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A COMPARISON OF TWO METHODS FOR CLASSIFYING BRITISH BROADLEAVED WOODLAND

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ABSTRACT

461 quadrats, recorded from woods in eight areas mainly in upland Britain, were classified according to the "Merlewood" Plot Type system and to the "Stand Type" classification. Within the limited range of woodland types examined the results showed a broad correlation between the two methods despite the differences in emphasis which each places upon ground flora and canopy variations.

Sixty-two quadrats were recorded from the Duddon Valley, Cumbria. Unrestricted random samples of six quadrats drawn from this block of quadrats were compared with a stratified-random sample, using Stand Types as the basis for the stratification. The stratified sample proved more efficient in detecting the Plot Types and species present in the block of sixty-two quadrats. The use of two classification systems in the same survey provided a better description of the variation present than either did separately, while involving relatively little additional labour.

INTRODUCTION

ONE part of any woodland nature conservation strategy is likely to be the selection of a series of sites which, between them, contain the range of natural or semi-natural vegetation types present. This implies some form of classification.

For many years the broadscale classification of British woodlands has followed Tansley (1939), although this is itself largely based on much earlier work. Since then classification methods and even the woods themselves have changed and several new systems have recently been published or are close to completion. These are:

(a) The "Merlewood" Plot Type classification, developed by Dr. R. G. H. Bunce and M. W. Shaw (Institute of Terrestrial Ecology).

(b) The Stand Type system developed by Dr. G. F. Peterken (Nature Conservancy Council).

(c) The National Vegetation Classification (NVC) sponsored by the Nature Conservancy Council and coordinated by Dr. J. Rodwell of Lancaster University.

All these classifications can be applied throughout Britain. In addition, Rackham (1980) contains a classification of coppice types which deals mainly with eastern England, but is not dissimilar to the Stand Type system.

A group of woods may be similar in some respects but not in others, e.g. they may have a similar canopy composition but differ greatly in their ground flora (used here to include both the ground layer and the field layer). The Merlewood and the Stand Type classifications have been used widely within the Nature Conservancy Council (NCC) and by others, in surveys designed to identify different types of semi-natural woodland for nature conservation purposes. The two methods differ considerably in the emphasis placed upon the ground flora in the allocation of a sample to a particular type. This paper examines the way that these contrasting systems divide the same block of woodland data.

Since the two classifications bring out different aspects of the variation, their combination in one survey may yield more information about a wood than either used separately. This was investigated using results from the Duddon Valley (Cumbria).

For some purposes one classification system may be very much more useful than the others and will be used to deal with the results from that particular survey. There are, however, occasions when it is necessary to compare woods using a classification system different to that used in the original surveys. It is impractical to resurvey all the woods each time using the new system. On the other hand, it may not be always possible to re-classify the original results directly. There are, for example, differences in the size of quadrat used (Table 1). To help overcome this problem, a table was produced which shows the approximate degree of equivalence between the Plot Types of the Merlewood classification and Stand Types. This was done empirically, by using results which could be classified according to both systems.

Table 1. *Comparison of the quadrat records used in the different classification systems*

	System	Size of quadrat	Information needed to classify a quadrat*
(a)	Merlewood Plot Type system	14.1 × 14.1 m (200 m²)	All vascular plant species present, plus presence or absence of 16 bryophyte species growing on the ground.
(b)	Stand Type system	30 × 30 m (900 m²)	Tree and shrub species present (excluding saplings seedlings, planted trees). Soil pH, texture and drainage needed to separate some types within a group.
(c)	National Vegetation Classification	4 × 4 m (16 m²)	All vascular plant species (except trees and shrubs) plus all bryophytes.
		50 × 50 m (2500 m²)	Tree and shrub species present.
(d)	Record used for comparing classifications in this study.	14.1 × 14.1 m	All vascular plant species present. Bryophytes on ground distinguished from others.
		30 × 30 m	Additional tree and shrub species (not in inner quadrat) recorded. Distinction made between saplings, seedlings, planted trees and others. Soil texture, pH and drainage noted.

*These are the minimum records needed. In practice, all systems usually include estimates of ground flora cover, soil factors, and general plot description even where this is not directly used in the classification. Thus the real difference in the observations normally made (as distinct from the data necessarily employed in the classification) is in the size of the quadrat.

Methods

The two classification methods are outlined below. The Merlewood Plot Type classification is based on survey work described in Bunce and Shaw (1972, 1973) and an example of its use is given in Bunce (1981). A synopsis of Stand Types appeared in Brooks (1980) and a full description of the types is given in Peterken (1981).

