

MONITORING FARMLAND BIRDS IN BRITAIN:  
COMPOSITION AND REPRESENTATIVENESS OF  
COMMON BIRDS CENSUS SAMPLES

A report from the British Trust for Ornithology  
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## SUMMARY

(1) The Common Birds Census, established in 1962, is the only existing scheme for monitoring breeding farmland bird populations in Britain. The representativeness and the long-term composition of the plot samples were examined in terms of regional distribution and habitat type. Relationships between bird density and both regions and broad habitats (land classes) were also examined.

(2) The majority of CBC plots has been and is in southern and eastern England. The distribution of plots between different regions of Britain did not change significantly between 1962 and 1982.

(3) The mean area of plots has decreased since 1962 but there has been high overall consistency in the relative areas sampled from different regions.

(4) A system of land classification was applied to the farmland CBC plots. The types of land classes sampled from year to year were highly consistent. The distribution of land classes in the CBC was not representative of the country as a whole nor of the complete British lowlands. The farmland CBC was, however, representative of lowland land classes throughout much of England excluding the extreme north and south-west.

(5) The land classes most strongly represented were those prevalent in southern England, the midlands and East Anglia; they include a variety of farmland types. The most poorly covered classes included several upland types and cereal/mixed farmland in east Scotland and north-east England.

(6) Within England the broad crop types on CBC plots reflected the agricultural statistics closely, especially in south and east England. The agreement was good in Scotland when rough grazing was excluded from the official statistics. Regional variation in the wheat:barley ratio was generally reflected in the CBC plots.

(7) Estimated densities of eleven common species were studied. Variations in density were frequently associated with region and several species showed clear geographical trends in density. Variations in density were comparatively rarely associated with land classes.

(8) It is concluded that the CBC does not reflect population changes of birds on British farmland as a whole but is representative of farmland throughout most of lowland England and that there have been no serious long-term changes in sampling effort. The production of regional indices is considered to be a preferable alternative to national indices which may mask regional variation in population trends.

## INTRODUCTION

The Common Birds Census (CBC) was launched by the British Trust for Ornithology at the request of the Nature Conservancy in 1961 and to the present day remains the only reliable scheme for assessing annually the population levels of the commoner bird species breeding in Britain. Initially the emphasis of the CBC was placed on farmland habitats because ornithologists suspected widespread declines in their bird populations (Williamson & Homes 1964). This period was one of increasing usage of agricultural chemicals. Structural changes also taking place on farmland included hedgerow removal, grassland improvement and conversion of grassland to arable. Each of these changes in farming practice held potential consequences for bird populations on farmland. The scheme has developed into a major national source of information on populations and habitats of birds, both on farmland and in woodland. In addition to its role of providing the basis for long-term population monitoring, CBC data have a wide range of potential ecological applications (e.g. Moore and Hooper 1975, Cousins 1977, Taylor, Woiwood & Perry 1978, 1980, O'Connor 1980 a, b, Arnold 1983, Woolhouse 1983).

The objectives and methods of the CBC have recently been appraised by a joint British Trust for Ornithology/Nature Conservancy Council Review Group. The report of the Group (O'Connor & Fuller 1984) details the assumptions and efficiency of the CBC and considers aspects of the methodology requiring validation or routine checking. Amongst these are the long-term consistency of the CBC samples in terms of geographical location, area and habitat of the study plots. The present report examines the characteristics of the CBC farmland plots in terms

of temporal composition and representativeness of the farmland environment.

Monitoring by the CBC has been performed by calculating species-specific indices of abundance (e.g. Batten & Marchant 1976, Marchant 1983 a). The indices are derived from counts of birds made on sample plots by volunteer observers. The boundaries of these plots are usually chosen by these same observers who are encouraged to census the plot, in the same standardised manner, for as many years as possible. The birds are counted using a territory mapping method (Williams 1936, Kendeigh 1944, Enemar 1959, Williamson & Homes 1964). Such methods are the best available for obtaining a total census of breeding pairs (Tomialojc 1980). The exact method used in the CBC is described in Marchant (1983 b).

In a mapping census a series of visits is made to the study plot, during which the positions of all birds recorded are plotted on large scale maps. These registrations are subsequently interpreted by distinguishing clusters, each of which is assumed to represent a territory. The ratio between the estimated number and the true number of territories (census efficiency) is rarely 100% (Svensson 1979). For monitoring purposes absolute efficiency is not required provided that observers maintain the same level of efficiency from year to year (see below).

A farmland CBC index is calculated for each species in each year, irrespective of the nature and locations of the plots in the sample. The index was set at a level of 100 in 1966 and is derived from percentage changes in the numbers of territories in consecutive pairs of years. In any pair of years changes are derived from the same sample of plots, thus ensuring short-term comparability. However, long-term turnover in the sample is substantial because the

average "life" of a farmland plot is only 4-5 years.

To produce a valid index from the CBC the following conditions must be satisfied:

- (i) Observers must be consistent from year to year in their standards and techniques of observation, to ensure that their personal levels of efficiency remain constant. This condition has been validated by Taylor (1965) and O'Connor (1981 ).
- (ii) Workers responsible for interpreting the mapping censuses (census analysts) must remain consistent from year to year in their techniques, and be comparable with one another. Potentially this is a major source of error with mapping censuses (Svensson 1974, Best 1975) but with the CBC all census analysts undergo prolonged training to ensure they are of similar efficiency to one another (O'Connor 1981 ). Furthermore, year to year internal consistency in the CBC data has been demonstrated by Mountford (1982 and in press).
- (iii) The plots added to, and lost from, the CBC each year should on average be similar in their locations, areas and habitats.
- (iv) The plots should be drawn representatively from land types and farmland throughout Britain if, but only if, the published indices are to reflect national population trends.

There has been no systematic investigation of the last two conditions listed above and this is attempted here. In order to assess whether index trends could be a reflection of changes in the sample, the long-term sampling effort in different regions and habitats is assessed. The degree to which CBC plots are representative of British farmland is examined. Implications of the findings for interpretation of CBC results are considered.

## MATERIALS AND METHODS

Farmland habitats were described at two levels. Firstly, a system of land classification was used to position CBC plots within an objective framework of ecological land types. Four sample years spanning a period of sixteen years were chosen for this exercise. Secondly, at a more detailed level, the types of farmland monitored by the CBC in 1966 and 1981 were examined by comparing national agricultural statistics for those years with the BTO plots. The regions of Britain used in this paper are defined in Table 1.

### Classification of land types

Bunce, Barr and Whittaker (1981a) describe a system of environmental classification which is applicable to anywhere in Britain. The sampling unit is the 1-km square of the National Grid and the system is designed to allocate any square to one of 32 land classes. Most of the 32 land classes have clear patterns of geographical distribution (Bunce, Barr & Whittaker 1981b). It is possible to characterise each in terms of key topographical, landscape,



land-use and vegetational features and outline descriptions are given in Appendix 1. The principal features of the classes were originally defined using a multivariate analysis of 282 attributes concerned with climate, physiography, geology and human artefacts. 74 key indicator attributes can, however, be used to assign any 1-km square to its land class and these have been used in the present study to classify squares in which farmland CBC plots are located. The attributes fall into four categories: (i) climatic (e.g. minimum January temperature) (ii) topographic and positional (e.g. altitude) (iii) geological (bedrock and drift) (iv) human artefacts (e.g. length of roads). Details of climate are derived from 1:1,000,000 climate maps, topography and human artefacts from 1:50,000 Ordnance Survey maps and geology from 1:625,000 maps published by the Institute of Geological Sciences.

This land classification is a potentially valuable tool for use in ecological studies where it is necessary to identify sampling sites which are representative of certain environments. In the present study it is used to assess long-term trends in the sampling of different land classes by the farmland CBC and the degree to which the plots are representative of land classes in Britain as a whole. These analyses are performed only for England, Scotland and Wales. Because the key attributes are subject to little temporal change the system is suitable for describing land classes over a long run of years. However, the land classification says nothing about long-term agricultural practice which may be subject to change as a result of economic factors so that examination of agricultural

statistics is also desirable.

Four sample years were chosen, spread across the period for which the CBC farmland indices have been compiled. Plots which contributed to the following index samples were examined: 1965/66, 1970/71, 1975/76, 1980/81. The total number of plots in each sample were respectively: 103, 88, 90 and 84 (excluding Northern Ireland and the Isle of Man). From each of these sets of plots 50 were taken at random. The data were sub-sampled in this way because classification of each plot was extremely time consuming. For each plot thus selected, the 1-km square in which the greatest proportion of the plot occurred was classified by the Bunce, Barr and Whittaker (1981a) system. It was assumed that the plots were representative of the square to which they were allocated; this is reasonable because the mean area of the plots in the four years lay between 0.64 and 0.77 km<sup>2</sup>.

Five years was regarded as a convenient sampling interval for a preliminary examination of long-term trends on the assumption that further sampling would be necessary only if evidence of temporal changes was found. 1965/66 was taken as an appropriate starting point because the field methods had been standardised by 1965 (Bailey 1967).

