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DECIDUOUS WOODLAND SURVEY OF SCOTLAND

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SUMMARY

The project has been concerned with two main groups of objectives, the first concerned with the composition and distribution of the principal native woodlands in Scotland; and the second with the rates of change as determined by comparison with the Forestry Commission census of 1947.

The first objectives were answered by a low detail survey of sites and has successfully determined the major patterns. The second group of objectives has posed major difficulties as the same data have been used as a basis for comparison. In the original formulation of the project, it was not the intention to make a detailed comparison with past surveys. Interest in comparisons has increased in the course of the project. However, the principal features of difference have emerged and the basis has been laid whereby more extensive and detailed comparisons can be made.

The survey involved initially a search of the 7th Series 1:63,360 Ordnance Survey maps for all woods over 5 ha marked with deciduous woodland symbols. These sites were then used as a basis for ground survey involving visual estimates of the species composition of the canopy. Checks were made of the accuracy of these estimates that confirmed that they were sufficiently reliable for such a general survey.

These data enabled the principal patterns of woods and their species composition to be defined throughout Scotland. They were also analysed to determine the principal combinations of species canopy composition. The use of these groups as strata for a subsequent ground flora survey is discussed and related to the availability of existent data.

The information from the field survey is stored in a computer data bank the flexibility of which is demonstrated by its application to data listing, data summary, data interrogation and mapping.

The assessment of change in Scottish deciduous woodland cover is discussed in relation to the use of Ordnance Survey maps and a comparison made with the 1947 Forestry Commission census of woodlands.

Detailed studies of the counties of Selkirk and Nairn have been undertaken. These include a simulated survey of 1947 woods using the original Forestry Commission data and an assessment of the accuracy of the 1977 survey using the 2½" OS map. Results indicate that the 1947 county summary results overestimate the area of deciduous woods (in woods of over 5 ha) whereas the same figure is underestimated by the 1977 survey. Taking these sources of error into account, a provisional estimate of the decline in deciduous woodlands over the past 30 years is 39%.

1. Introduction

1.1 Contract history

1.1.1 The contract started on 1 April 1976 with the following objectives, dated 25 May 1976.

1. To estimate the quantity of broadleaf woodland in Scotland, with particular reference to semi-natural types.
2. To classify these woodlands into ecological groups based on vegetation, site factors and climate; to describe, estimate the quantity and demonstrate the distribution of each ecological type.
3. To relate this classification to the composition and structure of the tree and shrub strata; to describe, estimate the quantity and demonstrate the distribution of each stand type.
4. To determine the broad directions and rates of change in each of the above features.

These objectives should be achieved in such a way that:

- (a) the classifications can be used independently by regional staff in regional survey;
- (b) the information is stored in a manner which permits recall in different ways and for various purposes, and which permits later survey data to be incorporated;
- (c) the information is presented in map form, whenever practicable;
- (d) NCC staff can contribute and assist in the field survey and evaluation of other sources of information;
- (e) the data gathered can form a baseline for quantifying any future changes.

1.1.2 However, at an early stage in the project, it became apparent that the existing information available from files or staff experience would

not provide standardized information on the canopy composition of the woods, as had been hoped, although there was widespread knowledge of a qualitative type. The position was further complicated by the departure of J. E. A. Procter from ITE, with a subsequent delay in the training of new staff. An additional factor was the dispersed nature of many of the residual woods from the early survey work. The first stage in the modification of the original plan was made in December 1976 when new objectives were defined as follows:-

1. Quantity: to estimate the extent and species composition of the deciduous woodlands of Scotland, including those with some admixture of conifers.
2. Distribution: to determine the distribution of these woodlands in Scotland by species and by regions in relation to administrative boundaries.
3. Change: to compare the extent of these woodlands at the present time with figures available from the 1947 and 1965 censuses.
4. Classification: to carry out intensive surveys of representative sites in order to provide data on floristic composition and, by analysis of these data, an ecological classification.
5. Extent: to determine the distribution and extent of the types provided by the classification and to relate these to ecological factors.
6. Report: to report the findings so that they can be used readily by Regional staff, with clear descriptions of types and maps of their distribution.

1.1.3 It became progressively apparent that the detailed survey of individual sites needed careful appraisal, not only because of the current state of survey data already collected using the standard 200 m² plots, but also because of duplication with the National Vegetation Classification. The most recent statement is given in new objectives produced on 11 January 1979, which were as follows:-

"The contract started on 1 April 1976. During 1978-79, the aim will be to complete the broad survey of all broadleaf woodlands, to make comparisons at a general level with the situation in 1947; to place this information in a data bank for NCC use; to test the accuracy of the comparisons with 1947 by more detailed comparisons of selected areas; and to report the findings by 31 March 1979".

1.1.4 The present report follows the outline discussed in the joint meeting between ITE and NCC in November 1978. Modifications were made in the data presentation following the suggestions made at that meeting. In particular, the analysis of different types of woodland based on the canopy estimates proposed at that meeting has been followed up successfully. The current report states the stage reached in the project and should form the basis for discussion of any future contract. In view of the need for further research, some proposals for further developments have been included in section 7.2 and may broadly be included under two headings:

- i) Further detailed comparisons with the 1947 census, and other methods of comparing the rate of change.
- ii) Discussions of the various options for carrying out a detailed survey of ground vegetation.

1.1.5 J. E. A. Procter carried out the majority of work in the first year of the project. R. C. Munro subsequently carried out the remaining field work and the acquisition of the basic data. T. W. Parr set up the data bank and is responsible for the sections on that topic and the assessment of change.

2. Methods

2.1 Map and field procedures

2.1.1 A search of the 7th series 1:63360 maps had been initiated before the start of the project. This series had been selected as the most recent set of maps on which woods are marked with broad leaf or conifer tree symbols. A lower limit of 5 ha was set in the initial project plan, approximately as the smallest wood to

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contain a broadleaf tree symbol. Some woods larger than 5 ha were so narrow that they could not accommodate a tree symbol and subsequently posed problems, as discussed in section 5.

In the subsequent analysis of the data, it was found that different rules had been followed in the inclusion of woods under 5 ha in the initial survey carried out before the contract started, and in the later series. In the latter case, some woods under 5 ha were included and were therefore surveyed. The results from these woods are listed in Appendix 10.

Mixed stands were included, as there was no way of estimating the composition of the mixture. A decision was made to include policy woods, as any division between them and shelterbelts would have been arbitrary. Any or all of these categories may contain any ratio of natural to wholly planted woodland. The problems of coordination between the different series of maps are considerable and are discussed in section 5.

2.1.2 The old county name, the new district name, and the new region were also recorded for each wood. In addition, the highest and lowest altitudes of the wood were taken from the OS maps. The solid geology was also recorded - if the wood crossed more than one type, then both were noted. The grid reference was taken from as near the centre of the wood as possible, or in the centre of a group of linked blocks. The name taken was, either the name given on the wood, or the nearest appropriate name on the map. Wood names often give rise to confusion, not only with different maps but also because of different names in local usage as opposed to those on the maps.

The list of names has been circulated to appropriate NCC staff and it is hoped that differences of nomenclature and spelling have been sorted out. The data were punched in the standard format explained in section 3, where the data bank is described.

2.1.3 The field reconnaissance survey was designed to answer the following two questions about each wood:

(a) Does it exist? (i.e. is the wood marked on the map a broadleaf wood, has it been removed from this category, or is its area and configuration the same as marked on the map?)

(b) If so, what is the percentage composition of its canopy, by species?

In 1976, 926 woods were inspected by J. E. A. Procter, mainly in the west and north of Scotland. In 1977, 3 teams under the supervision of R. C. Munro surveyed a further 1913 woods, and, in 1978, the remainder, 396 woods, were completed. The rate of survey varied widely according to the degree of isolation of the woods, the density and the condition of the roads, but in general 10-17 woods were surveyed per day.

2.1.4 In assessing canopy percentage, an attempt was made to visualise an aerial view of the wood. Only those species actually forming part of the canopy were recorded. Thus, all individuals of dominant species such as oak were recorded, but understorey species such as hazel were recorded only when they formed part of the canopy. Any other procedure would either have resulted in totals exceeding 100%, which would therefore include non-canopy cover estimates, and it would have been difficult to devise consistent methods for the whole survey.

Species percentages were recorded as follows. First, a species-list was compiled for the wood, then percentages were allocated, starting at the lower end (1% representing 1% or less) and working upwards. Finally, the resulting list was compared with the wood as a whole, and any adjustments made. This procedure accounts for some apparently unlikely percentages e.g. birch 89 or oak 73.

Gaps in the canopy were ignored if they were scattered uniformly through the wood (i.e. the wood had an open canopy). When the extent of such gaps exceeded about 50% the 'wood' was regarded as no longer in the category of woodland and was deleted from the record (i.e. marked "delete"). Gaps which were not uniformly scattered through the wood (i.e. patches of closed-canopy woodland separated by large open areas) were almost always mapped as such by the OS. In a few other cases, a small adjustment to the area was made during field work.

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In cases where a wood had been recently underplanted with conifers, either after felling, or through an existing open broadleaved stand, it was marked "delete", even though, at the moment of inspection, the residual broadleaved trees may have formed the bulk of the canopy. Similarly, woods which were actually in the process of being felled, were marked "delete".

Exotics In many woods, many of the trees are planted. Some of these are native British species (or widely naturalized, e.g. sycamore) which do not now grow as natives in the area concerned. Planted species which have been recorded separately are beech, limes, Scots pine and sycamore. Other exotics, mainly but not exclusively conifers, were recorded together.

Mixed stands When the canopy contains up to 50 per cent exotics, it is recorded in detail. When exotics occupy more than 50 per cent of the canopy, the wood is marked "delete", except in a very few cases where there was held to be a local justification for retaining the wood in the record. In cases where conifers and broadleaved trees formed coherent blocks, the conifer areas were marked "delete" and the broadleaf areas treated as separate woods.

Woods seen during field survey, but not marked on the OS map, were recorded. Obviously, there remain areas of country which have not been searched in this way, and there probably remains a small residuum of woods which have not been detected. Woods marked on OS maps, but without any tree symbol, were inspected during the survey and recorded if appropriate.

Most of the woods containing less than 50% broadleaved trees had been underplanted, but a few had been eliminated and replaced by agriculture. A few were so cut-over and divided by house plots or caravan sites that they could no longer be regarded as open ground (with scattered moribund trees). The reasons for deletions of woods are discussed in section 3.

Woods originally recorded as "not seen" were mainly those regarded as inaccessible, within the resources of time and transport available. All the woods, with only four exceptions (given in Appendix 11), have been subsequently surveyed.

The field survey thus resulted in a series of modifications to the original data bank extracted from the OS maps. It must be borne in mind that the revision dates of the OS maps from 1954 to 1967 (more than half before 1957) and the sources of the revision data are not known. Therefore, the OS maps do not themselves constitute a 'base-line'. They are merely a convenient cartographical starting point for the data bank compilation.

2.1.5 The following are the main classes of information not collected by the present reconnaissance survey.

1. Woods smaller than 5 ha (but see above).
2. Riverine and gully strips and patches which cannot be mapped as distinct woods, but which, if joined, would be considered as sites over 5 ha. The problems of site definition are discussed below.
3. Scrub which is not coloured green on OS maps. (The meanings of the terms 'wood', 'scrub', 'tree' are not well-defined. In particular, the Forestry Commission employs a more rigorous usage than the NCC. A consistent and uniform approach has been adopted for this survey. In general, this has been inclusive rather than exclusive, on the principle that it is easier to reject data once collected than to make supplementary data collections).
4. Status (age, regeneration, successional relationships).
5. Woody species not forming part of the canopy.

2.1.6 The above description of the field procedure is essentially that provided by J. E. A. Proctor following his initial field season and it has been followed as carefully as possible. Continual checks have been made between observers to ensure that, as far as possible, the data are consistent. Checking was done mainly by the separate members of a team making independent estimates and comparing results. In addition to the two internal checks on the accuracy of the estimates, discussed in section 2.2.7, more general checks were made.

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First, in the Dumfries and Galloway region, a broad survey of woodlands has been carried out by NCC, using similar methods to that used in the current survey. A close correspondence of the results was found, with few differences in the selection of woods when the same criteria were used. Difficulties were also encountered in some additional surveys carried out in the north-east region, due primarily to the dissected nature of the woods considered.

In addition, spot checks have been made in the field using the data bank information and have been found to be reliable. A critical factor is the selection of the boundaries used in the original assessments, and these have been circulated to NCC staff for verification. Finally, circulation of the basic data bank to NCC staff for checking the names of the woods should also have helped to remove any remaining discrepancies.

2.1.7 The first internal check carried out was to compare the visual estimates of canopy composition with previous basal area measurements. The results from this comparison are given in Table 1. There is good general agreement between the figures, with all the leading species being adequately estimated in each of the sites. Several conclusions can however be drawn in relation to the likely further findings in a more detailed study:-

- i) Boundaries need to be closely defined for precise comparison. In Glan Nant, the boundaries were found not to compare sufficiently closely for a valid comparison to be made. In the present table, the differences between the amount of birch estimated in Garroch Wood, could well be accounted for by this lack of definition.
- ii) Difficulties are present when hazel is being estimated i.e. when does it become a canopy species? However, it usually occurs as a low proportion of the basal area in mixed sites, whilst it only exists as a canopy species in limited areas.
- iii) Basal area estimates can be misleading in terms of the canopy as, in some woods, the major tree species also occur as understorey species e.g. birch. This feature probably accounts for the discrepancy in the alder estimates for Glasdrum.

Table 1. Comparison of visual estimates of canopy composition made during the survey, with measurements of basal area recorded independently. S.W.S. = Scottish Woodland Survey. B.A. = Basal area measurement.

	<u>Wood of Cree</u>		<u>Garroch Wood</u>		<u>Glasdrum</u>		<u>Arriundle</u>	
	S.W.S.	B.A.	S.W.S.	B.A.	S.W.S.	B.A.	S.W.S.	B.A.
Oak	50	63	45	40	30	20	75	80
Birch	30	27	25	6	30	31	13	12
Hazel	1	4	-	-	3	3	-	-
Ash	10	1	5	4	30	31	-	-
Exotics	6	-	10	16	-	-	12	-
Willow	1	-	1	1	-	-	-	-
Alder	1	1	2	1	2	9	-	-
Wych elm	-	-	4	8	5	1	-	-
Sycamore	-	-	2	14	-	-	-	-
Pine	-	-	1	10	-	-	-	-
Others	-	-	-	-	-	-	-	8

Data for Wood of Cree, Glasdrum and Arriundle provided by J. M. Sykes and A. D. Horrill.

Data for Garroch Wood from the National Woodlands Survey.

Table 2. Examples of different estimates of canopy composition by three teams of observers for five different woods.

	<u>ONE</u>			<u>TWO</u>			<u>THREE</u>			<u>FOUR</u>			<u>FIVE</u>		
Sycamore	2	6	4	45	48	62	8	12	15	-	-	-	18	20	26
Elm	12	6	10	20	6	12	55	48	37	-	-	-	10	9	4
Beech	8	1	6	10	10	6	2	4	1	-	-	-	15	28	25
Ash	-	6	10	7	5	12	34	35	42	-	-	-	5	4	5
Exotics	-	-	-	7	7	3	-	-	-	-	-	-	8	3	6
Lime	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scots pine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oak	3	15	10	8	15	4	-	1	2	-	-	-	36	32	28
Willow	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Alder	75	66	60	-	-	-	1	-	2	-	-	-	-	-	-
Hazel	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-
Rowan	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-
Birch	-	-	-	-	4	-	-	-	-	99	97	98	5	1	3
Others	-	-	-	3	1	1	-	-	-	1	3	1	2	4	2

iv) Where there are complex topographical variations in a wood, it seems likely that estimates, particularly of the minor species, are likely to be difficult to make.

v) Where the species composition is simple, as in Arriundle, then the two estimates are consistent.

2.1.3 The second internal check was made by a comparison of three teams' estimates of the canopy composition of 10 woods on the same day. The results are shown in Table 2.

The table gives only five woods since the data are repetitive and the principles are adequately shown. Detailed statistical comparisons seem unnecessary as the figures speak for themselves. The important background to these comparisons lies in the overall objective of the project which was to obtain a broad assessment of the canopy composition, rather than a greatly detailed inventory. Within the limits of the present project, these data support the validity of the recording method.

The figures have similar degrees of variation to those obtained above and it is difficult to gain an absolute estimate of the degree of accuracy since there is no final measure of the "right" figure. Although the estimates for woods with a low number of species are very close in their percentage estimates, they differ widely in relative terms when compared directly. At the other extreme, although the dominant species have larger overall percentage differences between them, the figures as proportions of the entire wood are closely comparable.

2.1.9 Alder and oak are sometimes difficult to distinguish, but some of the minor species are also difficult to tell from a distance, as also is the decision as to whether they contribute to the canopy. Further detailed surveys of the sites could be carried out, but the figures seem to be adequately consistent for the purpose of the present study. As has been mentioned above, other problems concerned with boundary definition and the identification of the woods from the original maps seem much more likely to be the major sources of discrepancies, rather than the actual estimation of the canopy composition. In addition, four sites were visited in the test survey and all marked as "delete".

3. The data bank

3.1 Listing and presentation of the data

3.1.1 All the relevant information from the survey is stored in a computer data bank. The data are available on both paper tape and disc files in a manner enabling easy access to information, ease of data revision and flexibility with regard to analysis and interrogation.

The format of the data bank is shown in Appendices 1 and 2. For each wood included in the survey, the bank includes information on:

- County
- district
- top and bottom altitude
- solid geology
- wood classification
- grid reference
- wood name
- wood area
- species list or reason for deletion

All the information contained in the data bank is given in Appendices 3 to 11 inclusive. The maps and tables are put at the end of the section to enable the easier reading of the text.

3.1.2 Appendix 3 summarises the data for each of the 53 Scottish districts in three tables. The first is a general summary table showing the number and area of existing and deleted woods in each district. This table, reproduced as Table 3 in this report, shows that a total of 3188 woods included in the survey 752 (24%) were found to be deleted. The remaining 2436 existing woods cover an area of 61,664 hectares, or just under 1% of the land area of Scotland. The distribution pattern of the existing woods is shown in Fig. 1. The principal mountain massifs in Scotland stand out clearly as areas where woodlands are absent. Otherwise the patterns reflect local conditions and can be related to specific areas of known high concentrations, such as south Argyll and Perthshire.

Table 3 Summary of 1977 survey data for Scottish Districts. Areas in hectares.
GENERAL SUMMARY TABLE (PERCENTAGE OF TOTAL IN BRACKETS)

DISTRICT	NO. OF WOODS		AREA OF WOODS	
	EXISTING	DELETED	EXISTING	DELETED
SUTHERLAND	142 (94)	9 (6)	2687 (91)	263 (9)
CAITHNESS	52 (87)	8 (13)	1144 (93)	85 (7)
ROSS	148 (85)	27 (15)	3065 (71)	1236 (29)
SHYDE	40 (93)	3 (7)	1050 (93)	84 (7)
WEST DUNDEE	73 (92)	6 (8)	1864 (83)	389 (17)
WILTSHIRE	131 (76)	41 (24)	4377 (89)	570 (11)
WILTSHIRE	12 (74)	4 (21)	428 (83)	90 (17)
WILTSHIRE	56 (91)	6 (10)	2732 (83)	574 (17)
WILTSHIRE	49 (84)	9 (16)	1527 (87)	226 (13)
WILTSHIRE	19 (54)	16 (46)	444 (61)	288 (39)
GORDON	58 (68)	27 (32)	1413 (61)	891 (39)
KINCARDINE	51 (66)	26 (34)	1615 (56)	1246 (44)
ABERDEEN	0 (0)	0 (0)	0 (0)	0 (0)
ANGUS	80 (60)	53 (40)	1287 (52)	1167 (48)
PERTH	246 (74)	88 (26)	6433 (73)	2428 (27)
PERTH	11 (56)	8 (42)	69 (45)	93 (57)
STIRLING	118 (72)	47 (28)	2644 (72)	1023 (28)
WILTSHIRE	3 (80)	2 (20)	197 (59)	137 (41)
WILTSHIRE	23 (82)	5 (18)	588 (81)	139 (19)
N.E. FIFE	19 (39)	30 (61)	283 (35)	521 (65)
N.E. FIFE	17 (81)	4 (19)	469 (83)	97 (16)
N.E. FIFE	27 (90)	3 (10)	501 (91)	48 (9)
WILTSHIRE	380 (87)	53 (13)	8907 (88)	1243 (12)
WILTSHIRE	11 (85)	2 (15)	475 (88)	61 (12)
WILTSHIRE	70 (90)	8 (10)	1299 (68)	607 (32)
WILTSHIRE	11 (85)	2 (15)	149 (75)	12 (7)
WILTSHIRE	20 (69)	9 (31)	342 (61)	219 (39)
CLYDEBANK	0 (0)	0 (0)	0 (0)	0 (0)
GLASGOW	4 (80)	1 (20)	62 (70)	26 (30)
STRATHKELVIN	5 (100)	0 (0)	119 (100)	0 (0)
CUMBERNAULD	8 (62)	5 (38)	179 (59)	123 (41)
EASTWOOD	0 (0)	2 (100)	0 (0)	79 (100)
GLASGOW	2 (67)	1 (33)	72 (94)	5 (6)
GLASGOW	23 (85)	4 (15)	485 (79)	129 (21)
GLASGOW	12 (71)	5 (29)	362 (86)	89 (14)
HAMILTON	8 (73)	3 (27)	210 (53)	189 (47)
EAST DUNDEE	5 (84)	1 (17)	69 (93)	5 (7)
KILMARNOCK	16 (89)	2 (11)	406 (94)	28 (6)
KYLE	87 (83)	15 (17)	1174 (86)	186 (14)
GLASGOW	10 (85)	2 (17)	154 (93)	16 (7)
GLASGOW	22 (65)	12 (35)	625 (60)	425 (40)
W. LOTHIAN	17 (89)	2 (11)	222 (56)	171 (44)
EDINBURGH	16 (76)	5 (24)	504 (88)	71 (12)
MIDLOTHIAN	19 (95)	1 (5)	995 (99)	7 (1)
E. LOTHIAN	31 (67)	15 (33)	998 (58)	710 (42)
TWEEDDALE	16 (67)	8 (33)	327 (70)	138 (30)
ETTRICK	30 (73)	11 (27)	378 (48)	416 (52)
BERVICKSHIRE	31 (59)	21 (41)	719 (53)	643 (47)
ROXBURGH	23 (52)	21 (48)	466 (61)	304 (39)
WIGTOWN	54 (74)	19 (26)	1011 (75)	338 (25)
STEWARTON	63 (67)	31 (33)	1371 (72)	537 (28)
WILTSHIRE	51 (54)	47 (42)	896 (50)	898 (50)
WILTSHIRE	11 (74)	4 (27)	341 (20)	1327 (80)
WILTSHIRE	11 (76)	4 (24)	1664 (78)	2142 (26)

The second table of Appendix 3 shows the total area of each canopy species within each district. The third table (reproduced as Table 4) gives the canopy composition as a percentage of the total for each district. In Scotland as a whole, 45% of the deciduous woods are made up of birch, with the next most abundant species being oak (19%). Generally speaking, birch is relatively more abundant in the highland districts, and decreases in abundance as oak and policy wood species such as beech, elm and sycamore increase in the lowland areas.