The Merlewood Classification

This is based on 1648 plots, each 14.1×14.1 m (200 m^2), recorded from 103 woods. The woods were selected as a representative sample from an initial list of over 2000 woods throughout Britain. Species lists from these plots were subjected to an Indicator Species Analysis (Hill, Bunce and Shaw, 1975). This produced 32 "Plot Types". Any plot recorded in the same way as in the original survey can be allocated to one or other of these types by using a dichotomous key (Bunce, 1982), the first five divisions of which are shown in Table 2. Of the 121 species which occur in the key, 18 are tree or shrub species (with no distinction made between seedlings, saplings, mature trees etc.), 87 are other vascular plants and 16 are bryophytes (mostly common species).

The Stand Type Classification

Over 700 records from 30×30 m (900 m^2) plots in ancient semi-natural woods were examined by Peterken. By inspection these were split into 12 "Stand Groups" according to the presence or absence in the plot, *as long-established individuals*, of 11 woody species; seedlings, saplings and obviously planted trees were ignored for this purpose. A key to these groups is given in Table 3. The groups were further sub-divided on the basis of additional tree and shrub species or site conditions (soil texture, pH and drainage) to give a total of 39 stand types. The sub-divisions of stand group 3 (ash-hazel stands) and group 6 (oak-birch stands) are shown in Table 4 as examples.

Collection of samples for plot and stand type determination

Table 1 sets out the records needed to assign a quadrat record to either a Stand Type or a Plot Type. During 1979 a system of quadrat recording was introduced within NCC (Table 1d) which allowed both classifications to be used. Additional results from earlier surveys were traced where both Stand Type and Plot Type could be determined for the same quadrat.

About 480 suitable samples had been collected by December 1981, mainly from upland Britain (Fig. 1). Over half the quadrats (300) were positioned at random within the woods surveyed; other woods were first divided into areas based on the Stand Type classification and these areas were used as the basis for a stratified random sample (100 quadrats); the remaining 80 quadrats were subjectively placed to represent particular areas of vegetation. The differences in the positioning of the plots were determined by the purposes of the surveys concerned. Between 3 and 16 quadrats were recorded per wood.

Comparison of the Merlewood Plot Type and Stand Type classifications

The 480 sample plots were assigned to the appropriate Stand and Plot Types using keys provided by the authors of the two classifications. The two systems were first compared in terms of how evenly they divided up the sample. The relative similarity of the sample areas

Table 2. *The first 5 divisions in the key to "Merlewood" Plot Types* (from information supplied by Dr. R. G. H. Bunce and fully described in Bunce (1982))

Negative	Positive
Division 1	
Circaea lutetiana	*Anthoxanthum odoratum*
Eurhynchium praelongum	*Deschampsia flexuosa*
Fraxinus excelsior	*Galium saxatile*
Geum urbanum	*Polytrichum spp.*
Mercurialis perennis	*Pteridium aquilinum*
Score −1 or less ..... To division 2	
Score 0 or more 17	
Division 2	
Acer campestre	*Athyrium filix-femina*
Arum maculatum	*Dryopteris austriaca*
Corylus avellana	*Holcus mollis*
Mercurialis perennis	*Lysimachia nemorum*
	Mnium hornum
	Oxalis acetosella
Score −1 or less 3	
Score 0 or more 10	
Division 3	
Acer pseudoplatanus	*Brachypodium sylvaticum*
Sambucus nigra	*Carex sylvatica*
Ulmus procera	*Corylus avellana*
	Crataegus monogyna
	Lonicera periclymenum
	Rubus fruticosus agg.
	Viola riviniana/reichenbachiana
Score 2 or less 4	
Score 3 or more 7	
Division 4	
Endymion non-scriptus	*Acer campestre*
Fagus sylvatica	*Circaea lutetiana*
Hedera helix	*Fissidens taxifolius*
Rubus fruticosus agg.	*Thamnium alopecurum*
Silene dioica	*Ulmus procera*
Score 0 or less 5	
Score 1 or more 6	
Division 5	
Circaea lutetiana	*Anthriscus sylvestris*
Corylus avellana	*Bromus ramosus*
Brachythecium rutabulum	*Crataegus monogyna*
	Heracleum sphondylium
	Poa trivialis/nemoralis
	Silene dioica
	Ulmus procera
Score 1 or less ..... *Type 1*	
Score 2 or more ..... *Type 2*	

−1 is scored for each species from the left-hand side of the division which is present in the plot and +1 for each species on the right of the division. The net score for the plot determines the next division. Species names for vascular plants follow *Flora of the British Isles*, second edition, by A. R. Clapham, T. G. Tutin and E. F. Warburg, C.U.P., (1962).

