THE EFFECTS ON SONGBIRDS OF LEAVING CEREAL CROP HEADLANDS UNSPRAYED

A REPORT TO THE GAME CONSERVANCY

JANUARY 1986

BY

G.S. CRACKNELL

British Trust for Ornithology

Beech Grove

Tring

Hertfordshire HP23 5NR

LIST OF CONTENTS

Page:

SUMMARY

1) Neither fledging success nor brood size differed significantly between experimental (unsprayed headlands) and control (sprayed headlands) areas.

2) No significant differences were obtained between experimental and control areas in the number of birds present in hedgerows adjacent to cereal fields. Nor were there any differences in the lengths of time spent by individuals in unsprayed and in sprayed headlands, although samples were very small.

3) The carrying capacity of woodland was considerably higher than that of hedgerows adjacent to cereal fields. This is probably a result of richer foraging habitats available in woodland.

4) Some young of hedgerow-nesting species (including Dunnock) moved into woodland and of woodland-nesting species (including Blackcap) moved into hedgerows, after fledging. Competition with adult birds might have displaced these juveniles into sub-optimal foraging habitats.

5) Cereal fields were an important foraging habitat for three of the four main hedgerow-nesting species at Manydown, namely Blackbirds, Dunnocks and Yellowhammers. For Chaffinches, however, cereal fields were not important.

6) Numbers foraging in cereal fields parallelled the number of birds holding territory in the hedgerow.

7) There was no evidence of preferential exploitation of unsprayed headlands.

8) Dunnocks foraged in the field edge zones and in the crop but remained close by the hedgerow cover.

9) Yellowhammers foraged relatively infrequently in field edge zones and most frequently in the far crop. Seasonally they exploited food available in non-adjacent cereal fields of a different crop type up to 1 km distant.

10) Blackbirds favoured the open foraging habitat of the crop-free strip, although when this became overgrown or overhung by tall, dense weed growth later in the season, Blackbirds did not forage there as much.

11) Relative to the area of each field-zone, all four species foraged very infrequently in the crop, in particular in the far crop, and most frequently in the edge habitats.

12) All four species showed a preference for wheat over barley for foraging and this is thought to reflect the greater abundance and availability of invertebrate food in wheat crops.

13) All four species exploited the other habitats available on the farm, principally woodland, individual trees along field boundaries, non-cereal fields, tracks/lanes and their verges and habitations. However, only Chaffinches foraged in these other habitats more than in the cereal fields adjacent to their hedgerow territory.

14) The woodland and trees were the most important foraging habitats for Chaffinches. When foraging in cereal fields, Chaffinches remained close to the hedgerow.

15) Whitethroats foraged close in the cover of the hedgerow and were seen feeding intensively in both cereal and dicotyledonous crops. Whitethroats are difficult to observe feeding in hedge-bottom vegetation but obviously this is an important foraging location. Good visibility in the green lane at Manydown revealed intensive feeding in the verge by Whitethroats.

INTRODUCTION

A number of recent studies have suggested that the use of agricultural chemicals on cereal fields has an adverse effect on some cereal insects (Southwood & Cross 1969; Potts & Vickerman 1974; Vickerman 1974; Vickerman & Sotherton 1983), both directly and by removing many of the weeds on which they feed. The insect species affected included species of importance to gamebird chicks. Rands (1985a, b) has shown that the mean brood size of both the Grey Partridge and the Pheasant is significantly larger in cereal field plots where a six metre headland around the border of each field was left unsprayed with agricultural chemicals. This was attributed largely to the presence of significantly higher numbers of prey insects in such headlands. Also, total weed densities and total weed cover have been shown to be significantly higher in unsprayed headlands than in sprayed headlands (Sotherton et al. in press).

Unsprayed headlands might benefit a range of other insectivorous and weed-seed eating birds and animals. This report investigates the effects on passerine birds (excluding the crows and hirundines) of leaving cereal headlands unsprayed. Comparison of experimental areas, containing blocks of cereal fields with unsprayed perimeters, and control areas, in which cereal fields were sprayed to the crop edge, enabled demonstration of the effects of unsprayed headlands.

Four features of the birds' ecology might be affected. These are:

a) the numbers of birds occurring;

b) breeding performance;

c) movement and turnover of birds after fledging or breeding;

d) foraging rates in different locations.

The numbers of birds holding territory on The Manydown Farm, Hampshire (the principal study area in the present investigation) were surveyed by detailed territory mapping in 1984 (Fuller 1984). No formal census was conducted in 1985. The songbird species which are most exposed to the reduced abundance of weeds and of insects in cereal fields as a result of agrochemical sprays are those species which are most commonly found breeding on farmland. These species were identified by reference to the Common Birds Census (Marchant 1983, 1984) and are listed in Appendix 2. Of the species listed, 25 forage on the ground or in the herb layer (and are therefore morphologically suited to the exploitation of cereal-fields), and all of these were present on The Manydown Farm in 1984 (Fuller 1984).

The project in 1985 addressed breeding, dispersal and foraging in songbirds in relation to experimental and in control areas. The following hypotheses were considered. If food abundance were a limiting factor: first the increase in numbers of prey insects and

weed seeds in the unsprayed headlands might enable birds to fledge more offspring. Second, fledglings and juveniles and post-breeding adults which are no longer tied to the nest might relocate to areas of abundant food. Movement and turnover were therefore investigated by comparisons of the numbers of ringed songbirds in experimental and control areas and the length of time spent by them in each area. Third, the species likely to gain most from the increase in food present in unsprayed headlands are those which habitually forage in cereal headlands. Some extra species, which do not forage regularly in cereal fields, might also exploit the weed-seeds and insects of headlands which have not been sprayed.

With the exception of the studies of Davis (1967) and Green (1978), no quantitative studies have been made of foraging by farmland songbirds. Frequency of foraging by songbirds in cereal fields was therefore examined in detail, with particular regard to seasonality and to habitat features such as crop type and field boundary that might have affected foraging location. Use of habitats other than cereal fields was also considered. Some data on foraging rates in cereal fields were collected in 1984 (Fuller 1984) but, owing to unexpectedly low foraging rates, the samples were rather small. In the 1985 study, therefore, the length and the frequency of foraging counts were increased and extended and continuous supplementary observations of foraging were added.

STUDY AREAS

The principal study site was a part of The Manydown Farm, Hampshire, an arable farm of 1,167 ha (Figure 1). In 1985, 604 ha were under cereal crops: 160 ha under spring barley; 171 ha under winter barley and 273 ha under winter wheat. The remainder of the crop area was under vegetable crops (139 ha), oilseed rape/linseed (100 ha) and grass (inclusive of herbage seed, 146 ha). There were also 64 ha of woodland and scrub, of which 39 ha were mainly broad-leaved woodland.

The 1984-85 crop-planting season was the third in which experimental manipulation of spraying regimes on cereal fields was carried out. The treatments used on each crop are noted in Table 1. There were two categories of 'unsprayed headland' in the experimental areas: those which received neither autumn nor spring treatments, and those which received no spring treatments but did have the appropriate autumn treatments. 'Sprayed headlands' received the same treatments as the remainder of the field crop. There were two separate areas for each of the three spraying regimes, and the locations of each are shown in Figure 1.

Both in experimental and in control areas at Manydown in 1985, a half-metre wide strip along the edge of almost all cereal fields was sprayed with the broad-spectrum, residual herbicide, Atrazine. This resulted in a 'crop-free' strip, a strip of earth, largely free of weeds, between the hedgerow, with its associated herb layer vegetation, and the field crop (Figure 2). As part of another Game Conservancy study, certain field boundaries on the farm did not have such a crop-free strip but only one of these was adjacent to a hedgerow included in this study (Figure 1). Crop-free strips one metre wide and rotovated to keep them clear of weeds were also present during the 1984 study. Rotovation was carried out in early spring, with a second rotovation carried out in June on strips which had become overgrown.

Approximately 6 km of hedgerows were selected for observation. Their locations are shown in Figure 1. Hedgerows were divided into three categories: those over 2 m high which had a relatively broad base and were dense with few gaps; those under 2 m high which were usually narrow, thin and had many gaps; and those composed largely of trees forming a dense canopy but with a rather open base. These three categories will be referred to as 'over 2 m', 'under 2 m' and 'treeline' respectively. One study hedgerow, in an experimental area, comprised two parallel hedgerows with a green lane running down the centre; on either side was winter wheat. Most study hedgerows at Manydown included one or more tree standards.

Two secondary study areas were visited. These were both principally arable farms in Norfolk: Courtyard Farm, Ringstead (304 ha) and East Hall Farm, Blakeney (162 ha). Both farms had one experimental and one control area of cereal fields and these are shown in Figures 3 and 4 respectively. A strip at or near the edge of the fields was left unsprayed with agricultural chemicals from 1 January 1985 in experimental areas. In all experimental cereal

fields at East Hall and in most experimental winter barley fields at Courtyard, this strip was at the field edge, but in most spring barley fields at Courtyard the unsprayed strip was 6-12 m from the edge of the field crop (Figure 3). A summary of the sprays used at each farm is given in Table 1.

Cereal crops at Courtyard and East Hall were drilled to the field boundary, i.e. there was no crop-free strip at the field edge. In 1985, Courtyard had 174 ha under cereal crops: 81 ha under spring barley; 56 ha under winter barley and 37 ha under winter wheat. East Hall had 114 ha under cereal crops in 1985; 53 ha under winter barley, 41 ha under spring barley and 20 ha under winter wheat. At Courtyard, approximately 8.8 km of hedgerows were studied and these are shown in Figure 3. Hedgerows were classified as 'over 2 m' and 'under 2 m', defined as at Manydown, plus a third group 'over 2 m with standards which comprised a hedge over 2 m in height containing tree standards at intervals of 10-30 m. At East Hall, approximately 9.9 km of hedgerows were studied (Figure 4). Hedgerows were classified as at Manydown. Courtyard has 15 ha of woodland, East Hall 2 ha.

METHODS

Breeding success

The relative success of breeding songbirds in experimental and in control areas was investigated through detailed documentation of all nests found. Of the 6.0 km of hedgerows searched, about half were in experimental and half in control areas. All hedgerows used in timed watches (see below) were included. A concentrated effort was made to find nests in mid-May, when hedgerows were not fully in leaf and the herb layer vegetation was low. Initially, Rob Fuller and the author made a systematic 'cold' search for nests. Potential nest sites were thoroughly investigated from both sides of each hedgerow and the vegetation was disturbed so that birds in the hedgerow were flushed. This would increase the likelihood of finding nests. Nests were subsequently located only by 'hot' searching, i.e. by watching bird activity closely and then searching a specific patch. On each visit, note was kept of the location of singing birds in study hedgerows and of the point of entry into hedgerows of birds carrying food. This enabled an estimate to be made of the number of territories held by each species along study hedgerows, although a formal mapping census was not attempted.

Study of breeding success from nest histories relies upon the finding of a large sample of nests and this involves a substantial input of time. Cold searching revealed approximately one nest per four man-hours of searching. Later in the season, nest searching was usually carried out in conjunction with other fieldwork. The rate of finding new nests is likely to decline as the proportion of all active nests which have already been located increases. However, this alone is unlikely to account for the very steep decline in the number of nests found in each successive week of the study (Figure 5). Few nests were located in June and none in July, even when the nest site was known to within a few metres and despite a fair amount of time spent searching. Difficulty in locating nests late in the season was largely a result of prolific grass and weed growth beside hedgerows. This applied particularly to those species which nest low down, such as Whitethroat and Yellowhammer. Dunnock nests were also hard to find because the birds are difficult to watch back to the nest (Campbell & Ferguson-Lees 1972). It was considered unwise to spend too much time searching for difficult nests owing to the dangers of desertion, predation, or of the young 'exploding' from the nest.

Population movements and turnover

Movements and turnover of birds within and between experimental and control areas at Manydown were investigated by ringing. This technique enabled individual identification of birds. The young at each hedgerow nest found were ringed with British Trust for Ornithology (BTO) numbered rings and also with a colour ring which identified the brood.

The aim was to follow broods during the post-fledging period both visually and through recaptures. In July, two experienced ringers, Paul Copestake and Peter Burns, were employed to catch and ring as many birds as possible at study hedgerows in control and experimental areas. Mist nets were set on 10 days, between 8th and 20th July, for a variable number of hours between 0430-1330 h and on one day between 1730-2030 h. Five different sites were selected (Figure 6). The three most successful sites in terms of numbers of birds caught were visited on three separate occasions to provide information on turnover of birds in experimental and control areas through recapture. All birds caught were ringed and Yellowhammers were individually colour-marked. The principal aim was to investigate differences between experimental and control areas, concentrating on study hedgerow sites adjacent to cereal crops. However, the paucity of birds caught in nets adjacent to hedgerows led to the inclusion of woodland and woodland edge habitats on subsequent days and the broadening of the project to give a more general picture of movement of birds around the farm and the post-fledging dispersal of juveniles in particular.

Mist-nets in cereal fields were erected in the crop-free strip parallel to hedgerows. In many cases these were the only sites available. The majority of nets used were 60-foot, four-shelf nets. Some 20-foot, 30-foot and 40-foot, two- and three-shelf nets were used perpendicular to the hedgerow at the end or in a suitable gap. All nets so placed, unless parallel and adjacent to a woodland edge, were fairly conspicuous, especially on fine days. In contrast, nets along rides or in clearings in woodland were relatively inconspicuous against the dark and varied background. More birds might fly into these nets without first seeing and possibly avoiding them.

Foraging rates in various habitats

Systematic observations of foraging birds were made along selected hedgerows immediately adjacent to cereal fields. Stretches of 100 m each were marked out and at each stretch the observer made five minutes of continuous observation. This is referred to as a timed watch. As far as possible, samples were matched in experimental and control areas to allow for the effects of crop type and hedge type. Birds foraging within the hedgerow were not recorded since the majority of such foraging bouts would not be visible to the observer. Hedgerows and their standards do, however, offer considerable foraging opportunities for birds.

The observer stood 10 m back from the beginning of the observation stretch to minimise disturbance. Early in the season, observations were made from the crop-free strip but, as the crop and hedge-bottom vegetation grew, better visibility was obtained by moving to the first tramline (Figure 2). The positions of all birds seen on the stretch and judged to be foraging were recorded. Cereal fields were divided into the field edge - comprising the hedge-bottom vegetation and crop-free strip (where appropriate) - and the crop (Figure 2). The crop was divided into headland, the peripheral 6 m of each field-crop,

and far crop, which encompassed the whole of the crop beyond the headland. Within the crop, distances from the hedgerow were estimated by reference to the tramlines. With the exception of birds foraging in crop-free strips in May and early June, the height of the vegetation made it impossible to watch birds foraging on the ground. Note was therefore made of the position of entry into and exit from the field by each bird. Birds sallying from the hedgerow without landing were recorded as foraging over the zone or zoness concerned. Only ten such sallies were recorded.

Presence of a bird in the field was recorded on entry and subsequently at 15 second intervals until the end of the five minute period. Each 15 second period is termed a feeding record. The sum of feeding records by any one bird is termed a feeding bout and is classified as short if one minute or less, or long, if over one minute. By definition, no feeding bout over five minutes in length could be recorded during timed watches. If a bird left the field from a different zone to its point of entry, feeding records were divided equally between the relevant zones. Feeding records of birds landing in a tramline were divided equally between adjacent zones. Birds which had entered the crop, but were not seen to leave within the five minute observation period and were not flushed by the observer (see below) at the end of the five minutes, were assumed to have been still in the same location.