3.1.3 Appendix 4 summarises the data for the 9 Scottish regions. Tables as in Appendix 3.

Appendix 5 summarises the data for 31 Scottish counties. Tables as in Appendix 3, with 2 additional species summary tables calculated on the basis of principal species (section 5.2.5).

Appendix 6 and Appendix 7 give the distribution maps for species and woodland types. These are discussed in section 5.

The distribution maps, as illustrated by Fig. 1, are examples of the way in which computer produced maps of this type can be used. Their strength is that a rapid display of data is possible and their use is primarily exploratory in that the quality of map produced is low. Large sets of data can be held and processed rapidly to demonstrate particular features of the data. The maps can be produced to any convenient scale, subject to the constraint of computer paper size. The scale used in the current series of maps corresponds to the 1:2,000,000 scale used in the Oxford Atlas of Britain and Northern Ireland. Outlines from this atlas could be used as a frame of reference for the computer maps, either to improve resolution or to overlay particular environmental patterns such as altitude or rainfall. At a later stage, the computer maps described here can be used as the basis for obtaining higher quality maps, such as those produced by the Experimental Cartography Unit. Both types of map are derived by a similar computer compatible procedure.

The computer maps show either the number of area of woods at a particular place. Where numbers exceed 9, the data are rescaled

from 1 to 9 and a conversion key printed at the base of the map. All the maps in this report show the number of woods in a rectangular area of the dimensions stated in the key (usually 5 km x 8 km). It is possible to produce maps for grid squares (e.g. 10 km squares), but constraints on the size of typeface means that the shape of Scotland as a whole would then have to be distorted.

3.1.4 Appendix 8 is a print-out of all the existing woods over 5 hectares included in the data bank. The format of the printout is not the same as that used in the data bank itself, but is designed to facilitate reference.

The data are printed out district by district, with woods arranged within each district by grid squares. Woods in the most north-westerly 10 km grid square are listed first. Each district contains two listings of the woods. The first (Table 5) gives the wood name, grid reference, wood class (see section 4.3), wood area and a species list given in the following order:

SY = sycamore, BE = beech, EL = elm, LI = lime, AS = ash,
HA = hawthorn, EX = exotics, OA = oak, WH = whitebeam, CH = cherry,
BL = blackthorn, SP = scots pine, AL = alder, HY = holly,
HZ = hazel, BI = birch, AP = aspen, RO = rowan, WI = willow.

The species are ordered according to the analysis of their ecological affinities (section 4.3.2). In this way, the patterns of species composition are more easily understood and the balance of woods in a particular district becomes clearer. Typical woods may therefore be picked out and an ecological interpretation of the data improved. An example of such a printout is given in Table 5. Here, the policy woods stand out clearly from the remainder of the sample in which birch is the dominant native species.

The second listing in Appendix 8 contains the remainder of the information on each wood, including the geological and altitudinal data.

3.1.5 Appendix 9 is a printout of all the deleted woods, organised in the same manner as Appendix 8. In addition to information on area, grid

Table 4. Summary of 1977 survey data showing average species composition of each district
 SPECIES SUMMARY TABLE (PERCENTAGES)

DISTRICT	SY	BE	EL	LI	AS	HA	EX	DA	WF
SCOTLAND	1	1	0	0	0	0	3	5	0
CAITHNESS	5	7	2	0	4	0	5	0	0
ROSS	1	5	0	0	1	0	4	9	0
SKYE	1	1	0	0	3	0	1	12	0
INVERNESS	1	1	0	0	2	0	6	5	0
LOCHABER	0	1	0	0	4	0	2	38	0
NAIRN	1	16	0	0	4	0	11	7	0
BADENACH	0	1	0	0	0	0	3	2	0
GLACAMANNAN	0	0	0	1	3	0	8	14	0
GLACAMANNAN	15	28	0	0	10	0	8	0	0
GLACAMANNAN	0	17	0	1	3	0	14	0	0
GLACAMANNAN	1	3	1	0	1	0	6	4	0
GLACAMANNAN	0	0	0	0	0	0	0	0	0
GLACAMANNAN	3	22	2	0	3	0	8	7	0
GLACAMANNAN	2	8	3	0	5	0	13	20	0
GLACAMANNAN	10	31	19	0	6	0	7	12	0
GLACAMANNAN	5	5	3	0	4	0	11	34	0
GLACAMANNAN	15	8	9	0	8	0	18	8	0
GLACAMANNAN	11	6	6	2	6	0	6	9	0
GLACAMANNAN	14	24	7	0	9	1	18	3	0
GLACAMANNAN	18	12	10	1	4	0	9	18	0
GLACAMANNAN	15	10	7	0	6	0	8	0	0
GLACAMANNAN	3	5	1	0	4	0	7	34	0
GLACAMANNAN	13	16	3	0	9	0	7	13	0
GLACAMANNAN	5	4	0	0	3	0	5	40	0
GLACAMANNAN	18	10	0	1	9	0	3	17	0
GLACAMANNAN	22	14	4	1	7	0	8	6	0
GLACAMANNAN	0	0	0	0	0	0	0	0	0
GLACAMANNAN	23	10	0	3	6	0	13	35	0
GLACAMANNAN	24	19	0	0	1	0	2	9	0
GLACAMANNAN	22	11	4	1	3	1	10	6	0
GLACAMANNAN	0	0	0	0	0	0	0	0	0
GLACAMANNAN	0	39	7	0	6	0	11	17	0
GLACAMANNAN	12	18	6	3	7	1	5	7	0
GLACAMANNAN	12	10	7	6	7	1	10	6	0
GLACAMANNAN	13	9	12	6	11	3	7	12	0
GLACAMANNAN	7	51	4	0	7	1	3	21	0
GLACAMANNAN	15	23	0	1	11	0	10	10	0
GLACAMANNAN	0	0	0	0	0	0	0	0	0
GLACAMANNAN	1	0	0	1	12	0	3	13	0
GLACAMANNAN	22	0	0	0	10	0	15	11	0
GLACAMANNAN	9	12	8	1	7	0	15	7	0
GLACAMANNAN	8	25	3	0	5	1	5	13	0
GLACAMANNAN	19	17	17	3	6	1	10	12	0
GLACAMANNAN	15	14	11	1	11	0	26	15	0
GLACAMANNAN	10	11	7	3	11	0	17	13	0
GLACAMANNAN	6	17	7	1	7	0	18	7	0
GLACAMANNAN	4	17	12	0	11	0	14	20	0
GLACAMANNAN	11	18	7	1	5	0	12	25	0
GLACAMANNAN	12	14	11	3	8	0	11	24	0
GLACAMANNAN	16	20	6	0	10	0	9	15	0
GLACAMANNAN	9	8	2	0	7	0	5	38	0
GLACAMANNAN	5	11	3	0	12	0	5	30	0
GLACAMANNAN	7	8	2	0	7	0	9	30	0
TOTALS	5	8	3	0	4	0	8	19	0

Table 4 (continued)

SPECIES SUMMARY TABLE (PERCENTAGES)

DISTRICT	CH	BL	SP	AL	HY	HZ	BI	AP	RO	WI
ABERDEEN	0	0	5	3	0	2	72	1	4	1
ABERDEENSHIRE	0	0	1	3	0	1	67	0	2	1
ABERDEENSHIRE	0	0	7	2	0	2	65	0	2	1
ABERDEENSHIRE	0	0	2	4	0	6	66	0	3	1
ABERDEENSHIRE	0	0	14	2	0	0	67	0	0	0
ABERDEENSHIRE	0	0	3	2	0	1	49	0	1	0
ABERDEENSHIRE	0	0	1	0	0	0	57	0	0	0
ABERDEENSHIRE	0	0	1	1	0	0	58	0	1	0
ABERDEENSHIRE	0	0	3	1	0	0	34	0	1	0
ABERDEENSHIRE	0	0	3	1	0	0	22	0	0	0
ABERDEENSHIRE	0	0	0	1	0	0	53	0	1	2
ABERDEENSHIRE	0	0	3	1	0	0	73	1	1	1
ABERDEENSHIRE	0	0	0	0	0	0	0	0	0	0
ABERDEENSHIRE	0	0	5	1	0	0	47	0	1	2
PERTH	0	0	1	2	0	0	45	0	0	0
DUNDEE	0	0	3	1	0	0	10	0	0	0
STIRLING	0	0	2	3	0	0	31	0	0	1
CLACKMANNAN	0	0	4	3	0	0	28	0	0	1
FALTAK	0	0	3	0	0	0	48	0	1	2
NEWCASTLE	0	0	3	1	0	0	14	0	0	2
KIRKCALDY	0	0	3	0	0	0	22	0	0	1
GLASGOW	0	0	1	1	0	0	37	0	0	1
GLASGOW	0	0	1	3	0	2	39	0	0	1
GLASGOW	0	0	1	4	0	2	29	0	1	2
GLASGOW	0	0	2	4	0	1	32	0	0	0
GLASGOW	0	0	1	1	0	0	31	0	0	1
GLASGOW	0	0	1	0	0	0	35	0	0	1
GLASGOW	0	0	0	0	0	0	0	0	0	0
GLASGOW	0	0	2	0	0	0	5	0	0	2
GLASGOW	0	0	1	0	0	0	40	0	1	2
CUMBERNAULD	1	0	3	1	0	0	35	0	1	1
EASTWOOD	0	0	0	0	0	0	0	0	0	0
GLASGOW	1	0	0	0	0	0	4	0	0	0
HUNKLANDS	0	0	3	1	0	0	34	0	1	3
MOTHERWELL	0	0	3	2	0	0	32	0	0	3
HAMILTON	0	0	0	5	0	0	14	0	0	5
EAST KILBRIDE	0	0	0	0	0	0	4	0	0	0
GLASGOW	0	0	1	1	0	0	7	0	0	0
GLASGOW	0	0	1	1	0	0	31	0	0	0
GLASGOW	0	0	7	1	0	0	11	0	0	1
GLASGOW	0	0	6	1	0	0	29	0	0	2
GLASGOW	0	0	4	0	0	0	30	0	0	3
GLASGOW	0	0	5	0	0	0	6	0	0	1
FIFE	0	0	2	0	0	0	7	0	0	0
EVLOTHIAN	0	0	2	0	0	0	14	0	0	1
TWEEDDALE	0	0	13	1	0	2	19	0	0	1
ETTRICK	0	0	4	0	0	0	17	0	0	0
BERWICKSHIRE	0	0	3	0	0	0	17	0	0	1
ROXBURGH	1	0	2	2	0	0	11	0	0	1
WIGTOWN	0	0	2	3	0	0	16	0	0	3
STEWARTON	0	0	0	2	0	0	25	0	0	2
WITCHSELL	0	0	1	1	0	0	27	0	0	2
ANNANDALE	0	0	3	3	0	0	29	0	0	0
TOTALS	0	0	3	2	0	1	45	0	1	1

reference, geology and altitude, a code number representing the reason for deletion is included. This code number is discussed in more detail in section 5.1.5.

Appendix 10 is a listing of small woods. During the course of the survey, 562 woods of area less than 5 ha were included (section 2.1.1). These are listed in this Appendix in a format identical to Appendix 8.

Appendix 10 also contains a distribution map and summary tables of these small woods.

Appendix 11. Four woods were unsurveyed due to the inaccessibility of the sites. These woods have not been included in any of the printouts or tables given above, but are listed in this Appendix.

3.3 Interrogation of data bank

3.3.1 The data bank can be interrogated in order to answer specific questions of an ecological or distributional nature. Thus it is possible to find and printout details of woods in or at:

- i) Any specified county, region or district
- ii) Any range of altitudes
- iii) Any range of wood area
- iv) Any species composition
- v) Any wood in which a particular species is dominant
- vi) Any geological type
- vii) Any woodland class
- viii) Any combination of the above characters.

The interrogation of the data can be combined with the map plotting procedure in order to display the number and area of any particular wood type. Examples of this plotting are given in section 4, where the distributions of woodland classes and dominant species is discussed. One further example will be given here in order to illustrate how the data interrogation system can be used.

3.3.2 Example of data interrogation: what is the distribution of woods occurring at an altitude of over 1000 ft and which of these woods contains less than 50% birch? Figure 2 shows that the high altitude woods are distributed mainly around the margins of the high mountain blocks of the Cairngorms, Monadhliaths, Mamores and western Highlands, with an outlying block in the Lammermuir Hills. Fig. 3 shows which of these woods contain less than 50% birch. The distribution pattern is similar to, but more restricted than, that shown in Fig. 2, as species other than birch are less tolerant of high altitude conditions. For example there are few woods of this type in the Cairngorms area since the conditions are suitable for few species other than birch. In west Perthshire, however, the more varied geological conditions enable more species to become established, and consequently more of the high altitude woods have less than 50% birch. A wide range of such questions can be put singly or in combination.

4. Ecological analysis

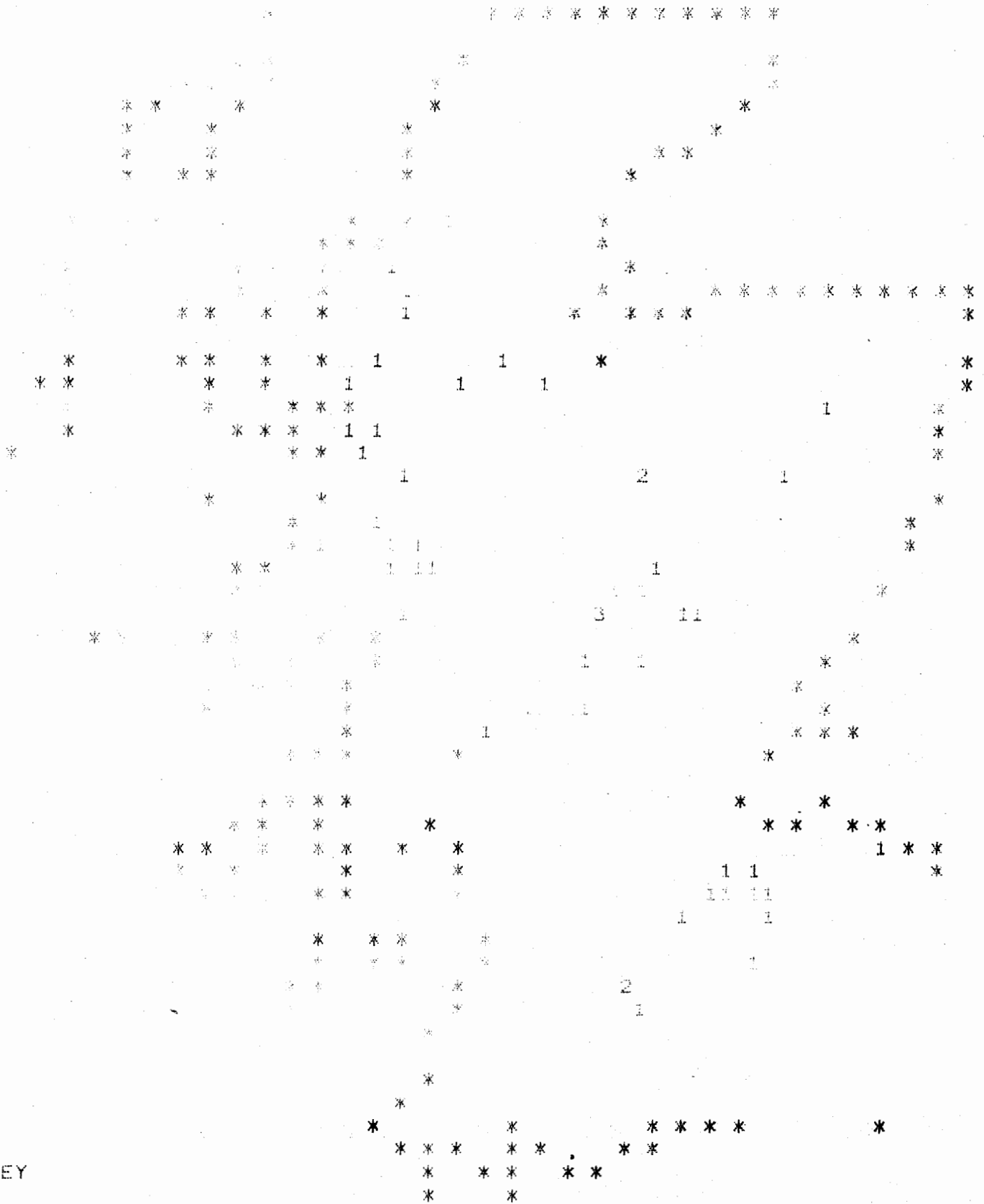
4.1 General introduction

4.1.1 The vegetation ecology of Scotland has been described in many of general publications which are largely based on personal interpretations of available data. However in ITE Project 424, the UK Ecological Survey, a systematic approach has been adopted which enables standardised comparisons to be made from a consistent data base and enables the affinities of Scotland to be assessed on nationally.

Data were recorded for a wide range of environmental features from 1228 1 km squares on a 15 x 15 km grid throughout the UK. By analyses, these data were divided into 32 types of square, termed land classes, and provided a key enabling a further 4000 squares to be assigned to their appropriate class. The distribution of these land classes and their proportional occurrence within regions, enables comparisons to be drawn

Fig. 3. Example of data bank interrogation.

DISTRIBUTION OF WOODS OVER 1000 FT. WITH LESS THAN 50% BIRCH



KEY

EACH POINT = 5 X 8 KM.

Table 6.

Proportions of groups of the land classes, defined by the U.K. Ecological Survey, in Scotland as compared with Britain as a whole. (The names refer to the centres of the distribution patterns).

	% in Scotland
Land classes 1-4 (English eastern lowlands)	less than 1%
Land classes 5-8 (South and western coasts)	0.9%
Land classes 9-12 (English midlands)	4.6%
Land classes 13-16 (English northern lowlands)	20.2%
Land classes 17-20 (Marginal uplands)	38.9%
Land classes 21-24 (Principal mountain areas)	87.6%
Land classes 25-28 (Scottish lowlands)	75.2%
Land classes 29-32 (Northwestern coasts and islands)	95.9%

17

between the affinities of the regions concerned. At the current stage of the project data are being processed to define the land classes in terms of their overall ecology. However, sufficient information is already available to show that there are high correlations between the classification and biological features such as acreages of crops and bird distribution patterns.

For the present purpose it seems unnecessary to consider the full range of 32 land classes and these are therefore reduced in the next section to eight groups of 4 classes each in order to define the patterns in broad terms.

- 4.1.2 Within the data recorded for the whole of the UK 2240 squares were from Scotland and the land classes to which they were assigned in comparison with the whole of the UK are given in Table 6. A brief summary of each group of land classes in terms of distribution and ecological characteristics is given below.

Land classes 1-4

These land classes are characterised by being almost flat and with a markedly continental type of climate. The land use is dominated by intensive agriculture, particularly cereals. Very few squares fall within this land class in Scotland.