Table 3. *Key to the Stand Groups*
(From "Classification of stand types in semi-natural woodland", Peterken (1980). The classification is more fully described in Peterken (1981)).

In this key "present" means that the species (1) occurs as adult or maturing trees, or as coppice, (2) was not obviously planted, and (3) was not likely to be descended by natural seeding from recently introduced stock. Thus a species which occurs only as seedlings or saplings is deemed to be "absent" for the purposes of this key. Likewise, planted trees and the so-called sub-spontaneous pines (south of the Highlands) and beech north of the line joining Carmarthen Bay to the Wash should be ignored when using this key.

1.	One or more of the following genera present: *Alnus, Fagus, Carpinus, Ulmus* or *Pinus*	 2
	All the above genera absent	 4
2.	*Ulmus glabra* present, but *Alnus, Fagus, Carpinus, Pinus, U. carpinifolia* and *U. procera* all absent	*Group 1*
	Not as above	 3
3.	*Alnus* present	*Group 7*
	Fagus present	*Group 8*
	Carpinus present	*Group 9*
	Ulmus carpinifolia/U. procera present	*Group 10*
	Pinus present	*Group 11*
	Two or more of the genera present: Intermediate between appropriate groups	
4.	*Tilia cordata/T. platyphyllos* present	 5
	Tilia absent	 6
5.	*Fraxinus* present	*Group 4*
	Fraxinus absent	*Group 5*
6.	*Acer campestre* present	*Group 2*
	Acer campestre absent	 7
7.	*Fraxinus* present	*Group 3*
	Fraxinus absent	 8
8.	*Quercus* present	*Group 6*
	Quercus absent; *Betula* present	*Group 12*
	Betula absent Not classifiable by this system	

Group	*Name*		*Name*
1	Wych elm-ash stands	7	Alder stands
2	Maple-ash stands	8	Beech stands
3	Ash-hazel stands	9	Hornbeam stands
4	Lime-ash stands	10	Suckering elm stands
5	Lime-oak stands	11	Pine stands
6	Oak-birch stands	12	Birch stands

was assessed by examining the range of Stand Types present, and the range of Plot Types present, independently of each other. A cross-classification table was drawn up showing which Plot Types were found with a given Stand Type and vice-versa.

A combination of the two classifications in one survey

Woods in the Duddon Valley, Cumbria, were mapped using the Stand Type system, by walking through them in a series of rough transects about 100 m apart (Kirby, 1982). Quadrats were recorded within the different Stand Types distinguished, and keyed out to the appropriate Plot Type.

The effectiveness of random placing of the quadrats in a wood in terms of species and Plot

Table 4. *Sub-division of Groups 3 and 6 in the Stand Type key*

(a) *Group 3. Ash-hazel stands*
Stands containing *Fraxinus*, but not *Acer campestre*, *Alnus*, *Carpinus*, *Fagus*, *Pinus*, *Tilia* or *Ulmus*. Almost all stands contain *Corylus*, and most contain *Betula*, *Crataegus monogyna*, *Lonicera* and *Quercus*.

1. Main associated oak is *Q. robur*. (*Q. petraea* is absent or rare) 2
   Main associated oak is *Q. petraea*. 3
2. Soils mostly freely-drained, alkaline. *Betula* rare, some calcicole shrubs present. (Rare) Type 3B
   Soils either poorly-drained, heavy or acid, or both. Most stands contain *Betula*, *Crataegus monogyna* and *Lonicera*. Type 3A
3. Soils neutral—alkaline, freely-drained, on or near limestone. *Betula* (often *B. pendula*), *Sorbus aucuparia*, *Taxus* frequent Type 3C
   Soils acid, medium textured, usually freely-drained and slightly flushed. *Betula* (often *B. pubescens*) usually common. (Often on lower slopes in birch-oak woodland). Type 3D

(b) *Group 6 Birch-oak stands*
Stands containing *Quercus petraea* and/or *robur*, but not *Acer campestre*, *Alnus*, *Carpinus*, *Fagus*, *Fraxinus*, *Pinus*, *Tilia* or *Ulmus*. (*Fagus* and *Pinus* may be present as a result of planting in or near the stand, but are not original natural constituents.) *Betula*, *Ilex*, *Lonicera* and *Sorbus aucuparia* are usually frequent. Soils are mostly light-medium, acid.