At the end of each timed watch, the observer walked along the stretch in the crop-free strip or first tramline and the position of any bird flushed was noted. Inevitably, more birds were flushed near the observer, who walked the field edge at the end of each timed watch, than from the far crop. Of the 55 birds flushed at Manydown 83% were disturbed from the headland or the field edge habitats. Significantly more birds were flushed later in the observation season at Manydown (Table 2). Furthermore, 83% of those birds recorded on entry into a zone but which did not leave within and were not flushed at the end of the five minute observation period, were from the far crop. This happened especially later in the observation season (Table 2) presumably as a result of increased cover provided by the crop resulting in fewer birds being flushed. These results suggest that foraging bouts in the far crop were underestimated. Flushing of birds before the start of a timed watch appeared to be minimal, involving only 16 birds in the 768 timed watches carried out at Manydown.

It became increasingly difficult to observe birds visiting the hedge-bottom vegetation as the vegetation grew higher and more dense. Birds could descend into this vegetation from the cover of the hedgerow without being seen. Feeding records in the hedge-bottom vegetation are therefore likely to be underestimated, especially later in the season. Birds descending to ground level in the hedge-bottom vegetation could also have fed in the crop-free strip and moved into the crop without being recorded. If this happened, however, they were more likely to be seen flying up from these zones or to be flushed from them than from the far crop.

At Manydown, 48 stretches spread throughout the study area were

selected (Figure 1). Half of these were in experimental and half in control areas. Crops adjacent to study hedgerows were: spring barley, 18 stretches (9 sprayed, 9 unsprayed); winter wheat, 27 stretches (15 sprayed, 12 unsprayed); and winter barley, 3 stretches (unsprayed only). There were no suitable hedgerows next to sprayed winter barley and a very limited sample beside unsprayed winter barley. The number of stretches adjacent to each of the hedgerow types was: over 2 m, 24 (9 sprayed, 15 unsprayed); under 2 m, 21 (15 sprayed, 6 unsprayed) and treeline, three (unsprayed only). Each stretch was visited on 16 occasions between 24 May and 9 August. Each complete set of timed watches - a round - took between one and three mornings and approximately three rounds were carried out each two weeks. The order of visits to each stretch was rotated. Observations were begun approximately one or two hours after dawn and ceased at midday.

At Courtyard and East Hall, timed feeding observations were carried out on a single, two-day visit in mid-July. This visit was designed particularly to look at species not abundant at Manydown and to provide comparable data in order to ensure that the principal study site was not particularly atypical. Observations were made by the author, Peter Lack, John Marchant and Michael Rands. At Courtyard Farm, 136 timed watches were carried out along 88 stretches of 100 m (Figure 3) between 0615-1100 hours and 1715-2000 hours on 16 July and between 0615-1100 hours on 17 July. There were 51 timed watches on sprayed fields and 85 on fields with an unsprayed 6 m strip. Crops adjacent to study hedgerows were: winter barley, 58 (27 sprayed, 31 unsprayed); and spring barley, 78 (24 sprayed, 54 unsprayed). The number of timed watches beside hedgerows over 2 m was 49, beside hedgerows under 2 m was 50 and beside hedgerows over 2 m with standards was 37. At East Hall Farm, 99 timed watches were conducted on 16 July between 0600-1000 hours and 1715-1915 hours, covering all suitable hedgerows adjacent to cereal crops (Figure 4). There were 36 timed watches adjacent to sprayed headlands and 63 adjacent to unsprayed headlands. Crops adjacent to study hedgerows were: spring barley, 42 (10 sprayed, 32 unsprayed); winter barley, 38 (17 sprayed, 21 unsprayed) and winter wheat, 19 (9 sprayed, 10 unsprayed). The number of stretches beside hedgerows over 2 m was 36, beside hedgerows under 2 m was 60 and beside treeline hedges was three.

Other foraging observations

Notes were kept of all songbird foraging bouts seen during the course of fieldwork. In addition, systematic and detailed observations of foraging by particular species were made from mid-June to the end of July at study hedgerows. Continuous observation periods varied between half an hour and six hours. Yellowhammer was the target species for this detailed study and particular note was kept of the activity of all breeding pairs in study hedgerows. Fourteen pairs were monitored. Seven of these became the subject of intensive observation when each pair started making more frequent and regular foraging flights to collect food for nestlings or fledglings. Colour ringing of adult Yellowhammers and broods was carried out to enable identification of

individuals. The aim was to obtain, as far as possible, a continuous timed record of foraging bouts in both control and experimental areas. Detailed nest histories were kept to complement intensive observations of foraging activity. When possible, the type of food brought to nestlings was noted and a few faecal sacs were collected at two nests. Faecal analysis was carried out by Steve Moreby of the Game Conservancy. Locations of foraging by the other hedgerow-nesting species were also noted during intensive observations of Yellowhammers, and several hours were spent observing foraging by Blackbirds, Chaffinches and Whitethroats.

Notes on analyses

Throughout this report the term significant is used in its statistical sense only, with probability values less than 0.05 being described as 'significant' and of less than 0.01 as 'highly significant'.

Results reported relate to the principal study area at Manydown unless otherwise specified. At Manydown, a family party of Chaffinches present during one timed watch in mid-July accounted for 35% of all Chaffinch foraging bouts. Chaffinch foraging results presented exclude this family party, with inclusive figures in parentheses. At Courtyard, foraging bouts in the unsprayed strip in experimental areas, whether this was the headland or 6-12 m from the field edge, were compared with the equivalent strip in control areas. Also at Courtyard, one timed watch was excluded from the analysis since a flock of about 30 Tree Sparrows made many rapid foraging bouts into the cereal field which were too frequent to record in detail.

RESULTS AND DISCUSSION

Breeding success, movement and turnover of birds

A successful nest was defined as one from which at least one young fledged and a failed nest as one from which no young fledged. No significant difference was evident between experimental and control areas in the number of successful and of failed nests. This was true both overall and for Blackbirds, Chaffinches and Yellowhammers individually (Table 3), although samples for individual species were very small. Nests found at the nestling stage were excluded from this analysis since their inclusion would bias results in favour of success (Snow 1955). Brood sizes fledged by Blackbirds, Chaffinches, Dunnocks and Yellowhammers did not differ significantly between experimental and control areas (Table 4).

Re-sighting and re-trapping of colour-marked broods was intended to give precise information on the post-fledging movements of songbirds raised at known locations. No useful information was obtained since only two individuals out of 59 nestlings from 17 broods ringed were subsequently re-sighted. One, a Blackbird, was found dead, in garden nets protecting strawberries, 300 m from its nest site and the other, a Song Thrush, was caught two weeks after fledging in a copse adjacent to the hedgerow in which it was reared. The lack of re-sighting and re-trapping of colour-marked young raised in study hedgerows was probably a result of several factors. These included the small proportion of the total number of birds on the farm which were colour-ringed, nest failures which occurred at the nestling stage but after ringing (two known instances), post-fledging mortality and movement into other habitats such as woodland. The practical difficulties of observing broods in dense hedgerow cover were also considerable.

Intensive ringing in July provided some information on songbird movement and turnover on the farm in relation to experimental and control areas. In all, 325 birds of 22 species were caught (Tables 5 and 6). In comparing experimental and control areas, only those birds (N=105) caught in nets adjacent to hedgerows around cereal fields were included. More birds were caught per 100 foot-hour of net in experimental than in control areas but the difference was not significant ($d=3.12, df\ 2, P<0.10$). Such a difference in numbers caught could be accounted for by the location of the hedgerows concerned in relation to woodland, since hedges might act as corridors for bird movement. In two of the three sites in experimental areas, the hedgerows adjoined woodland at both ends. The third site did not adjoin woodland and few birds were caught there. At control sites, only one hedgerow adjoined woodland and this only at one end. The greater numbers of birds caught in experimental areas was therefore probably not related to the presence of unsprayed headlands.

Recapture rates gave an indication of the length of time birds were remaining in hedgerows and these are plotted for nets at hedgerows

adjacent to cereal fields in two experimental and one control area (Figure 7). There was no difference between experimental and control areas in the number of birds remaining in the hedgerows although the number of birds re-trapped there was very small. Retraps (N=30) indicated that there were some movements through and between habitats by individuals. This was between woodlands, between cereal hedgerow and woodland, and between experimental and control areas, though all re-traps were within 500 m of their site of ringing. Samples were very small but there was no evidence of an overall movement into experimental areas by birds ringed in control areas, or vice versa.

The carrying capacity of hedgerows was apparently considerably lower than that of woodland in July. The average number of birds caught per 100 foot-hour of net at hedgerows adjacent to cereal fields was 0.50 (N=5, standard error (SE)=0.16) compared with 2.11 (N=4, SE=0.47) caught in woodland/woodland edge habitats. This difference was highly significant ($t=3.58, df\ 7, P<0.01$). The average number of species caught per 100 foot-hour of net at cereal hedgerow sites was less than half that at woodland/woodland edge sites. Although it is difficult to interpret the significance of this difference between hedgerows and woodland since they are vastly different in suitability for mist-netting (see above), results in 1984 indicated that woodland may be a richer foraging habitat for songbirds (Fuller 1984, and see below).

Marked variations occurred between species in the ratio of juveniles to adults caught at hedgerows adjacent to cereal fields and at woodland-edge sites (Table 7). The juvenile:adult ratio of Dunnocks was significantly higher in woodland/woodland edge than in cereal fields in mid-July. Blackbirds showed the same trend although it was not significant. In contrast, juvenile Blackcaps were relatively more abundant than adults in hedgerows adjacent to cereal fields than in woodland, although not significantly so. These results suggest that some young of the hedgerow-nesting species, such as Dunnock, move into woodland after fledging whilst some offspring of the woodland-nesting species, Blackcap, move into the hedgerows. Such movements may arise from competition for food between juveniles and adults, resulting in juveniles being displaced into sub-optimal foraging habitats. Casual observations supported these results although in total few fledglings, colour-marked or otherwise, were noted in hedgerows.

The results presented here suggest that the breeding success of hedgerow-nesting songbirds at Manydown was not affected by the lack of spraying of experimental headlands, although it should be noted that sample sizes were small. Furthermore, there was no indication in July that more birds were in hedgerows adjacent to unsprayed headlands, nor that those present were spending longer there. Songbirds are nidicolous, that is, they remain in the nest for a period during which they are fed by the adults, usually some 10-15 days. The parent birds usually continue to feed their young for at least a few days after they have fledged. Fledglings must then become independent in foraging for themselves. Information on the location of foraging by songbirds in relation to unsprayed cereal-field headlands is therefore critical to a complete assessment of the importance of these unsprayed headlands.

Foraging rates

As in 1984 (Fuller 1984), the absolute frequency of birds foraging in cereal fields was low. Birds were seen foraging in the field zones on only 19% of all timed watches (N=768). Only 13 of the 25 common farmland species that might be affected by the experimental treatment were recorded feeding during timed watches. These are listed in Table 8.

Wren, Willow Warbler, Starling, House Sparrow and Goldfinch were recorded only on one or two timed watches. A greater variety of species was recorded from late July onwards, when the only records of the Willow Warbler, Blue Tit, Great Tit, House Sparrow and Goldfinch were obtained. These were likely to be dispersing juveniles (see above) and adults, since none of these species bred in the study hedgerows in 1985. Family parties of tits and finches were regularly seen in hedgerows and their standards late in the season. The Goldfinches were recorded foraging only on thistles which were present in the hedge-bottom vegetation and in the sprayed headland of one field. Goldfinches are well known to expoit this food source and their morphology is particularly adapted to exploit seeds of the thistle family (Newton 1972). The tits made predominantly short foraging bouts to the hedge-bottom vegetation and headland, staying close by the cover of the hedgerow, and in the headlands these bouts were focussed on the standing grain. Whitethroats were recorded foraging only beside the green lane and then only ten bouts were recorded in the 128 timed watches at this double hedgerow. No foraging was recorded in the unsprayed headland, although half of all bouts were to the far crop. The headland adjacent to the Whitethroat territories was lodged and possibly this made it unattractive to foraging Whitethroats (see below, other foraging observations).

Only four species - Blackbird, Chaffinch, Dunnock and Yellowhammer - were recorded on more than 1% of all timed watches, a frequency giving sufficient samples to compare foraging in experimental and control areas. Chaffinch foraging samples were, however, inflated by a family party foraging during one timed watch (see above). These four species are also those most commonly found breeding in the hedgerows at Manydown in 1984 (Fuller 1984). These four species forage primarily on the ground and feed their young mainly on animal material, particularly insects and their larvae.

Use of unsprayed and sprayed headlands

The effects of leaving sprays off the headlands on the foraging frequency of songbirds may be shown by comparing the relative use of headland and far crop in experimental and in control areas. This comparison is made in Table 9 for spring barley, winter wheat and for these two crops combined. It is evident that none of the three species

for which sufficiently large samples are available - Blackbird, Dunnock and Yellowhammer - fed in unsprayed headlands more, or less, than in sprayed headlands. Furthermore, there was no significant difference in the length of foraging bout made by each species in sprayed and unsprayed headlands (Table 10). Data from Courtyard and East Hall for Yellowhammer, Chaffinch and House Sparrow were used in similar comparisons but again no significant differences between unsprayed and sprayed headlands or strips were detected (Table 11).

Why should it be that songbirds do not seem to exploit the increased food stocks present in unsprayed headlands? Songbirds make little use of cereal headlands for foraging thus the failure to detect differential use of unsprayed and sprayed headlands is not surprising. Furthermore, potential food, present in any particular location, is not necessarily 'available' to the birds. Food availability is dependent on the morphology and foraging ecology of the bird species involved as well as on the structure of the environment. Some possible factors are discussed in the following sections.

Distance from the hedgerow of the foraging location

Timed watches showed that, with the exception of Yellowhammers, the majority of foraging bouts recorded were made in the edge of the field - in the hedge-bottom vegetation, in the crop-free strip or in the headland. Foraging bouts in the hedge-bottom vegetation were probably under-recorded since visibility was restricted by vegetation growth (see Methods). The tendancy to forage at the edge of fields, rather than in the centre, was particularly marked for Dunnocks (80% of foraging bouts in the three field-edge zones), Chaffinches (80% or 88% including the family party) and Blackbirds, (75%). In contrast, over half (55%) of all Yellowhammer foraging bouts were in the crop beyond the headland. However, it would be misleading to emphasise solely the number of visits made by Yellowhammers to the far crop without taking account of the area covered by each zone. Figure 8 shows the number of foraging bouts per unit area in each field zone made by each of the four main species. This demonstrates very clearly the extremely low frequency of foraging in the cereal crop by those songbirds most commonly recorded foraging there. The length, and presumably also the density, of vegetation is known to inhibit foraging by some ground-feeders (e.g. Brough & Bridgeman 1980). Relative to zone-area, Blackbirds, Chaffinches, Dunnocks and Yellowhammers all foraged most frequently in the crop-free strip. Since each of the four species are primarily ground-foragers which locate their prey visually, it seems likely that it was the bare soil of the crop-free strip which attracted these birds. For each species the hedge-bottom vegetation was the second most frequented foraging habitat, despite its probable under-representation in foraging records. The vegetation in this zone became tall and dense as the season progressed but not uniformly so in the manner of a cereal stand. Structural differences between the hedge-bottom vegetation and the cereal crop probably result in a marked difference in the foraging opportunities for songbirds in each zone and, in particular, in the availability of food present.

