BTO
Looking out for birds

BTO Research Report No. 599

Lorna M Shaw, Dan Chamberlain, Greg J Conway & Mike Toms

Spatial distribution and habitat preferences of the House Sparrow, *Passer domesticus* in urbanised landscapes.

ISBN 978–1–906204–97–6

Spatial distribution and habitat preferences of the House Sparrow, *Passer domesticus* in urbanised landscapes.

Lorna M. Shaw, Dan Chamberlain[1], Greg Conway[1] & Mike Toms[1]

BTO Research Report No. 599

British Trust for Ornithology
The Nunnery
Thetford
Norfolk
IP24 2PU
www.bto.org
info@bto.org
+44/0 1842-750050

ISBN 978–1–906204–97–6

[1]British Trust for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU. www.bto.org
Registered Charity No 216652 (England & Wales) No SC039193 (Scotland)
Company Limited by Guarantee No 357284 (England & Wales)

The BTO's purpose and public benefit is to deliver objective information and advice, through undertaking impartial research and analysis, about birds, other species and habitats, and to advance understanding of nature. We inform policies and evidence-based decisions that impact on the environment such that future generations can benefit from a healthy and wildlife-rich environment.

Shaw, L.M., Chamberlain, D., Conway, G. & Toms, M. (2011). Spatial distribution and habitat preferences of the House Sparrow *Passer domesticus* in urbanised landscapes. BTO Research Report 599, British Trust for Ornithology, Thetford.

Photographs by: John Harding

Summary

The House Sparrow *Passer domesticus* has declined in urban areas across Europe since the late 1970s and is now listed as a species of conservation concern. Recent research into the causes of decline suggests that breeding populations may be influenced by a number of urban habitat features. These include pollution levels, insect abundance, nest site availability and the presence of predators.

Here we examine how the presence of certain features within the urban environment relates to the location of House Sparrow colonies. We do this by comparing the distance between actual nest sites and features of interest, with that between the same features and a series of randomly-generated points. We also test the preferences of House Sparrows for a number of habitat types by using compositional habitat analysis.

We found that houses with gardens were strongly preferred to any other habitat type. Interestingly, in more rural areas, allotments and greenspace were found to provide useful alternatives to houses with gardens. Predators and roads were not avoided, something that may be a result of their ubiquitous nature rather than any lack of detrimental impact.

Mitigation measures to prevent the loss of House Sparrow breeding colonies should, therefore, concentrate on the maintenance and enhancement of quality urban gardens and the resources they contain. This may be of particular importance in the most densely populated urban areas.

Contents

Executive summary

1. The House Sparrow *Passer domesticus* has declined in urban areas across Europe since the late 1970s and is now listed as a species of conservation concern. Recent evidence suggests that the reported decline has been particularly severe in urban areas, and is not linked to earlier declines in farmland bird abundance. Research into the causes of the decline within urban areas suggests that breeding populations may be influenced by a number of features of the urban environments. These include pollution levels, insect abundance, nest site availability and the presence of predators.

2. Breeding House Sparrows have restricted foraging ranges and, as such, there is the potential for breeding opportunities to be limited by the availability of nest sites and suitable feeding habitat within close proximity. While some indication of what these suitable habitats (for nesting and feeding) are has been revealed by previous research (*e.g.* Chamberlain *et al.* 2007), more fine-scale work is needed to examine these relationships in more detail.

3. Here we used detailed data derived from the BTO House Sparrow Survey, working at a finer scale than has been possible before. We tested whether House Sparrows appeared to actively select certain habitat types during the breeding season, before going on to examine the location of breeding sites in relation to the proximity of features thought to be important to the species.

4. The House Sparrow survey data were derived from a random sample of survey sites, stratified on the basis of the degree of urbanisation (termed 'human cover' and derived from CS2000 data). Observers visited the squares in early 2003 to map available habitats and this was followed by three more visits (two in 2003 and one in 2004) to plot the locations of House Sparrows and their predators/competitors. House Sparrows were identified as chirping males, all males, females and birds of unknown sex.

5. Data from the surveys were mapped in ArcMap and then used to examine the use of individual habitat types in relation to their availability. Compositional Analysis was deployed, as per the methodology of Aebischer *et al*. 1993.

