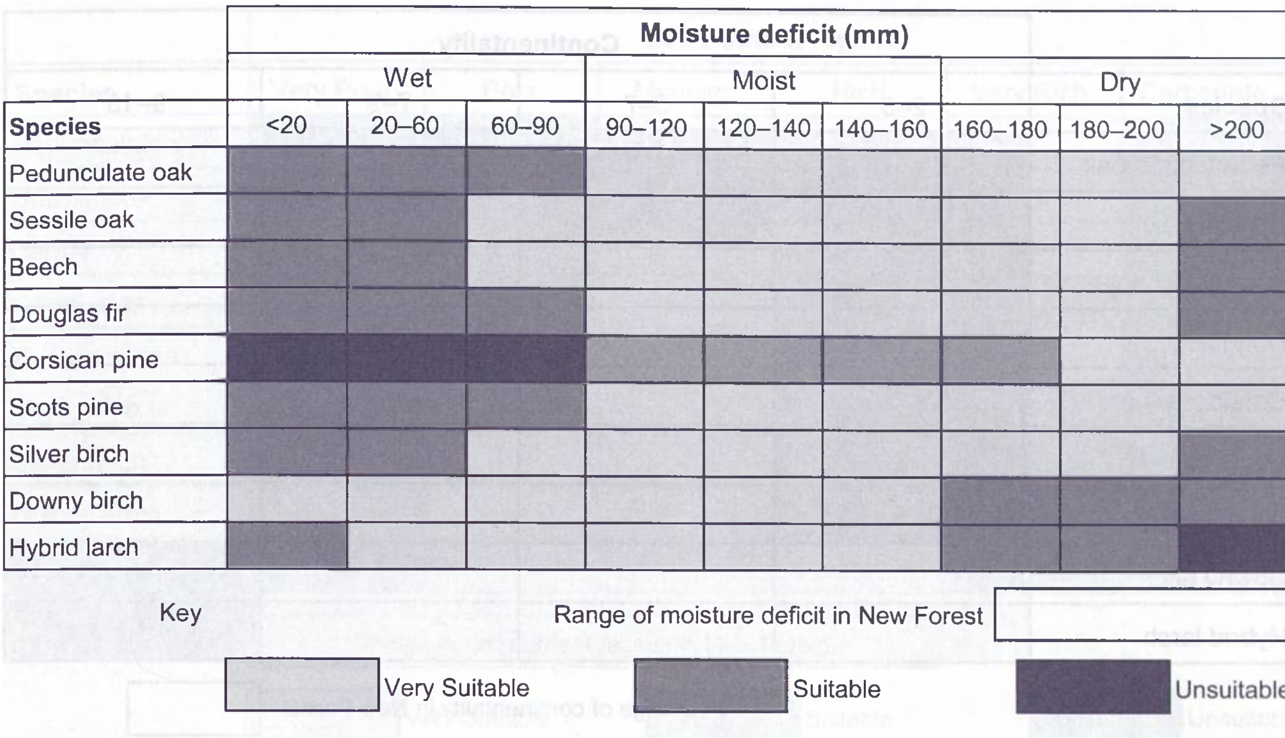


Figure 5 Suitability of species by windiness.

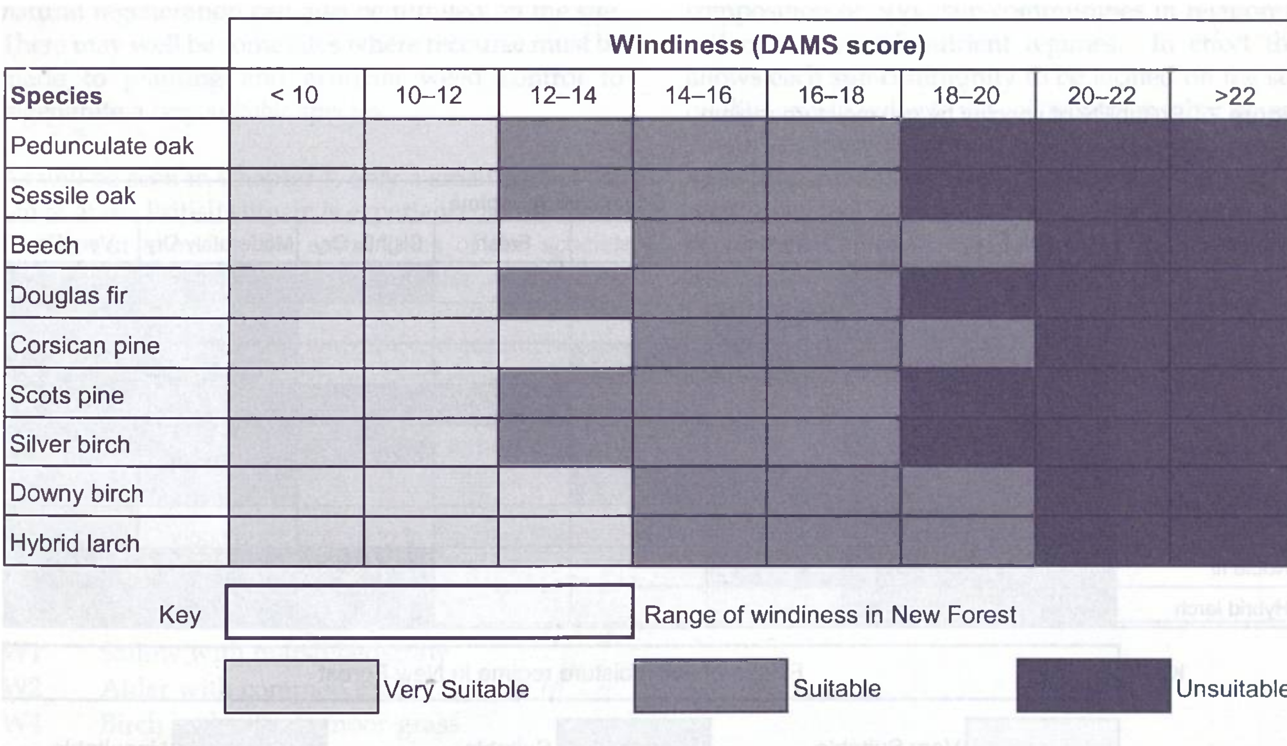


Figure 6 Suitability of species by continentality.

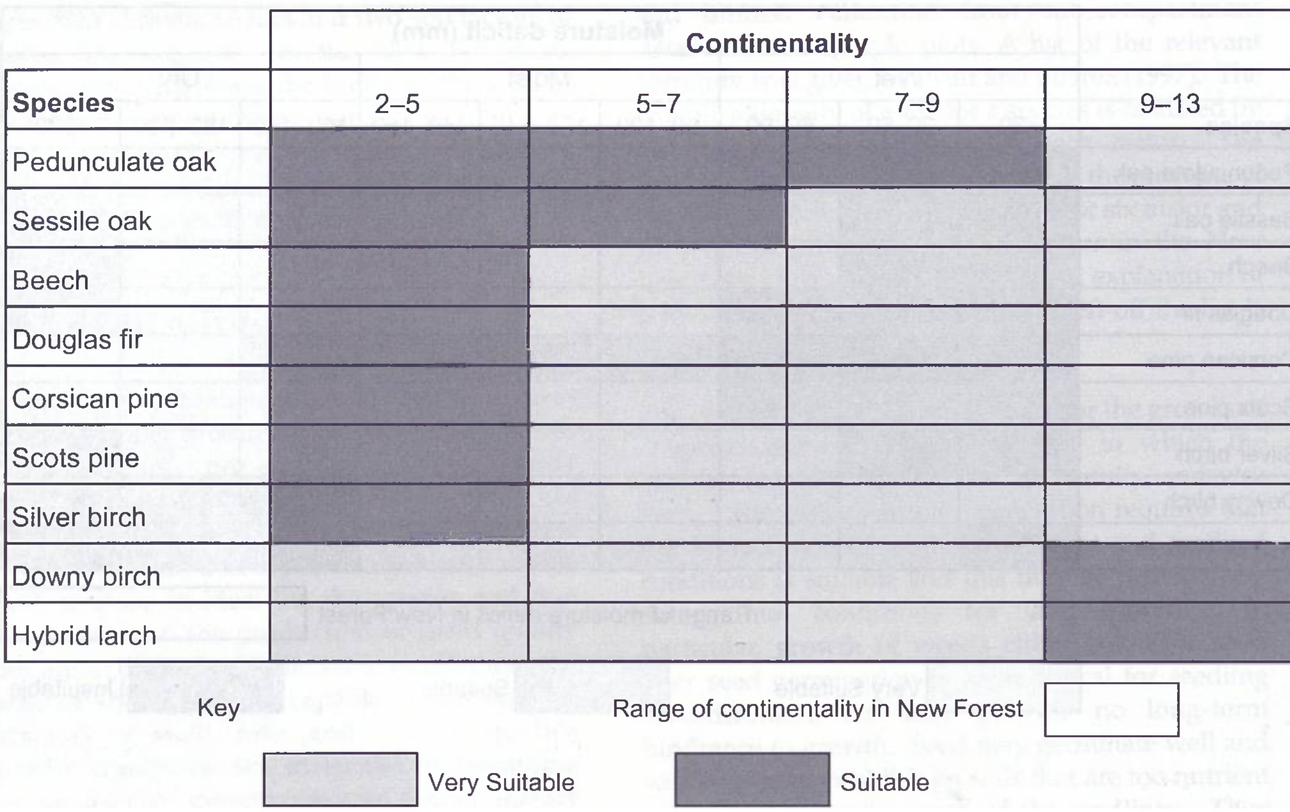


Figure 7 Suitability of species by soil moisture regime.

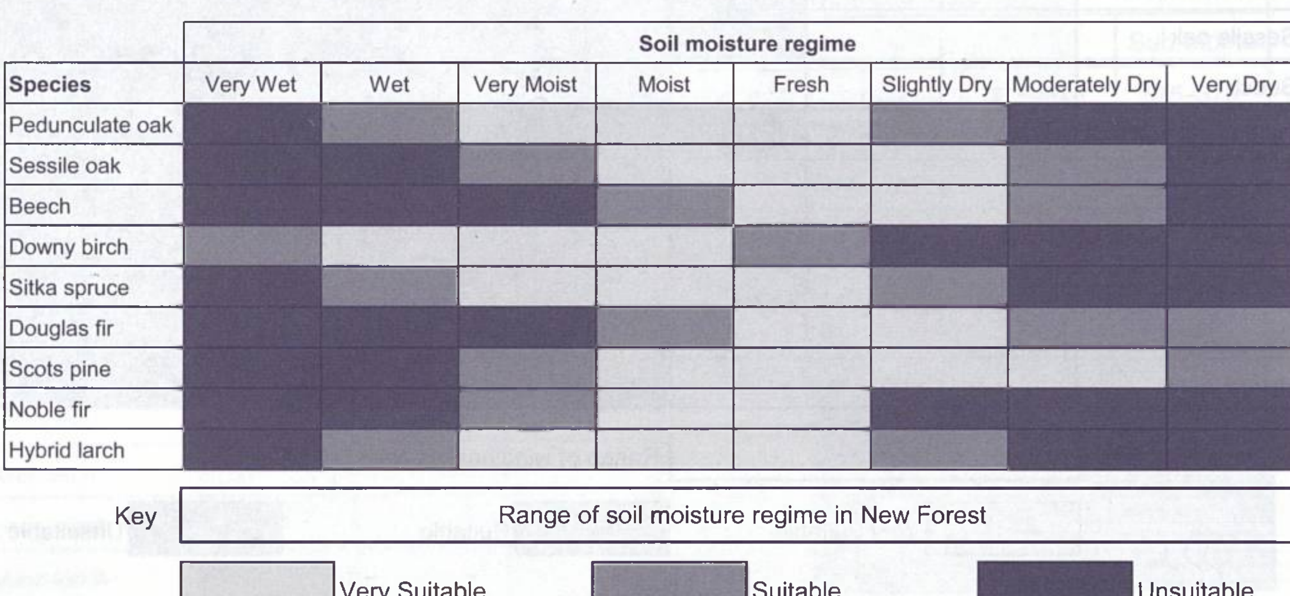
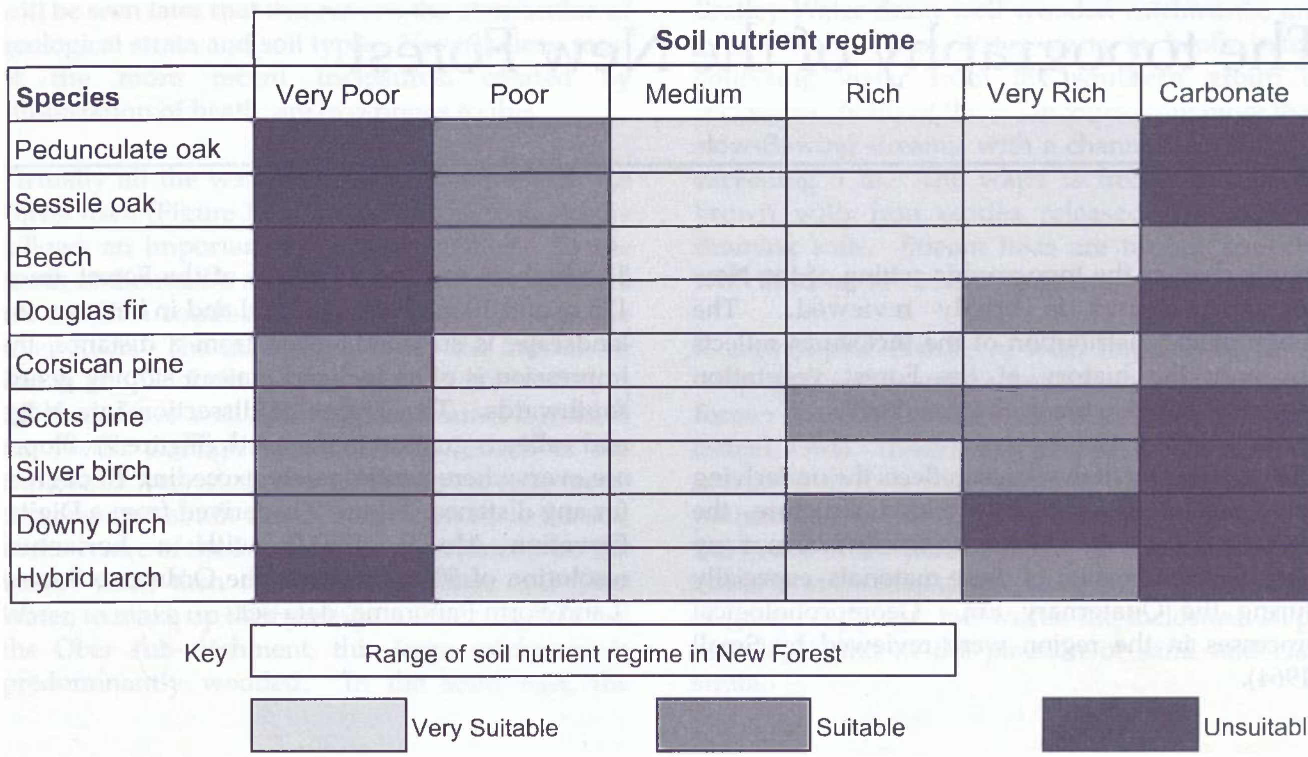


Figure 8 Suitability of species by soil nutrient regime.



can be regenerated naturally can only be made after first considering whether the site is suitable for growth and secondly whether the conditions for natural regeneration can also be fulfilled on the site. There may well be some sites where recourse must be made to planting and artificial weed control to regenerate a *very suitable* species.

As will be seen in Chapter 4, only a small part of the range of the British climate is experienced in the New Forest, but showing the suitabilities of the species throughout Britain helps to put the Forest into context. The climate is seen to be ideal for all six major species in terms of warmth and continentality, but sub-optimal (suitable) in terms of moisture deficit for Douglas fir, sessile oak and beech. Windiness may be a limitation on a few exceptionally exposed sites.

Similar ratings have been made for native woodland communities and sub-communities of the NVC. These are based on an examination of the species composition of NVC sub-communities in relation to soil moisture and nutrient regimes. In effect this allows each sub-community to be located on the soil quality grid to indicate the soil conditions that permit its full expression in both trees and ground flora. Suitability ratings for NVC woodland communities were given by Pyatt *et al.*, 2001. The communities that occur in the New Forest (Table 5) are placed on the soil quality grid in Figures 32 and 33.

Table 5 NVC woodlands occurring in the New Forest (names after Rodwell and Patterson, 1994)

Code	Community
W1	Sallow with marsh bedstraw
W2	Alder with common reed
W4	Birch with purple moor-grass
W5	Alder with tussock sedge
W6	Alder with stinging nettle
W7	Alder–ash with yellow pimpernel
W8	Lowland mixed broadleaved with dog's mercury
W10	Lowland mixed broadleaved with bluebell / wild hyacinth
W14	Beech–oak with bramble
W15	Beech–oak with wavy hair-grass
W16	Lowland oak–birch with wavy hair-grass

Chapter 3

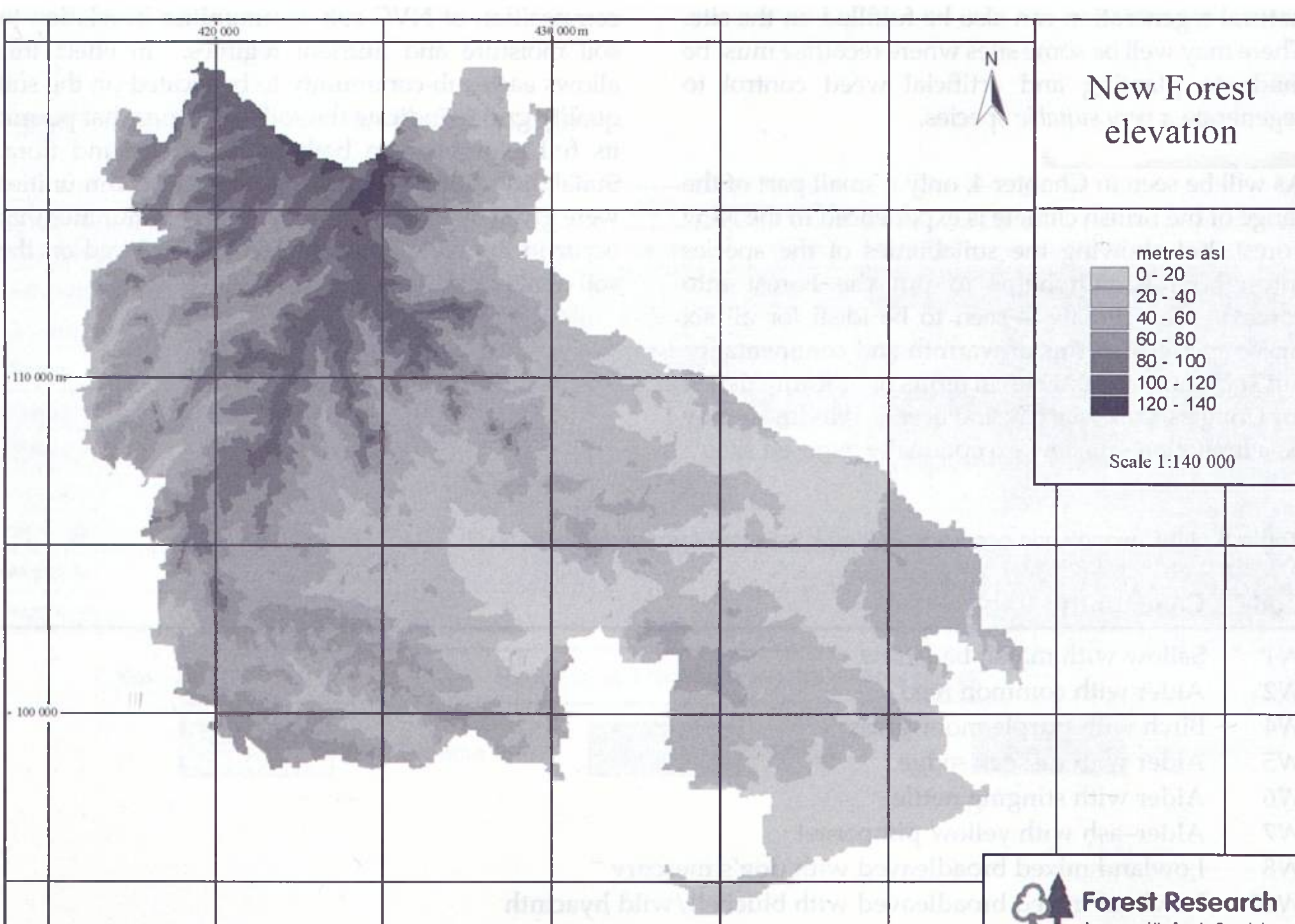
The topography of the New Forest

In this chapter the topographic setting of the New Forest Inclosures is briefly reviewed. The geographical distribution of the Inclosures reflects not only the history of the Forest vegetation generally, but also the geology and soils.

The topography of the Forest reflects the underlying geological strata and their folded structure, the superficial deposits which form the surface in many areas and the erosion of these materials, especially during the Quaternary Era. Geomorphological processes in the region were reviewed by Small (1964).

The highest and lowest points of the Forest are at 125 m and 10 m above sea level and in between the landscape is subdued. Seen from a distance, the impression is of an inclined plateau sloping gently southwards. The degree of dissection into ridge and valley is greatest in the north (Figure 9). Slopes are everywhere gentle, rarely exceeding 10 degrees for any distance. Figure 9 is derived from a Digital Elevation Model (DEM) with a horizontal resolution of 50 m based on the Ordnance Survey 'Land-Form Panorama' data-set.

Figure 9 Map of elevation for the New Forest.

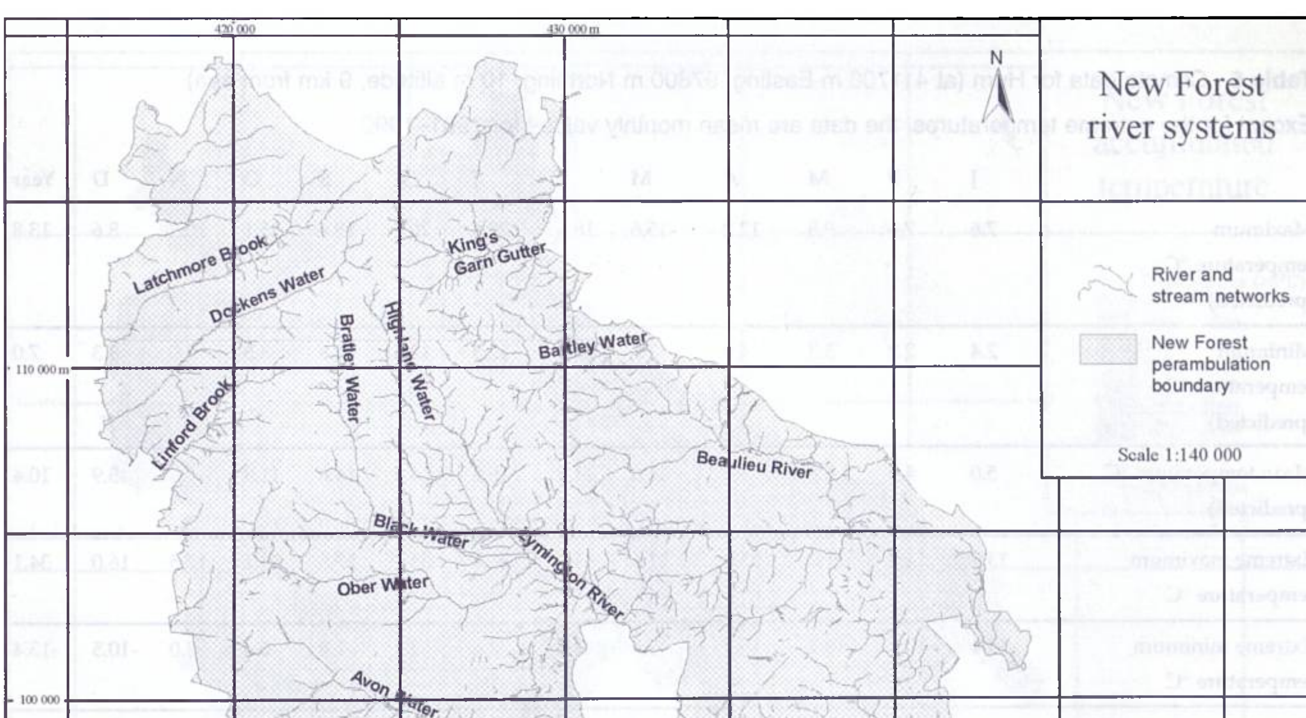


Many of the Inclosures lie in valleys or broad basins between the ridges, which tend to carry heath. It will be seen later that this reflects the distribution of geological strata and soil types. Nevertheless, most of the more recent Inclosures, created by afforestation of heath, are exceptions to this.

Virtually all the watercourses originate within the Forest itself (Figure 10). The A31 trunk road closely follows an important internal watershed. To the north of the road a series of relatively deep valleys are cut in a south-westerly direction towards the river Avon. The main streams are the Latchmore Brook, the Dockens Water and the Linford Brook. All three have well wooded headwaters but leave the Forest through heath. To the south of the watershed, very shallow valleys carry watercourses running east, south-east or south directly to the sea. In the centre of the Forest the Bratley Water joins the Black Water, then the Highland Water and Ober Water, to make up the Lymington River. Apart from the Ober sub-catchment, this large catchment is predominantly wooded. In the south-east, the Beaulieu River runs mainly through heath and mire. In the north-east, the King's Garn Gutter and the Bratley Water drain well wooded catchments, and in the south Avon Water starts in heath before collecting water from the southern group of Inclosures. None of the watercourses are more than slow-flowing streams, with a channel width rarely exceeding 5 m. The water is frequently stained brown with iron oxides released from slowly draining soils. Stream beds are usually gravelly with flints up to about 10 cm size.

A topographic feature of local importance is the 'seepage step' found in heath and Inclosures on former heath, especially those near to the A31 road (Small, 1964). These nearly vertical breaks of slope, usually 1 to 2 m high, occur at the boundary of permeable and impermeable strata, usually around the heads of the main valleys. In the heath of the north-west the seepage step is often seen at the edge of gravel cappings, but within the Inclosures steps are also found at the junction of sand and clay strata.

Figure 10 Map of the river systems of the New Forest.



Chapter 4

The climate of the New Forest

The climate of the Forest is of crucial importance to the ecology and silviculture, setting limits not only on the rates of growth of commercial tree species but also on the variety of attendant species than can exist in each habitat.

As befits its place within the southern lowlands of Britain the New Forest has a warm, sunny climate although the rainfall is somewhat higher than the average for south-east England. Barry (1964) presented a broad picture of the climate and weather of the Southampton region and showed that many elements of the climate vary appreciably with elevation. Mayes (1997) provided a more up to date account of the climate of the south-east England region including the New Forest area. The following data refer to the most recent recording period of 1961–1990. Mean annual rainfall ranges from 730 mm at low levels to 840 mm on the highest ground. The rainfall is fairly evenly distributed but with a spring/summer minimum and a winter peak. Snow can be expected in most years but heavy accumulations are rare. Nevertheless, damaging snowfalls can be expected within the life-span of most trees (see for example Young, 1938). Only in exceptional winters such as 1947 and 1963 does snow lie for more than a few days. The mean annual temperature at Lyndhurst is 10.0 °C, varying with elevation at a rate of about 0.7 °C per 100 m. The mean daily maximum temperature in July is 20.5 °C and the mean daily minimum temperature in February is 1.7 °C.

The nearest relevant meteorological station is at Hurn airport, some 20 km south-west of Lyndhurst, and is the source of the data in Table 6. Most of the data are derived directly from Meteorological Office records, but the 'predicted' data have been interpolated as described below.

Table 6 Climate data for Hurn (at 411700 m Easting, 97800 m Northing, 10 m altitude, 9 km from sea)

Except for the extreme temperatures, the data are mean monthly values for 1961–1990

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Maximum temperature °C (predicted)	7.6	7.6	9.8	12.2	15.6	18.6	20.6	20.5	18.4	15.1	10.8	8.6	13.8
Minimum temperature °C (predicted)	2.4	2.2	3.3	4.9	7.7	10.5	12.5	12.5	10.8	8.5	5.0	3.3	7.0
Mean temperature °C (predicted)	5.0	4.9	6.6	8.6	11.6	14.6	16.6	16.5	14.6	11.8	7.9	5.9	10.4
Extreme maximum temperature °C	13.7	14.2	21.0	23.1	27.6	33.8	32.9	34.1	27.5	23.1	17.5	16.0	34.1
Extreme minimum temperature °C	-13.4	-10.3	-10.2	-5.7	-3.6	0.4	2.6	2.1	-1.4	-6.4	-8.0	-10.5	-13.4
Precipitation (mm)	89	62	66	48	55	54	40	56	66	80	84	91	791
Total sunshine hours	58	78	122	171	211	215	219	201	154	110	76	57	1672
Days with snow/ sleet falling	2.9	3.3	2.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.9	12.1
Days with snow lying	2.4	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	4.5
Days of grass frost	15.2	14.9	15.6	12.7	6.6	1.8	0.4	0.4	2.2	6.3	12.7	14.6	103.3
Mean wind speed (m/s)	4.7	4.7	4.8	4.5	4.3	4.0	3.9	3.9	3.8	4.0	4.3	4.6	4.3

The Forest lies within the Warm Dry climatic zone defined by ESC based on accumulated temperature and moisture deficit. White *et al.* (2000) described a method of interpolation of climatic data from a 10 x 10 km gridded dataset for Britain supplied by the Climatic Research Unit, University of East Anglia (Barrow *et al.*, 1993). The 'predicted' values for maximum, minimum and mean temperature for Hurn are derived using such an interpolation.

The method is also used to interpolate values of the four ESC climatic factors and thence to make maps. Maps for the New Forest area for three of the ESC factors are shown in Figures 11–13. The variation in continentality in the New Forest is insufficient to require a map. Continentality increases in a north-easterly direction across the Forest, from about 9.0 around Burley to 9.6 near Cadnam. Accumulated temperature and moisture deficit are calculated for each year in the period 1961–1990, then the period mean is taken for each 10 x 10 km square. Interpolation then follows. The interpolation equation relates (for the whole of Britain) the value of the climatic variable to its grid reference, altitude and (for some factors) distance from the sea, all of which are derived from the Ordnance Survey DEM mentioned in Chapter 3. The interpolation equation is then used in a raster GIS package to create a dataset at any desired resolution for Britain or any part of it.

The range of accumulated temperature in the Forest is from 1770 to 2070 day-degrees, and is almost entirely dependent on elevation (Figure 11). Although 1800 day-degrees is the boundary between 'sub-zones' within the Warm Dry zone, the extent of land with less than 1800 day-degrees is negligible.

Moisture deficit changes quite rapidly in the vicinity of the New Forest, although the trend is confounded with the increase in elevation to the north-west (Figure 12). The range of values, from 160 to 220 mm, includes all three of the moisture sub-zones within the Warm Dry zone. The likely effect of this variation on soil moisture regime can be gauged from Table 2. In the relevant three columns of the table, depending on the available water capacity of the soil, the range in soil moisture regime is only about a half-class. This does not therefore justify a sub-zonation of the Forest.