The length of foraging bout made by each species varied (Table 12). Dunnocks and Chaffinches made predominantly short foraging bouts and these were made close to the hedgerow, whilst Yellowhammers, which made more foraging bouts to the far crop, made predominantly long foraging bouts. Blackbirds, however, made an equal number of long and of short foraging bouts. Interspecific differences in foraging are discussed in more detail below.

Crop type

Timed watches were few on winter barley and no results are presented for this crop. Table 13 compares the relative use of crop and edge zones in wheat and in barley and indicates that Blackbirds, Dunnocks and Yellowhammers preferred wheat rather than barley for foraging. Dunnocks and Blackbirds both made greater use of wheat crops than of barley crops, relative to their use of the respective edge zones in both cases. Yellowhammers, however, preferred crop over edge both in wheat and in barley, with little differential between the two in this preference. The edge habitat itself was similar in all cereal fields, so it is likely to be the relative attractiveness of the crop which is at issue. The attractiveness of a foraging habitat presumably relates primarily to the abundance and availability of food. Green (1984) has shown that densities of certain arthropods, including those commonly eaten by songbirds, and grass spikelets are significantly higher in wheat than in barley crops. The greater abundance of food in wheat crops may also be more available to foraging birds since wheat tillers do not extend so far laterally as barley tillers and there is more bare ground between plants. Wheat may therefore be a physically easier habitat in which to forage than barley.

One apparent anomaly was that Blackbirds fed significantly more frequently in spring barley fields (including the edge zones and the crop) than in wheat fields. Blackbirds foraging in barley fields mostly did so in the edge zones (see above), therefore it is not the difference in the crop which is at issue. Indeed Blackbirds preferred wheat for foraging (see above). The incidence of Blackbirds present on stretches adjacent to spring barley (N=18) and to wheat (N=27) showed no concentration effect (chi square = 0.08, df1, $P<0.80$). The estimated number of Blackbird territories per kilometre of hedgerow adjacent to each crop type was similar and the proximity of other habitats, such as woodland, was not notably different between hedgerows adjacent to each crop type.

Table 14 compares use of headland and far crop in barley and in wheat. Blackbirds, Chaffinches and Yellowhammers made similar use of the headland and the far crop for foraging in barley and in wheat. Dunnocks, however, made significantly more foraging bouts in headlands than in the far crop of barley when compared to foraging in these two zones in wheat, although no Dunnocks were recorded in either crop further than 30 m from the hedgerow. All four species foraged more frequently in the headland than in the far crop in both barley and wheat, when taking account of the relative area of each zone.

Hedgerow quality

Hedgerows of different height, width and structure are likely to support different numbers of breeding birds and the availability and quality of feeding sites within each hedgerow may affect the numbers feeding there. These factors may in turn affect the amount of field-feeding recorded. Table 15 shows that Blackbirds and Yellowhammers fed far more frequently in cereal fields adjacent to hedgerows over 2 m than in fields adjacent to hedgerows under 2 m. In contrast, Dunnocks fed significantly more in fields beside hedgerows under 2 m than beside those over 2 m.

Seasonal trends

Invertebrate numbers increase through spring into summer, so the difference between sprayed and unsprayed headlands in weed growth and insect abundance was likely to have become increasingly apparent as the season progressed. In 1984, differences in foraging were evident between April-May and June-July (Fuller 1984): Dunnocks and Chaffinches foraged in crops more frequently after mid-June and a higher proportion of Blackbirds were recorded in the crops later in the season. In 1985, a difference between unsprayed and sprayed winter-sown cereal headlands was obvious from the start of fieldwork in mid-May.

Figure 9 shows that Blackbird, Yellowhammer, Dunnock and Chaffinch all differed in their seasonal pattern of foraging in cereals. Within each species, however, trends were similar in spring barley and in winter wheat (Table 16). Yellowhammers increased markedly in the number of foraging bouts made from about mid-June on and this increase was reflected in both the crop and in the edge habitats (Figure 10). Such an increase could reflect the increased intensity of foraging by adults collecting food for nestlings or fledglings, since several pairs had young at this time. In contrast, Blackbirds showed a decline in the overall number of foraging bouts recorded as the season advanced. However, Figure 10 shows that this decline was only in the number of foraging bouts by Blackbirds recorded in the field-edge habitats. The number of foraging bouts in the crop during the same timed watch rounds actually increased slightly. The decline was unlikely to be simply a result of a decrease in detectability of birds foraging in the edge habitats, since the number of foraging bouts made in these zones by Yellowhammers and Dunnocks (both of which are less conspicuous than Blackbirds) increased towards the end of the season. It is possible that the decline was due to the growth of weeds and grasses in the crop-free strips and to prolific growth of the hedge-bottom vegetation encroaching on and overhanging the strips,. The strips might thus have become less attractive as a foraging habitat for Blackbirds. Alternatively, the decline may have been the result of a change in food source and/or location,; for example, earthworms become less available

and caterpillars more so in late summer. Furthermore, Blackbirds are known to travel outside their breeding territory to woodland, for example, to collect caterpillars dropping to the ground to pupate (Simms 1978). Neither Dunnock nor Chaffinch showed any overall seasonal trend in foraging in cereal fields, although Chaffinches made more foraging bouts in the crop towards the end of the season. It is probable that they were exploiting the ripening cereal seeds at this time (see below).

The principal and secondary study areas compared

Rather more birds were seen feeding in cereal fields in July at Courtyard than at Manydown or East Hall, with feeding recorded on 6-7% more of the timed watches at Courtyard. Even so, samples obtained on both farms in Norfolk were small. The species recorded foraging in cereal fields at each farm are listed in Table 17. Courtyard and East Hall farms lacked a crop-free strip and this may account for the notable scarcity of Blackbirds foraging in the cereal fields in Norfolk. Blackbirds were absent from East Hall and were seen in only 2% of 136 timed watches at Courtyard (against 7% of 96 timed watches in July at Manydown). Similarly, the occurrence of Blackbird territories in hedges at Courtyard averaged only 1.25 territories/km (D.J. Girling and A.K. Naylor, pers. comm.) against 1.45 territories/km at Manydown. However, the three farms also differed markedly in area and structure of woodland present, though the effects of this are not directly known.

Comparison of the use of the different crops between study areas was limited by the crops present and by the small samples. However, the following points may be noted. Yellowhammers at Courtyard foraged most frequently in the far crop (Table 18), confirming the results obtained at Manydown. Chaffinches feeding in cereal fields at East Hall made a similar number of foraging bouts on barley (spring and winter), and winter wheat (chi square=0.5, df2:$P<0.80$), and were more tied to the field edge (79% of all foraging bouts to the hedge-bottom vegetation or headland) than those at Courtyard (Table 18). However, this difference between the two farms was not significant (Fisher Exact Test, two-tailed probability: $P=0.10$). Chaffinch foraging frequency at East Hall, both absolute and relative to zone-area, was less in the far crop than in the headlands (Table 11). Chaffinches feeding in cereal fields on all three farms made predominantly short foraging bouts. House Sparrows at East Hall were seen only in spring barley and showed a similar (77%) edge effect to Chaffinches there. For Whitethroats, cover provided by the hedgerow seemed important at both Courtyard and Manydown. None was seen foraging more than 30 m from the hedgerow although there was a difference between the two farms in the use of the far crop: at Manydown, 50% of foraging bouts were to the far crop, at Courtyard only 12%. The lodged headland at Manydown may have increased the number of visits to the crop beyond.

At Courtyard, Yellowhammers were recorded most frequently foraging in fields adjacent to hedgerows over 2 m with standards. This agrees with the Manydown results and with Morgan and O'Connor (1980) who have

demonstrated a positive correlation between the density of Yellowhammers and a vertical habitat component in the form of trees in hedgerows.

Other foraging observations

The timed watches provided systematic information on the use of cereal field zones by songbirds, but, as noted, the sample sizes were rather small. To investigate how important were the cereal fields, in particular the headlands, for individual birds, some continuous observations were made of birds feeding young in the hedgerows. Birds at this stage of the nesting cycle were chosen both because the adults were making more foraging trips and because individuals could be identified more easily. Attention was concentrated on Yellowhammer and Chaffinch but observations were also made on Blackbirds and Dunnocks, and briefly on Whitethroats. Attempts were made to colour-ring individually adults of both species but this met with only limited success. Nevertheless, individual Yellowhammers, particularly the males, were fairly readily identifiable from their nest locations and by plumage characters. Observations were made on birds nesting in hedgerows adjacent both to sprayed and to unsprayed headlands.

Cereal fields were important foraging locations for Blackbirds, Dunnocks and Yellowhammers (Table 19). Woodland appears to be a more important foraging location for Chaffinches (Table 20), although they nest commonly in the hedgerows at Manydown (Fuller 1984). Each species is discussed more fully below and some information on Whitethroats from both Manydown and Courtyard Farms is included at the end of this section.

Yellowhammer

During timed watches, Yellowhammers were recorded not only foraging in cereal fields adjacent to their nesting hedgerow but also flying to woodland, to individual trees and, in the first half of July, to other cereal fields over 500 m distant. The number of such visits amounted to only a small percentage of the total number of foraging bouts recorded (12% to woodland or trees and 7% to distant fields). However, during the two timed watch rounds on which foraging bouts to non-adjacent cereal fields were recorded, such visits accounted for 40% of all foraging bouts recorded. A seasonal importance of certain crop types as a food source is indicated.

Table 21 gives some detailed information on foraging locations collected during almost 95 hours of observation from late June to early August at seven sites. These data confirm the tendencies for Yellowhammer to forage in the far crop (Table 14, Figure 8) but also

show the importance of the cereal crop relative to other habitats such as woodland for foraging and the distance Yellowhammers will fly to forage in cereal fields not adjacent to their breeding territory. Of 430 bouts seen, 77% were to cereal fields (edge plus crop) and the remainder were to non-cereal crops, woodland, habitations and unknown destinations (Table 21).

Within cereal fields, 88% of foraging bouts recorded (N=329) were made in the crop itself, mainly (70% of 243 known locations) in the far crop. Furthermore, at each individual observation site, more foraging bouts were located in the far crop than in the headland. It is evident that, for foraging Yellowhammers, cover from the hedgerow was not important (compare Dunnock and Whitethroat below). Moreover, unlike the other hedgerow-nesting species observed at Manydown, Yellowhammers were often seen flying distances of up to 1 km to forage in cereal fields not adjacent to their nesting territory. Adults from four separate Yellowhammer territories were observed to make these relatively long distance foraging flights. Two were in control areas (one spring barley, one winter wheat) and two in experimental areas (again one spring barley and one winter wheat).

Pair 1 had two nestlings in a hedgerow adjacent to spring barley in a control area, and, in 19.25 hours in late June, 57 foraging bouts were observed by the adults. Some 61% were made to cereal crops (excluding the hedge-bottom vegetation and crop-free strip) and 83% of these were made to a winter barley field over 500 m distant and frequently involved their flying over the hedgerow territory of another pair, still within the control area. The remainder were made to the spring barley crop adjacent to the hedgerow territory.

Foraging bouts were directed principally to three locations in the winter barley field, usually within 50 m of the edge of the field. Each bout involved a round trip of over 1 km and nine of the 29 involved a round trip of at least 2 km. The majority of these feeding bouts resulted in the returning adult bringing food to the nestlings. On almost half of all recorded visits to this nest, the returning adults were seen carrying 2-3 (usually) green caterpillars in their beaks. Faecal sacs from this nest were collected and analysed to find out in more detail the type of food received by the nestlings. Table 22 lists the contents of faecal sacs collected at this nest (nest 1). Only a general outline of the range of food consumed can be inferred, since only the most recently deposited sac was separable from the pile of faecal sacs accumulated over a number of days. There was, however, evidence of a large number of Lepidoptera larvae (caterpillars) which accords with visual observations.

Pair 2 were in a control area and were feeding fledglings in a hedgerow adjacent to winter wheat. In 4.75 hours of observation on 9 July, the two adults of the pair were seen six times to fly over some mature silver birches (Betula pendula) and the railway line, into an experimental winter barley field 250 m distant. No foraging was seen in the winter wheat field adjacent to the nest but at least ten trips were made to the bean field on the other side of the hedgerow, and three flights to the birch trees beside the railway. None of the

foraging bouts into the winter barley field were to the unsprayed headland. The pair was not seen on previous or subsequent visits to the site.

Pair 3 had nestlings in a hedgerow adjacent to spring barley in an experimental area and in 6.5 hours at the end of July, the adults were seen to make 49 foraging bouts. Fifteen bouts were to the adjacent barley but 10 were to a winter wheat field 200 m away although still in the experimental area. Other bouts were to the edge zones, the orchard and garden of the house beyond the track beside this study hedgerow and (once) to a treeline hedge about 200 m distant.

Pair 4 had three nestlings in the hedgerow of the green lane adjacent to winter wheat in an experimental area, and was the only pair seen making regular long foraging flights early in the season (late May). The male and female of the pair were several times seen to fly together, over the woodland 75 m north of the nest. The destination could not be seen but it is likely that they landed either in the woodland itself or in the control fields of barley 250 m distant. They usually flew beyond the woodland edge over the tree canopy. When feeding a second brood in late July, however, adults of this same pair were rarely seen to visit the woodland or to fly over its canopy. Instead, they fed almost entirely in the vegetation of the green lane or in the winter wheat adjacent to the hedgerow.

In late July, there were three pairs breeding along the green lane, at least two of which were feeding nestlings at the time of the observations. Birds were recorded feeding regularly in the winter wheat crop and the vegetation of the green lane but as it was impossible to watch both sides simultaneously, the relative importance of the lane and crop could not be assessed. Only one foraging bout was recorded in the hedge-bottom vegetation and only four to the woodland. A total of 88 trips to the wheat field was recorded, of which 77% were to the far crop. This figure is higher than was recorded for Yellowhammers during the timed watches but it may be relevant that the unsprayed headlands of this field were particularly dense with grasses and cleavers. Furthermore, much of both the headland and the crop was lodged at this stage.

Considering these observations with those from the timed watches, it is clear that Yellowhammers use cereal crops extensively for feeding and that they are prepared to forage further out into the field, away from the cover of the hedgerow, than most species. It is also clear that they are prepared to fly quite long distances to exploit good food sources. These areas were certainly well outside their breeding territories. Nevertheless, there is no indication that unsprayed headlands were especially attractive to Yellowhammers. It may be that such areas are actively avoided if very densely clogged with weeds, perhaps because of the difficulty of moving around and of visually locating prey. The factors which determine where Yellowhammers feed are as yet unknown, but they evidently must search over quite a wide area and do return repeatedly to good places located on previous excursions.

Chaffinch

There were an estimated seven Chaffinch territories held in study hedgerows, yet in timed watches few Chaffinches were recorded feeding in cereal fields. Observations suggested that other features of the farmland habitat, in particular the woodland and the treeline hedges, were more important.

Table 20 shows the use of different features of the farmland habitat through the season. It is evident that a significant proportion of Chaffinch observations were of birds seen flying between hedgerow and woodland, and rather few were seen to feed in the cereal fields adjacent to their nests. Several observations involved some quite long distance flights from their nest sites in the hedgerows, especially early in the season.

Chaffinches in both control and experimental areas were seen flying to woodland from known hedgerow nests. About two-thirds of the 50 flights recorded involved a distance of 100-500 m to or from woodland. Although it was not possible to see whether or not the returning individuals were carrying food, the birds were presumably foraging in the woodland. As with Yellowhammers, therefore, Chaffinches were foraging regularly in areas well outside their territories.