1. Site in "Highland" zone* 2
   Site in "Lowland" zone 4
2. *Q. petraea* present; *Q. robur* absent or very rare 3
   Q. robur frequent; *Q. petraea* absent Type 6B**
3. Type 6A
   Corylus absent or very rare, most birches *B. pubescens*. Stands poor in species and soils strongly acid. Type 6Ab
   Corylus frequent; *Crataegus* also frequent Type 6Ac
4. *Q. petraea* present. *Betula pendula*, *Ilex*, *Prunus avium* often present. Type 6C**
   Q. petraea absent or very rare. *Q. robur* present Type 6D**

*"Highland" zone is the area to the north and west of the boundary of Palaeozoic Rocks.
**Types 6B, 6C, 6D may be sub-divided in an analogous manner to type 6A.

Type detection was compared with a stratified-random sampling pattern using Stand Types to determine the strata. The sixty-two plots from all the woods in the valley were brought together to create a hypothetical wood for which there was 100% quadrat cover. Two sampling strategies were then adopted.

(a) Six quadrats were selected at random from the sixty-two plots.

(b) The quadrats were first stratified according to their stand type group, three blocks of quadrats being distinguished, and then two quadrats were selected at random from each block. Precise details of the stratification are given in Table 7.

The Plot Types of the quadrats selected were noted. Ten replicate selections were made using each sampling strategy with the quadrats being replaced after each selection. Any quadrat could thus appear in more than one replicate. The number of species found in six quadrats was also recorded for ten replicates using each sampling procedure.

RESULTS

In the 480 plots examined eight Stand Types and four Plot Types were each represented by less than three samples and were left out of the subsequent analysis. The other 461 quadrats

FIG. 1
Distribution of the quadrat samples.

	No. of quadrats recorded		No. of quadrats recorded
A. Norfolk	35	E. Gwynedd	24
B. Wiltshire	8	F. Lake District	102
C. Wye Valley	72	G. Borders Region	10
D. Brecon district	144	H. Lochaber and Argyll	66

included 25 Stand Types and 22 Plot Types. There was no significant difference in the mean number of samples per type or in the variance of the mean; 18.4 ± 4 samples per Stand Type, 20.9 ± 3 samples per Plot Type.

The bias in the distribution of sample areas (Fig. 1) meant that not all Stand and Plot Types

Table 5 (a). *The number of quadrats in each area keying out to a particular Plot Type*

AREA	*Total No. of quadrats*	*Plot Type*																							*No of Types*
		1	*7*	*2*	*5*	*6*	*8*	*12*	*11*	*10*	*13*	*30*	*22*	*23*	*24*	*15*	*16*	*26*	*25*	*29*	*27*	*18*	*17*	
Norfolk	35	7	12	1	6	5	.	1	2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	8
Wiltshire	8	.	3	.	2	.	.	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	5
Wye valley	72	6	6	1	10	9	3	1	3	13	3	.	5	10	1	.	.	.	1	.	.	.	.	14
Brecon District	144	.	1	1	1	.	.	28	8	17	.	1	1	.	4	6	8	8	13	14	22	6	5	17
Gwynedd	24	1	1	.	3	1	.	5	.	3	.	.	2	2	.	.	.	1	2	1	1	1	.	13
Lake District	102	.	2	.	3	2	4	7	7	7	1	3	12	4	.	3	.	8	30	1	6	2	.	17
Borders	10	.	.	1	1	.	.	.	1	1	.	1	1	.	.	.	.	3	.	.	1	.	.	8
Argyll	66	.	.	.	.	.	.	11	.	1	.	19	.	.	.	.	2	7	2	6	18	.	.	8
Number of quadrats	461	14	25	4	26	17	7	54	22	42	4	25	22	16	5	9	10	27	48	22	48	9	5	

Table 5 (b). *The number of quadrats keying out to a particular Stand Type in each area*

AREA	*Total No. of quadrats*	*7C*	*10*	*2A*	*8E*	*1C*	*2B*	*4C*	*1A*	*3A*	*3C*	*9A*	*1D*	*6D*	*2C*	*6C*	*5B*	*8A*	*7E*	*7Ab*	*3D*	*7D*	*7Aa*	*6Ac*	*12*	*6Ab*	*No of Types*
Norfolk	35	6	4	11	.	.	.	.	.	5	.	8	.	.	.	1	.	.	.	.	.	.	.	.	.	.	6
Wiltshire	8	.	1	.	.	.	.	.	.	.	.	.	.	3	4	.	.	.	.	.	.	.	.	.	.	.	3
Wye Valley	72	.	.	.	5	5	5	5	10	1	.	.	5	5	6	4	7	5	.	6	1	.	.	1	.	1	16
Brecon District	144	.	.	.	.	.	.	.	.	.	.	.	6	.	9	.	.	.	16	16	25	.	11	2	.	59	8
Gwynedd	24	.	.	.	.	.	.	.	12	.	.	.	.	.	.	.	.	.	.	1	1	.	.	6	.	4	5
Lake District	102	.	.	.	.	5	.	.	.	.	11	.	4	.	.	.	.	.	.	9	19	.	4	17	.	33	8
Borders	10	.	.	.	.	.	.	.	1	.	.	.	3	.	.	.	.	.	.	.	1	.	.	.	1	4	5
Argyll	66	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	.	.	.	.	4	26	3	4	19	4	7
Number of quadrats	461	6	5	11	5	10	5	5	23	6	11	8	24	8	19	5	7	5	16	32	51	26	18	30	20	105	

