Habitat utilisation and distribution of several common farmland bird species

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Habitat Utilisation and Distribution of Several Common Farmland Bird Species.

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Summary

- Over a thirteen week period between May 18th and August 7th, the distribution, relative abundance and habitat selection of nine bird species, common to low-lying farmland, were studied.
- The study site located south east of Sedgefield (NZ 32 N.E. 435500 529500), was sampled 27 times at regular intervals through the use of a 27 km line transect, traversed by bicycle.
- Observations of birds were noted on detailed 1:10000 scale OS maps of the study site, additional notes on bird activity, habitat characteristics etc., were made.
- A detailed GIS of the site was produced, this gave accurate information on the land use patterns found at the site, i.e. areas of various crop types etc. The GIS in addition was used to spatially reference all bird observations made and their associated observational attribute data to the land use map.
- Querying of the GIS data base provided summary tables of data from which statistical analysis could be undertaken.
- From the observations made during the line transects, Rooks were found to be the most abundant of the nine species within the area, in comparison Curlew were found to be the least abundant of the study species.
- Habitat utilisation analysis of the nine species showed a significant reliance on grassland and set aside for many of the species. It also showed how many crop types were not utilised to any great extent during the duration of the study e.g. Winter Barley.
- The 'R' statistic was used to determine the distribution patterns of the more abundant species. The results indicate that all the species analysed exhibited a clumped distribution. Correlation analysis on the data was used to determine how the distribution patterns of the species changed with time. Both Crow and Lapwing showed significant changes in their distribution patterns with time, individuals of both species becoming more aggregated.
- The importance of specific farmland habitat types most noticeably grassland and set aside was elucidated through the use of various estimates of utilisation. This indicated that in terms of sheer numbers feeding Grassland was the most important habitat type, in terms of proportional utilisation however set aside proved to be the most valuable. Grassland and set aside were additionally found to be the most species rich habitats

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Section 1
Introduction

Introduction

In this study I set out to examine the habitat preferences of 9 common farmland birds in an area of mixed arable farming. This is important because agricultural habitats are changing rapidly, and future changes to CAP, set aside policy etc., are likely to have important implications for our agricultural avifauna. This study makes use of a relatively new technology for ecologists, GIS. As spatial datasets for land use (eg. CORINE) and land cover (eg. ITE land cover) become increasingly available, use of GIS in habitat utilisation studies is likely to become increasingly commonplace.

Section 1.1.
Farming in Britain.

Agriculture has been a major force in determining the present state of the British countryside. In the last thousand years agricultural practices have created many new habitat types. Hedgerows and open fields for example, are two habitat types created solely through agricultural practices. Overall agricultural development has changed a predominantly wooded island into one with a more open and diverse structure. Many of the new habitats created have been ideal for bird colonisation, however the increase in avian diversity observed in these agricultural habitats are incidental to the main economic purpose of food production. During the present century the face of agriculture has changed as dramatically as it had done in the previous ten centuries. Increased mechanisation, changes in management practices, the implementation of drainage schemes, new crop types, and the widespread application of agricultural chemicals have resulted in an intensification of the agricultural landscape and the subsequent loss of habitat diversity, with their consequential knock-on effect on bird populations.

Modern agricultural practices and their effects on bird populations.

Technical advances which facilitated changes in the farming calendar have been responsible for significant influences on farmland bird populations. Amongst these changes the switching from spring to autumn sown cereal crops (Galbraith, 1988), the introduction of new crops (Inglis, *et al.*, 1989), a general shift from grassland to cereal production (Donald & Evans, 1994) the consequential increases in stocking densities on grassland are amongst the most significant factors affecting bird populations. Additionally the specialisation in arable and livestock enterprises on a regional basis combined with the intensification of previously low intensity agricultural areas has resulted in the loss of significant heterogeneity previously evident in the British countryside. The heterogeneous nature of the British agricultural landscape is well known to be of particular importance to many bird species, e.g. Lapwing, *Vanellus vanellus* (Redfern 1982).

Habitat Loss.

Combined with the switch to cereal production and the general intensification of agriculture evident during this century there has been an increase in field size and a subsequent loss of hedgerow. As a result over the last 40 years an estimated 230,000 kms of hedgerow have been lost (O'Connor & Shrubb 1986). Hedgerows are a valuable habitat for birds providing shelter, nest sites and potential feeding areas (Moor 1970). Associated with the loss of hedgerows is the loss of a large number of hedgerow trees in the last 25 years as a result of Dutch elm disease. A number of species have undoubtedly benefited from the effects of Dutch elm disease eg. the Lesser Spotted Woodpecker, *Dendrocopos minor*, Osborne 1982). However, in areas badly effected by the disease many other species have been lost, territories sizes have been affected and a general decrease in the structural diversity of hedgerows with the subsequent loss of potential nesting sites and feeding areas has occurred. Wet grasslands are another habitat type which have declined dramatically during the last 40 years as a result of agricultural practices. Drainage schemes have been implemented in many of these wet regions to improve grassland quality for pasture and species such as snipe which rely heavily on these wet grassland areas for breeding sites have been effected dramatically by this practice. Increased grazing pressure and a reduction in the length of the breeding season have been cited as the main reasons for the decline (Green 1988).

The use of agricultural chemicals.

The wide scale application of agricultural chemicals has had dramatic effects on bird populations of the British countryside. Because of the nature of these agricultural chemicals it is not always possible to link their use with trends in farmland bird populations. Historically however some cases where pesticides have caused direct effects on bird populations are well known (Berg *et al.*, 1966). Declines of up to 90% in Stockdove populations evident in the 1950's have been attributed to the widespread use of organochlorine insecticides as seed dressings (O'Connor & Mead 1984). In addition to having direct effects on the breeding physiology of many birds (Ratcliffe 1963), pesticides can have secondary affects by reducing the availability of food items. Recent findings have revealed that certain fungicides are toxic to earthworms, insects and other classes of invertebrates (Henderson 1989, Rand 1985). Earthworms not only play vital roles in soil fertilisation but are also important key species in the diets of many common farmland bird species e.g. Lapwing, Hogstedt, 1974. While modern pesticides are less persistant and work at lower concentrations they are undoubtedly still working their way up the food chain and effecting bird species at the population level.

1.2. The Study Species

Nine common farmland bird species were selected because of the effects modern agricultural practices were known to be having on them, for example the loss of the farming mosaic effecting Lapwing populations to the use of pesticides and their effects on Partridge chicks. Because of the sampling method used it was decided not to study any 'hedgerow species' eg. Yellowhammer, *Emberiza citrinella*. An in-depth review of the ecology of the nine study species at this juncture was deemed inappropriate, for an overview of the study species ecology, distribution and population trends, see Witherby *et al.*, 1945, Gibbons, *et al.*, 1993 and Marchant, *et al.*, 1990. More in-depth studies on various aspects of the ecology of the species are cited below.

Rook (*Corvus frugilegus frugilegus* L.)
Feare *et al.*, 1974, Brenchley, 1986.
Carrion Crow (*Corvus corone corone* L.).
Saino, 1992.
Jackdaw (*Corvus monedula spermologous* V.).
Lockie 1955, Soler 1988.
Magpie (*Pica pica pica* L.).
Holyoak, 1974.
Woodpigeon (*Columba palumbus palumbus*).
Murton *et al.*, 1964; Inglis *et al.*, 1990.
Lapwing (*Vanellus vanellus* L.).
Galbriath 1988, Spencer 1953., Shrubb, M. & Lack, P.C., 1989 and Baines, 1990.
Common Curlew (*Numenius arquata arquata*).
Mulder and Swann 1988, Berg 1992.
Grey Partridge (*Perdix perdix perdix* L.).
Southwood and Cross 1969, Potts 1986.
Pheasant (*Phasianus colchicus* L.).
Hill 1985, Hill and Robertson 1988 and Ridley and Hill 1987.

1.3. Habitat Selection.

Pivotal to the study of animal ecology is the utilisation an animal makes of its environment; specifically the kinds of foods it selects and the types of habitats it utilises. Probably no other taxonomic group has (and presumably exercises) the ability of bird species for habitat selection. Birds typically are extremely active, mobile and wide ranging, and of the number of habitats they pass through or over only specific habitats types are selected for foraging, breeding and overwintering (Hilden 1965). The habitat selections made by individual and groups affect their potential for both survival and reproduction and must as a result be the product of many generations of natural selection. The rapid changes which have occurred in agricultural patterns and practices mentioned in section 1.1. must have had as a result dramatic consequences on the choices made by species and subsequently on the populations of these species.

1.4 Line Transects.

Because of the nature of many bird species, being predominantly active and wide ranging, their quantitative sampling is innately difficult. As a consequence of this a plethora of censusing methods have been developed each with their own characteristic advantages and disadvantages. One of the main types of bird censusing techniques applied commonly in bird studies today is the line transect. The idea of walking a line and counting birds is fundamentally simple. One would expect to find more birds in habitats which were favoured, and more birds in total during good years. This method of censusing has been widely applied and not solely in bird or terrestrial studies. Examples of recent bird studies employing line transects as the sampling technique include the study of population change in Cappercaillie (*Tetrao urogallus*) by Rolstad and Wegge 1987, the study of habitat preference of Shrub Steppe birds by Wiens and Rotenberry 1985 and Newton's 1988 study of density dependence in Sparrowhawks. As is evident from the cited references, line transects can be a valuable source of ecological information.

1.5. Geographical Information Systems (G.I.S.).

A G.I.S. can be defined as 'an organised collection of computer hardware, software, and geographic data designed to efficiently capture, store, update, manipulate, analyse and display all forms of geographically referenced information' (ESRI, 1990). In essence a G.I.S. allows you to ask powerful spatial questions (on location, condition, trends, patterns and modelling) of numerous data sets which are spatially linked (i.e. share the same reference points). Previously the use of this tool had been restricted to governments and multinational corporations, however with the decrease in computing costs it has become more widely available and as a result more common place. It's potential in the field of ecology is now only really being explored, recent papers in this field include, Breininger *et al.*, 1992.

1.6. Aims and Objectives.

- To determine the relative abundance of the nine species within the study site during the study period.

- To look at the changes in numbers observed in species over time and to attempt to explain these changes in terms of the species ecology.

- To determine the habitat utilisation patterns of the nine study species.

- To determine how similar / different the nine species were with regards to there utilisation patterns during the study period.

- To determine if significant changes occurred in the utilisation patterns of the species during the study.

- To attempt to determine the distribution patterns of the most abundant of the study species and to see whether significant changes occurred in these patterns through time.

- To determine the relative value of the various landuse types with regards their value as habitats for birds.

- To look in detail at a number of the habitat types and to determine there patterns of utilisation by the study species.

SECTION 2
Materials & Methods

2.1. Fieldwork Methodology

2.1.1. Introduction.

From the 18th of May to August the 7th 27 transects were undertaken along a 28km stretch of low-lying agricultural land in a region located southeast of Sedgefield (NZ 32 N.E. 435500 5295000) in North-East England. In total observations were made on nine different common farmland bird species. The species studied included the corvids Rook, Crow, Jackdaw and Magpie as well as Woodpigeon, Curlew, Lapwing, Pheasant and Partridge.

2.1.2. Sedgefield Study Site.

In 1995 the study area at Sedgefield, County Durham, comprised 2868 ha of which 4.8 % was woodland and 6.5 % buildings, roads etc. Approximately 54% of the farmland was devoted to cereal production with Winter Wheat being by far the dominant crop (1338 ha, 46.6 %). The other cereal crops grown in the region included Spring Wheat (13.8 ha, 0.5 %), Winter Barley (166 ha, 5.8 %), Spring Barley (12.9 ha, 0.4 %) and Winter Oats (4.2 ha, < 0.01%). A number of vegetable crops were grown in the region these included Cabbage, Potato and Broad Bean. The vegetable crops in total comprised 34.7 ha or 1.2 % of the study area. Oil seed rape was quite a common crop in the region taking up approximately 294.8 ha or 10.3 % of the study area. Some 488.7 ha or 17.1 % of the Sedgefield site was devoted to pasture, much of it grazed periodically or continuously by sheep, cattle and horses. A significant proportion of the grassland element was devoted to silage production, and was cut periodically throughout the study period. Approximately 183.7 ha or 6.4 % of the study area was categorised as Set Aside and subject to strict E.C. regulations.

In addition to having a diverse agricultural pattern the Sedgefield site was additionally chosen for a number of practical reasons these included the flat topography of the region which allowed for unrestricted views as well as facilitating the use of a bicycle. Other factors of importance were the presence of a number of rookeries in the area as well as a number of bus routes which passed the site.

2.1.3. Line Transects.

At the start of each line transect the starting time and date was noted, in addition a general description of the prevailing weather conditions was made. Each transect was undertaken during relatively constant weather conditions, i.e. relatively dry and between the hours of nine in the morning and seven in the evening. This time period has been shown to be the most suited for this type of study. The starting times and starting locations of the transects were varied systematically so as to avoid the observation of routine activity patterns and thus giving independent data (Bibby *et al.*, 1992). Each transect took approximately six hours, however those undertaken at the start of the study took slightly longer than those carried out at the end of the study period. Familiarity with the study site and an increase in bird identification skills accounted for this trend.

During the transects observations were made using Swift Belmont 8x, 30 binoculars and if required a Swift 15x-60x telescope and tripod. Observations were made continuously along the transect, i.e. whenever a species under investigation was observed it was recorded. Sightings of the nine study species were located as accurately as possible on photocopied A4 size sections of a 1:10,000 scale map of the study site. Birds located on the ground were noted only once in the location in which they were first observed, subsequent movements of these individual were not intentionally recorded but may have on occasion been recorded accidentally. Landing locations of birds first seen in flight were only noted if their flight paths appeared to have been undisturbed by the presence of the observer. Attributes of the observations were noted on the data sheets and incuded the following.

- Species type.
- Activity.
- Time of observation.
- Field height (arbitrary scale used†).
- Presence, type and number of grazers, (if any).
- Sex and age of the individual if possible and appropriate.
- Miscellaneous points of interest. (eg. Road Type, categorical system used based on traffic pressure of the road, five categories in all, Type 1 = Dual carriageway, Type 3 = Farm entrance (see plates16, 17 & 18. Appendix 1))

†Both cereal and grassland fields were categorised on the basis of there height, before any of the transects were undertaken this system was tested statistically, see Appendix 4.

2.2. Geographic Information System Methodology

2.2.1. The Study Area Map

Before digitising the study area the site had been surveyed and changes to field boundaries not evident on the 1982 version of the 1:10,000 scale O.S. maps were added or deleted as appropriate. A number of quite significant alterations were made. The study area was digitised using a digitiser attached to a P.C. running ARC Version 3.0.. Using the Arc command 'Adds' features such as field boundaries, roads, buildings and wooded areas were digitised. Labels were attached to different groups of landuse type in such a way that they could be easily queried later. In total twelve different landuse categories were identified, these included Winter Wheat (W.W.), Spring Wheat (S.W.), Winter Barley (W.B.), Spring Barley (S.B.), Oil Seed Rape (Osr), Set Aside (SA), Grassland (Grass), Woodland (Wood), Rural Settlement (R.S.) Roads (Roads) and an unclassified category for unclassified areas. The several digitised sections of the study site were 'cleaned' and transferred to a UNIX driven workstation running ARC/INFO Version 7.0.. These digitised sections were then transformed into real world co-ordinates using the Arc command 'Transform' and appended to create an overall coverage of the study area. The commands of 'Append' and 'Mapjoin' were used to bring together the different digitised sections and additionally removed overlapping lines, double labels and other such errors. The finished digitised map is presented in Fig 2.1. 'The Study Area'.

2.2.2. Observational Point Coverage & Attribute Data.

Next the observational data from the line transects was digitised. Separate coverage's for each line transect were created by positioning observations made on the 1:10,000 scale O.S. maps as closely as possible to their original position by using the study area coverage as a template. Twenty-seven such point coverage's were produced. In each of these point coverage's individual bird observation were given unique identifying numbers. Corresponding Excel databases were created containing the attributes attached to each bird observation, the first column of these 27 Excel database files used the unique bird id. numbers as reference points. In Arc, 27 new data base files were defined using Tables, these new databases were formatted in such a manner so as to match the format of their corresponding Excel data base files. The Excel data base files were saved in a text format and a computer program 'SCR.bjc' (See Appendix 2) run on them to replace all blank values with -9's and all tab entries with spaces. The use of this program enabled the importation to Arc of the 27 data bases into the newly created data base files. Using the command 'joinitem' the point coverage's and their corresponding attribute data base files were joined.

2.2.3. View field Analysis & The Line Transect.

Not every area of the study site was sampled during each transect, certain areas for example were screened by buildings or woodlands while other areas were hidden in hollows or by slight undulations in the topography of the region. To overcome this problem a view field analysis from the transect was produced The view field was produced by placing the observational points of all the line transects in one overall coverage and by subsequently joining the furthest points together to form a polygon clip coverage. In the same fashion by joining observational points which encapsulated areas where no observations were made erase coverage's were created. By using the Arc driven commands of 'clip' and 'erase' the view field coverage was then produced. Fig 2.2 'The Sampled Area' (see page 11) shows a graphical representation of the area sampled from the line transect.