6. The distance of House Sparrow nest sites from a number of habitats deemed to be of interest was examined through a Proximity Analyis, using the ArcGIS and the Multiple Minimum Distance Tool. The main habitats of interest were allotments, brownfield sites, greenspace, gardens and sites with domestic animals or livestock.

7. The most commonly available habitat was residential areas with gardens, which accounted for 42% of the total habitat recorded in the survey. A further 10% of land area was occupied by buildings without gardens attached to them. Three of the six major habitat types available showed larger differences in their proportional contribution to the level of urban cover. Residential areas (both with and without gardens) increased proportionally as urban cover increased, whilst the proportion of urban greenspace decreased.

8. Habitat usage by House Sparrows was significantly non-random within the core 50 m around their nest sites. Sparrows consistently selected residential areas with gardens over very other habitat type, regardless of the level of human cover. The least preferred habitats were buildings without gardens and urban greenspace. The avoidance of urban greenspace may reflect the open and rather homogenous nature of such greenspaces with UK cities (in contrast to greenspace elsewhere in Europe).

9. Neither the presence of roads nor predators was found to have a negative effect on the location of breeding House Sparrows. It was thought that this may be linked to the ubiquitous nature of both within the built environment.

10. Mitigation measures to preserve House Sparrow populations should concentrate on improving existing garden habitats wherever possible, including limitation of development in areas where sparrows are present. Attention should also be paid to preserving good quality greenspace and brownfield sites.

Introduction

The House Sparrow *Passer domesticus* is a widespread and common bird, to the extent that it was once considered to be a pest species in many parts of its range (Crick, 2002). It is often considered to be an urban specialist (Summers-Smith 2003), but has declined throughout much of Europe since the late 1970s (Heij 1985, Siriwardena *et al.* 2002). The House Sparrow is currently red-listed as a species of conservation concern as a result, and recent evidence suggests that the reported decline in numbers has been particularly severe in urban areas, and is not linked to earlier declines in farmland bird abundance (Siriwardena *et al*. 2002). Furthermore, the decline of the species appears to vary substantially in severity between different cities and regions, with socially deprived regions being relatively little affected (Shaw *et al*. 2008, Shaw 2009). Many potential causes of this decline have been suggested (Summers-Smith 2003, Shaw *et al*. 2008) but the high degree of spatial variation in the severity of House Sparrow population changes suggests that many different factors are affecting the species (Summers-Smith 2003).

In spite of this, some general patterns are evident that suggest avenues for future research. It appears unlikely, for example, that over-winter survival is affecting House Sparrow population levels, as survival rates for adult birds are usually relatively high in urban areas in comparison to other habitats (Marzluff 2001). Furthermore, the survival rate of adult House Sparrows does not appear to have changed, and in fact adult condition in urban habitats appears to be good, possibly as a result of supplementary feeding (Siriwardena *et al*. 2002, Chamberlain *et al*. 2009a). Instead, studies have shown that the availability of insectivorous food for nestlings during the breeding season is likely to be a major factor influencing the breeding success of this species (Vincent 2005, Peach *et al*. 2008). The restricted foraging range of adult sparrows, particularly when feeding young, suggests that the availability of nest sites in close proximity to foraging areas may also be a limiting factor. The range of adult House Sparrows is commonly estimated at < 2 km (Snow *et al*. 2003). However, in the breeding season adult birds forage predominantly within a distance of just 60–70 m metres from their nest site (Vincent 2005, Peach *et al*. 2008). Furthermore, a radio tracking study of House Sparrows in urban Bristol, UK, found that the home range of foraging birds in the breeding season was approximately 800 m^2, with the core of the home range covering little as 100 m^2 (Shaw, 2009).

The constraints of such a restricted range may lead to a reduction in House Sparrow breeding success where habitat quality is sub-optimal in some way. Habitat quality could be affected by a variety of factors but pollution, the presence of predators and the type of invertebrate food available in urban areas increasingly affected by development, have all been shown to have a potentially negative impact on House Sparrow survival (Baker *et al*. 2005, Vincent 2005, Peach *et al*. 2008). Similarly, habitat types such as houses with gardens (as opposed to those without), allotments and 'brownfield sites' or areas of previously developed land have been associated with high densities of House Sparrows (Chamberlain *et al*. 2007).