#### Agricultural statistics

The areas of land under different crop types were measured for all the English, Welsh and Scottish CBC plots used to calculate population indices in 1966 and 1981. Each CBC observer is asked to return a 1:2500 map showing crop types on a field by field basis for each year. Areas of crops for the 1966 CBC sample had previously been calculated

but those for 1981 were unknown. Areas of individual fields were unknown so the proportion of each CBC plot under different types of crops and grassland was assessed from the crop maps using a squared grid of points corresponding to 50m intervals on the ground. The number of points falling on each type of crop was assumed to be directly proportional to the area of land it covered. In each year a small number of plots (less than ten) had to be omitted because adequate crop data were unavailable.

The June 1966 and June 1981 agricultural censuses organised by the Ministry of Agriculture, Fisheries and Food (MAFF) and the Department of Agriculture and Fisheries for Scotland (DAFS) were taken as a standard for comparison with the 1966 and 1981 samples of CBC plots.

## RESULTS

### Long-term changes in geographical distribution

The distributions of all farmland plots used in compiling CBC indices in four sample years are shown in Figure 1. The majority of plots were consistently in the south-east and midlands of England. Representation in the south-west and extreme north of England, Wales and Scotland and Northern Ireland has always been small by comparison. Indeed Northern Ireland has featured in the farmland CBC only since 1970.

There is no evidence of any broad-scale change in regional distribution of CBC plots between 1962 and 1982. This was confirmed by a chi-squared test using a 6 x 20 contingency table containing the number of plots censused in each region in each year. The numbers of plots in Northern Ireland were combined with those for Wales in order to remove <sup>small</sup> expected frequencies. ( $\chi^2 = 66.86$ , 95 d.f.,  $P > 0.50$ ). Complete removal of the data for Northern Ireland gave a similar result ( $\chi^2 = 68.28$ , 95 d.f.,  $P > 0.50$ ).

#### Long-term changes in plot area

The mean area of farmland plots has declined over the duration of the CBC (Figure 2). If there were differences in this trend between the regions this could introduce a long-term geographical drift in the sampling effort. Such a sampling change would be potentially serious if species showed major regional differences in density and population trends. Also, decreases in plot area may bias comparisons of density, particularly for species with large territories, derived from different years. This is because smaller plots may include a higher proportion of edge territories leading to inflated estimates of density (Marchant 1981, Verner 1981). However, the farmland plots surveyed in the CBC are probably sufficiently large to avoid excessive edge effect.

The long-term sampling effort in each region is represented in Figure 3 by the percentage contribution of each region to the total area sampled in each year of the CBC. Three regions show significant trends in the

relative area covered: Northern England, Western England and Northern Ireland. In the latter case, an increase reflects the absence of any plots in the Province prior to 1970. The contribution of Northern Ireland to the total area covered is small (4.3% was the maximum) therefore this is unlikely to have caused an important long-term bias in any of the indices. However, in the case of northern and western England the contribution to the total sample is greater (Figure 3). The relative area of plots in Northern England has increased, although since the mid 1970s a decrease is evident. The trend in Western England is by far the strongest, where the contribution of the region has steadily decreased from more than 20% to approximately 10%. Despite these changes there was a highly pronounced degree of regional uniformity in the sampling effort throughout the study period. This was demonstrated by using Kendall's coefficient of concordance (Siegel 1956) to test the consistency of the contribution of each region over the full twenty years. The result ( $W = 0.92$ ,  $P < 0.001$ ) was highly significant.

#### Numbers and areas of plots in each land class

The frequency distribution, by number and area of plots sampled in the 32 land classes are shown in Figure 4.

For all years the numbers and total areas of plots in each land class were very strongly correlated. This is demonstrated in Figure 5 where, the percent area is plotted against the percent numbers for each class in the four samples. The agreement is emphasised by the fact that

51 of the 68 points plotted show a discrepancy of one per cent or less, 61 differ by two per cent or less and 65 by three per cent or less. Only two of the points differ by more than 5 per cent: in the 1980/81 sample, land class 1 (mixed farmland in central and southern England) contributed 10% of plots but 20% of the total area and land class 2 (mainly arable in southern England) contributed 14% of the plots but only 9% of the total area. This high correlation means that conclusions drawn in this paper from analyses of numbers of plots will also hold true for the areas of plots in different land classes.

#### Long-term changes in habitat composition

Visually, the histograms in Figure 4 suggest that patterns of sampling have remained fairly constant since the mid-1960s with respect to land classes. This impression of homogeneity between years was strongly supported by a chi-squared test in which a 4 x 6 contingency table was drawn up for the numbers of plots in each year which were allocated to the different land classes. In order to remove small expected values (Siegel 1956) the data for land classes 5-12 and 13-32 were combined. This was acceptable because adjacent numbered land classes have close affinities, particularly in groups of four and eight. The result of this test ( $\chi^2_{15} = 7.17$ ,  $P > 0.95$ ) is strong evidence that the types of plots are extremely consistent from year to year.

As a further, independent check on the long-term uniformity of the data, Kendall's coefficient of concordance was calculated to test the agreement between the four years in the ranking of the numbers of plots in each land class. There was high concordance ( $W = 0.709$ ,  $P < 0.001$ ), indicating great similarity between the four years in terms of the land classes represented.

In detail, some variation is discernible from Figure 4. The total number of land classes sampled each year declined over the period: 18, 19, 17 and 14 respectively. There is also a suggestion of a more even spread of plots between the land classes sampled in 1965/66 than in subsequent years.

Are CBC plots representative of national or regional land types?

The strong bias towards southern Britain in the distribution of the plots (see above) suggests it is most unlikely that the CBC monitors trends in the national populations of farmland birds. More probably the CBC is representative of farmland in the lowlands and especially in south and central England.

The geographical representativeness of CBC plots was examined by conducting chi-squared tests comparing the number of plots in different land classes with those expected from the national and regional statistics derived from Bunce, Barr and Whittaker (1981a). Where necessary adjacent land classes were combined (always in groups of four or eight closely related classes) to produce sufficiently large expected values. Certain land classes do not sustain agriculture of a type included in the CBC. In particular, crofting and the most rugged mountain grazing are excluded from CBC. These

land uses are primarily represented in classes 23, 24, 29-32 (Appendix 1), so in assessing representativeness of CBC plots, these classes were excluded from all analyses.

Representativeness was examined on three broad geographical scales:

- A National (upland and lowland) - all land classes except rugged mountains and croft lands.
- B National (mainly lowland) - all land classes except 18-24 and 29-32 which include crofting and predominantly unimproved uplands.
- C Regional (south-east Britain) - excluding the above classes and arbitrarily defined as the region to the south and east of the easting 3000 and northing 5000 of the National Grid (Figure 1).

The results are given in Table 2 and they indicate that nationally the composition of the CBC samples was significantly different from the national statistics but was not different from those for south-east Britain. These results indicate that CBC plots do not reflect national land types but that they are typical of land in the south-east lowlands of Britain.



Types of land sampled by the CBC

The purpose of this section is to ascertain which land classes are most poorly covered and which are relatively well covered. For each land class an index of representation (IR) was calculated from:

$$IR_i = \frac{\% \text{ of CBC plots in class } i}{\% \text{ of Britain in class } i}$$

For each of the four sample years the index was calculated both on the basis of numbers of plots and areas of plots in each class. All the indices are tabulated in Appendix 2. There was good agreement between the two sets of indices with the exception of land class 8 (estuarine coasts) in the first two years. This discrepancy is of little significance however, for this class relates to a very small proportion of Britain's land surface (less than 1%) and no more than two CBC plots (Figure 4) were in this class. The eight indices available for each class were used to assess the representation of individual land classes. The criteria used and a list of the classes which were consistently under-or over-represented in the CBC sample are given in Table 3. Six classes showed no consistent pattern of representation: 5 (pasture, central/south England), 11 (arable, east/central England), 14 (lowland arable/urban in north England), 15 (mixed farmland, Wales and north England) and 20 (uplands, south Scotland). In most of these cases the sampling was erratic with no or few plots in some years but several plots in other years. Class 3 was sampled in about the correct proportion. This land class is predominantly cereal agriculture in East Anglia and the Weald.

The majority of the classes over-represented in the CBC occur in counties in southern England, the Midlands and East Anglia. These classes include a variety of arable and mixed farmland. Some of the classes, notably 2 (arable, south England), 4 (cereal/urban on edge of East Anglia), 9 (ley/arable, Midlands and north-east England) and 12 (arable, east Midlands), are intensive arable, some demonstrating considerable hedgerow loss.

The most poorly covered land types come, without exception, from northern and western Britain including south-west England and Wales. Important classes which are barely covered, include several upland types and cereal and mixed farmland in eastern Scotland and north-east England. It is particularly in these areas that large increases would be required in the number of CBC plots in order to produce a nationally representative collection of farmland sites. The land classes which CBC does not cover adequately relate to approximately 48% of Britain's land compared with 34% for those classes which are sampled most strongly.