Figure 11 Map of accumulated temperature for the New Forest.

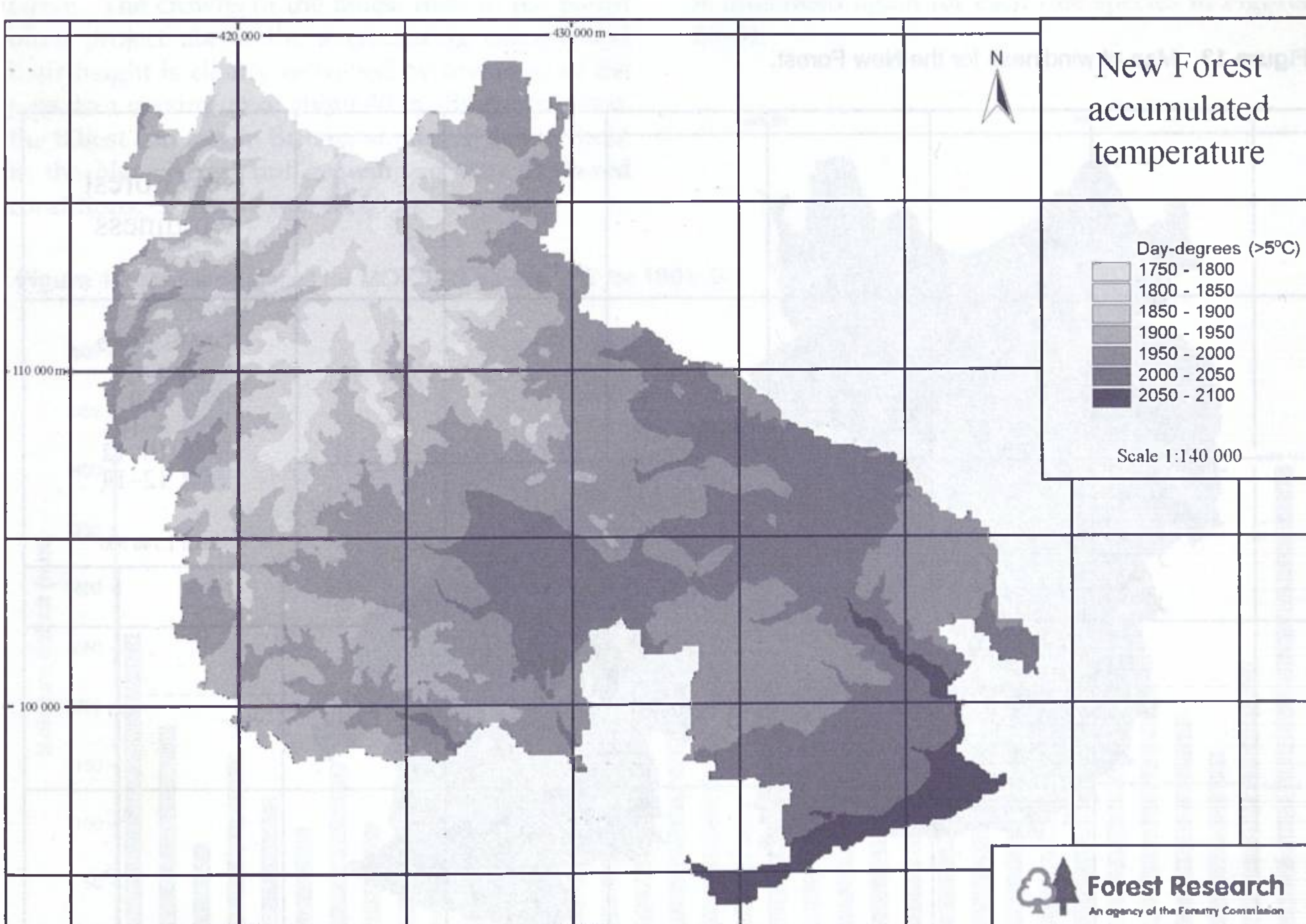


Figure 12 Map of moisture deficit for the New Forest.

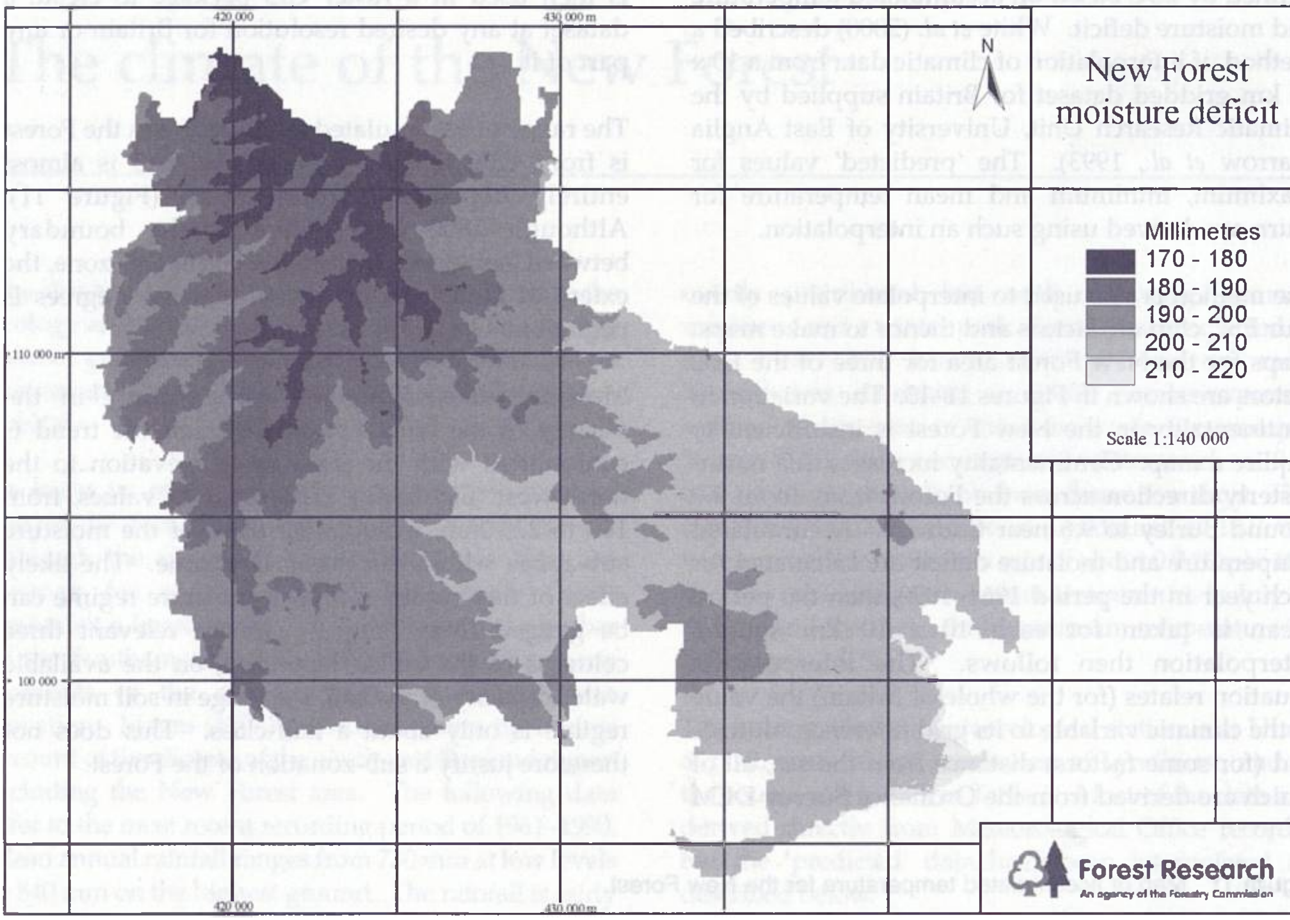
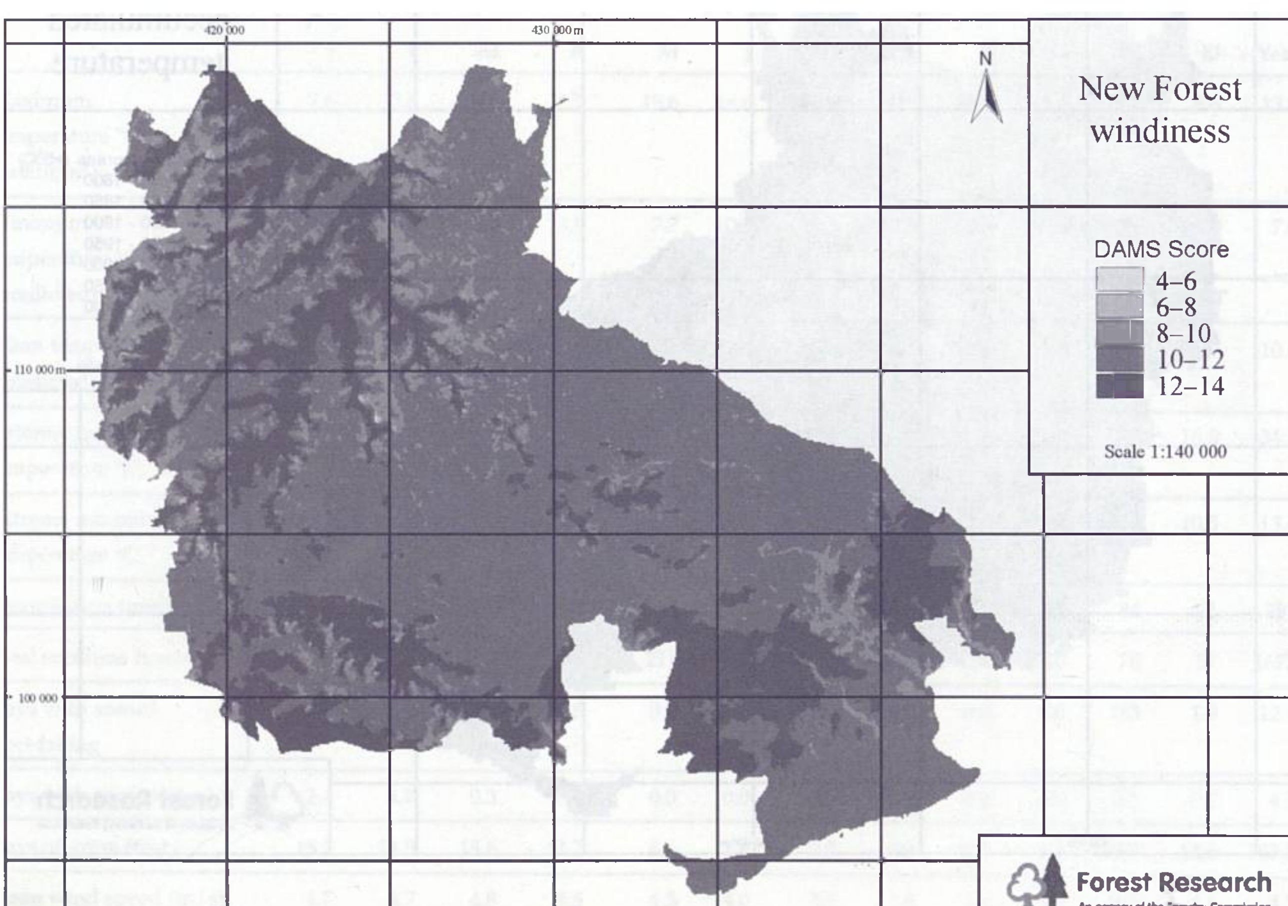


Figure 13 Map of windiness for the New Forest.



The Forest, like the rest of Southern England, is not subject to frequent strong winds, but in the past 20 years there have been two severe storms (in October 1987 and January 1990) that caused extensive windthrow of mature stands and isolated trees. The subdued landscape provides little topographic shelter and much of the Forest has a small range of windiness, within the DAMS score range 10–12 (Figure 13). This is, however, within the very suitable range for growth of all timber-producing species. Greater windiness is experienced on the high ridges in the north-west of the Forest and on the relatively low-lying but exposed plateaus in the south. Here DAMS scores reach 14 and wind blast would have a small but significant deleterious effect on the growth of trees, especially in the first few years after restocking and for sensitive species (see Figure 5). The most sheltered sites in the Forest are found in the valleys of the north-west. Although DAMS scores of 4–6 and 6–8 occur there, the areas involved are negligible, and scores of 8–10 are more representative.

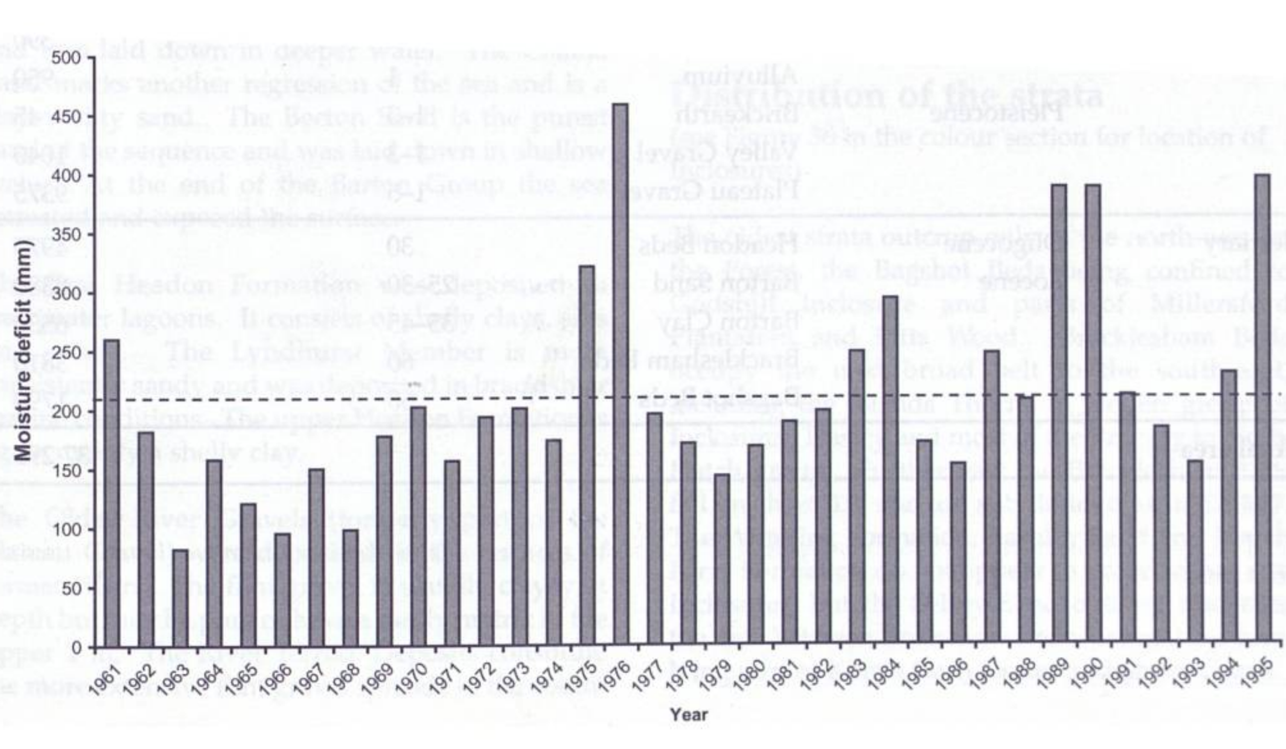
The absence of strong topographic shelter is partly offset by the mutual shelter afforded by extensive woodland and this is evident in the maximum height reached by trees. The average height seems to be greatest, at around 30 m, in the central part of the Forest, as along the Rhinefield Ornamental Drive. The crowns of the tallest trees in the Forest often project above the surrounding canopy and their height is clearly restricted by breakage of the tops, to a maximum of about 40 m. By comparison, the tallest conifers in Britain, similar in age to those in the New Forest but growing in very sheltered conditions, currently exceed 60 m.

The range of the four ESC climatic factors is summarised in Figure 25.

The method of calculation of the ESC climatic factors takes into account the year to year variation in temperature and precipitation, but does not reveal the amount of it. Year to year variation in temperature is fairly unimportant except for the extremes and in terms of unseasonable frosts and is then essentially unpredictable. Variations in precipitation, especially seasonally, are more important and lead to large fluctuations in moisture deficit from year to year. Figure 14 shows the moisture deficit values for 1961–1995 for the New Forest area falling in the MORECS 40 x 40 km square number 182. MORECS is the Meteorological Office Rainfall and Evaporation Calculation System, the source of the moisture deficit data for ESC. It is evident that the forest has experienced very large moisture deficits several times within the 35 years. The ability of a tree to survive the drought stress will depend on its innate tolerance and on the capacity of the soil to continue to supply moisture throughout the summer. Ecological site classification attempts to predict this through the soil moisture regime.

The climate information is used to assess the species suitability ratings in Figures 3–6. This information is illustrated again for each tree species in Figures 26–31.

Figure 14 Moisture deficit for MORECS square 182 for 1961–95.



Chapter 5

The geology of the New Forest

An appreciation of the geological structure and of the sedimentary nature of the soil parent materials is essential to an understanding of the variations in the woodlands and their sites. Although geology is not used as a component of the eventual site classification the nature and distribution of the site types depend directly on the underlying strata.

The Forest lies in the western half of the geological structure known as the Hampshire Basin, a downfold within the underlying Cretaceous, Jurassic and Triassic rocks. The folding took place at the time the European Alps were uplifted, culminating in the Miocene Period. The basin is filled with Palaeogene (Tertiary) unconsolidated clays and sands, often capped with thin superficial deposits of Quaternary age. The lowest Palaeogene strata are the Reading Beds and London Clay but their outcrop lies outside the Forest. The oldest strata outcrop in the north-west of the area, the youngest in the south-east, with the superficial deposits being scattered throughout.

Stratigraphy

Map sheets 314, 315, 329 and 330 of the Geological Survey at a scale of 1:50 000 cover the New Forest. Sheets 314 (north-west) and 330 (south-east) date from 1974 and present a stratigraphy as used in the soil survey of 1963 (Table 7). Revised versions of Sheet 315 and 329 were published in 1987 and 1991 respectively. On the newer sheets the stratigraphy is slightly more detailed as is the mapping (Table 8). A Memoir of the British Geological Survey covers Sheet 315 (Edwards and Freshney, 1987). See also a review of the geology of the Hampshire Basin by Hodson (1964).

The areas given in Table 7 are derived with the aid of GIS from digitised boundaries of the geological strata. In order to provide complete and consistent coverage of the Forest only the maps showing the former stratigraphy were digitised (Figure 15 in the colour section).

Table 7 Former stratigraphy of the Tertiary and Quaternary formations of the New Forest

Era	System	Formation	Maximum thickness (m)	Area within Forest perambulation (ha)
Quaternary	Recent	Peat	2	390
		Alluvium	1	950
	Pleistocene	Brickearth	1–3	45
		Valley Gravel	1–3	1040
		Plateau Gravel	1–5	9375
Tertiary	Oligocene	Headon Beds	30	4975
	Eocene	Barton Sand	25–30	8380
		Barton Clay	35–45	6530
		Bracklesham Beds	60	3810
		Bagshot Beds	60	1790
Total area				37 295

Table 8 Current stratigraphy of the Paleogene and Quaternary formations of the New Forest

Era	System	Formation	Thickness (m)
Quaternary	Recent	Alluvium	1
	Pleistocene	River Terrace Deposits	5
		Older River Gravels	5
Palaeogene	Eocene	Headon Formation (clay)	18
		Lyndhurst Member (sandy)	12
		Headon Formation (clay)	8
		Becton Sand	15–70
		Chama Sand	7–15
		Barton Clay	55–80
		Selsey Sand	30–50
		Marsh Farm Formation	18–25
		Earnley Sand	0–24
		Wittering Formation	23–57

Deposition and lithology of the strata

The Palaeogene strata were deposited during a period of repeated transgressions and regressions of the sea. The Wittering Formation is at the base of the Bracklesham Group and consists of laminated sands and clays laid down in an intertidal zone. The Earnley Sand is a glauconitic silty and clayey sand laid down in shallow water. The Marsh Farm Formation is again an intertidal deposit similar to the Wittering Formation. The Selsey Sand is similar to the Earnley Sand and was also formed when the sea transgressed further.

The Barton Clay marks the start of the Barton Group and was laid down in deeper water. The Chama Sand marks another regression of the sea and is a clayey silty sand. The Becton Sand is the purest sand of the sequence and was laid down in shallow water. At the end of the Barton Group the sea retreated and exposed the surface.

The first Headon Formation was deposited in freshwater lagoons. It consists of shelly clays, silts and sands. The Lyndhurst Member is more consistently sandy and was deposited in brackish or marine conditions. The upper Headon Formation is again mainly a shelly clay.

The Older River Gravels (formerly part of the Plateau Gravel) were deposited on the terraces of former rivers. The flint gravel is usually clayey at depth but may be pure or have a sandy matrix in the upper 1 m. The River Terrace Deposits constitute the more extensive flint gravel spreads to the south-east of the Burley Hill – Lyndhurst Hill line, and include part of the former Plateau Gravel and the former Valley Gravel. The deposits are complex mixtures of gravel, sand and clay. The upper 0.5 to 1 m is usually less clayey than below. Clayey and sandy silts overlie several of the gravels, those on the younger terraces constitute the 'brickearth' of the previous map and may have a partially aeolian (loessial) origin.

The newly defined strata, such as the Chama Sand and Lyndhurst Member of the Headon are shown only on the updated Sheets 315 and 329 and their boundaries have not been digitised. The description that follows therefore includes the additional strata recorded on the updated sheets and not shown on Figure 15.

Distribution of the strata

(see Figure 36 in the colour section for location of Inclosures)

The oldest strata outcrop only in the north-west of the Forest, the Bagshot Beds being confined to Godshill Inclosure and parts of Millersford Plantation and Pitts Wood. Bracklesham Beds occupy the next broad belt to the south-east, including the Islands Thorns to Sloden group of Inclosures, Hasley and most of the Broomy to Holly Hatch group. Further east the Bracklesham Beds fall on sheet 315 and are sub-divided as in Table 7. The Wittering Formation, Earnley Sand and Marsh Farm Formation do not appear to occur within any Inclosures, but the Selsey Sand outcrop underlies the area between Bramshaw Inclosure and the low-lying part of King's Garn Gutter and Shave Green.

All three members of the Barton Group are more extensive than the Bagshot and Bracklesham Beds. The north-western limit of the Barton Clay appears not to have changed on the updated maps, but the newly recognised Chama Sand has reduced the southern and south-eastern extent. Barton Clay forms a broad belt starting in the north-west with the Linford to Milkham group of Inclosures, stretching north-eastwards via the Bentley Inclosures to the Coppice of Linwood. The outcrop then swings south-east to Brockishill, Busketts Lawn and the western half of Churchplace Inclosure. Elsewhere there are only small exposures in valley bottoms in the Oakleys and Burley Inclosure. The Chama Sand now occupies substantial areas previously mapped as Barton Clay or Barton Sand, particularly in Highland Water, Holidays Hill and south to Vinney Ridge and west to Burley New. Further east it begins again in the eastern half of Churchplace and extends almost continuously to Dibden and King's Hat. The Becton Sand (the well-known fine sand of the White Moor to the east of Lyndhurst village) has a smaller outcrop than the Barton Sand of the older maps. It begins in the west along the route of the A31 road at Picket Post, extending to Backley Inclosure. It is next found as a zone on the slopes of Bolderwood through to Anderwood and Knightwood. Smaller outcrops occur in Manor Wood, Hursthill, the north end of Denny and in Longdown and Ipley Inclosures. Much of its potential outcrop in the central part of the Forest seems to be overlain with the River Terrace Deposits. On the old map Barton Sand is extensive again from Aldridgehill south to Wilverley and Setthorns, but we do no know how much of this would now be allocated to Chama Sand or Becton Sand.

The three members of the Headon Beds occur mainly in the east central part of the Forest extending all the way from Parkgrounds to Perry Wood Ironshill and Hawkhill Inclosures. At least a half of this large area is occupied by the newly defined Lyndhurst Member but unfortunately we have no idea of its extent to the south of the railway on Sheet 330. The upper Headon clay bed is of minor extent. The Headon Beds have small outliers on prominent hills to the north-west of the main area, notably at Bolderwood and Northerwood House.

The Older River Gravels occur on ridge and plateau tops to the north-west of a line joining Burley Hill (grid ref. SU 200035) to Lyndhurst Hill (grid ref. SU 287082) at elevations of 89 to 129 m. To the south and east of this line the gravels form more extensive, less eroded spreads and are referred to as the River Terrace Deposits. The most continuous deposits are in the Hursthill – Poundhill – New Park area (the former Valley Gravel), on the south-eastern plateaus occupied by Fawley, Dibden and Norley Inclosures and on the south-western plateaus occupied by Wootton – Wilverley Inclosures. All the River Terrace Deposits lie at elevations below 80 m, the highest levels being in the south-west at Dur Hill Inclosure.

Alluvium occupies narrow strips along all the main streams, with the few wider spreads lying outside the Inclosures.

Soil parent materials

In terms of soil parent materials the various strata can be simplified to a few main types: clays, loams, sands and gravels including layered combinations thereof. The Barton and Headon clays invariably produce heavy clay soils, the main difference being that the shelly nature of the Headon sometimes imparts a more base-rich character to the soil. Shelly fragments are frequently encountered within 1.2 m depth. The most sandy stratum is the Becton Sand, but even this often has a light loamy character. The Chama Sand seems mainly to be a loamy deposit rarely forming freely draining soils. The outcrop of the Lyndhurst Member is not noticeably less clayey than the rest of the Headon. The various beds of the Bagshot and Bracklesham strata gives rise mainly to clays and loams, though there are also some very sandy materials in places. On the Bracklesham there is a lateral gradation of texture from the Islands Thorns and Bramshaw area where clayey textures predominate, towards the south-west at Rockford Common where sandy textures are common. The sandy facies can be seen in a quarry at grid ref. SU 164084. In several places, notably in Bramshaw Inclosure, the clays are rich in the dark green mineral glauconite which contains potassium. At the eastern edge of Hasley Inclosure there is a localised development of a strikingly orange-red sand.

The Older River Gravels are rarely thick enough to form the whole soil profile, and the lower layers of gravel tend to reflect the nature of the underlying stratum. The purest gravel is found at Mogshade Hill near Highland Water Inclosure. Where it lies on the Barton or Headon Clay the lower layer of gravel has a clayey matrix. If it is thick enough, the deposit tends to have an upper layer of almost pure flints. The plateau at Bolderwood is a good example. The River Terrace Deposits are almost always diluted with sandy material, e.g. at Hursthill and Wilverley. In the far south, as at Norley, the gravel has a silty-loamy admixture akin to the brickearth deposits seen along the coast. Alluvium is loamy or clayey in texture and often inter-layered with gravel, as is readily seen in deepened streams and drains along Highland Water.

Chapter 6

The soil types of the New Forest

The site classification is constructed by combining soil types with plant communities in a particular way. Neither the soil types nor the plant communities on their own supply all the ecological information needed for the intended management purposes. Nor is it possible to rank soil types or plant communities as generally more important to the site classification; it will depend on the particular application; The soil types convey most of the physical information on the sites whereas the plant communities supply more insight into the soil chemistry. It is not necessary, however, to carry out a soil survey and a vegetation survey with an interval of 35 years in between, it should be possible to map both features at the same time!

A brief review of the soils of the Hampshire Basin was given by Birch (1964). The only soil survey of the whole Forest was presented on the 1:250 000 map of the Soil Survey of England & Wales and described in their Bulletin 15 (Jarvis *et al.*, 1984).

A soil survey of the Inclosures of the New Forest was carried out between June 1962 and April 1963 by Graham Pyatt and Ion Carolan of the Forestry Commission Research Division (Pyatt, 1964). Some 8500 ha were mapped at a scale of 1:10 560, the maps being later converted to the 1:10 000 scale. The survey was undertaken to provide information for forest management, including the performance of different tree species. The soils were first divided on a pedological basis into four major groups: podzols, ground-water gleys, brown earths and surface-water gleys. This was in accordance with the then current practice of the Soil Survey of England & Wales on similar geological strata elsewhere, although the national soil survey had not at that time done any routine mapping within the Forest. Further sub-division of the major soil groups was based on textural and drainage criteria to create ten types. The ten soil types are listed in Table 9. No attempt was made formally to sub-divide types according to geological strata, although the profile descriptions always acknowledged the geological parentage of the soil material.

Following the detailed survey of the Inclosures, the soils of most of the ancient and ornamental woodlands of the open Forest were mapped in less detail. The classification was reduced to the four major groups for this purpose.

Table 9 Soil classification in the New Forest Inclosures

Group	Type	Characteristics	Area (ha)	Total area (ha)
Podzols	1	Sands and gravels, freely drained	379	908
	2	Sands and gravels, impeded in B and C horizons	529	
Ground-water gleys	3	Sandy/loamy soils with high water table	522	730
	4	Sandy/loamy soils with high water table and peaty surface layer	161	
	5	Alluvial soils with high water table	47	
Brown earths	6	Freely drained sand	259	2384
	7	Freely and imperfectly drained sandy loam	1099	
	8	Imperfectly drained loams	1026	
Surface-water gleys	9	'Straight clay'	1682	4273
	10	'Two-storeyed loam over clay'	2592	

The areas shown in Table 9 have been updated with the benefit of GIS following the digitising of the maps of soil types. A map of the soil types in the Inclosures is given as Figure 16 in the colour section.

The podzols

The podzols are characterised by the presence of a bleached, often whitish subsurface layer underlain by dark brown subsoil layers. On the surface there is an accumulation of several centimetres of slightly decomposed mor humus. The upper subsoil layer is often black due to the deposition of finely divided organic material. Podzols are formed by the removal of iron oxides from the whitish layer and their partial deposition in the subsoil. This process of podzolisation takes place in well-aerated conditions although the podzol layers can overlie impeded subsoil material. Podzols form in sandy or gravelly parent materials and are acid and usually infertile. In the Forest they are commonly found in the Older River Gravels and the sandy strata, particularly the Becton Sand. Where podzols appear to occur on Barton Clay, it is because there is a thin overlay of either Becton Sand or River Gravel (not shown on the geology map). Occasionally in gravelly materials a thin and usually discontinuous ironpan may be found in the subsoil between the black humus deposition and the dark brown layer.

The best places to see podzols are in the gravel and sand quarries, e.g. at Holmsley Ridge (grid ref. SU 216011) in the younger gravels and at Denny Sand Pit (grid ref. SU 335069) in Becton Sand. Long exposures of Becton Sand podzols can be seen in roadside cuttings at Longdown Inclosure.

The division into two types of podzol recognises that gravels and sands are sometimes deep and freely draining (type 1), but alternatively may overlie finer textured materials giving a subsoil with slightly impeded drainage (type 2). Type 2 also includes podzols where the subsoil is affected by a rising water table in the winter. Such soils are typically located on slopes between type 1 podzols above and ground-water gleys below. It was thought that the type 2 podzols may provide greater reserves of moisture during droughts than the type 1 podzols. The current view is that the two types of podzol are similar in silvicultural properties. Both kinds of podzol in sandy materials are exposed in roadside cuttings at Longdown Inclosure.