Here we use data derived from a nationwide survey to look at House Sparrow habitat associations in greater detail, working at a finer scale than has been possible in previous studies (*e.g.* Chamberlain *et al.* 2007). Such fine scale analysis is likely to be more relevant to a species which, as we have seen, has a rather small foraging range. Our findings are, therefore, likely to have greater ecological relevance than those published previously. We seek to test whether House Sparrows appear to actively select certain habitat types during the breeding season and then go on to examine the location of nests in relation to the proximity of features that are potentially beneficial to the species. This will enable us to establish which features are common within the foraging range of breeding individuals and to determine whether the preferences of House Sparrows change according to the degree of urbanisation within their wider surroundings. In this way, the results of this paper may enable future mitigation measures to be guided by the relative importance of different habitats according to the degree of urbanisation and the likelihood of usage of each habitat type.

Methods

Data collection:

Data on House Sparrows living within urbanised landscapes were obtained from the BTO House Sparrow Survey, a volunteer-based survey undertaken in 2003–4 (Chamberlain *et al.* 2007). 1-km British National Grid squares were randomly selected using a stratified sampling technique in order to ensure that each geographic region, based on Government Office Regions, was proportionally represented. The selected grid squares were also stratified by the extent of 'human cover' present within each square. This was derived by combining the Countryside Survey (CS)2000 habitat categories 'suburban/rural development' and 'continuous urban development' into a single variable (Fuller *et al.* 2002). This variable was used to stratify the data set for each of 266,000 1-km squares within the UK into classes of human coverage. Based on the cumulative square root *f*(*y*) rule (Krebs 1989) and on visual inspection of square distribution, three stata of human cover were defined: Stratum A, having 25–49.9% human cover; Stratum B, having 50–74.9% human cover and Stratum C, having 75–100% human cover. Squares with < 25% human cover were excluded from the survey on the grounds that they would have little urban habitat suitable for House Sparrows. In total, some 2,420 squares were targeted for coverage: 977 from Stratum A, 762 from Stratum B and 661 from Stratum C.

Grid squares were then divided into 500 x 500 m sampling units, one of which was selected at random for survey coverage. Each sampling unit was then allocated to a BTO volunteer, selected according to their proximity to the survey site. Volunteers were required to make an initial visit to their allocated square and to record the key habitat types present (Figure 1a), using a list of 30 habitat codes (see Chamberlain *et al*. 2007 for additional details). Further visits were then made to map the location of House Sparrows within the square in early and late spring 2003 (with a minimum of one week separating the two visits), and in spring 2004. During these visits, observers were asked to walk along all pavements, paths and roads, into parks and allotments (small areas within or on the edges of urban settlements that are leased to the public for small-scale horticulture) and along field boundaries with the aim of mapping the location of all House Sparrows detected (in the habitat patch in which they were first seen or heard). Chirping males, other males, females and birds of unknown sex were recorded separately, and the locations of potential predators such as cats, Sparrowhawks and Magpies were also noted. The recommended start time was within two hours of sunrise.