#### Farmland types sampled by the CBC

Whilst land classes give general indication of the likely types of agriculture, they do not preclude temporal changes in farmland type and crop type. Furthermore, some of the land classes support varied agriculture and it would be possible for CBC plots to be representative in terms of land classes but not in the proportions of different crops or

farming practices which they sustained. The national agricultural statistics were, therefore, consulted as an additional and independent source of information on farmland types. Spatial representativeness and temporal changes in the CBC sample were studied by comparing the CBC crop statistics with the official statistics for two years: 1966 and 1981.

There is much regional variation in farming practice and crop types in Britain, and CBC plots were therefore examined on a regional basis. In the first instance crop type was classified as one of three general types: grassland (including all permanent and temporary types), non-cereal arable land and cereal crops. The percentage frequencies of these three types are given in Figure 6 for both the CBC plots and the agricultural returns. The latter include "rough grazing" but precise definition of such grasslands is not given with the statistics. Therefore it was impossible to provide directly comparable figures from the CBC cropping plans. For this reason, the official statistics in Figure 6 are presented both including and excluding rough grazing. It has been shown above that CBC is not representative of upland land classes which presumably carry the largest areas of rough grazing land. Therefore, it might be expected that CBC plots should be most representative of those farmland statistics which exclude rough grazing.

Within England CBC plots generally reflect the agricultural statistics well. This is particularly so in south and east England which contribute between them more than 50% of the CBC sample (Figure 3). These regions also cover much of the

area over which CBC plots are representative in terms of land classes. In both years the predominance of cereals in eastern England relative to other parts of Britain is clearly reflected in the CBC plots. The main discrepancy for England lay in the over-representation of grassland by 10-11% and 8-18% respectively in the west and north in 1981.

In Wales and Scotland the CBC plots did not fit well with the full 1966 agricultural statistics. The CBC undercovered grassland by 28% in both cases. Exclusion of rough grazing greatly improved the fit for Scotland but no such improvement was evident for Wales. The 1981 Welsh data were, however, much closer to the official statistics. In this year the Scottish CBC plots again conformed most closely to those statistics which excluded rough grazing.

Sample sizes were sufficiently large to compare the relative areas of the two major cereal crops, wheat and barley. Figure 7 presents the ratio of wheat to barley as shown by the official statistics for each region and by the CBC plots. The CBC generally reflects the regional variation in cereal crops, with barley assuming predominance in northern and western Britain. The main exception was Wales in 1966 where the CBC greatly over-sampled wheat relative to barley. Also, in 1981 the sample contained no wheat in western England, Wales and Scotland.

Bird densities in relation to land classes and regions

Biases in the distribution of CBC plots and long-term changes in the sampling effort between different types of farmland and regions will be particularly significant for monitoring purposes if there are associated differences in bird density between the farmland types or between the regions. The presence of any such differences would strongly argue for representative sampling of farmland or the use of some correction factor if the aim were to produce one index which was valid for the country as a whole. It was demonstrated above that the CBC is representative only of farmland in certain parts of Britain. In order to assess some implications of this finding, densities ("territories"/km<sup>2</sup>) were calculated for eleven species which are particularly common on farmland (Williamson 1967). For each species, Kruskal-Wallis one-way analyses of variance were then used to test for differences in bird density firstly between different land classes and, secondly, between different regions of Britain. Separate analyses were performed for the four sample years studied in the earlier sections of the paper: 1966, 1971, 1976 and 1981. The samples of 50 plots were used to assess differences in land classes but the full annual samples were available for the regional analyses.

No species displayed a systematic relationship with land classes (Table 4). Densities of six species showed differences between land classes, but only Skylark Alauda arvensis showed a relationship in more than one year. This absence of annually consistent patterns makes the results difficult to interpret,

however, the number of statistically significant cases (seven out of 44) is more than would be expected by chance alone (less than three). This suggests that only in some years do land classes assume significance for bird densities, but that generally land classes are not good indicators of bird habitats. A possible explanation for the erratic pattern of relationships with land classes is that temporal changes in the average density of birds might alter the habitat distribution of a species. This phenomenon has been described for Kestrel Falco tinnunculus (O'Connor 1982) and Wren Troglodytes troglodytes (Williamson 1969). Yellowhammer Emberiza citrinella showed a particularly marked systematic increase in the Kruskal-Wallis statistic over the four years studied (Table 4). There was, however, no evidence from the CBC farmland index for Yellowhammer of a long-term population trend which might have been related to occupancy of land classes.

The analyses for regional densities (Table 5) show a high proportion of significant results and clear patterns of annual consistency. 28 of the 44 cases (64%) were statistically significant. Three species showed significant differences in all four years: Skylark, Willow Warbler Phylloscopus trochilus and Yellowhammer. Four species were significant in three years: Wren, Dunnock Prunella modularis, Blackbird Turdus merula and Chaffinch Fringilla coelebs. Only two species - Song Thrush Turdus philomelos and Blue Tit Parus caeruleus showed no evidence of regional variations in density. Thus, there is very strong evidence that regional differences in farmland bird densities are widespread.

Most of the land classes have distinct patterns of geographical distribution. Therefore it is possible that some density differences found with land classes indirectly result from regional variations in bird density. Only one case - Chaffinch in 1986 - showed a significant difference in density with land classes but not with regions.

These results should not give the impression that habitat factors are of minor significance in determining bird densities on farmland. Indeed, some of the density differences demonstrated in Tables 4 and 5 may be a consequence of variations in the samples of plots with respect to habitat features such as hedgerow length and tree abundance. Such factors which strongly influence local abundance of many farmland birds (e.g. Moore, Hooper & Davis 1967, Biber & Biber 1980, Laursen 1980, Morgan & O'Connor 1980, Arnold 1983) may be independent of land classes and more influenced by chance variation in the samples of plots used for calculating densities. Alternatively, the samples available for many of the land classes may have been too small to detect density differences. It should also be noted that because of the small samples of upland farms available, the regional analyses are essentially comparing densities on lowland farmland and not average densities for each region as a whole.

Estimated bird density is inversely related to the size of the census plot where plots are small and no correction is made for edge effects (Marchant 1981, Verner 1981).

(run on)

Therefore

any differences in the area of plots, between the land class or regional groupings used in the above analyses of variance could have produced spurious results. However, in only one of the eight samples used in Tables 4 and 5 were there any such differences in plot area: the regional samples used in 1966 varied in area ( $H = 12.541$ , 5 d.f.,  $P < 0.05$ ).

Therefore this potential bias did not affect the overall conclusions drawn from the examination of bird densities.

#### Regional variations in density

Seven species consistently showed variations in density between regions: Skylark, Wren, Dunnock, Blackbird, Willow Warbler, Chaffinch and Yellowhammer. This section examines which areas held the highest densities and which the lowest densities and whether the patterns of regional variation were consistent from year to year. Kendall's coefficient of concordance was applied to the mean regional densities of each species for the four years (Table 6). All species showed significant agreement between years in their regional variation. The pattern of regional variation in density is summarised in Table 6 for each species.

Several species demonstrated geographical density gradients. Three of the residents - Wren, Dunnock and Blackbird - were generally more abundant in southern than northern Britain. In the case of Wren, plots in Wales held higher densities than those elsewhere. Skylark appears to decrease in density both towards the north (Scotland) and the west (Wales). Chaffinch, on the other hand shows an opposite pattern, being most abundant in Wales and Scotland. Yellowhammer followed



no obvious geographical trend. The one migrant - Willow Warbler - was most abundant in the north and west. These results are broadly consistent with Herrera's (1978) observation that the proportion of tropical migrants in Northern European communities is greater than in more southerly ones. It is evident, however, that not all resident species are most abundant on farmland in the south. Also there is a large degree of longitudinal, as well as latitudinal variation, a point made by Fuller (1982) for several British bird communities. It is evident that several species are particularly abundant on farmland in those regions which are poorly sampled by the CBC.

#### DISCUSSION

Since the start of the CBC the sampling effort in different regions has remained broadly uniform, both in terms of the distribution of plots and the relative areas sampled. The CBC has also been sampling similar habitat types throughout its existence. Therefore, it is most unlikely that any population trends in farmland birds observed by the CBC could result from temporal shifts in the pattern of sampling. It is evident, however, that the CBC does not sample British farmland types in proportion to their areas in the country as a whole, although throughout much of lowland England the CBC plots provide a good reflection of the dominant land classes.

The current practice in monitoring farmland bird populations in Britain is to calculate a single index based on all the plots available irrespective of their geographical positions. It has been argued (Taylor 1965, Bailey 1967) that this procedure will give indices typical of a large part of our farmland. We have shown, however, that farmland in northern and western Britain is greatly under-sampled by the CBC so that population changes in these regions are most unlikely to be detected. Furthermore, we have shown that some lowland farmland species occur at relatively high density in regions which are poorly sampled by the CBC. Therefore, the published CBC indices cannot be regarded as reflecting farmland bird populations throughout Britain. Although they are heavily biased towards lowland southern Britain the indices can not be regarded as entirely satisfactory for this region because there has been no attempt to exclude those plots which occur in the north and west.