During the 1987 and 1990 storms windthrow was a common phenomenon on the gravelly podzols, in spite of the fairly deep rooting (usually over 70 cm). Most of the sites were on exposed plateaus, but it is not clear whether the extra wind speed or a lack of soil strength in gravelly material was the key factor responsible.

The ground-water gleys

Ground-water gleys are soils in permeable sandy or loamy materials where the water table is seasonally high. Symptoms of gleying include mottled or dominantly drab grey colours often stained dark with organic matter. In very wet conditions a thin peaty layer may be present at the surface and the subsoil may have a greenish or bluish hue due to the presence of ferrous ions. The existence of ground-water gleys is therefore dependent on suitable parent material and topography. Such conditions arise near the boundary between sandy strata and underlying more clayey strata, such as Becton Sand/Chama Sand, River Terrace Deposits/Chama Sand, River Terrace Deposits/ Headon Clay and Chama Sand/Barton Clay. The texture of ground-water gleys usually becomes more clayey with depth. Soil structure in ground-water gleys is always weak and the consistence of the material is friable. This can be contrasted with the typically strong prismatic structure and firm clayey subsoil of surface-water gleys (see below). As the water table in a ground-water gley falls in spring, air enters through root channels, which become lined with rust-coloured ferric hydroxide. At all seasons ground-water gleys release dissolved iron to the drainage water and are probably the main source of the brown staining in stream water.

Most ground-water gleys in the Inclosures have been intensively drained and have a water table well below the natural level. They are common soils within existing heaths, being associated with 'humid heath' and 'wet heath' vegetation, and in those Inclosures that were previously heath. Ground-water gleys are commonly found on concave slopes between podzols on higher ground and surface-water gleys on the clay stratum further downslope. They are strongly acid soils with low or very low nutrient content. They characteristically occupy the portion of the slope below a 'seepage step'.

Two types were recognised in the 1963 survey. The predominant type (type 3) lacks a peaty surface layer and is mainly found within the older ex-heath Inclosures. The peaty type (type 4) occurs in recently enclosed heath and represents the wettest sites in valley bottoms. The peat layer was generally less than 25 cm thick when mapped and it is likely to have decreased within the first rotation of trees. The main long-term difference between the two types is therefore likely to be that of wetness.

The alluvial soils (type 5) are frequently associated with the ground-water gleys and have been placed in the same group. They also suffer from a high water table but have many differences from the previous two types. Texturally they are more clayey

Figure 1 Simplified distribution of soil types and humus forms.

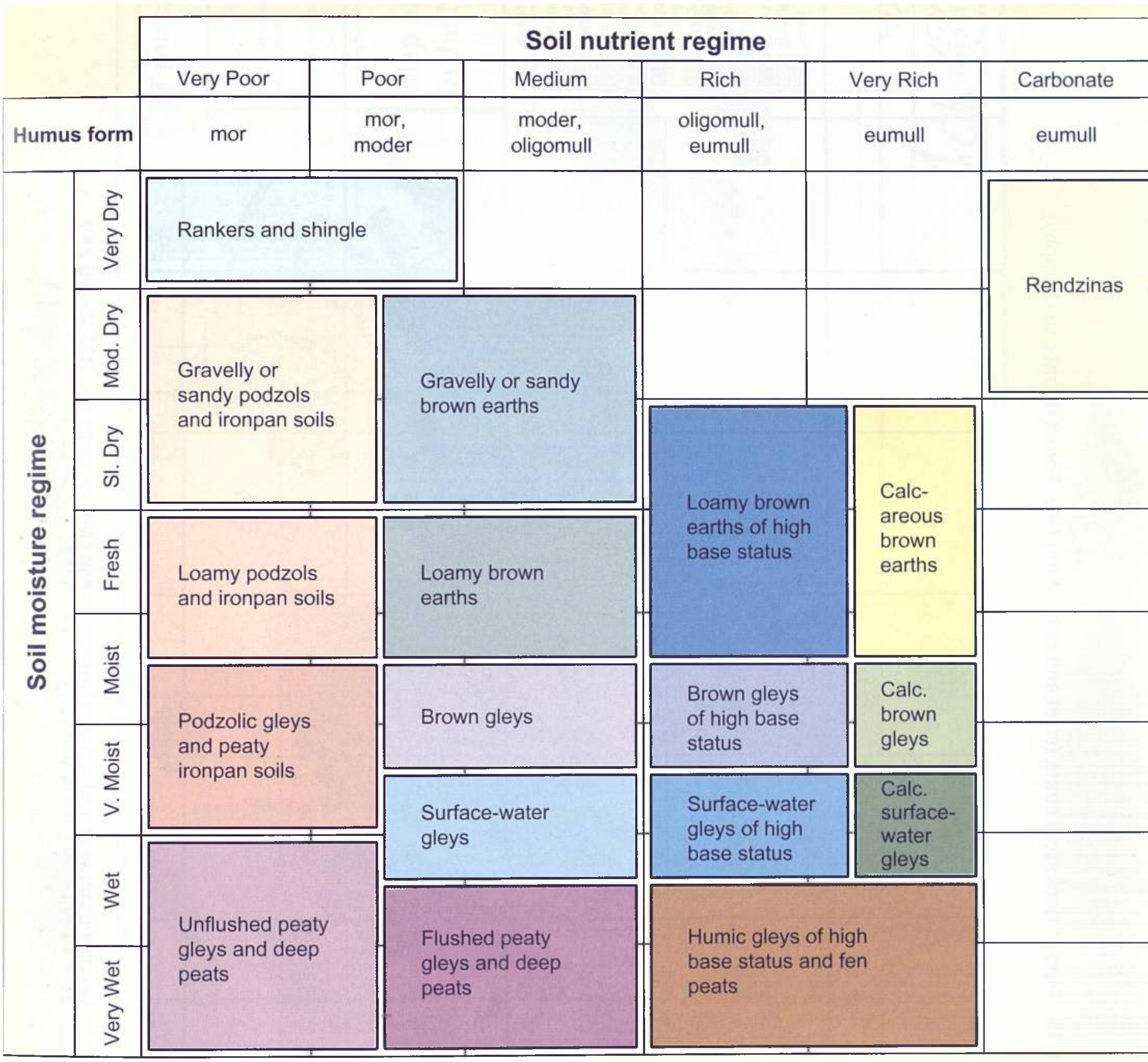
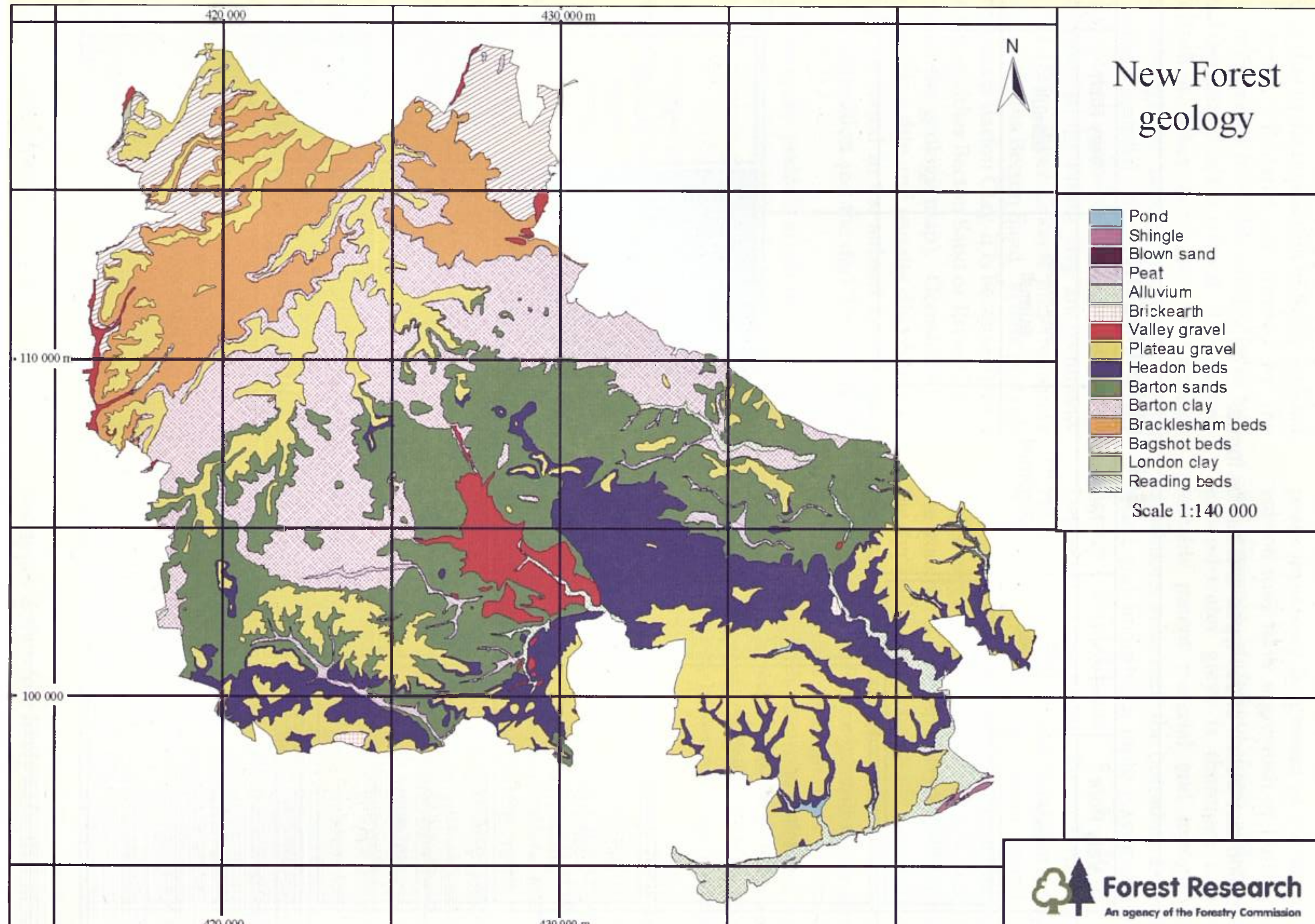


Figure 15 Map of geological strata (solid and drift) of the New Forest (former stratigraphy).



(Digitised by Geodata Institute of Southampton University from Geology maps 314, 315, 329 and 330)

Figure 16 Map of soil types in the New Forest Inclosures.

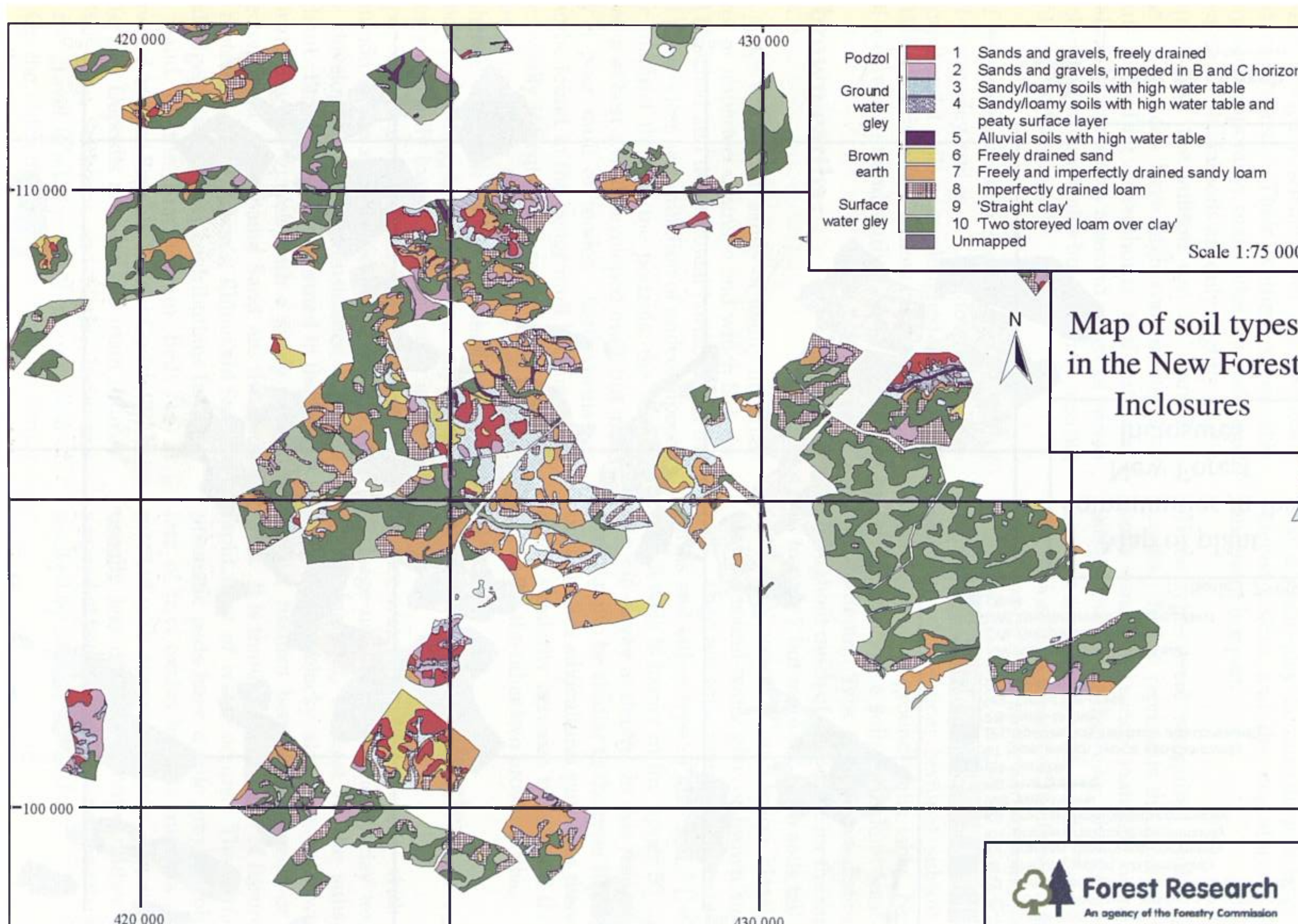
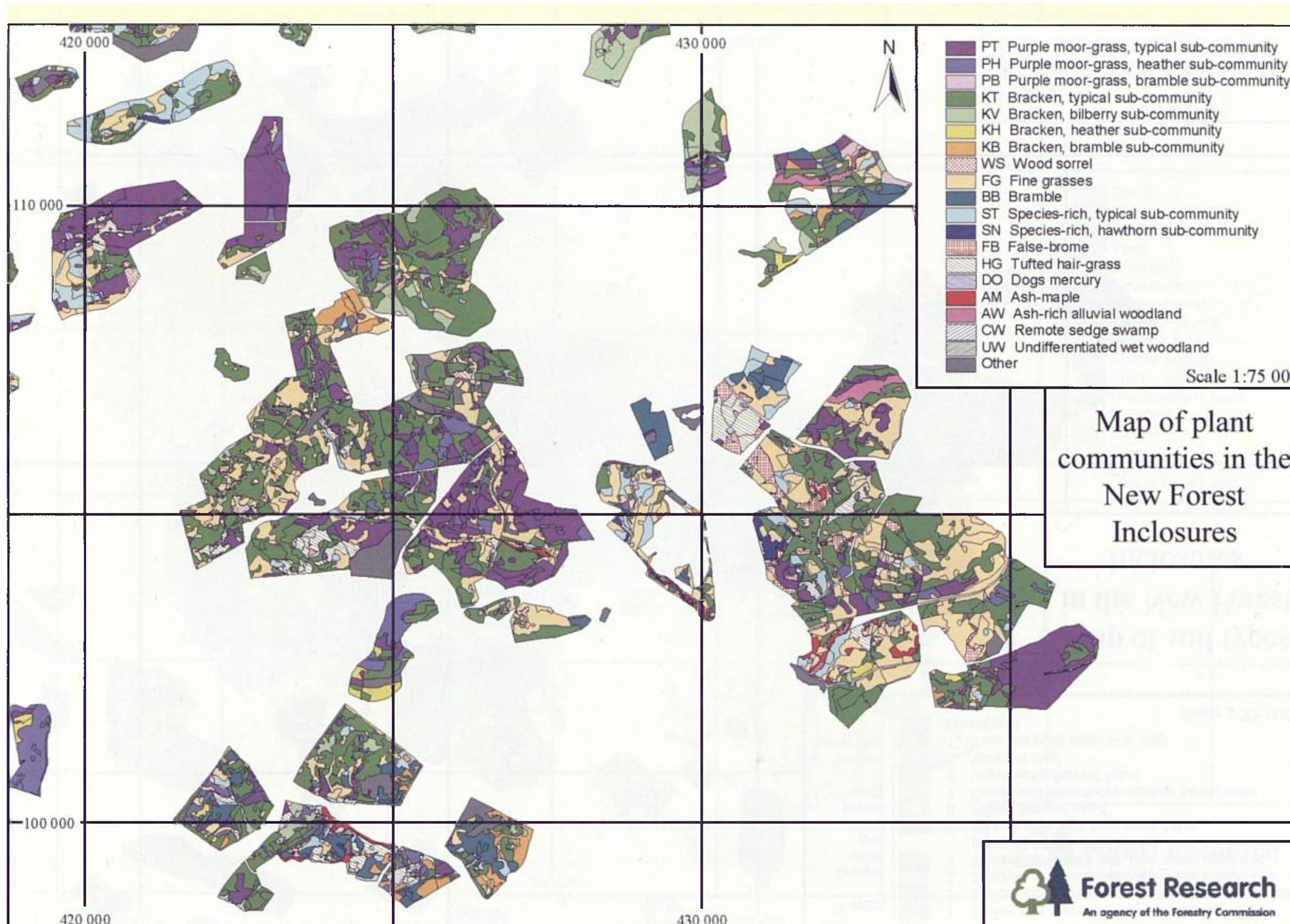


Figure 17 Map of plant communities in the New Forest Inclosures.



throughout, though at depth gravelly material probably increases the permeability relative to the true clayey soils. The upper layer of alluvial soils is rich in humus but this is well incorporated by high biological activity. In spite of the dark colour, rusty streaks due to gleying are usually evident. Mottled colours are prominent in the subsoil. Alluvial soils are found alongside streams and are frequently flooded and silted. Their wetness is variable spatially and temporally; many sites are undrained and swampy. Alluvial soils are only slightly acid in the topsoil and the subsoil can be neutral to alkaline. They can have high concentrations of nutrients including phosphorus and nitrogen. Alluvial soils are probably a second source of brown iron staining in stream water but they may also act as a sink during flooding.

One of the best places to see all three kinds of ground-water gley soil is at Longdown Inclosure. The types 3 and 4 soils were ploughed and planted in the 1960s, but the alder–willow carr on the type 5 alluvial soils was left undisturbed.

The brown earths

Brown earths are soils in sandy or loamy materials with free or imperfect drainage and which lack the podzol bleached and depositional horizons. At the surface there is less accumulation of undecomposed organic material than in the podzols, the humus form being at best a well developed mull, but more usually a poor mull or moder. Earthworms are likely to be found in the better mull humus forms but are usually infrequent or rare. Mineral layers are brown in colour throughout the profile with little change at depth except for the increasing likelihood of mottling, indicating some impedance. Textures are usually loamy sand or sandy loam in the upper 50 cm but medium or fine loamy textures are common in the subsoil. Soil structure is very weakly developed and the consistence is friable throughout. Brown earths are formed in the sandy strata including the gravels with a sandy matrix. The Becton Sand and Chama Sand are the main parent materials as at Wooson's, Rhinefield Sandys and Aldridgehill with lesser contributions from the Selsey Sand of the Bracklesham Beds as at Amberwood and the Bagshot Beds at Godshill. The River Terrace Deposits are also important sources, as at Wilverley, Setthorns and Norley Inclosures where the gravel is admixed with a great deal of loam. On the older maps, where in places Barton Clay is ostensibly the parent material for brown earths, the new maps show that in fact there is Chama Sand.

Brown earths in the New Forest are strongly acid soils with low to medium nutrient contents. Some degree of podzolisation may be present as partially bleached sand in the upper 20 cm of the most sandy and freely drained examples. A 'micro-podzol' feature, consisting of very thin bleached and darker brown depositional layers, often occurs within the upper 10 cm of the profile, commonly under beech stands. Sometimes this phenomenon appears more like a 'micro-gley' because the pale layer has a drab gleyed colour and the depositional layer is an incipient ironpan.

Three types were recognised within the brown earths. Type 6 represents the most freely drained soils usually in sandy materials or on shedding sites. Even here however, the texture tends to become more loamy with depth. Type 7 represents the typical brown earth of the Forest, with a sandy loam texture in its upper part, becoming sandy clay loam in the subsoil with a modest degree of mottling. The mottling can be due to impeded drainage in the finer textured subsoil or to the proximity of the ground-water table. Nevertheless, type 7 and type 6 soils provide at least 100 cm of rooting depth. Type 8 soils have distinct mottling throughout much of the profile for the same reasons as in type 7 but more so. Such soils fall within the national Forestry Commission classification of brown ground-water gley or brown surface-water gley. They are thus intermediate between brown earths and either type of gley soil. The texture of type 8 soils is loamy in the upper 50 cm but may become clayey at depth. In this respect the parent material can be similar to the type 10 clay soils (see below). For silvicultural purposes there may be a closer similarity between type 8 and the clay soils than with the other two brown earths.

The surface-water gleys

Surface-water gleys are soils with impeded drainage usually due to heavy clay texture. The clayey material, at least in the subsoil, has a prismatic or blocky structure with well defined vertical fissures between the peds or structural units. It is through this system of fissures that any rapid flow of water occurs. The surfaces of the prismatic peds have a pale greyish colour due to loss of iron oxides but the interiors are strongly mottled with orange and grey. The upper layer is usually less distinctly mottled, either because of somewhat better aeration or because the colours are masked by organic material.

Surface-water gleys differ from ground-water gleys in that a soil pit in the former will fill with water slowly from the fissure system whereas in the latter it will fill from the bottom upwards relatively quickly. In a dry summer the surface-water gley dries out until there is no free water in the fissure system. Meanwhile in the ground-water gley the water table will retreat but plentiful water will exist in the capillary zone above it. The ground-water gley provides a safer location for a well, but the surface-water gley will provide a good enough location for a pond!

Several strata provide parent material for the clay soils. The Barton Clay occurs extensively from Milkham to Burley New and between Ravensnest and Church Place. The Headon Formation including the Lyndhurst Member provides an unrelieved clayey spread from Parkgrounds to Hawkhill. There are also large areas of clay on the Bracklesham Beds at Islands Thorns. The Chama Sand gives rise to small areas of type 10 clay soils, presumably where it is thinning out over the underlying Barton Clay. Rather surprisingly, there is a large area (about 500 ha) of mainly type 10 clay soils on Becton Sand. The most likely explanation is that there is a rather gradual transition from Becton Sand to Barton Clay. There are also 150 ha of this soil on Older River Gravels, presumably where the gravel has a clayey matrix. As mentioned earlier, the Headon clay is frequently shelly within 100–150 cm of the surface, and is therefore calcareous at those depths. But all the clay soils are acid, often quite strongly so, in the topsoil. In spite of the occasional base-richness of the subsoil, the clay soils are not particularly fertile, that is they are not rich in nitrogen or phosphorus.

Two types of clay soil were recognised in the 1963 survey, type 9 the 'Straight clay' and type 10 the 'Two-storeyed clay'. Type 9 has a clayey texture in both the subsoil and the topsoil, the latter usually having a definite blocky structure giving way fairly quickly with depth to prismatic structure. The type 10 soil has a layer of 20–50 cm of loamy textured material overlying the clay. The overlay is frequently gravelly and is partly derived from either the Older River Gravels or the River Terrace Deposits. Soil structure in this overlay is usually weak. Mottling is evident in the topsoil of type 9 soils whereas in type 10 a drab pale grey or yellowish colour often exists between the dark grey humose topsoil and the mottled clayey subsoil. Both types of clay soil can exist anywhere in the subdued topography and the drainage status is therefore variable. Type 10 soils appear to be particularly variable in respect of drainage status (and therefore rooting depth), fertility and thence silvicultural potential. The fact that they are easily the most extensive soils in the Forest (Table 8) emphasizes the importance of being able to classify them more effectively through the use of the ESC.

The 1963 soil survey provides almost complete coverage of the Inclosures to an acceptable accuracy but the information supplied in terms of site quality is inadequate to meet the needs of current forest management. The ten soil types provide much of what we need to know about the physical properties and limitations of the soils but give little refinement in terms of chemical properties. Overlaying lithology and soil types might effect a slight improvement, but this would involve sweeping assumptions about the uniformity of strata. Hence the decision was made to supplement the information provided by soil types and lithology using ground vegetation as a mappable indicator of soil nutrient and moisture regimes.

Chapter 7

The vegetation of the New Forest – an introduction

In this chapter the description of the Inclosures brings together their geography and their history. The mixture of woodland, heath, grassland and mire that is the Forest today is the result of many centuries of man's activity applied to the raw materials of natural vegetation, climate and soils. At the broadest level it is assumed that the natural vegetation following post-glacial warming was almost entirely woodland and that subsequent reversion to heath or grassland was essentially man-induced. At various later stages woodlands have been re-created (Tubbs, 1968). The area of the main vegetation types within the Forest perambulation is shown in Table 10.

History

Large parts of the Inclosures are derived from open forest habitats, such as heath, with lesser areas derived from 'lawn' and mire. Most of the remainder is derived from native pasture woodlands of oak and beech. A very few Inclosures are derived from areas of freehold farmland, converted to oak and beech plantations in the early 19th century.

The earliest Inclosures, from *c.*1700 through to the beginning of the 19th century, generally took the established woods of the open forest and enclosed them to improve their silvicultural management as oak and beech high forest. Later Inclosures took in more open ground and used a wider range of tree species, notably Scots pine and larch, alongside the oak and beech. Only comparatively recently, at the restocking of the established 18th and 19th century forest stands, has a wider range of conifer species been used within the Inclosures. The most successful conifers have been Douglas fir and Corsican pine, though large areas of western hemlock, Lawson cypress, Norway spruce and many other minor species have been planted. In the years following the Second World War large areas were restocked by natural regeneration, leading to extensive stands of generally poor form oak and beech in a patchy mosaic with birch and Scots pine.

Table 10 Extent of the main vegetation types in the New Forest*

Land use	Main category	Area (ha)	%
Enclosable land	Broadleaved woodland	3633	13
	Coniferous woodland	4612	17
	Other	403	1
	Sub-total	8648	32
Open forest	Ancient & ornamental woodland	3380	12
	'Natural' pine	1723	6
	Heath	5911	22
	Grassland with bracken, gorse	5364	20
	Forest 'lawns'	324	1
	Valley bog – Wet heath	2834	10
	Sub-total	18 511	68
Total		27 159	100

*From the New Forest guide map, Forestry Commission, 1986.

Establishment of the earlier Inclosures was achieved by the deliberate sowing of acorns, beech mast, hawthorn haws and holly berries. In later centuries establishment relied more heavily on planting. A consequence of this early reliance on planting, and the dominating interest of the Forest's administration in oak timber, has been the establishment of oak and beech woodland on a very wide variety of soils. More recent plantings have generally shown a greater appreciation of site conditions in species choice.

Woodland distribution and geography

At the broad landscape scale, the woodlands and open forest habitats of the New Forest show a distinctive pattern of distribution. The heaths are mainly located on the gravelly and sandy parent materials, where podzols and to a lesser extent brown earths are present. In striking contrast, most of the older woodland and earlier Inclosure plantings are on the clays of the Barton series and the Headon and Bracklesham Beds. In these areas the straight clay and two-storeyed clay soils predominate. In the heath areas valley bottoms are often occupied by mires, where the underlying clays prevent free drainage and the soils are peaty ground-water gleys. Within the woodlands the wetter low-lying areas may be occupied by fertile alluvial soils (often of surprisingly high pH) or by humose soils occupied by alder or sallow carrs or, very occasionally, wooded bogs of great antiquity.

Large areas of the more fertile brown earths and alluvial soils of the open Forest now support areas of grassy lawn created by long centuries of periodic flooding, heavy grazing, scrub management and the dunging of Forest livestock. Other very similar lawns have also been created in recent years by the drainage of the shallow peaty soils of former mires. Some examples of the ash, maple and hawthorn rich alluvial woodland from which these lawns are derived still persist in the ancient and ornamental woods, most notably along the course of the Highland Water in Brinken Wood.

It is generally assumed that the heaths are also entirely derived from former woodlands, but the nature of the present soils suggests that the kind of woodland present would have been quite different from the typical woodland found today on the better clay and brown earth soils. Rather it would have consisted of poor sessile oak with a lot of silver birch and rowan, and with downy birch and sallow on the wetter areas. Such soils would have been well suited to Scots pine but there is no evidence to suggest that pine survived into historical times from its extensive early post-glacial cover.

The influences of past forest landscapes on the post-enclosure woodlands have been profound but vary considerably.

Within the Inclosures derived from the drier heaths the heather dominated vegetation can be seen clearly expressed where sufficient light reaches the forest floor. In the former *humid heath* areas the strong growth of purple moor-grass dominates in the absence of grazing and burning, and the cross-leaved heath and other characteristic plants almost entirely disappear. This dominance by purple moor-grass persists even in well-illuminated situations, where bracken simply increases in frequency. Areas of former *mire* may retain clear evidence of past mire communities where conditions are wet and planting fails (though there may be an increase in the abundance of bog myrtle and purple moor-grass in the less waterlogged conditions that accompany failed or partial drainage). The vegetation may, however, closely resemble the purple moor-grass dominated stands derived from humid heath where the drainage has been effective and the planting successful. In many Inclosures the areas of mire have been clearly identifiable and excluded from this study. The areas of plantation conifers and, to some extent, oak on these former heath soils are not readily equated with equivalent native woodland types identified within the NVC, though clear affinities with W15 and W16 can be seen on the drier soils.

Areas of Inclosure derived from former *grasslands and lawns* can be far more readily identified with equivalent native woodland types in the NVC. A wide range of woodland herbs and grasses persist in the lawns, scrub and bracken brakes on brown earths of the open Forest, and where these have been converted to woodland they have reassembled the woodland plant communities typical of ancient woodland elsewhere in southern England. Bluebells, violets, wood spurge, wood anemone, greater stitchwort and a variety of woodland grasses are thus characteristic of woods on former lawns. Woods on former acid grasslands lack these species and may be indistinguishable from areas derived from former bracken brake or grassy heath. Only species wholly intolerant of grazing and trampling have failed to persist on the open Forest and these may also be absent or under-represented within the Inclosure stands. Clear variants of NVC W10 can be seen, as well as smaller areas of the wet soil, tufted hair-grass sub-community of the W8 ash-rich woodland. In each case the plant communities are clearly distinctive as a result of their peculiar grazing history and management as high forest.

The native oak plantations derived from former ancient pasture woodland may have the characteristics of the drier heath communities (equivalent to NVC W15 or W16) where the soils are poor in bases or markedly infertile, or may be clearly akin to the clay woodland types. An abundance of butcher's broom is often quoted as an indication of continuity of woodland cover.