Land classes 5-8

These land classes are widely represented in south-west England and have a gently rolling topography with a mild, moist oceanic climate. The land use is mixed with some cereals but mainly grass, with small fields, hedges and copses. A small proportion of squares in south west Scotland fall within this group of land classes and confirm the frequently observed similarity between south west Scotland and the south west of England.

Land classes 9-12

These classes are the more northern equivalent of 1-4 and have a more restricted climate for growth. The land is less uniformly

good for crops and so that the land use is not exclusively devoted to cereals, with more pasture although cereals still predominate in most areas. The flat lands of the Solway Plain and some of the land to the south of Edinburgh fall within this category. Few woodlands are present.

Land classes 13-16

Much of the southern lowlands of Scotland fall within this group of classes, which are mainly rather flat but which, because of the more variable conditions both in climate and soil, have an increasing area devoted to pasture and grass mainly leys. Woodlands with pronounced lowland affinities are quite frequent.

Land classes 17-20

These land classes contain the more rounded uplands around the margins of the higher mountains, but also occur to the west and south of Scotland where lower hills are present in their own right. Whilst there has been land improvement at lower levels, much of the ground is rough grazing. The exposure and altitude ensure that there are few woodlands within these classes.

Land classes 21-24

These classes contain the higher mountain areas in Scotland and are mainly present in the highlands, although there is some representation in the southern uplands. The majority of the land is unenclosed, with a restricted environment for growth. Few woodlands are present and those that occur invariably represent ecological extremes. These land classes are usually Scottish but others occur in northern England, mainly in the Lake District and Pennines.

Land classes 25-28

The northern lowlands of Scotland are a mixture of good arable land and poor soils due to variation in local conditions. These classes are therefore very variable, with elements from a wide range of

conditions, from arable and leys, to moorland under the poorer conditions. Woodlands are quite widespread and are also often variable both in canopy composition and general conditions.

Land classes 29-32

These classes are found almost exclusively in Scotland and represent the extremely variable ecological conditions of the western and northern coasts. Whilst there is some good grazing and a little arable land, the majority of the land is open moorland. The land forms vary from the low relief of Shetland to the more rugged scenery of Ardnamurchan. The woodlands are confined to the more sheltered areas and are dominated by the degree of exposure as well as the ground conditions.

4.1.3 The above summary emphasises the overall environmental trend in Scotland from the southern lowlands at the border with England, to the high mountains of the north on the one hand and the exposed western coasts on the other. As will be seen later in section 4.3, this trend is closely followed by the patterns of canopy composition established in the survey. A further comment is the high proportion of mountainous land classes in Scotland and their high contribution to this type of land in Britain. In addition, a major feature is the extremely varied nature of the south-western area of Scotland i.e. the Strathclyde and Dumfries and Galloway regions, as opposed to elsewhere in Scotland, as this area has a mixture of southern lowland classes as well as a representative of the exclusively Scottish types.

4.1.4 In the national woodlands survey (Bunce and Shaw 1972) the analysis of floristic data showed a trend from upland to lowland similar to that established for the land classification, further emphasizing the significance of this pattern in Scotland.

Taken in a British context, it seems likely that in this survey, although the range of variation was covered in Scotland, there is inadequate definition of types, since the proportion of woodland cover in Scotland to the rest of Britain is low and the number of sites covered was therefore small. Furthermore, because of the geological complexity, particularly in the west, when combined with the high rainfall, the ground conditions in Scottish woodlands are variable.

Therefore, following a parallel course to the strategy followed in the work on the Native Pinewoods, a more detailed analysis of Scottish woodland vegetation would produce a classification defining the types present in relation to Scottish conditions, and hence likely to be particularly useful in a Scottish context.

4.2 Species distributions

4.2.1 The relationships between the various species included in the canopy survey contain much ecological information. Some species, notably birch, occur over a wide range of environmental conditions and the factors affecting its distribution in the far north-west differ from those in the southern lowlands. The affinities between the species are studied in the next section and help to separate these influences - it is notable, for example, that, whilst birch occurs widely throughout Scottish woodlands, it tends to occur in pure stands only in the northern lowlands but in upland situations in the south. Birch also has different associates in the different areas.

In the present section, the background to the analyses will be set by comparing the distribution of the species. The method used to derive the maps is given in section 3.1 and a complete copy of all the species distributions given in Appendix 6. In the present section, the maps of the major species are given, together with some examples of the less important species, but a brief discussion of all the species is included. Two maps of each species were produced - where the species was dominant and where it was merely recorded as contributing to the canopy. The species are discussed in the order in which they appear in the Data Bank, derived from their affinities as determined in the next section.

4.2.2 In general terms, the species distribution patterns are distinct. The following notes highlight various points:-

Sycamore: (Figs 4 and 5). Occurs as a dominant mainly in the central valley, but is widely present in the lowlands elsewhere except in the north-west. It is absent from mountainous areas.

Beech: (Figs 6 and 7). Very similar to sycamore, except that it extends further as a dominant. The distribution of these species follows closely the pattern showed by the land classes 25-28 discussed in the previous sections.

Elm: (Figs 8 and 9). As a dominant, elm is restricted to a small area of the south-eastern lowlands, but, when considered as a constituent species it covers a comparable area to beech and sycamore although more restricted both in the mountains and the north and west.

Ash (Figs 10 and 11): Shows a very restricted distribution as a dominant, generally in coastal areas, but also in the central valley. However, when considered as a contributor to the canopy, it shows a pattern very similar to beech and sycamore, except that it extends somewhat further into the north-west.

Oak (Figs 12 and 13): Shows a distinctive pattern as a dominant in central Scotland, and particularly in Argyll, with an outlier in Dumfries. Otherwise, it is present widely throughout Scotland, except in the mountains and the far north. It is difficult to see an immediate reason for this distribution but the difference between the two maps perhaps indicate that it has an historical base, with selective felling outside the centre of its distribution causing a decline from an original wider distribution as a dominant.

Birch (Figs 14 and 15): Shows a widespread distribution, absent only from the higher mountain areas and the exposed far north-east.

Alder (Fig 16): Shows a scattered distribution, perhaps because it is controlled by local edaphic factors rather than on a larger scale.

Hazel (Fig 17): Shows a surprisingly widespread distribution as a contributor to the canopy, although mainly in the west, and particularly in Argyll. In contrast to oak and ash, however, it grows further north.

Rowan (Fig 18): Occurs around the margins of the mountains, but also widely in lowland districts, particularly in the north - perhaps reflecting its ability to compete in younger woodland, as it may still be widely present elsewhere as an understorey species (and hence not recorded).

Willow (Fig. 19): shows a surprisingly wide distribution, perhaps because several species are combined, the patterns of which may be superimposed. The centres of distribution in the central valley - Fife and Dumfries - are probably S. capraea, whereas other species are likely to be present in the north.

Of the minor species, Aspen (Fig 20) shows a distinctive pattern in the north.

Cherry (Fig 21): shows a similar pattern to beech although much more restricted in its occurrence. The remaining species show only isolated occurrences and are given in Appendix 6. Hawthorn (Fig 22) is mainly distributed in the central valley.

4.2.3 Another feature of the ecology of all species is their frequency of occurrence and this frequency is summarised for the 13 major species in Table 7. Sycamore, elm and ash show similar patterns, with very few sites attaining a high proportion - reflecting their ecological status as species occupying soil types that are of relatively limited extent.

Beech is more extensive, in that some woods are entirely composed of planted beech - although, in many areas in the east, particularly Aberdeenshire, it has become widely naturalised. Lime has a very low representation and has only been planted in policy woods. The high frequency of exotics is interesting, as they were present in 1465 woods (52% of the total number surveyed), indicating that less than half of the remaining native woods remain free of some planting within them. This number would be further reduced if the figures for Scots pine were considered. Oak is interesting in that its frequency pattern indicates its status, with birch, as the major native woodland dominant in Scotland. Oak occurs in 67% of all the woods surveyed and occurs as over half the

Table 7. Occurrence out of the total woods surveyed of the 13 major species in 5% canopy classes.

Canopy Classes	Sycamore	Beech	Elm	Ash	Lime	exotics	oak	Scots pine	Alder	Hazel	birch	Rowan	Willow
	1	2	3	4	5	6	7	8	9	10	11	12	13
1 - 5	654	510	564	871	192	713	606	578	660	324	264	710	629
6 - 10	242	261	178	337	22	291	278	123	132	37	210	41	62
11 - 15	111	148	100	113	8	122	144	38	47	17	143	10	18
16 - 20	101	130	45	88	5	117	119	25	27	10	135	4	16
21 - 25	64	78	12	42	1	67	82	7	11	1	66	2	5
26 - 30	54	71	18	47	1	55	89	16	14	4	87	-	6
31 - 35	27	36	9	18	-	31	56	6	6	3	52	1	3
36 - 40	16	36	6	12	1	38	69	11	6	2	111	-	4
41 - 45	14	20	3	5	-	15	62	6	1	1	76	-	2
46 - 50	7	33	3	4	-	9	60	10	2	1	99	1	2
51 - 55	3	17	4	-	-	51	1	2	2	61	61	-	3
56 - 60	7	19	-	4	-	4	52	2	3	-	76	-	-
61 - 65	4	17	3	3	-	-	37	1	2	1	58	-	-
66 - 70	3	9	1	2	-	2	46	-	2	2	104	-	-
71 - 75	6	17	2	-	-	-	43	-	5	1	83	-	1
76 - 80	4	12	1	2	-	1	47	-	4	2	113	-	1
81 - 85	3	11	-	2	-	-	27	-	4	-	110	-	-
86 - 90	-	8	-	1	-	-	39	1	2	-	201	-	1
91 - 95	-	8	-	1	-	-	12	-	1	-	214	-	-
96 - 00	-	2	-	-	-	-	8	-	1	-	242	-	-

DISTRIBUTION OF SYCAMORE DOMINANT WOODS

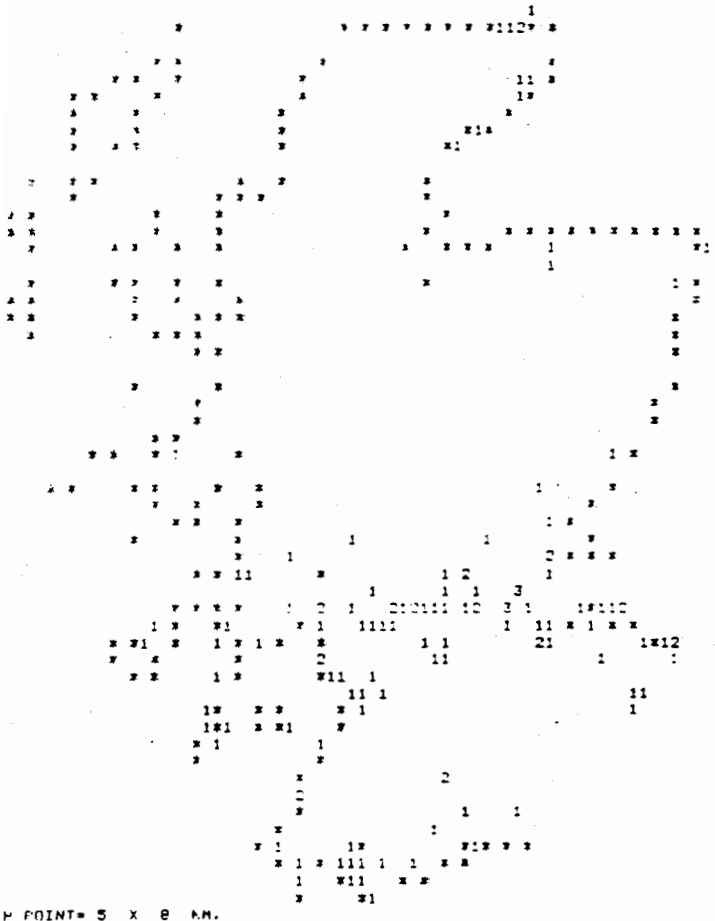


Fig 4

EACH POINT = 5 X 8 KM.

DISTRIBUTION OF WOODS CONTAINING SYCAMORE

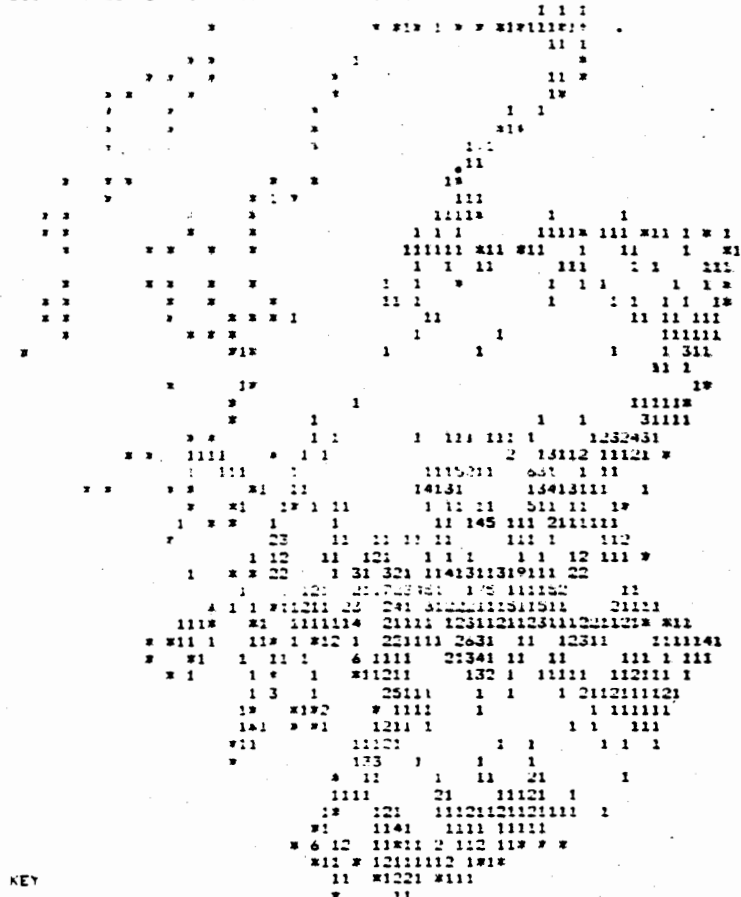


Fig 5

EACH POINT = 5 X 8 KM.

DISTRIBUTION OF BEECH DOMINANT WOODS

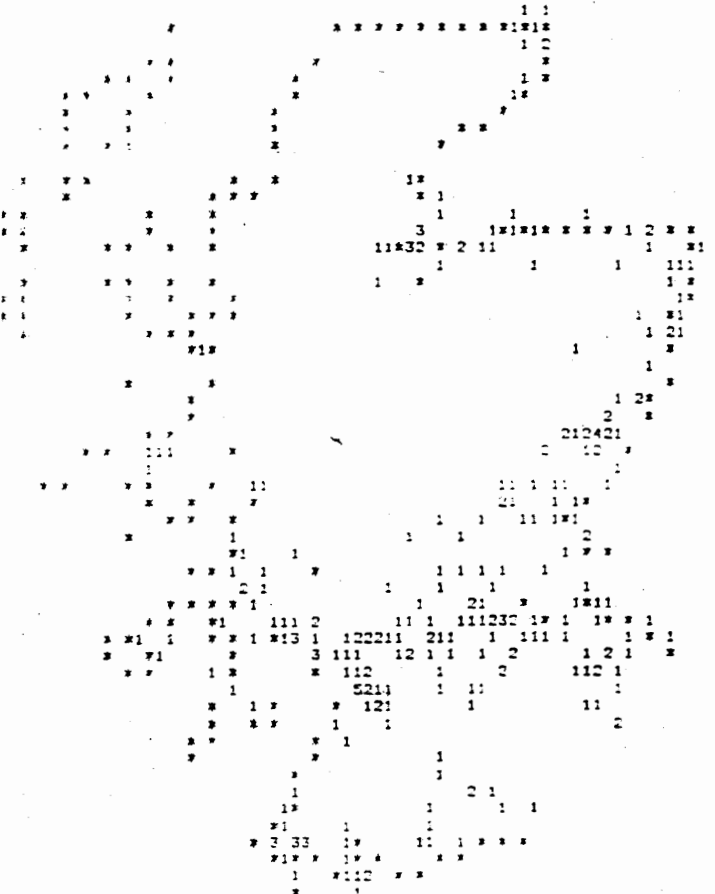


Fig 6

EACH POINT = 5 X 8 KM.

DISTRIBUTION OF WOODS CONTAINING BEECH



Fig 7

EACH POINT = 5 X 8 KM.

DISTRIBUTION OF ELM DOMINANT WOODS

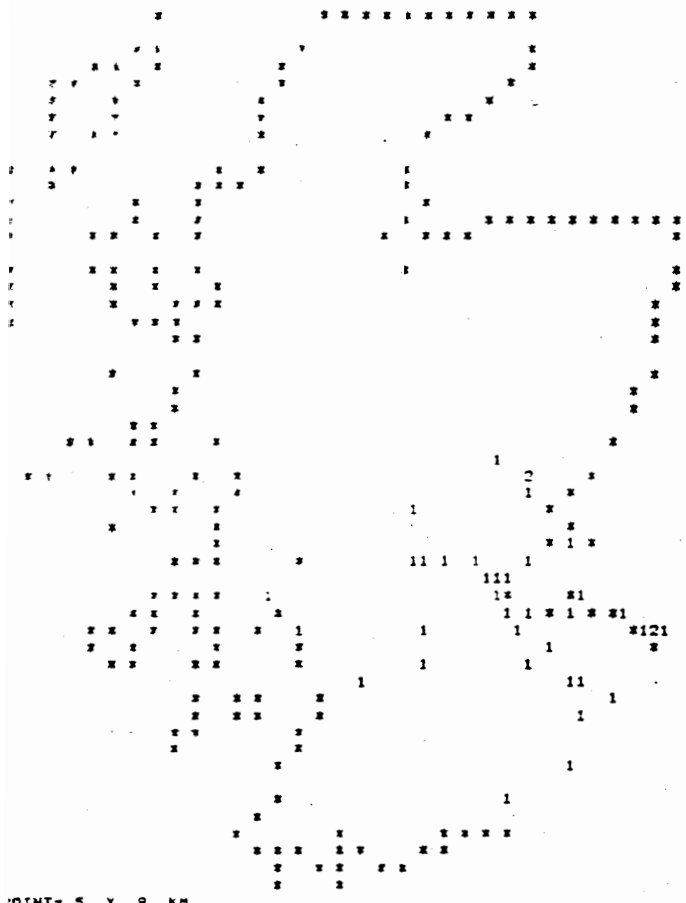
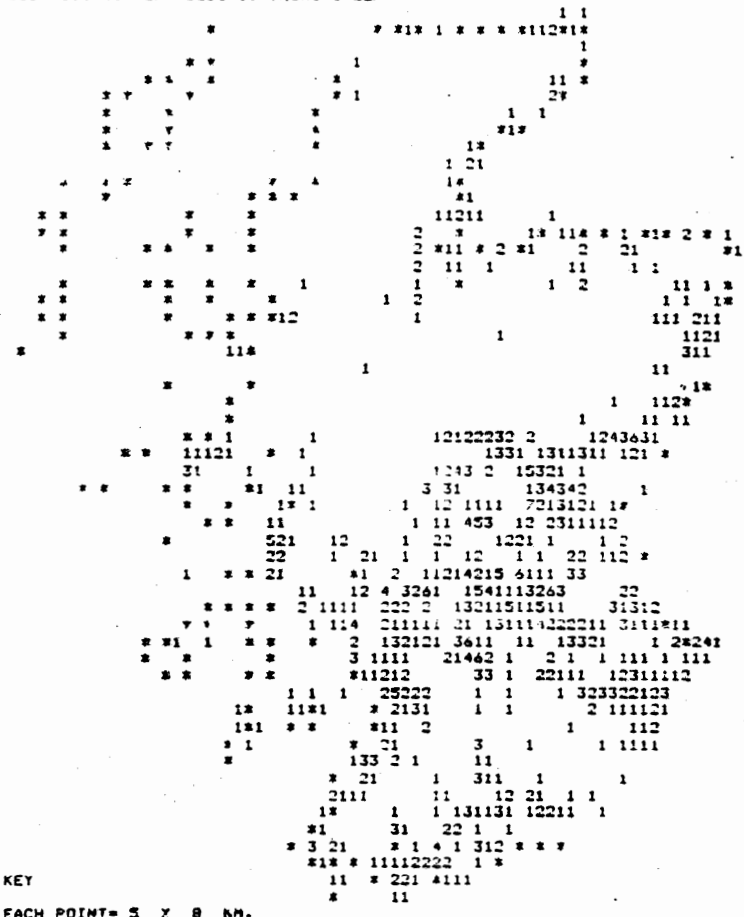


Fig 8

DISTRIBUTION OF WOODS CONTAINING ELM



KEY
EACH POINT= 5 X 9 KM.