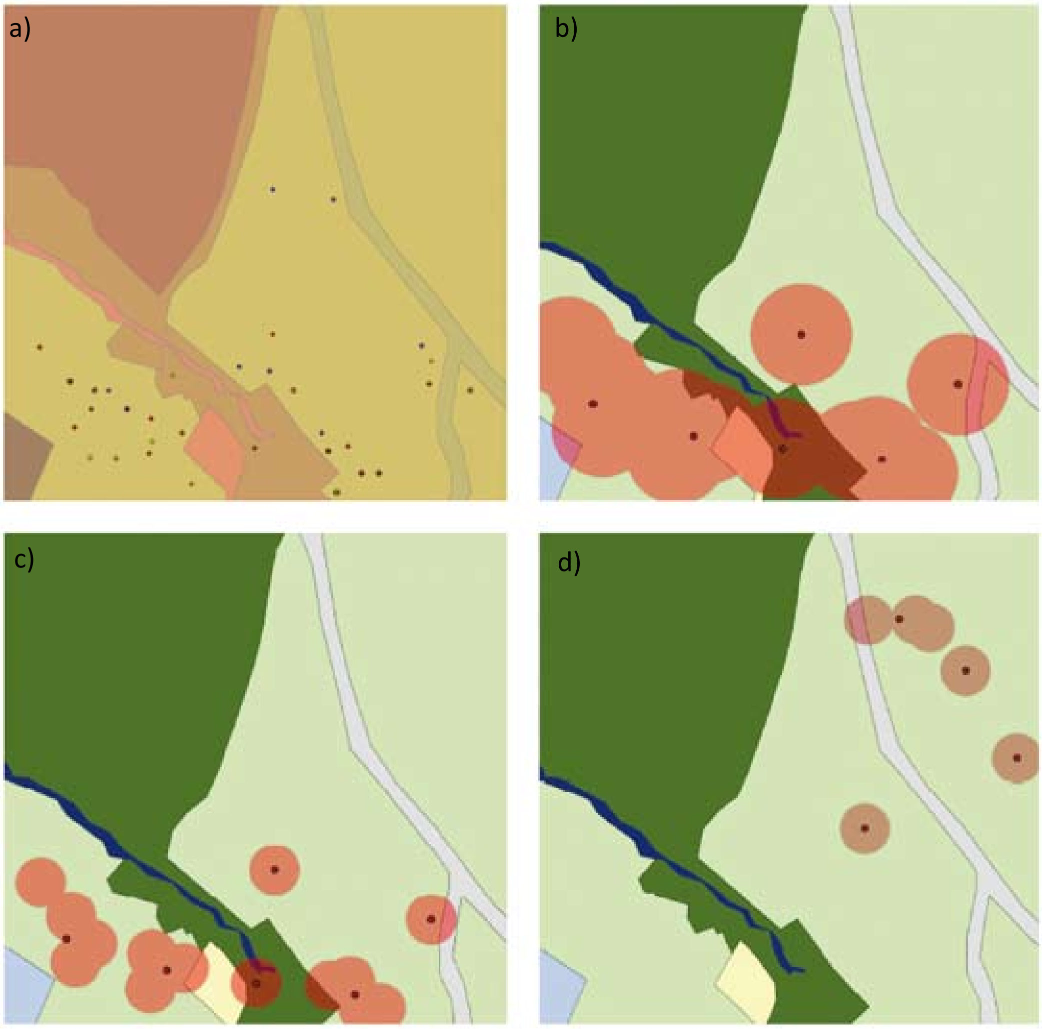
The data from these surveys was mapped using ArcMap (Esri: 2010, http://www.esri.com) to allow the locations of House Sparrows to be analysed in relation to the surrounding habitat and the proximity of predators (see Figure 1). The 30 habitat types recorded by survey volunteers were grouped into six main categories that were present in the majority of surveyed squares to some extent (Table 1). The locations of chirping males were used as indicators of actual or potential nest sites, and each chirping male was assumed to indicate the presence of a nest site for the purposes of this analysis. Both mated and unmated males utter the *chirrup* call to proclaim ownership of a site, thus preventing surveyors from distinguishing between the two without a more detailed watch of the site than was possible here (Summers-Smith 1963).

Compositional analysis:

Johnson (1980) defined four main spatial scales at which habitat selection occurs: the overall range of a species (first order), the home range of an individual or group (second order), habitat usage within a home range (third order) and the procurement of food from available sites within the home range (fourth order). We assessed habitat selection by House Sparrows at the scale of Johnson's fourth order selection, *i.e.* how the available habitat within each 500 x 500 m grid square was utilised by nesting birds.