Grazing has continued within the Inclosures since their establishment, either at periods when these have been thrown open to forest livestock or as a result of continued trespass. New Forest ponies are particularly adept at gaining entry to fenced Inclosures. In recent years deer numbers have also been high. This prevailing grazing regime has, over long periods of time, greatly influenced the composition of the ground cover communities of the more species-rich communities, favouring grassy swards and stands of browse-resistant plants such as spurge, and reducing the abundance of more sensitive plants such as primrose, anemone and violet. Overall, vascular plant diversity appears to be enhanced by such grazing, even if the shows of the more obvious flowers such as bluebell are diminished.

Chapter 8

Classification of plant communities for the purposes of predicting soil quality

The next three chapters describe the methods used to survey vegetation and to construct the site classification. This chapter is concerned with how the plant communities were classified and mapped. Nomenclature of plants follows Stace (1997).

Method of classification

The purpose of classifying and mapping plant communities is to help predict variation in soil moisture regime and soil nutrient regime ('soil quality') between and within the existing mapped soil types. The decision was taken not to use the National Vegetation Classification (NVC) because the link between the NVC and soil quality is uncertain and because experience suggests that the NVC is not effective in the planted stands that predominate in the Inclosures.

A local classification of ground vegetation was therefore developed, to include any shrub layer but ignoring the tree crop. The method started from knowledge of the nutrient indicator values of most of the plants that occur in the forest and an outline classification of plant communities in Britain with respect to soil nutrient and soil moisture regimes. This was refined for the New Forest during an initial reconnaissance. Quadrat samples were collected from 'representative' stands of each community and the data used to update the classification. The classification was therefore developed through an iterative process as mapping progressed. Revision involved the addition of new communities and the deletion or amalgamation of communities. Identification of communities was achieved using a 'sequential columnar' key similar to that developed by Hayward (1995) for wild flowers.

The survey of plant communities was carried out using parallel transects at intervals of about 50 m. In areas with heavy shading from the tree canopy the plant community could not be identified with certainty. For most of these areas the surveyors were, however, able to make 'best estimates' of the community. A residue of areas that were considered too uncertain to estimate were marked as 'unmappable'.

For representative stands (polygons) the vegetation was described in a set of ten quadrats each 2 x 2 m. Some small stands were described using five quadrats. Quadrats were spaced systematically through the stand. For each quadrat the abundance (cover percentage) of each vascular plant was recorded. The quadrat data were used to refine the definitions of each community and to provide estimates of soil moisture and nutrient regimes.

Table 11 summarises the collected data and gives brief descriptions of the communities. The numbers of quadrats broadly reflect the extent of each community. A map of the communities is given as Figure 17 in the colour section (see Chapter 10 for more details about the construction of this map).

The 19 communities loosely form seven groups, of which the first two are quite coherent whereas the later groups are rather loose. The first two groups are also species-poor, with usually fewer than ten species per set of quadrats, the later groups being more species-rich. The total number of species occurring in a community varies in a similar way but is clearly also dependent on the number of sites sampled. The first group of communities is strongly dominated by purple moor-grass. The second group is dominated by bracken or ericaceous species (heaths). The third and fourth groups of more species-rich or herb-rich communities tend to be less dominated by a single species. The fifth group consists of two communities mainly of coarse grasses on clay soils. The sixth group contains only the rare dog's mercury community restricted to Very Rich soils. The final group is one of 'wet woodlands' associated with watercourses. Fuller descriptions of each community are given in Appendix 2.

Table 11 Plant communities in the New Forest Inclosures

Community (s-c = sub-community)	Number of sites sampled	Mean number of species per site	Total number of species	Dominant species (mean cover)	Constant species (present on >75% of sites)	Frequent species (present on 50–75% of sites)	Characteristic species (defining species)	Nearest NVC equivalent	old code
PT Purple moor-grass, typical s-c	21	7	35	purple moor-grass (69%)	bracken	bramble, holly	purple moor-grass	W4	6a
PH Purple moor-grass, heather s-c	7	9	22	purple moor-grass (49%)	heather, cross-leaved heath	bracken, bell heather, wavy hair-grass, holly, bramble	purple moor-grass, heather or bell heather	W4c	6b
PB Purple moor-grass, bramble s-c	2	13	19	purple moor-grass (67%)	bramble, bracken, honeysuckle, ivy, common bent	velvet bent, wood sage	purple moor-grass, bramble	W4	6c
KT Bracken, typical s-c	21	9	34	bracken (41%)	holly, bramble	ivy, honeysuckle, purple moor-grass	bracken	W16a	1a
KV Bracken, bilberry s-c	13	7	18	bilberry (35%)	bracken, wavy hair-grass	holly, ivy, bramble, purple moor-grass	bilberry	W16	1c
KH Bracken, heather s-c	9	9	31	heather (31%) or bell heather (19%)		bracken (40%), holly, purple moor-grass, common gorse, bilberry, bramble, common bent	heather or bell heather	W16	1d
KB Bracken, bramble s-c	2	8	11	bracken(44%)	bramble (30% cover), ivy, purple moor-grass, wood sage	honeysuckle, holly, common bent, wood sorrel	bracken, bramble	W16	1b
WS Wood sorrel	9	13	37	wood sorrel (22%)	bracken, common bent, ivy, bramble	heath bedstraw, creeping soft-grass	wood sorrel	W16	2a
FG Fine grasses	12	12	43	common bent (36%) or yorkshire fog (18%)	heath bedstraw, ivy	bracken, bramble, holly, honeysuckle	common bent, yorkshire fog	W16	2c
BB Bramble	15	11	46	bramble (38%)	ivy, honeysuckle, holly	common bent, bracken, purple moor-grass	bramble	W10	2b
ST Species-rich, typical s-c	19	14	48	bluebell (20%)	common bent, bracken, wood sorrel, bramble, ivy, creeping soft-grass, holly	common violet	bluebell	W10	3a
SN Species-rich with hawthorn	7	18	42	hawthorn (shrub layer), common bent (22%)	common violet, ivy, wood sorrel, bluebell, bramble, bracken, wood speedwell	holly, wood spurge, chickweed, wood anemone, yellow pimpernel, tormentil, greater stitchwort	hawthorn, bluebell, wood sorrel, common violet, wood spurge	W10	3b
FB False-brome	2	10	16	false-brome (28%)	wood sorrel	bracken, tufted hair-grass, soft-rush, bramble, common violet	false-brome	W10b	4a
HG Tufted hair-grass	9	13	37	tufted hair-grass (38%)	common bent, honeysuckle	false-brome, bramble, common violet, ivy, wood sorrel, bracken	tufted hair-grass	W10b	4b
DO Dog's mercury	1	6	6	dog's mercury		false-brome, wood sorrel, wood spurge, common violet	dog's mercury	W8	5b
AM Typical ash–maple	3	20	42	ash, sycamore or field maple (tree layer)	wood spurge, false-brome, goose-grass, yellow pimpernel, gemander speedwell	common bent, velvet bent, bramble, herb robert, common violet	ash, sycamore or maple	W10	5a
AW Ash-rich alluvial woodland	0			ash, oak	creeping buttercup, lesser celandine, wood spurge		ash	W8/W10	7a
CW Remote sedge swamp	0			remote sedge	alder or willow		remote sedge	W7/W5	7b
UW Undifferentiated wet woodland	0						alder, willow	W7/W5	7

Chapter 9

Estimating soil quality from Ellenberg and Wilson indicator values

This chapter explains how species indicator values were used to estimate the soil nutrient and moisture regimes from the descriptions of the quadrats. Two alternative series of indicator values produced similar, but not identical, results. The treatment of the subject is more technical than most other chapters and the details are not essential for those who are more interested in the practical applications of the site classification. The main outcome of the chapter will be found in the final section 'Plant communities and the soil quality grid'. Hill-Ellenberg indicator values were not available at the time this work was done.

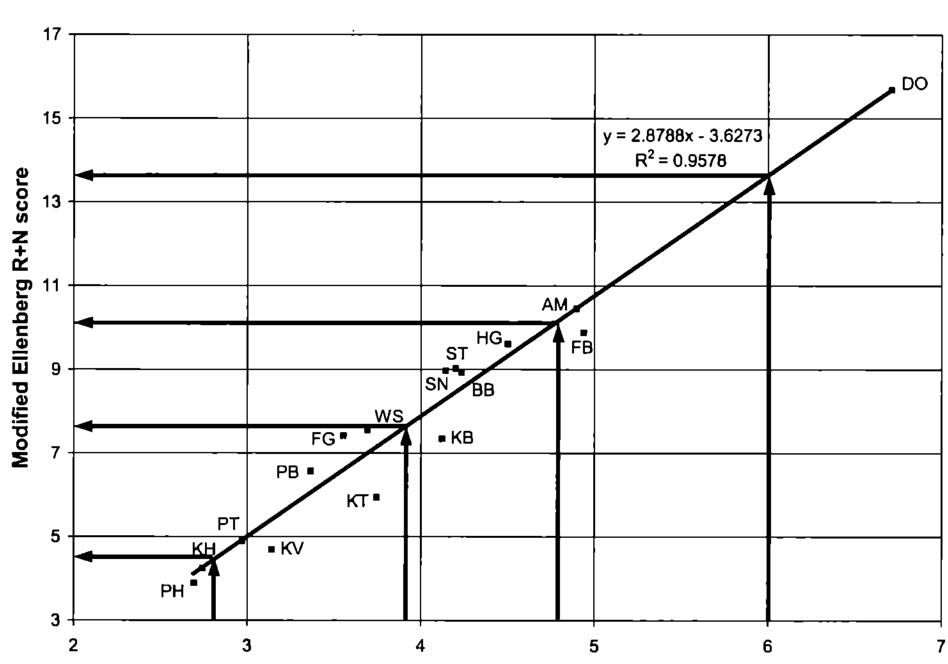
Community indicator values

The method of estimating soil nutrient regime from the species composition of the vegetation involved calculating a mean indicator value for the species present. The effectiveness of the method was tested using soil analytical data by Hawkes *et al.* (1997) and Wilson (1998). Hawkes *et al.* (1997) used indicator values provided by Ellenberg *et al.* (1992) for central European conditions and found them effective in Scottish woodlands. Ellenberg *et al.* (1992) provided separate indicator values (integers ranging from 1 to 9) for F (soil moisture), R (soil reaction or acidity) and N (soil nutrients, especially nitrate) for most vascular plants. Pyatt (1997) used Ellenberg indicator values in the absence of soil data to indicate the different preferences for soil quality shown by NVC woodlands. He used Ellenberg F as a proxy for soil moisture regime and the sum of Ellenberg R and N as the proxy for nutrient regime. Wilson (1998) derived values for 90 vascular plants in British woodlands from measured soil chemical properties. The Wilson indicator value (n) is directly related to soil nutrient regime.

Recently Diekmann and Falkengren-Grerup (1998) examined the soil nitrogen preferences of a numbei of species in broadleaved woodlands in Sweden and worked out indicator values comparable to Ellenberg N. For their commonest 80 species these values seem likely to be more appropriate for British conditions than Ellenberg N. A series of 'modified Ellenberg' indicator values was therefore formed by substituting the Swedish values for the N values for these 80 species.

The mean community scores using Wilson and modified Ellenberg values are compared in Figure 18. The two series of values give comparable results as can be deduced from the R^2 value of 0.96. The arrows originating from the Wilson n axis are placed at values that have been used by Pyatt *et al.* (2001) to define the five classes of soil nutrient regime, i.e. 2.8, 3.9, 4.8, and 6.0. If these arrows are then extended from the best-fit line to meet the modified Ellenberg axis they give class boundaries of approximately 4.4, 7.6, 10.2 and 13.6.

Figure 18 Comparison of Wilson and modified Ellenberg nutrient scores for plant communities.



Communities above the line of best fit have higher scores by Wilson values than by modified Ellenberg values, and vice versa for communities below the line. There is no objective way of deciding which method of scoring is to be preferred. It is not clear that Wilson indicator values are to be preferred to those of Ellenberg even though they have been derived objectively and are more local in origin. Many indicator species occurred in very few of Wilson's plots and the reliability of their values will be uncertain until further research can be done.

For estimates of soil moisture regime we are dependent on Ellenberg F values. Figure 19 presents the communities on a grid formed by axes of Ellenberg F and Wilson n values. Figure 20 shows the distribution using Ellenberg F and the Ellenberg R + modified N. In both Figures the class boundaries of nutrient regime are at the arrowed positions of Figure 18. Three classes of soil moisture regime are shown on the Ellenberg F axis. This provides a layout in accordance with the soil quality grid but the absolute positions of the communities on the grid are less important than their relative positions. Although the class boundaries have been placed in an attempt to separate different kinds of plant community, the boundaries are merely points on a continuum.

Figure 19 Distribution of plant communities on axes of Ellenberg F (soil moisture) and Wilson n (soil nutrients).

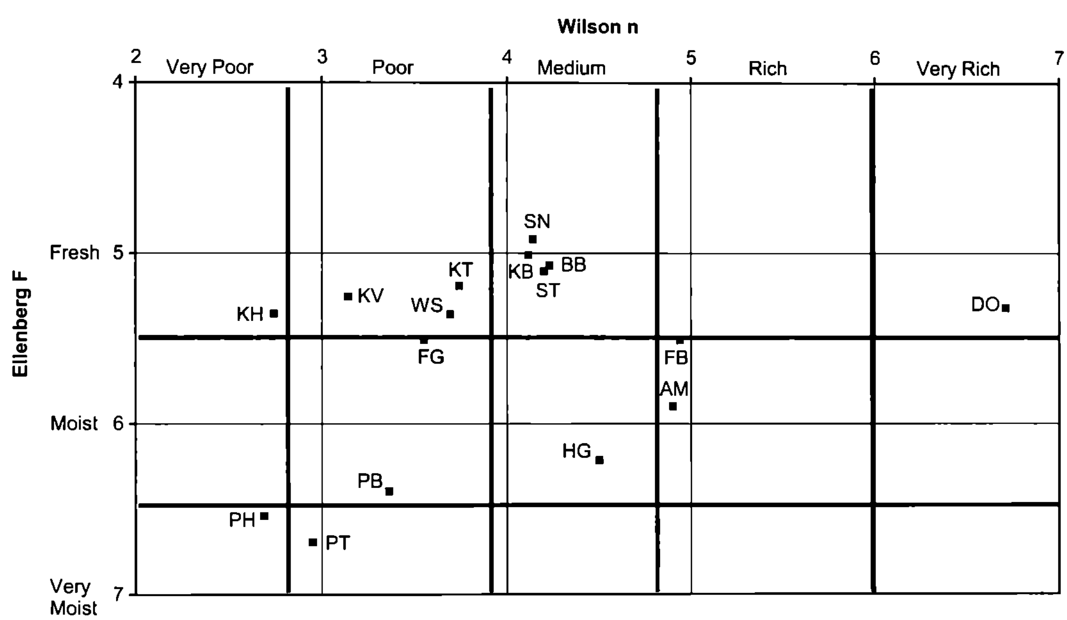
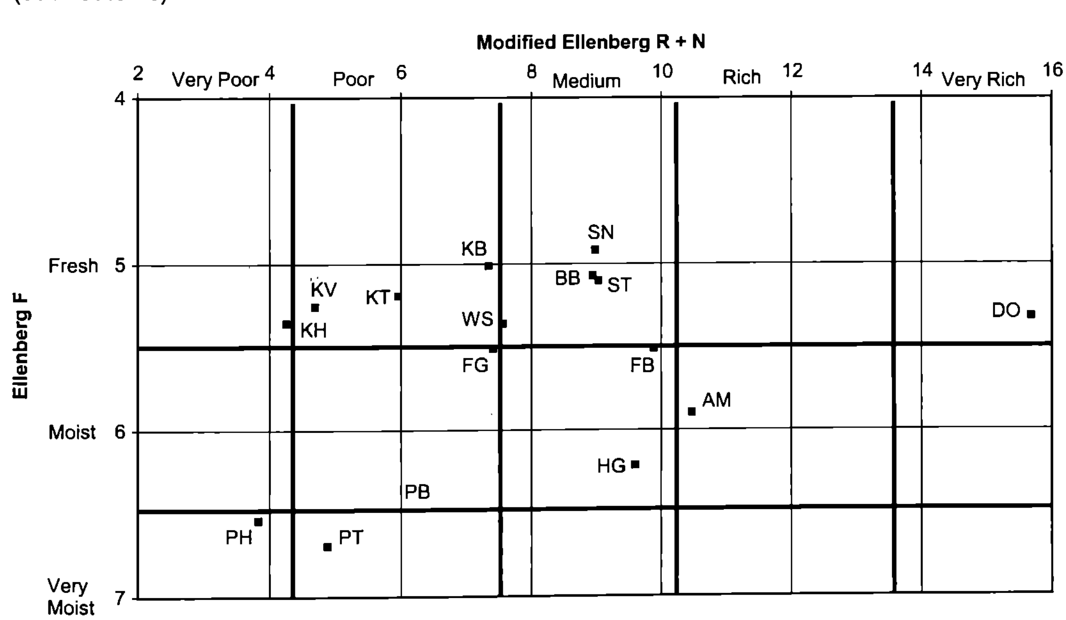


Figure 20 Distribution of plant communities on axes of Ellenberg F (soil moisture) and modified Ellenberg R+N (soil nutrients).



The distribution given by the modified Ellenberg indicator values is preferred to that of the Wilson values because the fine grassy pair of communities (WS and FG) is typically found on the brown earths whereas the bracken group (KT, KV, KH and KB) is frequently found on podzols. The clearer separation between the bracken with bramble sub-community (KB) and the species-rich and bramble group (ST, SN and BB) also accords with the range of soil types found. Analysis of variance of the mean quadrat scores has been carried out to reveal the significance of the differences between sub-communities and communities. The results from all 153 sets of quadrats were pooled for analysis, but the degree of replication (number of sets for each sub-community or community) affects the size of the least significant differences (lsd). The results of the analysis are given in Table 12. Given reasonable replication (e.g. 7, 7) for any two communities that differ by half a class in moisture or nutrient regime on Figures 19 or 20, the difference between the appropriate indicator values is likely to be statistically significant.

Plant communities and the soil quality grid

The purple moor-grass group has some of the poorest nutrient regimes. The ericaceous sub-community (PH) falls just in the Very Poor class with the typical community (PT) being Poor. Only two samples of the bramble variant (PB) were described, but the less poor regime was to be expected. The bracken group has a wider range of nutrient scores by Wilson indicator values than by the modified Ellenberg values. The heather sub-community (KH) is Poor to Very Poor, with the bilberry (KV) and the typical sub-communities (KT) in the Poor class. The bramble sub-community (KB) is rated by Wilson values in the Medium class alongside the bramble-dominant (BB) and species-rich communities (ST and SN), but the modified Ellenberg rating accords better with soil types.

The wood sorrel (WS) and fine grasses (FG) communities are rated in the Poor class alongside the typical bracken community (KT) by Wilson values whereas modified Ellenberg values place them on the Poor–Medium boundary. The species-rich and bramble group (ST, SN and BB) are rated Medium. According to both Ellenberg and Wilson, bluebell is an indicator of Rich soils. However, it extends on to Medium soils in mixture with bracken, as invariably is the case in the New Forest. The false-brome (FB), tufted hair-grass (HG) and ash-maple communities (AM) are rated Medium–Rich. The rating of the tufted hair-grass community given by the modified Ellenberg values is much higher than that given by unmodified Ellenberg values.

Ash woodlands are widely distributed in lowland Britain on base-rich rocks and their ground vegetation is rated Rich to Very Rich using Ellenberg or Wilson values. Although no examples have been described in detail, we can assume that the ash-rich woodlands of the alluvial fringes of the streams (AW) would be similarly rated. It seems, however, that the ash-maple community (AM) may represent some of the least fertile conditions under which ash and field maple can sustain themselves. The ecologically most appropriate place to find ash would be in the very rare dog's mercury community (DO), the only community to be rated Very Rich.

The purple moor-grass group is the only group rated in the Very Moist regime, followed by tufted hair-grass and ash–maple in Moist. The remaining communities do not show clear differences of moisture regime, although the differences between extreme members are significant.

The discussion of the results displayed in Figures 18, 19 and 20 is based on the positions of the mean values for each community. In spite of the significant differences between many of the communities in their moisture and nutrient indicator values, there is an appreciable range of values within some communities that may be related to soil type. This is considered in Chapter 10.

Table 12 Analysis of variance of plant community indicator values

Indicator value	Standard error	Replication	lsd (p<0.05)
Ellenberg F	0.3552	3, 3	0.57
		7, 7	0.38
Wilson n	0.2946	3, 3	0.41
		7, 7	0.31
Modified Ellenberg R+N	0.8462	3, 3	1.37
		7, 7	0.89

Chapter 10

Site classification

In this chapter the 10 soil types (Table 9) are combined with the 19 plant communities (Table 11) to create site types and soil quality ratings are assigned to them.

Creating site types using the GIS

The first step was to construct a complete coverage ('theme' in vector GIS terminology) of plant community polygons of all the surveyed Inclosures. Until this stage the three categories of map reliability ('normal', 'estimated' and 'unmappable') had been kept as separate layers in the GIS. The normal and estimated categories were accepted at face value and the unmappable was 'filled in' to complete the coverage, using soil type and surrounding vegetation as guides. This map (Figure 17) is therefore a temporary working copy, not a definitive version.

The plant community coverage was then overlaid on the soil type coverage and where both themes coincided the new polygons were listed with their areas. A pivot table was created from this list to summarise the combinations in terms of total areas and number of polygons (Table 13).

Many of the smaller site types will be fortuitous combinations resulting from marginal inaccuracies in either of the parent maps and for practical purposes can be ignored because they provide unreliable information. (In effect they will be amalgamated with neighbouring site type polygons.) Site types have therefore been classified as major if their total area in the Forest is over 25 ha, *lesser* if the total area is between 5–25 ha and *minor* if the area is less than 5 ha and shaded in Table 14. In subsequent chapters, the *minor* site types are ignored with the exception of the distinctive dog's mercury (DO) community.

Table 13 Area (ha) and number of polygons of site types in the New Forest Inclosures

		Plant community																				
Soil type	Data	PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	FB	HG	AM	CW	AW	UW	DO	Other	Total
1	Area	44	83	0	42	13	164	5	0	5	0	2	0	0	0	0	0	1	0	0	13	372
	Polygons	33	85	2	24	9	107	18	0	11	0	8	0	0	0	0	0	5	2	0	11	315
2	Area	55	93	1	78	42	147	7	0	32	0	1	8	0	1	0	0	5	0	0	20	489
	Polygons	57	127	2	63	40	178	22	0	25	0	5	9	0	4	0	0	9	5	0	33	579
3	Area	43	213	0	10	5	142	40	3	8	0	6	16	0	3	0	3	7	5	0	8	512
	Polygons	58	192	2	10	19	253	89	7	9	0	17	12	0	12	0	4	18	14	0	25	741
4	Area	29	57	1	9	5	19	3	0	1	0	0	0	0	0	0	0	8	10	0	15	157
	Polygons	47	75	3	35	7	48	8	0	5	0	0	0	0	0	0	2	16	14	0	8	268
5	Area	1	9	1	1	0	5	2	1	1	0	2	0	0	0	0	0	12	5	0	2	41
	Polygons	8	31	1	3	0	21	8	3	3	0	1	1	0	0	0	0	6	7	0	8	101
6	Area	1	8	0	1	4	152	44	1	2	0	24	10	0	0	0	0	0	0	0	11	259
	Polygons	2	19	0	2	11	117	62	4	6	2	36	7	0	0	0	2	2	2	0	13	287
7	Area	9	73	0	51	27	389	229	16	43	0	99	57	7	5	0	0	1	0	0	88	1096
	Polygons	15	128	0	35	43	405	251	23	34	2	84	45	3	16	1	1	6	3	1	59	1155
8	Area	26	149	0	24	27	323	166	8	20	0	90	48	5	38	8	3	2	2	0	48	987
	Polygons	53	199	0	33	64	457	262	28	38	4	105	82	11	43	19	6	6	9	0	65	1484
9	Area	22	225	6	3	164	408	320	14	13	16	91	66	71	142	35	9	15	9	1	24	1656
	Polygons	26	142	4	7	78	389	266	16	16	11	97	52	57	108	25	8	6	12	2	28	1350
10	Area	80	478	10	19	113	817	432	16	43	11	174	82	29	106	4	0	10	7	0	75	2507
	Polygons	58	287	8	35	104	695	372	26	51	11	175	87	49	132	18	3	18	20	0	61	2210
Other	Area	11	47	0	11	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	5	78
	Polygons	1	7	0	6	0	2	2	0	3	0	0	1	1	1	0	0	0	0	0	5	29
Blank	Area	1	0	0	0	10	8	3	0	1	0	0	0	0	0	0	1	0	0	0	4	27
	Polygons	2	3	0	0	17	18	4	0	1	0	0	0	0	1	0	3	3	0	0	5	57
Total area		322	1436	19	248	411	2573	1253	58	169	28	490	287	112	296	47	17	60	39	1	312	8181
Total polygons		360	1295	22	253	392	2690	1364	107	202	30	528	296	121	317	63	29	95	88	3	321	8576

Table 14 Site types and their soil quality

AWC = available water capacity (mm)
SMR = soil moisture regime
SNR = soil nutrient regime

Soil type		Plant community PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	FB	HG	AM	CW	AW	UW	DO
1	AWC	125	125	125	125	125	125	125		125		125						125	125	
	SMR	Fresh	Fresh	Fresh	Very Dry	Mod Dry	Very Dry	Mod Dry		Very Dry		Mod Dry						Moist	Moist	
	SNR	Very Poor	Poor	Poor	Very Poor	Poor	Poor	Poor		Medium		Medium						Medium	Medium	
2	AWC	175	175	175	175	175	175	175		175		175	175		175			175	175	
	SMR	Moist	Very Moist	Moist	Mod Dry	Mod Dry	Mod Dry	Sli Dry		Mod Dry		Sli Dry	Sli Dry		Moist			Moist	Moist	
	SNR	Very Poor	Poor	Poor	Very Poor	Poor	Poor	Poor		Medium		Medium	Medium		Poor			Medium	Medium	
3	AWC	> 250	> 250	> 250	> 250	> 250	> 250	> 250	> 250	> 250		> 250	> 250		> 250		> 250	> 250	> 250	
	SMR	Wet	Wet	Very Moist	Moist	Moist	Moist	Moist	Moist	Moist		Moist	Moist		Very Moist		Very Wet	Very Moist	Very Wet	
	SNR	Very Poor	Poor	Poor	Very Poor	Poor	Poor	Poor	Poor	Medium		Medium	Medium		Medium		Rich	Rich	Rich	
4	AWC	> 250	> 250	> 250	> 250	> 250	> 250	> 250		> 250							> 250	> 250	> 250	
	SMR	Wet	Wet	Very Moist	Moist	Moist	Moist	Moist		Moist							Very Wet	Very Moist	Very Wet	
	SNR	Very Poor	Poor	Poor	Very Poor	Poor	Poor	Poor		Medium							Rich	Rich	Rich	
5	AWC	> 250	> 250	> 250	> 250		> 250	> 250	> 250	> 250		> 250	> 250					> 250	> 250	
	SMR	Wet	Wet	Very Moist	Moist		Moist	Moist	Moist	Moist		Moist	Moist					Very Moist	Very Wet	
	SNR	Very Poor	Poor	Poor	Poor		Poor	Poor	Poor	Medium		Medium	Medium					Rich	Rich	
6	AWC	200	200		200	200	200	200	200	200	200	200	200				200	200	200	
	SMR	Fresh	Moist		Mod Dry	Mod Dry	Mod Dry	Sli Dry	Mod Dry	Mod Dry	Mod Dry	Mod Dry	Mod Dry				Moist	Moist	Moist	
	SNR	Poor	Poor		Poor	Poor	Poor	Poor	Poor	Medium	Medium	Medium	Medium				Rich	Rich	Rich	
7	AWC	250	250		250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
	SMR	Moist	Very Moist		Fresh	Fresh	Sli Dry	Sli Dry	Sli Dry	Sli Dry	Sli Dry	Sli Dry	Sli Dry	Fresh	Moist	Moist	Moist	Moist	Moist	Fresh
	SNR	Poor	Poor		Poor	Poor	Poor	Poor	Poor	Medium	Medium	Medium	Medium	Rich	Medium	Rich	Rich	Rich	Rich	Very Rich
8	AWC	250	250		250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	
	SMR	Very Moist	Very Moist		Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Very Moist	Moist	Very Moist	Very Moist	Very Moist	
	SNR	Poor	Poor		Poor	Poor	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Rich	Medium	Rich	Rich	Rich	Rich	
9	AWC	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
	SMR	Wet	Wet	Very Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Very Moist	Moist	Very Wet	Wet	Very Wet	Moist
	SNR	Poor	Poor	Poor	Poor	Poor	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Rich	Medium	Rich	Rich	Rich	Rich	Very Rich
10	AWC	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	
	SMR	Wet	Wet	Very Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Moist	Very Moist	Moist	Very Wet	Wet	Very Wet	
	SNR	Poor	Poor	Poor	Poor	Poor	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Rich	Medium	Rich	Rich	Rich	Rich	

KEY: Major site types (> 25 ha); Lesser site types (5–25 ha); Minor site types (< 5 ha); Non-existent combinations

Assigning soil moisture and nutrient regimes to site types

Each site type in Table 14 is assigned a class of soil moisture and soil nutrient regime based on knowledge of the soil types and the quantitative information on each plant community gained from the quadrats and species indicator values.

Where a water table is assumed to be present within the upper 1 m during the winter, the mean depth has set the moisture regime, using Table 1. Where the water table is deeper than this, a calculation of available water capacity has been made using Figure 2. The available water capacity (AWC) for each soil type is given in Table 14, even for soils where no moisture regime drier than Moist was assigned. Soil moisture regimes have been adjusted using the Ellenberg F values. Nevertheless, the lack of direct measurements of water tables has meant that assigning soil moisture regimes to plant communities has been a subjective process.

Within the purple moor-grass group, soil moisture regime varies from Fresh on type 1 podzols to Wet on the clays. Within the bracken group the variation is from Very Dry on type 1 podzols to Moist on the clays. Similar variation is predicted for the wood sorrel and fine grasses communities. These differences are seen in the columns of Table 14.

Within a few of the communities it has been possible to assign a different class of nutrient regime to different soil types. On the moist to wet, loamy to clayey soil types 8, 9 and 10 the typical bracken sub-community is rated Medium whereas on the other soils it is rated Poor. Within this sub-community the clayey soils have the highest scores, reflecting a species composition that is subtly different from the rest of the community. The wood sorrel and fine grasses communities are treated the same way, although the links with soil type are not so clear. A similar argument is applied to split the bracken with heather and the purple moor-grass with heather sub-communities into Very Poor on podzols and gleys and Poor on clays. These differences are seen in the rows of Table 14.

As predicted in the Introduction, the variation in moisture and nutrient regimes of individual soil types can be large. Podzols vary from Very Poor to Medium and from Very Dry to Very Moist. Ground-water gleys vary from Very Poor to Rich (the alluvial soil) and from Moist to Very Wet. Brown earths of Types 6 and 7 show a smaller range, from Poor to Medium and from Moderately Dry to Moist. The clay soils including Type 8 range from Poor to Very Rich and from Moist to Very Wet.