were equally represented. The number of woody species is less in the north-west than in southern Britain and consequently 23% of quadrats fell into one Stand Type (6Ab–upland sessile oak-birch). There were insufficient samples from south-east Britain to determine whether, there, the Stand Type classification would give a finer breakdown of the woods than the Plot Type classification although this might be expected.

Comparison of the types found in different sample areas

Within any one area the canopy composition often showed less variation than the ground flora, in which the mosaic pattern is on a smaller scale, and this was reflected in the tendency for fewer Stand Types than Plot Types to be recorded from an area (Table 5). At the same time, however, there was less overlap between areas in terms of their Stand Type composition (some were recorded from only one area) so that overall more Stand Types were recorded than Plot Types.

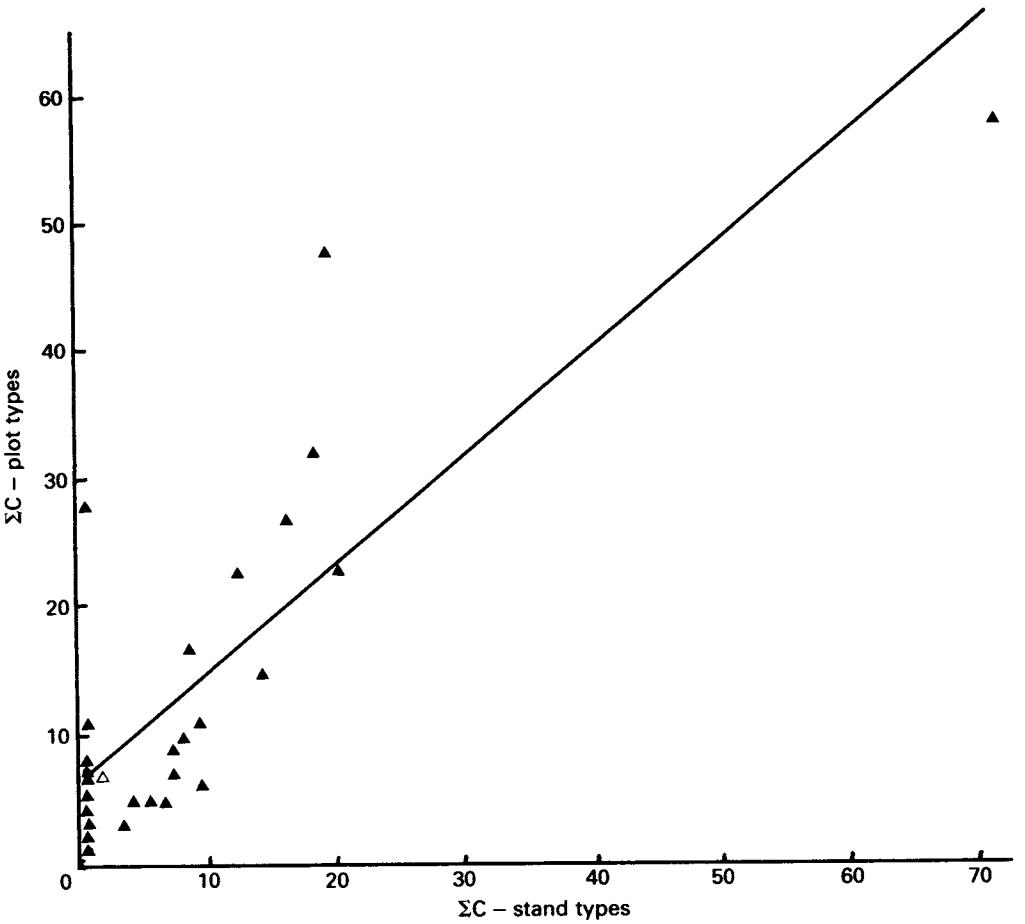

FIG. 2.