Fig 9

DISTRIBUTION OF ASH DOMINANT WOODS

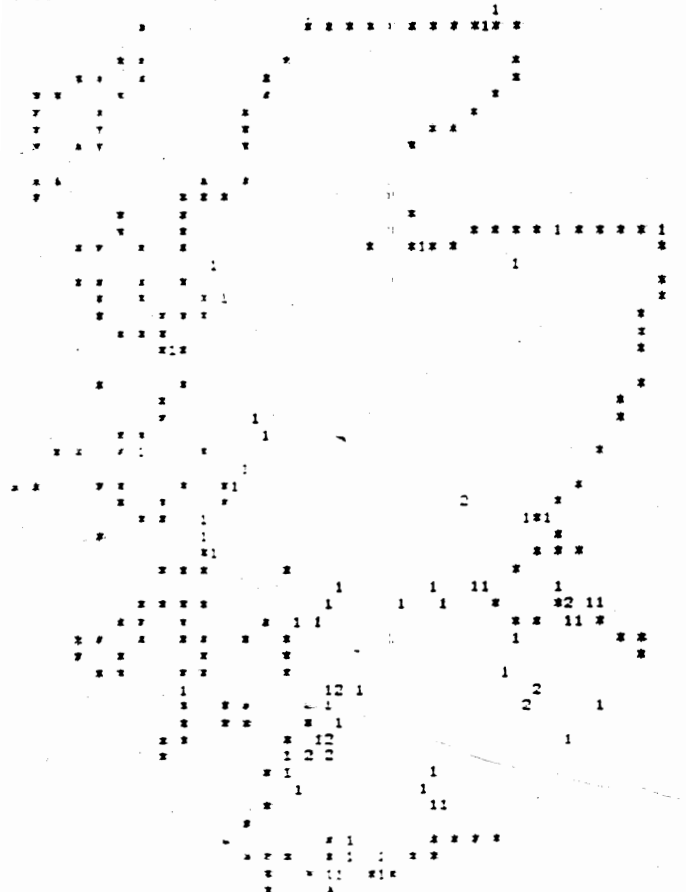


Fig 10

DISTRIBUTION OF WOODS CONTAINING ASH



KEY
EACH POINT= 5 X 9 KM.

Fig 11

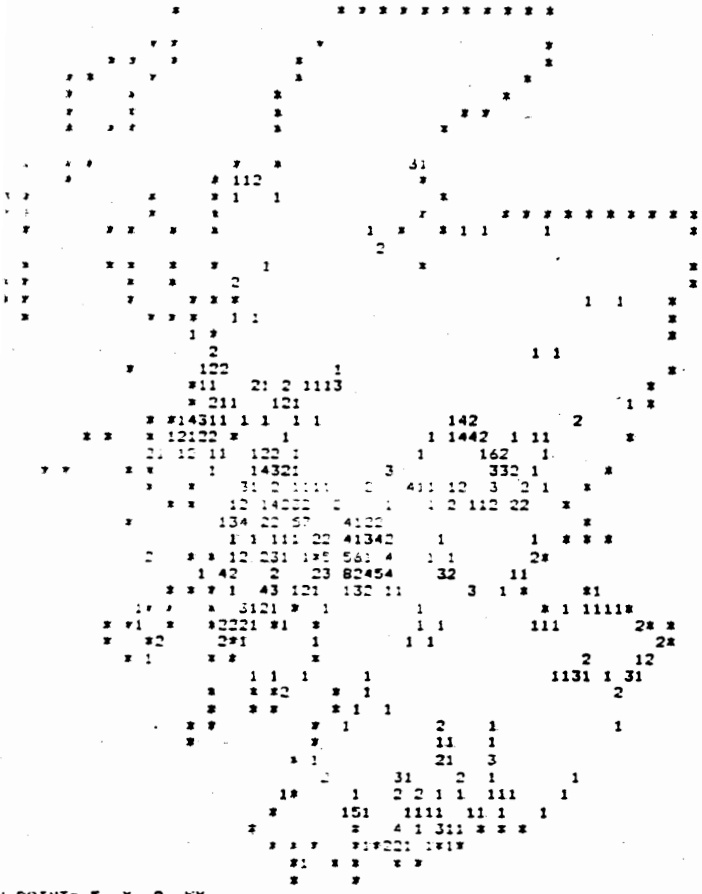


Fig 12



Fig 13

4 POINT= 5 X 8 KM.

KEY
EACH POINT= 5 X 8 KM.

- 1 = 1
- 2 = 2
- 3 = 3
- 4 = 4
- 5 = 5
- 6 = 6
- 7 = 7
- 8 = 8
- 9 = 9

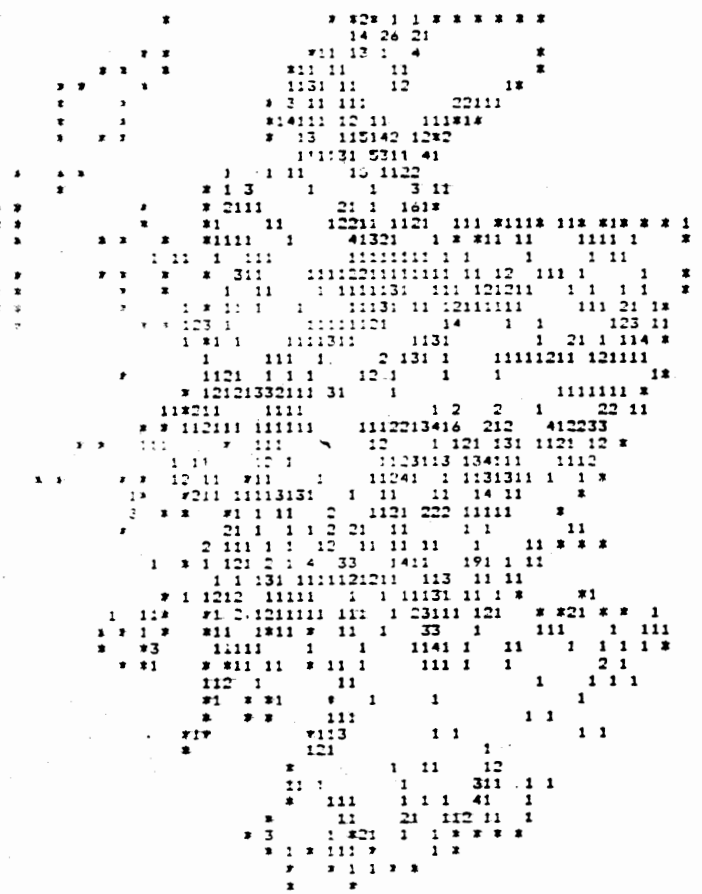


Fig 14

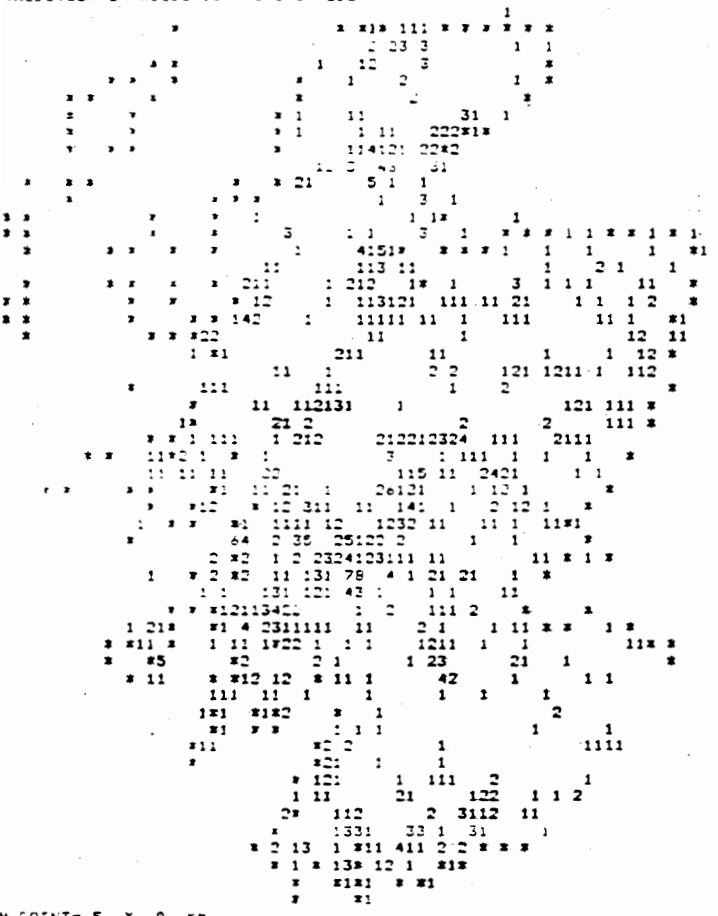


Fig 15

KEY
EACH POINT= 5 X 8 KM.

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- 2 = 2
- 3 = 3
- 4 = 4
- 5 = 5
- 6 = 6
- 7 = 7
- 8 = 8
- 9 = 9

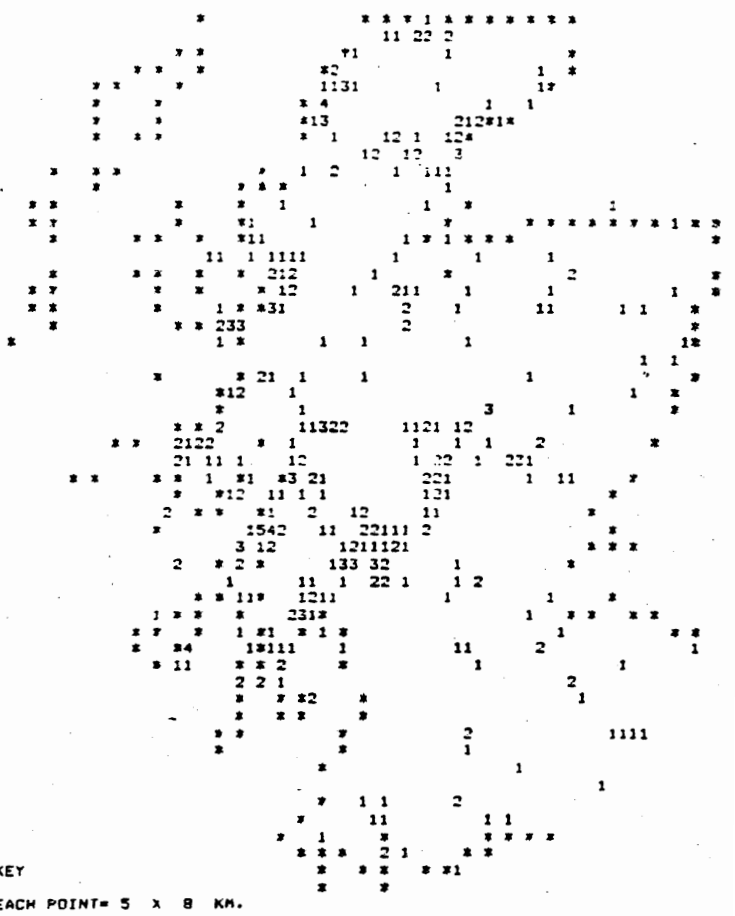
DISTRIBUTION OF WOODS CONTAINING ALDER



EACH POINT = 5 X 8 KM.

Fig 16

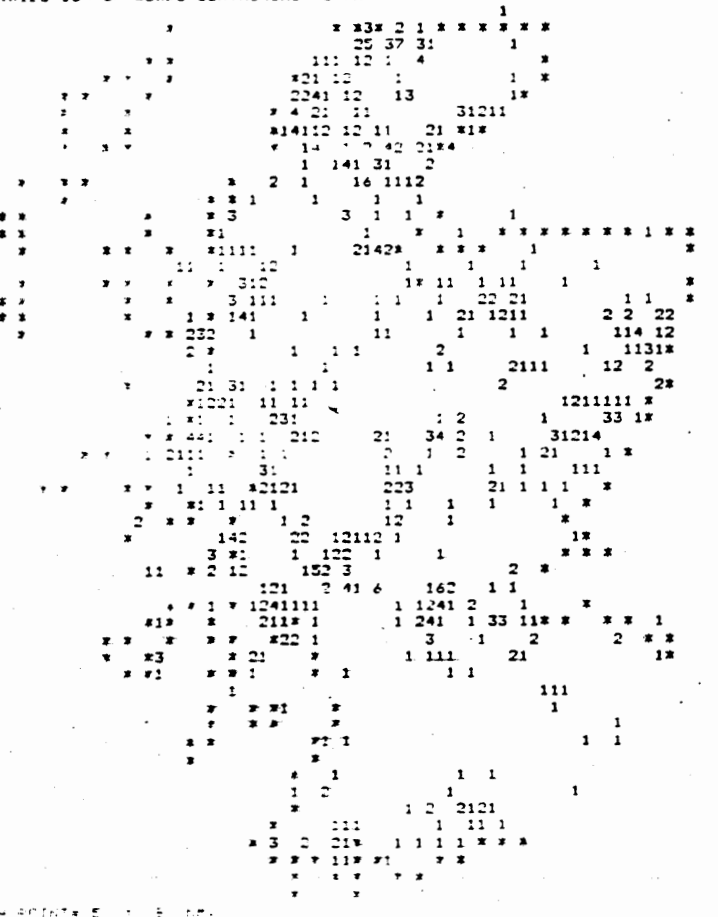
DISTRIBUTION OF WOODS CONTAINING HAZEL



KEY
EACH POINT = 5 X 8 KM.

Fig 17

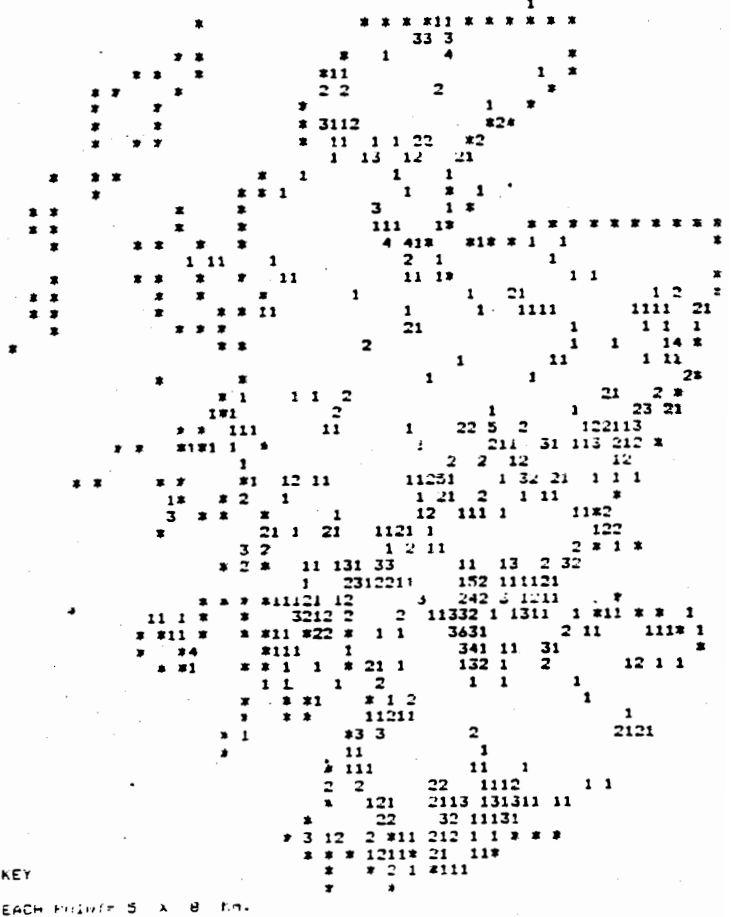
DISTRIBUTION OF WOODS CONTAINING ROWAN



EACH POINT = 5 X 8 KM.

Fig 18

DISTRIBUTION OF WOODS CONTAINING WILLOW



KEY
EACH POINT = 5 X 8 KM.

Fig 19

canopy in 13% of the sites. Alder occurs in a surprisingly large number of sites as a minor species and, in exceptional sites, renders a very high cover. Hazel, rowan and willow show similar patterns becoming significant contributors to the canopy only under exceptional conditions. Birch is the most widespread species occurring in 89% of all sites and occurs frequently in low and high proportions. It is possible that these reflect different aspects of its ecology - in low proportions, it may be acting as a colonising species, but, as a climax species, under different ecological conditions in pure stands. Further differences in distribution may be due to the ecological preferences of the two species.

4.2.4 The range of main woodland dominants is therefore restricted in Scotland and the species show well-defined patterns of distribution. Several of the minor species also show well-defined distribution patterns. Initially, it was intended to leave the study at this stage but it seemed useful to consider the occurrence of different combinations of species, as well as their overall interrelationships and these are considered in the next section.

4.3 Data analysis

4.3.1 Tests indicated that the data were sufficiently extensive to justify classification, in this case into broad groups of woods with a similar canopy composition, provided that their limitations are appreciated. Species with limited representation were eliminated, resulting in the thirteen species given in Table 7. Various methods are available for the analysis of such data, but the overriding problem in the present case is the number of woods which restricted the methods that could be used in the time available. The method used was the quantitative version of indicator species analysis (Hill et al 1975). The canopy composition was separated into the following categories, 1-10%, 11-40%, 41-80% and 81-100%. The first category indicated that the species was present, but in a small amount, whereas, if attaining the final category, it was effectively omnipresent. The middle categories were determined by dividing the remaining percentage in half. An earlier test using more classes had led to the separation of many minor facies, but this new test produced clearer patterns.

4.3.2 A diagrammatic view of the relationship between the species categories is given in Table 8. The species categories are grouped according to their ecological affinities. From left to right across the table, a trend can be recognised from canopy proportions likely to be associated with either southern upland or northern lowland conditions, to, at the other extreme, species compositions characteristic of southern and eastern lowlands. Thus, the species on the left are those which only achieve high degrees of cover in exposed or northern situations, such as rowan or birch, whereas, at the opposite extreme, sycamore and beech are particularly characteristic of lowland policy woods. In lower quantities, birch is associated with alder and willow, indicating, perhaps, that it occurs mainly on wetter sites when in these proportions.

The various categories of oak are closely related indicating that this species follows a distinctive pattern.

4.3.3 The relationships indicated by the above analysis are needed to assist in the interpretation of the next stage of the study, which was to classify the sites according to their species composition, the results of which are shown in Figures 25-25. For the present purposes, where groups produced by the analysis contained less than sixty woods, the group was taken at the next stage back up the hierarchy. The first division is primarily concerned with a separation of woods dominated by birch from those with either mixed canopies or dominated by other species. This separation may further be examined with reference to Table 9, in which the average species composition of each of the 21 groups of woods has been extracted, together with their frequency of occurrence. In the Table, a major separation can be seen between groups 11 and 12. Although birch occurs commonly in the first half of the analysis, nowhere does it reach such high levels of canopy cover as from group 12 onwards. Conversely, with the exception of groups 17 and 18, the frequency of sycamore is much lower from group 12 onwards. As with the species analysis, the divisions may be interpreted in environmental terms from sites of the northern lowlands and western and southern uplands to those in the lowlands of the south and east. Other environmental

	Willow 11-40		Alder 81-100		Oak 81-100				
	Willow 41-80	Hazell 11-40	Alder 41-80		Oak 41-80	Sycamore 11-40	Sycamore 41-80		
Birch 81-100	Hazel 41-80	Hazel 1-10	Alder 11-40	Oak 1-10	Oak 11-40	Beech 11-40	Beech 41-80	Sycamore 81-100	
Willow 81-100	Rowan 11-40	Rowan 1-10	Alder 1-10	Scots pine 11-40	Sycamore 1-10	Elm 1-10	Elm 11;40	Beech 81-100	
	Rowan 41-80	Birch 41-80	Willow 1-10	Scots pine 1-10	Beech 1-10	Lime 1-10	Lime 11-40		
		Scots pine 81-100	Birch 1-10		Ash 1-10	Ash 11-40	Ash 41-80		
			Birch 11-40		Exotics 1-10	Exotics 41-80	Ash 81-100		

Table 8. Summary of the affinities of the categories (%) used in the quantitative indicator species analysis of the canopy estimates. The species are ordered from left to right according to their weightings as determined in the first division of Fig. 21.

Table 9. Percentage canopy composition for the 21 groups (COV) and frequency of occurrence of the species as contribution to the canopy in that group (OCC).