A major disadvantage of a single nationwide index for each species is that it potentially masks regional patterns which in some cases might be responses to changing patterns in land use. Modern agricultural practices are widely affecting the composition of farmland bird communities (Murton & Westwood 1974, Bull, Mead & Williamson 1976, Haila, Järvinen & Väisänen<sup>1979</sup>, Møller 1980a, 1980b, Potts 1980, Ritter 1980, Fuchs & Schifferli 1981, Fuchs 1982, Matter 1982). Given the heterogeneous nature of British farming, such impacts on bird populations are unlikely to be readily detected at the national level.

There is ample evidence that regional differences do exist in the population trends of British birds. Lapwings Vanellus vanellus, for example, have declined in southern Britain but less so in the north (Batten & Williamson 1974). A decrease in the Magpie Pica pica since the second world war has been confined to eastern England (Cooke 1979) while in most other parts of the country the species has increased. Following the severe winter in 1978/79 Wrens decreased far less in southern England, south Wales, Merseyside and the Scottish central lowlands than elsewhere in Britain (Cawthorne & Marchant 1980). It would be surprising if geographical differences in population dynamics such as these were infrequent in a country as diverse in its climate, topography, vegetation and land use as Britain.

The existence of geographical variations, both in population trends and bird densities, argue strongly against the continued reliance on single national indices of population change for farmland bird species in Britain. The strong association of bird densities with regions (at least on the predominantly lowland plots available) suggests that monitoring on a regional basis is a preferable strategy. The present regional CBC samples, especially those for England, are highly representative of the grass and crop types found within these regions. This implies that regional sampling should be broadly typical of the farmland habitats occurring within these regions and that in this respect regional indices would be valid, at least for the regions defined in this paper.

This paper has examined representativeness at the level of macro-habitat and geographical features of the plots. Another aspect of representativeness concerns the composition of the plots in terms of their non-agricultural features. Plots frequently contain small woodlands, gardens, buildings, rivers, ditches, ponds as well as variable amounts of hedgerow shrubs and trees. The type of bird community found on a plot will be strongly influenced by the numbers and extent of such features (Williamson 1971, Benson & Williamson 1972, Gordon 1972, Yahner 1982, Schifferli 1981, Arnold 1983). It is not known whether there is any tendency for CBC observers to select plots which are richer in such habitats than the surrounding land. Only a detailed study would answer this point properly but it is clear that CBC plots do encompass a range of both bird densities and habitat conditions. Morgan and O'Connor (1980) for example, found that Yellowhammers ranged from zero to approximately 30 pairs/km<sup>2</sup> on farmland plots in 1965 and that there was considerable variation in the habitat composition of the plots.

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Table 1. Definition of <sup>the</sup> geographical regions used in this paper.

East England: Bedfordshire, Buckinghamshire, Cambridgeshire, Essex, Greater London (north of the Thames), Hertfordshire, Humberside (south), Leicestershire, Lincolnshire, Norfolk, Northamptonshire, Nottinghamshire, Oxfordshire (north of the Thames), Suffolk.

North England: Cleveland, Cumbria, Durham, Greater Manchester, Humberside (north), Lancashire, Merseyside, Northumberland, North Yorkshire, South Yorkshire, Tyne and Wear, West Yorkshire.

South England: Avon, Berkshire, Cornwall, Devon, Dorset, East Sussex, Greater London (south of the Thames), Hampshire, Kent, Oxfordshire (south of the Thames), Somerset, Surrey, West Sussex, Wiltshire.

West England: Cheshire, Derbyshire, Gloucestershire, Hereford and Worcester, Shropshire, Staffordshire, Warwickshire, West Midlands.

Scotland: all administrative regions.

Wales: all counties.

Northern Ireland: all counties.

Table 2. Results of chi-square tests to compare occurrence of land classes in CBC plot samples with that expected from the absolute frequency of land classes in three geographical regions.

Geographical region	Sample year	$\chi^2$	d.f.	P
A. National uplands and lowlands	1965-66	17.41	5	**
	1970-71	26.05	5	***
	1976-76	25.81	5	***
	1980-81	29.43	5	***
B. National lowlands	1965-66	10.03	4	*
	1970-71	18.10	4	**
	1975-76	12.36	4	*
	1980-81	17.02	4	**
C. South-east British lowlands	1965-66	2.67	4	<0.70
	1970-71	6.24	4	<0.20
	1975-76	2.03	4	<0.80
	1980-81	2.64	4	<0.70

Note: 1. Definitions of regions are given in the text

2. Levels of statistical significance: \*  $P < 0.05$  \*\*  $P < 0.01$

\*\*\*  $P < 0.001$

Table 3. The representation of individual land classes in the samples of farmland Common Birds Census plots.

	Land class numbers
UNDER-REPRESENTED	6, 7, 13, (17), 18, 19, 21, <sup>22,</sup> (25), (26), 27, (28)
OVER-REPRESENTED	1, 2, 4, (8), (9), 10, (12), (16)

Note: Indices of representation are in Appendix 2. The index is defined in the text. Eight indices are available for each class. Under-representation is defined as a class with at least six indices less than 1.00. Classes which are consistently over-represented have at least six indices greater than 1.00. Brackets indicate classes for which all indices were not greater than or less than 1.00.

Table 4. Kruskal-Wallis one-way analyses of variance used to test for differences in bird densities between land classes. Values of H and levels of significance are given; in all cases there are 8 degrees of freedom.

Species	1966 (50 plots)	1971 (50 plots)	1976 (50 plots)	1981 (50 plots)
Skylark <u>Alauda arvensis</u>	15.764*	8.675	18.374*	3.876
Wren <u>Troglodytes troglodytes</u>	5.871	12.431	8.138	8.838
Dunnock <u>Prunella modularis</u>	9.404	13.015	12.641	16.213*
Robin <u>Erithacus rubecula</u>	14.125	12.332	7.697	6.851
Blackbird <u>Turdus merula</u>	10.088	15.780*	11.628	14.093
Song Thrush <u>Turdus philomelos</u>	9.237	9.945	7.684	14.301
Willow Warbler <u>Phylloscopus trochilus</u>	9.578	10.997	14.366	12.928
Blue Tit <u>Parus caeruleus</u>	13.027	9.985	10.039	6.754
Great Tit <u>Parus major</u>	23.076**	9.884	4.420	10.273
Chaffinch <u>Fringilla coelebs</u>	16.923*	9.221	5.895	12.047
Yellowhammer <u>Emberiza citrinella</u>	1.885	9.653	13.761	19.177*
Proportion of species showing significant differences	0.27	0.09	0.09	0.18

Notes: (1) Significance levels are: \*  $P < 0.05$ , \*\*  $P < 0.01$

(2) In order to produce sufficient sample sizes some adjacent land classes were combined in the following nine groups of classes: 1, 2, 3, 4, 5-8, 9-12, 13-16, 17-20, 25-28.

Table 5. Kruskal-Wallis one-way analyses of variance used to test for differences in bird densities between regions of Britain. Values of H and levels of significance are given; in all cases there are 5 degrees of freedom.

Species	1966 (103 plots)	1971 (87 plots)	1976 (89 plots)	1981 (89 plots)
Skylark <u>Alauda arvensis</u>	16.097**	18.247**	27.841***	12.221*
Wren <u>Troglodytes troglodytes</u>	5.245	15.159**	16.905**	17.269**
Dunnock <u>Prunella modularis</u>	12.541*	6.192	13.228*	11.507*
Robin <u>Erithacus rubecula</u>	6.966	9.178	15.888**	16.295**
Blackbird <u>Turdus merula</u>	9.027	12.678*	17.918**	17.649**
Song Thrush <u>Turdus philomelos</u>	5.063	8.638	7.396	5.740
Willow Warbler <u>Phylloscopus trochilus</u>	17.437**	13.241*	13.888*	12.540*
Blue Tit <u>Parus caeruleus</u>	3.260	6.443	9.477	10.049
Great Tit <u>Parus major</u>	12.838*	9.719	11.650*	7.857
Chaffinch <u>Fringilla coelebs</u>	6.237	18.688**	15.117**	15.468**
Yellowhammer <u>Emberiza citrinella</u>	18.664**	14.204*	19.778**	14.402*
Proportion of species showing significant differences	0.45	0.55	0.82	0.73

- Notes: (1) Significance levels are: \* $P < 0.05$ , \*\*  $P < 0.01$ , \*\*\*  $P < 0.001$ .  
(2) The six regions examined were: eastern England, southern England, western England, northern England, Scotland and Wales. The regions are defined in Figure 2.

Table 6. Regional variation in the density of seven common bird species on farmland in Britain. Kendall's coefficient of concordance is used to judge the degree of consistency in the rankings of mean density between four years 1966, 1971, 1976 and 1981.

	Kendall's coefficient of concordance	Regional patterns of density in order of decreasing density
Skylark	0.88**	EE/NE > SE/WE > S > W
Wren	0.91**	W > SE > WE > EE > NE > S
Duncock	0.64*	EE > WE > SE > NE > W > S
Blackbird	0.71*	WE > SE > W > EE > NE > S
Willow Warbler	0.81**	S/W > NE > WE > SE > EE
Chaffinch	0.86**	W > S > SE > WE > EE/NE
Yellowhammer	0.64*	EE > WE > S > W > NE > SE

- Notes:
1. Significance levels are: \*  $P < 0.05$ , \*\*  $P < 0.01$ .
  2. The regional sequence of bird density was derived from the mean of the ranks assigned to each region in the four years.
  3. The regions are: SE southern England, EE eastern England, WE western England, NE northern England, W Wales, S Scotland. The regions are defined in Table 1.