Relative similarity of the eight sample areas using the Plot Type and Stand Type classifications. "C" is the numerator in Sorensen's Similarity Index (quantitative version), but using vegetation types rather than species. For a type present in two areas "C" is the smaller of the number of quadrats recorded as that type from one of the areas. Values of "C" were summed for all Plot Types and Stand Types independently which were common to a given pair of areas. The open triangle (1,7) represents the Norfolk-Wiltshire comparison which is worked through in the text. For the regression line: $y=6.6+0.84x$; $r^2=0.67$ ($r=0.81$; p (regression) = >0.999; number of pairs of observations = 28.

Areas could be compared using the quantitative version of Sorensen's Similarity Index, (Mueller-Dombois and Ellenberg, 1974) $\sum C/A+B$ where A and B are the total numbers of quadrats (all types) recorded from two areas and C is the lower of the number of quadrats recorded in one area for a type common to both areas.

For example, if the Norfolk and Wiltshire areas are compared, (Table 5a), C equals 3 for plot type 7, 2 for plot 5, 1 for plot type 12, 1 for plot type 11, so that $\sum C=7$. When the two areas are compared in terms of Stand types, only type 10 is common to the two areas and $\sum C=1$. This point is shown as an open triangle on Fig. 2. Values of $\sum C$ were calculated for each pair of areas for all Plot Types and compared with the equivalent value of $\sum C$ calculated using Stand Types, (Fig. 2). The regression line shows that the degree of similarity between areas as judged by the Stand Types present is highly correlated with the value calculated for Plot Types.

Table 6. *Classification of quadrat results into both Stand and Plot types*

The number of quadrats keying out to a particular combination of Plot and Stand Types is shown in each cell of the table.

Mean No. of plot types per stand type 5.5±0.4 (n=25)
Mean No. of stand types per plot type 6.0±0.8 (n=22)

Mean No. of quadrats per stand type 18.4±4.4 (n=25)
Mean No. of quadrats per plot type 20.9±3.5 (n=22)

Total No. of quadrats recorded=461.

		PLOT TYPES																										
		7C	*10*	*2A*	*8E*	*1C*	*2B*	*4C*	*1A*	*3A*	*3C*	*9A*	*1D*	*6D*	*2C*	*6C*	5B	8A	7E	7Ab	3D	7D	7Aa	6Ac	12	6Ab	Total No.
	1	2	4	1		1	2	1	2					1													14
	7	3		4	1	1		1	1	3	2	2			7												25
	2			1									1		2												4
	5	1	1	1	1	4	1	1	7		2	4	1		1	1											26
	6			4	1	1	1	1	4	1	1		1		1		1										17
	8				2	2					2					1											7
S	12					1			4		1	1	11	1	5				1	5	19	5					54
T	11						1	1		1	3	1	3	1	1				1	7	2						22
A	10								5	1			4	2			1		13	9	6	1					42
N	13												1							2	1						4
D	30													1							5	12	2	1	4		25
	22												2	1		1	2	1			4		1	7		3	22
T	23													1		2	2	4		1				6			16
Y	24														2		1						1	1			5
P	15																		1	7	1						9
E	16																			1	9						10
S	26																				1		4	7	3	12	27
	25																				1			6		41	48
	29																				1	4	10	1		6	22
	27																				1	4		1	13	29	48
	18																									9	9
	17																									5	5
	Total no.	6	5	11	5	10	5	5	23	6	11	8	24	8	19	5	7	5	16	32	51	26	18	30	20	105	461

Production of a cross-classification table

The results from the two classifications were hand-sorted to bring together the Plot Types which tended to be associated with a particular Stand Type and *vice versa* (Table 6). Samples from any one Stand Type tended to belong to only about six Plot Types and of these only three or four were usually common. The Plot Types associated with a particular Stand Type were mostly closely related. Thus Plot Types 10, 11 and 12 made up over half the samples from Stand Type 3D, while three quarters of the samples from Stand Type 6Ab fell into Plot Types 25, 26, 27. Conversely, Plot Type 5 was commonly found with Stand Types 1A, 1C, 2C and 3C–all characteristic types of free-draining, calcareous sites.

The combination of the two systems in the one survey

A Stand Type map is shown for one of the woods of the Duddon Valley in Fig. 3, together with the quadrat positions and the Plot Types recorded for that wood. A total of 12 Plot Types were in the sixty-two quadrats from the valley woods and these were distributed between the various Stand Types present as shown in Table 7.