Overhead movements of Chaffinches, observed casually, appeared to be regular and frequent in May and early June. Such movements are under-represented in Table 20 since their observation detracted from observation of the field zones. Most overhead flights observed involved a one-way distance of over 500 m and several continued beyond 700 m. During the same period of casual observations, not a single Chaffinch was seen to enter or to leave the field edge or cereal crops. This is consistent with data collected for this period during the timed watches - there were records of only three foraging bouts into the hedge-bottom vegetation or crop-free strip and none into the crop itself.

From mid-June to mid-July, very few Chaffinches were seen to make such long distance flights. However, some were seen feeding on the standing cereal grain and it appeared that this species was using the different crops in succession. In late June and very early July they were seen taking seeds of winter barley, in early July spring barley, and in early August winter wheat. However, the real importance of standing grain as a food source to Chaffinches on the farm cannot be determined since birds feeding on cereal stalks at the edges of fields were highly conspicuous.

A few family parties were seen flying over the fields and woodland in early July. In late July Chaffinch individuals were again seen flying overhead on flights of at least 500 m. Of the four Chaffinch pairs in the study hedgerows known to have fledged at least one young, only one pair appeared to remain, feeding fledglings in the hedgerow for several days after fledging. Although it was not certain that the other broods survived, it is possible that once the family becomes

mobile, adults and their young may move fairly quickly into the woodland. Although all these young and a few of the adults were colour-ringed, no colour-marked Chaffinches were seen at any time, either in the hedgerows or in the woods known to be visited by the adults in question.

In conclusion, it appears that Chaffinches make very little use of any cereal crops for feeding, whether in the headland or further out, except for a short period when they exploit the ripening grain of each crop. At Manydown, they make extensive use of the woodland areas for feeding and they may also use the hedges. The breeding density of Chaffinches at Manydown was high both in woodland and in hedgerow (Fuller 1984). Competition for food might be expected between birds flying to woodland from hedgerow territories and those birds holding territory within the woodland. However, no information on this was collected. What happens in less well-wooded areas is not known.

Blackbird

Cereal fields were an important feeding location for Blackbirds (Table 19), at least for those nesting in hedgerows adjacent to the cereal fields. Blackbirds were also seen to visit woodlands and lone trees to forage but these formed a relatively small proportion of all Blackbird bouts recorded. Furthermore, it appears that only certain Blackbirds nesting in study hedgerows foraged regularly in nearby woodland. In two hours of observation in mid-June, one Blackbird pair feeding young in a study hedgerow made 15 foraging bouts to the winter wheat crop (2 to the unsprayed headland, 13 to the far crop), 13 to woodland 150 m distant and three to unknown locations. It is notable that, at this site, no trips were made to the crop-free strip or hedge-bottom vegetation during this period, despite the preference shown by the species generally (timed watches). The crop-free strip at this study hedgerow became overhung by weed growth in the hedge-bottom vegetation and in the unsprayed headland. Thus it may well have become a less attractive landing and foraging site for Blackbirds (see above also).

Dunnock

Table 19 shows that the edge and crop of adjacent cereal fields were important foraging locations for hedgerow-nesting Dunnocks. They were also seen to visit woodland, copse and non-cereal crops but were not seen to visit non-adjacent cereal fields from study hedgerows. Dunnocks were recorded foraging in cereal fields only within 30 m of the hedgerow. However, a very few longer distance flights were observed and such flights were apparently made to exploit a particular food source. For example one adult flew 300 m to a bean field, returning with food. This Dunnock flew along the crop-free strip at a low level close to the hedgerow. The only foraging bouts observed in non-cereal crops were from early July onward. In general Dunnocks foraged close to the hedgerow and the cover provided by the hedgerow was apparently important to them.

Whitethroat at Manydown and Courtyard Farms

At Manydown, Whitethroats were observed only at the double hedgerow of the green lane which was adjacent to winter wheat with unsprayed headlands. This was the only study hedgerow in which Whitethroats were known to be breeding in 1985 and three territories were identified over a number of visits. The site was not a part of the mapping census in 1984 (Fuller 1984).

No Whitethroats were seen foraging in the wheat crop or the crop-free strip at any time in May or June. At least two pairs were in the hedgerow at this time and were regularly seen and heard giving alarm calls. In late June and early July, one pair of Whitethroats were feeding five nestlings in the verge of the green lane. During three one-hour observation periods, all foraging bouts seen were made by the adults to the field-layer vegetation of the green lane and to other locations in the hedgerow. On one occasion, 45 visits to this vegetation were recorded in half an hour. Observations could not be made simultaneously in the green lane and in the crop. However, Whitethroats were not seen foraging in the wheat crop or edge zones of either the field to the east nor to the west of the hedgerow in 30 minutes in each field. The nest was found to have been damaged on 9 July and regular foraging trips were not resumed until the pair had young at the nest again in late July. At this time, 88% of all recorded foraging bouts (N=72) were to the wheat crop itself. The herb layer vegetation in the green lane had been cut to ground level in mid-July and Whitethroats were not seen foraging there subsequently. Only four of the 72 foraging bouts recorded were to the unsprayed headland, although about 90% were to locations within 20 m of the hedgerow. Only one foraging bout to a location over 50 m away from the hedgerow was seen. No visits to other habitats such as woodland were observed.

At Courtyard, rather few foraging bouts made by Whitethroats were recorded during timed watches, although a Common Birds Census there (D.J. Girling & A.K. Naylor, pers. comm.) showed a minimum of nine hedgerow pairs there. To supplement the timed watch data, Whitethroats were watched at four sites by two observers between 0630 and 1100 hours on 17 July. One observer worked on control areas (looking at two sites) and the other on experimental areas (also two sites).

In general rather few foraging bouts were observed in cereal fields. At one site, on experimental spring barley, 12 foraging bouts were made to the field in two hours of observation. Half of these were to the vegetation beside the hedgerow or to the headland crop, usually to a location within 2 m of the hedgerow. Although in an experimental area, the headland was sprayed with chemicals. Only two of the 12 foraging bouts observed were made to the unsprayed strip (6-12 m from the hedgerow). No foraging bouts to locations other than the field were observed but visibility was restricted to only one side of the hedge adjacent to the cereal crop.

At the other site in an experimental area, no Whitethroats were recorded visiting the spring barley crop in 50 minutes of observation.

Foraging and collecting food, probably for the fledglings which were in the hedge-bottom vegetation, was focussed very locally along a 10 m stretch of the hedge-bottom vegetation which was here rather wider than at many hedges on Courtyard. The consequent more prolific growth of grasses, umbellifers and other herbage may have provided sufficient food for the pair, obviating the need to forage further afield.

In the control area, observation was made at a double hedgerow adjacent to spring barley and peas. No Whitethroats were seen feeding in the barley field but numerous and frequent foraging bouts were made by adult Whitethroats to the peas. Some 25 foraging bouts were made to the pea crop in a total of 50 minutes of observation, with the adults returning to the hedgerow with food for fledglings. During the same period, 12 foraging bouts were recorded at other locations. These locations may or may not have included cereal fields, but not the spring barley immediately adjacent. The foraging data collected at Courtyard, however, constitute too small a sample to compare foraging preferences in different crop types.

In conclusion, it appears that Whitethroats, although they usually feed close to their nest site, greatly prefer the hedge-bottom vegetation to the crop itself. When they are in the crop, no particular preference for the headland is evident, although they do feed fairly close to the hedge. If both crop-types are close at hand, they may prefer to feed in dicotyledonous crops than in cereal fields, but our samples from Courtyard Farm are too small to be sure of this. A similar result was found by Davis (1967), who compared several species including Whitethroats feeding in vegetable and wheat fields.

CONCLUDING DISCUSSION

Of the 31 passerine species (excluding the crows and hirundines) commonly found breeding on farmland in Britain, 25 are potentially suited, on the basis of their morphology and foraging behaviour, to the exploitation of cereal headlands. Each of these 25 species held territory in the principal study area in 1984. However, only four - Dunnock, Blackbird, Chaffinch and Yellowhammer - were regularly recorded foraging in cereal fields during the 1984 and 1985 breeding seasons.

Fieldwork in 1984 showed that very few birds breeding in the woodland came out to forage in cereal fields, despite a high breeding density within the woods (Fuller 1984). It is probable that the rich and varied foraging niches available in woodland obviated the need for passerines breeding in woods regularly to forage elsewhere. Whether this would apply on cereal farms with a lower proportion of woodland than Manydown is unknown. The data reported here from a farm with little woodland, East Hall, were too few to allow conclusions to be drawn.

At Manydown, only the most common hedgerow-nesting species foraged frequently in cereal fields. Furthermore, Blackbirds and Chaffinches, which bred commonly in woodland as well as in hedgerows, foraged far more frequently in cereal fields adjacent to hedgerows than in cereal fields beside woodland edges (Fuller 1984). Hedgerows, particularly those with few tree standards, probably offer considerably fewer foraging opportunities for songbirds than does woodland. Furthermore, by virtue of the small area of a hedgerow in relation to its length, songbirds are probably likely to forage more frequently in habitats adjacent to hedgerows than adjacent to woodland.

Nevertheless, although the hedgerow-nesting songbirds were the ones which foraged most frequently in cereal fields, there was no evidence to show that they benefitted from, nor preferentially exploited, the unsprayed headlands. Breeding performance, the dispersal of young after fledging and the movements of adults after breeding did not vary between experimental and control areas. The increased brood size of the Grey Partridge and of the Pheasant, as a result of leaving headlands unsprayed, was not matched in songbirds. There are probably several reasons for this. In particular, the present study shows that some hedgerow-nesting species exploit food supplies at a distance of at least 1 km from the nest while feeding young. This gives songbirds a range and flexibility to exploit food sources well beyond their breeding territory. In this respect, songbirds differ fundamentally from gamebirds. Gamebirds become mobile as a family unit soon after hatching, and travel largely on foot. Consequently, they may have a more limited daily range of possible foraging locations than an adult songbird. However, once a good food source has been found, the gamebird family party is well placed to exploit it. It has been shown (Green 1984) that Grey Partridges forage preferentially at field edges. Unsprayed headlands are therefore within the preferred foraging location of Grey Partridges during the

breeding season.

The present results on foraging demonstrate six main points. First, that songbirds make little use of cereal crops and in particular of cereal headlands. Assessment of differential use of unsprayed and of sprayed headlands is thus made rather difficult. Second, that wheat was preferred to barley for foraging by most species studied. Third, that species varied considerably in their preferred foraging habitat and location. Information gained is, therefore, dependent on the species composition of the study site. Nevertheless, data from our two Norfolk study sites supported results from Manydown in most instances. Fourth, that all species investigated, except Yellowhammer, preferred to forage in the field edge near the cover of the hedgerow. Fifth, that a cleared, crop-free strip is an important foraging location, particularly for Blackbirds and Dunnocks. Sixth, that other farmland habitats contained important foraging locations for certain species, in particular, the woodland for Chaffinches and the non-cereal crops and verge of the green lane for Whitethroats.

The songbirds studied did not exploit the greater abundance of insects and weed seeds known to be present (Rands 1985a, Sotherton et al. in press), in headlands which had not been sprayed. When Blackbirds foraged in the crop itself they actively avoided at least some of the unsprayed headlands. This may have been because dense weed growth amongst the uniform crop obscured visual cues and was more difficult to move through, thereby inhibiting prey location. Whitethroats also appeared to avoid those unsprayed headlands that were lodged and dense with weeds. In 1984, Dunnocks showed some preference for foraging in unsprayed headlands (Fuller 1984). In 1984, Dunnocks spent longer foraging in unsprayed than in sprayed headlands and, in fields with unsprayed rather than sprayed headlands, a higher proportion foraged in the crop than in the crop-free strip. Results were, however, significant only in spring-sown crops. This was probably because the effective uptake of pesticides applied to winter-sown crops reduced the difference in weed growth between unsprayed and sprayed headlands in the 1984 breeding season. In 1985, however, there was no evidence of any difference between unsprayed and sprayed headlands in foraging frequencies of Dunnocks.

The lack of differential exploitation of unsprayed headlands was, therefore, largely because frequency of foraging in headlands was very low and because the potential foods present in headlands which had not been sprayed were not available to the birds. This was either because the habitat was unsuitable for food location or because they preferred to forage in habitats other than the crop itself. Nevertheless, the data collected have provided new information on the foraging of songbirds and indicate areas of study potentially of considerable value in formulating guidelines for farmland management to benefit breeding songbirds. Meanwhile, the general conclusion must be that the patterns of feeding behaviour in passerine songbirds differ markedly from those of game birds in ways which greatly reduce their dependence on local invertebrate food sources. Songbird populations are, therefore, unlikely to benefit directly from the practice of leaving sprays off cereal field headlands to promote gamebird populations.

ACKNOWLEDGEMENTS

The BTO is most grateful to Mr. H.R. Oliver-Bellasis of The Manydown Farm, to Lord Peter Melchett of Courtyard Farm and to Mr. P. Allen of East Hall Farm for permission to work on their land. For their help and co-operation during fieldwork I thank Mr. Oliver-Bellasis, Mr. and Mrs. A. Dabinett and Miss E. Spicer. Throughout the work I received much assistance and advice from members of the staff of the Game Conservancy, in particular from Dr. Michael Rands and Dr. Nigel Boatman.

I thank Peter Burns and Paul Copestake for carrying out the systematic ringing fieldwork and Steven Moreby (Game Conservancy) for analysing the Yellowhammer faecal sacs. All other fieldwork was carried out by the author with assistance from Rob Fuller, Peter Lack, John Marchant and Michael Rands.

Elizabeth Murray drew the figures and Caroline Hunt typed the tables. Raymond O'Connor, Peter Lack, Rob Fuller and John Marchant made valuable comments on aspects of the analysis and on the draft report.

REFERENCES

BROUGH, T. & C.J. BRIDGEMAN. 1980. An evaluation of long grass as a bird deterrent on British airfields. Journal of Applied Ecology 17: 243-253.

CAMPBELL, B. & I.J. FERGUSON-LEES. 1972. A Field Guide to Birds' Nests. Constable, London.

DAVIS, B.N.K. 1967. Bird feeding preferences among different crops in an area near Huntingdon. Bird Study 14: 227-237.

FULLER, R.J. 1984. The distribution and feeding behaviour of breeding songbirds on cereal farmland at Manydown Farm, Hampshire, in 1984. A report to the Game Conservancy. British Trust for Ornithology, Tring. 25 pages.

GREEN, R.E. 1978. Factors affecting the diet of farmland skylarks, Alauda arvensis. Journal of Animal Ecology 47: 913-928.

GREEN, R.E. 1984. The feeding ecology and survival of Partridge chicks Alectoris rufa and Perdix perdix on arable farmland in East Anglia. Journal of Applied Ecology 21: 817-830.

MARCHANT, J.H. 1983. BTO Common Bird Census Instructions. British Trust for Ornithology, Tring. 12 pages.

MARCHANT, J.H. 1985. 1983-84 CBC Index Report. BTO News 140: 7-9.

MORGAN, R.A. & R.J. O'CONNOR. 1980. Farmland habitat and Yellowhammer distribution in Britain. Bird Study 27: 155-162.

NEWTON, I. 1972. Finches. Collins, London.

POTTS, G.R. & G.P. VICKERMAN. 1974. Studies on the cereal ecosystem. Advances in Ecological Research 8: 107-197.

RANDS, M.R.W. 1985a. Pesticide use on cereals and the survival of Grey Partridge chicks: a field experiment. Journal of Applied Ecology 22: 49-54.