The area of each habitat type within each 500 x 500 m grid square was calculated using Hawth's tools extension (Beyer 2004) in ArcMap. The area estimates were then expressed as a proportion of the total area available within the 500 x 500 m square. The core foraging area utilised by nesting House Sparrows

Figure 1. An example 500 x 500 m grid square showing a) original habitat classifications with the location of House Sparrows and predators shown as dots; b) simplified habitat classifications showing 50 m buffers around the locations of chirping males; c) the locations of chirping males plus 25 m buffers; d) the location of randomly plotted points showing 25 m buffers (see text).



was calculated by drawing a buffer of 50 m around each chirping male and calculating the proportion of each habitat patch present within the 50 m radius (Figure 1b). Where chirping males were within 50 m of each other, the buffered areas were combined to create 'communal foraging areas' within each grid square. A radius of 50 m was used as this covers an area approximate to the limited range of a foraging House Sparrow during the breeding season (Vincent 2005, Shaw 2009), whilst still being big enough to potentially cover a number of different habitat types.

The proportional habitat usage within each 50 m radius was then evaluated with reference to the proportion of each habitat type available within each grid square as a whole using the methodology outlined by Aebischer *et al.* (1993). Compositional analysis avoids the problems caused by the non-independence of proportion data by using one habitat type as the denominator in the analysis (here paving), and transforming the data using the log-ratio transformation to remove linear dependency (Aebischer *et al*. 1993, Pendleton *et al*. 1998). Furthermore, the individual is used as the sampling unit, avoiding the need to pool data across individuals and thereby increasing the sample size. In this case, however, the communal foraging area, rather than the individual, was treated as the sampling unit as the colonial nature of the House Sparrow would otherwise introduce a high degree of spatial autocorrelation

Table 1: Average percentage of each available habitat type according to urban stratification used.

Habitat type	Stratum A	Stratum B	Stratum C
Greenspace	56.35	29.61	12.47
Buildings	6.52	11.07	14.92
Gardens	25.96	46.82	60.64
Urban brownfield	3.62	4.05	3.96
Other	3.55	3.19	1.57
Paving	4.00	5.25	6.43

into the data. Ideally, all habitat types should be available to, and utilised by, each individual or group; however, due to the relatively small size of the areas used here this was not always the case. Where usage of a particular habitat type was effectively zero a small positive value (an order of magnitude less than the smallest non-zero proportion) was substituted into the dataset, as recommended by Aebischer *et al*. (1993).

Compositional analysis was carried out in SAS (www.SAS.com). Habitat usage within each communal foraging area was analysed in relation to the log ratios that would be expected if habitat use within each foraging area was random. Where habitat usage was non random with respect to availability, the habitat types were ranked in order of preference based on the log ratios of used to available habitat types. Due to the likely differences in habitat use between areas of differing urban cover, grid squares in each urban stratum were analysed separately. In addition the data from each survey visit were analysed separately to assess whether proportional habitat usage differed between surveys or between years.

Proximity analysis:

The distance of House Sparrow nest sites from a number of habitats of interest was calculated using the Multiple Minimum Distance tool in ArcGIS (Chasan 2005). The locations of chirping males were mapped, and distance from each location to the habitat boundary of interest was then measured. The main habitat types of interest were allotments, brownfield sites, green space, and the presence of animals kept outside (here defined as areas containing domestic animals and livestock). The proximity of predators (cats, Sparrowhawks and Magpies) to House Sparrow nests was also measured. An equivalent number of randomly generated points, representing potentially available nest sites were then generated in ArcMap using Hawth's Tools (Beyer 2004). In order that the random points were an accurate reflection of suitable nesting areas, points were only generated in areas where suitable sites for nesting were potentially available, *i.e*. in areas with buildings and not in areas of open space. The proximity of these random points to each habitat type, and to the location of predators, was also measured.

Where individual males were in close proximity to each other the point locations were buffered and then combined to form colonies; the centre point of each colony was used for the distance measurements. The range of adult House Sparrows is generally accepted to be between one and two kilometres (Summers-Smith 2003, Vincent 2005). The size of House Sparrow colonies is, however, less well documented. For the purposes of this analysis, a buffer distance of 25 m was used to define colony size, a distance roughly equal to the span of a typical semi-detached house (Figure 1c). This distance is large enough to cover a number of potential nest sites, whilst avoiding a high degree of overlap between individual buffers to the extent that the size of the colony would become larger than an individual's foraging range. As the early and late survey visits in 2003 were likely to be highly intercorrelated with regard to the location of House Sparrow nests, the data from these two surveys were merged prior to distance sampling being carried out.