GROUP		SY	BE	EL	LI	AS	EX	OA	SP	AL	HA	BI	RO	WI
1	OCC.	81.6	96.5	54.4	14.0	71.9	90.4	74.6	83.3	9.6	0.9	98.2	7.0	10.5
	COV.	5.7	17.2	2.7	0.3	3.3	15.2	4.5	6.5	0.3	0.0	43.4	0.2	0.5
2	OCC.	76.1	84.1	54.5	13.6	69.3	96.6	98.9	40.9	12.5	4.5	96.6	4.5	9.1
	COV.	5.6	17.8	3.0	0.4	3.9	18.6	21.8	2.4	0.5	0.1	25.7	0.1	0.2
3	OCC.	85.8	79.9	61.2	11.9	85.4	71.7	91.3	29.7	45.2	16.4	98.6	16.9	50.7
	COV.	6.9	4.4	3.2	0.3	7.1	3.7	12.7	1.7	4.2	0.9	51.3	0.3	2.9
4	OCC.	82.9	87.9	57.1	18.6	87.9	87.1	91.4	32.1	63.6	25.0	97.1	59.3	72.9
	COV.	6.7	16.2	2.5	0.8	6.6	13.9	15.9	1.7	5.3	0.6	24.9	1.2	2.9
5	OCC.	95.7	89.5	80.5	26.0	92.4	88.8	78.3	40.4	5.8	5.1	49.5	11.6	12.3
	COV.	23.0	15.9	12.1	1.3	14.1	13.4	12.3	2.4	0.3	0.3	3.8	0.2	0.3
6	OCC.	92.7	83.7	81.3	17.9	93.5	65.9	74.0	30.9	61.8	12.2	83.7	14.6	21.1
	COV.	17.8	15.1	10.7	0.7	18.3	4.9	10.4	1.5	4.7	0.5	14.1	0.2	0.6
7	OCC.	80.0	100.0	63.8	6.7	74.3	45.7	64.8	41.9	13.3	2.9	49.5	2.9	1.9
	COV.	11.8	65.0	4.0	0.2	6.0	1.8	3.6	3.1	1.2	0.2	2.7	0.0	0.0
8	OCC.	80.7	100.0	69.3	20.5	86.4	76.1	94.3	53.4	11.4	1.1	63.6	4.5	4.5
	COV.	5.2	39.7	4.3	1.0	6.5	13.3	22.3	3.7	0.4	0.0	3.3	0.0	0.2
9	OCC.	54.7	75.8	37.9	6.8	73.3	72.0	100.0	40.4	26.7	1.9	83.9	5.6	13.0
	COV.	2.7	5.7	1.8	0.1	4.9	7.8	60.2	1.8	1.8	0.0	12.6	0.1	0.3
10	OCC.	51.2	37.8	32.9	6.1	86.6	58.5	100.0	19.5	79.3	56.1	96.3	41.5	45.1
	COV.	1.9	2.0	1.2	0.1	5.9	3.2	58.7	0.4	4.5	3.4	16.8	0.7	1.2
11	OCC.	25.0	34.7	15.3	1.4	48.6	36.1	100.0	12.5	15.3	4.2	77.8	11.1	2.8
	COV.	0.6	1.5	0.4	0.0	1.3	1.4	88.7	0.2	0.5	0.2	5.1	0.1	0.0
12	OCC.	3.2	1.1	1.1	0.0	4.6	2.1	12.4	0.0	29.8	11.0	100.0	41.1	1.1
	COV.	0.1	0.1	0.0	0.0	0.1	0.1	0.5	0.0	1.3	0.4	95.6	1.5	0.0

Table 9. (continued)

GROUP		SY	BE	EL	LI	AS	EX	OA	SP	AL	HA	BI	RO	WI
13	OCC.	11.1	7.1	3.0	0.0	5.1	0.0	10.1	0.0	32.3	18.2	100.0	74.7	100.0
	COV.	0.3	0.2	0.1	0.0	0.1	0.0	0.3	0.0	1.2	0.3	91.4	2.3	3.5
14	OCC.	10.0	7.8	6.7	2.2	6.7	63.3	4.4	52.2	67.8	8.9	100.0	60.0	76.7
	COV.	0.3	0.3	0.1	0.0	0.1	4.2	0.1	1.6	7.2	0.1	76.5	1.6	7.5
15	OCC.	1.4	1.4	0.0	0.0	2.9	10.0	8.6	91.4	50.0	2.9	100.0	31.4	2.9
	COV.	0.1	0.3	0.0	0.0	0.0	0.8	0.3	18.2	3.8	0.0	75.3	0.9	0.0
16	OCC.	3.5	6.1	2.6	0.9	13.9	70.4	60.9	11.3	11.3	3.5	100.0	1.7	3.5
	COV.	0.1	0.2	0.0	0.0	0.3	5.1	2.7	0.3	0.4	0.1	90.6	0.0	0.1
17	OCC.	45.5	58.0	20.5	0.0	68.2	23.9	72.7	1.1	13.6	1.1	100.0	3.4	6.8
	COV.	1.2	2.7	0.4	0.0	2.0	0.8	2.5	0.0	0.5	0.0	89.4	0.0	0.3
18	OCC.	31.6	75.4	9.4	2.9	23.4	61.4	54.4	53.2	18.1	4.7	100.0	43.9	51.5
	COV.	1.0	4.6	0.2	0.1	0.6	5.1	2.0	5.2	1.0	0.1	76.5	1.1	2.2
19	OCC.	1.8	5.5	5.5	0.0	37.6	4.6	100.0	4.6	44.0	14.7	100.0	37.6	31.2
	COV.	0.0	0.2	0.1	0.0	1.9	0.3	63.5	0.1	3.1	0.3	28.2	1.1	1.1
20	OCC.	7.4	8.1	0.7	0.7	16.2	36.8	100.0	12.5	35.3	13.2	100.0	25.7	10.3
	COV.	0.3	0.3	0.0	0.0	0.8	2.9	31.9	0.9	2.9	0.8	57.5	0.7	0.6
21	OCC.	18.4	9.2	10.3	2.7	78.4	18.4	68.1	8.1	66.5	76.2	96.2	57.8	40.5
	COV.	0.9	0.5	0.3	0.3	6.0	1.8	8.9	0.7	9.2	7.6	58.0	2.3	3.1

interpretations are left until section 4.3.4. The second division in the lowland sections separates the oakwoods from the more mixed woods - groups 9-11 all have an average of over 50% canopy cover of oak. The other groups have more varied canopy compositions, with the next division separating woods with mainly birch in the canopy from those dominated by ash and beech. Within the birchwoods of the more upland types, the next division is between those woods with a more mixed composition as compared with those with almost pure birch. The latter are separated by the minor species such as willow that have specific ecological requirements. The more mixed woods are particularly associated with the west, and have a high proportion of oak, in addition to a wide range of minor species. The relative numbers of woods within each group indicate their abundance in Scotland.

4.3.4 The above outlines of the main divisions need to be considered in conjunction with Table 8, but also with the distribution patterns given in Figures 26-46. In due course, the environmental characteristics of these woods can be compared, but, for the moment, a brief interpretation of each group is given below. The names are given according to the canopy species, over 10% cover, and, where necessary, qualified additionally by a distribution pattern.

Group 1. Birch/beech/exotic (Fig 26).

Almost all these woods have some exotics included in the canopy, which is over 40% birch, as well as ash and elm. Probably mainly policy woods present in the lowlands of the east and the central valley, with a few outliers to the south and north. The birch may well have invaded.

Group 2. Birch/oak/exotics/beech (Fig 27).

Similar to Group 1, but with much less birch and with a high proportion of oak, perhaps indicating that these are oak woods which have been partially converted to a mixed canopy, whereas Group 1 may be established de novo. This conclusion is confirmed by the distribution which extends more into Argyll than group 1 and compares with the oak wood distributions of groups 9-11.

Group 3 Birch/oak (Fig 28).

The most widespread of the more mixed woods, containing a lower proportion of oak than group 2. There is also a wider range of other species, in particular ash and sycamore, indicating that the habitat composition is rather more varied, and, with the lower proportion of planted species, that the woods as a whole are less disturbed than groups 1 and 2. The distribution is more southerly than the previous types and has its main centre in the central valley and Perthshire.

Group 4 Birch/beechn/oak/exotics (Fig 29).

The higher frequency of the more upland species such as rowan and hazel indicates that this is perhaps a more upland and wetter group than the previous three. The canopy is also more evenly distributed between the species, but there are still many planted trees. The distribution is a more restricted variation of group 3.

Group 5 Sycamore/beechn/ash/exotic/elm/oak (Fig 30).

These woods are varied and from the species composition are on basiphilous lowland situations, in which a wide range of planted species have been included. As such, many are likely to be policy woods, but probably often on old woodland sites. The distribution is concentrated in the central valley and the southern lowlands.

Group 6 Ash/sycamore/beechn/birch/elm/oak (Fig 31).

Very mixed woodlands, composed mainly of native species, with some planted trees, but less than in the previous group. Probably smaller woods in basiphilous situations by streamsides. A more restricted pattern of distribution than group 5, but with a similar extent.

Group 7 Beechn/sycamore (Fig 32).

Plantations of beech come within this category with a small admixture of sycamore, also probably planted, but with a small cover of other species. Probably not on old woodland sites and with a restricted distribution to lowland situations.

Group 8 Beech/oak/exotic (Fig 33).

Comparable to group 7 but with a lower proportion of beech, which is replaced by oak, perhaps indicating conversion from originally native woodland. Lime and birch are also more frequent, but the overall pattern of distribution is rather similar to group 7.

Group 9 Oak/birch (Fig 34).

These woods are of the drier type of lowland oak with a distinctive distribution pattern in Argyll, Perthshire and Dumfries. Although species such as ash and sycamore are commonly present they rarely contribute much to the canopy.

Group 10 Oak/birch (western) (Fig 35).

This group, although having a similar overall canopy composition to 9 has a wider range of other species such as alder and willow indicating the presence of flushes. This is also reflected in the markedly western distribution of the type as in Argyll.

Group 11 Oak (Fig 36).

A restricted group in which oak forms almost the entire canopy - perhaps so pure that they may well be planted in many cases. The distribution pattern is a more restricted version of group 9, and only birch has a significant frequency, apart from the major species, but only attains a small canopy cover on average.

Group 12 Birch (highland) (Fig 37).

A well-defined group of almost pure birch from the margins of the higher hills in Central Scotland to the northern lowlands.

Group 13 Birch (upland) (Fig 38).

Although the canopy is still almost exclusively birch, the high frequency of willow and rowan separates this group from 12 and indicates a combination of more upland as well as probably wetter ground conditions. The distribution pattern is wide, being in the lowlands in the north and uplands to the south.

Group 14 Birch (eastern) (Fig 39).

Separated from the previous group by the presence of Scots pine, albeit in low quantities, this group represents the drier sites of the east, often with podsollic soils on morrainic material. The distribution is mainly in the east.

Group 15 Birch/Scots pine (Fig 40).

This group has a lower proportion of exotics than group 14, as well as lower frequencies of other species such as willow and is thus probably on less variable sites, perhaps where Scots pine have been cleared and subsequently invaded by Birch. The distribution is central and western rather than the marked eastern pattern of the previous group.

Group 16 Birch (Fig 41).

These woods apart from the high cover of birch have a consistently high frequency of oak and exotics, indicating some planting, but perhaps also that this group is intermediate between the pure oak and birch, with oak being reduced in quantity but surviving in most sites. The distribution pattern confirms this group as being intermediate between the two types of distributions described for oak and birch above.

Group 17 Birch (flushed) (Fig 42).

This group differs markedly from the previous group in having a consistently high representation of species such as ash, elm and sycamore, but in low quantities, indicating basiphilous flushes. The distribution is restricted mainly to Perthshire, with some outliers.

Group 18 Birch (with planted species) (Fig 43).

This group has a higher representation of beech, Scots pine and exotics than the previous type, as well as a lower proportion of the species from more basiphilous habitats. Therefore, it seems likely to be more disturbed as well as less diverse and its distribution is much more widespread but being absent from the west.

Group 19 Oak/birch (western) (Fig 44).

A relatively undisturbed group with a restricted distribution almost confined to Argyll. The high frequency of ash and willow indicate flushed conditions and the distribution pattern suggest a consistently high humidity.

Group 20 Birch/oak (north and western) (Fig 45).

A relatively even mixture of birch and oak with a much wider distribution than the previous group, extending to the northerly limits of sites containing an appreciable quantity of oak. Drier than the previous type also with evidence of more planting of exotics.

Group 21 Birch (mixed) (Fig 46).

The high proportion of alder and a number of species characteristic of open canopy composition, indicate that this group is rather wet and open and often flushed, as well. A wide range of native species is present and these woods are rather variable. The distribution is mainly in the west, but with outliers elsewhere.

- 4.3.5 These preliminary descriptions define the main combinations of the species canopy composition as defined by the analysis. With further interpretation, their ecological characteristics could be defined more closely, but a wide range of different patterns has emerged that throw up some interesting hypotheses. In particular, the lowland groups show the importance of management which dominates their species composition and relationships. The patterns of distribution of these types are similar variations on a theme. The more upland types, on the other hand, show more readily interpretable environmental patterns, presumably because they are less disturbed and the species composition is therefore more closely associated with the environment.

Fig. 2. Hierarchy of the Analysis of Canopy Composition (Part 1).

Cover categories. I = 1-10% M/L = 11-40% H/H = 41-80% H = 81-100% Thr = Threshold.

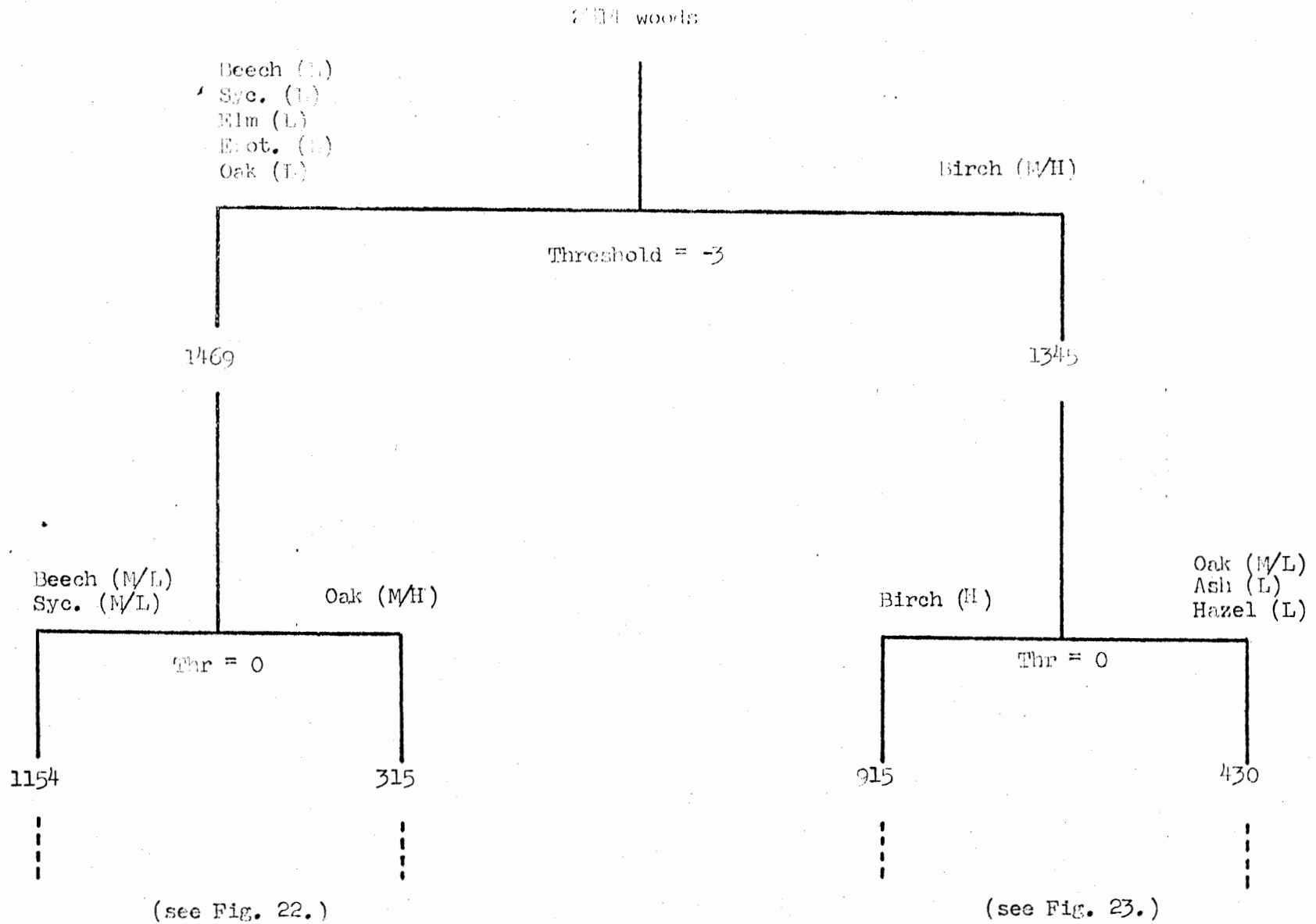


Fig. 24. Hierarchy of the Analysis of Canopy Composition (Part 2).

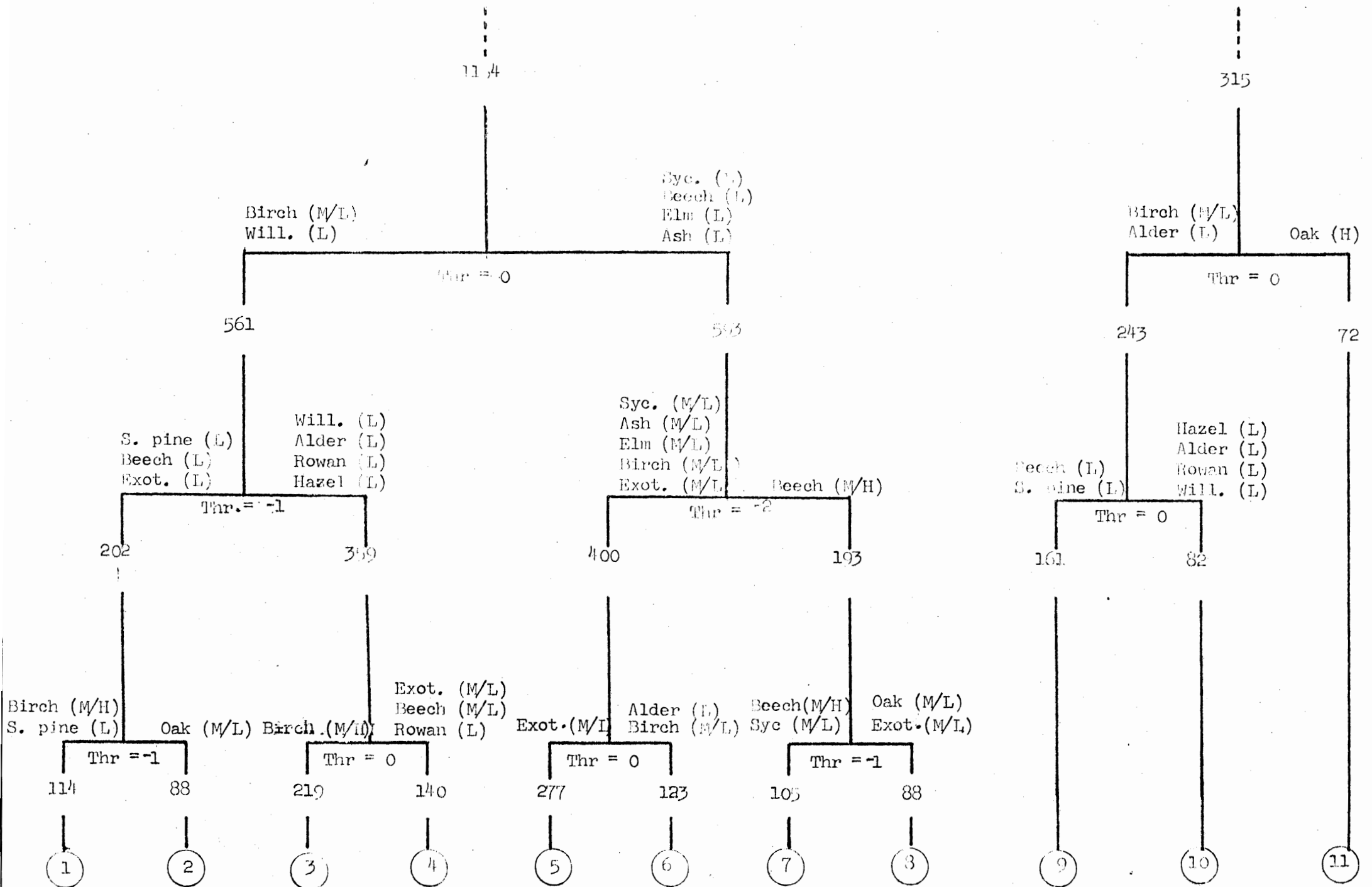
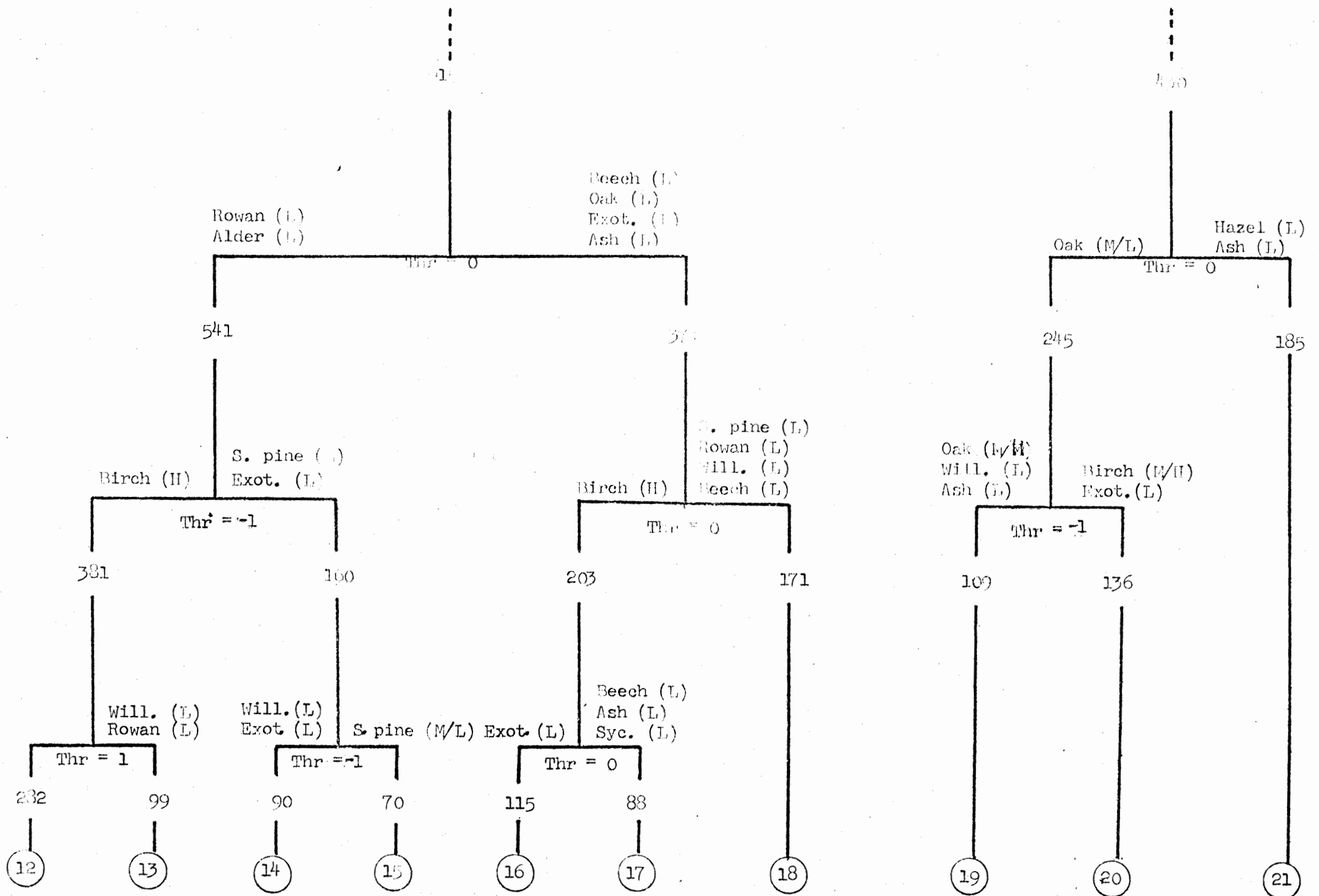


Fig. 25. Hierarchy of the Analysis of Canopy Composition (part 5).