RANDS, M.R.W. 1985b. The benefits of pesticide-free headlands to wild gamebirds. The Game Conservancy Annual Review 16: 32-37.

SHARROCK, J.T.R. (ed.) 1976. The Atlas of Breeding Birds in Britain and Ireland. Poyser, Berkhamsted.

SIMMS, E. 1978. British Thrushes. Collins, London.

SNOW, D.W. 1955. The Breeding of Blackbirds, Song Thrushes and Mistle Thrushes in Great Britain. Part III. Nesting success. Bird Study 2: 169-178.

SOTHERTON, N.W., M.R.W. RANDS & S.J. MOREBY. (In press). Comparison of herbicide treated and untreated headlands for the survival of game and wildlife. Proceedings 1985 British Crop Protection Conference.

SOUTHWOOD, T.R.E. & D.J. CROSS. 1969. The ecology of the partridge - III. Breeding success and the abundance of insects in natural habitats. Journal of Animal Ecology 38: 497-509.

VICKERMAN, G.P. 1974. Some effects of grass weed control on the arthropod fauna of cereals. Proceedings of the 12th British Weed Control Conference 3: 929-939.

VICKERMAN, G.P. & N.W. SOTHERTON. 1983. Effects of some foliar fungicides on the chrysomelid beetle Gastrophysa polygoni (L.). Pesticide Science 14: 405-411.

APPENDIX 1.

Scientific names of bird species mentioned in the text.

Grey Partridge	Perdix perdix
Pheasant	Phasianus colchicus
House Martin	Delichon urbica
Skylark	Alauda arvensis
Pied Wagtail	Motacilla alba
Wren	Troglodytes troglodytes
Dunnock	Prunella modularis
Robin	Erithacus rubecula
Nightingale	Luscinia megarhynchos
Blackbird	Turdus merula
Song Thrush	Turdus philomelos
Mistle Thrush	Turdus viscivorus
Sedge Warbler	Acrocephalus schoenobaenus
Lesser Whitethroat	Sylvia curruca
Whitethroat	Sylvia communis
Garden Warbler	Sylvia borin
Blackcap	Sylvia atricapilla
Chiffchaff	Phylloscopus collybita
Willow Warbler	Phylloscopus trochilus
Spotted Flycatcher	Muscicapa striata
Long-tailed Tit	Aegithalos caudatus
Marsh Tit	Parus palustris
Coal Tit	Parus ater
Blue Tit	Parus caeruleus
Great Tit	Parus major
Treecreeper	Certhia familiaris
Jay	Garrulus glandarius
Starling	Sturnus vulgaris
House Sparrow	Passer domesticus
Tree Sparrow	Passer montanus
Chaffinch	Fringilla coelebs
Greenfinch	Carduelis chloris
Goldfinch	Carduelis carduelis
Linnet	Carduelis cannabina
Lesser Redpoll	Carduelis flammea
Bullfinch	Pyrrhula pyrrhula
Yellowhammer	Emberiza citrina
Reed Bunting	Emberiza schoeniclus
Corn Bunting	Milaria calandra

APPENDIX 2.

List of passerine birds, excluding the crows and hirundines, indexed for farmland by the Common Birds Census.

Skylark
Pied Wagtail
Wren
Dunnock
Robin
Blackbird
Song Thrush
Mistle Thrush
Sedge Warbler
Lesser Whitethroat
Whitethroat
Garden Warbler
Blackcap
Chiffchaff
Willow Warbler
Spotted Flycatcher
Long-tailed Tit
Blue Tit
Great Tit
Treecreeper
Starling
*(House Sparrow)
Tree Sparrow
Chaffinch
Greenfinch
Goldfinch
Linnet
Bullfinch
Yellowhammer
Reed Bunting
Corn Bunting

* Not censused by the Common Birds Census.

TABLE 1. Summary of the treatments applied to cereal fields at Manydown, Courtyard and East Hall Farms in the autumn of 1984 and the spring of 1985

	Autumn applications	Spring/Summer applications
MANYDOWN		
Winter Barley	1 grass-weed/broad-leaved weed herbicide	1 fungicide
	1 insecticide (on 4/6 fields)	
Winter Wheat	1 grass-weed/broad-leaved weed herbicide	1 grass-weed/broad-leaved weed herbicide (on 5/17 fields)
	1 insecticide (on 14/17 fields)	1 late herbicide (half rate) (on 2/17 fields)
	1 molluscicide (on 3/17 fields)	1 growth-regulator (on var. Brimstone only)
		3 fungicides
Spring Barley	-	1 herbicide (on 9/13 fields)
		1 fungicide
COURTYARD		
Winter Barley	1 insecticide	2 fungicides
	1 fungicide	
Winter Wheat	1 grass-weed herbicide	-
	1 pre-emergence herbicide	
Spring Barley	-	1 grass-weed herbicide
		1 broad-leaved weed herbicide
EAST HALL		
Winter Barley	1 herbicide	Fields requiring herbicide treatment in spring were 'spot' treated as necessary.
	2 fungicides	
Winter Wheat	1 herbicide	
	3 fungicides	
	1 insecticide	
Spring Barley	-	1 herbicide
		2 fungicides

NOTE: Numbers refer to the number of applications. Treatments left off unsprayed headlands at each farm are detailed under study area.

TABLE 2. Flushing of birds in cereal field zones during timed watches at Manydown.

Bird	Dates of times watch rounds (starting date only) 24/5	29/5	3/6	7/6	12/6	17/6	22/6	25/6	4/7	8/7	11/7	19/7	22/7	27/7	1/8	8/8	Spearman's Rank Correlation Coefficient(rs), two-tailed:
A	0	1	2	0	0	1	0	0	3	2	3	2	4	1	9	5	rs = 0.71, df 14 t = 3.79 p < 0.01
B	0	1	1	0	1	1	2	1	0	1	4	1	2	0	4	3	rs = 0.52, df 14 t = 2.26 p < 0.05
C	0	0	0	0	0	1	4	0	0	7	1	6	4	6	6	13	rs = 0.83, df 14 t = 5.49 p < 0.001
D	20	22	3	3	12	5	6	4	5	4	19	17	4	5	24	22	rs = 0.22, df 14 t = 0.85 not significant

KEY: A Flushed at end of 5 minute observation but not seen to enter zone (ie. assume was there at start).

B Flushed at end of 5 minute observation and seen entering zone.

C Seen entering zone but not exited voluntarily within 5 minute observation period nor flushed at end of observation, (i.e. assume was still in field zone).

D Exited voluntarily during 5 minute observation period. Included birds seen and not seen entering zone.

TABLE 3. The number of successful and unsuccessful nests found in experimental and control areas at Manydown.

	Number of nests (%) Successful	Unsuccessful	Fisher Exact Test Two-tailed probability=
Blackbird			
Experimental areas	3 (43%)	4 (57%)	1.00
Control areas	3 (50%)	3 (50%)	
Chaffinch			
Experimental areas	2 (33%)	4 (66%)	0.21
Control areas	2 (100%)	0 (0%)	
Dunnock			
Experimental areas	1 (33%)	2 (66%)	-
Control areas	0 -	0 -	
Yellowhammer			
Experimental areas	2 (50%)	2 (50%)	1.00
Control areas	2 (66%)	1 (33%)	
Total, all species			
Experimental areas	8 (38%)	13 (62%)	0.16
Control areas	8 (67%)	4 (33%)	

NOTES: Only nests found during building or with eggs were included. Nests excluded because they were found at the nestling stage were: three Blackbird, one Chaffinch, three Dunnock and two Yellowhammers.

TABLE 4. The mean brood size for four species fledged in control and experimental areas at Manydown.

	Mean brood size 1/			
	Blackbird	Chaffinch	Dunnock	Yellowhammer
Control area	2.00	2.33	1.50	1.67
Experimental area	2.13	1.00	1.00	0.40

NOTES:

1/ Inclusive of failed nests

2) There was no siginficant difference in brood sizes between control and experimental areas:

Mann Whitney U Test (inclusive of failed nests).
Blackbird, U = 31.5 p >0.48 (N1 = 8 N2 = 8)*
Chaffinch U = 5.0 p =0.19 (N1 = 3 N2 = 6)
Dunncok U = 3.0 p =0.40 (N1 = 2 N2 = 4)
Yellowhammer U = 3.5 p >0.13 (N1 = 3 N2 = 5)

Blackbird, exclusive of failed nests U = 6.5 p> 0.21
(N1 = 5, N2 = 4)

* N1 = control areas
N2 = experimental areas

TABLE 5. Birds ringed and re-trapped during systematic ringing at Manydown.

SPECIES	Total number of birds ringed	Total number of birds re-trapped	Number of birds ringed (re-trapped) at each site on date specified. Site A 8/7	Site A 12/7	Site A 19/7	Site B 9/7	Site B 15/7	Site B 16/7	Site C 10/7	Site D 11/7	Site D 17/7	Site D 20/7	Site E 18/7
House Martin	1	0										1	
Wren	23	2	1		4(1)			1		4	6	4(1)	3
Dunnock	33	6	3	2(1)			1(1)	1(1)	2	8	7(2)	1(1)	8
Robin	15	1			3	1	0(1)	2	1	1	2	1	4
Nightingale	1	0				1							
Blackbird	35	4		2	1(1)	4(2)	1(1)		1	7	5	1	13
Song Thrush	4	1			1			0(1)		2			1
Lesser Whitethroat	3	0	1		1						1		
Whitethroat	5	4	1	1(2)	0(1)		1	0(1)		1			1
Blackcap	36	0	2		4					4	11	7	8
Chiffchaff	2	0	1							1			
Willow Warbler	9	0	3		2						1		3
Long-tailed Tit	11	0					7			2	2		
Marsh Tit	8	1			1(1)		1	5					1
Coal Tit	3	0	3										
Blue Tit	64	5	9	1	1(1)	2(1)	24(2)			4	11	0(1)	12
Great Tit	45	4	9	1(1)	0(1)	3	7(1)	5	2	4	7(1)		7
Treecreeper	4	0	1		1		1	1					
Jay	2	0								1	1		
Chaffinch	10	1		1		2(1)				1	3		3
Bullfinch	5	0			1	1				3			
Yellowhammer	6	1	1		1(1)	1			1	1			1
TOTAL BIRDS: RINGED	325	30	35	8	21	15	43	15	7	44	57	15	65
RE-TRAPPED			(0)	(4)	(7)	(4)	(6)	(3)	(0)	(0)	(3)	(3)	(0)

NOTE: Scientific names of birds are given in Appendix 1.

TABLE 6. The number of birds caught per hundred foot hours of net at each site at Manydown.

SITE	DATE	Total number of:- 100' hours of net set	birds caught	species caught	birds re-trapped	Numbers of birds caught/100' hours of net (not including re-traps).
A	8.7	31.50	35	12	0	1.11
	12.7	15.20	8	6	4	0.53
	19.7	43.00	21	12	8	0.49
A	9.7	49.19	15	8	4	0.30
	15.7	14.60	43	8	6	2.95
	16.7	16.80	15	6	3	0.89
C	10.7	35.10	7	5	0	0.20
D	11.7	29.70	44	15	0	1.48
	17.7	25.63	57	12	3	2.22
	20.7	23.40	15	6	3	0.64
E	18.7	22.00	65	13	0	2.95

NOTE: Location of sites is shown in Figure 6.

TABLE 7. The number of adult and juvenile Blackbirds, Blackcaps and Dunnocks caught during systematic netting sessions at Manydown.

Nesting site:	Blackbird: adult	juvenile	Fisher Exact Test Two-tailed probability=	Ratio of Juveniles/ adult
Ceareal hedge	4	3	0.39	0.75
Woodland/Woodland edge	9	18		2.00
	Blackcap: adult	juvenile		
Cereal hedge	1	5	0.64	5.00
Woodland/Woodland edge	10	20		2.00
	Dunnock: adult	juvenile		
Cereal hedge	7	3	0.002	0.43
Woodland/Woodland edge	3	20		6.67

TABLE 8. The number of timed watches on which species were recorded foraging on cereal fields at Manydown in 1985.

Species	Cereal field	Edge Zones	Crop
Wren	2 (0.3%)	1 (0.1%)	1 (0.1%)
Dunnock	55 (7.2%)	31 (4.0%)	30 (3.9%)
Blackbird	49 (6.4%)	32 (4.2%)	17 (2.2%)
Song Thrush	5 (0.7%)	4 (0.5%)	1 (0.1%)
Whitethroat	7 (0.9%)	3 (0.4%)	4 (0.5%)
Willow Warbler*	1 (0.1%)	1 (0.1%)	1 (0.1%)
Blue Tit	5 (0.8%)	4 (0.5%)	3 (0.4%)
Great Tit	3 (0.4%)	2 (0.3%)	2 (0.3%)
Starling	1 (0.1%)	0 -	1 (0.1%)
House Sparrow	2 (0.3%)	1 (0.1%)	2 (0.3%)
Chaffinch	10 (1.3%)	6 (0.8%)	2 (0.3%)
Goldfinch	1 (0.1%)	1 (0.1%)	0 -
Yellowhammer	30 (4.0%)	6 (0.8%)	23 (3.0%)

NOTE: * The two species Willow Warbler and Chiffchaff were not distinguished during timed watch observations.

The percentage of all timed watches (N = 768) on which species were present is given in parenthesis.

Foraging bouts were scored either as 'edge' or 'crop' according to where the majority of foraging bouts took place. If an equal number of bouts was made in each, the bird was excluded here (one Dunnock, one Yellowhammer).

TABLE 9. The number of foraging bouts made by four species in the headland and far crop in control and experimental areas of spring barley and winter wheat during timed watches at Manydown.

	Control area		Experimental area		Fisher Exact Test
	Headland	Far Crop	Headland	Far Crop	Two-tailed probability=
Spring barley					
Blackbird	2	5	1	0	0.38
Chaffinch	2	2	0	0	-
Dunnock	6	0	2	0	-
Yellowhammer	3	6	1	4	1.00
Winter wheat					
Blackbird	1	5	2	7	0.30
Chaffinch	2	0	0	0	-
Dunnock	14	9	4	6	0.45
Yellowhammer	1	1	3	13	0.41

NOTES: 1) A hyphen indicates that zero registrations precluded statistical testing.

2) A comparison of headland and far crop in unsprayed and sprayed areas for spring barley and winter wheat combined did not yield statistically significant results for any of the four species listed above.

TABLE 10. The number of short and long foraging bouts made by three species in control and experimental headlands during timed watches at Manydown.

	Short (≤1 min)	Long (>1 min)	Fisher Exact Test Two tailed-probability=
Blackbird			
Control area	1	3	Sample too small
Experimental area	1	2	
Dunnock			
Control area	13	9	0.37
Experimental area	2	4	
Yellowhammer			
Control area	3	1	0.19
Experimental area	1	5	

TABLE 11. The number of foraging bouts made by four species in experimental and control cereal field zones during timed watches at Courtyard and East Hall.

	Headland/ 6 m strip	Far/rest of crop	Fisher Exact Test Two-tailed probability=
COURTYARD			
Chaffinch:			
Control	1	1	-
Experimental	6	9	
Yellowhammer:			
Control	3	9	0.69
Experimental	6	10	
Whitethroat:			
Control	-	1	-
Experimental	-	4	
EAST HALL			
Chaffinch:			
Control	3	2	1.00
Experimental	3	1	
House Sparrow:			
Control	1	0	1.00
Experimental	6	3	

NOTE: A hyphen indicates that very small samples precluded statistical testing.