Data were analysed in R.2.5.1 (R Statistical Computing 2007). The distance to each habitat feature was compared between the randomly generated points (Figure 1d) and actual data on the locations of chirping males by means of a two-way analysis of covariance, with the distance of each point from the boundary of the 500 m square included as the covariate, to control for size in any aggregations of 500 m squares that may have formed from neighbouring 1-km squares having been selected during the stratification and selection process. Log and square root transformations were used, as required, on the distance data prior to analysis. Urban stratification level (Stratum A, Stratum B or Stratum C) was also included in the analysis as a factor, as this is likely to influence the distance to many features. Only distances of less than 2 km from each point (whether random or actual) to the features of interest were included in the analysis as any nesting birds further than 2 km from a feature of interest were unlikely to utilise that feature. The number of nests within range of each feature was, however, also noted.

Results

Compositional analysis:

The most commonly available habitat overall was residential areas with gardens, which accounted for 42% of the total habitat recorded in the survey. A further 10% of land area was taken up by buildings without gardens attached to them, meaning that built-up land accounted for over half of the total area surveyed. Of the remainder, 35.5% was classified as greenspace, and approximately 4% was occupied by allotments and brownfield sites, including railway lines and building sites. The remaining 5% was taken up by water features, such as lakes and rivers, and other habitat features, such as phone masts.

Of these six major habitat types available, only three showed large differences in their proportional contribution according to the level of urban cover. As would be expected, residential areas (both with and without gardens) increased proportionately as urban cover increased, whilst the proportion of greenspace decreased (Table 1). The proportion of paved areas in each grid square increased slightly with increasing human cover, but stayed relatively low, whilst the proportion of brownfield sites, allotments and other habitat types remained constant and comprised less than 5% of the total area regardless of the level of urbanisation.

Habitat usage by House Sparrows within the core 50 m around their nest sites was significantly non-random with respect to the availability of habitat types within the 500 x 500 m grid squares as a whole. This was true both for each survey visit and at each level of urban cover (Tables 1 & 2, Appendix A). House Sparrows consistently selected residential areas with gardens over every other habitat type, regardless of the level of urbanisation in the area. The least preferred habitats were buildings without gardens, and green space; the latter being the lowest ranked habitat on average. Of the three remaining habitat types paving was preferred, with an average ranking of between two and four depending on the level of urbanisation in the area. However, this habitat type was utilised less in proportion to its availability as urban cover increased, and in the more urban areas brownfield sites and other habitats were preferred over paved land (Table 3).

Table 2: Wilks' Lambda statistics derived from compositional analysis of the proportion of used vs available habitat in the core foraging areas around House Sparrow nest sites. Data were used from all three survey periods encompassing three urban strata, where A = 25-49.9% human cover; B = 50-74.5% urban cover, and C = 75-100% urban cover. P < 0.005 in all cases.

Survey period	Stratum A	Stratum B	Stratum C
Summer 2003 visit 1	0.77	0.55	0.51
Summer 2003 visit 2	0.68	0.53	0.48
Summer 2004	0.72	0.46	0.39

Table 3: Mean preference rankings for six main habitat types according to the proportion of used vs available habitat in the core foraging areas around House Sparrow nest sites, with a ranking of 5 = most preferred. Data were derived from compositional habitat analysis across three urban strata where A = 25–49.9% human cover; B = 50–74.5% urban cover, and C = 75–100% urban cover.

Habitat type	Stratum A	Stratum B	Stratum C
Greenspace	0.00	0.00	0.33
Buildings	1.33	1.00	0.66
Gardens	5.00	5.00	5.00
Urban brownfield	2.30	2.66	3.00
Other	2.00	2.66	4.00
Paving	4.00	3.67	2.00

Proximity analysis:

The random points generated in ArcMap were each more than 25 m apart and were, therefore, not aggregated to form 'colonies'. The presence of chirping males within 25 m of each other was, however, reported in both the 2003 and 2004 surveys, although the size of the colonies created by aggregating individual males varied according to urban stratum. Mean colony size was significantly smaller in the most urban areas, *i.e.* those classified as Stratum C (Analysis of Variance, F = 49.69 on 3 & 10,143 d.f. p<0.005), and peaked at intermediate levels of development (Stratum B). This trend was seen in both years. Colony sizes for 2003 are likely to slightly overestimate actual colony sizes due to the merging of data from two surveys during this year.