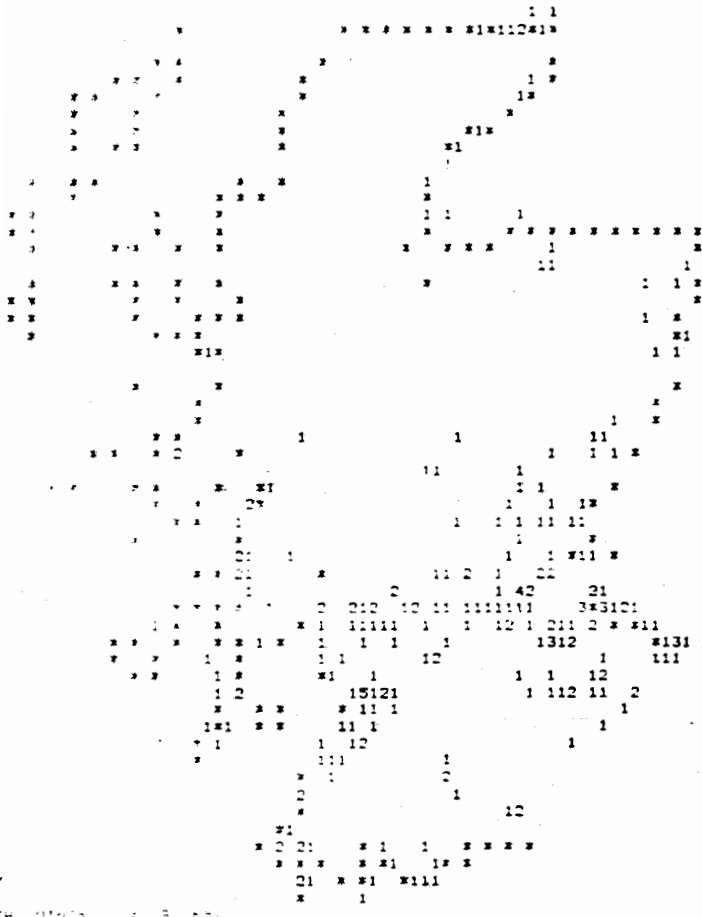
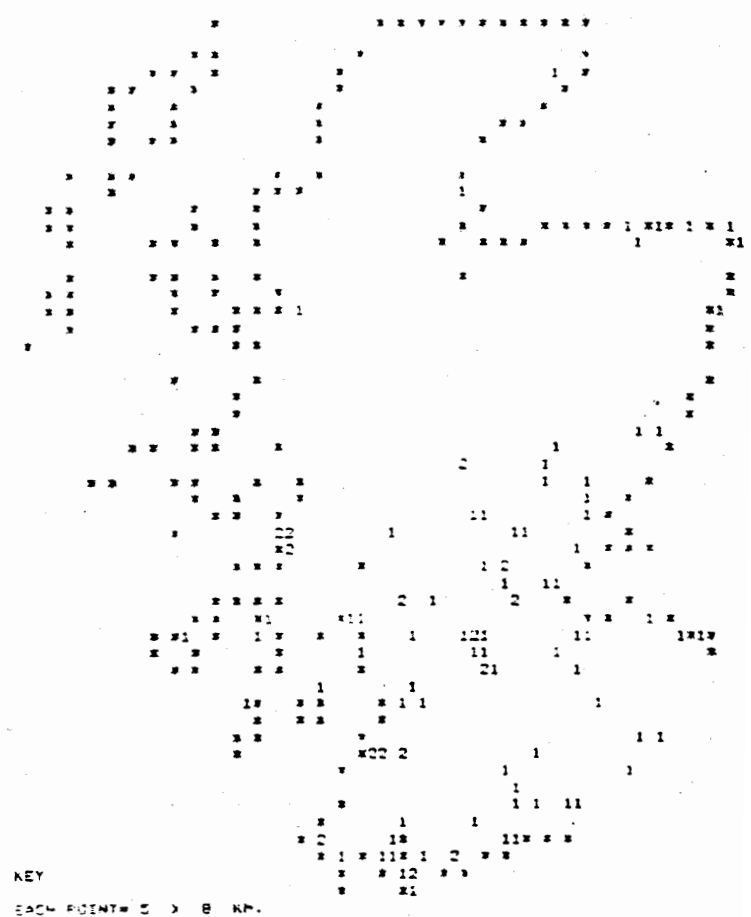


Fig 30
Sycamore/beech/ash/exotic/elm/oak



KEY
EACH POINT = 5 X 8 KM.

Fig 31
Ash/sycamore/beech/birch/elm/oak

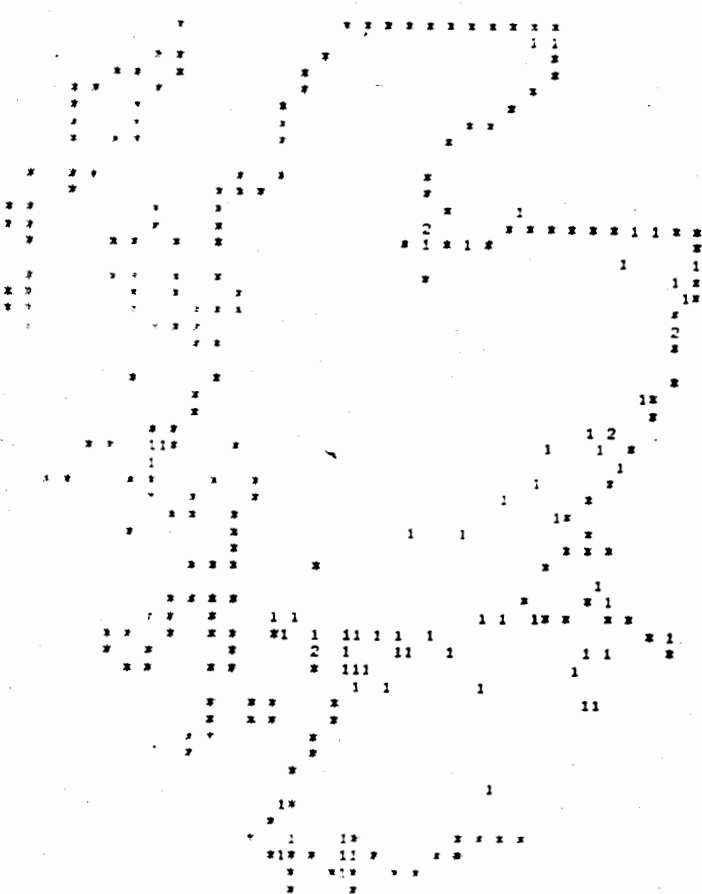
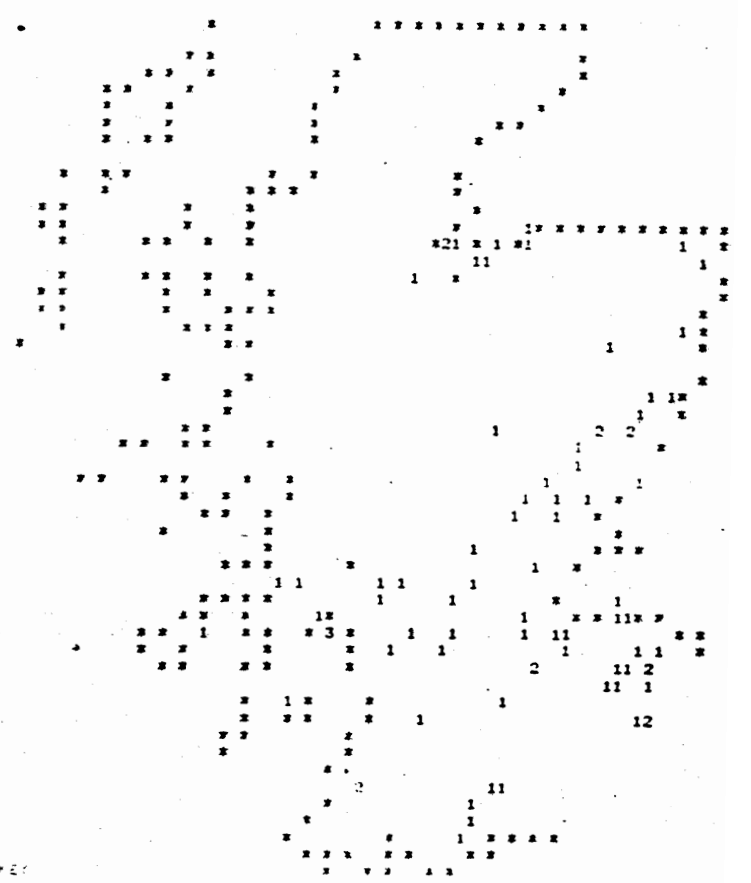
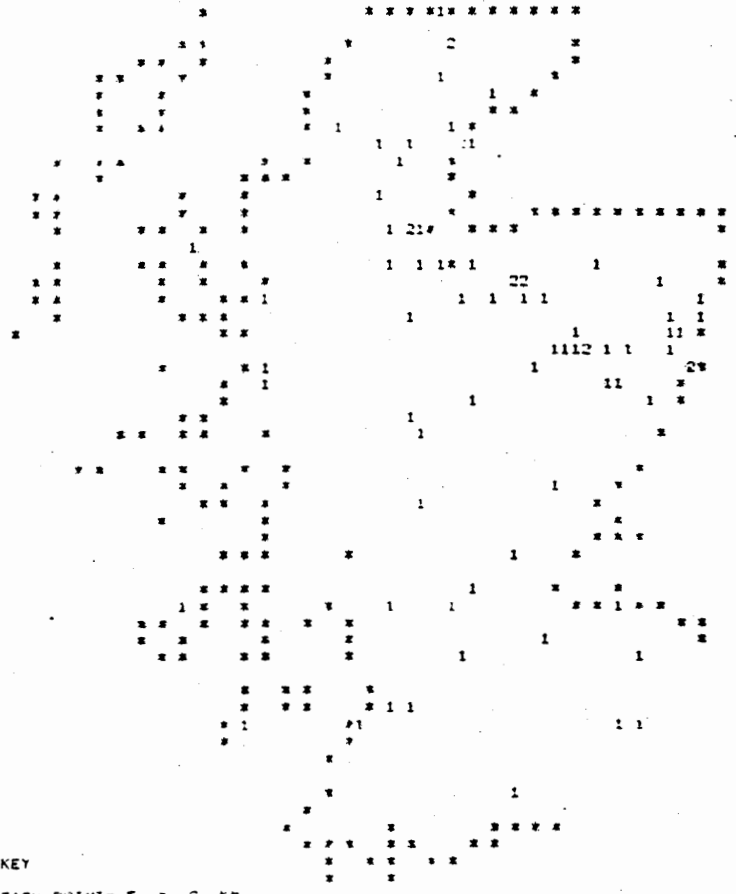
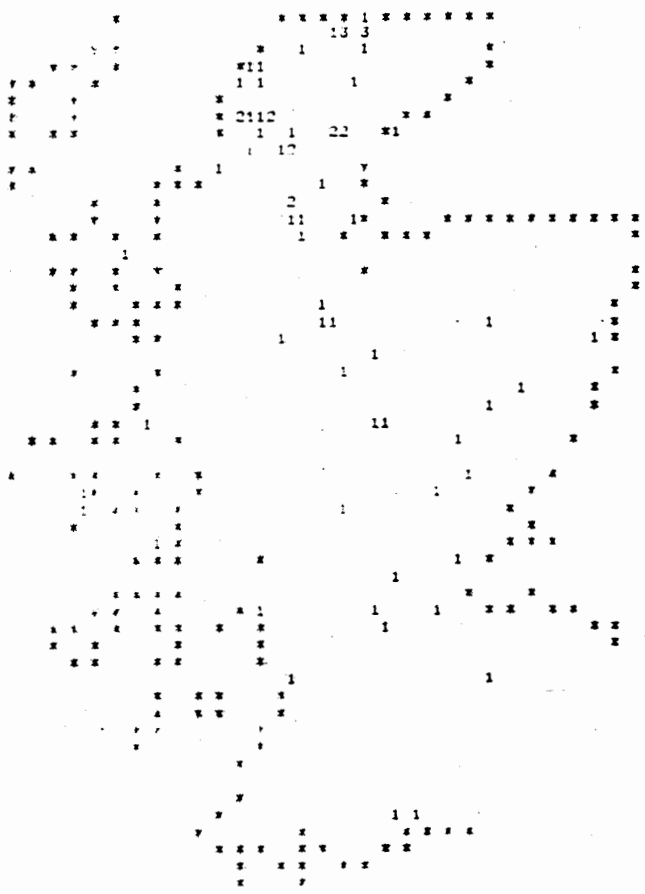


Fig 32
Beech/sycamore



KEY
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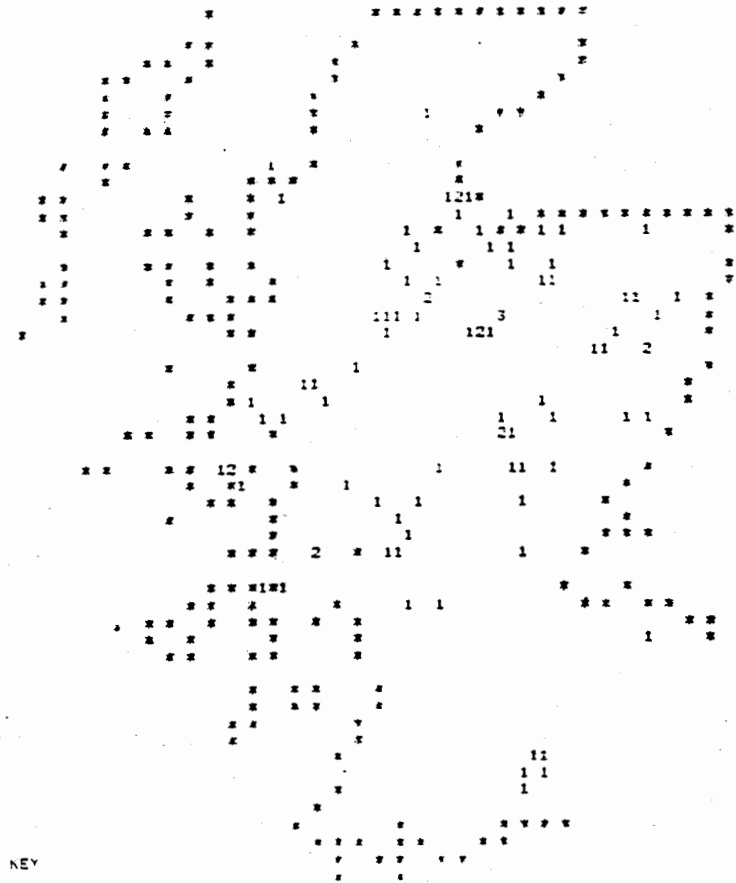
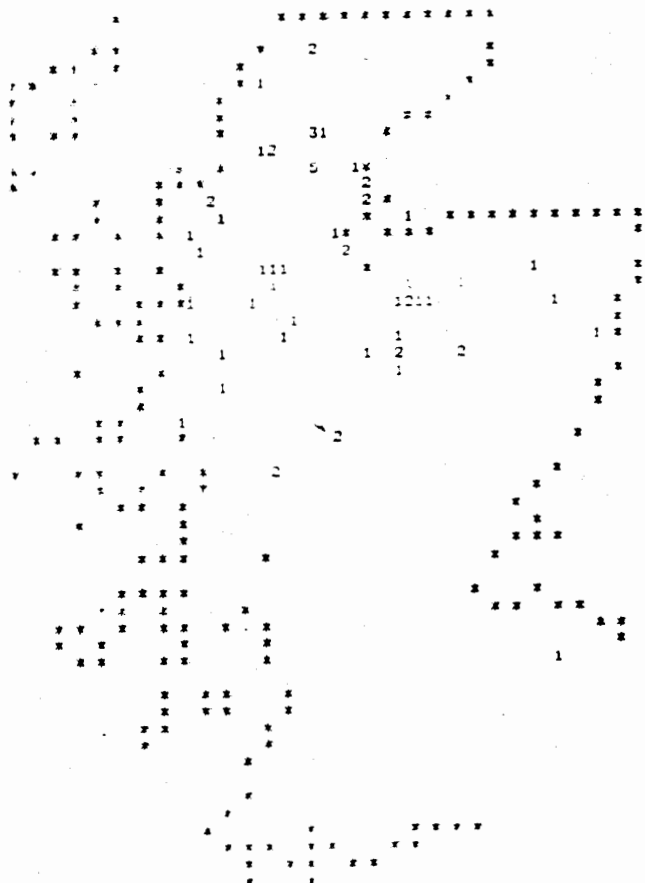
Fig 33
Beech/oak/exotic



KEY
EACH POINT = 5 x 5 KM.

Fig 38
Birch
upland

Fig 39
Birch
eastern



KEY
EACH POINT = 5 x 5 KM.

Fig 40
Birch/Scots pine

Fig 41
Birch

DISTRIBUTION OF WOOD CLASS 21

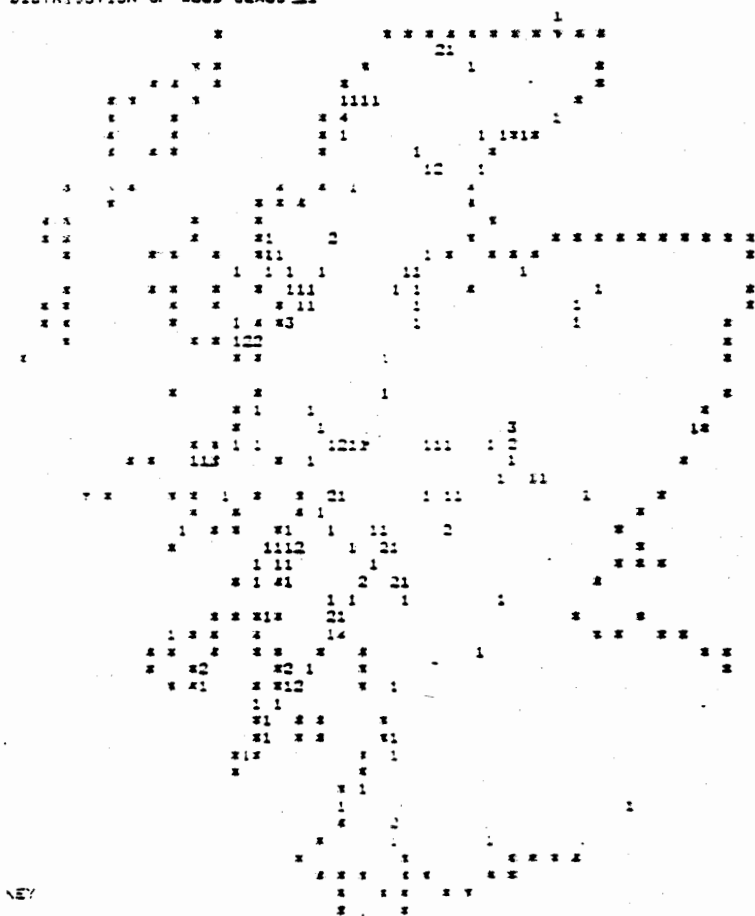


Fig 46
Birch
mixed

5.1.4 The revision dates of the 7th series OS maps range between 1954 and 1967, which should indicate that the decline of 36% has occurred over the past 20 years. However, this dating assumes that at the time of revision, all maps are perfectly accurate in their depiction of deciduous woodland areas. In order to examine this assumption, and to investigate the possibility of using OS maps to reveal longer-term changes in woodland cover, a search of old OS maps was carried out. Six-inch map editions were used, as these were found to give the best coverage of the areas chosen for the search. Eight, 1 km squares were selected from a range of UK land classes, from each of which approximately ten woods were chosen. The area of each wood was then measured on a series of maps whose revision dates varied from 1861 to 1978.