Appendix 1. Principal features of the land classes. Outliers from the core distribution are frequently present. Reproduced with permission from Bunce, Barr and Whittaker (1981a).

1. Mixed farmland in central and southern England
2. Predominantly arable farmland in southern England
3. Cereal land in East Anglia and the edge of the Weald
4. Cereal land with much urban development in the margins of East Anglia
5. Predominantly pastoral land in central and south-west England
6. Pastoral land in south-west England and south Wales
7. Coasts of south-west England and Wales
8. Coasts, mainly estuarine, of England and Scotland
9. Leys and arable land, mainly of the Midlands and north-east England
10. Grasslands and arable land mainly in the Midlands and north-east England
11. Arable land in the east and central English Midlands
12. Arable land in the east English Midlands
13. Variable land mainly pasture, <sup>mainly</sup> in north-west England
14. Arable and urban land of the lowlands of northern England
15. Pasture and arable land in northern England and Wales
16. Mixed farmland in northern England and south-west Scotland
- 17.\* Mainly improved upland pasture land in England and Wales
18. Roughed hills covered mainly with moorland in western Scotland
19. Often afforested uplands with moorland vegetation in northern England and southern Scotland
20. High land with rounded slopes and grasslands in southern Scotland
21. Steep mountains with moorland vegetation in the Scottish Highlands
22. High but smooth slopes with variable vegetation in the central Scottish Highlands.
23. Steep upper slopes covered with moorland in the north-east of Scotland
24. Rugged peat covered mountains in north-west Scotland
25. Cereal lands in east Scotland
26. Mixed farmland in north-east England

Appendix 1 cont....

27. Variable lowlands in north-east England and east Scotland.
28. Variable lowlands in northern Scotland
29. Rocky moorlands along the inner west coasts of Scotland
30. Rocky peatlands mainly on the outer coasts of western Scotland
31. Moorlands in the northern isles, Orkney and Shetland.
32. Peatlands of Shetland and north-west Scotland

Appendix 2. Representation of land classes in Common Birds Census samples.

For each land class indices have been calculated by dividing the percentage in the sample by the percentage contributed by that class to the national data. Indices greater than 1.00 indicate over-representation; values less 1.00 under-representation. Land classes 23, 24, 29-32 have been omitted because these are predominantly unenclosed uplands or crofting lands.

LAND CLASS	Index based on numbers of plots in each class				Index based on areas of plots in each class				% cover
	1965-66	1970-71	1975-76	1980-81	1965-66	1970-71	1975-76	1980-81	
1	1.25	1.75	1.75	1.25	1.08	1.88	1.94	2.55	8.0
2	2.46	2.81	1.75	2.46	2.47	2.75	1.82	1.58	5.7
3	1.38	0.69	1.03	1.03	1.38	0.52	0.97	0.64	5.8
4	1.85	3.70	3.33	3.70	2.17	4.39	2.85	3.39	5.4
5	1.00	0	1.00	0	1.13	0	1.05	0	4.0
6	0.20	0.39	0.78	0	0.76	0.51	0.63	0	5.1
7	0	0	0	0	0	0	0	0	0.8
8	2.22	2.22	2.22	4.44	0.33	0.78	2.33	4.11	0.9
9	1.18	0.39	1.18	1.96	1.67	0.43	1.31	1.54	5.1
10	1.22	1.63	1.63	2.04	1.29	1.76	1.76	1.92	4.9
11	1.00	1.00	2.00	2.00	0.95	0.55	2.15	1.60	2.0
12	5.00	2.00	3.00	1.00	3.70	1.80	2.75	1.10	2.0
13	0	0.61	0.61	0	0	0.30	0.42	0	3.3
14	1.67	0	0	0	1.33	0	0	0	1.2
15	0.87	0.87	0	1.74	0.96	1.04	0	1.65	2.3
16	1.67	1.67	1.67	0.83	2.04	1.89	2.04	0.88	2.4
17	0.27	0.53	0.53	1.07	0.39	0.52	0.57	1.20	7.5
18	0	0.48	0	0	0	0.31	0	0	4.2
19	0	0	0	0	0	0	0	0	2.4
20	2.73	1.82	0	0	3.14	1.50	0	0	2.2
21	0	0	0	0	0	0	0	0	3.2
22	0	0	0	0	0	0	0	0	6.5
25	0	0.47	0.93	0.93	0	0.72	0.95	1.37	4.3
26	1.08	0.54	0	0	0.65	0.43	0	0	3.7
27	0	0.95	0.48	0.48	0	0.67	0.29	0.38	4.2
28	1.38	0	0.68	0	1.31	0	0.86	0	2.9

Note: % cover is the area of Britain estimated to be covered by each land class (Bunce & Last 1981).



## LEGENDS TO FIGURES

- Figure 1      The distribution of CBC plots used in the calculation of population changes of birds in four pairs of years. Numbers of plots in Northern Ireland were: 1965 zero, 1970-71 one, 1975-76 two, 1980-81 five. In 1965-66 there was also one plot on the Isle of Man, but not subsequently. The broken lines are the easting 3000 and the northing 5000 of the National Grid. Regional boundaries are also shown.
- Figure 2      Mean area ( $\pm$  SE) of all farmland plots in the Common Birds Census since the inception of the scheme. ( $r = -0.862$ ,  $P < 0.001$ ).
- Figure 3      The percentage area of CBC farmland plots in seven regions of Britain since the start of the scheme. The regions are defined in Table 1.
- Figure 4      (a) The frequency with which land classes are represented in the samples of CBC plots. The uppermost histogram shows the percentage of the total area of Great Britain accounted for by each land class  
(b) The total areas (square km) of CBC plots allocated to different land classes.
- Figure 5      Relationships between the numbers and areas of plots in each land class, expressed as percentages. Each point represents one land class. Points falling on the line show exact agreement between numbers and areas. All Spearman rank correlation coefficients were significant at  $P < 0.001$ .
- Figure 6      The percentage frequency (by area) of main types of farmland as shown by MAFF and DAFS agricultural returns and BTO Common Birds Census plots in 1966 and 1981. The agricultural returns have been analysed both including and excluding "rough grazing" in the grassland category. The data are presented separately for six regions: SE Southern England, EE Eastern England, WE Western England, NE Northern England, W Wales, S Scotland. The regions are defined in Table 1. Sample sizes (ha) are given above the histograms for the BTO plots.
- Figure 7      The ratio of wheat to barley as shown by MAFF and DAFS agricultural returns and BTO Common Birds Census plots.