The mean distance of both random and actual points from roads increased as the level of human cover decreased, as would be expected. However, House Sparrow colonies in Stratum A were situated significantly nearer to roads than both colonies in more urban areas, and randomly generated points (Table 4, Figure 2). There was no difference between the chirping males recorded in the 2003 and 2004 surveys in terms of the distance of colonies from roads. All sites, whether actual nest sites or randomly generated points, were situated, on average, within 500 m of a road (within 250 m in the case of Stratum B and Stratum C). However, even though the vast majority (over 90%) of House Sparrow nests were within range of a road, 55% of roads were, on average, situated more than 100 m away from nest sites and were, therefore, beyond the usual foraging range of a breeding House Sparrow.

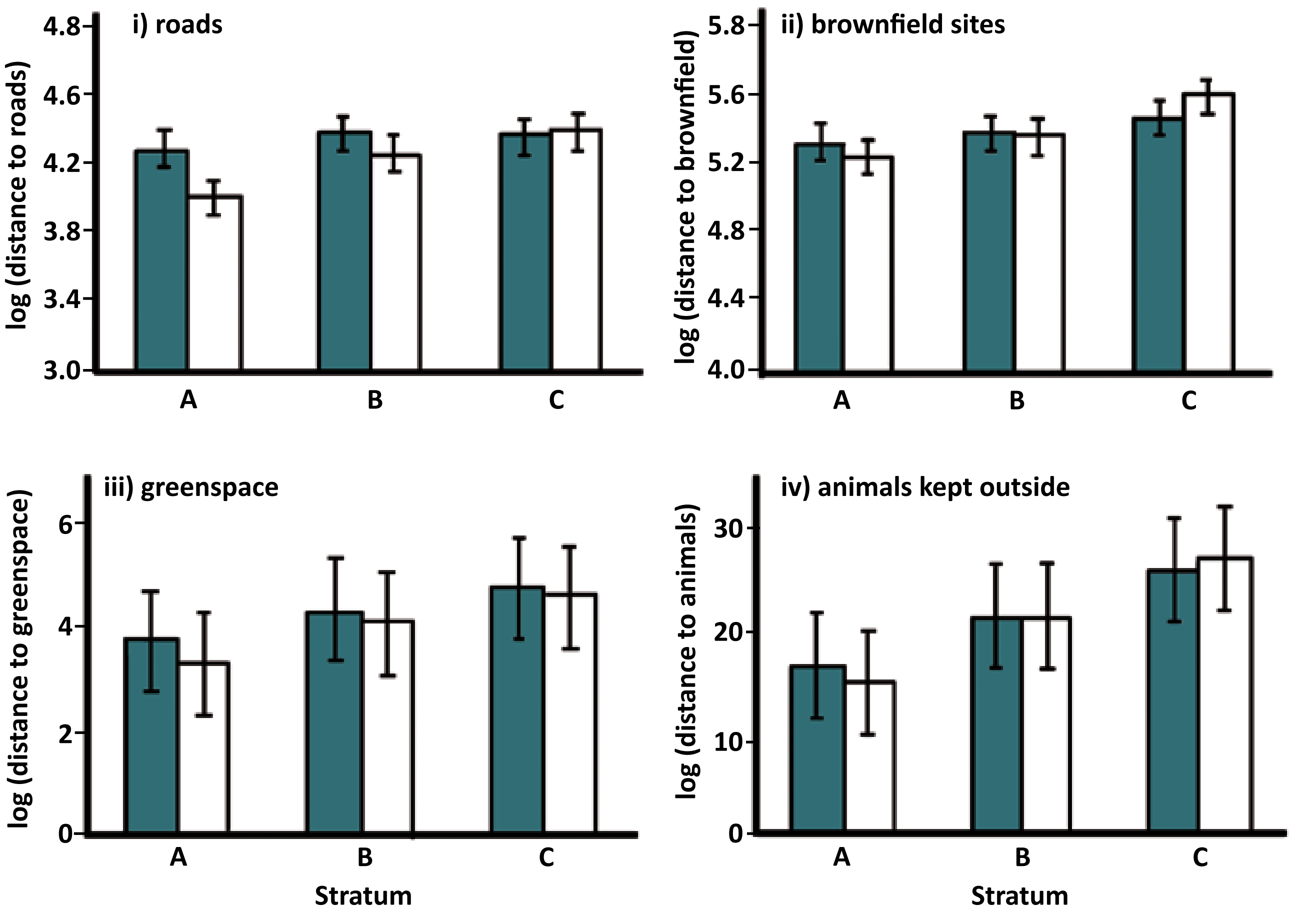
Table 4: Parameter estimates for Analyses of Covariance (ANCOVA) models comparing the distance of a number of different habitat types/features from House Sparrow nests, and from randomly generated points.