2.2.4. Buffer Generation.

While Fig 2.2 displays pictorially the area which was sampled from the line transect, observations were not made for all species within this area. Census counts of Pheasant and Partridge are typically undertaken at two distinct periods of the year, the spring census and the august stubble count (Potts, 1986). At both these times the vegetative cover is low, allowing the birds to be sampled easily (Potts, 1986). Observations of these two species during this study were made frequently through the disturbance of individuals from dense vegetation, because of this a disturbance buffer was generated to determine the composition of the area from which these two species were sampled. A flush distance of 30 m was chosen and a buffer produced in Arcedit from the line transect route. The buffer which was created was subsequently used to clip the study area producing a coverage of the area from which Partridge and Pheasant were sampled (See Fig 2.3). The areas of the different habitat types sampled within this coverage were generated and used in the analysis of the habitat utilisation patterns of these two species

Fig 2.3 Section of the Pheasant and Partridge sampled area

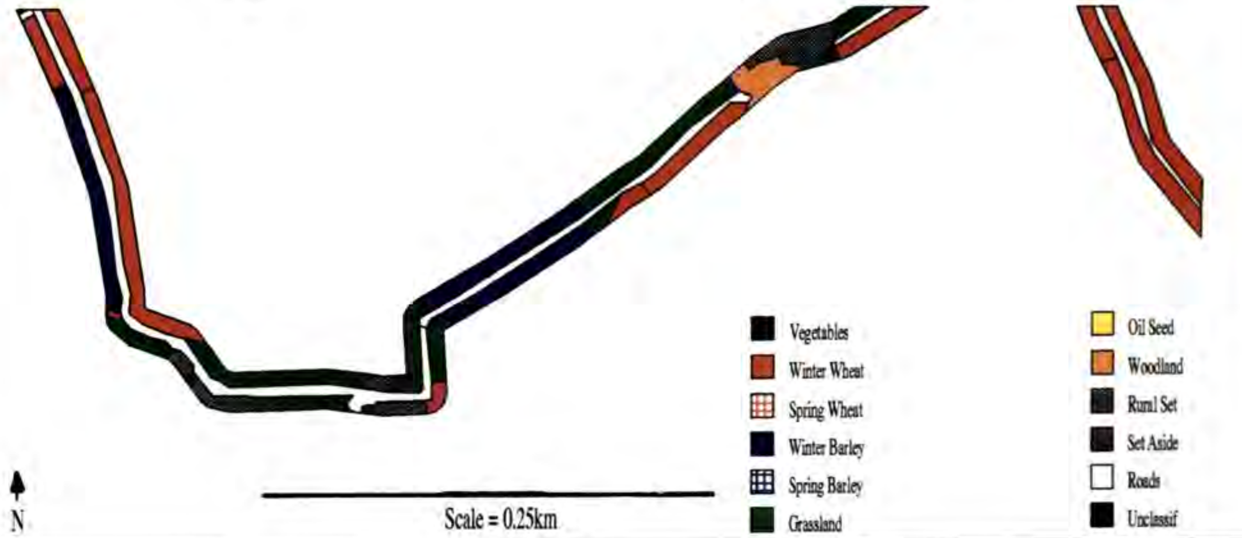


Fig 2.1 Sedgefield Study Area

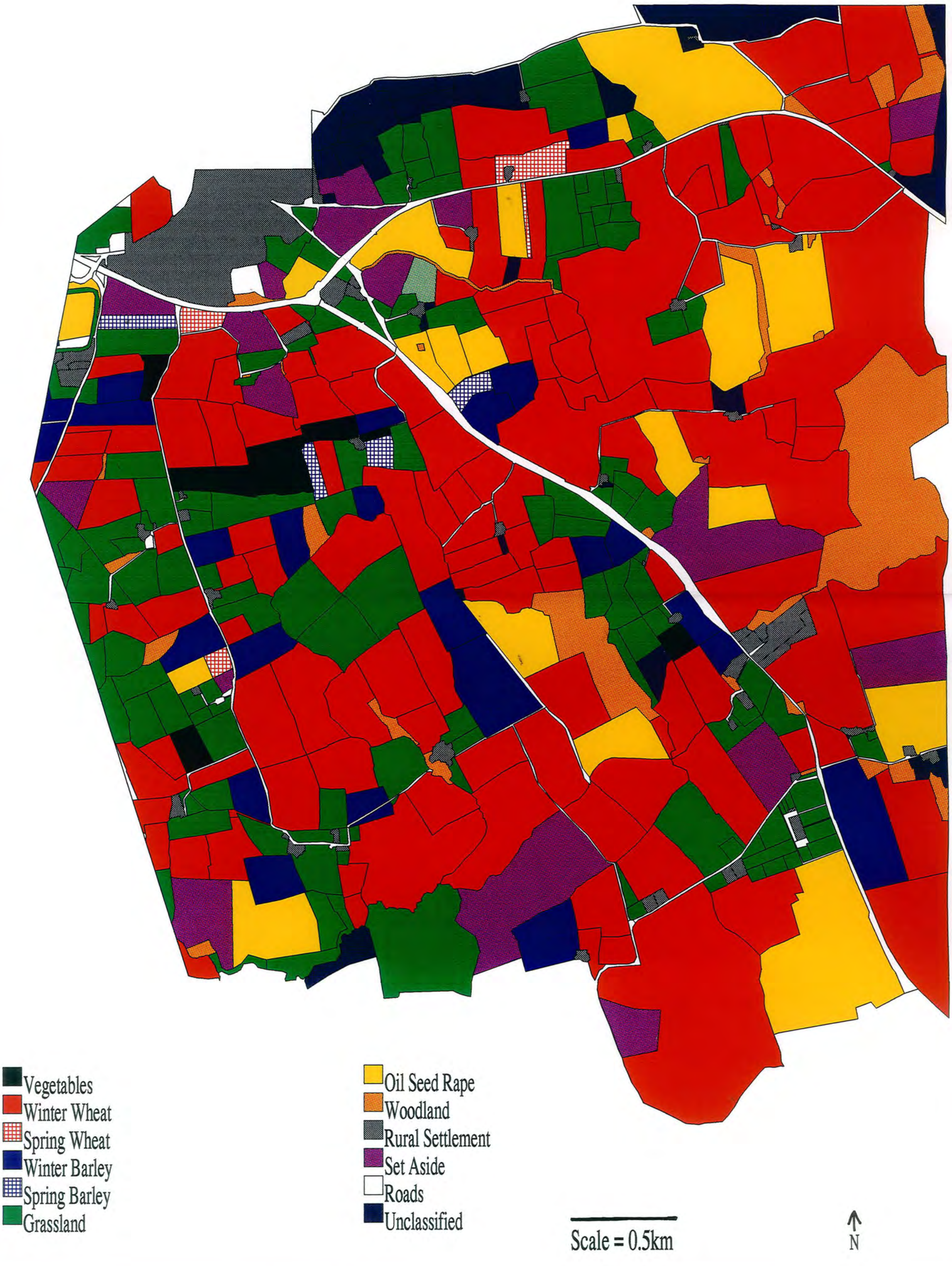
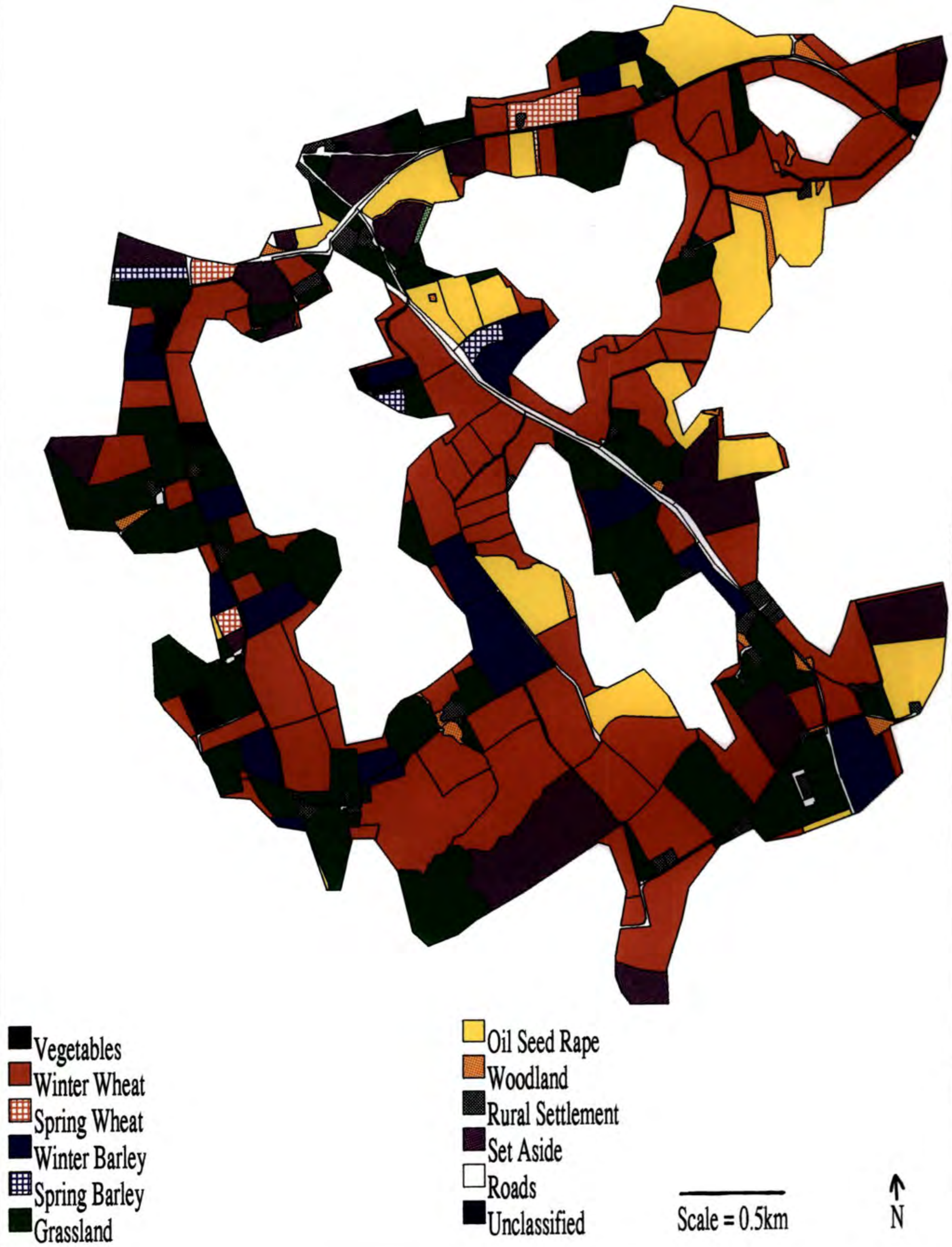


Fig 2.2 Sampled Area with Line Transect



2.2.5. The Third Dimension.

From the 1:10,000 scale O.S. maps of the study area a new coverage of the region was created by digitising in all the 5m interval contours. Each contour was assigned an id. label identical to that of its physical height, a spot height coverage was also produced in the same manner. A 3-dimensional TIN of the study area was then produced by combining the spot heights with the contours. By separately draping the study area and view field coverage's over the 3-dimensional model of the region and by queering the subsequently produced coverage it was hoped to ascertain the real world areas of fields and crops as well as working out the real world length of the line transect (i.e. including the effect of undulations). This however proved not to be very time consuming and was eventually abandoned. Because of the virtually flat topology of the Sedgefield site and the heterogeneous nature of its landuse one would presume that all habitat types were affected to the same extent and thus the error could be ignored.

2.2.6. Spatial analysis of the GIS.

From the digitised map of the study area containing features such as roads, buildings, field boundaries etc., areas for a number of landuse categories were obtained and an overall picture of the study area built up. A corresponding breakdown of the landuse types from the view field coverage was also produced and this enabled a comparison of the two to see whether the sampled area (the view field coverage) was representative of the study area coverage (See section 3.1, Table 3.1.1.). In addition to working out the areas of each of the different landuse categories the distance of the transect was calculated (27.08 km).

As well as being able to spatially analyse the physical attributes of the different landuse types, spatial analysis of the distribution patterns of the nine bird species was also possible. A FORTRAN program first written by Dr. Brian Huntley to study the distribution patterns of several species in a given area was adapted to analyse the distribution patterns of the nine bird species. From each of the 27 line transect point coverage's real world 'x' and 'y' co-ordinates were obtained (using the command ungenerate) for every bird observation. Using a text editor, species identifiers were added to all appropriate 'x' 'y' co-ordinates, this data was then imported into the computer program and the program run. A range of distribution type information was produced and included...

- a computation of the nearest neighbour regardless of identity and nearest conspecific neighbour.
- a frequency tally of nearest neighbour being of each taxon and, for conspecifics, excluding pairs that were mutually nearest neighbours.

- a mean and standard deviation of nearest neighbour distances regardless of identity and for conspecifics

2.2.7. GIS attribute analysis.

By overlaying the point coverages containing the attribute data from field observations over the polygon coverage containing the landuse attributes it was possible to identify the habitat in which each observation occured. By using the select and reselect commands in Tables numerous questions could be asked of the data. Examples of the questions asked include how many Rooks were observed feeding in winter wheat on any particular day or how many birds were observed feeding on roads and of those observations which road type (Number of categories used based on their utilisation by traffic) was the most commonly used. By asking the same questions to each of the attribute data base files (27 in all) a manageable database was created from which statistical analysis of the data could be undertaken.

2.3. Statistical analysis.

There were two main aspects to this study, firstly the determination of the habitat utilisation patterns of the different bird species. Whether these patterns differed between species or changed over time. The second aspect of the study was a spatial analysis of the distribution patterns of the species, with particular emphasis on the potential change in patterns over time. All data sets created were stored as Excel files and predominantley analysed using SPSS. Zar 1984 was used for all statistical referals.

Description of the data - Negative Binomial use of non parametric tests

The first step in the analysis of any data is the analysis of the distribution of that data. It was found that the habitat utilisation data in this study was distributed in a negative binomial fashion. Negative binomial distributions are typical of count data were the individuals being counted are not dispersed randomly, nor are they independent of one another (i.e. some degree of clumping is shown). This type of data is frequently obtained from defined sampling units (e.g. line transects). There are two approaches in the analyses of this type of data, firstly the data can be normalised (log transformation) and analysed through the use of parametric statistical tests, on the other hand the data can be analysed through the use of non parametric tests. Whenever possible the non normal raw data was used in statistical analysis, if an appropriate non normal test was not available or proved unsuitable the data was normalised using an appropriate transformation. Typical transformations used in the analysis of the data presented in this study included ArcSin transformation of percentage data and Log / Log + 1 transformations of the count data.

The first statistical test carried out on the habitat utilisation data was a Non Parametric Two-Factor Analysis of Variance (an extension of the Kruskall-Wallis test). The two factors being investigated in this test were Habitat type and Time, the null hypothesis being investigated being that no difference existed in the utilisation of all the habitat types and that no change occured in the utilization of all habitat types between three distinct periods of the study. A simple chi-square analysis to see whether the study species were distributed throughout the study area in proportion to the areas of the different landuse types was then undertaken. All chi-square analysis undertaken in this study used the the Roscoe & Bryars 1971 constraints with respect to sample size. The Ivlev index (Ivlev, 1961), an index of habitat preference was then used to ascertain which species selected which habitats preferentially within the study area. The Index used took into account the modification suggested by Jacob's (1974) and used in Inglis, *et al.*, (1990). This index of electivity uses a simple mathematical equation which relates the proportion of a particular species utilising a given habitat to the proportion of the habitat over the whole area. The index goes from a value of -1 for habitats which are always avoided, through zero which signifies no preference, to +1 which would indicate that all birds in the area were feeding on that crop regardless of its size in relation to the total overall area. In an attempt to determine how similar species were with regards to their habitat utilisation a Spearmans Rank Correlation was undertaken. This was carried out by ranking the frequency of habitat utilisation in the eleven habitat types in order of decreasing frequency for each species. Pairs of species were then systematically tested and a matrix of Rs values built up. From this matrix a similarity dendogram was produced by removing the highest shared value and then averaging these two species shared linkages with all other species. The next highest value from the new table was then used to determine the next most associated pair and so on until all possible associations were examined.

Nearest Neighbour Statistic

Ecologists are frequently interested in determining whether points in an area are distributed randomly, as opposed to being clumped or regularly spaced. Clark & Evans (1954) proposed a test for spatial randomness which has gained popularity recently in ecology. Recent applications of the test include Harrison & Gentry (1981), Horton & Wise (1983) and Lamberti & Resh (1983). Using the test suggested by Clark *et al.*, 1954, a computer program was written by Dr. Brian Huntley to determine the distribution patterns of up to 10 taxa and for up to 1000 individuals. This program was run using the 'x' and 'y' co-ordinates generated from the each of the 27 point coverage's. A distribution value was produced for each species from each of the line transects, this R value is used to describe the distribution pattern. A randomly distributed population would give a value for the nearest neighbour statistic R of one. Perfect aggregation would make all nearest neighbour distances zero and make R zero also. Regularity is indicated by an R statistic value of 1.25.

Results

Section 3.1. Summary Tables.

Table 3.1.1. Areas of the various habitat categories measured in hectares and given as an overall percentage occurrence in the study area and from the line transect sampled area.

Study Area			Sampled Area		
Habitat Type	**Area (Ha)**	**% Area**	**Habitat Type**	**Area (Ha)**	**% Area**
Winter Wheat	1337.5	46.6 %	**Winter Wheat**	562.1	39.4 %
Spring Wheat	13.8	0.5 %	**Spring Wheat**	13.2	0.9 %
Winter Barley	165.8	5.8 %	**Winter Barley**	107.3	7.5 %
Spring Barley	12.9	0.4 %	**Spring Barley**	8.8	0.6 %
Veg. Crops	34.7	1.2 %	**Veg. Crops**	12.1	0.8 %
Oil Seed Rape	294.8	10.3 %	**Oil Seed Rape**	158.1	11.1 %
Set Aside	183.7	6.4 %	**Set Aside**	140.9	9.9 %
Grassland	488.7	17.1 %	**Grassland**	322.2	22.6 %
Woodland Edge	142.3	4.9 %	**Woodland Edge**	15.8	1.1 %
Rural Settlement	100.7	3.5 %	**Rural Settlement**	24.7	1.7 %
Roads	92.7	3.2 %	**Roads**	61.7	4.3 %
Total	2867.8		**Total**	1426.9	

Examination of Table 3.1.1. shows that the sampled area is quite representative of the study area and thus of the total landscape available to the study species.