FIGURE 1

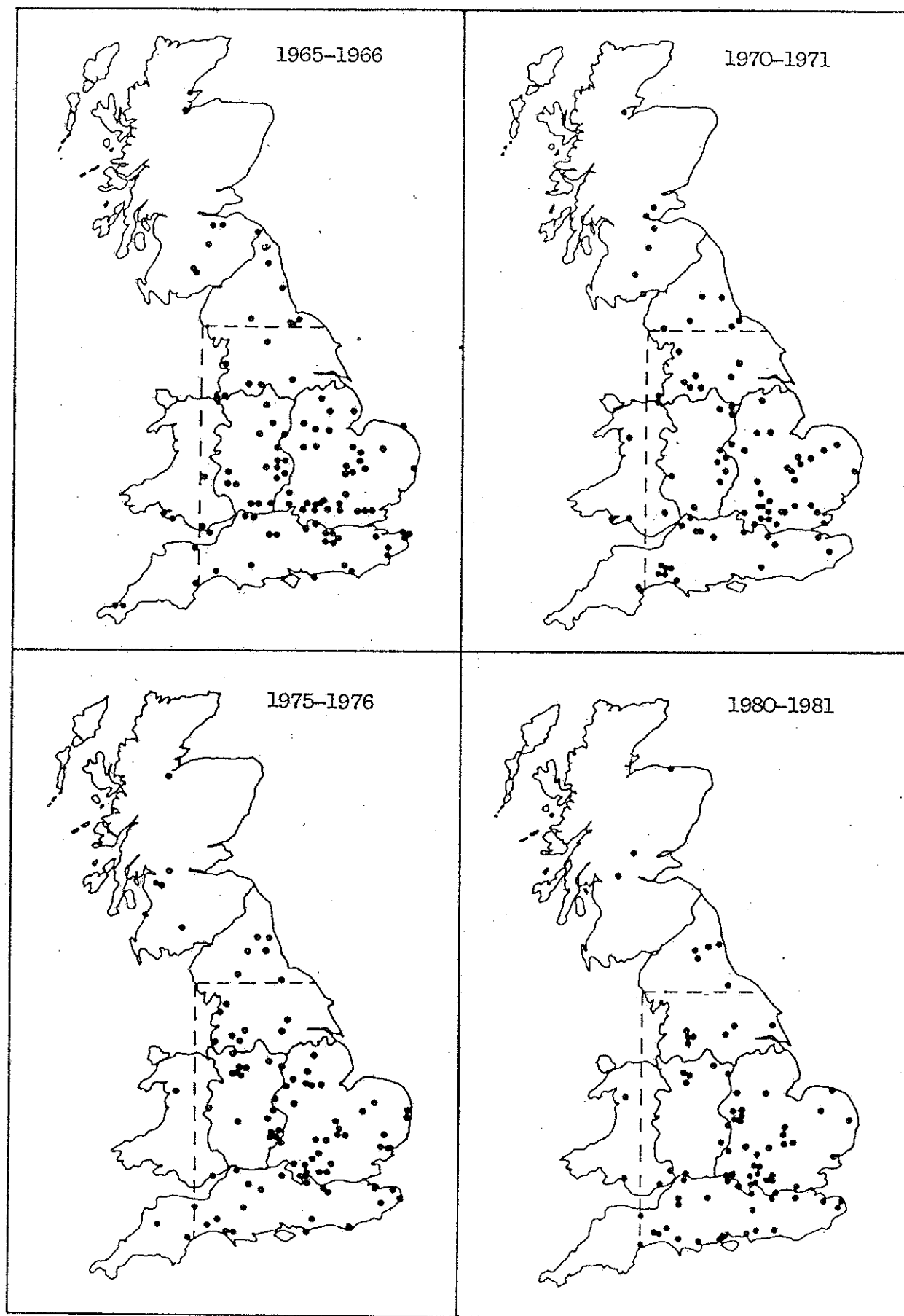


FIGURE 2

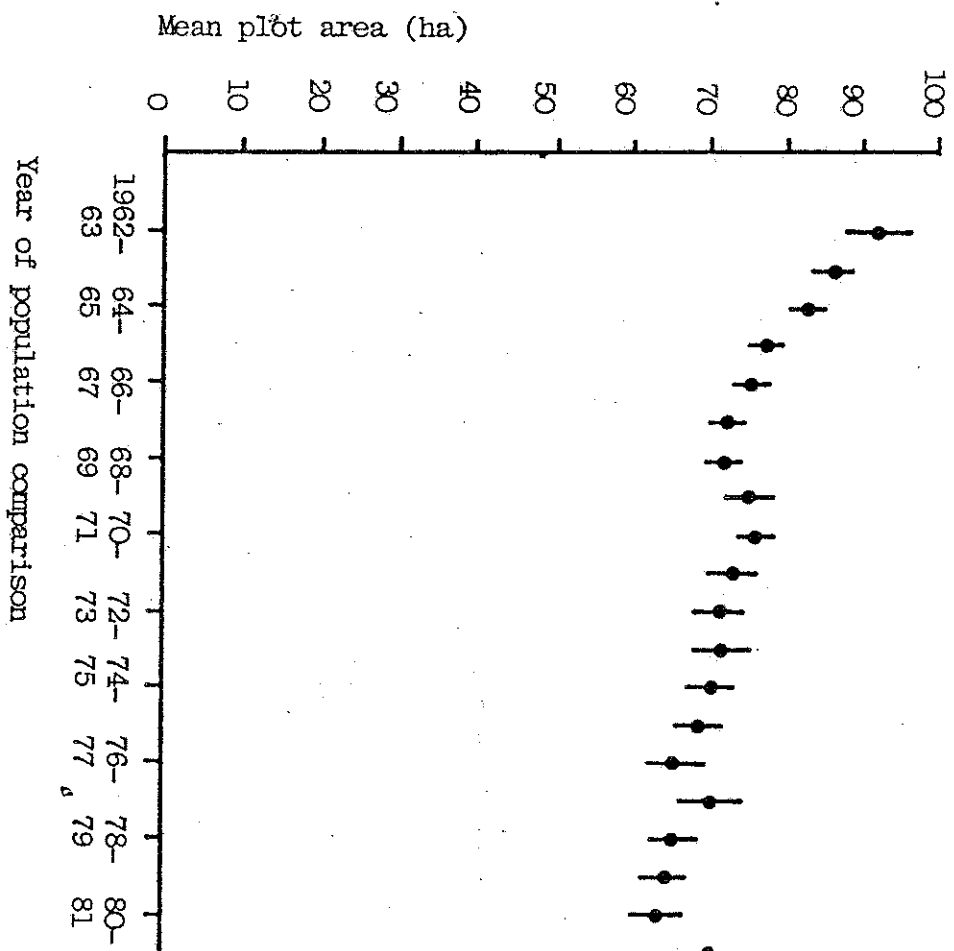




FIGURE 3

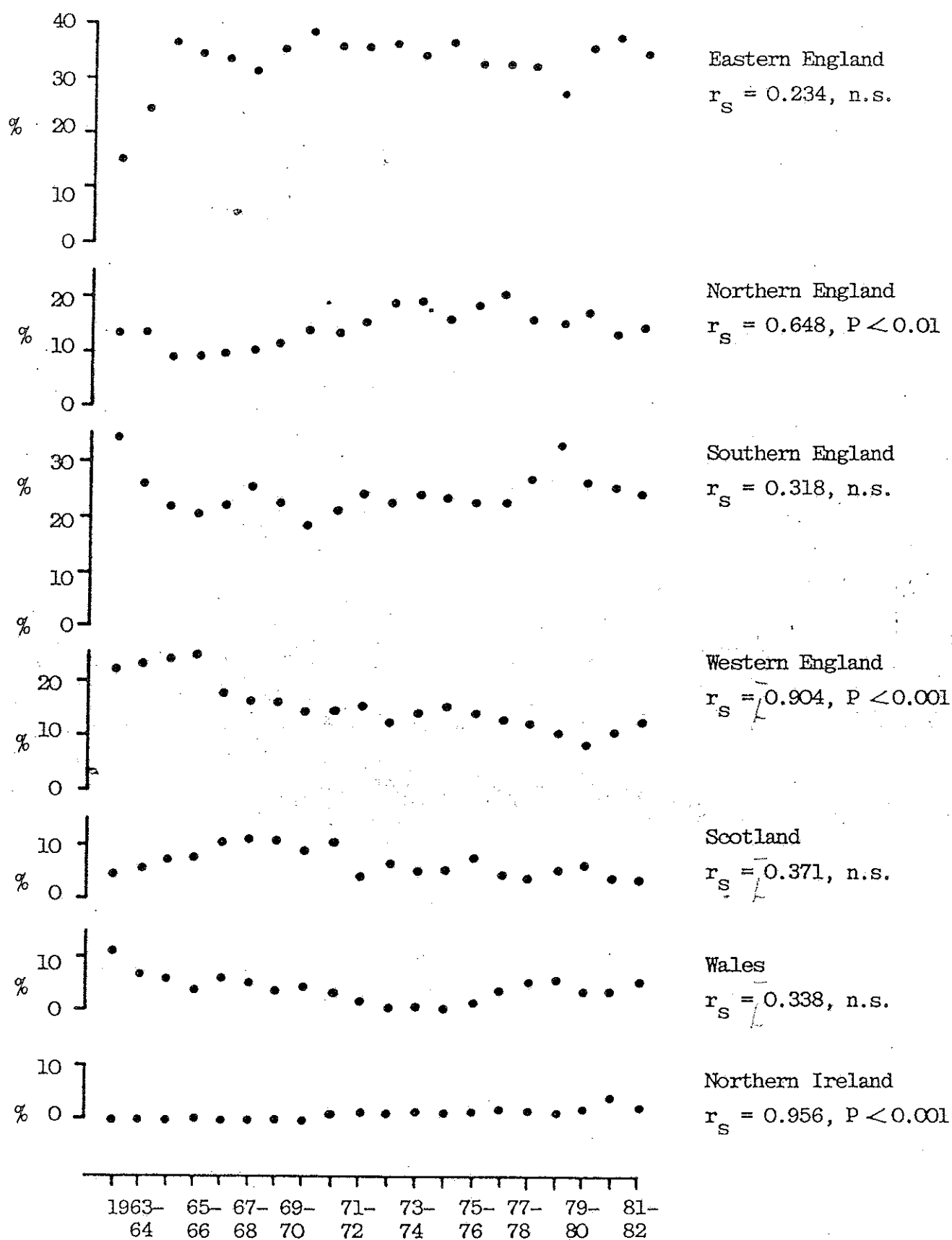
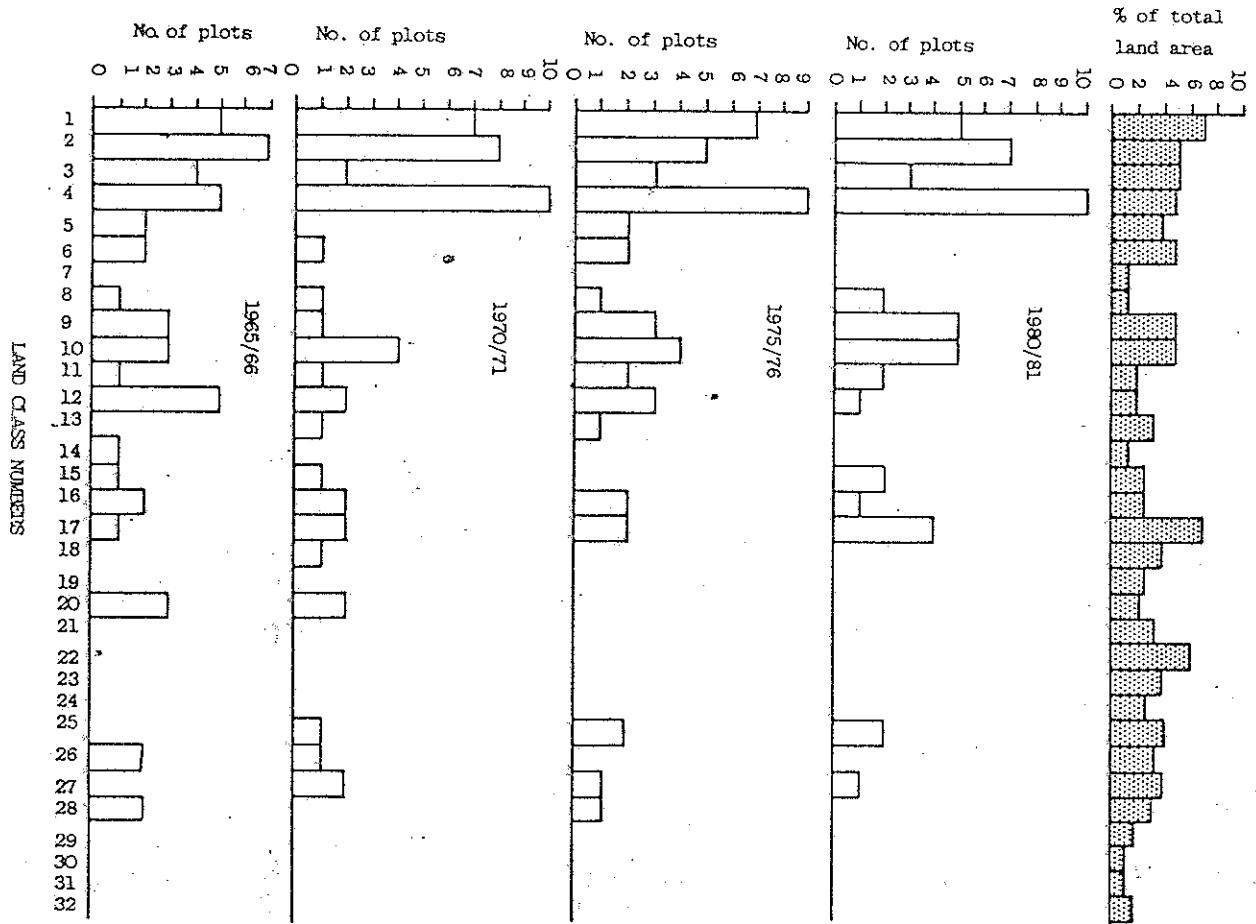