TABLE 12. The number of long and short feeding bouts made by four species during timed watches at Manydown.

	Length of feeding bout	
	Long (≤ 1 min)	Short (>1 min)
Blackbird	35	35
Chaffinch	17	6
Dunnock	44	37
Yellowhammer	18	26

$X^2 = 6.88$, df3

$p < 0.05$

TABLE 13. The number of foraging bouts made by four species in cereal field zones at Manydown during timed watches.

	Spring Barley Number of stretches=18		Winter Wheat Number of stretches =27		Fisher Exact Test Two-tailed probability =
	Field Edge 1/	Crop	Field Edge 1/	Crop	
Blackbird	29	8	15	15	0.02
Dunnock	16	8	22	33	0.05
Yellowhammer	8	14	3	18	0.16
	X^2 = 10.67, df 2 $p < 0.01$ (4 expected values = 4.0)		X^2 = 6.96, df 2 $p < 0.05$		
Chaffinch	3	4	4	2	0.59

NOTES: 1/ Hedge-bottom vegetation and crop-free strip combined.

Overall, significantly more Blackbirds fed in spring barley fields than in winter wheat fields:

X^2 = 6.47, df 1 : $p < 0.02$

Results for the three other species were not significant:

Chaffinch X^2 = 1.03, df 1 $p < 0.50$

Dunnock X^2 = 3.05, df 1 $p < 0.10$

Yellowhammer X^2 = 2.23, df 1 $p < 0.20$

TABLE 14. The number of foraging bouts made by four species in the headland and far crop of spring barley and winter wheat during timed watches at Manydown.

	Spring Barley No. of stretches =18		Winter Wheat No. of stretches=27		Fisher Exact Test
	Headland	Far Crop	Headland	Far Crop	Two-tailed probability=
Blackbird	3	5	3	12	0.62
Dunnock	8	0	19	14	0.04
Yellowhammer	4	10	4	14	0.70
	X^2 = 11.07, df 2		X^2 = 8.44, df 2		
	$p < 0.01$		$p < 0.02$		
	(Four expected values < 5)				
Chaffinch	2	2	2	0	0.47

NOTE: There is a highly significant difference between the three species, Blackbird, Dunnock and Yellowhammer, in use of headland and far crop (spring barley and winter wheat): X^2 = 15.67, df 2: $p < 0.001$.

TABLE 15. The number of foraging bouts made in cereal fields adjacent to hedgerows of different types by four species during timed watches at Manydown.

	Hedgerow over 2m	Hedgerow under 2m	Chi squared with Yates' correction
Blackbird	50	17	11.4, df1 $p < 0.01$
Chaffinch	5	7	0.06, df1 $p < 0.90$
Dunnock	32	47	4.5 df1 $p < 0.05$
Yellowhammer	36	6	16.4 df1 $p < 0.001$

TABLE 16. The number of foraging bouts made through the season in fields of spring barley and winter wheat by four species during timed watches at Manydown.

Inclusive dates of rounds:	Spring barley	Winter wheat
Blackbird		
24/5 - 7/6	14	11
12/6 - 25/6	11	10
4/7 - 8/8	12	9
	$X^2 = 0.11$, df 2 $p < 0.95$	
Chaffinch		
24/5 - 25/6	2	0
4/7 - 8/8	5	6
	Too small to test for significance.	

Inclusive dates of rounds:	Spring barley	Winter wheat
Dunnock		
24/5 - 7/6	10	11
12/6 - 25/6	5	8
4/7 - 8/8	9	36
	$X^2 = 5.64$, df 2 $p < 0.10$	
	(One expected value < 5)	
Yellowhammer		
24/5 - 25/6	6	1
4/7 - 19/7	6	11
22/7 - 8/8	10	9
	$X^2 = 5.07$, df 2 $p < 0.10$	
	(Two expected values < 5)	

TABLE 17. The number of timed watches on which species were recorded feeding in cereal fields at Courtyard and East Hall Farms.

Species	Courtyard	East Hall
Blackbird	3 (2)	-
Blue Tit	1 (1)	-
Chaffinch	16(12)	8 (8)
Dunnock	3 (2)	4 (4)
House Sparrow	3 (2)	7 (7)
Lesser Redpoll	-	1 (1)
Starling	-	1 (1)
Tree Sparrow	3 (2)	-
Whitethroat	6 (4)	1 (1)
Wood Pigeon	2 (1)	2 (2)
Yellowhammer	16(12)	3 (3)
Unidentified birds	1 (1)	-

NOTE: The percentage of all timed watches on which species were present. The number of timed watched at Courtyard was 136. At East Hall, 99.

TABLE 18. The number of feeding bouts made by three species in the edge and the far crop in cereal fields at Courtyard.

	Hedgebottom vegetation and headland	Far Crop
Chaffinch	11	12
Whitethroat	7	1
Yellowhammer	8	20

$X^2 = 8.98$, df 2

$p < 0.02$

(2 expected values < 5)

TABLE 19. The total number of feeding bouts made by three species in farmland habitats as recorded during timed watch rounds at Manydown.

	EDGE	CEREAL CROP		CEREAL FIELD (%) 1/	NON-CEREAL CROP	WOODLAND-TREES	OTHER HABITATS/ UNKNOWN	TOTAL NUMBER OF FEEDING BOUTS
		HEADLAND	FAR CROP					
Blackbird	63	8.5	27.5	83%	2	15	3	119
Dunnock	40	27.5	16.5	90%	4	5	0	95
Yellowhammer	17	11	40 2/	79%	0	10	8	86

NOTES:

Data collected during and between timed watches is included.

1/ The percentage of the total number of foraging bouts by each species made in specified habitat.

2/ Including six foraging bouts in far crop of fields not adjacent to study hedgerow under observation.

TABLE 20. Seasonal change in Chaffinch movement observed during timed watches and in the course of timed watch rounds at Manydown.

	Movement to/from hedge to/from: field: edge	crop	woods	overhead flight 3/
Mid May - mid June (to 15/6)	4	0	16(26)2/	15
Late June (16/6) + July (21/7)	13 1/	2	2(6)2/	1

NOTES: 1/ Nine during one timed watch.

2/ Figures in parenthesis include movement: to/from copses; standards not in study hedgerow; along study hedgerows at low level probably to woods.

3/ Flights at or above tree canopy level with origin and terminus beyond vision.

TABLE 21. The number and location of feeding bouts made by Yellowhammers during specific observations on control and experimental plots of different crops at Manydown.

HABITAT ADJACENT TO HEDGEROW UNDER OBSERVATION	Number of hours of observation	Field Edge 1/	Cereal Crop 2/	Non-Cereal Crop	Woodland	Other 3/	Cereal Crop 4/	
							Headland	Far Crop
CONTROL PLOTS								
Spring and winter barley	47.25	22	173	6	5	22	44	73
Winter wheat	10	-	15	19	-	6	-	8(12)5/
EXPERIMENTAL PLOTS								
Winter wheat	31	1	73	-	4	(35)6/	20	68
Spring barley	6.5	18	27	-	-	4	9(11)5/	6(11)5/
TOTAL	94.75	41	288	25	9	67	75	168
PERCENTAGE		10%	67%	6%	2%	15%		

NOTES:
1/ Includes hedgebottom vegetation and crop-free strip.
2/ Includes spring and winter barley and winter wheat.
3/ Includes habitation, tracks, foraging to unknown locations.
4/ The precise location of a foraging bout within the cereal crop was not always observed. Only those foraging bouts for which precise location was known are included here.
5/ Figures in parenthesis are the number of foraging bouts made to the far crop inclusive of those to the far crop in fields not adjacent to the hedgerow under observation.
6/ Estimated figure.

TABLE 22. The content of faecal sacs from Yellowhammer pulli collected at two nests on Manydown.

NEST 1. Contents of faecal sacs collected on 28/6/85 from pile of deposited sacs over 1 day old:-

47 Lepidoptera larvae (46 ⩾ 3 cm; 1 ca.1cm).
5 Carabid
3 Carabid larvae
1 Araneida
2 Staphylinid larvae
2 other beetles
3 Diptera, Acalypterate
1 Elaterid

Content of a single faecal sac from Nest 1:-

1 Lepidoptera larva
1 Carabid
1 Diptera

NEST 2.

Faecal sac No.1 (Collected 12/7/85 - pulli ca.4 days old)

1 Lepidoptera larvae (⩾ 3cm)
1 Carabid
1 Carabid larva
1 Araneida
1 Staphylinid larva
1 Diptera, calypterate
1 Elaterid
1 Chrysomelid larva (Lema melanopa)
1 Homoptera
35 Nematocera egg (probably Tipulid)

Faecal sac No.2 (Collected 15/7/85 - pulli ca.7 days old)

1 Carabid
1 Diptera, Acalypterate
1 Diptera, Calypterate
1 Elaterid
1 Tipulid
1 Lema larva
(1 ? Earthworm)

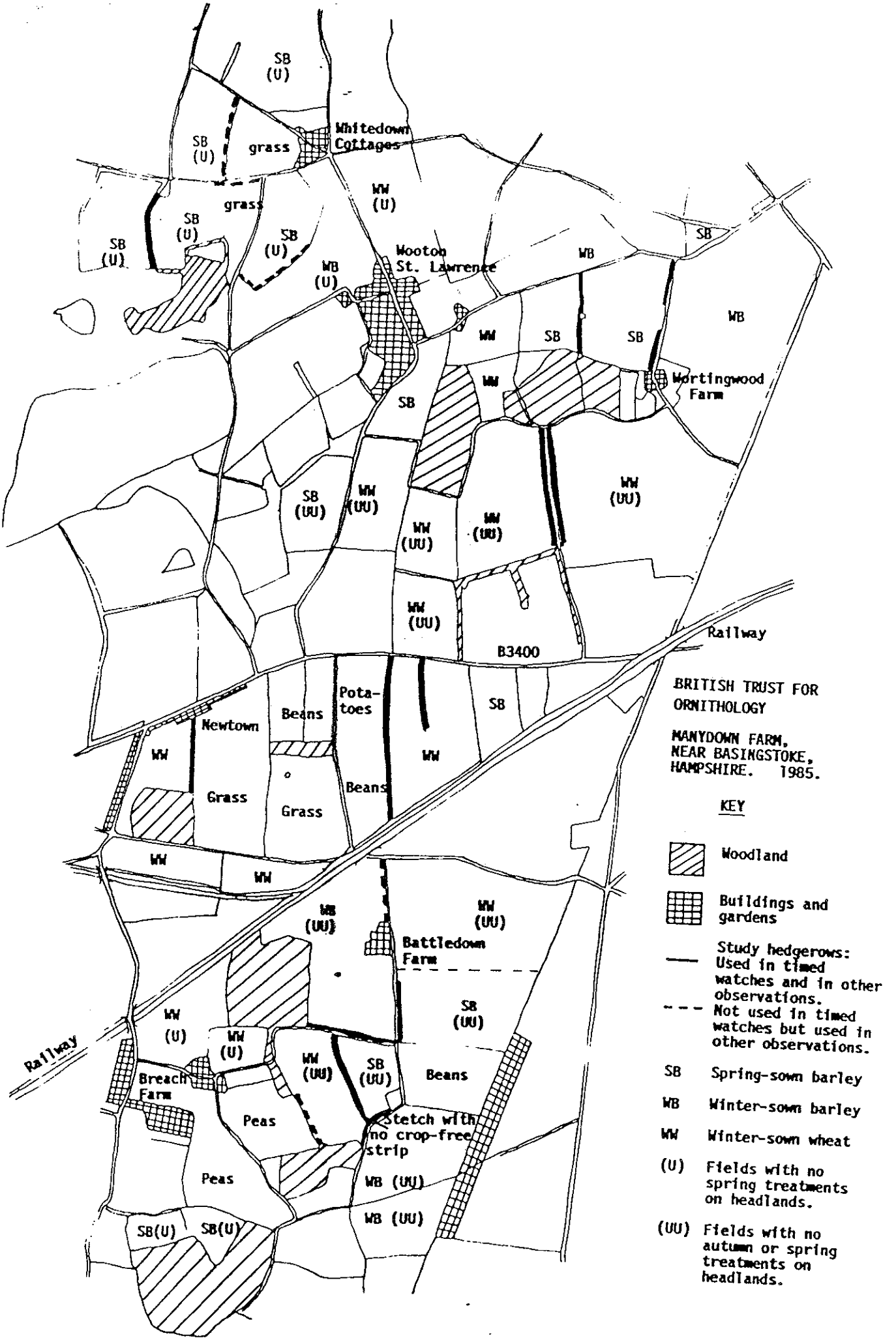


FIGURE 1. The study area at Manydown Farm (only fields in experimental or control areas are shown).

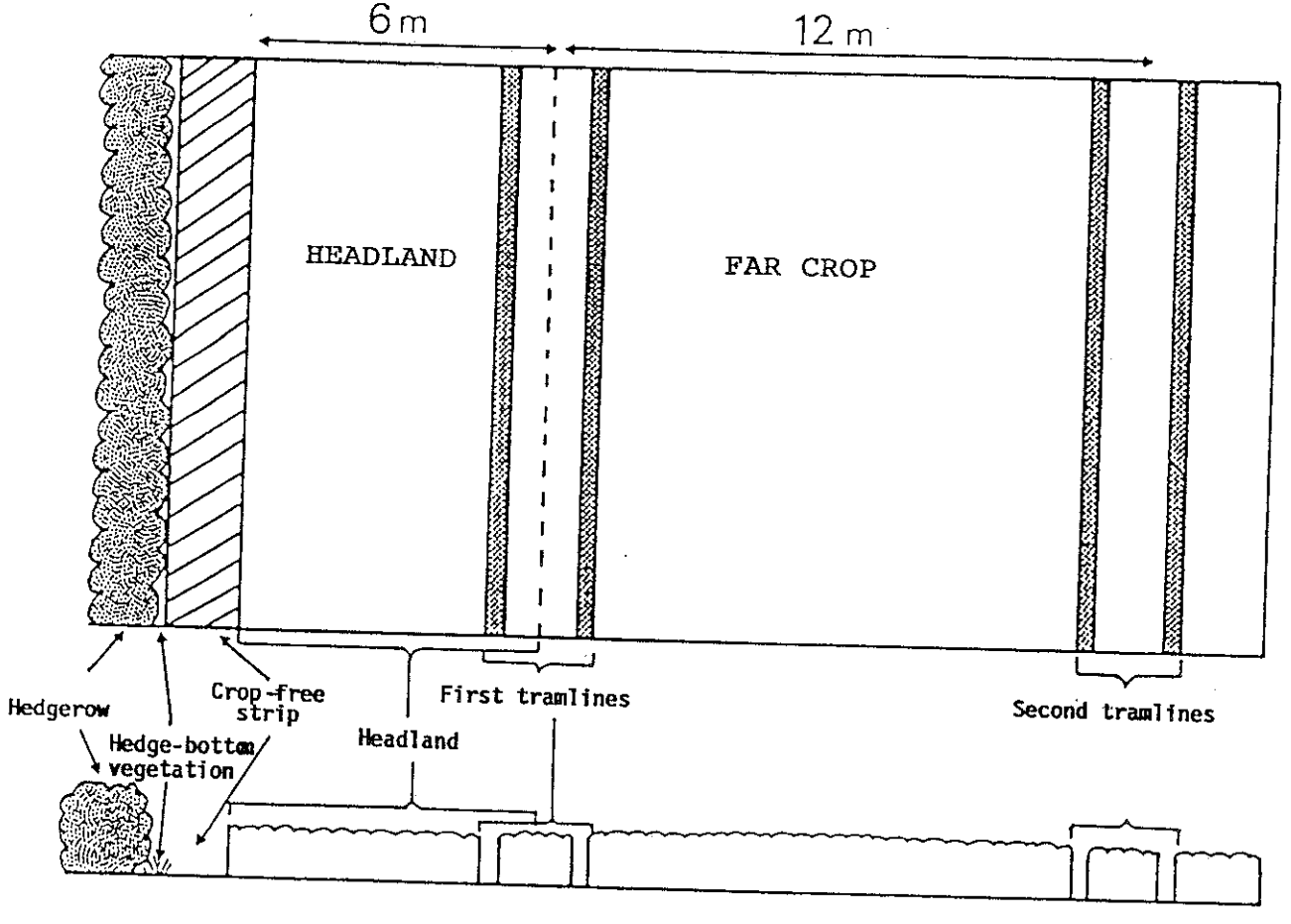


FIGURE 2. Schematic diagram of edge of cereal field at Manydown Farm 1985.