Table 3.1.2. Median number of observations made per transect in each of the eleven habitat types,
(95 % confidence intervals in parenthesis, n = 27)

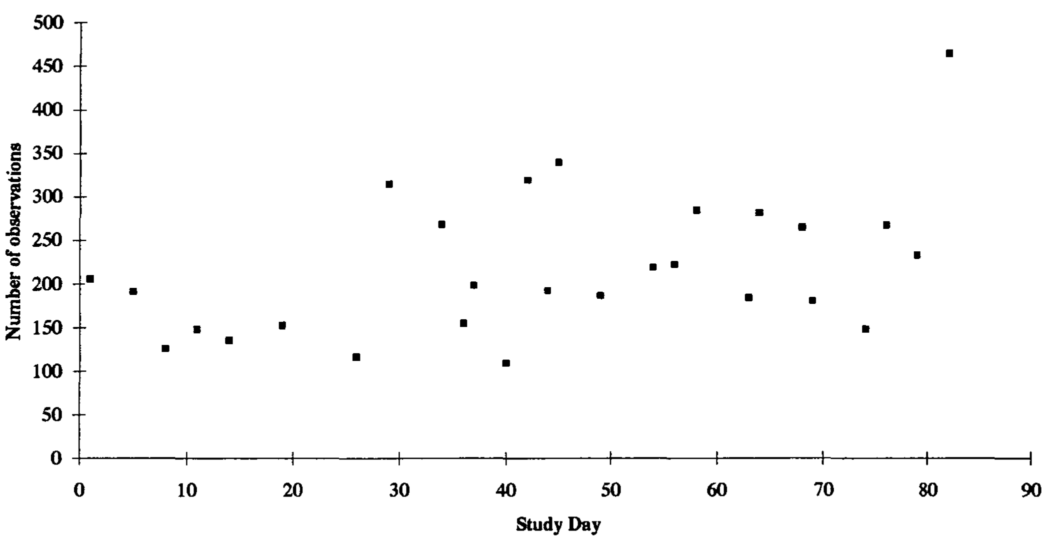
	Rook	Crow	Jackdaw	Magpie	Wood pigeon	Lapwing	Curlew	Pheasant	Partridge
Total	201.5 (180-267)	109.5 (92-121)	19 (14-30)	6.5 (5-8)	62 (40-83)	22.5 (5-40)	2 (1-3)	7 (3-11)	9 (6-13)
Winter Wheat	0 (0-1)	5 (2-8)	0 (0-0)	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-2)
Spring Wheat	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Winter Barley	0 (0-0)	0 (0-2)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Spring Barley	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Veg Crops	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Oil Seed Rape	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-0)	8.5 (2-28)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Set Aside	19.5 (4-39)	15.5 (13-20)	0 (0-3)	0 (0-1)	9.5 (4-14)	9.5 (4-21)	1 (0-2)	0 (0-0)	0 (0-1)
Grassland	149.5 (96-192)	43.5 (39-53)	13 (4-18)	2 (1-3)	6.5 (2-15)	0 (0-2)	0.5 (0-1)	2 (0-3)	1 (0-3)
Woodland Edge	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Rural Settlement	0 (0-0)	0.5 (0-1)	0 (0-0)	0 (0-0)	1 ((0-3)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Roads	0 (0-0)	8 (4-10)	0 (0-0)	0.5 (0-1)	0 (0-0)	0 (0-0)	0 (0-0)	2 (0-3)	2.5 (1-5)

From Table 3.1.2. it is apparent that certain habitat types are used much more frequently than others by all of the study species, e.g. Grassland v.'s Spring Barley. Another aspect to look at is how certain species e.g. Crows utilise many more of the habitat types than say for example Lapwings. Additionally the variability in the numbers of each species sampled over the 27 transects is another aspect of interest, the significant fluctuations are indicated by the 95 % confidence intervals.

Section 3.2. Bird Observations

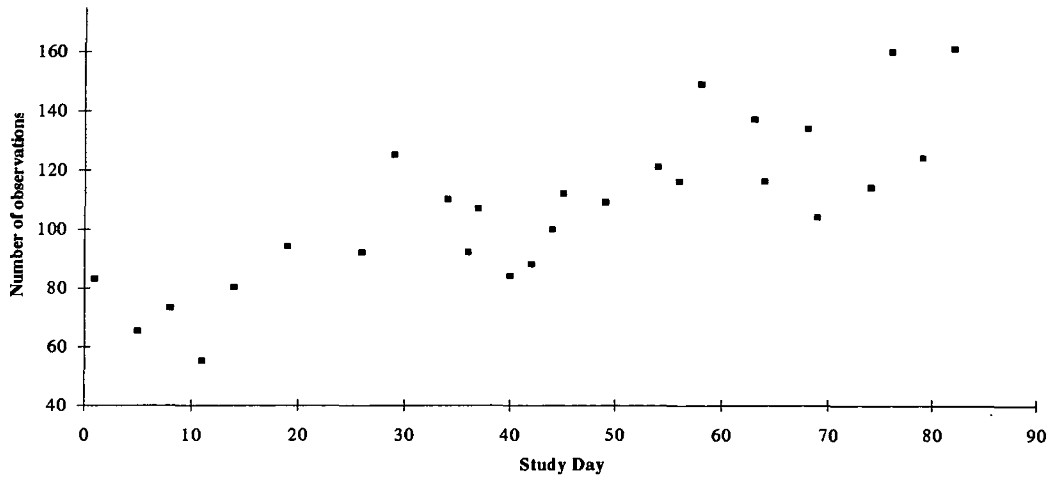
To discover what general trends existed in the overall numbers of observations made for each species, linear correlation analysis were undertaken whenever possible. In the following nine graphs (Graph 3.2.1. - Graph 3.2.9.) all values displayed are the non normal count observations made on each transect day. This non normal data was displayed as it gives a better indication as to the trends in actual bird numbers. The correlation analysis was only undertaken on the transformed data if a linear trend was observed between the number of birds observed and the study day. The data was transformed using one of two transformation methods, a Log + 1 transformation on non normal count data which contained zero value and a Log transformation for those data sets which contained no zero observations.

Graph 3.2.1. Number of Rooks per Transect (n = 27).



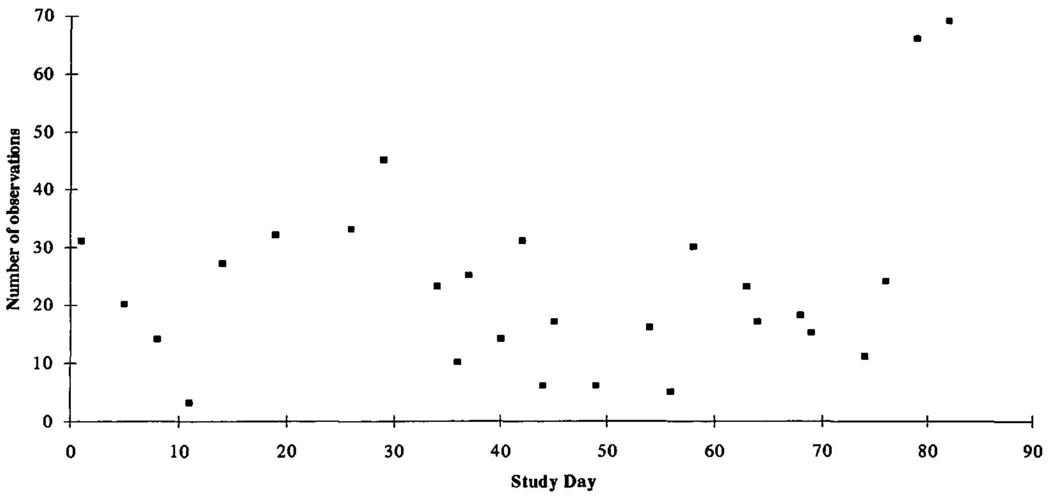
The data displayed in Graph 3.2.1. was normalised using a Log transformation and a correlation analysis undertaken on the transformed linear data. The result of this test indicated that a significant positive correlation exists between the Log of Rook numbers observed on each transect and study day. An R value of 0.486 with 25 d.f. gave a significant positive correlation at the $P < 0.02$ level. While an increase over time is evident tremendous fluctuations do occur between transects.

Graph 3.2.2. Number of Crows per Transect (n = 27).



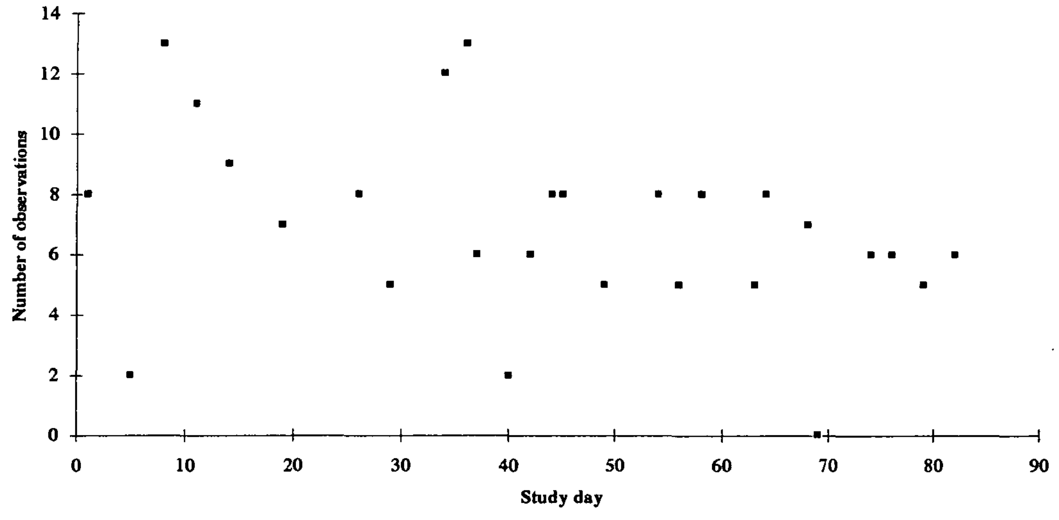
The Log transformed Crow observational data was plotted graphically and was found to approximate to linearity. A correlation analysis undertaken between the logged values for Crows observed on each transect with the study day gave a significant R value, $R = 0.8217$ at 25 d.f., $P < 0.001$.

Graph 3.2.3. Number of Jackdaw per Transect (n = 27).



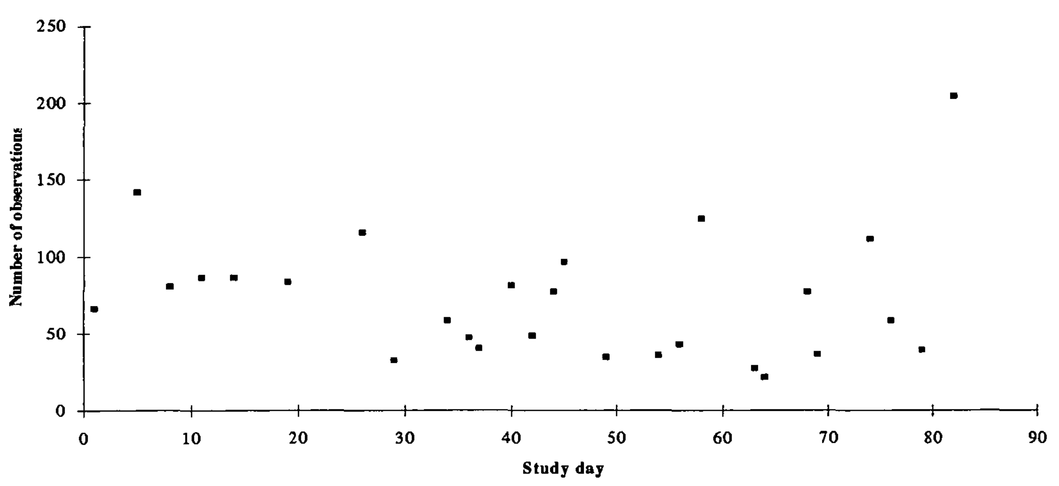
The Jackdaw observational data was transformed using a Log transformation and plotted to see if a linear relationship existed between the number of observations per transect and the study day. A linear relationship was not found and as a result a correlation analysis was not possible. Significant fluctuations are noticeable in the number of jackdaw sampled over time, these fluctuations may be explainable in terms of jackdaw colonies located on the periphery of the study area being sampled periodically.

Graph 3.2.4. Number of Magpie per Transect (n = 27).



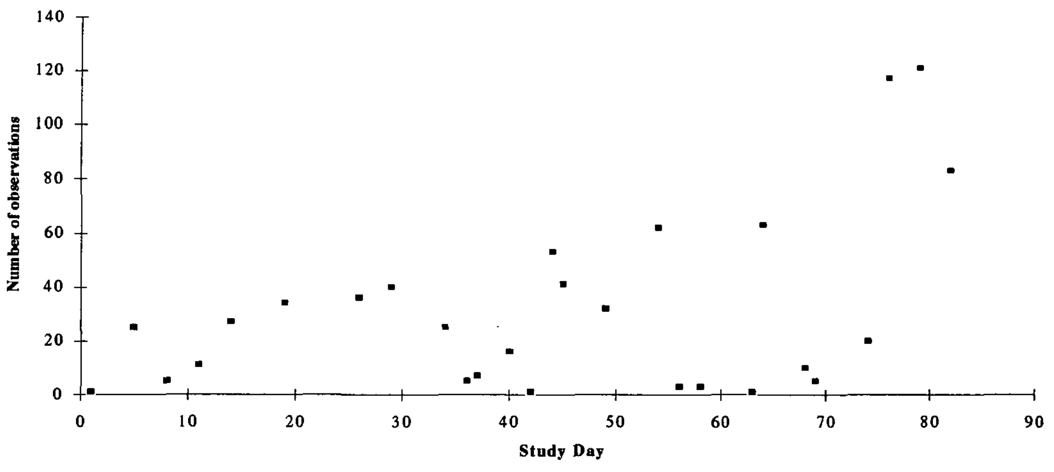
The data from graph 3.2.4 was normalised using a Log +1 transformation. This data was then plotted to see if a linear relationship with time occurred. A linear relationship appeared to be present if a number of outliers were ignored, this linear relationship was in a negative direction, R = -0.2726, d.f. 25, at the 5 % level this R value was found not to be significant.

Graph 3.2.5 Number of Woodpigeon per Transect (n = 27).



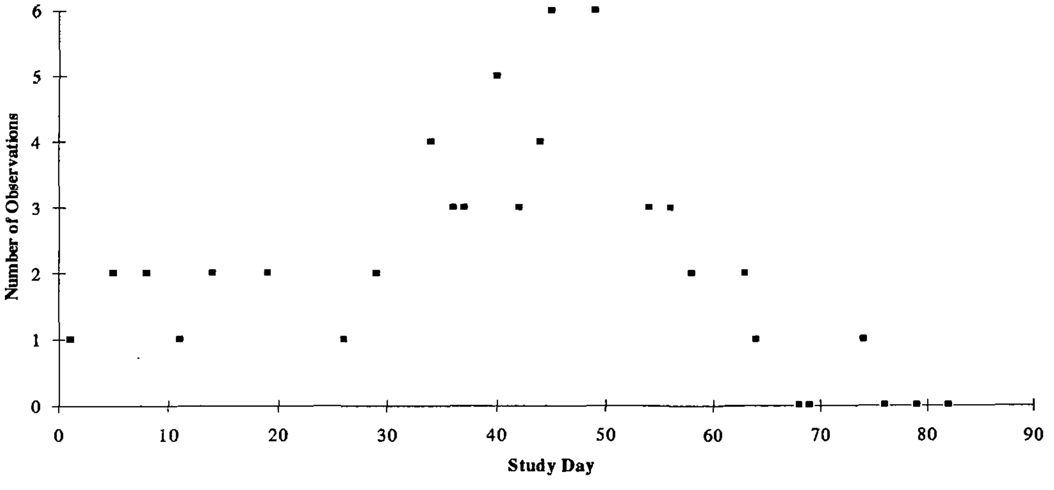
The Woodpigeon observational data displayed in Graph 3.2.5. was normalised using a Log transformation and plotted to check for a linear relationship with study day. No such relationship was evident.

Graph 3.2.6 Number of Lapwing per Transect.



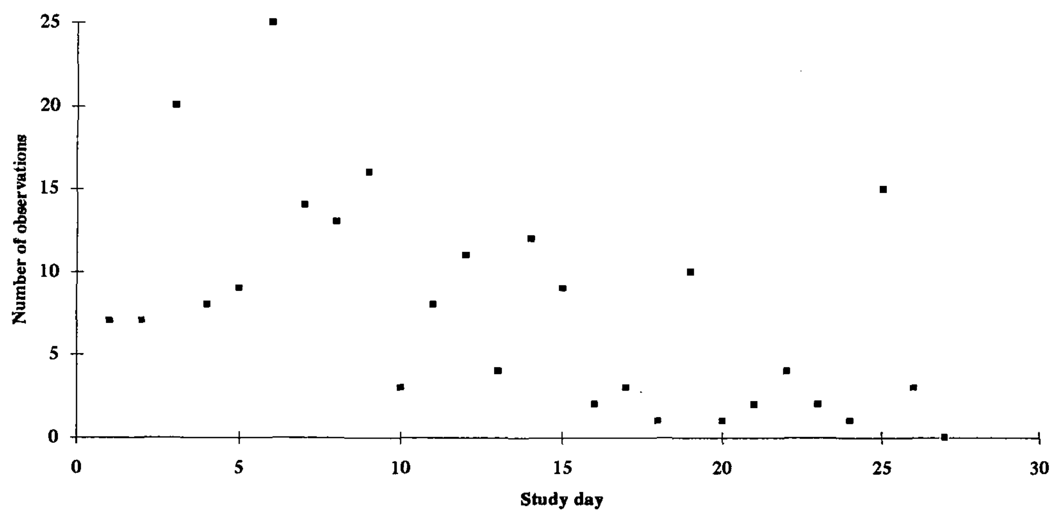
The Lapwing data was normalised using a Log + 1 transformation and checked to see if a linear relationship existed between the number of Lapwings per transect and Study day. A positive linear relationship was observable if a number of outliers present towards the end of the study period were ignored, R = 0.2487, d.f = 25, the correlation was however not significant at the 0.05 level. Large fluctuations between study days are evident and are probably related to the flocking behaviour of Lapwing at this time of year.

Graph 3.2.7. Number of Curlew per Transect.