FIGURE 4

(a)



(b)

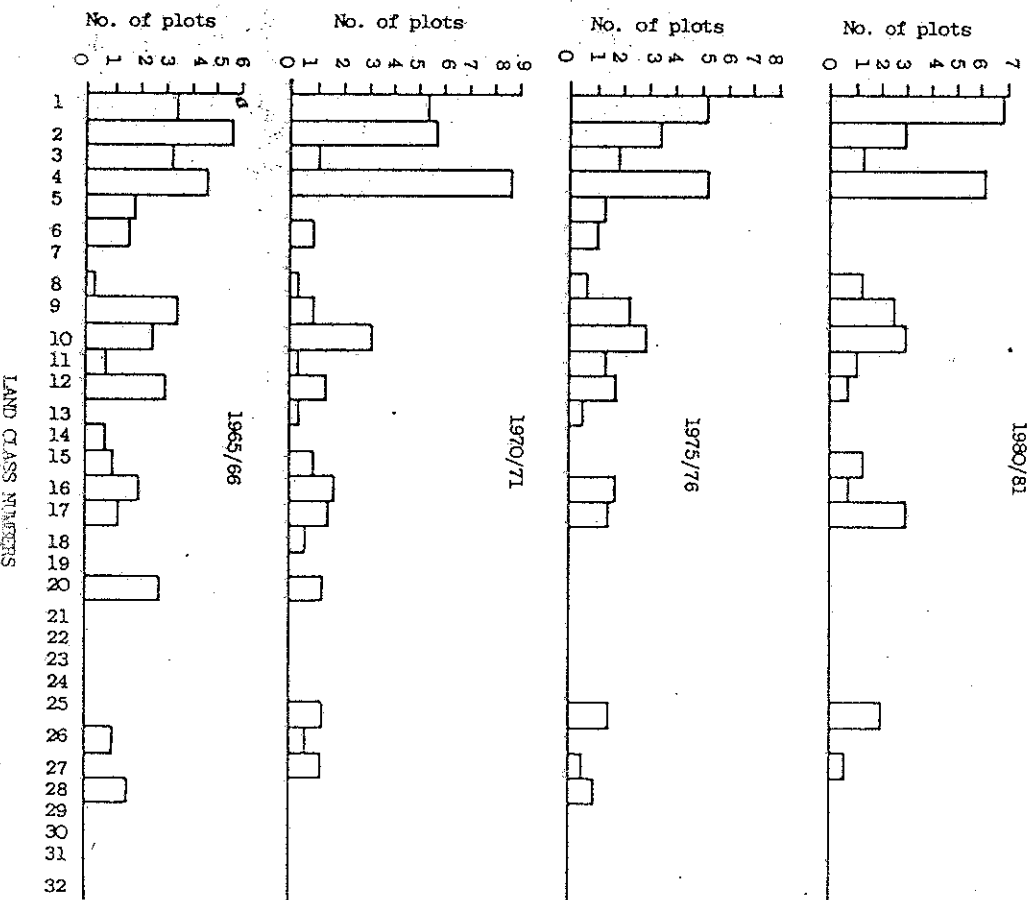


FIGURE 5

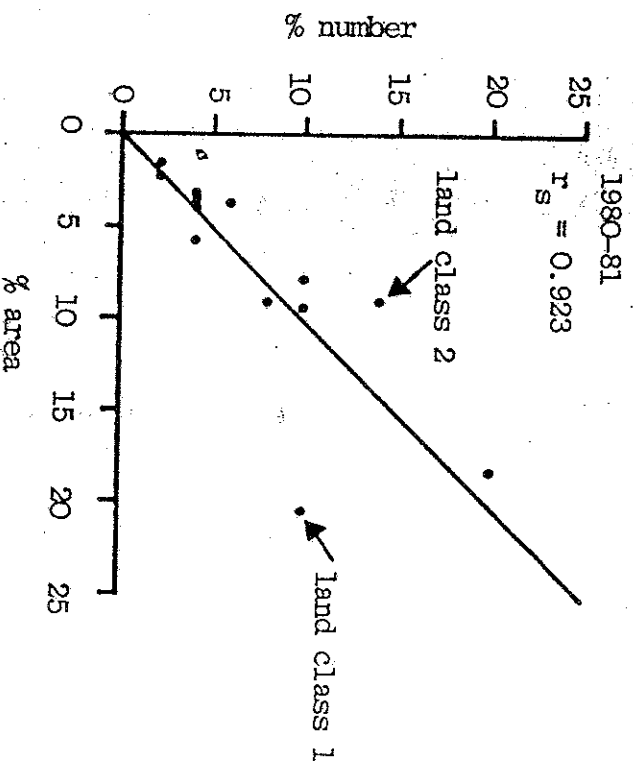
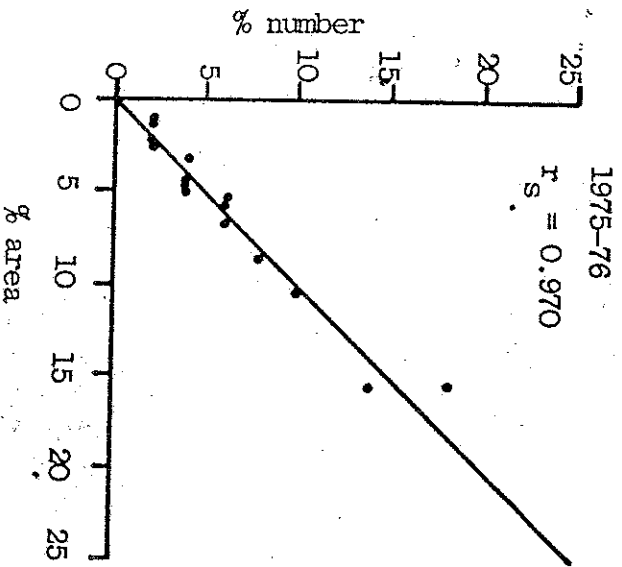
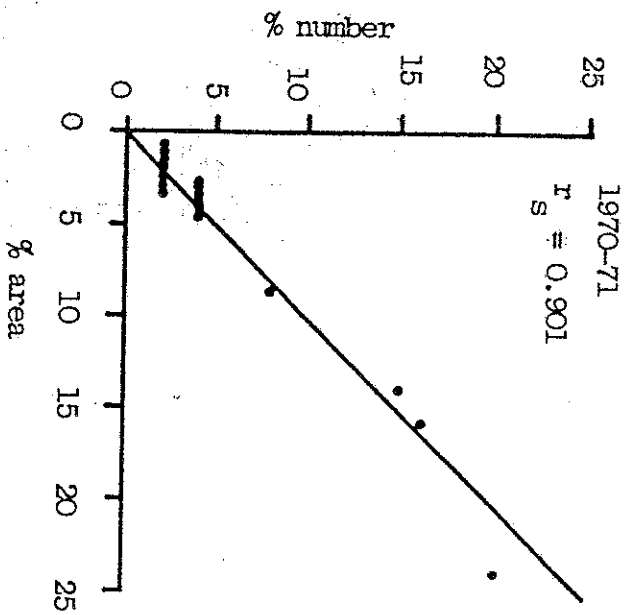
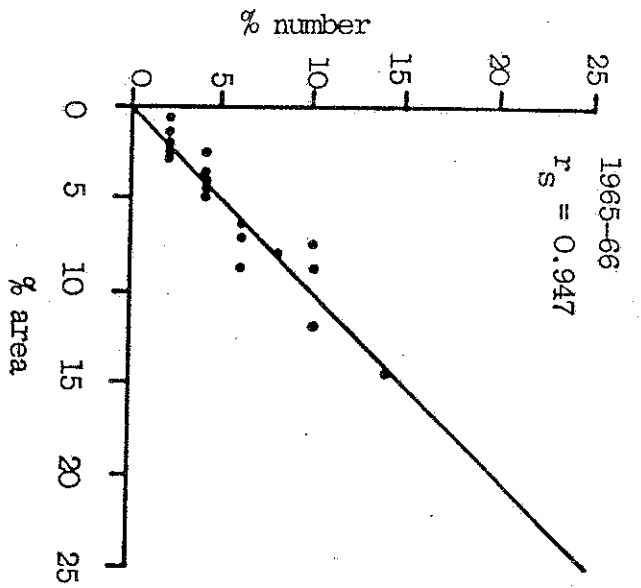
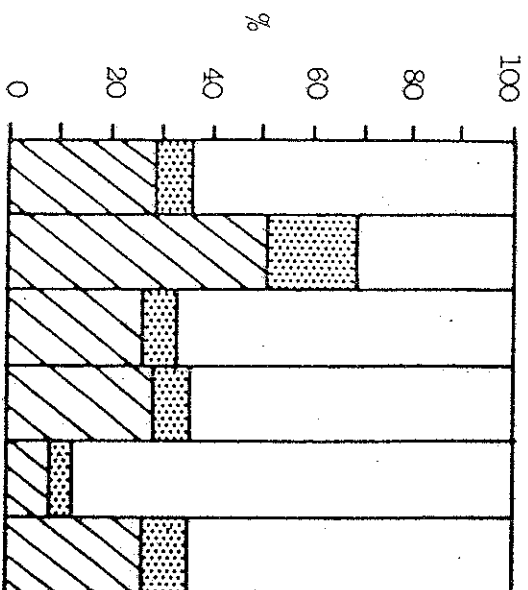
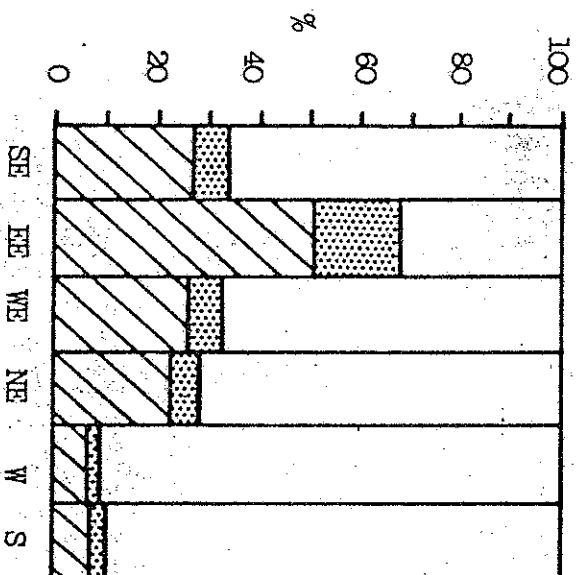


FIGURE 6

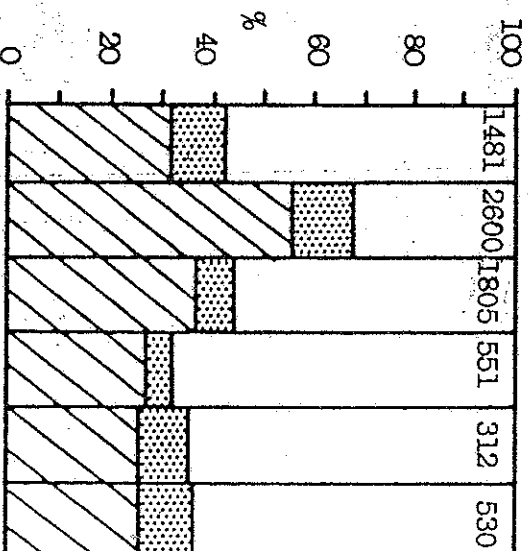
AGRICULTURAL RETURNS 1966  