On the earliest maps, the 90 woods included in the search covered an area of 2034 ha. This area had declined by 7%, to 1942 ha on the most recent maps. The overall impression was that woodland symbols were not updated where deciduous woods were converted to conifers, and, consequently, the decrease in deciduous woodland area was underestimated. OS maps do not therefore provide a reliable baseline for the assessment of change, and it is not possible to state with any certainty over what period of time the calculated 36% decrease in 5.1.3 has occurred.

5.1.5 Whilst the comparison given above may not give a precise measure of woodland change, it does provide a general indication of the trend; namely that the area of deciduous woodlands in Scotland has been decreasing. By classifying the deleted woods according to the reason for their deletion (Table 10) it can be seen that the main reason for the decline is conversion to conifers.

The distribution pattern of deleted woods is shown in Fig. 47. Apart from a concentration in Aberdeenshire, South Argyll and Dumfries, and exceptionally low numbers in Sutherland and Caithness, there is a fairly even pattern of deletions throughout Scotland.

5.2 Comparison with 1947 Forestry Commission census

5.2.1 Between 1947 and 1949 the Forestry Commission carried out a census of all Scottish woodlands over 5 acres (2 ha), in which woods were classified according to type of crop, age class, condition and

species composition. At a superficial level, the data from this census (as presented in the FC Census Report No. 4: Scottish County Details) can be compared directly with those of the present survey to give an indication of how woodland area and species composition have changed in the past 30 years (Tables 11 and 12). However, several methodological differences exist between the 1947 census and the 1977 survey which make such a direct comparison liable to considerable error. These differences are explained in the following sections.

- 5.2.2 The 1947 census included all woods of 5 acres (2 ha) or more, whereas the lower limit for the 1976/77 survey was 5 ha. Although the discrepancy between the two surveys will be great in terms of the number of woods included, the effect on the total areas of woodland will be less.
- 5.2.3 The 1947 census was based on 6" OS maps, where the 1977 survey was based on 1" OS maps. This difference gives rise to two possible sources of error. First, some woods of 5 ha or over do not contain a woodland symbol on the 1" maps, usually because they are of an unsuitable shape. Thus, the 1977 survey will probably have missed some woods that would have been included in 1947. Second, experience has shown that identical woods can be given markedly different areas according to the scale of the map used. This difference may partly be due to a difference in the revision dates of the maps, but also to a relative lack of resolution of woodland areas on the 1" map. In the 1977 survey, the field survey included a check on the areas recorded in the map search, but these checks would only reveal major discrepancies.
- 5.2.4 The unit on which the FC census was based was the 'stand'. A stand was defined as any area of woodland, one acre or more in extent, which was uniform for the purpose of description. In 1947, large woods would invariably have been divided up into a number of smaller homogenous units, whereas, in 1977, they would have been treated as a whole. This difference is illustrated by the fact that the 1947 census covered 100,890 stands, whereas only 3,188 were included in the 1977 survey. It is difficult to judge precisely what effect this difference would have on the total area of deciduous woodland recorded, but easier to see that it could markedly affect the species proportions. This latter aspect is discussed below.

Table 10. Deleted areas of woodland classified according to their reason for deletion (areas in ha).

Reason for deletion	deleted woods		reduction in	total	%
	No.	area	area of existing Woods		
Coniferisation (i.e. > 50% exotics)	711	20,530	13,931	34,461	97
Felled	15	256	150	406	1
In process of felling	2	28	-	28	-
Underplanting with conifers	17	455	51	506	1
Canopy too sparse	4	46	26	72	-
Other	3	27	19	46	-
TOTAL	752	21,342	14,127	35,469	100%

Table 11. Comparison between data from 1947 FC census and 1977 survey results. The estimated decline does not take into account any of the sources of error listed in section 5. (All areas in ha).

County	1947				Coppice	1977		Estimated decline
	Mixed H.F.	brd. lf. H.F.	brd. lf. Scrub	total brd. lf.		Existing woods		
Sutherland	129	180	3014	-	3263	2332	13%	
Caithness	76	93	375	-	498	479	4%	
Ross	499	900	7824	-	8922	3935	56%	
Inverness	941	1713	21911	-	24022	10323	57%	
Nairn	149	299	1613	-	1997	816	59%	
Moray	346	876	2017	-	3051	1003	67%	
Banff	399	855	2121	1	3171	1157	64%	
Aberdeen	1181	2066	4968	4	7658	2723	64%	
Kincardine	629	715	962	-	2135	437	80%	
Angus	632	1726	2731	-	4883	1422	71%	
Argyll	880	4244	19022	-	23782	10406	56%	
Perth	1577	5488	15107	106	21639	7323	66%	
Stirling	388	1461	2220	-	3938	2465	37%	
Kinross	53	106	91	-	234	197	16%	
Dunbarton	181	671	2021	-	2825	1273	55%	
Clackmannan	43	151	433	-	621	152	76%	
Fife	578	1827	919	-	3044	1260	59%	
Renfrew	147	346	486	-	911	721	21%	
Bute	165	211	757	-	1087	677	38%	
Ayr	874	1338	1779	-	3698	1744	53%	
Lanark	500	1977	1115	-	3382	2086	39%	
W. Lothian	145	486	332	3	888	338	62%	
Midlothian	287	1667	490	-	2315	1422	39%	
E. Lothian	421	1113	461	3	1857	964	48%	
Peebles	369	456	41	-	676	327	52%	
Berwick	873	1466	207	3	2219	677	69%	
Selkirk	271	367	152	-	646	149	80% *	
Roxburgh	586	1374	204	3	1874	725	61%	
Wigtown	429	1123	554	1	1927	986	49%	
Kirkcudbright	583	2057	1757	102	4353	1622	63%	
Dumfries	837	1909	1401	8	3807	1023	63%	
SCOTLAND	15069	39261	97085	234	145323	61664	58%	

* Figure does not include 3 woods included in data bank as a result of 2½" map search.

Table 12. Change in average species composition (percentage canopy cover) of Scottish deciduous woods between 1947 and 1977. (- = no equivalent figures in 1947 census).

	1947	All species	Principal species
Sycamore	3	5	4
Beech	14	8	8
Elm	2	3	1
Lime	-	1	1
Ash	2	4	2
Hawthorn	-	1	0
Exotics	-	8	7
Oak	20	19	20
Whitebeam	-	1	0
Cherry	-	1	0
Blackthorn	-	1	0
Scots pine	-	3	2
Alder	2	2	1
Holly	-	1	0
Hazel	1	1	1
Birch	56	45	54
Aspen	-	1	0
Rowan	-	1	1
Willow	1	1	1

5.2.5 In arriving at a classification of woodland types, the 1947 FC census made use of the concept of a 'principal' species. Under this system a whole stand is classified according to its one most dominant or 'principal' species. On a national scale, this procedure would tend to overestimate the area of the more abundant species and underestimate the area of rarer species. The FC practice of dividing large woods into homogeneous stands would tend to reduce the discrepancy, but it is apparent that the method is not equivalent to that used by ITE. The principal species concept can be applied to the ITE data (i.e. Appendix 5 Table v), but, once again, because of the use of stands by the FC, the figures are still not exactly comparable. A large wood classified by the FC technique of principal species in homogeneous stands would not usually be equivalent to taking the principal species of the wood as a whole. In terms of comparing the 1947 and 1977 data for species, it is likely that the 1947 figures are equivalent to a figure between the 1977 figures using all species and the figure using principal species only.

Although the county summaries of the FC census deal only with principal species, the original data were collected in a manner which would make them very closely comparable with the 1977 survey. This information is only available on the original FC record cards.

5.2.6 The 1947 FC census classified all existing woodlands into one of 7 types:-

- i) Coniferous high forest
- ii) Mixed high forest
- iii) Broadleaved high forest
- iv) Coppice with standards
- v) Coppice
- vi) Scrub
- vii) Devastated areas from which the best timber had been removed.

The category of mixed high forest includes all mixtures of conifers and broadleaf trees, where either category constitutes more than 20% of the whole. The 1977 survey marked woods as deleted if they contained more than 50% exotics. It is not clear what proportion of FC mixed

high forest would have been included in the 1977 survey. Similarly, the 1947 categories of scrub and devastated woodlands include both coniferous and broadleaf components. The situation in each of these categories can be resolved to some extent by considering the summaries given for principal species. Thus, the total area of broadleaf high forest in 1947 (including mixed and pure) is taken as the sum of the area of all the individual broadleaf species, calculated on the basis of principal species. These figures do not account for areas of broadleaf woodland in which exotic species may be the principal species or vice versa. In the 1977 survey, 2% of the deciduous woods had Scots pine and 7% had exotics as the principal species. It is not possible to estimate the percentage of conifer woods in which broadleaf species are dominant, but, because of the way in which such woods are managed, and because 'exotics' is a group composed of many species, this percentage is probably small.

5.2.7 It is assumed that all the FC categories of broadleaf high forest, broadleaf scrub, coppice and broadleaf devastated woodland have been included in the 1977 survey. Furthermore, it is assumed that all those areas of deciduous woodland in existence in 1977 are marked on the 1" OS maps. Bearing in mind that the revision date for these maps was between 1954 and 1967, this inclusion rejects the possibility of:-

- i) Coniferous woods reverting to deciduous woods
- ii) Formation of scrub woodlands as the result of natural successions
- iii) Newly planted areas of deciduous woodland
- iv) Differences in the definition of what constitutes deciduous woodland between the OS and the 1977 survey
- v) Woods over 5 ha without symbols.

The 1977 survey tried to accommodate for these sources of error by including any areas of deciduous woodland which were not marked on the maps, but which were seen during the field survey. Although 1556 ha of woodland were found in this manner, it is likely that some areas were missed.

5.2.8 Despite the considerable degree of incompatibility that exists between the 1947 census and the 1977 survey, and hence the difficulty of arriving at definite conclusions, some discussion of the results presented in Tables 11 and 12 is warranted.

In 1947, the FC recorded a total area of 145,323 ha of broadleaf woodland (Table 11). Comparing this total with the 61634 found in the 1977 survey indicates that there has been a decline of 58% in deciduous woodland cover during the last 30 years. For reasons given above, this figure must be treated with caution. Although it is undoubtedly an overestimate, it does reflect a general feeling amongst field workers in Scotland that there has been a considerable decline in the area of deciduous woodland. The results at the county level indicate that the decline has shown no clear regional pattern, with most areas of Scotland being equally affected. The pattern agrees with that shown in the map of deletions in Fig. 47.

As described in section 5.1.5 the major reason for the decline in deciduous woodland has been conversion to conifers. This conversion has been of two main types:-

i) Underplanting of mature deciduous woodlands with young conifers which eventually come to dominate the wood. This type of conversion is a rather gradual process but is serious in that it generally leads to the loss of mature woodland types.

ii) Clearance of scrub woodlands and subsequent replanting with conifers. Scrub woodland would have been relatively common on the 1947 FC census, owing to the felling of large areas of woodland during the pre-war years and the subsequent development of scrub vegetation. If the loss of scrub woodland has been the major cause of the decline, it could be argued that the apparent decline in deciduous woodland cover is largely due to the circumstances in which the 1947 census was carried out.

As most scrub woodland of the above type is dominated by birch, a decline in the proportion of scrub woodland should also lead to a decline in the proportion of birch. In 1947, 56% of all woodland was birch dominated, whereas the comparable figure in 1977 would be about 50%. Although some decline in birch cover has taken place, it has not been large. The argument is not conclusive, in that it does not take into account degenerative changes in other woods or formation of new birch woods. However, the results of the 1977

survey do not support the hypothesis that loss of scrub woodland has been the main reason for the decline. It would seem that, in Scotland as a whole, the reduction in deciduous woodland cover has not been selective, but has been throughout a range of canopy types.

Table 12 shows how the average species composition of Scottish woods has changed. For explanation of the 1977 figures for principal species, see Section 5.2.5. In general, there has been very little change in species composition; the most marked change being in beech which has declined from 14% to 8% cover, a decline which may reflect a trend towards coniferisation of policy woods.

5.3 Checks on the accuracy of the comparison in Selkirk and Nairn

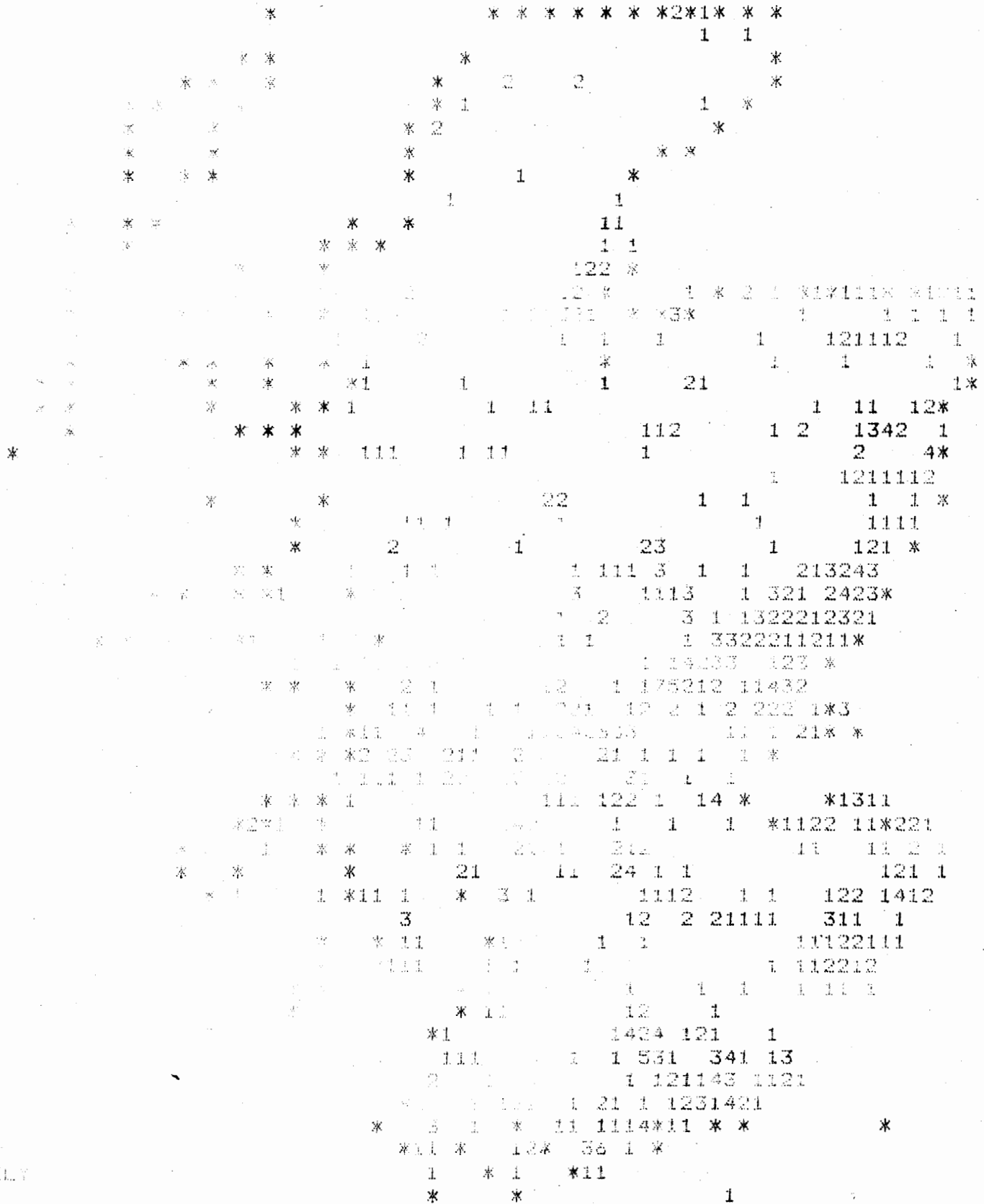
5.3.1 A direct comparison of the kind given above may be adequate to indicate the broad direction of woodland change, but it is of little use for establishing precise rates. The methodological differences that exist between the two surveys could alone account for much of the apparent decrease. In order to evaluate the effects of these differences in relation to the assessment of change, two counties Selkirk and Nairn, have been examined in greater detail.

The procedure adopted for these counties has involved two lines of approach. First, a check was made on the accuracy of the 1977 survey by examining 2½" OS maps followed by field check of the area. The aim of this check was to investigate:-

- i) The number and area of small woods between 2 and 5 ha.
- ii) The number and areas of woods greater than 5 ha that may have been missed in the 1" map search.
- iii) Discrepancies in the area of individual woods as shown on the 1" and 2½" maps.

The second approach involved an examination of the original FC records for the 1947 census. From these records, it was possible to carry out a simulated survey of the 1947 Scottish woods in which the ITE criteria for the inclusion of woods were applied. Basically, this meant including any woods (or groups of stands) with a total area of 5 ha or over which had a deciduous tree cover of at least 50%. A survey of this kind should give results of a form ideally suited for comparison with the 1977 survey.

DISTRIBUTION OF DELETED WOODS INCLUDED IN 1977 SURVEY



ALY
EACH POINT= 5 X 8 KM.

Fig. 47

The examination of 1947 FC records was carried out with the help of Mr. G. M. L. Locke of the Forestry Commission.

- 5.3.2 The 1947 FC census of Selkirk recorded 649 hectares of broadleaf forest (including areas of mixed forest and scrub). The 1977 survey (before it was revised to include some results from the 2½" map search) recorded an area of 129 ha giving an estimated decline in the past 30 years of 80%.

A total of 379 ha of woods were recorded on the 1" maps, including areas of deleted woods. The 2½" map search recorded a total of 773 ha, of which 9% was in woods over 5 ha in size, 405 ha was in woods that were classed as deleted in the field survey. This leaves a total of 295 ha of existing woods found on the 2½" map search as compared to 129 ha found as a result of the 1" map search. The difference of 112 ha can be accounted for in two ways. First, the eleven woods found in both surveys were shown as occupying 17 ha more on the 2½" map, and, second, the 2½" maps revealed 12 additional woods with a total area of 102 ha. Most of these woods were long and thin in shape and included shelter belts or roadside and riverside woods which were not wide enough to contain a broadleaf symbol on the 1" maps.

The results of the 2½" map search are summarised below.

Area of 11 woods included in 1977 survey as measured on 2½" maps	=	146 ha
--	---	--------

Area of 12 additional woods found on 2½" maps	=	102 ha
---	---	--------

Area of existing woods between 2 ha and 5 ha	=	<u>29 ha</u>
--	---	--------------

Revised total for 1977		277 ha
		—

Equivalent total for 1947		649 ha
		—

Estimated reduction	=	57%
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5.3.3 The results of the 1947 simulated survey of Selkirk can be summarised as follows:

1947 total area of broadleaf
woodland recorded = 643 ha

Area of woods < 5 ha = 170 ha (26% of total)

Area of woods > 5 ha = 473 ha (74% of total)

The 473 ha of woods in 1947 simulated survey can be accounted for in the 1977 survey as follows:-

- i) 235 ha confirmed deleted
- ii) 105 ha in 6 existing woods but reduced in area to 78 ha
- iii) 133 ha in 14 woods not included in the 1977 survey.

A resurvey of these missed woods showed that 6 of them must now be classified as deleted and the remaining 8 are mostly narrow woods, still in existence and covering an area of 74 ha.

In addition to the woods included in the 1947 survey, 5 more woods (51 ha) were included in the 1977 survey. As a result of the 2½" map search, 4 more woods (28 ha) not included in either survey should be added to the 1977 total. These woods were either not recorded at all in 1947, or were recorded either as woods under 5 ha or as coniferous woods.

These results give:

Total area in 1947 = 473 ha
(woods > 5 ha)

Total area in 1977 = 78 + 74 + 51 + 28 = 231 ha

Therefore estimated reduction = 51%.