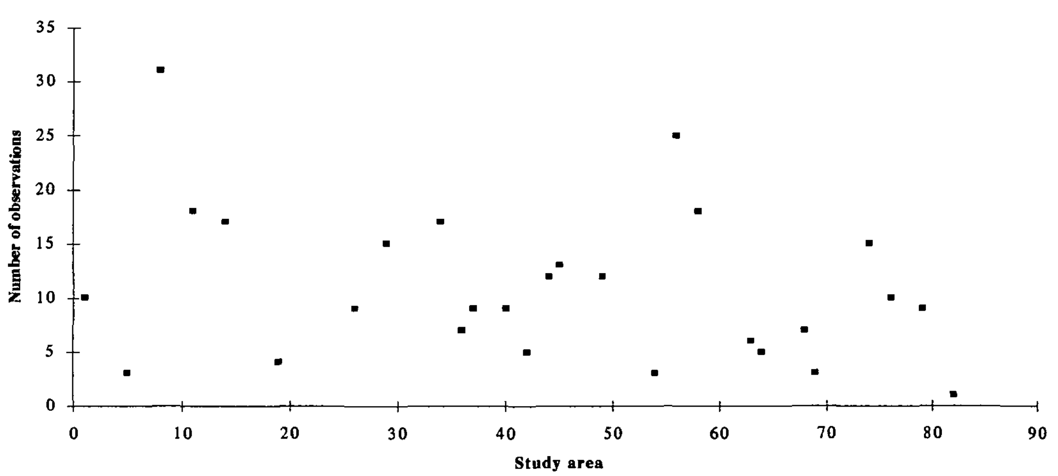
The Curlew data presented above displays a distinctive pattern which is easily explained. The peak located around study day 45 was caused by the repeated sampling of a number of Curlew chicks in one area of the transect over a number of consecutive study days. From that stage onwards there is a decline in Curlew observations as the young Curlew become more cryptic, before all Curlew appear to move from the study area.

Graph 3.2.8. Number of Pheasant per Transect.



The data presented in graph 3.2.8. was normalised using a Log + 1 transformation and plotted graphically. A linear relationship was evident between the Log + 1 number of Pheasants observed per transect and study day. A correlation analysis was undertaken on this data and a significant negative R value -0.624 was obtained, d.f. = 27, $P < 0.001$. The decrease in number of Pheasant observed over time may be explainable behaviourally in terms of anti predator behaviour by adults with young.

Graph 3.2.9. Number of Partridge per Transect.



The data presented in the above graph was normalised using a Log transformation and checked to see if a linear relationship existed between the Log of Partridge numbers observed per transect and study day. A tentative negative linear relationship was evident. A correlation analysis undertaken on the normalised data was found to have a correlation coefficient of -0.229 however this was found not to be significant at the 0.05 level, d.f. = 25. The apparent decrease in numbers observed over time may be again explainable in terms of behavioural changes during the breeding season.

To determine whether factors such as weather conditions played any role in the number of individual species sampled during the study a series of simple correlation analysis were undertaken. The Log transformed observational data for pairs of species were compared using correlation analysis and a matrix of R values produced, see Table 3.2.1..

Table 3.2.1. Matrix of paired species number correlation's, n = 27, d.f. = 25. Significance at the 0.05 level indicated by *, 0.01 ** and 0.001 ***.

	Crow	Jackdaw	Magpie	Wood pigeon	Lapwing	Curlew	Pheasant	Partridge
Rook	0.685***	0.441*	0.028	-0.090	0.215	-0.127	-0.334	-0.314
Crow		0.382*	-0.040	-0.189	0.222	-0.220	-0.390*	-0.230
Jackdaw			-0.070	0.120	0.240	-0.390*	0.070	0.391*
Magpie				0.116	0.008	0.211	0.262	0.410*
Woodpigeon					0.121	-0.127	0.214	-0.018
Lapwing						-0.206	0.122	-0.230
Curlew							0.231	0.294
Pheasant								0.415*

While it is apparent that some pairs show significant correlation's with regards their observed numbers the general pattern is of non significance. This would suggest that a factor such as weather condition did not play a major role in determining the number of individuals observed. This suggests that the trends observed in the observational data have a biological explanation, i.e. can be explained in terms of behaviour, feeding ecology, reproductive biology, etc..

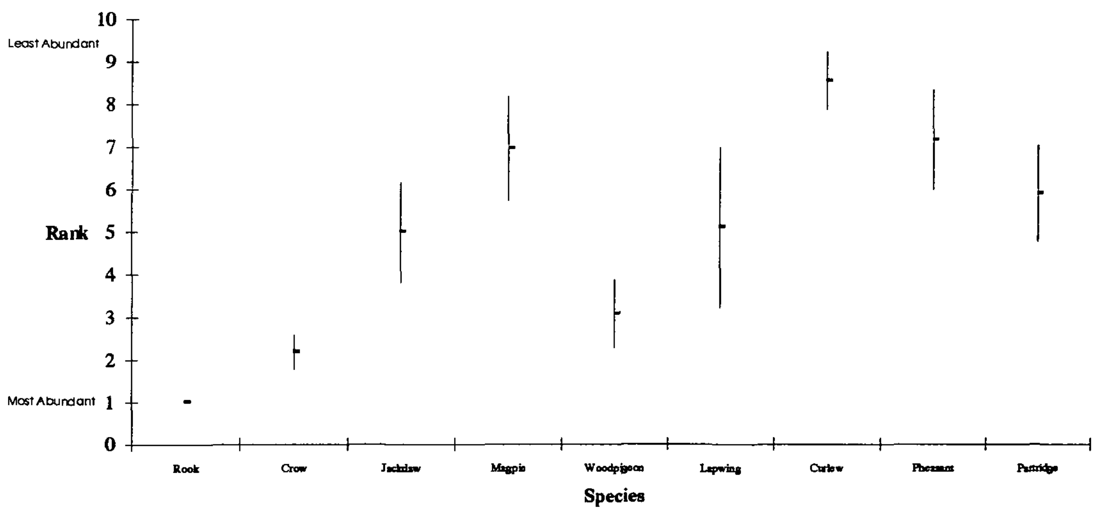
Species Relative Abundance

To determine the relative abundance of each of the nine species in the study area the species were ranked in accordance to the frequency observed in each of the 27 transects. The mean rankings of each species where then calculated and a graph produced of the mean rank values +/- the standard deviation of each species rank, see Graph 3.2.10. For full table of rankings see Appendix 3.

Table 3.2.2. Relative abundance of the nine study species.

Rook > Crow > Woodpigeon > Jackdaw ≅ Lapwing > Partridge > Pheasant ≅ Magpie > Curlew

Graph 3.2.10. Mean rank abundance of each of the nine study species +/- standard deviation (n = 27).



Section 3.3 Habitat Utilisation

One of the main aspects of this study was to determine whether changes occurred in the feeding patterns of the study species through time. For this reason the study was broken into three distinct periods between which comparisons could be made.

Period 1 18/5/95 - 16/5/95
Period 2 17/5/95 - 10/6/95
Period 3 11/6/95 - 7/8/95

From this point forwards any reference to period 1, period 2 or period 3 refers to the dates quoted above.

Section 3.3. Habitat Utilisation

A non parametric two-factor analysis of variance was undertaken on the habitat utilisation data using an extension of the Kruskall-Wallis test (Zarr, 1984). The two factors under investigation were Time and Habitat type. The three null hypothesis (Ho) being investigated for each of the nine species are listed below.

Ho.1-There is no significant difference in the utilisation of habitats between the three time periods.

Ho.2-There is no significant difference in the utilisation of the eleven habitat types.

Ho.3-There is no significant interaction between Time and habitat type on the habitat utilisation of the species.

Table 3.3.1. Results of Non parametric two-factor analysis of variance.

Species	Factor	H - Value	d.f.	Significance
Rook	Time	0.1496	2	N.S.
	Habitat Type	1640.13	10	P < 0.001
	Interaction	65.716	20	P < 0.001
Crow	Time	29.24	2	P < 0.001
	Habitat Type	930.56	10	P < 0.001
	Interaction	41.96	20	P < 0.005
Jackdaw	Time	13.78	2	P < 0.005
	Habitat Type	602.07	10	P < 0.001
	Interaction	43.45	20	P < 0.001
Magpie	Time	8.08	2	N.S.
	Habitat Type	488.21	10	P < 0.001
	Interaction	54.16	20	P < 0.001
Woodpigeon	Time	10.61	2	P < 0.005
	Habitat Type	1004.74	10	P < 0.001
	Interaction	156.55	20	P < 0.001
Lapwing	Time	0.655	2	N.S.
	Habitat Type	587.49	10	P < 0.001
	Interaction	21.36	20	N.S.
Curlew	Time	1540.53	2	P < 0.001
	Habitat Type	1838.13	10	P < 0.001
	Interaction	-1414.814	20	P < 0.001
Pheasant	Time	64.57	2	P < 0.001
	Habitat Type	491.14	10	P < 0.001
	Interaction	89.33	20	P < 0.001
Partridge	Time	22.37	2	P < 0.001
	Habitat Type	516.15	10	P < 0.001
	Interaction	67.15	20	P < 0.001

From the results presented in (Table 3.3.1., page 25) it is evident that between the three time periods differences in the habitat utilisation patterns do occur for six of the nine species. Significant differences at the 0.001 level were found for Crow (H value 29.24, 2 d.f.), Curlew (H value 1540.53, 2 d.f.), Pheasant (H value 64.57, 2 d.f.) and Partridge (H value 22.37, 2 d.f.). Differences at the 0.005 level where observed for Jackdaw (H value 13.78, 2 d.f.) and Woodpigeon (H value 10.61, 2 d.f.). Non significant results with regards time where observed for Rook (h value 0.1495, 2 d.f.), Magpie (H value 8.08, 2 d.f.) and Lapwing (H value 0.655, 2 d.f.). Significant differences with regards utilisation of the eleven different habitat types were evident for all nine species at the 0.001 level at 10 d.f.. The H-values obtained were as follows, Rook (1640.13, 10 d.f.), Crow (930.56, 10 d.f.), Jackdaw (602.07, 10 d.f.), Magpie (488.21, 10 d.f.), Woodpigeon (1004.74, 10 d.f.), Lapwing (587.49, 10 d.f.), Curlew (1838.13, 10 d.f.), Pheasant (491.14, 10 d.f.) and Partridge (516.15, 10 d.f.).

It can be seen from table 3.3.1 that all of the nine species utilised the eleven habitat types unevenly. A Chi-square analysis was undertaken to ensure that such non random selection occurred, the results of this test are presented in table 3.3.2. The null hypothesis being investigated is that all nine species were distributed among the eleven habitat types in proportion to the area of each habitat i.e. suggesting no preference.

Table 3.3.2. Results of Chi-square analysis of habitat utilisation of individual species.

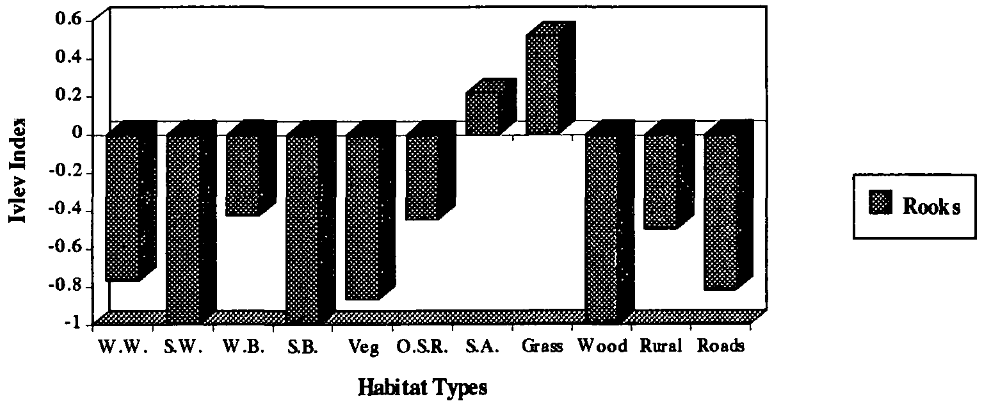
Species	**Chi-square value**	**Significance (d.f. = 10)**
Rook	2001.03	P < 0.001
Crow	785.60	P < 0.001
Jackdaw	164.44	P < 0.001
Magpie	69.06	P < 0.001
Woodpigeon	4362.22	P < 0.001
Lapwing	3701.00	P < 0.001
Curlew	38.64	P < 0.001
Pheasant	150.35	P < 0.001
Partridge	73.15	P < 0.001

It can be seen from the results presented in Table 3.3.2. that all nine species rejected the null hypothesis, indicating that all of them to some extent or another selected or avoided specific habitat types. A habitat preference index was subsequently produced (the Ivlev Index) to determine which habitat types were selected and which were avoided. The results of this statistic are presented in graphical form in the following two pages (See Graph 3.3.1. - Graph 3.3.9.). As mentioned in section 2.3. page 14, the values calculated using the Ivlev index refer to the selection or avoidance of specific habitat types. Positive values of any magnitude indicate preference, the degree of which is indicated by the magnitude of the positive value. Negative values are indicative of habitat avoidance, again the magnitude of the value indicates the degree of avoidance. Values of +1 and -1 indicate that all observations were made on that habitat type or that no observations were ever made in that habitat type, respectively.

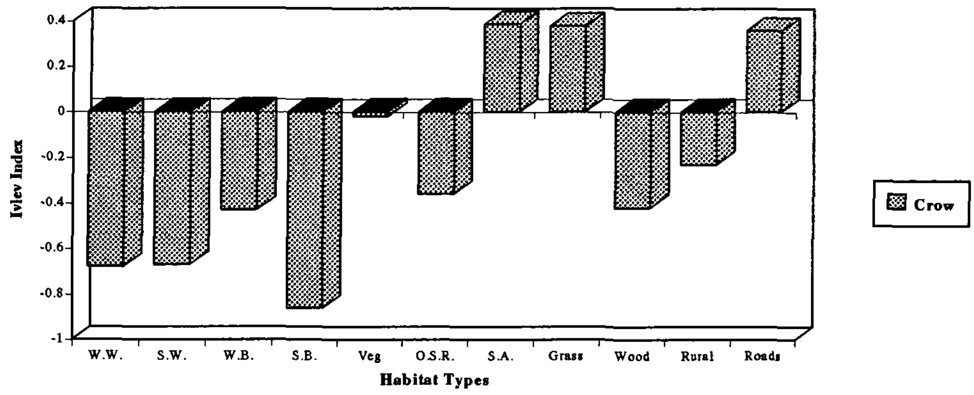
Table 3.3.3. Species Ivlev Index Values (Habitat selection indicated by italics). Total number of observations, Rook (n = 5,558), Crow (n = 2,825), Jackdaw (n = 604), Magpie (n = 178), Woodpigeon (n =1,859), Lapwing (n = 827), Curlew (n= 57), Pheasant (n = 201) and Partridge (n = 276).

	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
Rook	-0.77	-1.00	-0.43	-1.00	-0.87	-0.45	*0.22*	*0.52*	-1.00	-0.50	-0.82
Crow	-0.68	-0.67	-0.43	-0.86	-0.02	-0.36	*0.39*	*0.38*	-0.42	-0.23	*0.36*
Jackdaw	-0.59	-1.00	-0.61	-1.00	-1.00	*0.09*	*0.18*	*0.44*	-1.00	-0.62	-0.25
Magpie	-0.96	-0.03	-0.79	-1.00	*0.67*	-0.73	*0.28*	*0.32*	-1.00	*0.43*	*0.72*
Wood pigeon	-0.93	-1.00	-0.12	-1.00	-0.33	*0.56*	*0.43*	*0.03*	-0.88	*0.28*	-0.63
Lapwing	-1.00	-1.00	-1.00	-1.00	-1.00	-0.96	*0.77*	*0.03*	-1.00	-1.00	-1.00
Curlew	-1.00	-1.00	-0.52	-1.00	-1.00	-1.00	*0.68*	*0.33*	-1.00	-1.00	-1.00
Pheasant	-0.73	*0.45*	-0.67	*0.10*	-1.00	-0.10	*0.24*	*0.53*	-1.00	-0.68	-0.05
Partridge	-0.24	*0.17*	-1.00	-1.00	-1.00	-0.03	*0.05*	*0.34*	-1.00	-1.00	*0.15*

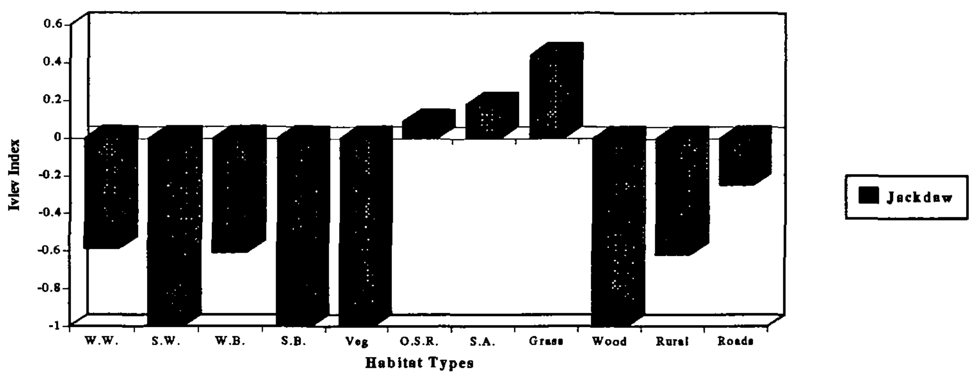
Graph 3.3.1. Ivlev index values indicating habitat utilisation of Rook (n = 5,558).



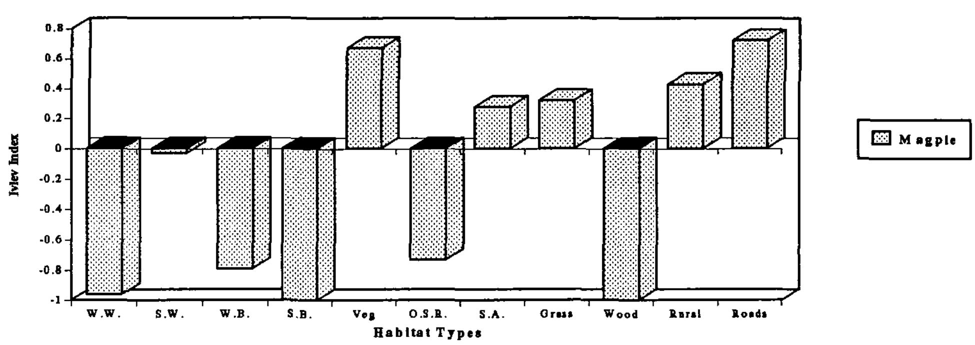
Graph 3.3.2. Ivlev index values indicating habitat utilisation of Crows (n = 2,825).