excluding rough grazing



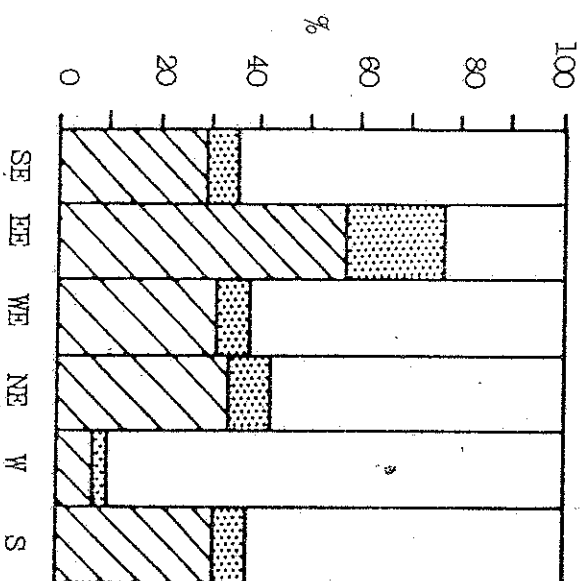
AGRICULTURAL RETURNS 1966  
including rough grazing



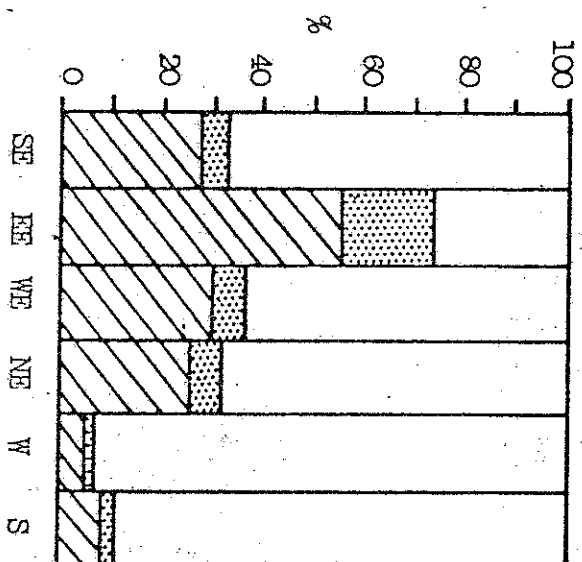
BTO FARMLAND PLOTS 1966



AGRICULTURAL RETURNS 1981  
excluding rough grazing



AGRICULTURAL RETURNS 1981  
including rough grazing



BTO FARMLAND PLOTS 1981

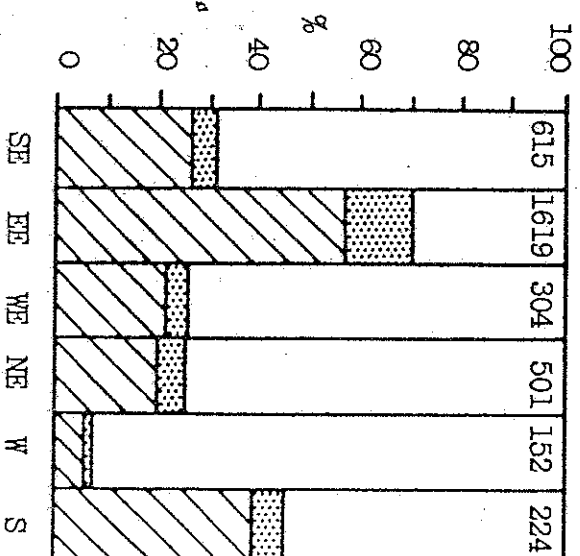


FIGURE 7