With some simplification, the soil quality of the groups of plant communities has been summarised in Figure 21. A similar summary for the soil types is given as Figure 22. While these summaries are convenient they are not very precise. For example, in Figure 21 the bluebell, fine grassy and bramble communities are grouped together but this does not mean that they are regarded as having the same soil quality (for greater precision, see Figures 19 and 20).

These Figures serve to emphasise that neither the soil types nor the plant communities alone can convey soil quality with guaranteed precision, although some of the less widespread members of each classification are quite tightly defined. It is also noteworthy that these summaries have only been possible as a result of all the work that has been carried out on both aspects of site quality.

Alignment of soil nutrient regimes with the national classes

So far a site classification has been created where soil quality has been assessed using ecological indicator values. Both Modified Ellenberg and Wilson indicator values have an objective basis but a degree of extrapolation is involved in using them in the New Forest. Soil sampling in the vegetation quadrats would have allowed comparative statistical analysis of soil and vegetational data. Although this was not undertaken, there is some directly relevant soil information.

Wilson (1998) included one site in the New Forest in the 70 plots sampled during his research into the relationships between soil chemistry and ground vegetation in British woodlands. The plot is a permanent sample plot maintained and measured by the Mensuration Branch of Forest Research. It is situated in South Oakley Inclosure at grid reference SU 227055 in a Scots pine stand planted in 1924. According to Geology sheet 314 of the old series the underlying stratum is Barton Clay, but extrapolating from the sheet 329 of the new series the plot could well lie on the Chama Sand (see Table 7). Soil sampling consisted of 9 cores to 50 cm depth, three of which were clayey while the rest were sandy loam. The majority soil type is a brown earth of type 7 and the plant community falls within the KT Typical bracken. The best-fit NVC community is W16 'Oak–birch with wavy hair-grass'. According to the soil chemistry the nutrient regime is in the upper half of the Poor class. Compared with the other Poor soils in Wilson's plots, this one has typical pH values, very high calcium, high magnesium, very high potassium, low total phosphorus, low mineralisable NO_3, high mineralisable NH_4 and typical total carbon (organic

Figure 21 Soil quality of plant communities in the New Forest Inclosures.

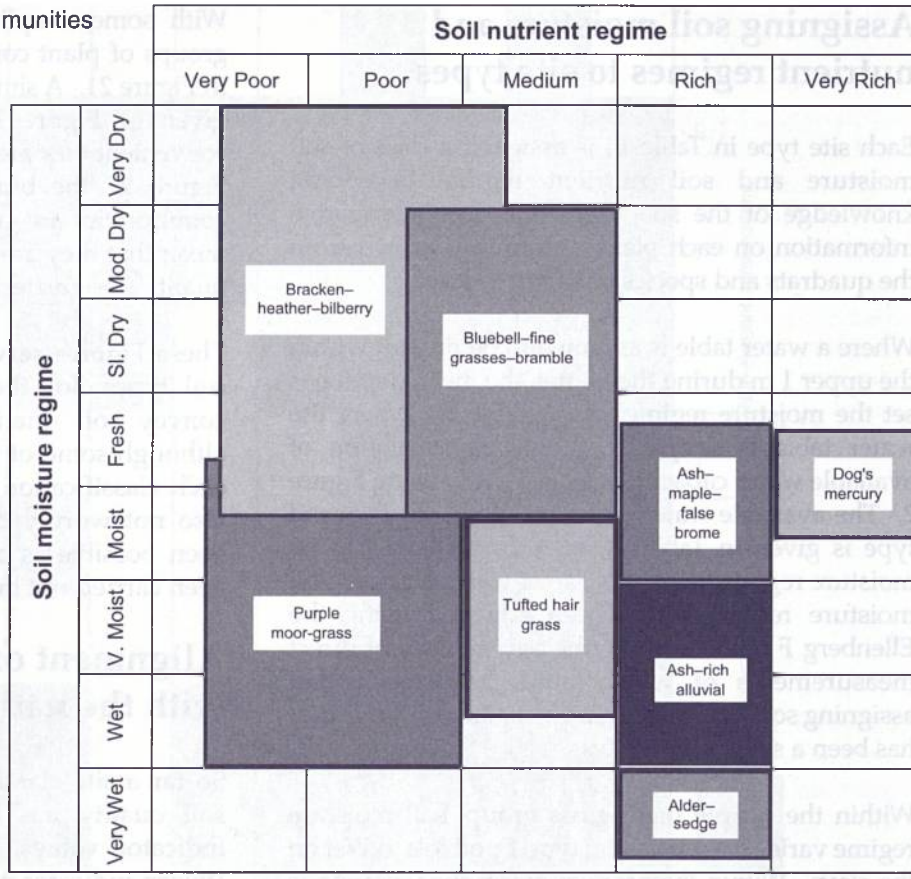
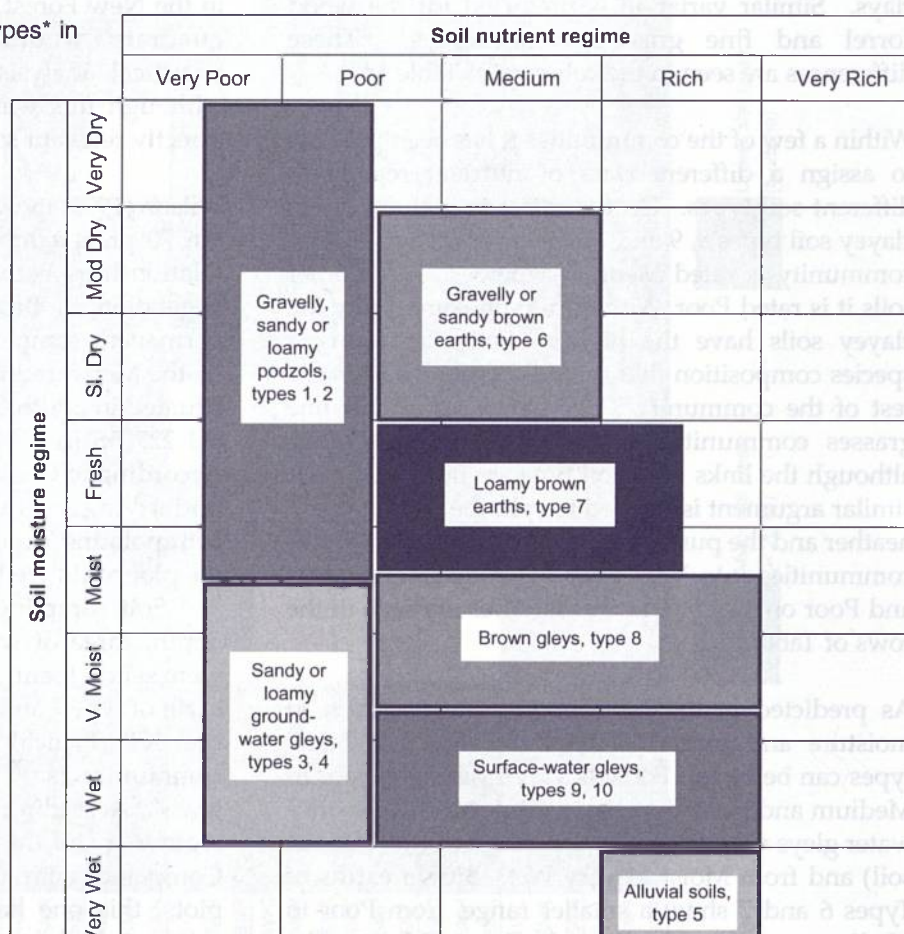


Figure 22 Soil quality of the soil types* in the New Forest Inclosures.



* Excludes the rare Very Rich soils

matter). The potassium may originate from the glauconite mineral which is a feature of several of the Tertiary sediments including both Chama Sand and Barton Clay. Unweathered Barton Clay is frequently a shelly deposit and this may explain the high calcium content in spite of the low pH (3.6 – 3.8, measured in water).

Another of Wilson's plots is relevant to the New Forest because it is also on one of the Tertiary sediments, the Bagshot Sand. This plot is in Bramshill Forest in the geological 'London Basin' rather than the Hampshire Basin. The soil type is a podzolic gley, akin to the transition between our podzol type 2 and the ground-water gley type 3. The plant community is bracken with purple moor-grass, also community KT. This plot has an overall soil nutrient regime very similar to the South Oakley brown earth, rated in the upper half of the Poor class. Although all cations and phosphorus are less abundant than at Oakley, the nitrogen status at Bramshill is slightly higher. The soil data from these two plots thus supports the location of communities on the soil quality grid as shown on Figures 19 and 20, particularly the former.

Soil moisture and nutrient regimes and their distribution

A map of the site types in terms of their soil moisture regime is given as Figure 23 in the colour section. The association with the clay soils ensures that Moist is the most extensive single class. The dominance over wide areas of the Inclosures of the Moist to Wet classes is clear.

The equivalent map of site types in terms of their soil nutrient regime is given as Figure 24 in the colour section. The Poor and Medium classes dominate the scene, the Medium class being associated with most of the clays and the Poor class with most of the brown earths and some of the podzols. The Very Poor class is confined to those podzol and ground-water gleys that have remained heathery within the recent Inclosures of heath. The Rich class is small and scattered, being found on a few clays and brown earths and on alluvial soils. The Very Rich class (the dog's mercury sites) is too small to be visible at this scale.

Site classification – concluding comments

This chapter demonstrates the benefits of being able to handle maps as datasets within a GIS. For example it was possible to combine maps to create new maps, to select a single attribute (e.g. soil nutrient regime) and show it on a map, to measure easily and precisely the areas of any of the mapped features and to work with complex datasets and to simplify them when required.

The data are complex and can be used for many purposes, some of which are clear and immediate, but others that are less obvious or in the future. The general principle adopted has therefore been to retain the maximum genuine information content until the final use of the data for a particular management purpose. This approach permits the creation of a large number of site types, because there is a means of amalgamating them for particular purposes.

The plant communities were defined for the purpose of evaluating soil quality, not for their botanical or phyto-sociological interest. Nevertheless, for some purposes, it may be the plant communities or the soil types rather than their combinations that are the main interest.

In this chapter soil types have been combined with plant communities to create site types, and species indicator values and other knowledge have been used to place each site type on the soil quality grid. The insight gained can now be applied to practical tasks; starting with choice of tree species. To do this the site types in terms of their soil moisture and nutrient regimes are compared with the suitability ratings for tree species given in Chapter 2.

Chapter 11

Choice of tree species for ESC site types

In this chapter the ecological requirements of six major timber-producing species and three minor species are reviewed to see how well they are met by the site types of the New Forest. Consideration is then given as to how the species could be used to optimise timber production. The treatment is largely theoretical and excludes some of the considerations that will affect the manager's strategy. The discussion of growth rates and timber quality is confined to site-related effects.

During the past 200 years some forty species of tree have been planted in the Inclosures of the New Forest. The climate is so benign for tree growth that most of these species have reached an age at which they can regenerate themselves. There are, however, cogent arguments now for reducing the number of species. Harvesting and marketing is more straightforward if there are fewer kinds of timber in large, regular quantities. Some of the introduced species have grown quickly but either have not produced good quality stems or are prone to timber-rotting diseases. Other species of little timber value, such as Lawson cypress (*Chamaecyparis lawsoniana*) regenerate naturally to such an extent that they are now regarded as weed species little better than *Rhododendron ponticum*.

The areas presently (1998) occupied by the six major and other groups of species are given in Table 15. The areas of pedunculate and sessile oak are not known separately.

Table 15 Areas (ha) of major and minor tree species in the Inclosures

Species	Productive area	Unproductive area	Total area
Pedunculate and sessile oak	1987	49	2036
Beech	784	20	804
Other broadleaved species	668	28	696
Total broadleaves	**3439**	**97**	**3536**
Douglas fir	833	93	926
Corsican pine	1030	70	1100
Scots pine	1513	96	1609
Other conifers	853	82	935
Total conifers	**4229**	**341**	**4570**
Broadleaves and conifers	**7668**	**438**	**8106**

'Productive area' is the part of the sub-compartment covered by trees, 'unproductive area' is open space within such sub-compartments.

Figure 23 Map of soil moisture regime in New Forest Inclosures.

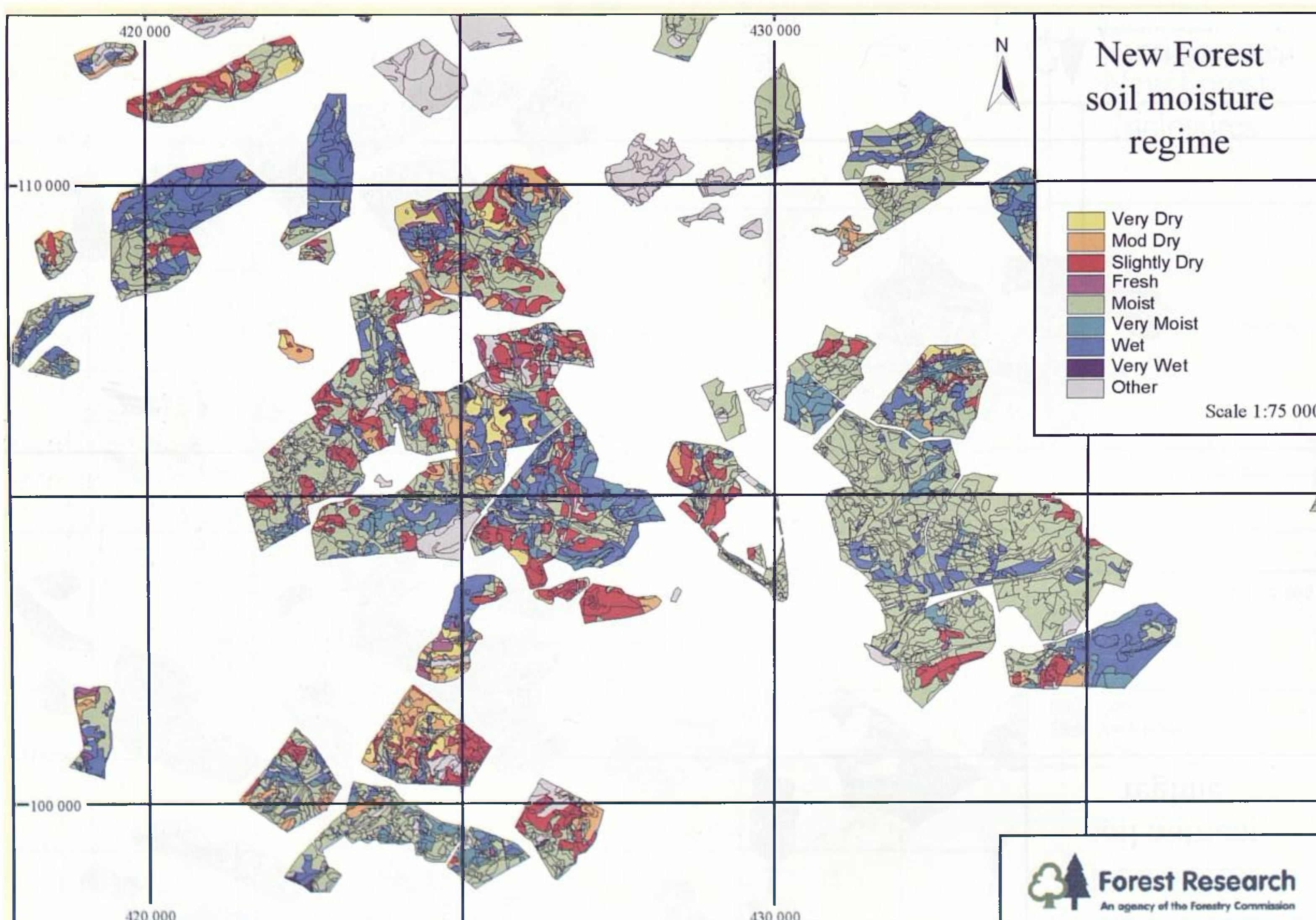


Figure 24 Map of soil nutrient regime in New Forest Inclosures.

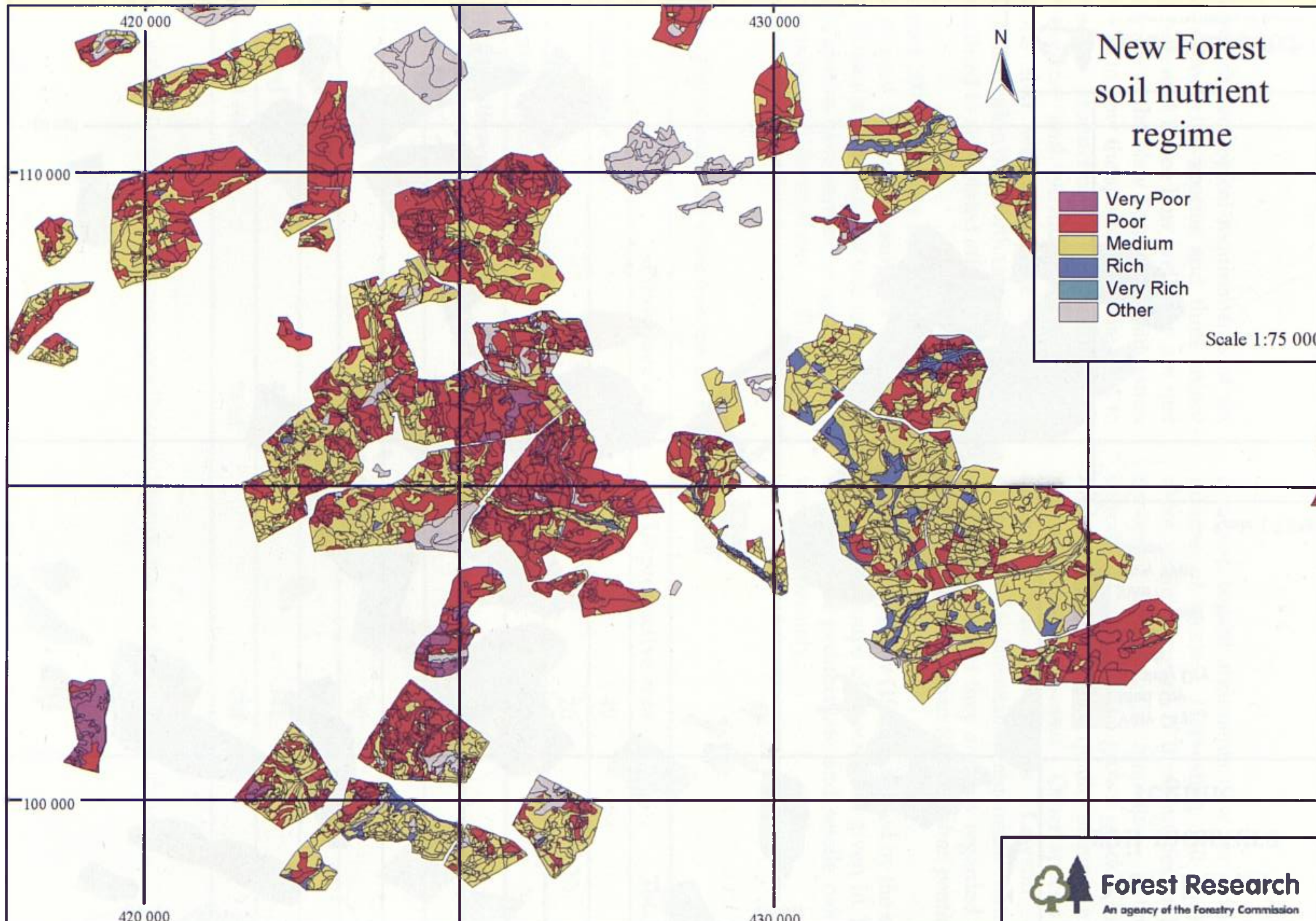
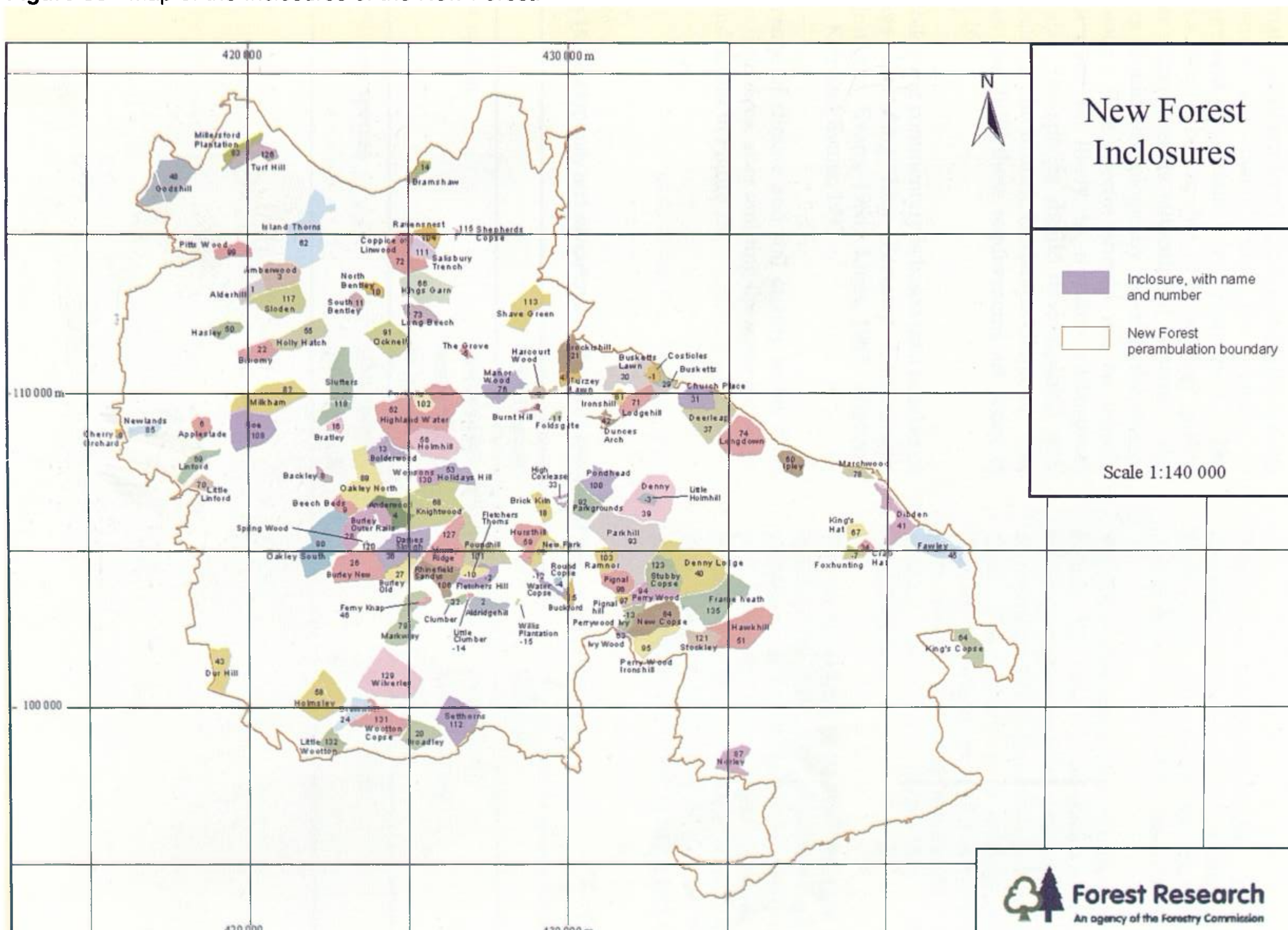


Figure 36 Map of the Inclosures of the New Forest.



The major limiting factors to choice of species in the New Forest Inclosures are the extensive infertile soils, the extensive soils that are wet in winter (yet may be dry in summer), a general windiness due to lack of topographic shelter and the occasional droughts.

The main considerations in choice of species for the Inclosures are taken from the objects of management, as detailed in Appendix 1. The species should be capable of producing quality timber using feasible silvicultural systems. The species should be ecologically suited to the climate and soils. The species should not be unduly invasive or be likely to threaten endangered habitats. The species should be compatible with maintaining the historic landscape character. The species that fulfil these requirements are listed in Table 16.

The following commentary is based on a number of sources including four Forestry Commission publications: Evans, 1984; Lines, 1987; Hibberd, 1991; Kerr and Evans, 1993.

The range of climate and soil quality in the New Forest Inclosures, after omitting the *minor* site types is summarised in Figure 25.

The range of warmth and wetness of the climate of Britain is shown in the upper left grid where accumulated temperature and moisture deficit are combined to show six of the seven climatic zones (the Alpine zone is omitted). The New Forest falls in the warmest class and in the three driest classes of the Warm Dry zone.

Windiness and continentality in Britain are combined in the small grid at centre right. The New Forest falls within the least windy three classes of the range and the most continental class.

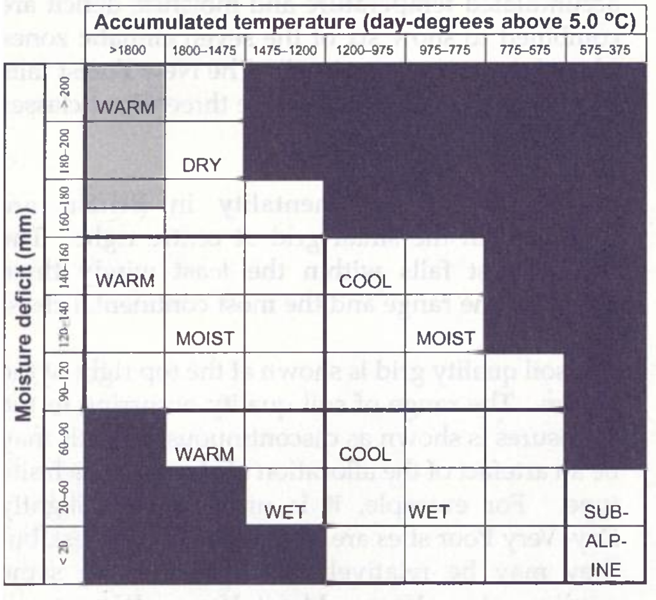
The soil quality grid is shown at the top right of the Figure. The range of soil quality occurring in the Inclosures is shown as discontinuous, but this may be an artefact of the allocation of classes to each site type. For example, it is unlikely that Slightly Dry–Very Poor sites are absent from the Forest, but they may be relatively infrequent. The same applies to Very Moist–Very Poor and Fresh–Medium.

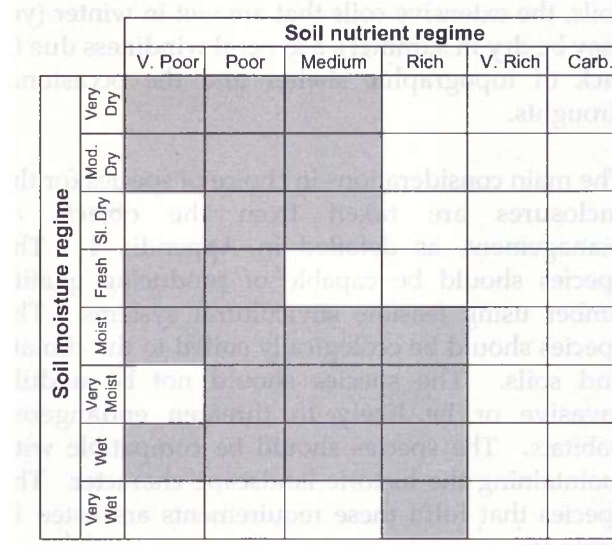
The site types table at the bottom of the Figure is a repeat of the data given in Table 14 split into two parts to show the site types separately in terms of soil moisture and nutrient regimes. Species suitability is shown the same in each part of the table irrespective of whether it is the moisture or nutrient regime that is the limiting factor.

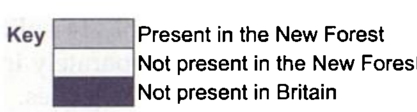
Table 16 Ecologically and silviculturally suited tree species for New Forest Inclosures

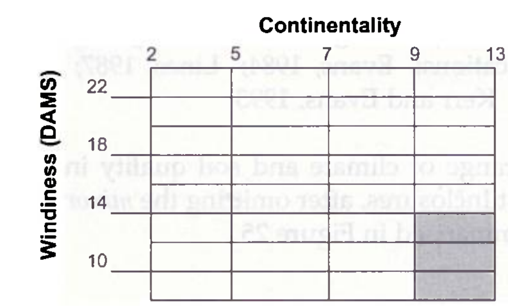
	Broadleaves	**Conifers**
Major species	pedunculate oak sessile oak beech	Douglas fir Corsican pine Scots pine
Subordinate species	silver birch downy birch	hybrid larch

Figure 25 Range of climatic and soil conditions in the New Forest Inclosures.









Site types (minor site types omitted)

Soil moisture regime

Soil type		PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	HG	FB	AM	AW	CW	UW
Podzols	1	F	F		VD	MD	VD	MD		VD									
	2	Mo	VM		MD	MD	MD	SD		MD			SD				Mo		
Ground-water gleys	3	W	W		Mo	Mo	Mo	Mo		Mo		Mo	Mo				VW		VW
	4	W	W		Mo	Mo	Mo										VW		VW
	5		W				Mo										VW		VW
Brown earths	6		Mo				MD	SD				MD	MD						
	7	Mo	VM		F	F	SD	SD	SD	SD		SD	SD	Mo	F				
	8	VM	VM		Mo	Mo	Mo	Mo	Mo	Mo		Mo	Mo	VM	Mo	Mo			
Surface-water gleys (clays)	9	W	W	VM		Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo	Mo	W	VW	W
	10	W	W	VM	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo		W		W

VD: Very Dry
MD: Moderately Dry
SD: Slightly Dry
F: Fresh
Mo: Moist
VM: Very Moist
W: Wet
VW: Very Wet

Soil nutrient regime

Soil type		PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	HG	FB	AM	AW	CW	UW
Podzols	1	VP	P		VP	P	P	P		Me									
	2	VP	P		VP	P	P	P		Me			Me				Me		
Ground-water gleys	3	VP	P		VP	P	P	P		Me		Me	Me				R		R
	4	VP	P		VP	P	P										R		R
	5		P				P										R		R
Brown earths	6		P				P	P				Me	Me						
	7	P	P		P	P	P	P	P	Me		Me	Me	Me	R				
	8	P	P		P	P	Me	Me	Me	Me		Me	Me	Me	R	R			
Surface-water gleys (clays)	9	P	P	P		P	Me	Me	Me	Me	Me	Me	Me	Me	R	R	R	R	R
	10	P	P	P	P	P	Me	Me	Me	Me	Me	Me	Me	Me	R		R		R

VP: Very Poor
P: Poor
Me: Medium
R: Rich
VR: Very Rich

Pedunculate oak (*Quercus robur* L.)