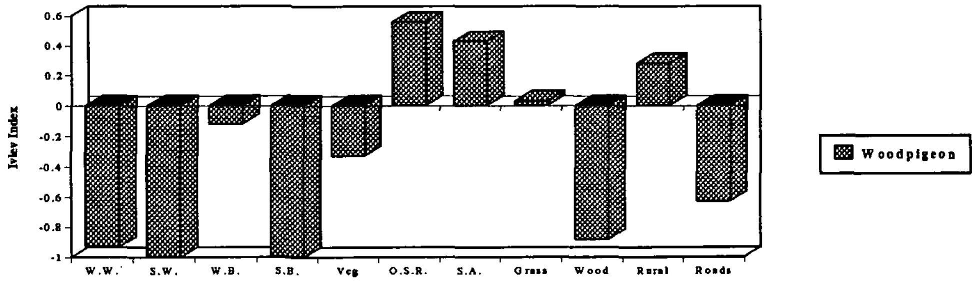
Graph 3.3.3. Ivlev index values indicating habitat utilisation of Jackdaw (n = 604).



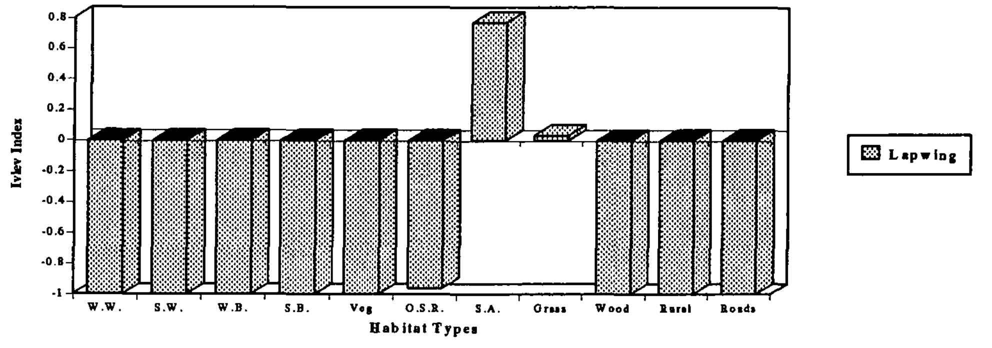
Graph 3.3.4. Ivlev index values indicating habitat utilisation of Magpie (n = 178).



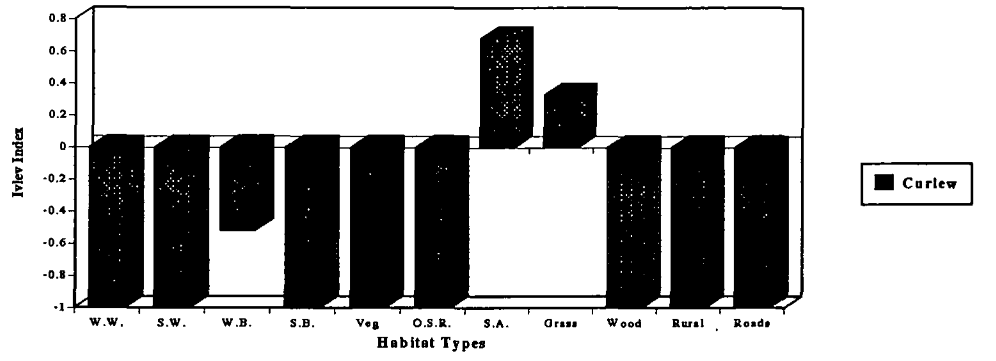
Graph 3.3.5. Ivlev index values indicating habitat utilisation of Woodpigeon (n = 1,859).



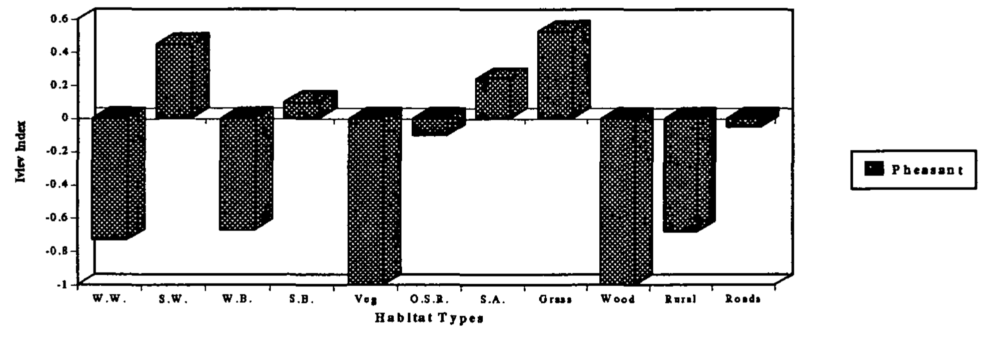
Graph 3.3.6. Ivlev index values indicating habitat utilisation of Lapwing (n = 827).



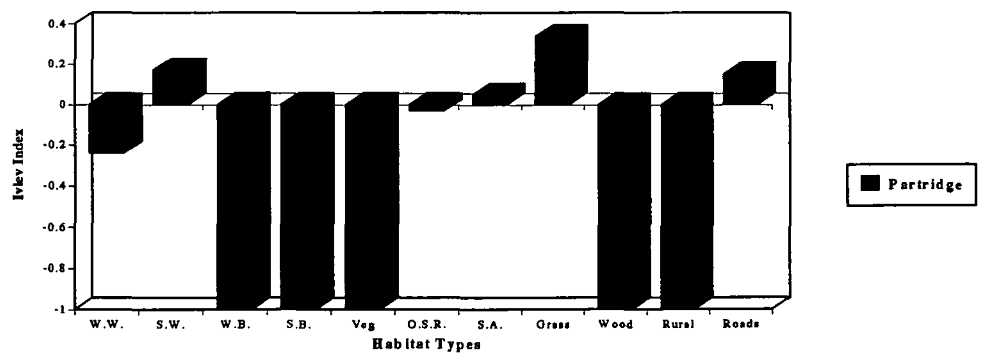
Graph 3.3.7. Ivlev index values indicating habitat utilisation of Curlew (n = 57).



Graph 3.3.8. Ivlev index values indicating habitat utilisation of Pheasant (n = 201).



Graph 3.3.9. Ivlev index values indicating habitat utilisation of Partridge (n = 276).



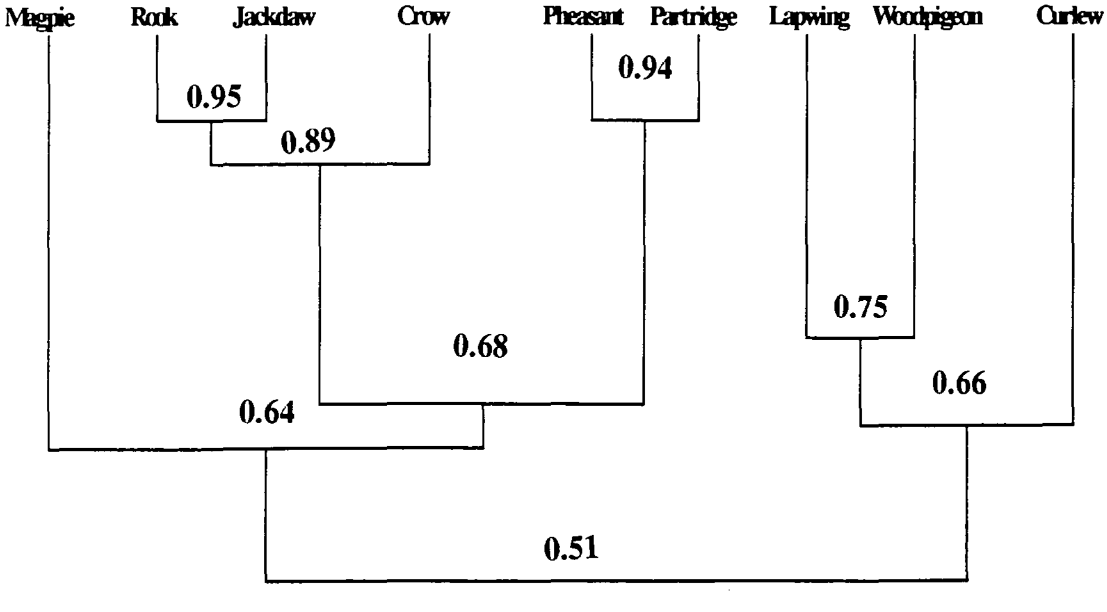
To test for significant similarity between the study species with regards to their habitat utilisation a Spearmans Rank Correlation analysis was undertaken. By ranking each species habitat utilisation (over the whole study period) in decreasing order of frequency and comparing between all possible species pairs a similarity / dissimilarity matrix was produced (See Table 3.3.4.).

Table 3.3.4. Matrix of paired Spearman Rank (Rs) Correlations. Symbol * = $P < 0.05$, ** = $P < 0.02$, *** = $P < 0.01$, N.S. = non significant result, n = 11, d.f. = 10.

	Rook	Crow	Jackdaw	Magpie	Woodpigeon	Lapwing	Curlew	Pheasant	Partridge
Rook	/	0.9000 ***	0.9500 ***	0.6227 *	0.8841 ***	0.7227 **	0.6727 *	0.7136**	0.6091 N.S.
Crow		/	0.8818 ***	0.6364 *	0.5773 N.S.	0.4193 N.S.	0.3193 N.S.	0.6727 *	0.6046 N.S.
Jackdaw			/	0.6614 *	0.8705 ***	0.7864 ***	0.6364 *	0.8523 ***	0.7636 **
Magpie				/	0.5636 N.S.	0.5591 N.S.	0.4591 N.S.	0.6455 *	0.6409 **
Woodpigeon					/	0.7477 **	0.5977 N.S.	0.5273 N.S.	0.4068 N.S.
Lapwing						/	0.7250 **	0.6000 N.S.	0.5136 N.S.
Curlew							/	0.5000 N.S.	0.3136 N.S.
Phesant								/	0.9409 ***
Partridge									/

From the above matrix it is evident that all species in this study show positive correlation with respect to their habitat utilisation patterns. Significant correlations at the $P < 0.05$, $P < 0.02$ and $P < 0.01$ levels are indicated by ***, **, and * symbols shown within the table, non significant results are indicated by N.S.. From Table 3.3.4. it was possible to produce a similarity index dendogram (See Section 2.3., page 15) to display graphically how similar in habitat utilisation the nine species were.

Graph 3.3.10. Habitat utilisation similarity index.



At the start of section 3.3. (Habitat Utilisation, page 25) a non parametric two factor analysis of variance was undertaken on the raw habitat utilisation data. One of the two factors analysed at that stage was the effect of time on habitat utilisation. The data was split up into three approximately equal time periods each of which contained data from nine transects. The results of this test, presented in table 3.3.1(page 25) show that significant differences exist in the habitat utilisation patterns between time periods in six of the nine species. The six species which showed changes in habitat utilisation patterns between the three time periods were Crow ($P < 0.001$), Jackdaw ($P < 0.005$), Woodpigeon ($P < 0.005$), Curlew ($P < 0.001$), Pheasant ($P < 0.001$) and Partridge ($P < 0.001$). The three species which appeared to show no change in their utilisation patterns were Rooks, Magpie and Lapwing, all of which showed H-values less then 18.07 at the 0.05 level.

For those species which showed significant change over time with respect to their habitat utilisation patterns (see table 3.3.1), separate Ivlev values were calculated for each habitat type in each of the three time period. The following six diagrams graphically display the changes in habitat utilisation over time. To determine which habitat types accounted for the significant differences observed between the time periods a series of ANOVA's were undertaken for each habitat type across the three time periods ($n = 9$). Before this test could be done all the observational data was normalised using a Log + 1 transformation. The results of each separate ANOVA are presented in tabular form underneath the table with the corresponding calculated Ivlev index values.

Graph 3.3.11. Habitat utilisation of Crows over three set periods of the study. Period 1 n = 697, Period 2 n = 929 and Period 3 n = 1,199.

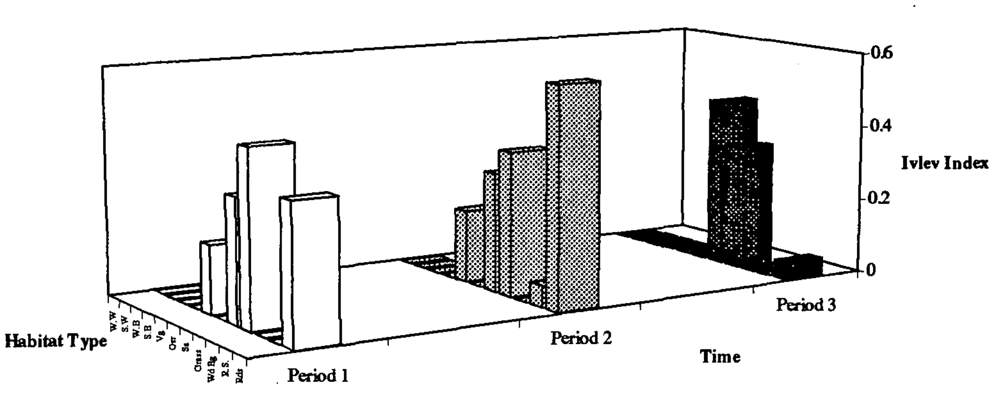


Table 3.3.5.a/b Calculated Crow Ivlev index values for each habitat type over three set periods (Habitat selection indicated in italics). Number of observations, Period 1 (n = 697), Period 2 (n = 929) and Period 3 (n = 1199). ANOVA result - d.f. = 26, n = 9.

a	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
Period 1	-0.78	-0.07	-0.81	-0.51	*0.18*	-0.72	*0.32*	*0.46*	-0.16	-0.26	*0.36*
Period 2	-0.62	-1.00	-0.83	-1.00	*0.19*	-0.84	*0.31*	*0.38*	-0.23	*0.06*	*0.58*
Period 3	-0.68	-1.00	-0.13	-1.00	-0.47	-0.05	*0.45*	*0.33*	-0.83	-0.55	*0.05*

b	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
ANOVA RESULT	N.S.	N.S.	P< 0.05	N.S.	N.S.	N.S.	P< 0.001	P< 0.01	N.S.	N.S.	P< 0.001

Graph 3.3.12. Habitat utilisation of Jackdaw during three set periods of the study. Period 1 n = 201, Period 2 n = 130 and Period 3 n = 273.

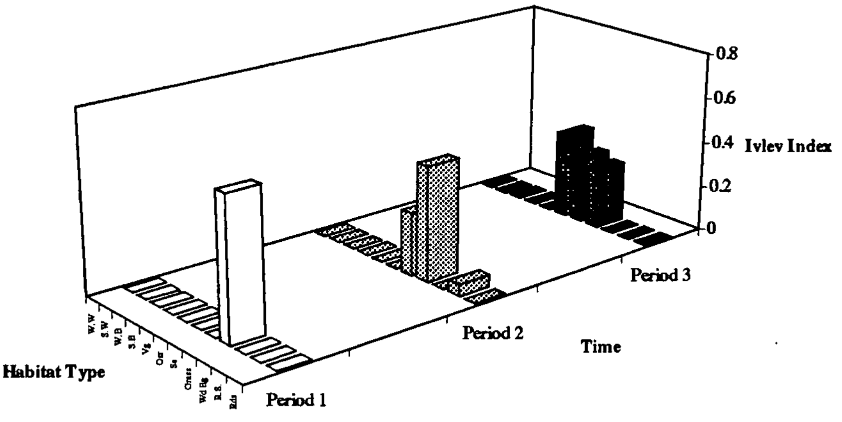


Table 3.3.6.a/b Calculated Jackdaw Ivlev index values for each habitat type over three set periods (Habitat selection indicated by italics). Number of observations, Period 1 (n = 201), Period 2 (n = 130) and Period 3 (n = 273). ANOVA result - d.f. = 26, n = 9.

a	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
Period 1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-0.50	*0.62*	-1.00	-1.00	-0.73
Period 2	-0.55	-1.00	-1.00	-1.00	-1.00	-1.00	*0.27*	*0.50*	-1.00	*0.05*	-0.64
Period 3	-0.48	-1.00	-0.39	-1.00	-1.00	*0.38*	*0.29*	*0.26*	-1.00	-1.00	-0.49

b	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
ANOVA RESULT	N.S.	N/A.	N.S.	N/A.	N/A.	P< 0.05	P< 0.05	N.S.	N/A.	N.S.	N.S.

Graph 3.3.13. Habitat utilisation of Woodpigeon during three set periods of the study. Period 1 n = 661, Period 2 n = 501 and Period 3 n = 697.

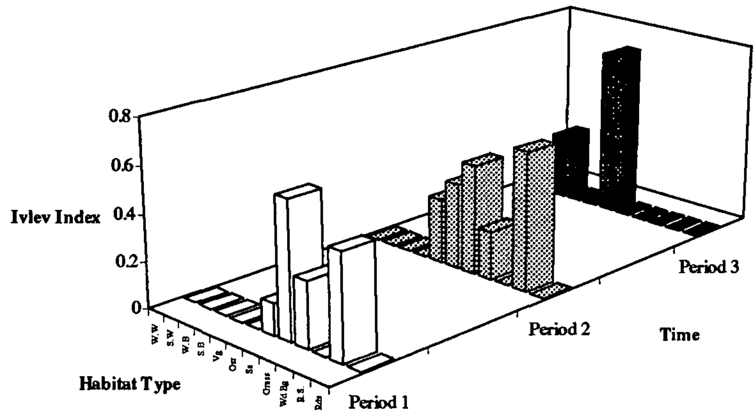


Table 3.3.7.a/b Calculated Woodpigeon Ivlev index values for each habitat type over three set periods (Habitat selection indicated by bold italics). Number of observations, Period 1 (n = 661), Period 2 (n = 501) and Period 3 (n = 697). ANOVA result -d.f. = 26,n=9.

a	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
Period 1	-0.95	-1.00	-1.00	-1.00	-1.00	***0.14***	***0.59***	***0.28***	-0.72	***0.45***	-0.49
Period 2	-0.94	-1.00	-0.52	-1.00	***0.28***	***0.37***	***0.47***	***0.21***	-0.57	***0.60***	-0.48
Period 3	-0.91	-1.00	***0.29***	-1.00	-0.65	***0.73***	-0.08	-0.66	-1.00	-0.24	-0.72

b	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
ANOVA RESULT	N.S.	N/A.	N.S.>	N/A.	P< 0.05	P< 0.005	P< 0.005	P< 0.05	N.S.	N.S.	N.S.