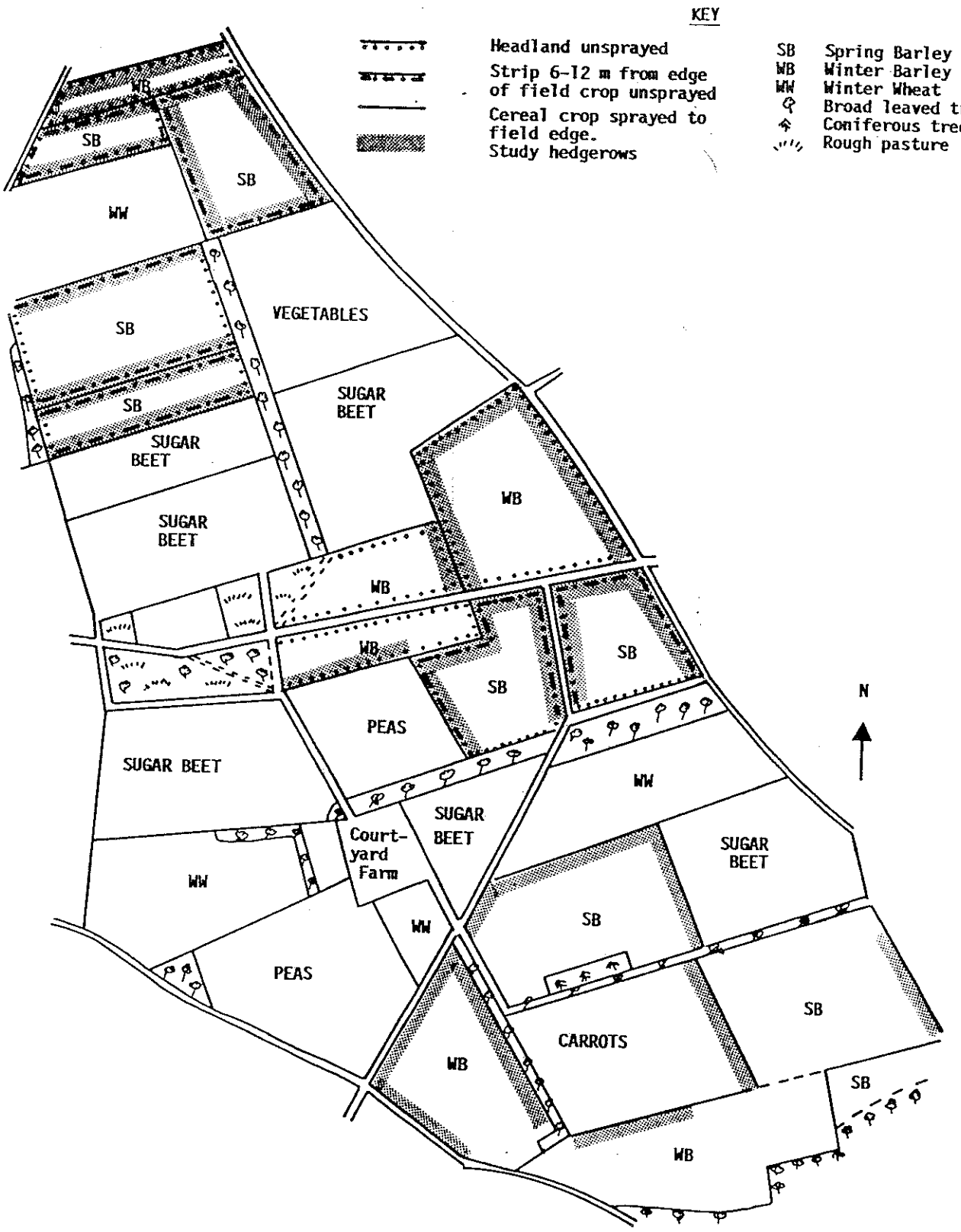


FIGURE 3. The study area at Courtyard Farm, Norfolk.

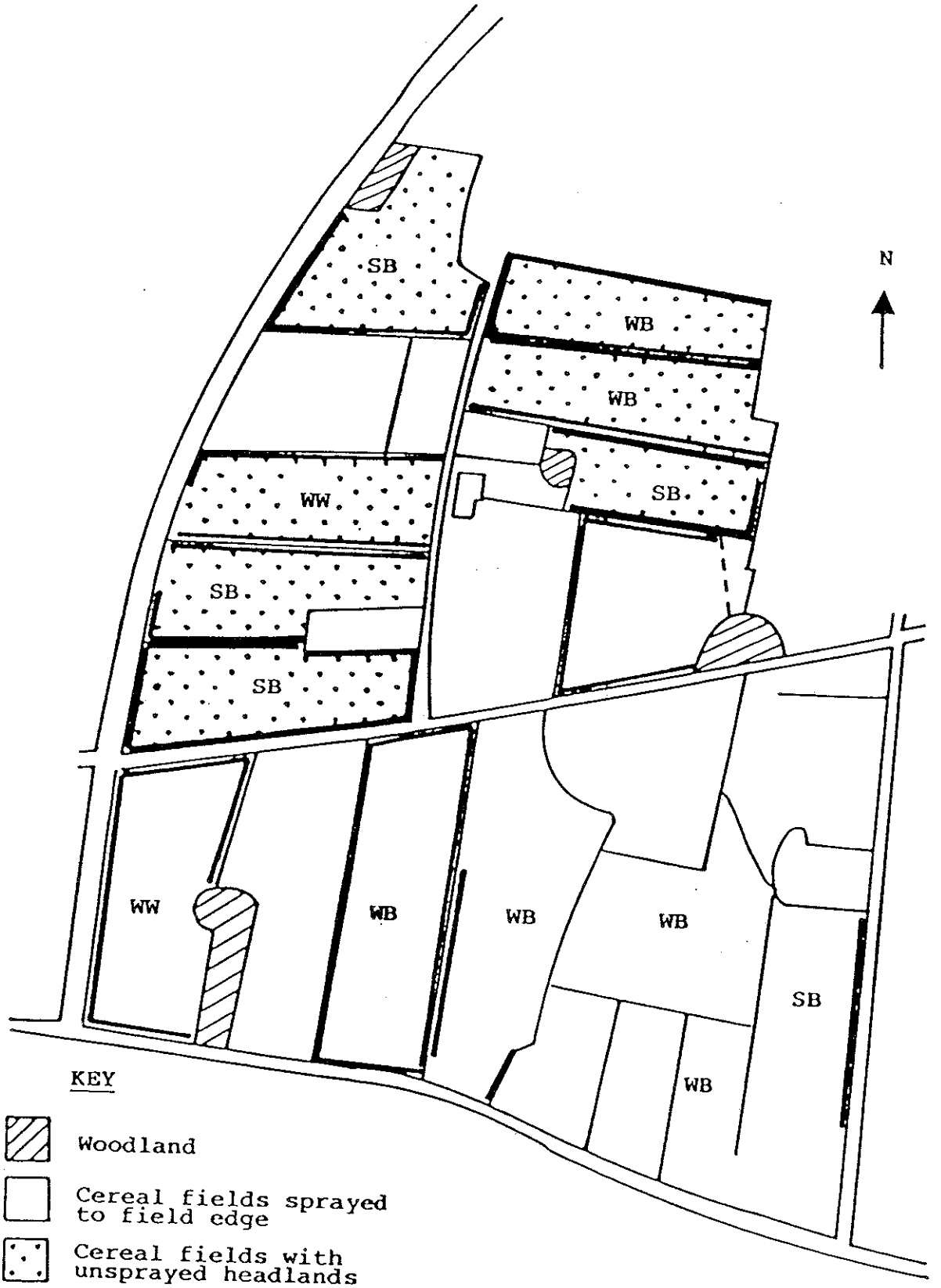
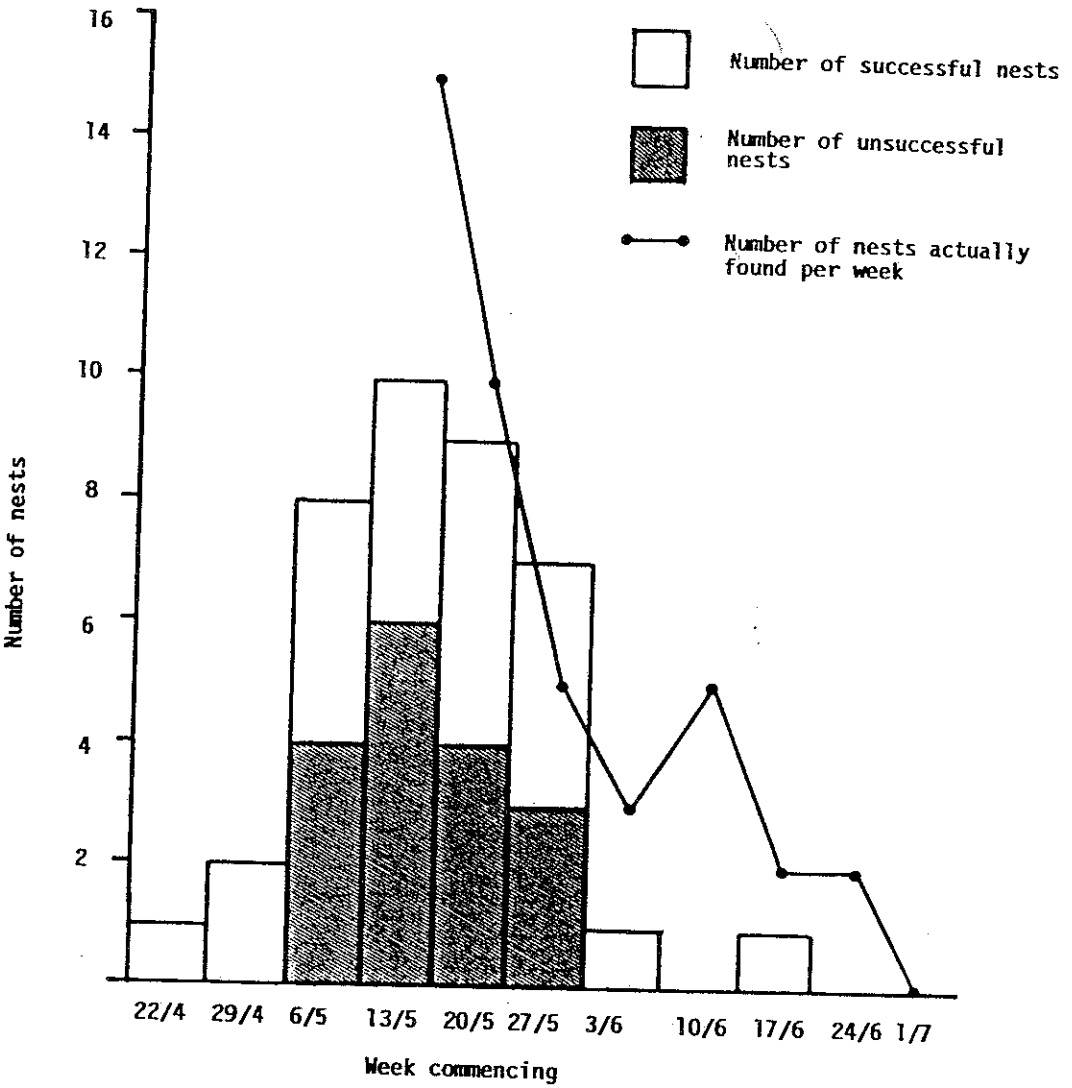


Figure 4. The study area at East Hall F[illegible]



NOTE: Nests are dated by extrapolating the week during which the first egg was laid. Three nests were excluded since first egg dates could not be extrapolated.

FIGURE 5. The number of nests successful and unsuccessful in fledging at least one young and the number of nests found in each week of study at Manydown.