5.3.4 The 1947 FC census of Nairn recorded 1999 ha of broadleaf forest as compared to 816 ha in the 1977 census. This comparison represents an estimated decline of 59%.

The results of the 2 1/2" map search are presented in the same manner as for Selkirk.

The 2 1/2" map search recorded a total of 1172 ha of deciduous woodlands of which only 1% was in woods of less than 5 ha. Of the 1160 ha in woods of 5 ha or over, 221 ha was in woods that were classed as deleted. This leaves 939 ha of existing woods, as compared to 316 ha found as a result of the 1" map search.

The results of the 2 1/2" map search of Nairn can be summarised as follows:

Area of 14 woods included in 1977 survey as measured on 2 1/2" maps	= 848 ha
Area of 8 additional woods found on 2 1/2" maps	= 91 ha
Area of existing woods between 2 ha and 5 ha	= <u>4</u> ha
Revised total for 1977	943 ha
	—
Equivalent total for 1947	1999 ha
	—

Therefore estimated reduction = 53%

5.3.5 The results of the 1947 simulated survey of Nairn can be summarised as follows:

1947 - total area of broadleaf woodland	= 1925 ha
Area of woods < 5 ha	= 91 ha (5% of total)
Area of woods > 5 ha	= 1834 ha (95% of total)

The 1834 ha of woods in the 1947 simulated survey can be accounted for as follows:-

- i) 132 ha confirmed deleted
- ii) 1555 ha in 14 existing woods, but reduced to 816 ha
- iii) 147 ha in 11 woods not included in the 1977 survey.

A survey of the missed woods showed that 6 of these must now be classified as deleted and the remaining 5 were still in existence, and covering an area of 39 ha.

Three additional woods were found during the 2½" map search which were not included in either the 1947 survey or the 1977 survey. These woods had a total area of 52 ha.

The results of the comparison based on the simulated survey are:-

Total area of deciduous woodland in 1974 = 1834 ha
in woods > 5 ha

Total area in 1977 = 816 + 39 + 52 = 907 ha

Estimated reduction = 57%

5.4 Discussion of comparisons for Selkirk and Nairn

5.4.1 Table 13 summarises the results of the comparison for Selkirk and Nairn. Several points concerning the results are of general relevance. The areas of deciduous woodland present in 1947, as calculated from the county summary tables (section 5.2.6), agree well with the totals obtained from the simulation survey. They match to within 4% for Nairn and 1% for Selkirk.

5.4.2 In the 1947 simulated survey of Nairn, only 5% of the deciduous woodland areas were in woods of less than 5 ha. In Selkirk, the figure was 26%. Such a large difference obviously makes it difficult to extrapolate these results to other counties or to Scotland as a whole. There are at least three factors which may affect the relative proportion of small woodlands. First, the much greater fragmentation of woods in Selkirk, where the overall woodland cover is relatively low (0.2% of land area), will tend to increase the proportion of small woods. This effect will be exaggerated by the tendency of the 1977 survey to join together

small pieces of woodland if they were in close proximity to each other. Second, many of the small areas recorded in 1947 would in fact be stands of deciduous woodland within coniferous woods. If the degree of heterogeneity of woods varies, then this heterogeneity will also affect the apparent number of small woods. Third, regional variation in environmental factors, topography and management factors may affect the proportion of small woods.

It should be noted that, while the $2\frac{1}{2}$ " map search underestimated the proportion of small woods by 17% in Selkirk and 4% in Nairn, it did show up the relative difference in the area of small woods. This result may make it possible to use a survey of $2\frac{1}{2}$ " maps to establish the proportion of small woods included in the 1947 survey. Preliminary steps towards testing this approach have been taken with further $2\frac{1}{2}$ " map searches. A search of Caithness, a county which has shown a relatively low decrease of 4%, found only 2 more existing woods. These had an area of 10 ha or 2% of the total area of deciduous woods in Caithness. Similar searches of sample areas in Inverness, Kirkcudbright and Argyll revealed larger areas of missed woods, but these estimates have not been checked in the field and therefore it is not known whether they are existing or deleted woods. This work suggests that there is a positive correlation between the estimated decline in an area and the error in the 1977 survey due to missed woods.

5.4.3 There was a considerable discrepancy in the 1977 survey due to the omission of woods over 5 ha. In Selkirk, 12 woods of area 102 ha (41% of the total) were missed, as compared to 8 woods of area 91 ha (10% of total) in Nairn. Most of the woods missed were small, long thin woods such as shelter belts or roadside woods which in terms of their value as native woodlands may be regarded as relatively unimportant. However, in terms of assessing the rates of change in conjunction with the 1947 census, these areas must be accounted for. Once again, the number of woods missed may vary between counties according to fragmentation of woods, average wood size and environmental features in a way that cannot be adequately predicted from two counties alone.

5.4.4 The best estimate of the actual decline in woodland cover of each county comes from comparing the areas recorded in 1977 as a result of the $2\frac{1}{2}$ " map search with the areas recorded in 1947 as a result of

small pieces of woodland if they were in close proximity to each other. Second, many of the small areas recorded in 1947 would in fact be stands of deciduous woodland within coniferous woods. If the degree of heterogeneity of woods varies, then this heterogeneity will also affect the apparent number of small woods. Third, regional variation in environmental factors, topography and management factors may affect the proportion of small woods.

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5.4.4 The best estimate of the actual decline in woodland cover of each county comes from comparing the areas recorded in 1977 as a result of the 2 $\frac{1}{2}$ " map search with the areas recorded in 1947 as a result of

the simulated survey (Table 13). In Selkirk, there has been a decline of 48% in the total area of woods larger than 5 ha, and, in Nairn, the decline has been 51%. These figures can be compared with those given in Table 11 in which no account of possible errors was taken and where the estimated declines were given as 80% and 59% respectively. In both cases, Table 11 overestimated the decline, the error being greater for Selkirk than for Nairn.

- 5.4.5 In Selkirk, 225 ha of deciduous woodland has been lost, the majority of which was in one estate where a total of 180 ha of woodland has been deleted. Much of this area was high forest which has been converted to conifers by underplanting and the rest was in areas of birch scrub which have been completely replanted with conifers.
- 5.4.6 In Nairn, 986 ha have been lost. That much of this area has been due to the conversion of scrub woodland is supported by the fact that birch has declined in relative abundance from 79% to about 67%.
- 5.4.7 With only 2 counties having been sampled in detail, any extrapolation of the results for Nairn and Selkirk to include other counties, or to Scotland as a whole, must be tentative. Extrapolation is particularly dangerous when the results for the two counties show such marked differences in the degree of error. The estimates of error given here are weighted averages of the results for the two counties, and, while they probably enable a more accurate assessment of change to be made at the national level, they do not establish the confidence limits of these estimates.

Overestimation of 1947 figures (from county summary) for deciduous woodland cover as compared to results of simulated survey = 3%

Overestimation of 1947 figures due to inclusion of small woods = 10%

Underestimation of 1977 figures due to inaccuracies in map search (e.g. missed woods etc.) = 26%

Applying these correction factors to the results of the 1947 and 1977 surveys gives:

Estimated area of deciduous woods
over 5 ha in 1947 $= 145323 - 13\% = 126431$ ha

Estimated area of deciduous woods
over 5 ha in 1977 $= 61664 + 26\% = 77696$

Therefore estimated decrease between 1947 and 1977 = 39%.

A similar procedure can be adopted for each county, but, because of local variations, the results are likely to be less accurate than for Scotland as a whole. In general, the correction factors will tend to overcompensate in counties that have shown a relatively small decrease and undercompensate in counties that have shown a large decrease. It will be noted that this figure is very close to the 36% obtained from the OS maps (section 5.1.3). Although this may be a coincidence, it is possible that the sources of error discussed in relation to the OS maps may have cancelled themselves out, enabling the woods marked as deciduous to be a representative sample of the overall population.

5.5 Concluding discussion

5.5.1 Two tacit assumptions have been made in conducting the above comparisons. The first, that the FC census of 1947 was perfectly accurate in its recording of deciduous woodland cover, is difficult to verify. However, as the 1947 census covered all woods over 2 acres, including coniferous areas, it is unlikely that many deciduous woods over 5 ha in size would have been missed.

The second assumption is that the ITE survey teams accurately assessed the area and status of existing woods, and that this assessment corresponds to that which would have been made by the FC in 1947. That the ITE survey is accurate within the criteria decided upon for the project is shown in sections 2.1.7 and 2.1.8. Whether this classification corresponds to that the

FC might use is more difficult to establish. An assessment of the decline in deciduous woodland cover of Nairn based on current FC records shows a 36% drop (G. M. L. Locke, pers. comm.). However, this figure is not based on a field survey and is therefore not strictly comparable to the estimate of 51% made as a result of the 1977 survey.

5.5.2 The accuracy of the 1977 survey, in terms of finding all areas of deciduous woodland, has already been discussed, but doubt still remains as to whether even a thorough search of an area in conjunction with a search of 2 $\frac{1}{2}$ " maps will succeed in finding all the remaining areas. The Forestry Commission record that over 1,000 ha of broadleaved planting has been subsidized in Scotland in the last 8 years, of which only about two-thirds is classed as replacement of felled crops. Such areas may be missed in even a detailed field search. In addition to these planted areas, there will also be natural regeneration on bare or felled sites.

Overall, however, the proportion of woods missed after a detailed map and field search will be low and the comparisons given for Nairn and Selkirk are probably as accurate as can be achieved, given the relatively coarse nature of the 1977 survey.

5.5.3 Whatever the cause and rate of decline, the present survey has covered consistently and using standard procedure, the woodland of sites with predominantly deciduous species. These are the sites with which NCC are primarily concerned and therefore, currently the extent of such cover is lower than has previously been thought. However, there will be a considerable further area of deciduous woodland incorporated in largely coniferous forests or as small scattered woodlands. The extent of these areas may well add to the resource as a whole, but not to the sites in which the NCC are likely to be primarily interested.

6. Detailed survey

6.1 Surveys completed to date

6.1.1 Various surveys have been completed in Scotland since the standard woodland survey technique was developed in 1971. Most of these have been on a local basis and have concentrated on particular areas. Overall, however they represent a considerable body of data. The various surveys are described briefly below.

6.1.2 In the original national woodlands survey, 13 sites were surveyed in Scotland, although two of these were mainly pine, with varying amounts of birch. Sixteen random plots were surveyed at each site with records of vegetation trees and, in less detail, soil, being made.

Table 14. List of sites surveyed in the national woodlands survey.

Number of Plots	Name of wood	Grid Ref.
16	Blane Smiddy	509 852
16	Craighall Gorge	175 483
16	Garroch Wood	595 822
16	Den of Alyth	230 487
16	Gartfairn Wood	434 896
16	Dounduff	478 495
16	Glen Beasdale	710 850
16	Coille Coire Chuilc	330 280
16	Tynron	826 927
16	Mill Wood	455 505
16	Callender	150 367
16	Corrieshalloch Gorge	205 778
16	Mullen Wood	329 516

6.1.3 A survey of selected oakwoods was carried out in Perthshire by Dr. Rosalind Smith. A varying number of randomised plots were surveyed in 24 sites. These were run down using the national woodlands classification. A local analysis of the data was also carried out and a report produced.

Table 15. List of sites included in the survey of Pershire oakwoods.

Number of Plots	Name of wood	Grid. Ref.
4	Butterstre	NO 060 465
4	Craig	NO 035 427
4	Den of Alyth	NO 230 488
3	Leargan	NN 640 595
3	Glen Lochay W.	NN 552 350
6	E. Loch Katrine	NN 500 075
4	Cuilrena	NN 490 016
4	Pass of Leny	NN 595 090
4	Glen Nan Goarrun	NN 315 204
4	Coble Land	NN 470 286
4	Tynrioch	NN 223 326
6	Twenty Shilling	NN 762 226
3	Ardtrostan	NN 685 328
3	Coshieville	NN 900 526
5	Drummond Castle	NN 845 185
5	Almond Bank	NC 055 265
4	Pitcairngreen	NO 085 275
4	Court Hill	NO 135 328
4	Lethendry	NO 128 423
5	Kincardine Castle	NN 945 115
4	Kippenrait Glen	NN 796 996
4	Dunning Glen	NO 026 130
3	Glen Devon	NN 998 033
3	Gleneagles	NO 932 080

6.1.4 A survey of woods on Speyside was carried out in cooperation with N.C.C. * 17 sites were surveyed, with 16 randomised plots in most sites but 8 in some. The affinities of the plots were established using the national woodlands classification. A local analysis was also carried out and a report submitted to N.C.C.

Table 16 List of Sites included in the survey of Speyside birchwoods.

Number of Plots	Name of wood	Map reference at centre
8	Spey Dam	NN/555922
16	Creag Dubhe	NN/700995
16	Glentromie	NN/775965
16	Craigbui	NH/790030
8	Dunachton	NH/810051
16	Alvie	NH/872086
8	Ord Ban	NH/891085
16	Craigellachie NNR	NH/888126
16	Craigellachie SSSI	NH/886109
16	Granish	NH/900150
8	Pityoulish	NH/925140
8	Croftmore	NH/941148
16	Glenbeg	NJ/010282
8	Lettoch	NJ/095323
8	Upper Findhorn	NH/802259
16	Lower Findhorn	NH/935434
16	Craigellachie Road	NH/891119

6.1.5 The monitoring work carried out by J. M. Sykes and A. D. Horrill has involved intensive sampling at four sites.

J. M. Sykes and A. D. Horrill;

N.C.C. Monitoring Contract

Glasdrum NNR (71 plots) Wood of Cree (55 plots)

Glen Nant FNR (120 plots)

Arriundle NNR (73 plots)

In addition the following plots have been completed by other surveys.

M. W. Shaw

Ruabha Mor (16 plots)

Glen Falloch (16 plots)

R. G. H. Bunce

Lawers Larch wood (16 with A. D. Horrill)

The Mound Alderwood (8 plots)

Boars Knoll (Glen Lochart) (3 plots)

Lonchan an Drang (Wester Ross) (4 plots)

Native pinewoods

131 plots contained birch trees and could also be included

6.1.6 Regional staff of N.C.C. have also carried out surveys of detailed plots in the Borders area. C. Badenoch (ARO Borders) has carried out most of this work.

Table 17. Details of sites included in the Borders survey (1977).

Name of wood	Grid reference	Number of plots
<u>Lothians</u>		
Woodhall dean	NT 680 728	8
Roslin Glen	NT 278 630	8
Carriber Glen	NS 968 753	8
<u>Borders</u>		
Sprouston and Newtown burn	NT 58-32 NT 58-31	8
Leaderfoot	NT 58-34 NT 58-33 NT 59-34	16
Peose Bridge Glen	NT 795695	8
Airhouse Wood	NT 477538	8
Abbey St. Bathans		
Godscroft	NT 73-63	8
Shannabank (W)	NT 75-62	8
Shannabank (E)	NT 75/76-62	8
Cragbank wood	NT 390 075	8
Lower Tarras	NT 392 821	8
<u>Ochils (I. Bonner and R. Keymer)</u>		
Site		
Kippenrait Glen	NS 790 994	12
Abbey Craig	NS 810 955	12
Hermitage Wood	NS 810 970	12

Mine Woods	NS 795 978	10
Wood Hill	NS 900 975	8
Dollar Glen	NS 963 990	11
Yellowcraig Wood	NS 820 970	8

In 1978, R. Keymer carried out further survey in the Central region covering 50 sites and 200 plots.

7. Future developments

7.1 General

7.1.1 The main objectives defined in section 1 have been achieved in the project, except that the ground flora assessments have not been made. There are however a number of ways in which the data can be further utilised to exploit fully the ecological information contained within them, especially further interpretive analysis of the canopy composition. Accordingly, some brief suggestions are outlined below, combined with some indications as to how a survey of the ground flora may be achieved.

Considerations of further developments concerning the rates of change in Scottish woodlands are considered in the next section.

7.1.2 The first stage of a more detailed ecological analysis of the data should concentrate on the classification of the canopy composition. Further supporting data are required on environmental relationships. Comparisons could be made with the land classes of the UK Ecological Survey to establish correlations. The land classes could also be used to examine the factors underlying the distribution of individual species in more detail.

7.1.3 Another area where further work is required is in the smaller woods. It has been pointed out that these woods often contain interesting assemblages of species, as they are often riverine or by gillsides in the mountains. An assessment of their species composition is required, as well as their contribution to the area of woodland as a whole. Because of the large numbers of these woods, stratification would be required to enable subsamples to be studied in detail and the results then related to the whole of Scotland. The land classes of UK ecological survey could provide such a base. In conjunction with such a study, it would be useful to assess the composition of the scrub woodlands of the islands and in the north and west in order to examine their relationship with the present survey.

7.1.4 Any detailed survey of the ground flora of Scottish woodlands needs to be carried out in two stages.

- (i) An exercise involving the bringing together of all the data described in section 6. These data need to be put into a consistent format for computer handling. The degree of coverage could then be assessed and gaps identified by using the canopy composition classes and/or an environmental stratification.
- (ii) Once the gaps had been identified, sufficient experience of detailed woodland surveys is available to design a procedure that would result in a ground flora classification specific to Scotland.

7.1.5 The present survey would form a base for detailed local surveys of particular areas in which there are features of special interest or where a particular canopy type may be identified as being unusual. The data bank provides a ready way in which woods can be identified for such detailed local surveys. More detailed analysis of the affinities of different regions could also be carried out. A wide range of such studies could be developed but will probably evolve in response to specific local problems. Variations of canopy composition with time also need consideration.

7.1.6 A final comment concerns the way the results should be presented for publication, and it would seem most appropriate to present the species distribution and canopy groups in Atlas form with a minimum of descriptive writing. The Oxford Atlas of the British Isles perhaps presents an indication of the form of map that could be adopted. The assessment of change on the other hand (Sections 3 and 5 of this report) is probably best considered as a separate publication.

7.2 Assessment of change: proposals

7.2.1 The current project has established that there has been a significant decline in the area of Scottish deciduous woodlands during the past 30 years, and that this decline has varied considerably between counties, without showing any clear regional trends. A more accurate assessment of change on a local and national scale would be useful in identifying areas most at risk. These areas could be classified, for example, in terms of land use class, topography, geology or species composition to provide information of use in the management of the woodland resource.

7.2.2. An accurate assessment of change can only be made by reference to the original records from the FC census of 1947. This assessment has been done successfully for two counties, Nairn and Selkirk, but the results cannot be extrapolated reliably to other counties, or to Scotland as a whole.

Three steps were involved in carrying out the detailed comparisons for Nairn and Selkirk:-

(i) A simulated survey of 1947 woods using the original FC records and the ITE criterion for inclusion of woods.

(ii) A search of 2½" OS maps in order to find areas of woodland that may have been missed in the 1" map search.

(iii) A field survey to determine the status of any additional woods found in i) and ii) and to find new woods not marked on any of the maps.

The rationale behind this procedure is, first, to make the 1947 census figures directly comparable to those of 1977, principally by excluding areas under 5 ha, and, second, to determine the accuracy of the 1977 survey. The results from Nairn and Selkirk suggest that the manner in which both these aspects affect a comparison may vary considerably according to average wood size, wood density, topographical and environmental features and the local pattern of deletions. The county comparisons described in this report were useful in pinpointing possible sources of error, but were limited with respect to making more general predictions. To obtain the required information, detailed comparisons of the kind suggested above must be carried out on a randomly selected sample of areas. An adequate sample, perhaps based on the 1 km squares used in the 1965 FC census of woodlands, would also provide confidence limits for the errors given in sections 5.4.7.

7.2.3 In Nairn and Selkirk, the main source of error was found to be in inaccuracies in the 1977 survey with respect to finding all areas of woodland over 5 ha. Most of these missed woods could be found as a result of a search of 2½" OS maps followed by a field survey of the area. In the event of a simulated survey of FC records being judged too time consuming, 2½" map searches of the sample areas could give much of the information required for accurately

assessing change. These map searches could show the relationship between regional variation, environmental variation, accuracy of the 1977 survey and the distribution and quantity of small woods thereby establishing figures of woodland area comparable to those in the county summaries of the 1947 census.

7.2.4 Strictly speaking, a simulated survey of the 1947 census data results in a loss of information as it tends to lump together small stands into larger woods. It may also be subject to error, especially when assessing the overall area and species composition of mixed woods. An alternative method of assessing change would be to ignore the 1977 survey and re-examine all the individual stands included in the 1947 survey. Although this method would give the most accurate results with respect to assessing the change that has occurred in those woodlands recorded in the 1947 census, it would be extremely costly in terms of time and field effort. The method would also require an independent field survey to establish the presence of new areas of woodland.

7.2.5 In discussing the assessment of change, the role of the 1977 survey in assessing future changes in woodland area must not be forgotten. Although the computer data bank must be revised periodically to meet NCC requirements for an up-to-date inventory of Scottish woods, it is essential that a copy of the original data bank and field maps (as of 31/3/79) be kept to provide a baseline for the assessment of future changes. The strength of the 1977 survey in relation to assessing change is not so much its use in establishing past change, but its use as a baseline by which future changes can be easily and consistently measured.

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