In Britain, pedunculate oak is regarded as warmth-demanding and sensitive to unseasonable frosts, but deep rooting and fairly resistant to drought. It is very wind-firm though it is quite sensitive to exposure damage and even large limbs are liable to be broken by heavy snowfall. In lowland England pedunculate oak is regarded as being better adapted than sessile oak to heavy soils with a high level of fertility. It would therefore be expected to have been historically the most important broadleaved species in the New Forest. It is capable of producing good quality timber on suitable site types, albeit with yield classes of only 4 to 6 m^3 ha^{-1} yr^{-1} and with a rotation length of about 100 years. By far the most valuable use for the timber is for veneers, but only a small proportion of logs achieve this quality and prime furniture grade timber is a more realistic expectation. Oak timber can suffer from 'shake', longitudinal cracks either in a radial direction or between annual rings. The incidence of shake is thought to be higher on light-textured soils. Natural regeneration is difficult on clay soils because of the rewetting of the soil and the growth of competitive weeds that follows felling.

The site requirements for pedunculate oak in Britain are shown in Figures 3–8 and in the New Forest in Figure 26. The climate of the New Forest falls within the *very suitable* range for the species in respect of accumulated temperature, moisture deficit and continentality. In terms of windiness, *very suitable* conditions exist in the major valleys whereas upper slopes and plateaus provide *suitable* conditions. The best estimates of the total area of *very suitable, suitable* and *unsuitable* sites for pedunculate oak and the other five major species are given in Table 17. The 'blank' area is that part of the Inclosures for which there is incomplete site type information, i.e. either soil type or plant community has not been mapped.

Very suitable soil conditions are Fresh to Very Moist and Medium to Very Rich. These conditions are provided by several of the communities on soil types 8, 9 and 10, totalling 3690 ha. Suitable conditions extend almost throughout these same soil types and on the moister parts of the other soils, giving a further 3120 ha. *Unsuitable* conditions are provided by the Moderately Dry or Very Dry sandy brown earths and podzols, especially if the latter are also Very Poor, and by the Very Wet sedge swamps.

Sessile oak (*Quercus petraea* (Mattuschka) Liebl.)

In the English lowlands sessile oak is found naturally on lighter, well drained soils than pedunculate oak and is also more characteristic of the uplands where shallow or strongly acid soils predominate. It is possible therefore, that in the New Forest it was more common on the brown earths than on the clays, relative to pedunculate oak. It seems to be as sensitive as pedunculate oak to unseasonable frost, exposure and snow breakage. Timber quality and yield are also similar. The relative incidence of shake in the two oak species does not seem to be known. Thus it is not clear whether the worst problems arise when pedunculate rather than sessile is grown on the lighter soils. Nevertheless, a sensible precaution would be to avoid the driest sites even with sessile. Natural regeneration is somewhat easier to achieve on well drained soils than on clays because weeds, apart from bracken, are less competitive. Regeneration of oak is possible within grass swards provided light levels are high enough.

The site requirements for sessile oak in Britain are shown in Figures 3–8 and in the New Forest in Figure 27. The climate of the New Forest falls within the *very suitable* range for the species in respect of accumulated temperature and continentality. The moisture deficit, however, is considered to be slightly too high to be very suitable, except on the highest ground. In terms of windiness, *very suitable* conditions exist in the major valleys whereas upper slopes and plateaus provide suitable conditions. On the higher ground therefore, windiness and moisture deficit have conflicting effects for this species.

Very suitable soil conditions are Slightly Dry to Moist and Medium to Very Rich, amounting to 3580 ha. *Suitable* soil conditions are provided by most of the soil types, giving a further 2560 ha, the only *unsuitable* ones being the Very Poor, Very Dry, Wet or Very Wet sites. Sessile oak is less tolerant of waterlogging than pedunculate oak and any site with purple moor-grass should be viewed with suspicion.

Figure 26 Pedunculate oak – site suitability in the New Forest.

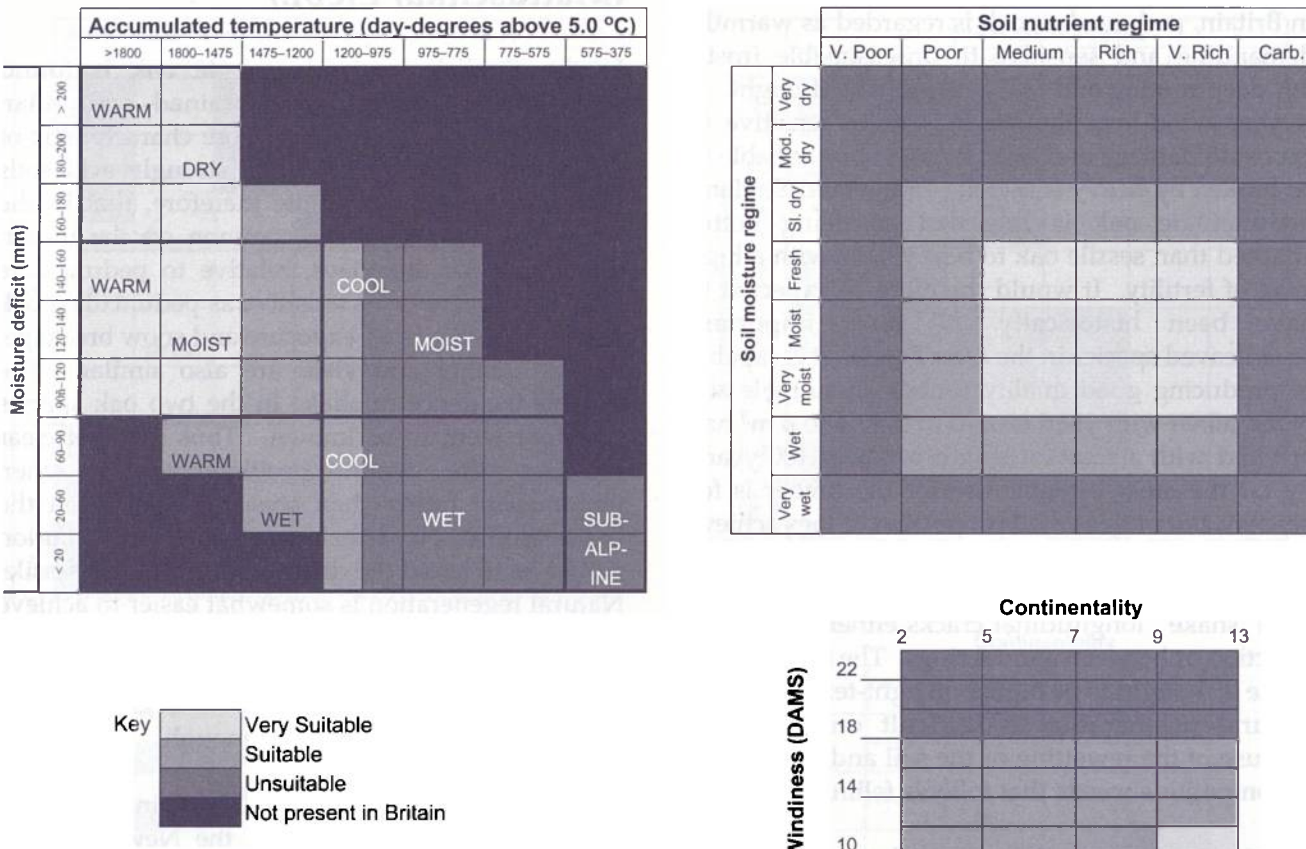
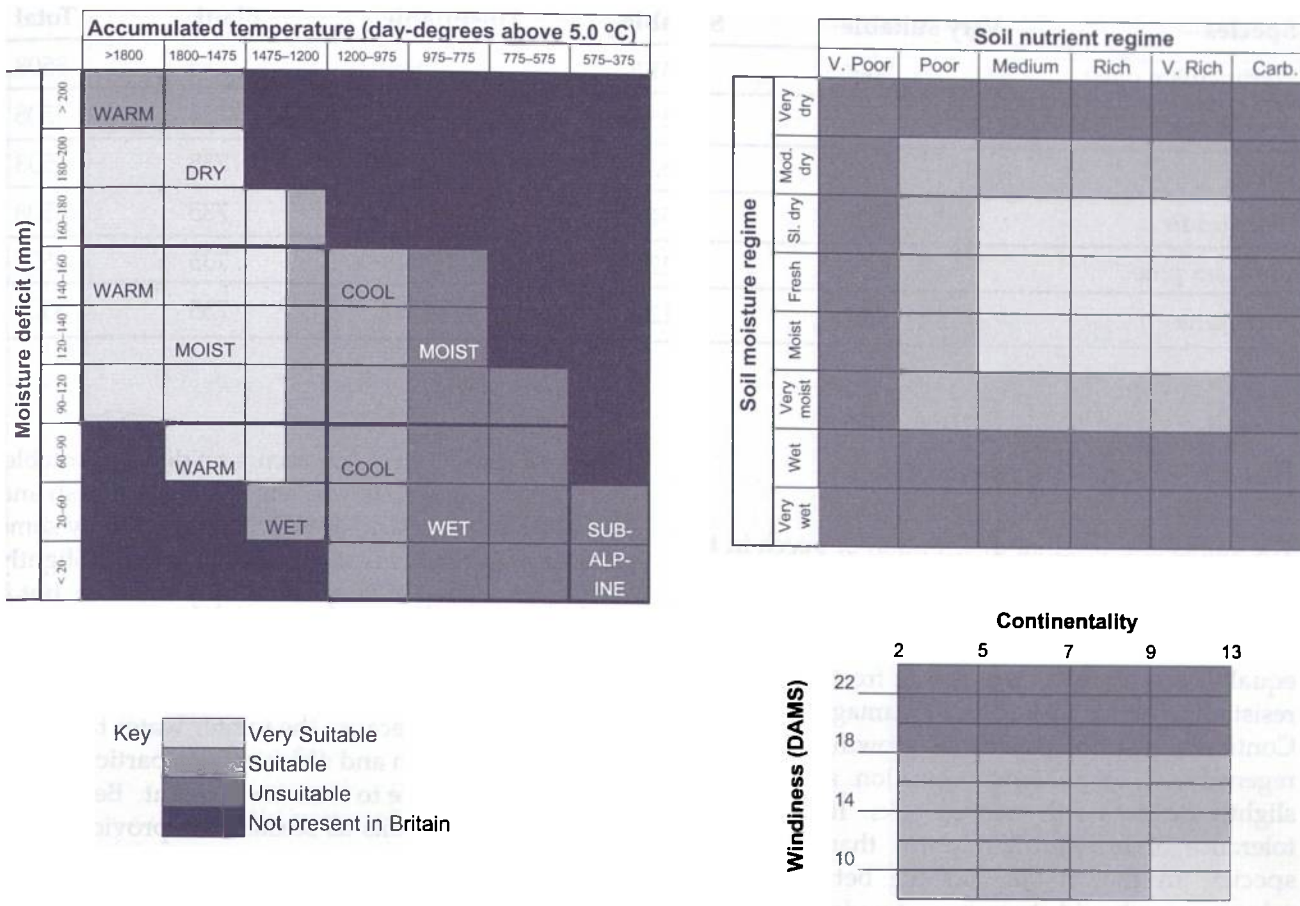


Figure 27 Sessile oak – site suitability in the New Forest.



Site types (minor site types omitted)

Soil moisture regime

Soil type		PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	HG	FB	AM	AW	CW	UW
Podzols	1	F	F		VD	MD	VD	MD		VD									
	2	Mo	VM		MD	MD	MD	SD		MD			SD				Mo		
Ground-water gleys	3	W	W		Mo	Mo	Mo	Mo		Mo		Mo	Mo				VW		VW
	4	W	W		Mo	Mo	Mo										VW		VW
	5		W				Mo										VW		VW
Brown earths	6		Mo				MD	SD				MD	MD						
	7	Mo	VM		F	F	SD	SD	SD	SD		SD	SD	Mo	F				
	8	VM	VM		Mo	Mo	Mo	Mo	Mo	Mo		Mo	Mo	VM	Mo	Mo			
Surface-water gleys (clays)	9	W	W	VM		Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo	Mo	W	VW	Mo
	10	W	W	VM	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo		W		Mo

VD: Very Dry
MD: Moderately Dry
SD : Slightly Dry
F: Fresh
Mo: Moist
VM: Very Moist
W: Wet
VW: Very Wet

Soil nutrient regime

Soil type		PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	HG	FB	AM	AW	CW	UW
Podzols	1	VP	P		VP	P	P	P		Me									
	2	VP	P		VP	P	P	P		Me			Me				Me		
Ground-water gleys	3	VP	P		VP	P	P	P		Me		Me	Me				R		R
	4	VP	P		VP	P	P										R		R
	5		P				P										R		R
Brown earths	6		P				P	P				Me	Me						
	7	P	P		P	P	P	P	P	Me		Me	Me	Me	R				
	8	P	P		P	P	Me	Me	Me	Me		Me	Me	Me	R	R			
Surface-water gleys (clays)	9	P	P	P		P	Me	Me	Me	Me	Me	Me	Me	Me	R	R	R	R	VR
	10	P	P	P	P	P	Me	Me	Me	Me	Me	Me	Me	Me	R		R		VR

VP: Very Poor
P: Poor
Me: Medium
R: Rich
VR: Very Rich

Table 17 Total area (ha) very suitable, suitable or unsuitable for the six major tree species

Species	Very suitable	Suitable	Unsuitable	Blank	Total
Pedunculate oak	3690	3120	963	735	8508
Sessile oak	3575	2559	1638	735	8508
Beech	217	5235	2321	735	8508
Douglas fir	216	5404	2152	735	8508
Corsican pine	5451	2273	48	735	8508
Scots pine	5288	1254	1231	735	8508

Beech (*Fagus sylvatica* L.)

The status and original distribution of beech in the New Forest is somewhat uncertain, although there is no doubt that it is native. It is regarded in Britain as less warmth-demanding than the oaks, but equally sensitive to unseasonable frosts; it is more resistant to exposure and snow damage. As on the Continent, beech is capable of growth and natural regeneration to a higher elevation and perhaps slightly further north than the oaks. It has a wider tolerance of soil nutrient status than either oak species, in that it can survive better on both calcareous soils and strongly acid podzols. It is less tolerant of soils with seasonal waterlogging and, especially in old age, is more susceptible to drought. Prolific natural regeneration is more easily obtained than with the oaks, and the seedlings are more persistent because of their greater shade tolerance. The timber of beech has many uses. On good sites yield is greater than for oaks, 6 m^3 ha^{-1} yr^{-1} being typical.

Figures 3–8 and 28 show the site requirements for beech in Britain and the New Forest. The climate of the Forest is *very suitable* in terms of accumulated temperature and continentality. Its greater resistance to wind exposure, not evident in the Figures, is sufficient for this factor also not to be a limitation in the Forest. As for sessile oak, the moisture deficit in much of the Forest is slightly too high to be *very suitable*.

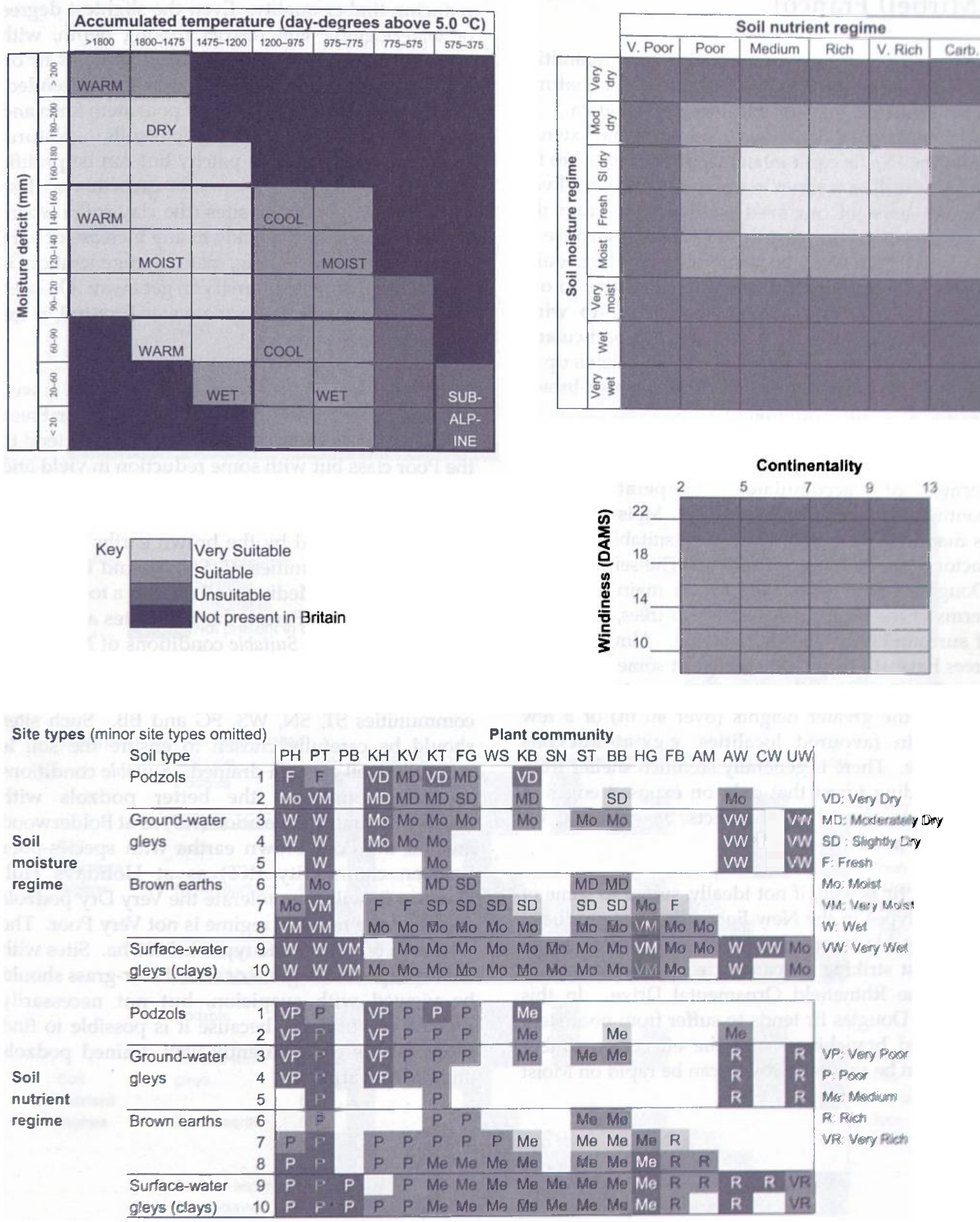
The best growth of beech occurs on deeply rootable, fertile soils; in ESC terms, Slightly Dry to Fresh and Medium to Very Rich, of which there are only some 220 ha in the Inclosures. Beech will tolerate Slightly Dry soils as long as they are deeply rootable, but it is less suited than sessile oak to Moderately Dry soils. Nevertheless, the total area of *suitable* sites is much larger, at 5240 ha. It is not recommended on Very Moist soils because the winter water table will limit rooting depth and older trees in particular will become susceptible to summer drought. Beech is as tolerant of Poor soils as sessile oak, provided they are well drained.

Beech is particularly vulnerable to bark stripping by grey squirrels and this can have a devastating effect on young pole-stage trees. Grey squirrels are present throughout the New Forest and the threat of damage has precluded the planting of beech as a crop tree for many years. The prospect of improved squirrel control measures in the future is not yet clear enough to change this policy.

Other broadleaves

Silver birch (*Betula pendula* Roth) and downy birch (*Betula pubescens* Ehrh.) are common throughout the Forest and are a characteristic feature of the landscape both within and outside the Inclosures. Silver birch in particular has a high amenity and conservation value when mature. Stem form is often not very good, but both species produce small quantities of timber of general usefulness especially for firewood. Downy birch has a minor silvicultural place on Poor Wet soils and silver birch on Fresh to Slightly Dry, Poor soils especially those derived from heaths (Figures 3–8).

Figure 28 Beech – site suitability in the New Forest.



Douglas fir (*Pseudotsuga menziesii* (Mirbel) Franco)

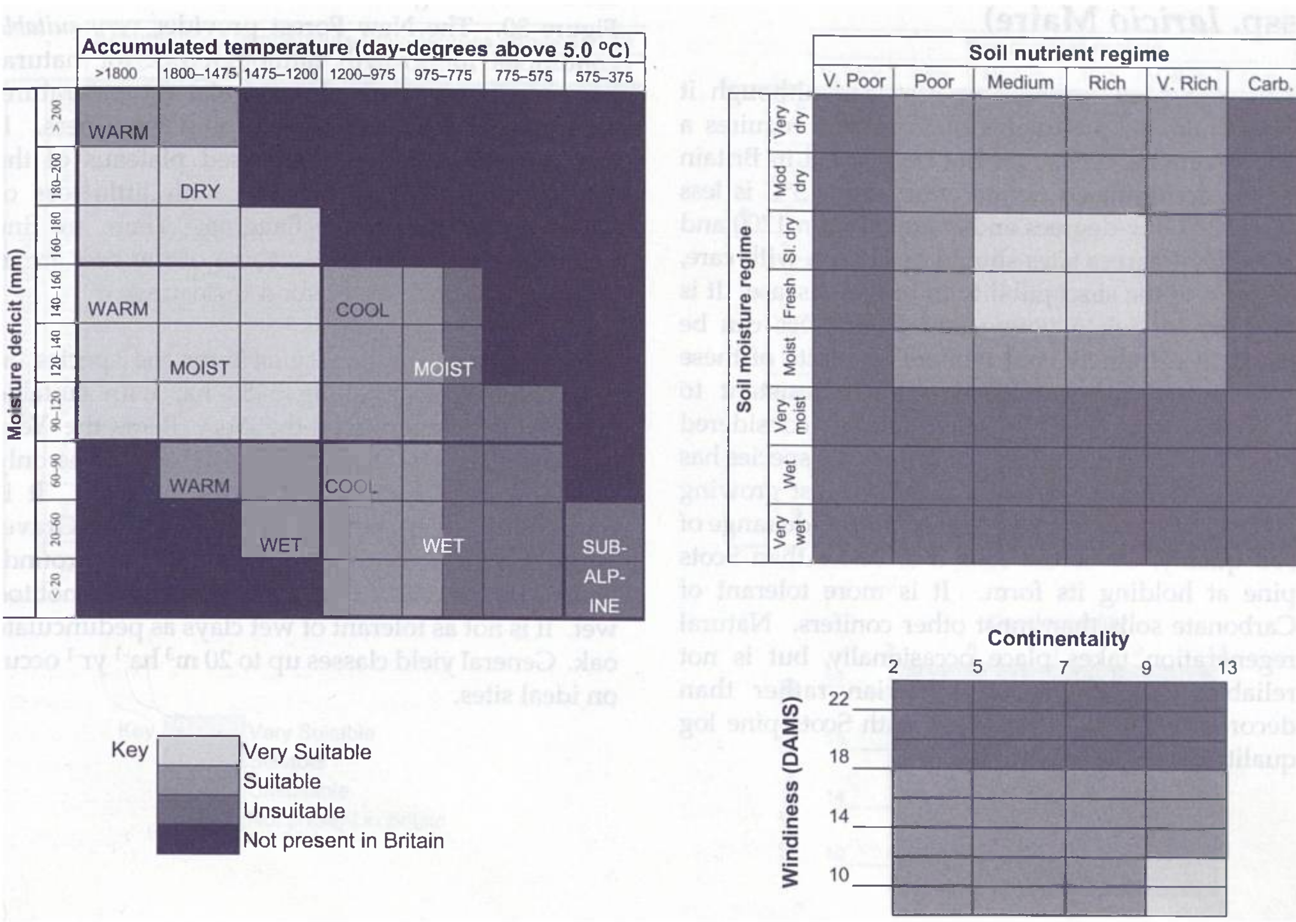
Douglas fir is capable of producing large quantities of excellent timber in Britain. Its natural distribution in north-west America is predominantly at latitudes below 50°N and extends from the Pacific coast inland to climates that are far drier, as well as warmer in summer, than ours. Even though most of our seed sources were from the western half of that distribution, it is no surprise to find that the species is warmth-demanding, quite tolerant of dry conditions and not sensitive to our degree of winter cold. It is sensitive to wind exposure and unseasonable frosts. It is particularly intolerant of a fluctuating water table. Yields up to 22 m^3 ha^{-1} yr^{-1} are possible on the better brown earths, as at Minstead Manor Wood.

The climate of the New Forest is *very suitable* in terms of accumulated temperature and continentality (Figures 3–8 and 29). Moisture deficit is marginally too high to be very suitable, but this factor is unlikely to be limiting. The sensitivity of Douglas fir to wind exposure is mainly seen in terms of the height reached by old trees, especially if surrounding shelter is removed. Almost all old trees have suffered top breakage at some time. The benefits of topographic or even mutual shelter are seen in the greater heights (over 40 m) of a few stands in favoured localities, e.g. at Puckpits Inclosure. There is generally so much shelter from surrounding forest that only on exposed edges of Inclosures would blast effects be expected on younger trees.

Douglas fir is well, if not ideally, suited to some of the site types in the New Forest and has produced some notable stands as well as some of the largest and most striking specimen trees in the Forest, as along the Rhinefield Ornamental Drive. In this country, Douglas fir tends to suffer from poor stem form and branchiness and the effects on timber value can be severe. Growth can be rapid on Moist and even Very Moist soils but there is an increased risk of leaning or sinuous stems and large branches reducing timber quality. Even the slightest degree of waterlogging will restrict rooting depth, with added risk of windthrow. Planting Douglas fir on Very Moist soil is therefore not recommended. There are also increased risks of poor stem form and heavy branching on Very Rich soils. Natural regeneration tends to be patchy but can be prolific on Dry soils where weed growth is less troublesome. On moist sites (the clay soils) where rank weeds respond quickly to any increase of light following seeding felling, natural regeneration is often overwhelmed before it can get away. On such sites planting, with appropriate weed control, is the correct ecological choice.

Douglas fir responds to deep, fertile soil that is well aerated, in ESC terms this is Slightly Dry or Fresh and Medium or Rich. Suitable conditions extend to the Poor class but with some reduction in yield and to the Very Rich class with increased risk of inferior timber quality. *Very suitable* soil quality for the species is provided by the brown earths of type 7 with plant communities ST, SN, BB and KB giving Slightly Dry and Medium soil quality, a total area of 215 ha within the Forest, the same sites as are *very suitable* for beech. *Suitable* conditions of Moist and Medium are provided by the better drained two-storeyed clay soils, exemplified by plant communities ST, SN, WS, FG and BB. Such sites should be carefully chosen to ensure the soil is naturally well enough drained. *Suitable* conditions are also found on the better podzols with bracken/bramble vegetation (KB) as at Bolderwood and on the Poor brown earths with species-poor bracken community (KT) as at Holidays Hill. Douglas fir will even tolerate the Very Dry podzols provided the nutrient regime is not Very Poor. The total area of *suitable* site types is 5400 ha. Sites with some purple moor-grass or tufted hair-grass should be viewed with suspicion, but not necessarily rejected out of hand, because it is possible to find these species on apparently well drained podzols and brown earths.

Figure 29 Douglas fir – site suitability in the New Forest.



Site types (minor site types omitted)

Soil moisture regime

Soil type		PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	HG	FB	AM	AW	CW	UW
Podzols	1	F	F		VD	MD	VD	MD		VD									
	2	Mo	VM		MD	MD	MD	SD		MD			SD				Mo		
Ground-water	3	W	W		Mo	Mo	Mo	Mo		Mo		Mo	Mo				VW		VW
gleys	4	W	W		Mo	Mo	Mo										VW		VW
	5		W				Mo										VW		VW
Brown earths	6		Mo				MD	SD				MD	MD						
	7	Mo	VM		F	F	SD	SD	SD	SD		SD	SD	Mo	F				
	8	VM	VM		Mo	Mo	Mo	Mo	Mo	Mo		Mo	Mo	VM	Mo	Mo			
Surface-water	9	W	W	VM		Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo	Mo	W	VW	Mo
gleys (clays)	10	W	W	VM	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo		W		Mo

VD: Very Dry
MD: Moderately Dry
SD: Slightly Dry
F: Fresh
Mo: Moist
VM: Very Moist
W: Wet
VW: Very Wet

Soil nutrient regime

Soil type		PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	HG	FB	AM	AW	CW	UW
Podzols	1	VP	P		VP	P	P	P		Me									
	2	VP	P		VP	P	P	P		Me			Me				Me		
Ground-water	3	VP	P		VP	P	P	P		Me		Me	Me				R		R
gleys	4	VP	P		VP	P	P										R		R
	5		P				P										R		R
Brown earths	6		P				P	P				Me	Me						
	7	P	P		P	P	P	P	P	Me		Me	Me	Me	R				
	8	P	P		P	P	Me	Me	Me	Me		Me	Me	Me	R	R			
Surface-water	9	P	P	P		P	Me	Me	Me	Me	Me	Me	Me	Me	R	R	R	R	VR
gleys (clays)	10	P	P	P	P	P	Me	Me	Me	Me	Me	Me	Me	Me	R		R		VR

VP: Very Poor
P: Poor
Me: Medium
R: Rich
VR: Very Rich

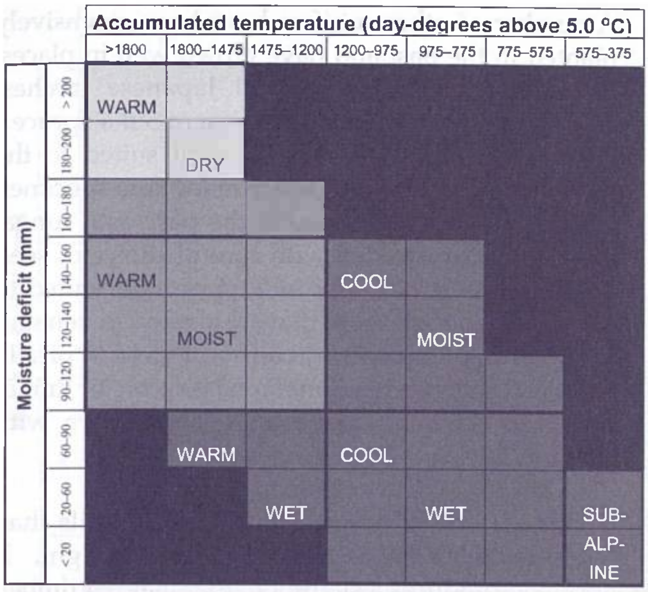
Corsican pine (*Pinus nigra* Arnold ssp. *laricio* Maire)

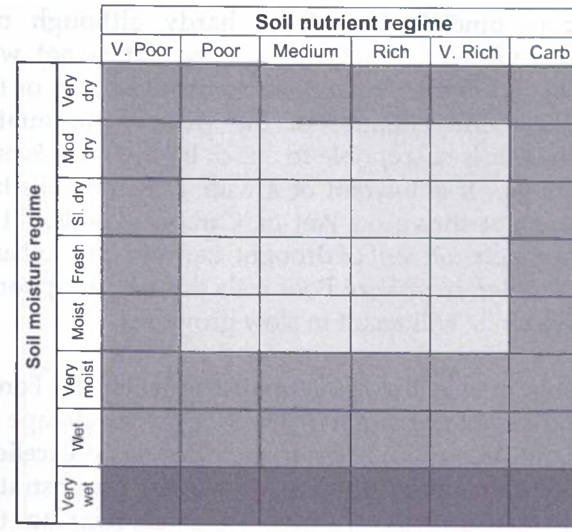
This is a Mediterranean species and although it hails from the mountains of Corsica it requires a warm climate. It should not be planted in Britain where accumulated temperature above 5°C is less than 1200 day-degrees and even between 1200 and 1475 day-degrees sites should be chosen with care, because of the susceptibility to fungal disease. It is frost tender when young and older trees can be killed in extremely cold winters. In spite of these sensitivities Corsican pine is more resistant to exposure than the five other species considered here. In the warmest parts of Britain the species has shown itself to be drought resistant, fast growing with good stem form and tolerant of a wide range of soil quality. On fertile soils it is better than Scots pine at holding its form. It is more tolerant of Carbonate soils than most other conifers. Natural regeneration takes place occasionally, but is not reliable. Its timber is utilitarian rather than decorative, but in comparison with Scots pine log quality is consistently higher.