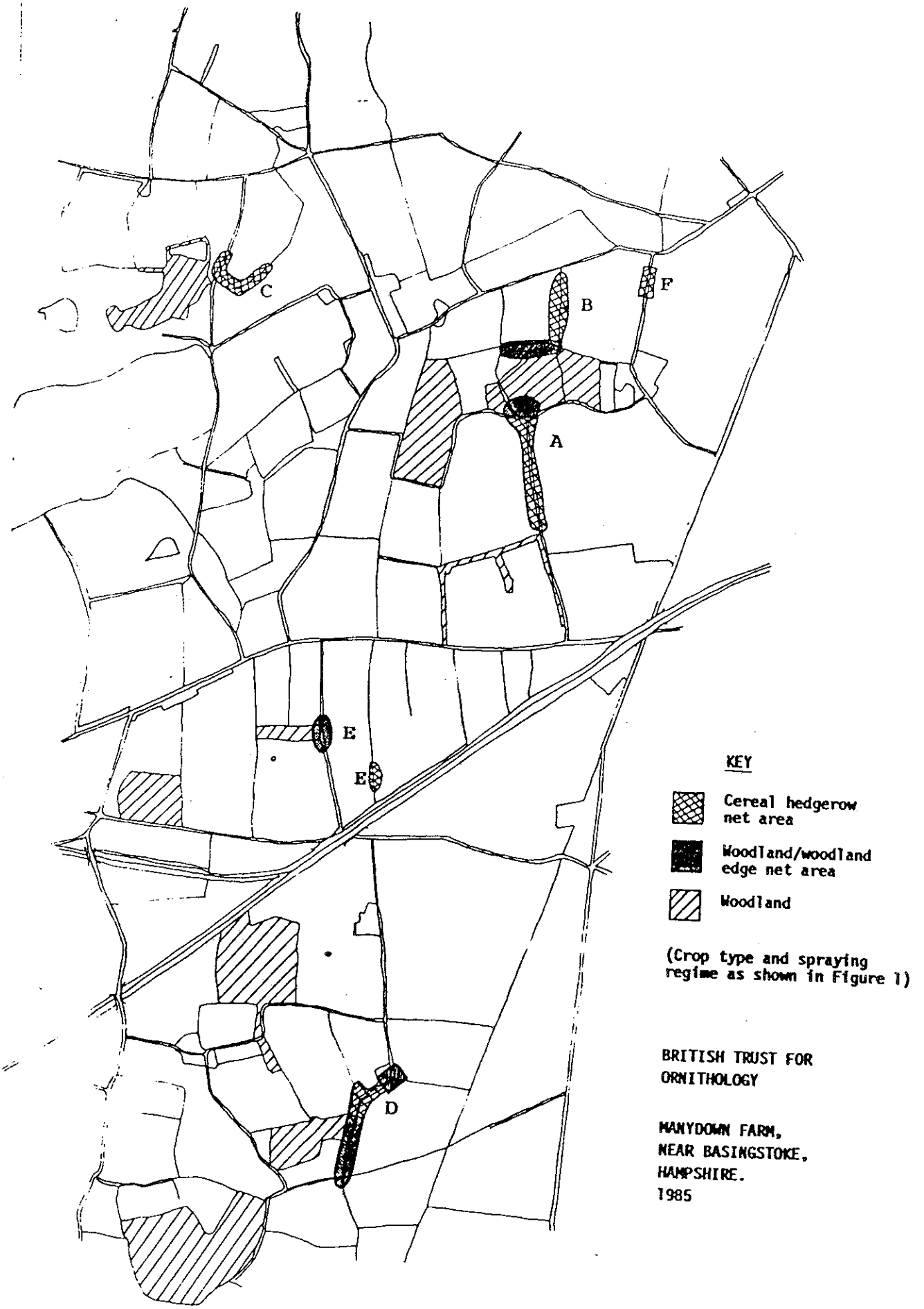
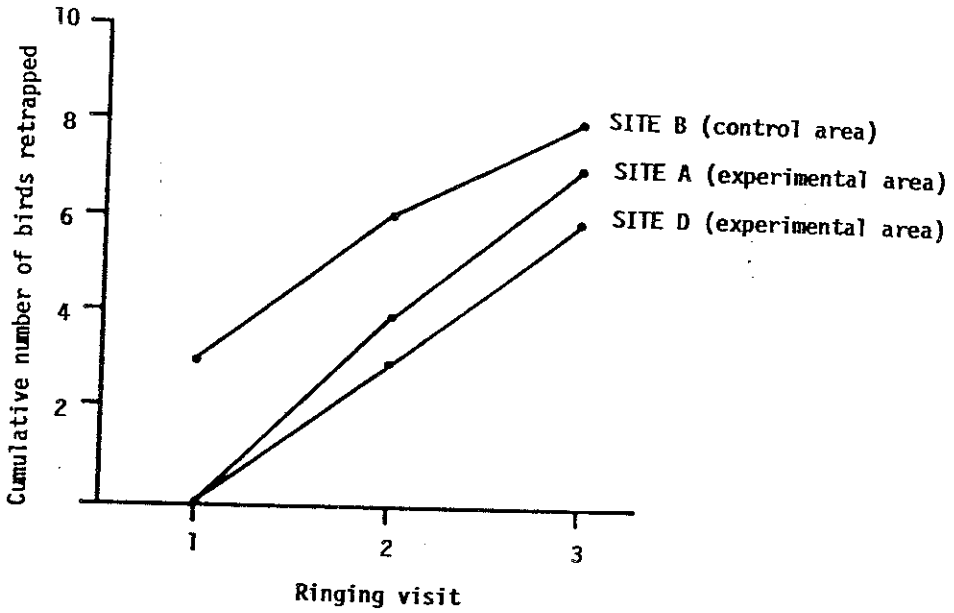


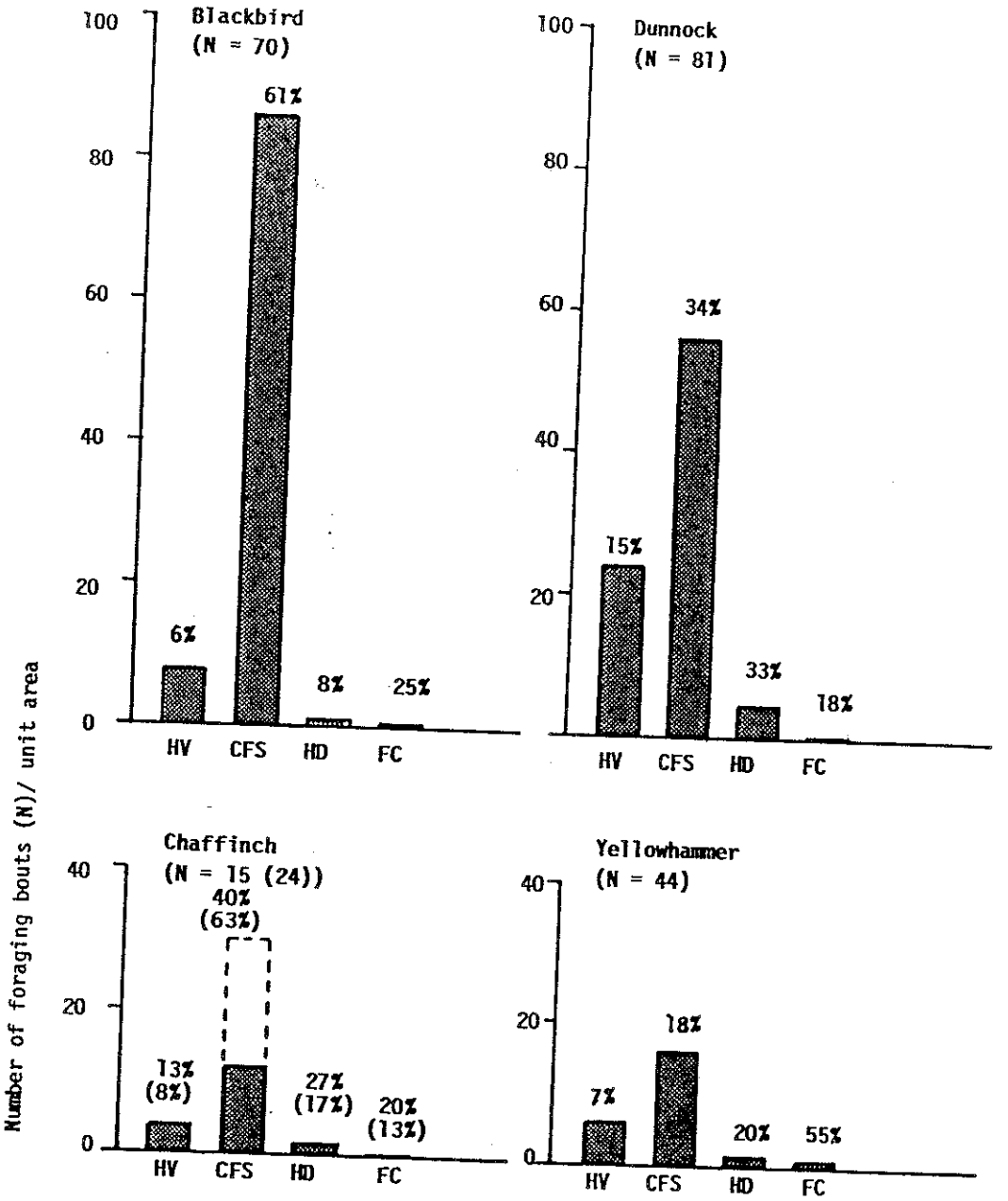
FIGURE 6. Sites of systematic ringing.



NOTES: Site locations are shown in Figure 6.

Only birds retrapped at the hedgerow at which they were ringed are included.

FIGURE 7. Cumulative number of birds retrapped in experimental and control areas at Manydown.



KEY:
- HV Hedge-bottom vegetation (calculated @ 0.5 x 100 m)
- CFS Crop-free strip (calculated @ 0.5 x 100 m)
- HD Headland (calculated @ 6 x 100 m)
- FC Far crop (calculated @ 200 x 100 m. an arbitrary mid-field distance)
- - - - Includes Chaffinch family party.
- % Percentage of the number of foraging bouts in each zone.

FIGURE 8. The number of foraging bouts made in the four field zones relative to the area of each zone by four species at Manydown.

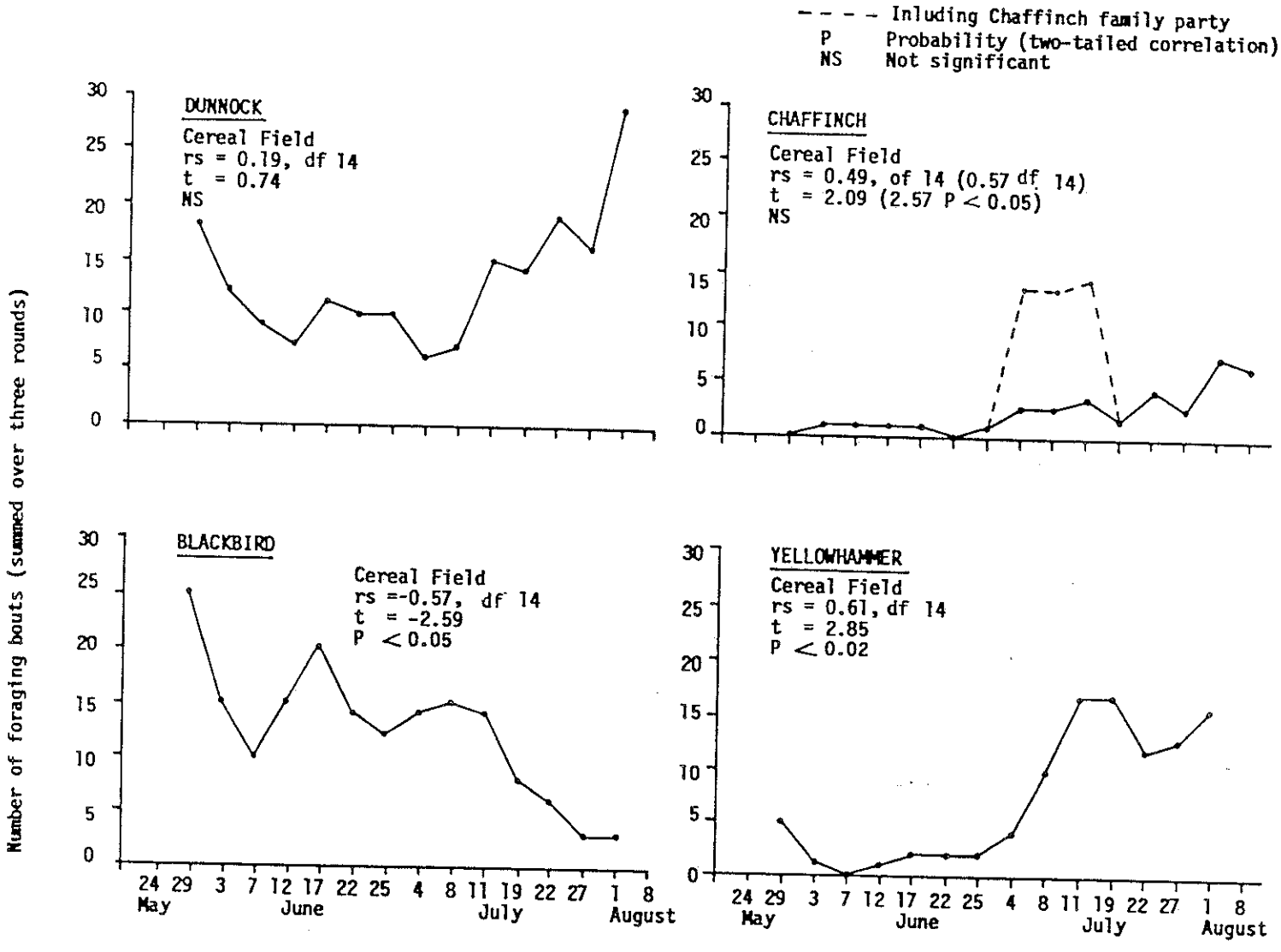


FIGURE 9. Three visit running totals of the number of foraging birds made in cereal fields by four species during timed watches at Manydown Farm.

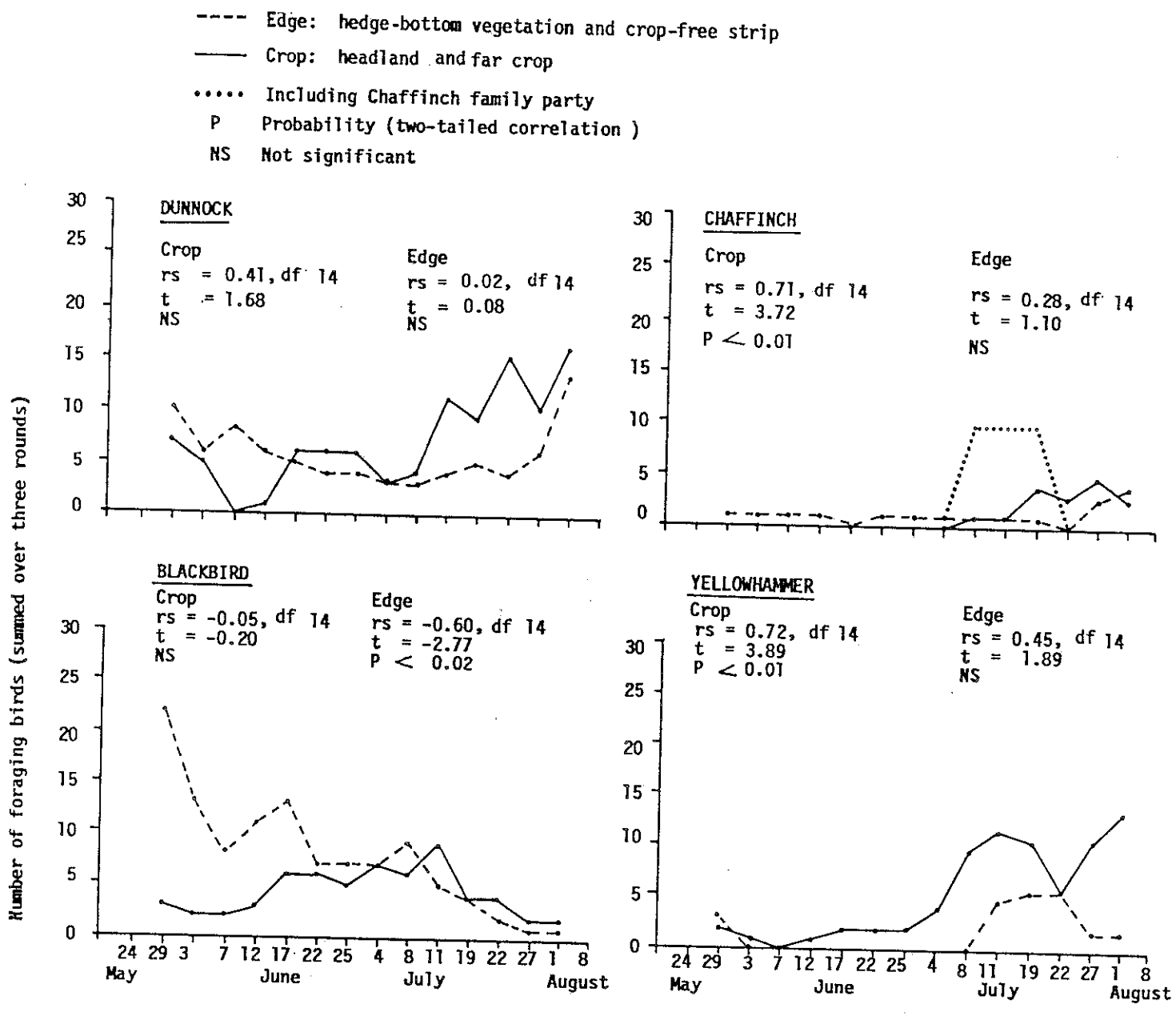


FIGURE 10. Three visit running totals of the number of foraging bouts made on field edge zones and in cereal crops at Manydown Farm.