Graph 3.3.14. Habitat utilisation of Curlew during three set periods of the study. Period 1 n = 15, Period 2 n = 36 and Period 3 n = 6.

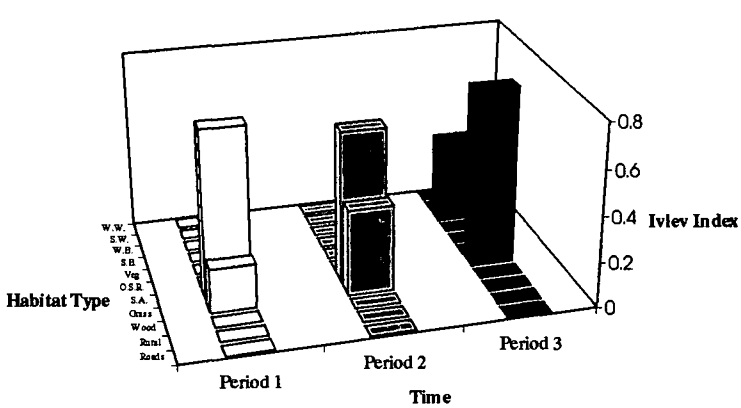


Table 3.3.8.a/b Calculated Curlew Ivlev index values for each habitat type over three set periods (Habitat selection indicated by bold italics). Number of observations, Period 1 (n = 15), Period 2 (n = 36) and Period 3 (n = 6). ANOVA result - d.f. = 26, n = 9.

a	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
Period 1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	0.74	0.19	-1.00	-1.00	-1.00
Period 2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	0.67	0.38	-1.00	-1.00	-1.00
Period 3	-1.00	-1.00	-0.38	-1.00	-1.00	-1.00	0.79	-1.00	-1.00	-1.00	-1.00

b	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
ANOVA RESULT	N/A.	N/A.	N.S.	N/A.	N/A.	N/A.	P< 0.05	P< 0.001	N/A.	N/A.	N/A.

Graph 3.3.15. Habitat utilisation of Pheasant during three set periods of the study. Period 1 n = 110, Period 2 n = 53 and Period 3 n = 38.

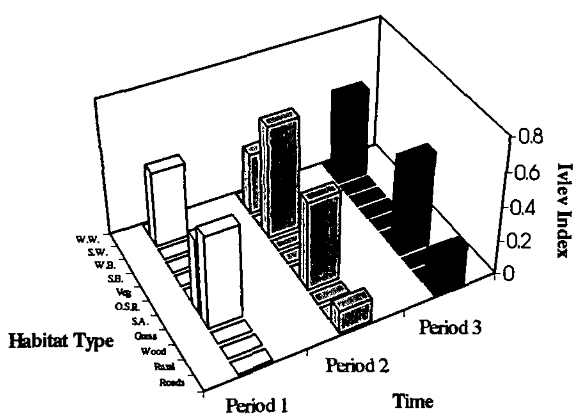


Table 3.3.9.a/b Calculated Pheasant Ivlev index values for each habitat type over three set periods (Habitat selection indicated by italics). Number of observations Period 1 (n = 110), Period 2 (n = 53), Period 3 (n = 38). ANOVA result - d.f. = 26, n = 9.

a	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
Period 1	-0.72	0.44	-0.51	-1.00	-1.00	-0.02	0.43	0.53	-1.00	-1.00	-0.04
Period 2	-0.61	0.36	-1.00	0.67	-1.00	-0.36	-0.41	0.52	-1.00	-0.13	0.13
Period 3	-1.00	0.53	-1.00	-1.00	-1.00	-0.17	-1.00	0.55	-1.00	-1.00	0.23

b	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
ANOVA RESULT	N.S.	N.S.	N.S.	N.S.	N/A.	N.S.	P< 0.001	P< 0.01	N/A.	N.S.	N.S.

Graph 3.3.16. Habitat utilisation of Partridge during three set periods of the study.
Period 1 n = 107, Period 2 n = 95 and Period 3 n = 74.

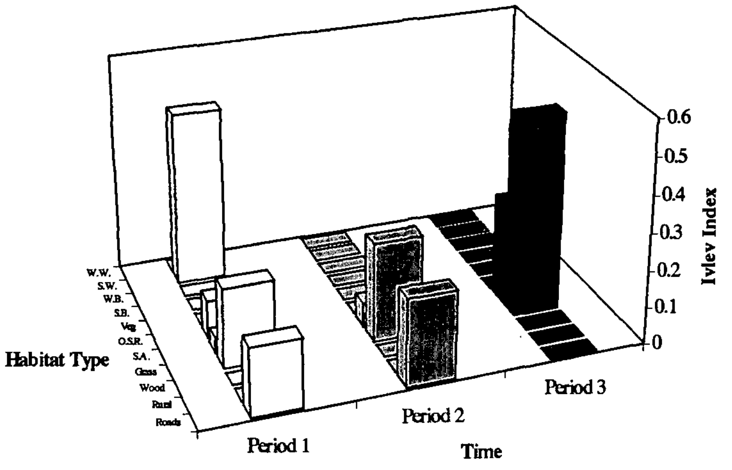


Table 3.3.10.a/b Calculated Partridge Ivlev index values for each habitat type over three set periods (Habitat selection indicated by bold italics). Number of observations, Period 1 (n = 107), Period 2 (n = 95) and Period 3 (n = 74). ANOVA result - d.f. = 26, n = 9.

a	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
Period 1	-0.72	0.44	-0.51	-1.00	-1.00	-0.02	0.43	0.53	-1.00	-1.00	-0.04
Period 2	-0.61	0.36	-1.00	0.67	-1.00	-0.36	-0.41	0.52	-1.00	-0.13	0.13
Period 3	-1.00	0.53	-1.00	-1.00	-1.00	-0.17	-1.00	0.55	-1.00	-1.00	0.23

b	W.W	S.W.	W.B.	S.B.	Veg	O.S.R.	S.A.	Grass	Wood	Rural	Roads
ANOVA RESULT	N.S.	N.S.	N/A.	N/A.	N/A.	P < 0.05	N.S.	N.S.	N/A.	N/A.	P < 0.005

Section 3.4.

Distribution analysis

In this section the distribution patterns of the nine species were investigated. Particular emphasis being on the relationships between species, i.e. association patterns e.g. nearest neighbours. In addition it was attempted to determine the distribution patterns of several of the study species and to see whether these patterns change with time.

Table 3.4.1. Frequency Summary of Nearest Neighbours (n = 12,377).

	Rook	Crow	Jackdaw	Magpie	Woodpigeon	Lapwing	Curlew	Pheasant	Partridge
Rook	5,022	300	238	9	20	3	3	8	6
Crow	250	2,089	71	59	135	18	19	63	52
Jackdaw	245	73	280	2	6	1	0	2	2
Magpie	5	52	0	56	20	1	2	4	3
Woodpigeon	21	166	11	35	1,654	12	5	32	9
Lapwing	5	28	1	2	6	790	5	2	1
Curlew	9	44	0	2	12	2	0	0	4
Pheasant	2	48	1	10	5	0	2	73	1
Partridge	3	20	2	3	2	0	9	9	196
TOTALS	5,562	2,820	602	178	1,860	827	61	193	274

Interpretation of Table 3.4.1. From the above table it is evident that of the 5,562 Rook observations made, the nearest neighbour was another Rook on 5,022 occasions, a Crow on 250 occasions, a Jackdaw on 245 occasions etc..

A chi-square analysis of the nearest neighbour distances of the nine species was undertaken the null hypothesis under investigation being that the nearest neighbours of all species would be in proportion to the percentage of each of the species.

Table 3.4.2. Results of Nearest Neighbour Chi-squares for all nine study species (d.f.=8).

	Rook	Crow	Jackdaw	Magpie	Woodpigeon	Lapwing	Curlew	Partridge	Pheasant
Rook	2,545.83	738.28	3.91	63.00	796.33	365.66	21.74	130.49	134.30
Crow	816.58	3,256.46	31.91	8.39	196.80	154.15	1.87	17.14	5.51
Jackdaw	2.41	30.01	2,146.84	5.12	78.87	38.25	2.97	0.05	0.05
Magpie	70.30	3.23	8.66	1,15.60	1.70	9.98	1.44	9.00	4.01
Woodpigeon	794.38	156.81	69.81	2.55	6,758.77	101.44	1.89	15.00	3.20
Lapwing	361.71	136.59	38.25	8.23	112.57	9,769.54	0.21	0.40	1.53
Curlew	12.38	65.20	2.97	1.44	0.88	1.06	0.30	1.00	9.03
Pheasant	80.84	0.37	7.50	18.80	19.87	12.90	1.16	87.00	23.74
Partridge	119.16	28.84	13.33	0.23	37.27	18.31	414.17	35.00	403.16
χ^2	4,803.56	4,415.72	2323.16	1,223.35	8003.04	10,047.27	445.75	295.66	584.76
Significance	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$

The results of the nine Chi-square analysis (Table 3.4.2) indicate that significant difference exist between the observed nearest neighbours and expected neighbours for all nine species at the $P < 0.001$ level. The results of this statistical test while indicating a significant non random distribution for all nine of the study species may be looked at somewhat sceptically. The reason is due to the potential non independence of the data.

The R Statistic

The FORTRAN program used to find the identity of species nearest neighbours was also used to determine the distribution patterns of the species on each of the study days. This was achieved through the use of the 'R' statistic, a statistic which describes the distribution patterns of objects in space. Of the nine study species only five occurred in sufficient numbers to use in the 'R' statistic analysis. The results of the distribution analysis of these species are presented in Table 3.4.3.. The variation in the n value for each species is as a result of the inability of the program to calculate an 'R' value when the total number of individual of a particular species is very low. The values from the results of the 'R' statistic from each species were checked for normality and found to be normal. These R values were then correlated with the study day to see if any significant changes occurred over time, the results of these tests are presented with the mean and standard deviation 'R' values in Table 3.4.3.

Table 3.4.3. The mean and standard deviation values calculated for the 'R' statistic with the correlation coefficients for five of the study species over the study period.

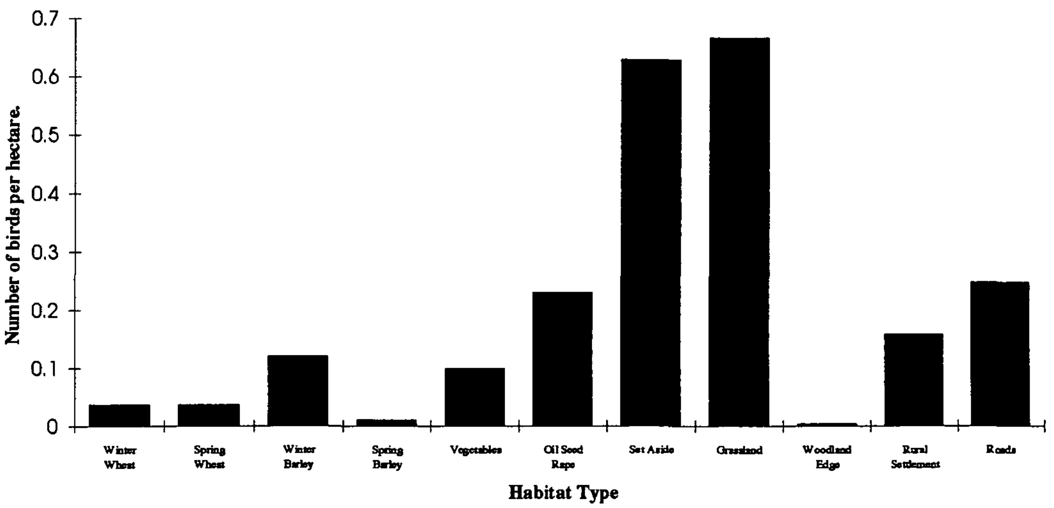
Species	**n**	**Mean 'R Statistic'**	**Standard deviation**	**Correlation coefficient**	**Significance (d.f.= n - 2)**
Rook	27	0.1075	0.0416	-0.1746	N.S.
Crow	27	0.4208	0.1256	-0.7260	P < 0.001
Jackdaw	21	0.1381	0.1409	-0.1821	N.S.
Woodpigeon	25	0.2572	0.1258	0.1462	N.S.
Lapwing	23	0.2717	0.2889	-0.57959	P < 0.01

As well as using the 'R' statistic to look at the distribution patterns of individuals of the five study species, the distribution patterns of Crow nest sites were additionally looked at. In total through observations made during the 27 transects 47 Crow nest sites were pinpointed. The co-ordinates from these nest sites were used to determine their distribution pattern again using the 'R' statistic. The results indicate that the nest sites are distributed in a random but approaching regular fashion. Whilst not every nest site was located in the study area a large proportion appear to have been found, as a result the 'R' value obtained (1.08) is probably quite realistic.

Section 3.5 Habitat Types.

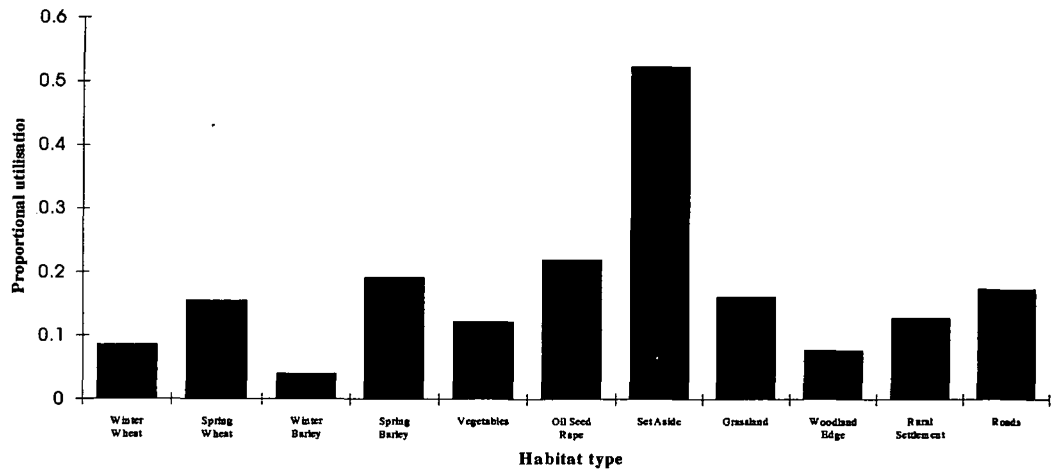
In this section the relative value of the habitats is determined by looking at the overall numbers of bird observations made in each habitat in proportion to the area of the available habitat, the proportional utilisation of the habitat types is also determined on a presence absence basis, this nullifies the bias towards flocking species (e.g. Woodpigeon, Rooks and Lapwing) which occurs when total numbers of observations are looked at. Finally all habitat types are analysed as regards the frequency with which various species diversity were observed within them.

Graph 3.5.1. Mean number of observations (combining all species) made per hectare in the various habitat types.



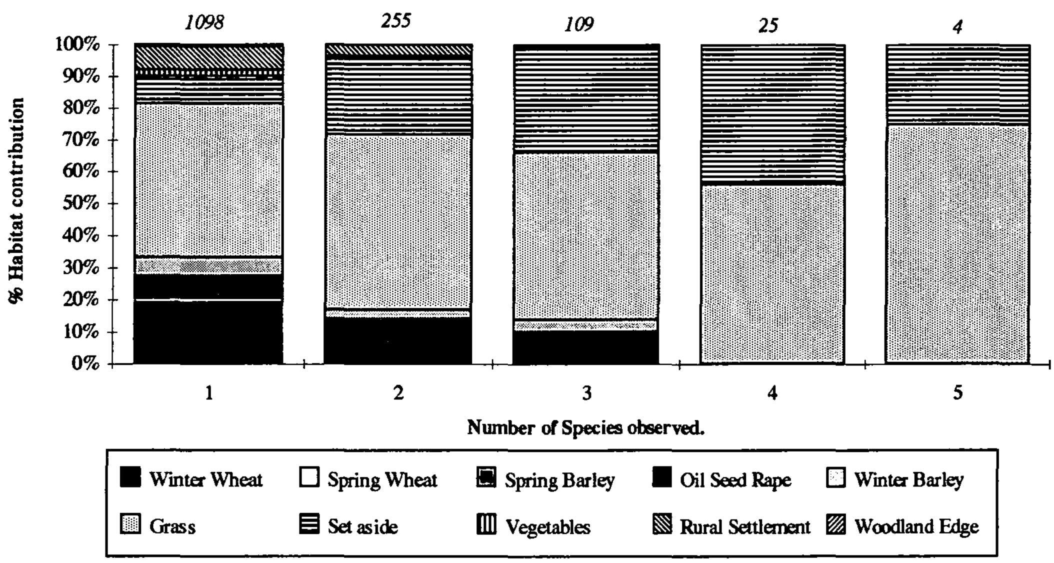
From graph 3.5.1. it is apparent that both grassland and set aside are by far the two most utilised habitat types in terms of the sheer numbers observed feeding on them within the Sedgefield study area. Large flocks of Woodpigeon, Rook and Lapwing were frequently observed feeding in these two habitat types and as a result their value as habitat types may be biased in favour of these species, thus giving a false overall picture as to the habitats value to birds. In graph 3.5.2. a proportional utilisation type analysis was undertaken, this looked at the proportional occurrence of the species in the various habitat types on a presence absence basis. This reveals a new side to the utilisation patterns of the species in the habitats.

Graph 3.5.2. Proportional utilisation of habitat types by all species.



From graph 3.5.2. it is apparent that of the eleven habitat types set aside is the one in which the greatest likelihood of finding one of the nine species occurs. While grassland supports a large number of feeding birds in terms of the total numbers observed (see graph 3.5.2.), it is evident that many grass fields were total devoid of any of the nine species under investigation during the study.