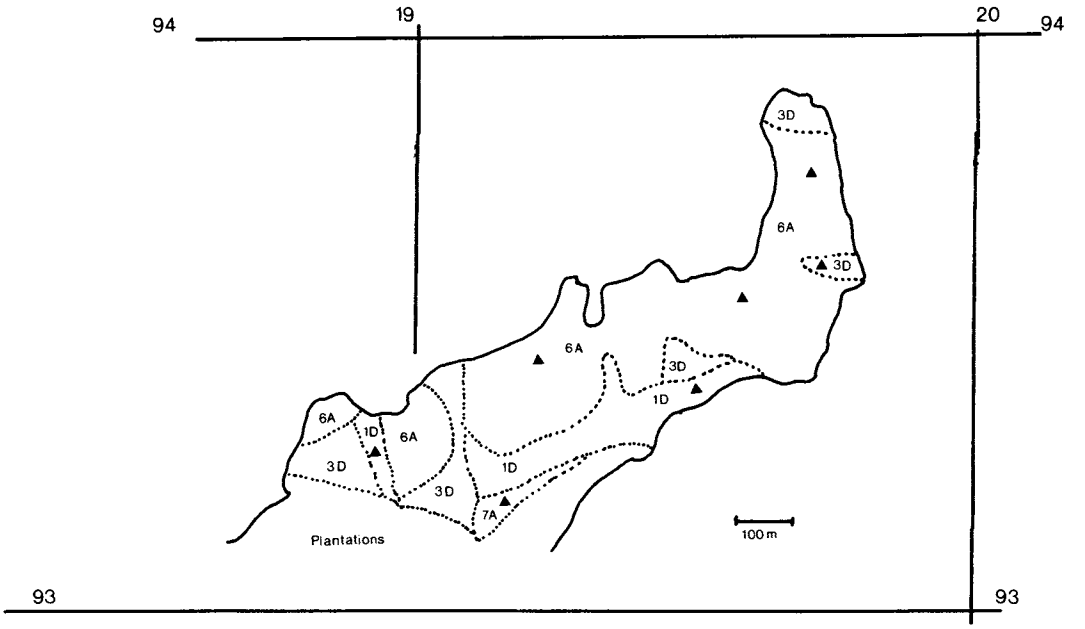

FIG. 3.

Stand Type map for Rainsbarrow Wood, Cumbria; one of the woods examined in the Duddon Valley survey (SD194934), ▲ = quadrat position.

Stand Type Area	Plot Type recorded
6A	25, 25, 25
1D	22, 22
3D	11
7A	12

When this block of sixty-two quadrats was combined to form a hypothetical wood, stratified random sampling based on the Stand Type groups present was significantly more efficient than unrestricted random sampling. This was shown in the greater mean number of Plot Types and species detected using six quadrats, and in the greater numbers found when all replicates were combined (Table 8). The result was expected both from sampling theory (Snedecor and Cochran, 1967) and from the experimental work of Smart and Grainger (1974).

DISCUSSION

The Merlewood and Stand Type classifications are very different in origin—the former is strictly numerical while the latter has a strong subjective element in its derivation. The Stand Type classification depends largely on tree and shrub species (plus some site features) whereas, in the Merlewood classification, 85% of the key species are in the ground flora (including bryophytes). Despite these differences this paper has shown that there is a clear association between the types produced by the two systems.

Misclassifications can occur with either system and in practice where these can be identified in the field the plots should be re-assigned to the appropriate type. No attempt was made to do this here since it would have partially invalidated the comparison. Misclassifications may account for some of the outlying samples in the cross-classification table but a one-to-one relationship between the systems would be very unlikely for a variety of reasons. Even in relatively undisturbed woodland, tree and shrub communities and the ground flora may respond differently to climatic or soil features so that overlapping patterns rather than precise

Table 7. *Classification of quadrats from the Duddon Valley, Cumbria*

Plot type	Stand Type				
	1D	3D	7A	7B	6A
11	1	2			
10	1	2	1		
29		1		2	
22	2	2		2	4
12		1	1	1	
15			1		
32				1	
26			2		
23					3
25					25
27					5
18					2

To test the relative efficiency of stratified-random sampling within this block of sixty-two quadrats the results were combined as follows:

Stand types 1D and 3D	12 quadrats	5 plot types
Stand group 7	11 quadrats	7 plot types
Stand group 6	39 quadrats	5 plot types

Two plots were then chosen at random from each stratum.

correspondence would be expected (e.g. Daubenmire, 1952). In Britain the mosaic of variations in the ground flora tends to be at a smaller scale than the variations in canopy species. Since the quadrat used in the Merlewood classification is less than a quarter the size of the basic Stand Type quadrat, up to four Plot Types could theoretically exist within one Stand Type quadrat. The ground flora or the canopy may be affected independently by woodland management. Heavy grazing in an area might alter its classification according to the Merlewood system, whereas selective felling might alter its Stand Type. More samples are needed particularly from the south-east if the comparison is to be extended.