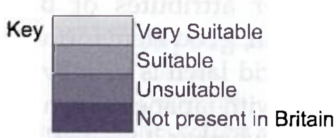
The site requirements for Corsican pine in Britain are shown in Figures 3–8 and in the New Forest in Figure 30. The New Forest provides *very suitable* conditions for growth (although not for natural regeneration) in terms of accumulated temperature, moisture deficit, continentality and windiness. It has grown on the most exposed plateaus of the Forest, e.g. at Mogshade Hill with little loss of height growth or crown flagging. There are fine stands in many Inclosures, some of the best are in Knightwood and Anderwood Inclosures.

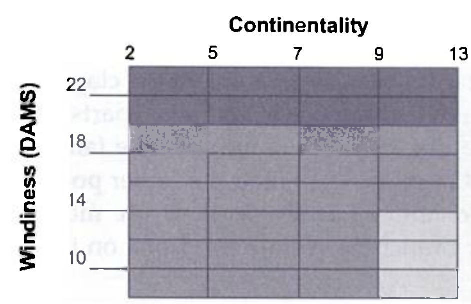
Soil conditions are *very suitable* for the species on most site types, totalling 5450 ha, with suitable conditions extending to the Very Poor, the Very Moist or the Very Dry, a further 2270 ha. The only *unsuitable* sites are the Very Wet swamps. It is particularly well suited to the Plateau Gravel podzols, but is also a good performer on ground-water gleys and clay soils provided they are not too wet. It is not as tolerant of wet clays as pedunculate oak. General yield classes up to 20 m^3 ha^{-1} yr^{-1} occur on ideal sites.

Figure 30 Corsican pine – site suitability in the New Forest.









Site types (minor site types omitted)

Plant community

Soil moisture regime

Soil type		PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	HG	FB	AM	AW	CW	UW
Podzols	1	F	F		VD	MD	VD	MD		VD									
	2	Mo	VM		MD	MD	MD	SD		MD			SD				Mo		
Ground-water	3	W	W		Mo	Mo	Mo	Mo		Mo		Mo	Mo				VW		VW
gleys	4	W	W		Mo	Mo	Mo										VW		VW
	5		W				Mo										VW		VW
Brown earths	6		Mo				MD	SD				MD	MD						
	7	Mo	VM		F	F	SD	SD	SD	SD		SD	SD	Mo	F				
	8	VM	VM		Mo	Mo	Mo	Mo	Mo	Mo		Mo	Mo	VM	Mo	Mo			
Surface-water	9	W	W	VM		Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo	Mo	W	VW	Mo
gleys (clays)	10	W	W	VM	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo		W		Mo

VD: Very Dry
MD: Moderately Dry
SD : Slightly Dry
F: Fresh
Mo: Moist
VM: Very Moist
W: Wet
VW: Very Wet

Soil nutrient regime

Soil type		PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	HG	FB	AM	AW	CW	UW
Podzols	1	VP	P		VP	P	P	P		Me									
	2	VP	P		VP	P	P	P		Me			Me				Me		
Ground-water	3	VP	P		VP	P	P	P		Me		Me	Me				R		R
gleys	4	VP	P		VP	P	P										R		R
	5		P				P										R		R
Brown earths	6		P				P	P				Me	Me						
	7	P	P		P	P	P	P	P	Me		Me	Me	Me	R				
	8	P	P		P	P	Me	Me	Me	Me		Me	Me	Me	R	R			
Surface-water	9	P	P	P		P	Me	Me	Me	Me	Me	Me	Me	Me	R	R	R	R	VR
gleys (clays)	10	P	P	P	P	P	Me	Me	Me	Me	Me	Me	Me	Me	R		R		VR

VP: Very Poor
P: Poor
Me: Medium
R: Rich
VR: Very Rich

Scots pine (*Pinus sylvestris* L.)

Scots pine is very frost hardy although not particularly tolerant of exposure. It is not well adapted to the more oceanic parts of Britain, or the cold damp climates of the western mountains where it is susceptible to attack by the *Brunchorstia* fungus. It is tolerant of a wide range of soils but does not thrive on Wet or Carbonate soils. It is extremely tolerant of drought, i.e. Very Dry soil and also tolerant of Very Poor soils though phosphorus deficiency will result in slow growth.

Scots pine is the commonest conifer in the Forest and is an important feature of the landscape in many areas. The Forest provides some excellent conditions in Britain for the species, demonstrated by fast growth and tall trees as near to the Rhinefield Ornamental Drive. One of the finest specimens is to be seen in Amberwood Inclosure at grid reference SU 215135. It regenerates freely on a range of soils, including some clays. It is an aggressive coloniser of the drier parts of the open heath. Its main limitations are the fairly low yield (up to 14 m^3 ha^{-1} yr^{-1}) and the rather poor stem form for a conifer. Impersistence of the main stem and heavy branching seem to be worst on fertile soils.

The site requirements for Scots pine in Britain are shown in Figures 3–8 and in the New Forest in Figure 31. The New Forest provides *very suitable* conditions in terms of accumulated temperature, moisture deficit and continentality, and windiness is only a limiting factor on the most exposed plateaus.

Although in the New Forest Scots pine seems to tolerate Very Moist and Wet soils better than it does further north in Britain, it is less well adapted to the clays than Corsican pine. *Very suitable* site types are therefore slightly less extensive, at 5290 ha. This difference should affect species choice on the wetter sites exemplified by purple moor-grass or tufted hair-grass. *Suitable* site types for Scots pine are also restricted compared with those for Corsican pine and amount to a further 1250 ha. Although Scots pine is thought to be better adapted to Very Poor soils than Corsican, this difference is only likely to become evident on unfertilised dry heath soils.

Other conifers

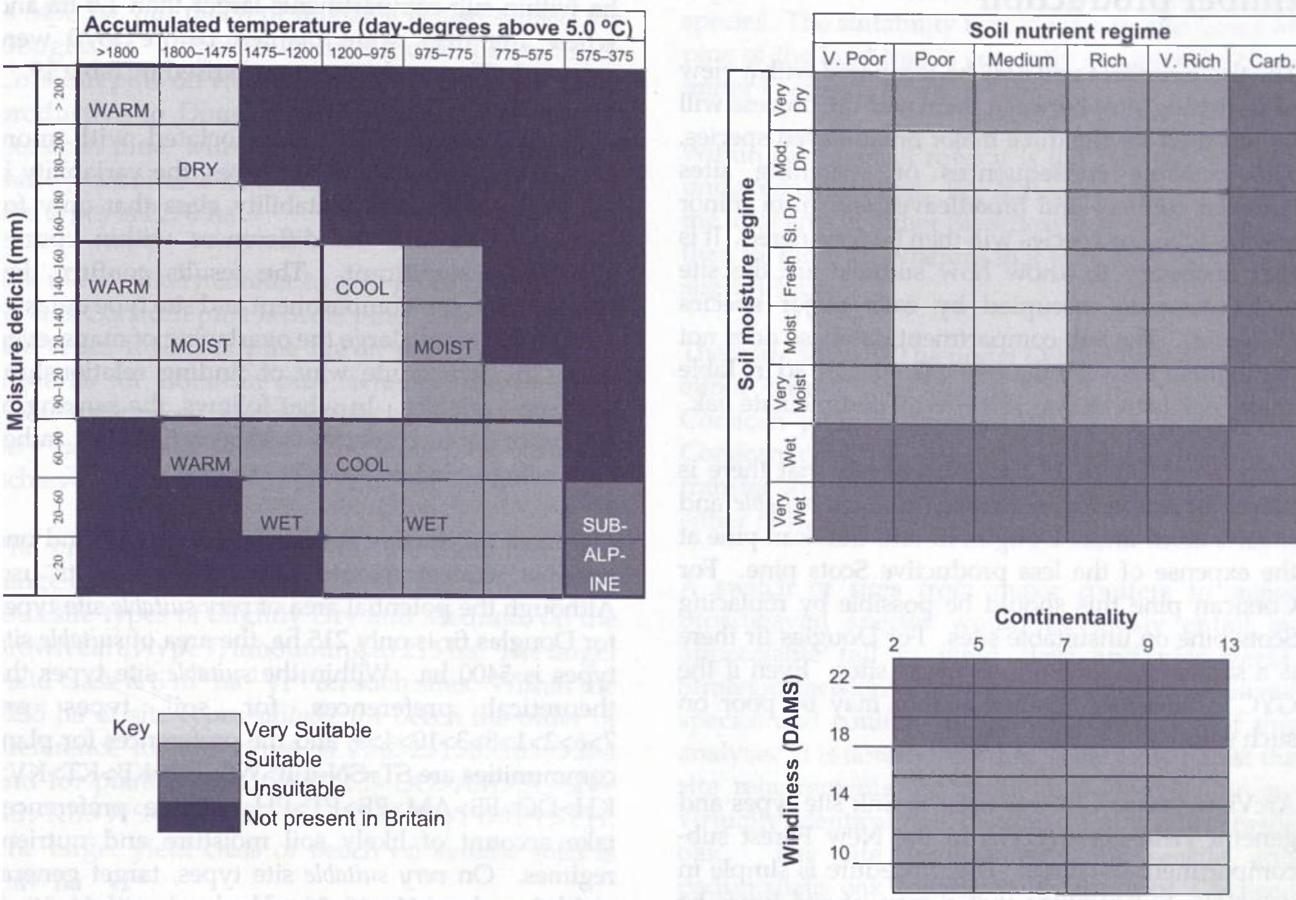
A number of other conifers have been extensively planted in the past and have grown well in places. These include European and Japanese larches, Norway spruce and to a lesser extent Sitka spruce. European larch is ecologically well suited to the New Forest and has produced many fine specimen trees. Problems that arose in the past with fungal disease can be avoided with careful choice of seed origin (Lines, 1987). The site types most suited to European larch are those that are already in demand for Douglas fir or beech. In terms of yield (typically 8 m^3 ha^{-1} yr^{-1}) and the marketability of its timber European larch is not seen as competitive with Douglas fir.

Japanese larch is more tolerant of poor soils than European larch but is less tolerant of drought. It normally produces a slightly higher yield of timber, at 10 m^3 ha^{-1} yr^{-1}. The species has effectively been replaced by hybrid larch which is presumed to combine the better attributes of both parents, namely rapid growth, good stem form and freedom from disease. Hybrid larch is usually bracketed in silvicultural terms with Japanese larch (Figures 3–8) but it is not known whether it is equally susceptible to drought.

Norway spruce has been planted extensively, especially on ground-water gleys. It grows well in the early stages and can produce substantial volumes of valuable timber. As it matures, however, it can become susceptible to the severest droughts leading to a long-term decline in vigour and some dieback and it is not now recommended for extensive planting. In spite of this, some fine specimen trees are to be seen on sloping, moist, sheltered sites as at Puckpits Inclosure.

Even stronger reservations must be made about Sitka spruce for which the climate of the New Forest is unsuitable in terms of moisture deficit (too dry). On suitably moist ground-water gley sites the early growth of Sitka spruce can be very impressive, but the species is very susceptible to droughts and becomes prey to aphids that can cause a devastating reduction in crown density and stem growth. It is therefore not recommended for extensive planting. A few small stands with some large individual trees are to be seen in Knightwood Inclosure near the Forest Drive.

Figure 31 Scots pine – site suitability in the New Forest.



Site types (minor site types omitted)

Plant community

	Soil type		PH	PT	PB	KH	KV	KT	FG	WS	KB	SN	ST	BB	HG	FB	AM	AW	CW	UW
Soil moisture regime	Podzols	1	F	F		VD	MD	VD	MD		VD									
		2	Mo	VM		MD	MD	MD	SD		MD			SD				Mo		
	Ground-water gleys	3	W	W		Mo	Mo	Mo	Mo		Mo		Mo	Mo				VW		VW
		4	W	W		Mo	Mo	Mo										VW		VW
		5		W				Mo										VW		VW
	Brown earths	6		Mo				MD	SD				MD	MD						
		7	Mo	VM		F	F	SD	SD	SD	SD		SD	SD	Mo	F				
		8	VM	VM		Mo	Mo	Mo	Mo	Mo	Mo		Mo	Mo	VM	Mo	Mo			
	Surface-water gleys (clays)	9	W	W	VM		Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo	Mo	W	VW	Mo
		10	W	W	VM	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	VM	Mo		W		Mo
Soil nutrient regime	Podzols	1	VP	P		VP	P	P	P		Me									
		2	VP	P		VP	P	P	P		Me			Me				Me		
	Ground-water gleys	3	VP	P		VP	P	P	P		Me		Me	Me				R		R
		4	VP	P		VP	P	P										R		R
		5		P				P										R		R
	Brown earths	6		P				P	P				Me	Me						
		7	P	P		P	P	P	P	P	Me		Me	Me	Me	R				
		8	P	P		P	P	Me	Me	Me	Me		Me	Me	Me	R	R			
	Surface-water gleys (clays)	9	P	P	P		P	Me	Me	Me	Me	Me	Me	Me	Me	R	R	R	R	VR
		10	P	P	P	P	P	Me	Me	Me	Me	Me	Me	Me	Me	R		R		VR

VD: Very Dry
MD: Moderately Dry
SD : Slightly Dry
F: Fresh
Mo: Moist
VM: Very Moist
W: Wet
VW: Very Wet

VP: Very Poor
P: Poor
Me: Medium
R: Rich
VR: Very Rich

Optimising species' choice for timber production

The three conifers will now be compared with a view to switching sites between them and the process will be repeated for the three major broadleaved species. The possible consequences of switching sites between conifers and broadleaves and from minor species to major species will then be considered. It is first necessary to know how suitable are the site types currently occupied by each major species (Table 18). The sub-compartment database does not distinguish between the two oak species, so in Table 18 the oak is treated as if it was all pedunculate oak.

Comparing Tables 18 and 17 suggests that there is plenty of scope for increasing the *very suitable* and *suitable* areas under Douglas fir and Corsican pine at the expense of the less productive Scots pine. For Corsican pine this should be possible by replacing Scots pine on unsuitable sites. For Douglas fir there is a substantial area on *unsuitable* sites. Even if the GYC is adequate, timber quality may be poor on such sites.

ArcView vector GIS was used to link site types and general yield class (GYC) in the New Forest sub-compartment database. The procedure is simple in principle, but requires that a map of site types be overlayed on a map of sub-compartments linked to their database. Three filters were imposed on the resulting polygons. Only polygons larger than 0.25 ha within sub-compartments larger than 1.0 ha and where the trees were planted before 1970 were accepted. The results are summarised in Table 19.

Although higher GYC is associated with more ecologically appropriate site types, the variability is so great within each suitability class that only for Corsican pine are the differences within species statistically significant. The results confirm that although the sub-compartment and site type datasets are encouragingly large the overlaying of maps, even in a GIS, is a crude way of finding relationships between variables. In what follows, the ranking of site types for each species is a theoretical one, rather than being based on the GYC values.

The most productive species is Douglas fir and one possible strategy would be to maximise its use. Although the potential area of *very suitable* site types for Douglas fir is only 215 ha, the area of *suitable* site types is 5400 ha. Within the *suitable* site types the theoretical preferences for soil types are 7>6>2>1>8>3>10>4>9, and the preferences for plant communities are ST=SN=BB>WS=FG=KB>KT>KV>KH>DO>FB>AM>PB>PT>PH. These preferences take account of likely soil moisture and nutrient regimes. On *very suitable* site types, target general yield class should be 18–20 $m^3\ ha^{-1}\ yr^{-1}$, with 16–18 on *suitable* site types.

Table 18 Suitability of sites currently occupied by each major species (area in hectares)

Species	Very suitable	Suitable	Unsuitable	Blank	Total
Oak	1354	628	116	186	2284
Beech	14	442	77	79	612
Douglas fir	43	658	161	112	973
Corsican pine	543	557	3	71	1174
Scots pine	977	331	428	31	1767

Table 19 Weighted mean GYC (and area of sub-compartments after filtering) for the five major tree species on currently occupied very suitable, suitable and unsuitable sites

	GYC ($m^3\ ha^{-1}\ yr^{-1}$) – area (ha)			
Species	**Very suitable**	**Suitable**	**Unsuitable**	**Overall**
Pedunculate oak	4.5 – 1122	4.3 – 490	4.0 – 82	4.4 – 1694
Beech	5.3 – 9	4.3 – 361	4.3 – 57	4.3 – 426
Douglas fir	15.6 – 21	14.0 – 297	13.9 – 66	14.1 – 384
Corsican pine	15.1 – 233	13.5 – 234		14.3 – 467
Scots pine	11.1 – 742	10.8 – 250	10.4 – 325	10.9 – 1317

The next most productive species is Corsican pine. The area of *very suitable* site types for Corsican pine is 5450 ha, but much of this area is also *suitable* for Douglas fir. Target yield class should be 16–18 for Corsican pine on *very suitable* sites, so it is similarly productive to Douglas fir. *Suitable* site types for Corsican pine, with target yield class of 14–16, are mostly unsuitable for Douglas fir. The area of these site types is 2270 ha.

The mostly likely conifer to give ground to Douglas fir and Corsican pine is Scots pine. The *very suitable* site types for Scots pine are in practice much the same as for Corsican pine, whereas the range of *suitable* site types is appreciably less wide. On both *very suitable* and *suitable* sites Scots pine currently achieves a yield class of 10–12 $m^3\ ha^{-1}\ yr^{-1}$.

The broadleaved species with the most restricted range of *very suitable* conditions is beech, with only four site types of Slightly Dry and Medium, on the brown earth type 7, amounting to 215 ha. The target yield class is 6 $m^3\ ha^{-1}\ yr^{-1}$ on such sites. Within the 5235 ha of site types *suitable* for beech the order of preference for soil types is 7>6>2>1>8>10>9>3>4 and for plant communities it is DO>AM>ST=SN=BB>KB>WS=FG>KT>KV>KH>FB>PB>PT>PH. The target yield class of beech on *suitable* soils is 5 $m^3\ ha^{-1}\ yr^{-1}$.

The soil requirements of sessile oak match those of beech but also include Moist and Very Moist soils. Therefore it might be possible to find *very suitable* sites for sessile oak on Moist and Medium brown earths and clays outwith the *very suitable* and better *suitable* range of beech. The target yield class of sessile oak is 4–6 $m^3\ ha^{-1}\ yr^{-1}$.

The *very suitable* range of pedunculate oak overlaps that of sessile oak but includes Very Moist sites. Therefore again, it should be possible to meet the *very suitable* requirements of both species by allocating Moist sites to sessile oak and Very Moist to pedunculate oak. The process could be extended to the *suitable* site types for each species.

In addition to these six species there are substantial areas of Other Conifers and Other Broadleaved species. The suitability for Douglas fir and Corsican pine of the land that is currently occupied by these minor species is given in Table 20.

Within each pair of rows it is the same area that is under consideration. For reasons that are not clear, the total area of Other Broadleaves here is much less than in Table 15, whereas that for Other Conifers is slightly larger.

There are some 550 ha under Other Conifers that are either *suitable* for Douglas fir or *very suitable* for Corsican pine; a further 280 ha are *suitable* for Corsican pine. It should also not be difficult to transfer areas of land from Other Broadleaves to either of these conifers.

A switch of sites from major conifers to major broadleaved species would obviously entail an appreciable fall in yield class and vice versa. Strategic decisions about the balance of broadleaved species and conifers are outside the scope of this analysis. It is noteworthy that in the New Forest the site requirements for beech and Douglas fir are virtually identical and overlap greatly with sessile oak. The site requirements for sessile and pedunculate oak overlap with those of Corsican pine. Pedunculate oak should be treated as more tolerant of the wettest clays than Corsican pine in spite of these sites being classed as *suitable* for both species. In terms of site suitabilities, a switch from Scots pine to pedunculate oak on the wetter clay soils would also be an appropriate move. An appropriate move in the other direction would be to switch from sessile oak to Douglas fir on well drained brown earths.

Table 20 Suitability for major conifers of areas (ha) currently occupied by Other Broadleaves and Other Conifers

Species	Very suitable	Suitable	Unsuitable	Blank	Total
		Other Broadleaves			
Douglas fir	4	231	120	45	399
Corsican pine	227	107	21	45	399
		Other Conifers			
Douglas fir	21	560	274	109	963
Corsican pine	570	279	5	109	963

Chapter 12

Native woodlands and ESC site types

There are difficulties in applying the NVC (Rodwell, 1991) to the woodlands of the New Forest (Peterken *et al.*, 1997). The classification of plant communities used in the survey of the Inclosures is not intended to rival the NVC, but is a local scheme designed to indicate soil quality. The links that exist throughout Britain between ESC soil quality (and climate) and NVC woodlands can be helpful in understanding the ecology of native woodlands. While most of the semi-natural woodland of the Forest is to be found in the ancient and ornamental woods outside the Inclosures, the importance of the Inclosures themselves should not be underestimated. Not only do they include important segments of the semi-natural woodlands of the Forest, they also offer the most realistic opportunity to restore such woodland to a near-natural condition within extensive and unfragmented woodland cover (see 'Objects of management' in Appendix 1). It is in the context of this restoration, and the possible reintroduction of apparently missing tree species, that it is important to appreciate the influence of site type on woodland composition.

The warm lowland climate and the absence of well drained calcareous soils set limits on the kinds of woodlands that can occur in the area. The communities most likely to be ecologically suited to the New Forest are the lowland acid or mesotrophic oak–birchwoods W10 and W16, the lowland acid or mesotrophic beechwoods W15 and W14 and the 'wet woodlands' W1, W2 and W4–7. The calcicolous mixed broadleaved woodland W8 is likely to be a rare type (Rodwell, 1991; Whitbread and Kirby, 1994; Hall, 1998).

Mean indicator values for the species lists of each sub-community in Rodwell (1991) have been calculated using the method described in Chapter 9, although with the difference that here the weighting has perforce used species frequency rather than abundance. Based on the resulting moisture and nutrient scores (Wilson and modified Ellenberg) of the sub-communities, each community likely to occur in the New Forest has been assigned a rectangular portion of the soil quality grid as shown in Figures 32 and 33.

Figure 32 Very suitable soil quality for oak, birch, ash and willow woodlands.

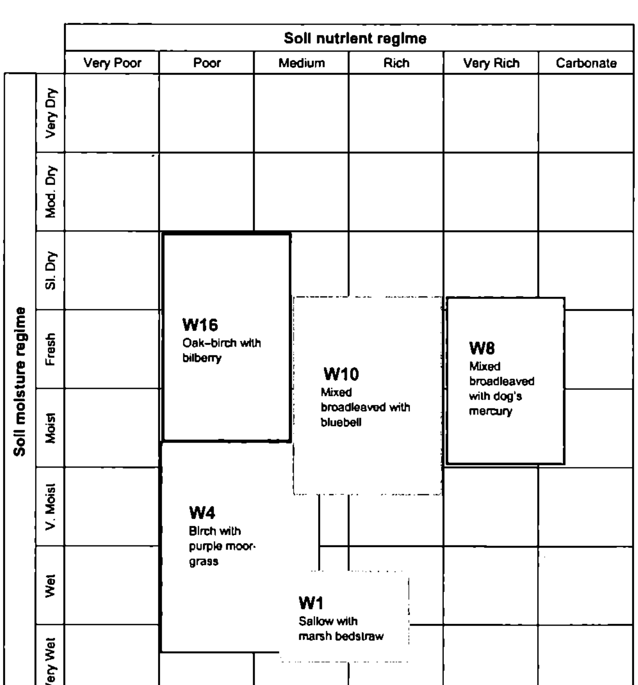
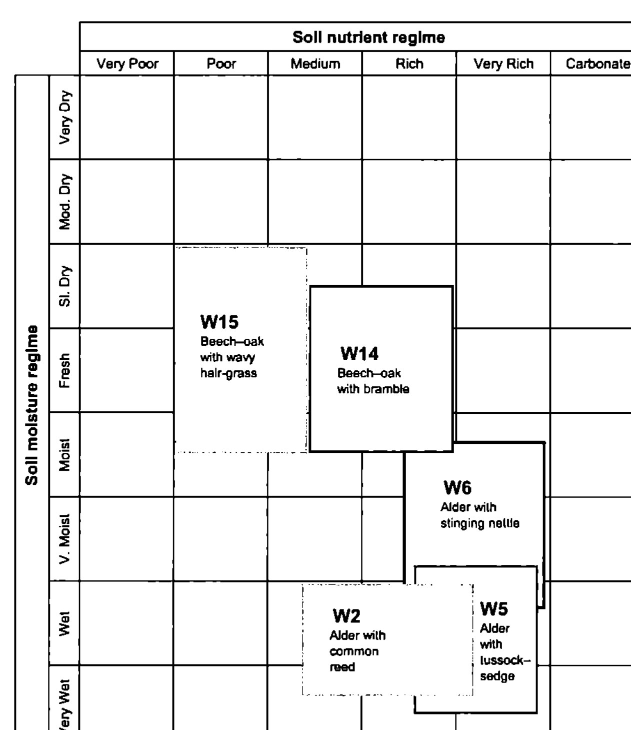


Figure 33 Very suitable soil quality for beech and alder woodlands.



Several native tree and shrub species that are characteristic members of these NVC woodlands are rare or absent from the native woodlands of the New Forest for reasons that are not always clear but probably due to centuries of grazing and management. Those of particular interest are given in Table 21.

The numbers in the table give the frequencies with which the species occurs on average in 50 x 50 m quadrats of each community in Britain, thus 1 = present in < 20 % of quadrats, through to 5 = present in 80–100% of quadrats. The comments in the final column are obtained from the details of the sub-communities.

Site types suitable for the acid, nutrient-poor W16 oak–birch and W15 beech woodlands are more abundant in the New Forest than site types suitable for the mesotrophic W10 oak–birch and W14 beech woodlands, and site types suitable for the rich W8 ash–maple woodlands are localised and rare. Nevertheless, it is clear that there is scope for adding to tree species diversity at a low frequency within most of the native woodlands and within plantations of oak and beech. It is an essential part of this policy that any species should be self-sustaining once introduced. The wet woodlands (NVC W1–W7) have been excluded from this part of the discussion because they are relatively undisturbed by management (see the comment at the end of Appendix 2).

Table 21 Frequency of tree species in some NVC woodlands (Rodwell, 1991)

Species	W8	W10	W14	W15	W16	Comments
Tilia cordata	1	1	-	-	-	
Ulmus glabra	2	1	1	-	-	
Carpinus betulus	1	1	-	-	-	More frequent in W8 than W10
Fraxinus excelsior	4	2	1	-	-	
Acer campestre	2	1	-	-	-	
Sorbus torminalis	1	-	-	-	-	Rare
Sorbus aria	1	-	1	-	1	Scarce in all communities
Malus sylvestris	1	1	-	-	-	Scarce in both communities
Corylus avellana	5	3	1	-	1	
Taxus baccata	1	1	1	1	-	Rare in all four communities

Chapter 13

ESC and other locally important aspects of forest management

The site classification is relevant to a number of other silvicultural and conservation activities within the Inclosures, including control of weed growth, avoidance of soil compaction, restoration of heath, restoration of open ground for the benefit of plant diversity and site recovery after rhododendron clearance. The following notes are aimed specifically at the New Forest but may have some significance in other lowland forests.

Weed growth

A site classification that includes a description of the existing or potential ground vegetation is clearly likely to be useful for predicting the growth of weeds. Weeds are defined as any plants that would compete with the planted or naturally regenerated crop of trees. Site types can be used to predict the species of weed and their likely vigour given appropriate light. Site types can also help predict the changes in soil moisture consequent upon heavy thinning or clearfelling.

All soils will become wetter following a reduction or removal of the rainfall intercepting effect of the tree canopy. The impeded soils, the type 9 and 10 clays and the imperfectly drained brown earth type 8, will be most affected because they have a small capacity to absorb additional water in winter and also they shed water slowly. Within these soils, the severity of the problem will increase in the sequence of soil moisture classes Moist, Very Moist, Wet (there are no site types classed as Very Wet). See also the next section dealing with soil compaction.

The ground-water gleys, types 3 and 4, are also liable to suffer from a rising water table but, being sandy or loamy in texture, are more permeable and provided drains are maintained after clearfelling, will shed excess water more effectively than the clays. The type 5 alluvial soils can be ignored in this context as they mainly carry native woodlands.

The podzols and brown earths (types 6 and 7) should not develop weed problems due to rewetting, as they will retain their freely draining nature.

Table 22 lists the main weed species in terms of their response to rewetting and their potential vigour in full light on the major site types.

Table 22 Weed species and their response to clearfelling on main site groups

Weed species	Main site groups SMR/SNR	Response to rewetting	Response to full light
Tufted hair-grass	Mo/Me	increased vigour	increased vigour and flowering
Bracken	MD–SD/P	none	increased vigour
Purple moor-grass	W/P	slight increase in vigour	increased vigour and flowering
Rushes	W/P, Mo/P, Mo/Me	increased vigour	increased vigour
Bramble	Mo/Me, SD–MD/Me	none	slight increase in vigour
Rosebay willowherb	Mo/Me	none	invasion via airborne seed
Fine grasses	SD–Mo/P–Me	slight increase in vigour	increased density and vigour

Soil compaction

Soil compaction is a term loosely used to describe serious damage to soil caused by heavy machinery, especially during the harvesting of timber. Soil damage includes compaction (increase in bulk density), rutting and puddling (displacement of topsoil and exposure of subsoil), burying of humus and other organic debris and in severe cases the formation of pools. Damage may occur within the stand, but tends to be concentrated on rides where the number of vehicle passes is greater and where the soil may be softer. Compaction in the strict sense is probably less of a problem than the rutting and puddling. The combined effect is to reduce the infiltration rate of water into the soil and to gather water into pools where it stagnates. This damage is not only very unsightly and a demonstration of unsustainable practice, it is harmful to the roots of existing crops, ground vegetation, restocked trees and to watercourses downstream. Such damage is difficult to restore and can only be successfully tackled when the soil has dried out.

The risk is greatest on the wetter clay soils (soil types 9, 10 and 8 with moisture regimes Wet to Moist). Harvesting with ground-based machinery should be avoided on these soils when they are wet. The ground-water gley soils are also vulnerable, but because of their lighter texture the damage is more easily restored by natural or artificial methods. The brown earth soils of type 6 and 7 and the sandy podzols can also suffer damage during wet conditions, but again can normally be expected to recover naturally within acceptable timescales. The gravelly podzols are the least likely to suffer soil damage. On well drained soils the main harmful effect is the burying and effective loss of humus from the root zone of newly planted trees, reducing the availability of nitrogen and phosphorus.