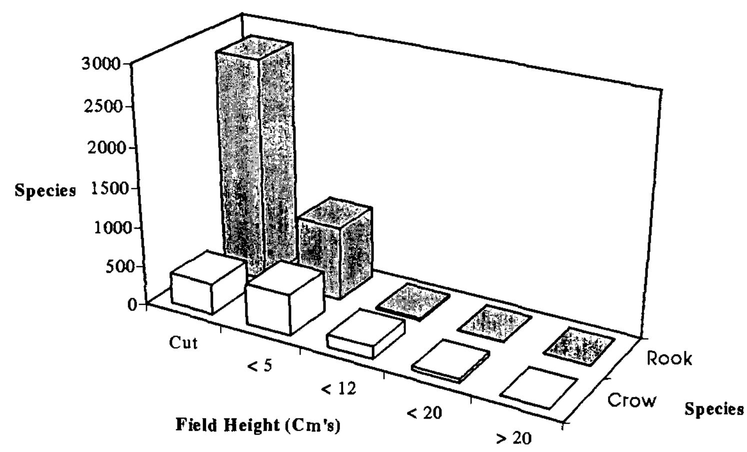
Graph 3.5.3. Percentage habitat breakdown of observed species diversity (Frequecy of occurrence in itlaics).



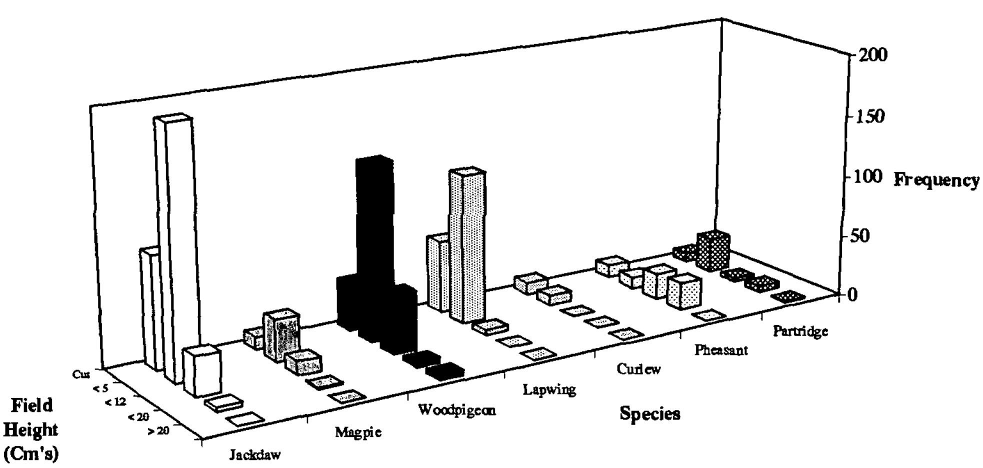
It is evident from graph 3.5.3. that as the observed species diversity increases the frequency of observation decreases. In addition it is very noticeable that when relatively high species diversity (greater than three species per habitat field) was observed it was always seen in grassland and set aside fields.

Habitat 1 - Grassland

Graph 3.5.4. Number of Rook (n = 3,691) and Crow (n = 1,099) observations made over a range of grassland field heights.



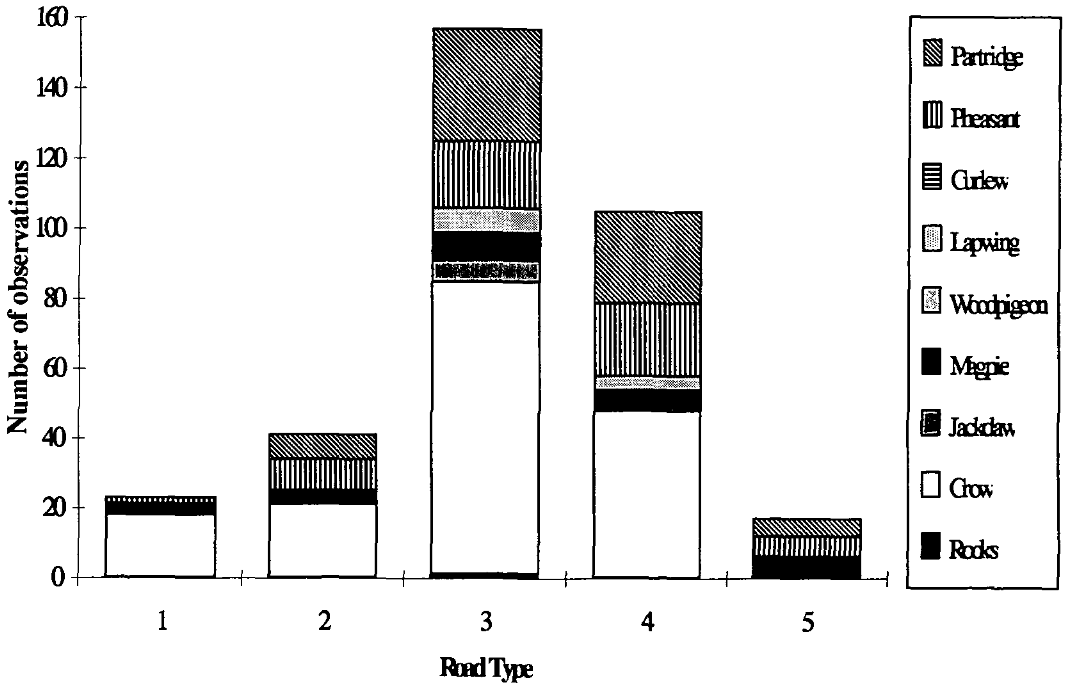
Graph 3.5.5. Number of birds observed feeding over a range of grassland field heights. Jackdaw (n = 287), Magpie (n = 50), Woodpigeon (n = 340), Lapwing (n = 193), Curlew (n = 19), Pheasant (n = 63) and Partridge (44).



A chi-square analysis carried out on the data presented in Graphs 3.5.1. and 3.5.2. indicated that the nine species utilised the 4 different grass field heights in a non random fashion, $\chi^2 = 1,984$, d.f. 24, n = 36. It was not possible to determine the areas of the various field height categories as these changed daily with grazing etc., thus it was not possible to statistically show selection of particular grass field heights. From personnel observations it was noticeable that Rooks preferentially selected grass which had been freshly cut, Woodpigeon on the other hand selected grass fields with higher non-agricultural species eg. older meadows (pers obs).

Habitat 2 Roads

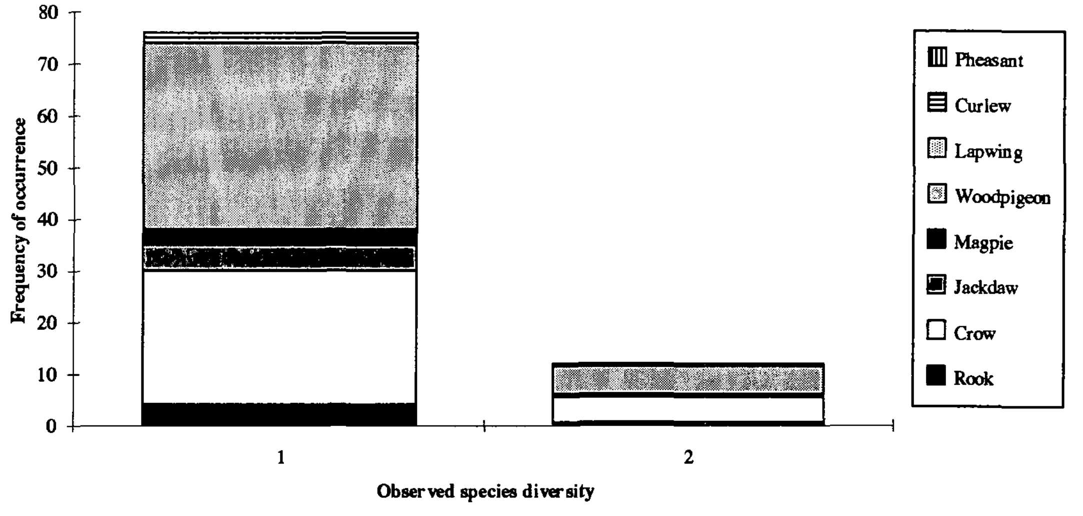
Graph 3.5.6. Number of bird observations made on the five road categories, with individual species contributions (n=344).



A chi-square analysis of the data was undertaken the null hypothesis being investigated was that there was no significant difference in the utilisation of roads by the nine species. The results from this test indicated that significant differences do exist between species, $\chi^2 = 1435$, d.f. = 8, $P < 0.001$. Additional chi-squares were undertaken on the individual species which were observed to occur in this habitat type regularly (Crow, Magpie, Pheasant and Partridge). The null hypothesis being investigated was that the four species were distributed within the five road categories in proportion to the areas of these road types within the study area. The results of these chi-squares indicated that all four species utilised the different road types in a non-normal manner, i.e. some road types were selected preferentially in comparison to others. Crow $\chi^2 = 220$, d.f. = 4, $P < 0.001$, Magpie $\chi^2 = 227$, d.f. = 4, $P < 0.001$, Pheasant $\chi^2 = 49.4$, d.f. = 4, $P < 0.001$ and Partridge $\chi^2 = 155.9$, d.f. = 4, $P < 0.001$.

Habitat 3 Oil Seed Rape

Graph 3.5.7. Species diversity observed in Oil Seed Rape, with frequency contributions of the nine study species (n = 88).



It is apparent from the above graph that the main species utilising Oil Seed Rape were Woodpigeon and Crow, these two species combined accounted for 82 % of presence observations.

Section 4
The Discussion

Species observations made during the study fluctuated greatly from study day to study day, despite this, obvious trends in numbers were evident. From the results of the cross correlations between the log of the species numbers, it is evident that no dominant factor determined the numbers of birds observed (e.g. weather conditions). This indicates that the observed trends in bird numbers are explainable in terms of the species reproductive biology, behavioural ecology etc.,.

Trends in numbers

This investigation was undertaken during the breeding season of all the study species, as a consequence one would have expected to see increased numbers of observations for all species over the duration of the study. While increases in numbers were observed for certain species, most noticeably Crow, other species including Partridge, Pheasant and Magpie decreased in the numbers of observations made over the study period. A number of possible explanations exist to explain both the increasing and decreasing trends observed in these species.

The sampling method used in this study is more accurate for sampling short ranging territorial species, Crows for example were regularly sampled within the same areas on nearly every transect day, Lapwing and Woodpigeon flocks on the other hand because of their wide ranging nature may often have been missed from the line transect (Yalden *et al.*, 1989). This is the main reason why significant increases in Crow observations were observed over the duration of the study. From the first couple of line transects the locations of 46 Crow nest sites were identified and the development of the fledglings from these nests were monitored regularly.

In comparison while a general increasing trend is evident in the number of Rooks observed with time, the increases evident are not statistically significant. Large fluctuations are evident in this data set and are explainable in terms of large flocks of Rooks from the study area being periodically missed while on other occasions large flocks were sampled within the study area but had originated from outside it.

The variations in the numbers of Lapwing sampled over the duration of the study are easily explained. At the start of the study period Lapwing territories within the study area were well established, as the summer progressed and the breeding season ended these breeding territories broke up and large groups of Lapwings formed, this is a well known pattern of behaviour of Lapwings (Spencer, 1953). These flocks were regularly observed feeding within the study area on cut grassland and set aside fields. While a general increase was observed in numbers of Lapwing over the study period, it was not possible to determine whether this increase was as a result of fledged young from the Sedgefield area being sampled or whether it was from large flocks of Lapwings moving around in the region, the latter being the more likely of the two explanations.

Decreases in the numbers of observations made on three of the study species occurred over the sampling period. Pheasant, Partridge and Magpie all became less common over the duration of the study. Pheasant numbers in particular showed a dramatic decline, Partridge while also declining in numbers did so much less dramatically. Reasons for the decrease in numbers of observations made on these two species are not immediately obvious. They may however be explainable in terms of changes in the behaviour of adults with offspring as an anti predator response, or possibly as a response to extreme daytime temperatures which occurred during the latter stages of the study, i.e. individuals becoming less active during the warmest parts of the day, a third explanation may have been the effect of poaching on Pheasant and Partridge numbers, this however hasn't been a problem in the region for quite some time (pers com, Mr. Smith, local farmer).

Magpie observations were also seen to decline over the duration of the study, the observed decrease evident in Graph 3.2.4. however, proved not to be statistically significant. Over the entire duration of the study very few juvenile Magpie observations were made, this was despite the fact that approximately 14 territories appeared to exist in the general vicinity of the line transect (pers obs). Magpies have for a long time been systematically persecuted because of their perceived threat to game birds reproductive output, i.e. through nest predation (Potts, 1986). Within the area encompassing the line transect at least three of the farmers were known to and were on a number of occasions observed employing control measures (crow traps with live magpies as stool pigeons and shooting of juveniles in the nest). This is probably the main explanation for the low numbers of juvenile Magpies observed as well as the overall decrease in total observations made over the study period. How significant the persecution of Magpies is in the Sedgefield area may be worthy of further study, the presence of 14 territories within the study area would suggest that the persecution is however periodic as opposed to being a regular occurrence.

Over the entire duration of the study, from the 1,427 hectares regularly sampled from the line transect only one breeding pair of Curlew was observed. The low percentage of spring sown cereals within the region as a whole is probably one of the main reasons for the low numbers of breeding pairs (Berg, 1992). Set aside recently introduced to the farming landscape may offer the potential for increases in the density of this species within the study area.

Relative abundances

While it was impossible to give estimates of the densities of the nine study species within the study area, it was possible to rank them in accordance to their relative abundance within the site. The results indicated that Rooks were by far the most abundant species within the Sedgefield study area as a whole. Other common species within the study area were Crow and Woodpigeon. What factors are responsible for Rooks being the most abundant of the 9 study species. Historically, Co. Durham has had the largest Rookeries in the country (Sage, 1978), as a result whenever Rookeries are found in the county they tend to be large in size (mean of 54 nests). Two rookeries were situated within the study site, one containing approximately 54 breeding pairs while the other contained approximately 30 pairs. The numbers of actively breeding pairs were taken as being identical to the number of well maintained nests in the rookery at the beginning of the breeding season (Mulmberg, 1971). In addition to the two rookeries lying within the line transect sampling area three others were located in close proximity to the study site, the closest of which contained over 100 breeding pairs. Rooks (and Jackdaws) from these peripheral rookeries were sampled periodically, as a result it is not suprising that large numbers of Rooks were observed consistently over the duration of the study. Additionally the presence of suitable nesting sites, permanent grassland areas, a mixed agricultural landscape, the presence of a large (>6,000) winter rookery in the vicinity, low apparent persecution of the species, all probably play roles in allowing large numbers of Rooks to exist in the general area.

Whilst Rooks may have been the most abundant of the study species observed, Curlew were by far the least abundant within the study area In over 160 hours of sampling from the line transect only 61 observations were made on Curlew, in comparison over the same time period some 5,500 Rook observations were made. As has already been mentioned the small areas of spring sown crops, which are of particular importance to Curlew over winter is probably the main reason for the low density of Curlew observed within the region (Mulder *et al.*, 1988).

Habitat Utilisation

From the results of the habitat utilisation study it is apparent that all nine species displayed a non random distribution within the study area, that is to say that they preferentially selected certain habitats while systematically avoiding others. Three of the species (Rook, Magpie, and Lapwing) selected the same habitat types throughout the duration of the study. Rooks for example were predominantly observed feeding in grassland and occasionally on freshly ploughed set aside. Rooks are well known to rely heavily on grassland particularly during the breeding season (Feare *et al.*, 1974).

Lapwings were another species which utilised grassland and set aside solely over the duration of the study, this has been noted in other studies (Berg, 1993). In comparison to the limited utilisation of habitats exhibited by both Rooks and Lapwing, Magpies were observed to utilise preferentially a wide range of habitat types. It has been noted that this species is quite a versatile one and its success in colonising urban and even industrial habitats within the last 40 years is evident of this versatility (Tatner, 1982).

In comparison to Rooks, Lapwing and Magpie, the other six species all changed their habitat preferences over the three time periods. Woodpigeons for example were noted to switch from feeding on grassland, set aside, oil seed rape and in rural settlements during the first two periods of the study to feeding almost exclusively on oil seed rape and winter barley in the last period. Woodpigeon are a well known pest species of both cereal crops and in particular oil seed rape (Murton, 1965 and Lane, 1984).

Over the whole study every species was observed to utilise both set aside and grassland preferentially (see Graph 3.3.1. - Graph 3.3.9.). Variations with regards the utilisation of the other nine habitat types occurred between species. Magpies and Woodpigeon for example were the only species observed to utilise both rural settlement and roads preferentially, whereas Partridge and Pheasant were the only species observed to utilise spring barley preferentially. Another noticeable feature of the utilisation data is the specialist patterns of certain species, when compared with the generalist feeding behaviour of others. Crows for example were observed in every one of the eleven habitat types at some stage or another, in comparison a species like Lapwing was only observed in three of the habitat types during the duration of the study. The variation evident in the patterns of utilisation of the eleven habitat types by the study species is not suprising because of the widely different foraging methods and food preferences of the nine study species.

When the species were examined to see how similar they were with regards their feeding patterns it was noticeable that all species showed positive correlations. That is too say that all species utilised the same habitat types to some extent or another. The most similar species with regards habitat utilisation patterns were Rook and Jackdaw (see Table 3.3.4). This association has been well documented, Lockie, 1956. The similarity index 3.3.10. grouped the species together in order of there similarity with regards their habitat utilisation patterns. This similarity index grouped eight of the nine species into three distinct groups. The first group contained the corvids Rook, Crow and Jackdaw, the second grouped both Pheasant and Partridge, while the third grouped Lapwing, Woodpigeon and Curlew. Magpies exhibited a low similarity relative to most of the species, this can be explained in terms of this species wide utilisation of the available habitat types, thus it shared habitats with all of the other study species.