The Stand Type classification should strictly only be used in sites with a long-established semi-natural woodland cover. This is not a major limitation for NCC use since such woods are likely to be of most interest for nature conservation (Peterken, 1977). Only a small number of conspicuous species are used in the classification plus site features which can usually be deduced easily. Experience in various parts of the country has shown that Stand Types can be identified reasonably accurately and mapped as in Fig. 3 while walking through a wood, without the need to set out a quadrat.

The Merlewood classification can be applied to any broadleaved wood. It is not necessary to lay out the 200 m^2 quadrat to use the key, provided the surveyor estimates the approximate area involved. In practice it is helpful to use a quadrat since the key species may not be abundant and sometimes can be easily overlooked. Five divisions of the key are needed to determine a type, so that thirty to forty species may have to be checked-off as definitely present or absent to classify an area. It is thus often more time-consuming to decide by casual

Table 8. *Comparison of unrestricted random and stratified random (based on stand type groups) sampling for the detection of plot types and plant species.*

	Stratified random sample	Unrestricted random sample
Mean number of types detected in 6 quadrats (n = 10)	4.8 ± 0.1	4.0 ± 0.2
	Difference significant using t-test at p = 0.99 level	
Number of types detected all replicates combined	12	10
Mean number of species detected in 6 quadrats (n = 10)	60.0 ± 2.5	47.9 ± 2.5
	Difference significant using t-test at p = 0.99 level	
Number of species detected in all replicates combined	106	89

Number of plot types in the complete block of sixty-two quadrats = 12.
Number of plant species in the complete block of sixty-two quadrats = 115.

inspection where one type changes to another (and so to produce a vegetation map) than with the Stand Type system.

Both systems have practical and theoretical limitations in the way that they have been generated and in the range of sites from which they were originally derived. Rackham (1983) draws attention, for example, to the weakness of the Merlewood system created by the use of random plot positions in the original survey. Others have pointed out the difficulty of correct stand type identification in woods where the oaks cannot be assigned unequivocably to either *Quercus robur* or *Quercus petraea*. Both classifications provide only a limited number of types which may be too broad to describe adequately variations at a local level. Problems also arise with vegetation types which were not represented in the original surveys.

Neither classification by itself provides a "foolproof" way of classifying British woodlands but the two are in many ways complementary. The 54 samples which fell into Plot Type 12 (Table 7) may be split on the basis of their canopy differences, into those with alder present (Stand Type group 7), those with wych elm present (group 1), those with maple present (group 2) etc. Equally, the 51 plots classified as Stand Type 3D can be split into those with a fairly base-rich character (Plot Types 10, 11, 12) and those with a more base-poor nature (22, 23, 25, 30). Use of Stand Type area as a basis for a stratified random quadrat sample leads to more efficient sampling of the Plot Types present, while the quadrats define the characteristics of the particular Stand Type area more precisely. Frenkel and Harrison (1974) also concluded that a combination of techniques (in their example the Braun-Blanquet method and a numerical method) was often desirable.

The National Vegetation Classification (NVC) will be available shortly. The record used in the comparisons made here (Table 1d) is broadly compatible with the NVC (Table 1c) if, as is usually the case, the 200 m² quadrat is recorded as a series of nested plots—5 × 5 m, 7 × 7 m, 10 × 10 m and 14 × 14 m. The canopy record is smaller (30 × 30 m rather than 50 × 50 m) but it seems unlikely that this will result in major misclassifications. Hence results in this form can provide a link between the NVC types and other work which has used the Merlewood and Stand Type classifications.

The presence of several classification schemes for woodlands can be confusing, although as indicated in this paper there is a broad degree of equivalence between them. The advantage of having several methods available is that users can select a system which is appropriate for those aspects of the variation in which they are interested e.g. canopy composition, ground flora, bryophytes only etc. but which still places the wood in a wider British context. From a nature conservation viewpoint, classification provides a means whereby examples of woodland can be selected from across the spectrum of ecological variation (Ratcliffe, 1977; Goodfellow and Peterken, 1981). Differences between classifications in terms of the precise points at which the spectrum is split are thus often relatively unimportant. Use of more than one system can however help prevent elements in the woodland variation being overlooked.

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