It is particularly important to avoid vehicle access to the Very Wet soils of the wet woodlands when harvesting adjacent commercial stands.

Restoration of heath and mire

In the New Forest heath is classified into three broad types: dry, humid and wet. The dry heaths are dominated by heather, usually accompanied by bell heather. Accessory plants of lower conservation value include bracken and a number of fine grasses such as *Agrostis curtisii* and wavy hair-grass. Common gorse is an important habitat when it occurs in extensive patches.

Dry heath will be most easily re-created within the Inclosures on Very Dry–Slightly Dry and Very Poor site types. These are found on the podzol soils, particularly type 1. Those podzols with moister soil moisture regimes will encourage growth of purple moor-grass. Following clearfelling a phase of purple moor-grass invasion is normal even on dry Very Poor and Poor sites, but should be succeeded by the ericaceous species. Those podzols and brown earths with Poor to Medium nutrient regimes will encourage growth of fine grasses, though heather can eventually achieve dominance on sandy brown earths. European gorse favours patches of well drained brown earth soils within the heaths (Poor to Medium nutrient regime).

Humid heath is also dominated by heather but with the moisture-loving cross-leaved heath rather than bell heather. Purple moor-grass is liable to be abundant and dwarf gorse (*Ulex minor*) tends to replace common gorse. This kind of vegetation is more difficult to restore to a good condition because of the likelihood that purple moor-grass will dominate. The nutrient requirements (particularly for nitrogen) of purple moor-grass are higher than those of heather, and following a crop of trees mineralisation of nitrogen in the humus is likely to be active for several years.

Humid heath is most likely to be created on the moister fringes of the podzols and the less wet ground-water gleys, where the site types are Moist and Poor or Very Poor. There are site types on the clay soils with these same moisture and nutrient regimes, but greater rewetting may cause these to become dominated by purple moor-grass.

Wet heath has much less heather than humid heath and relatively more cross-leaved heath, purple moor-grass, bog myrtle and bog-mosses (*Sphagnum* spp.). The conservation interest is in the rarer and often smaller plants that find their niches here such as sundew (*Drosera rotundifolia*). The appropriate sites for attempting re-creation of wet heath are the ground-water gleys types 3 and 4. These have the necessary Very Poor or Poor nutrient regime whereas the clays would tend to be too rich. In the ex-heath Inclosures patches of 'failed' plantation, usually with a few stunted Scots pine present in a sea of rank purple moor-grass, are not uncommon. Such sites need little or no management but have limited botanical interest.

Wet heath merges with valley mire as the soil becomes more peaty and specialised plants such as white beak-sedge (*Rhychospora alba*) appear. Restoration of this kind of mire might well involve raising the water table, an operation that will not necessarily be straightforward, depending on the topography. Restoration of a peaty layer will be extremely slow.

There are numerous very small mires or wetlands with a variety of plant communities including relatively rich ones, scattered through the Inclosures. These may not all appear on any map. Apart from the sub-compartment map, a good place to look would be the soil maps, where any small enclosed or headwater area of soil types 3 and 4 (ground-water gleys) could harbour an interesting habitat. Such habitats should be protected from encroachment by uncharacteristic tree seedlings and undue shading from surrounding stands.

Restoration of open ground for increased plant diversity

There is a general perception that biological diversity on much agricultural land has decreased markedly with the intensification of farming methods. This gives forests a larger role in providing space not only for characteristic woodland plants but also the much larger number of species that demand high light levels. This role has been recognised in national forestry policy by the requirement that forests maintain a significant proportion of open land within the boundary. In the New Forest the possible aims for Inclosures include increase of appropriate biodiversity and the re-creation not only of heath but also mire and grassland from conifer plantations.

Forest rides and roads with their associated ditches provide a wide variety of sites important in this context, but tend to be shaded to some degree. There is already a programme of ride widening in places for the benefit of butterflies and other wildlife. In the New Forest streamsides are also usually heavily shaded. There is scope for opening up some streamsides, especially in association with patches of heath or grassland. Larger patches of open ground are provided by deer lawns and some archaeological protection areas. Smaller plants that benefit from the grazing of coarser growth should find the grazing levels in the New Forest Inclosures to their liking.

Site recovery after rhododendron clearance

After the removal of rhododendron the ground tends to be very bare of vegetation and covered in litter that is slow to decompose. Where the soil is well drained some degree of shallow cultivation might be beneficial in exposing mineral soil and burying some of the organic material to encourage decomposition. There may well be an increase in grasses initially, but the vegetation should gradually revert to a community appropriate to the underlying soil.

Where the soil is a clay, no cultivation should be attempted, as the mixing of organic and mineral soil in wet conditions will increase stagnation and at best only encourage rushes.

Chapter 14

Conclusions and implications of the work for other forests

It is appropriate to consider whether there are ways in which the work could have been done more effectively, whether there is more that could profitably be done, and what lessons have been learnt that are relevant to other forests in lowland Britain and elsewhere.

A site classification has been created based mainly on soil moisture and soil nutrient regimes, but also taking account of the physical properties of the soil types. Existing knowledge of the soil physical properties, derived from a detailed but much earlier soil survey, has been supplemented with insight into nutrient regimes obtained from a survey of plant communities. For predicting nutrient regime two alternative series of indicator values have been used, neither of which is perfectly adequate, but they have given broadly similar outcomes. The indicator values were tested for use in the New Forest at one site where soil chemical analysis has been carried out. Species suitability ratings have been used to link the soil moisture and nutrient regimes to the growth requirements of tree species and native woodlands. The site classification could not have been created and its apparent complexity handled effectively without a GIS.

Possible improvements

An undesirable feature of the classification is the existence of several communities with very few or no quadrats. More attention could be given to the difficulty of mapping heavily shaded areas, either by making use of bryophytes or a reduced list of key indicator species. The range of soil types on which some plant communities are found is still a matter of surprise. This resulted in a spread of mean indicator values and allowed different classes of moisture and nutrient regime to be assigned to the same soil. The subtleties of the variation in composition within one community on different soils deserve further study. The 'Modified Ellenberg' indicator values could be replaced with the Hill-Ellenberg values (see Chapter 2) which should be more reliable for British conditions. These have been incorporated into the ESC Bulletin and the ESC–DSS manual and software as an alternative to the Wilson values.

Further work

The range and quantity of uses of the site classification in the management of the Forest will no doubt increase as expertise is gained by local staff. This case study only shows a few general and particular applications evident at this early stage.

The main limitation of the work in the New Forest from the point of view of ESC in Britain is that the range of soil quality has covered only half of the soil quality grid. Only a small part of the variety of Rich soils has been sampled and Very Rich and Carbonate soils have hardly been encountered at all. This is reflected in the limited range of tree species and native woodlands that are relevant. From the national perspective it would be beneficial to extend the site survey to a wider range of soil conditions, especially to the soils of higher pH which are important in lowland England. This would allow more of the 'calibration plots' of Wilson (1998) to be brought into consideration. It would also bring a wider range of tree species and native woodlands into play and help refine their suitability ratings.

Implications for other forests

The management of all forests will benefit from using an ESC. It provides the means by which the ecological potential of sites can be evaluated, a necessary step before their present habitats can be put into perspective. One of the 'perspectives' is the landscape in which the site, or in practice many sites, are set. Management of a landscape usually requires that a number of objectives, some of them potentially conflicting, be met. Not all sites can be managed to achieve their maximum potential. But it is only when we know that potential that we can take the best decisions.

In the New Forest the two soil components are more important than climate in the site classification. This will usually be so throughout lowland Britain, but the relative importance of climate increases in the uplands and especially in the mountainous areas. In such areas a climatic zonation will be an essential first part of the site classification.

To some extent the work in the New Forest has been a pioneering effort. We have only just begun to see how GIS will enable the benefits of site classification to be achieved in practice and to make it possible to compare the outcome of alternative management strategies.

Nevertheless, it is possible to see how similar results could be obtained in other forests with less time and effort, given one of the three following circumstances.

1. *New survey by site surveyor*

Map the forest using the Forestry Commission soil classification, and simultaneously take note of ground vegetation, preferably using proper quadrat descriptions. Each soil type/plant community can then be rated in terms of soil moisture and nutrient regimes. It may be possible to subdivide soil types into separate plant communities with different moisture and nutrient regimes, as at the New Forest. If this is not done, it is likely that each site type will have a wider span of classes on each axis. For deciding the soil moisture regime the surveyor will make more use of field observations including rooting depth than of indicator values. The surveyor will also make use of humus form to confirm nutrient regime.

This is more or less the current practice of the Forestry Commission site surveyor. Note that this is definitely not the same thing as carrying out an NVC vegetation survey. The input of soil information is of a higher order.

2. *Vegetation survey and existing map of FC soil types*

A vegetation survey alone can be sufficient provided there is in existence a soil map at 1:10 000 scale using the Forestry Commission classification. The classification of plant communities should follow the lead given by the New Forest and should pay most attention to the indicator plants of Table 4. The surveyor should be given sufficient training to be able to recognise the soil types and produce quadrat descriptions of the plant communities on each soil type as in method 1. This method will be more successful for nutrient regime, for which reliable indicator values are available, than for moisture regime, but the surveyor should measure rooting depths wherever windthrown trees are available.

3. *No vegetation survey or map of FC soil types*

In these circumstances the forest staff should take every opportunity to learn about their site types directly. Everywhere in Britain has a soil map of some kind, such as a 1:50 000 or 1:250 000 national soil survey map. The accompanying bulletin or report will contain useful information particularly on physical properties such as drainage class or wetness class that can be interpreted in terms of soil moisture regime. Interpretation of soil nutrient regime will have to be obtained by direct observation of vegetation and use of Table 4.

Final remarks – the ESC Decision Support System – further training

In parallel with the work carried out in the New Forest, a description of the national system has been published in Forestry Commission Bulletin 124 (Pyatt *et al.*, 2001) and as the ESC–DSS manual and software (Ray, 2001). The ESC–DSS software enables quadrat descriptions to be easily processed through to predictions of soil nutrient regime and contains a wealth of ancillary information on soils, climate and their relationship to yield class for up to 30 tree species. Application of ESC to lowland forests will be facilitated by accessing these sources.

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Appendix 1

Objects of management for New Forest Inclosures

The general aims for the Inclosures

- The restoration of sub-optimal, or re-creation of destroyed habitats, where resources permit and priorities dictate.
- The maintenance or enhancement of existing New Forest habitats of international and national importance for nature conservation, which sustain populations of characteristic plants and animals.
- The management and absorption of public access to protect more vulnerable habitats.
- The linkage of open space and old trees within a network of nature conservation and recreation needs.
- The growing of quality timber for future generations using silvicultural systems and species correlated to soils and geography.
- The appropriate protection and setting of archaeological sites in their historical landscape context.
- The softening of Inclosure boundaries and diversification of internal woodland character.

Possible detailed aims for the Inclosures

Nature conservation

Maintenance and enhancement

1. To maintain the favourable status of woodland habitats.
2. To remove invasive plants and animals that threaten endangered habitats.
3. To perpetuate the regeneration dynamics of woodland habitats through a range of silvicultural treatments and grazing regimes.
4. To increase appropriate biodiversity.
5. To implement a strategic management of deer populations.

Restoration/re-creation

1. To restore and re-create wood pasture and its associated habitats where there is evidence for its previous existence.
2. To extend native woodland habitats on appropriate sites.
3. To re-create heath, mire and associated grassland habitats from conifer plantations.
4. To extend grazing where appropriate.

Visitor management

1. To implement a strategic plan to direct 'local' and 'visitor' access.
2. To absorb recreational pressure from more vulnerable habitats.
3. To interpret key forest 'messages' in a subtle and effective manner.
4. To maintain an atmosphere of peace and quiet.

Timber production

1. To produce timber for local markets.
2. To maintain existing timber productivity.
3. To maintain or increase levels of employment generated by timber production.

Heritage

1. To ensure special treatment for nationally important archaeological sites.
2. To maintain best examples of other aspects of New Forest heritage where they occur.
3. To take account of historic landscape character.
4. To use open space to protect archaeological sites and enhance their settings.
5. To identify appropriate sites to encourage understanding and enjoyment of the New Forest heritage.

Landscape

1. To better integrate Inclosure boundaries with the wider landscape.
2. To better integrate conifer/broadleaved boundaries within Inclosures.
3. To create vistas within the Inclosure landscape.
4. To identify trees and woodland with a key screening role.

General

1. To implement sustainable programmes based on natural processes.
2. To maintain a history of New Forest management cultures in modern working examples.

Appendix 2

Description of the plant communities of the Inclosures

The 19 plant communities are described in some detail, starting with the frequency distribution of six particularly widespread species. The first three of these are often dominant, whereas the others are always subordinate. Frequency refers to the number of quadrats in which the species is present, regardless of its abundance.

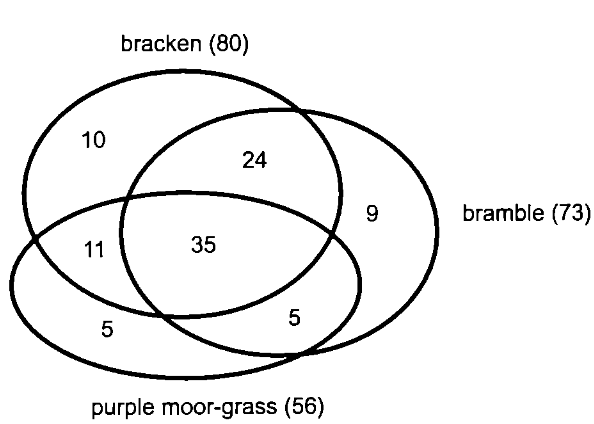
Frequency of bracken, purple moor-grass and bramble

Within the Inclosures bracken, purple moor-grass and bramble are particularly widespread as well as often being abundant (Figure 34a). Bracken is at its most vigorous on Dry or Fresh, Poor soils whereas purple moor-grass is typical of Wet, Poor soils. Both are fairly shade tolerant but purple moor-grass is slightly more so, and in the degree of shade found under pole-stage pines it can form a thin cover on its own on soils that are Moist or Fresh. Purple moor-grass also shows an increase in abundance on clearfelled areas, a presence that is likely to persist until canopy closure. Bramble reaches dominance on Fresh or Moist, Medium soils, but in a less vigorous form often occurs among bracken or purple moor-grass.

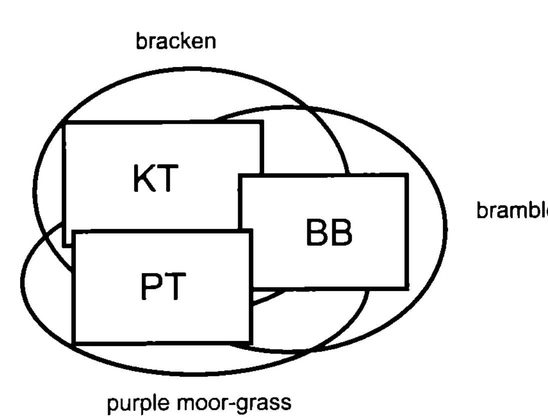
The three major communities defined by the relative dominance of these three species (KT, PT and BB) are superimposed on the same diagram in Figure 34b. Apart from when all three species are present, the overlaps in frequency composition between the communities are fairly small. The three communities can thus be seen as distinct 'poles' in terms of relative abundance but having some overlap in relative frequency.

Figure 34 Frequency of bracken, purple moor-grass and bramble in quadrats.

a. Percentage of total quadrats (153) for each combination of species.



b. Approximate location of three major communities.

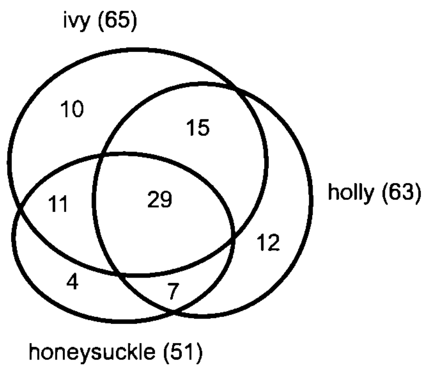


Frequency of ivy, holly and honeysuckle

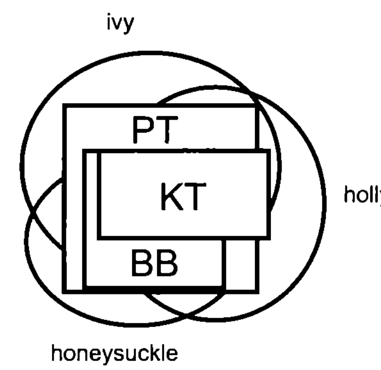
These species are extremely widespread in the Inclosures but rarely occur in large quantities (Figure 35a). The species show a great deal of overlap in terms of frequency, indeed all three occur together about as often as not and they are seldom found alone. Although holly does occasionally occur as tree-sized specimens or as heavily grazed low scrub within the Inclosures, its main presence is as small seedlings beneath bracken.

Figure 35 Frequency of ivy, holly and honeysuckle in quadrats.

a. Percentage of total quadrats (153) for each combination of species.



b. Approximate location of three major communities.



Three communities that frequently contain these species are superimposed on the same diagram in Figure 35b. In contrast to Figure 34b, the overlaps in frequency distribution between these communities are large. All three species appear in the 'constant' or 'frequent' columns of Table 11, but do not feature in the 'characteristic' species column, in other words they are not useful indicator species.

Purple moor-grass communities (PT, PH and PB)

This group of communities is so coherent and readily recognised that the members of it are treated as sub-communities. The typical sub-community (PT) is usually strongly dominated by the grass and can be almost pure. The only important associate is bracken, especially under the thin canopy of a mature pine crop. On average there are only seven species in a stand and although the total number of species encountered is quite large (at 35), most of these have a cover of less than 2 % of the quadrat. The community mainly occurs on ground-water gleys, surface-water gleys and the moister podzols. Increasing cover and vigour of bracken indicates less wet soil.

The sub-community with heather (PH) can actually include one or more of heather, cross-leaved heath and bell heather. All these species need more light for survival than purple moor-grass and this sub-community is more typical of restocked areas than of established stands. Heather or bell heather indicates less wet soil than cross-leaved heath. This community clearly shows the link between the purple moor-grass community of the woodlands and the 'humid heath' outside. It is particularly common at Dur Hill Inclosure.

The sub-community with bramble (PB) has more species and is found on less wet clayey soils of greater fertility than the other sub-communities.

Purple moor-grass communities have been extensively mapped in the so-called Heathland Inclosures beneath pole-stage pine crops where the shade is too dense for bracken to survive. Under these conditions, purple moor-grass can form an almost pure, albeit thin and non-tussocky, cover on podzols and ground-water gley soils with a wide range of wetness, as at Longdown and Ipley Inclosures.

Bracken communities (KT, KV, KH and KB)

Bracken is present in most communities in the Forest but in this group of four sub-communities it is the dominant species. In the typical sub-community (KT) the bracken is dense and 1.5–2 m tall. Few species can survive the shade and heavy litter of the bracken and those that do have a small percentage cover. The most frequent species are purple moor-grass, holly, ivy, honeysuckle and bramble. The community occurs on well-drained acid brown earths and podzols but also on clay soils, where the cover of bracken is somewhat reduced. It is a very extensive community in Godshill, Highland Water, Holmhill and Wilverley Inclosures.

Bilberry is rarely able to compete with bracken in good light, but as the shade increases and bracken vigour declines so there can be a gradual replacement of the fern with the sub-shrub. Under the densest shade of beech the bilberry gives way to a scatter of cushions of the moss *Leucobryum glaucum*. In the sub-community with bilberry (KV), therefore, there is a wide range of cover of the sub-shrub. The sub-community is often associated with the podzols of type 2 but occurs extensively on clay soils as at Shave Green and Brockishill. Wavy hair-grass is sometimes a major associate as at Wilverley. It is surprising that wavy hair-grass does not warrant a community of its own, considering how widespread it is in many parts of Britain.

The sub-community with heather (KH) includes patches of genuine heath within the forest and restocked areas with well-drained podzolic soils. On the driest sites, bell heather may be more abundant than ling heather. The better lighting conditions provide niches for more species than in the second and the fourth sub-communities. The sub-community has been mapped mainly in Fawley and Dibden Inclosures.

The sub-community with bramble (KB) has not been mapped extensively, but it may have been under-recorded in the early stages of mapping. Bramble is highly susceptible to browsing by deer and this may also play a part in limiting the cover of this community. It is also physically difficult to find a small amount of bramble beneath vigorous bracken! It is associated with more fertile soils than the other bracken communities but these soils range fairly widely in moisture regime. Good examples are found at Bolderwood and Setthorns Inclosures.

Fine grassy communities (WS and FG)

The third group of communities represents a decline in bracken dominance and an increase in the cover of fine grasses. There is also an increase in species-richness and this reflects a level of fertility higher than in most of the previous communities. Wood sorrel is one of the most shade tolerant species and the (WS) community may consistently represent the more shady conditions whereas the fine grasses (FG) community extends from light canopy into fully lit restocked sites. Common associates of wood sorrel are the shade tolerant broad buckler-fern and narrow buckler-fern. The wood sorrel community is rare; one of the best places to see it is in Aldridgehill Inclosure.

'Fine grasses' as defined here include common bent, Yorkshire fog, creeping soft-grass, velvet bent and sweet vernal-grass. Wavy hair-grass is rarely present in any quantity. The fine grasses themselves have different tolerances of shade, with creeping soft-grass, velvet bent and common bent being more tolerant than Yorkshire fog and sweet vernal-grass. This may explain why it is usually two or three of the species that are found together on one site and never more than four. In terms of soil moisture, all five species are tolerant of a wide range, especially creeping soft-grass and velvet bent. Both communities have a preference for fairly well drained soils, either brown earths or the better parts of the two-storeyed clays. In comparison with the bracken group, these two communities are rarely found on podzols. In contrast with wood sorrel, the fine grasses form a widespread community, on brown earths as at Hursthill and especially on clays as at Islands Thorns, Denny Lodge and New Copse Inclosures.

Species-rich and bramble communities (ST, SN and BB)

The species-rich (ST and SN) and bramble (BB) communities are grouped together because of their similar soil nutrient indications. They reflect a marked increase in fertility compared with soils of the previous communities.

Bramble is present in many communities but in the BB community it is dominant and between 0.5 and 1.5 m tall. Bramble is rather tolerant of shade and has a preference for moist and clayey soils. On the other hand its abundance can be greatly reduced by browsing. The BB community is probably less widespread than are the conditions that are suitable for it, but in certain Inclosures in the south of the Forest it is quite common. It extends from the more fertile clays on to some of the more fertile brown earths, e.g. in Norley Inclosure where a thin layer of brickearth enriches the gravel. It is also a feature of two Inclosures derived from former cultivated fields, namely Brick Kiln and Pondhead. Bracken is usually present as a subordinate but important species, tending to vie with common bent in this role. In places common bent or Yorkshire fog are abundant along 'paths' between almost impenetrable bramble patches as at Setthorns. The two species-rich or, more precisely, 'herb-rich' communities are similar in composition and treated as sub-communities. Although bluebell is the characteristic species for the typical sub-community (ST), it is not invariably present. The definition requires that any three or more of the following should be present: bluebell, common violet, wood spurge, wood sorrel, wood anemone, wood speedwell and greater stitchwort. Bracken is almost invariably present and occasionally may be dominant, but not sufficiently so to eliminate the herbs. Fine grasses, usually common bent or creeping soft-grass, may vie with the herbs for prominence and this may reflect the degree of grazing. Some of the Inclosures that are partly open to ponies and cattle, such as Amberwood, show that the effects of damage to this community are as much due to trampling as to grazing. The more poisonous herbs, such as wood spurge, may be more abundant where grazing is strongest. Another frequent herb in this community is yellow pimpernel (*Lysimachia nemorum*). The community shows a distinct preference for fairly well drained but moist soils, usually brown earths of types 7 and 8, but it extends on to the better drained parts of the two-storeyed clays (type 10). The best examples are to be found in Amberwood (extensive but not dramatic), Hursthill and New Park (not so extensive but very dramatic). This community is easily recognised in the spring flowering season, but by midsummer subsides into an obscurity of bracken following the decomposition of the bluebell leaves. Identification then depends on spotting the persistent bleached flower-stalks of the bluebells.

The hawthorn-rich sub-community (SN) is a minor variant found mainly at Amberwood. Apart from the prominence of the shrub component, in places it has more abundant wood spurge. There are several stands in Amberwood Inclosure where it seems to be associated with abundant wood spurge and a good mull humus. The occurrence of ash trees, a rare phenomenon in the Forest away from alluvial sites, also suggests higher than usual fertility. Greater fertility is not, however, evident in the generality of the quadrats (see Chapter 9).

Communities of the more fertile soils (FB, HG, DO and AM)

The fifth, rather loose group of communities occurs on fertile and moist or very moist soils, most commonly the clays, but including also the alluvial soils. The false-brome community (FB) represents the least wet conditions and is largely restricted to better drained parts of the straight clay (type 9) soil. False-brome shows its soil preference by being most prominent along drain spoil heaps rather than in the lower-lying ground in between. The relatively high frequency of bracken and the rarity of purple moor-grass in this community also emphasise the better than average drainage for clay soils.

The tufted hair-grass community (HG) is typical of wet and fairly fertile clay soils of both types 9 and 10. In spite of its tough and sharp-edged leaves, tufted hair-grass is frequently grazed and the size of individual plants kept in check, so the cover percentage may not always be high. It is frequently accompanied by common bent, occasionally with one or more of velvet bent, creeping soft-grass or Yorkshire fog, or with false brome along the ditch spoil. Purple moor-grass or bracken are occasionally frequent in wetter or drier places respectively. Neither in this nor the previous community is bramble an appreciable participant. In a few places, notably in parts of Churchplace Inclosure, species indicative of higher nutrient status or higher pH, such as sanicle, bugle or wood millet, are found but are not extensive enough to justify recognition as a sub-community. This variant would be included with the ash–maple community (see below) if it had the appropriate tree species.

The dog's mercury community (DO) is very rare, occupying only 2–3 ha in the mapped area, but distinctive not only floristically but also in soil conditions. Dog's mercury (*Mercurialis perennis*) is well-known for occurring on fertile soils with fairly high pH, sometimes accompanied by ramsons/wild garlic (*Allium ursinum*), hedge woundwort (*Stachys sylvatica*) or stinging nettle (*Urtica dioica*). While the last two and a number of more ruderal species are likely to be indicative of sites of human disturbance within the Forest, dog's mercury is a more reliable indicator of inherent fertility. Only one set of quadrats, in Ramnor Inclosure, has been described, this within a community heavily dominated by dog's mercury. Small patches of the species have been seen within the alluvial woodland (AW, see below) where protected from trampling by hawthorn scrub or fallen deadwood. In Pondhead Inclosure there is a small patch associated with wych elm, a rare tree in the Forest.

The ash–maple community (AM) is a rare community that may have greater similarity with the false brome than the tufted hair-grass type and thus represent less wet conditions. Ash may occur in all sizes from seedlings to large mature trees, with or without an understorey of field maple. Oak may be as abundant as ash, but only in the upper canopy. Major species include wood spurge, bramble, false brome and either common bent or velvet bent. Characteristic but minor species include cuckoo pint, wood anemone, primrose, sanicle and black bryony. These species, together with the ash and field maple, suggest that the soil here has a higher pH than for any of the previous communities excepting dog's mercury. The mean number of species present (20) is the highest of any community. The community is limited to a few Inclosures, notably New Copse, Perrywood Ivy and Wootton Copse. The latter Inclosure forms part of similar woodland outside the Inclosures extending along the Avon Water, but wet enough to be included in the following group.

Wet woodlands (AW, CW and UW)

Outwith the Inclosures there are many narrow strips of ash–alder–oak woodland adjacent to streams where flooding is frequent and the soils are overlain with alluvium. Within the Inclosures the ash-rich alluvial woodland (AW) is essentially an oak woodland in a few broad valley bottoms where ponding is frequent but alluvial deposition is of minor significance. No quadrats have been described, but the ground flora seems to be distinguished by the frequency of creeping buttercup and lesser celandine. Wood spurge can be very abundant on patches of drier ground. Ramsons occurs frequently in the woods along the Avon Water. The soil is likely to be at least as fertile but wetter than that of the ash–maple community.

The remote sedge swamp (CW) community represents the most recognisable type of a rather variable collection of very wet woodlands ('carrs') fringing small streams or ditches, especially in the headwaters of the drainage basins. Such swamps may extend only 10 to 20 m from the stream. Alder is the main tree species, with some willow and occasional ash and oak. The soils are swampy but inherently fertile. No quadrats have been described, but remote sedge, creeping buttercup and lesser celandine are common. One example dominated by greater tussock-sedge has been seen.

The final community of undifferentiated wet woodland (UW) comprises those wet woodlands, either alongside streams or in other swampy sites, that do not conform to any of the above types. They are assumed to be similar in site conditions to the sedge swamps. Where the tree cover is sparse these swamps or fens can be rich in species found nowhere else in the Forest, but little effort was put into mapping them because they are so small and they have been little affected by past planting.

The wet woodlands of the New Forest, both within and outwith the Inclosures have great conservation importance. In this survey we have not given them much attention because they are already accurately mapped on stock maps and because their management is not controversial. It also seems probable that they can be classified satisfactorily within the NVC.

Appendix 3

Tree species' names

Table 23 Names and abbreviations of tree species

Abbreviation	Common name	Scientific name
SP	Scots pine	*Pinus sylvestris* L.
CP	Corsican pine	*Pinus nigra* Arnold ssp. *laricio* Maire
SS	Sitka spruce	*Picea sitchensis* (Bong.) Carrière
NS	Norway spruce	*Picea abies* (L.) Karsten
EL	European larch	*Larix decidua* Miller
JL	Japanese larch	*Larix kaempferi* (Lindley) Carrière
HL	Hybrid larch	*Larix* x *eurolepis*
DF	Douglas fir	*Pseudotsuga menziesii* (Mirbel) Franco
WH	western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
LC	Lawson cypress	*Chamaecyparis lawsoniana*
SOK	sessile oak	*Quercus petraea* (Mattuschka) Liebl.
POK	pedunculate oak	*Quercus robur* L.
BE	beech	*Fagus sylvatica* L.
AH	ash	*Fraxinus excelsior* L.
SBI	silver birch	*Betula pendula* Roth
DBI	downy birch	*Betula pubescens* Ehrh.
CAR	common alder	*Alnus glutinosa* (L.) Gaertner

Applying the Ecological Site Classification in the Lowlands is an illustrated case study of the New Forest Inclosures, which cover an area of 8500 hectares in southern Britain. *An Ecological Site Classification for Forestry in Great Britain* is described in Forestry Commission Bulletin 124 and is available as an interactive PC-based decision support system to assist the managers of Britain's forests.

Ecological site classification provides a sound basis for the sustainable management of multi-purpose forests. The ecological potential of a site can be determined from climatic and soil factors. Informed decisions on the choice of tree species appropriate for timber production, and on the choice of woodland type for conservation benefits, can then be made.

For the New Forest the detailed aims for the future of the Inclosures include the restoration of heath, grassland and mire habitats from existing plantations, an extention to the wood pasture system, and an increase in appropriate biodiversity whilst maintaining existing timber productivity.

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