Distribution analysis

Nearest neighbour

In the first part of this section the frequencies of each species nearest neighbour were determined through the use of a FORTRAN program, the results of the analysis are presented in Table 3.4.1.. It is apparent from this data that many of the species show significant clumping, that is too say that an extremely large percentage of their nearest neighbours were individuals of the same species. Lapwing nearest neighbours were on 95% of all occasions other Lapwings, in comparison on not one occasion was a Curlews nearest neighbour another Curlew. The high % intraspecific association of Lapwings can be explained by two factors, firstly during the breeding season Lapwing form tight pair bonds and as a result it is not surprising that the nearest neighbour to a incubating / brooding female would be a vigilant male (Spencer, 1953). Secondly the large flocks which were observed to develop later in the season were typically uniform in their composition, i.e. composed predominantly of Lapwings. The low % association of Curlew is explainable as a behavioural defence mechanism during the breeding season. Pairs of Curlew were observed to move away from each other and in particular away from their offspring. Both adults taking to the air noisily calling, thus drawing the attention of a would be predator from the nest / fledglings location (pers obs). This is one of the main reasons accounting for the low intraspecific association in Curlew. Other species which exhibited very high intraspecific associations were Rook (90%) and Woodpigeon (89%), both of which are well known flocking species (Murton, 1965 and McDonald *et al.*, 1986). Other high intraspecific association values were obtained for Crow (74%) and Partridge (71%). The high percentage of pair observations made during the study on Partridge and the numerous observations of Crow families account for the high intraspecific associations found in these species

Distribution Patterns

The investigation of the distribution patterns of the most abundant species (Rook, Crow, Jackdaw, Woodpigeon, and Lapwing) was undertaken using the 'R' statistic (Clark *et al.*, 1954) to describe the existing distribution patterns and a correlation analysis undertaken to see how these patterns changed with time. The results of this test presented in Table 3.4.3. show all five of the species looked at to be displaying clumped distributions. Of the five species Rooks, and Jackdaw were found to be the most significantly clumped species observed over the duration of the study. Significant changes which occurred over time in the distribution patterns occurred for both Crow and Lapwing. There are two main benefits attached to organisms occurring in groups, one is the increase in predator avoidance (Kenward 1978) / the second is through increased foraging efficiency (Zahavai, 1971). In this investigation it was found that both Jackdaw and Rooks appeared to become more aggregated as the study went on. During the summer period the levels of soil invertebrates are well known to decrease in availability, this occurs in response to the drying out of the soil (Feare *et al.*, 1974). Over the duration of much of this study the weather was extremely hot and one would presume that consequently levels of invertebrates significantly declined in their availability to birds. As a result it was not suprising to find more aggregated flocks later in the study when the main food sources available to both Jackdaw and Rooks were ephemeral and occurring in discrete locations. Examples of such food ephemeral sources where silage fields cropped, in which previously unavailable invertebrates became available. The large numbers of both Rook and Jackdaw observed feeding on cut silage fields is evident of this fact. Another discrete food source utilised by both species was created by the periodic ploughing of certain set aside fields. A study undertaken by McDonald *et al.* 1986 on the distribution patterns of Rooks in Ireland, found that over the same basic time period (early to late summer, Feare et al., 1974) Rooks became less aggregated. It is difficult to compare the distributions of Rooks from both studies because of the uniqueness of the weather conditions experienced in this study and because of the lack of detailed information on % land use areas in their study.

Problems with the 'R' statistic.

The program used to run the 'R' statistic in this investigation was originally written to study the distribution of plants, as a result it is not going to be ideal for the study of mobile socially interacting species such as birds. In this study the FORTRAN proved to be biased in favour of clumped distributions. When for example you look at the distribution of Lapwing within the study area two distinct distribution stages are obvious, firstly there's the stage when the majority of Lapwings were distributed in discrete pairs around the study area, the second stage is when the large flocks of Lapwing began to form. In the first instance nearest neighbour distances are quite small as the distance from a brooding female to her vigilant male partner is presumably short, many such pairs would give a low 'R' value, indicating a clumped distribution. Presumably if the program had looked for the distance to the second nearest Lapwing (assuming both Lapwings in the pair had been located) this would have given a more true representation as to the distribution of the species in the overall area. A comparison of the distribution pattern of Crows and Crow nest sites gives some indication as to the bias of the program. Crows while being found to be the least clumped of the five species who's distribution patterns were studied displayed a much more aggregated distribution when compared to the distribution of their nest sites. Over the duration of the study as juvenile Crows left the nest and followed their parents intraspecific Crow nearest neighbour distances were low, this is the main reason why such clumped pattens of distribution were obtained. If the program could have taken into account the Crow family unit, i.e. whenever 4-6 Crows were located in close proximity (< 10 m) it was taken as a family unit and the nearest neighbour was taken as the mean distance of these Crows to the next Crow.

Having said all that the program used did give the relative distribution patterns of the five species, that is too say Rooks were the most aggregated of the species, while Crows were found to be the least aggregated. In addition the standard deviation gives us an indication of the variability observed in the distribution pattern of each species over the study period, while the correlated value gives us an indication of the change over time.

Habitat types

In the final section of the study the relative values of the eleven farmland habitat types was determined with regards their value to the nine study species. In Graph 3.5.1. the value of the eleven habitats are displayed in terms of the total number of birds which they supported on average per hectare over the duration of the study. Of the eleven habitats set aside and grassland were by far the two most utilised habitats in terms of the sheer numbers observed feeding in them. Lowest values were obtained for spring barley and woodland edge. While in general it is apparent that the two cereal crops (Wheat and Barley) in terms of supporting total numbers of birds were poor habitats during the study period. Large flocks of Rooks, Lapwing and Woodpigeon utilising both set aside and grassland may have given these habitat types an inflated appearance as regards their value to bird species, because of this the habitats were also looked at in terms of presence absence of species. The results of the presence absence analysis are presented in graphical form in Graph 3.5.2., it is immediately obvious that of the eleven habitat types set aside was the one most likely to contain one of the nine study species (> 50 % likelihood). Winter Barley proved to be the habitat type with the lowest likelihood of finding any one of the nine species (< 5 %). It is noticeably that grassland while supporting the greatest number of species in terms of sheer numbers observed feeding was utilised by any one of the study species on less then 20% of all occasions. In addition to set aside and grassland being by far the two most utilised of habitats in terms both of sheer numbers and proportional utilisation they were also the two habitats which recorded the highest number of species most frequently (see graph 3.5.3.).

Set aside

Set aside became a common feature of the agricultural landscape in autumn 1992, when wide ranging agricultural reforms of the Common Agricultural Policy meant that farmers would be compensated for decreases in the support prices of cereals and oil seed rape only if they set aside 15 % of their land area growing these crops. Within the space of a single harvest some half a million hectares were allocated to the scheme, changing dramatically the face of the farming landscape. Two types of set aside exist, 'non rotational set aside' (see Plate 3) which is left in place for five years, and 'rotational set aside' (see Plate 2) which is rotated annually within the farm, so that any one area is set aside only once every six years. Management of set aside is under strict regulation by the EC, in general these regulations ensure that set aside land is kept in good agricultural condition.

In the last three decades many populations of farmland bird species have declined both in numbers and range throughout Britain (Marchant *et al.*, 1990). Several fundamental changes which have occurred in agricultural practice and land use have been cited as causing and or aggravating these declines. One of the principle ones has been the loss of the weedy stubble's provided by spring sown cereal crops which act as important habitats for birds over winter (O'Connor *et al.*, 1986).

Rotational set aside with a naturally regenerated green cover has reintroduced weedy over winter stubble's to areas which have been for the last few decades cereal deserts (Wilson et al., 1995). In addition grass cover has reintroduced 'grassland' to tillage dominated arable landscapes, and both forms of set aside provide pockets of land which escape the annual barrage of pesticides and insecticides. These agricultural chemicals are known to have significant detrimental effects on the availability of insects an important component of many bird species diets (Henderson, 1989 and Rand 1985). One of the main factors attributed to the recent decline observed in the Grey Partridge population has been the decrease in availability of invertebrates to chicks in cereal areas (Potts, 1986). Many recent studies have cited the value of set aside to bird species since it's introduction (Wilson *et al.*, 1993).. Set aside in this investigation was found to be utilised in the greatest proportion when compared with the other ten habitats (see Graph 3.5.2.), in addition set aside was one of the two most species diverse habitats (see Graph 3.5.3.). From the utilisation index produced for each species over the whole study period all nine of the study species selected set aside preferentially (see Graph 3.3.1. - Graph 3.3.9.).

Grassland

Grasslands provide valuable habitats for birds, providing cover, feeding and nesting sites, and their importance to many species of birds is unquestionable (Green, 1988). Changes in grassland usage over the last three decades have been significant, drainage of wet grasslands, changes in the harvesting times of silage and the application of fertilisers have all been seen to have had detrimental effects on bird populations. Silage production, with its high growth rates has resulted in earlier harvesting times, many birds which utilise grasslands as nesting grounds have been detrimentally effected by the consequential nest destruction and loss of cover resulting in increased predation.

In this study the low proportional utilisation of grassland fields (< 20%, see graph 3.5.2.) can be explained in terms of the variation in the height of the grass sward and the effects that this has on the availability of the fields to the nine study species. Graphs 3.5.4. and 3.5.5. display the utilisation of various grass field heights by the nine study species, a chi square analysis of this data revealed that the nine species utilised the various grass field heights in a non random fashion. That is to say certain field heights were selected while others were systematically avoided. Species such as Rook showed a preference for cut grassland fields, in comparison Pheasant were observed frequently in grassland fields of much greater length > 12cm's. The importance of the periodic cutting of silage fields and the subsequent short term availability of high levels of invertebrates can be seen by the high level of utilisation of these field type by most of the study species.

Cereal crops

During the duration of the study both cereal field crops were utilised infrequently by most of the study species with the exception of Lapwing who were never observed to utilise either (Barley or Wheat). As the season progressed and the grain began to develop a number of species (Woodpigeon, Rook and Jackdaw most noticeably) were observed utilising these crops more frequently. One of the most intriguing aspects in the utilisation of the cereal crops by Rooks observed during the study was how for a ten day period or so large numbers of juvenile Rooks and Jackdaws were observed feeding in Wheat which hadn't at that stage matured properly (i.e. was still green). The importance of cereal crops to juvenile Rooks is well known, *. It was noticeable in the one field were this occurred that both the Rooks and Jackdaw were preferentially selecting volunteer Barley which was growing within the Wheat crop. Barley require less organic input when compared with Wheat (pers comm, R.Kraggs, local farmer), as a result the Barley seeds lying dormant in the soil (from previous years harvest) are at a competitive advantage and grow quicker because of the higher then normal levels of fertiliser being applied to them. Combine the increased nutrients with the support given to the growing Barley plant by the surrounding but noticeably shorter Wheat stems and as a result the Barley grain develops quickly. The preferential selection of Barley was evident by the huge number of Barley grain heads found daily along the edge of the Wheat field, this despite the fact the nearest Barley field was over 500 meters away. It would be interesting to see if this is a pattern which occurs regularly, if that was the case there would be a significant reduction in Rook damage in Barley crops following Wheat as opposed to Barley following Wheat, may be worthy of further study

Later on in the growing season Rooks, Crow and Jackdaw were all observed feeding on both Wheat and Barley fields, causing significant damage to these crops (see Plate 13). Woodpigeon are one of Britain's greatest agricultural pests, as well as the tremendous damage they do to oil seed rape crops (Lane, 1984) they also are known to feed on and as a consequence damage large areas of cereal crops (Murton, 1965). In this study large numbers of Woodpigeon were only observed on a few occasions feeding in cereal crops, predominantly Barley fields in any great numbers. Tremendous damage to the crops was however caused in these locations. Wind throw (see Plate 14) opens up cereal crops to feeding by many bird species, it is caused by the over application / uneven application of fertilisers to cereal crops, this causes certain areas of the crop to grow more quickly when compared with the rest of the crop, these enriched areas become top heavy and are easily knocked over by strong winds and rain. These wind throw areas become important sites for feeding, birds particularly Rook, Crow and Woodpigeon are known to utilise these areas and enlarge them for feeding. Later in the season as the crops began to be harvested mixed flocks of Rook and Jackdaw were observed feeding on the stubble of the harvested crops, other species including even Curlew were observed utilising these stubble fields. It was noticeable on the last transect day that large areas of stubble were being prepared for autumn sowing of both cereal and non food crops. This has been cited (Galbraith, 1988) as one of the main reasons for the decline in many farmland bird populations, that is to say the removal of large areas of stubble over winter with their associated plant and invertebrate fauna.

Oil seed Rape

In 1974 the oil seed rape harvest in Britain was an incidental 50,000 tonnes, by 1984 the estimated harvest had reached one million tonnes The rapid increase in oil seed rape production has now meant that it has become the third most important arable crop in the UK. after Wheat and Barley. The huge increase in acreage of oil seed rape has literally changed the agricultural landscape and has affected a number of farmland bird species. In this study Woodpigeon were shown to preferentially select oil seed rape over the whole study period (see Graph 3.3.5. and Graph 3.5.7.). Other studies have shown the importance of oil seed rape to Woodpigeon, Inglis et al 1990 have described how fields of oil seed rape sown at autumn, provide an important source of food reducing mortality over the winter period.

Large scale changes are sweeping the agricultural landscape, these are in the form of new crop types, sowing methods, and changes in agricultural practices. If careful monitoring of the effects these changes are having on our farmland birds is not continued and the lessons learnt from these studies, then the declines seen in the last four decades will continue.

Conclusions

- Grassland and set aside were by far the two most utilised habitat types over the duration of the study.

- Rooks were by far the most abundant species in the study area while Curlew were the least abundant.

- Trends in the numbers of observations made on each transect day over the duration of the study day were generally explainable in terms of the ecology of the study species.

- Differences existed in the utilisation patterns of the study species between time periods in six of the species, only Rooks, Lapwing and Magpie were seen to utilise the same habitat types over the entire study.

- Both sillage cutting and ocassional ploughing of set aside acted in providing an ephemeral food supply which proved very important for many of the study species (most noticably Rooks), at times when general invertebrate availability would have been low.

- The selection of Volunteer Barley by juvenile Rooks and Jackdaw from within Wheat fields probably resulted in a significant loss in Wheat yield. If this is a regular occurence and not just as a result of unusual weather conditions it may be worthy of further study.

- Magpies appeared to be persecuted within the study area, what the status of the population as a whole in the region may be worthy of further investigation.

- While the 'R' statistic may have given information on the relative distributions of five of the study species, as well as indicating how these patterns changed over time, it is apparent that the 'R' values quoted were biased in favour of clumped distributions. Changes to either the FORTRAN program or to the way observations were digitised, could have if time had allowed removed this bias.

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Appendix I

Selection of Habitat Types available at the Sedgefield study site.

Plate 1
Ploughed and rolled Set Aside.

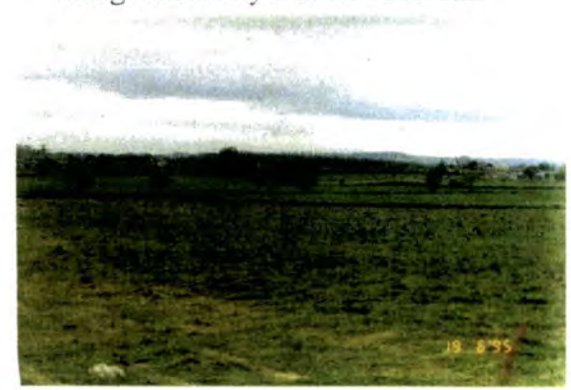
Plate 2
Short term Set Aside.

Plate 3
Long term Set Aside.

Plate 4
Sheep grazing on permanent pasture.

Plate 5
Mixed grazing on permanent pasture .

Plate 6
Freshly cut temporary grassland being utilised by a flock of Rooks.



Habitat Types cont'd.......

Plate 7
Vegetable crop (potato) being grown in the study area.

Plate 8
Field of flowering Oil Seed Rape.

Plate 9
Stuble left from harvested Oil Seed Rape.

Plate 10
Field of Winter Barley.

Plate 11
Field of Winter Barley being harvested.

Plate 12
Set aside being ploughed.

Habitat Types cont'd.......

Plate 13
Field edge of Winter Wheat showing evidence of crop damage.

Plate 14
Windthrow in Winter Wheat.

Plate 15
Harvested Winter Wheat field.

Plate 16
Road type one.

Plate 17
Road type three.

Plate 18
Road type four.

Appendix 2

BJC.SCR Fortran Program

```
#!/bin/csh -f
foreach file (tran*.txt)
  ls -l $file
  tr '\011' ' ' <$file >/tmp/$$
  mv /tmp/$$ $file
  ls -l $file
end
exit

  ed $file <<%
g/      *    /s//        /g
g/      *    /s//        /g
g/           /s//   -9   /g
g/           /s//   -9   /g
g/^...\$/d
g/^....\$/d
g/^...  -9   -9   -9   -9   -9   -9   -9   -9   -9   -9   \$/d
w
q
%
end
```

Appendix 3

Table of Species Rankings from the 27 transects. Mean values used to work out the relative abundance of the species.

Transect Number	Rook	Crow	Jackdaw	Magpie	Woodpigeon	Lapwing	Curlew	Pheasant	Partridge
1	1	2	4	6.5	3	6.5	9	8	5
2	1	3	5	8.5	2	4	8.5	6	7
3	1	2	6	8	3	4	9	6	7
4	1	3	6	7	2	8	9	5	4
5	1	3	8	5.5	2	5.5	9	7	4
6	1	2	5	7	3	4	9	6	8
7	1	3	5	8	2	4	9	6	7
8	1	2	3	8	5	4	9	7	6
9	1	2	5	8	3	4	9	7	6
10	1	2	5	4	3	7	8.5	8.5	6
11	1	2	4	8	3	7	9	6	5
12	1	2	5	9	3	4	8	6	7
13	1	2	4	5	3	9	8	7	6
14	1	2	8	7	3	4	9	5.5	5.5
15	1	2	5	8	3	4	9	7	6
16	1	2	6.5	8	3	4	6.5	9	5
17	1	2	5	6	4	3	8	8	8
18	1	2	5.5	5.5	3	7.5	7.5	9	4
19	1	2	4	7	3	8	9	6	5
20	1	2	4	6	3	8.5	7	8.5	5
21	1	2	5	6	4	3	9	8	7
22	1	2	4	6.5	3	5	9	8	6.5
23	1	2	4	8.5	3	5	8.5	7	6
24	1	2	6	7	3	4	8.5	8.5	5
25	1	2	5	8	4	3	9	6	7
26	1	2	4	7	5	3	9	8	6
27	1	3	5	6	2	4	8.5	8.5	7
Sum Rank	27	59	136	189	83	137	231.5	192.5	161
Mean Rank	1.00	2.19	5.04	7.00	3.07	5.07	8.57	7.13	5.96

Appendix 4

Test to see if grassland category expected was the one found, n = 5, d.f. = 4.

Field Category	**Observed**	**Expected**
Cut	1	1
Field Height 1	54	52
Field Height 2	38	40
Field Height 3	24	23
Field Height 4	11	12
χ^2	0.3015	
Significance	N.S.	