Habitat type /feature	Parameter	Sum of squares(d.f.)	F-value	P-value
Roads	distance to boundary	54.8 (1)	30.32	$<0.001^{***}$
	urban strata	164.9 (2)	45.60	$<0.001^{***}$
	random/actual data	40.9 (1)	22.61	$<0.001^{***}$
	distance to boundary*urban strata	16.7 (2)	4.62	$<0.001^{***}$
	urban strata*random/actual data	50.8 92)	14.04	$<0.001^{***}$
Allotments	distance to boundary	3,165.0 (1)	31.16	$<0.001^{***}$
	urban strata	4,421.0 (2)	21.76	$<0.001^{***}$
	survey	6,695.0 (2)	32.95	$<0.001^{***}$
	strata*survey	1,561.0 (4)	3.84	$<0.005^{**}$
Brownfield	distance to boundary	125.1 (1)	72.30	$<0.001^{***}$
	urban strata	136.4 (2)	39.41	$<0.001^{***}$
	random/actual data	0.5 (1)	0.27	0.61
	distance to boundary*urban strata	14.3 (2)	4.13	0.02^{*}
	urban strata*random/actual data	25.6 (2)	7.40	$<0.001^{***}$
Greenspace	distance to boundary	152.0 (1)	68.58	$<0.001^{***}$
	urban strata	3,689.0 (2)	832.14	$<0.001^{***}$
	random/actual data	312.0 (1)	140.57	$<0.001^{***}$
	urban strata*random/actual data	39.0 (2)	8.75	$<0.001^{***}$
Animals kept outside	distance to boundary	3,712.0 (1)	40.01	$<0.001^{***}$
	urban strata	99,870.0 (2)	538.32	$<0.001^{***}$

The mean distance of randomly generated points from allotments was significantly greater than from actual House Sparrow colonies/individuals, regardless of the level of human cover (Table 4, Figure 3). In addition, for those colonies that were within range of allotments the mean distance to the closest allotment was significantly smaller for grid squares with less than 50% human cover (Stratum A) than for other areas, even though the overall distance to allotments was lowest in the most densely populated areas (Stratum C). The distance of both randomly generated points and actual nest sites from allotments generally increased with increasing urbanisation, with the exception of the survey carried out in summer 2004, during which the distance of House Sparrow nests from allotments peaked at intermediate levels of human cover.

The mean distance of House Sparrow nests from brownfield sites within the range of an adult House Sparrow increased significantly as the percentage of human cover increased, although there was no difference between colonies recorded in 2003 and 2004. In contrast, the distance of randomly generated points to brownfield sites increased only very slightly (Figure 2). However, overall the distance from both random points and actual sparrow nests decreased as the level of urbanisation increased, suggesting that

Figure 2. The differences in the distance (m) of actual House Sparrow nest sites (white bars) and randomly generated points (blue bars) from i) roads, ii) brownfield sites, iii) green spaces and iv) animals kept outside according to urban stratum where A = 25–49.9% human cover, B = 50–74.9% human cover and C => 75% human cover.



brownfield sites may be more common in more urban areas. As a consequence, actual House Sparrow nests were closer to brownfield sites than randomly generated points in the most rural sites (Stratum A), but further away from brownfield sites in the most urban areas (Stratum C).

The mean distance of nest sites to greenspace was lowest in the most rural sites, which is to be expected given the greater proportion of greenspace in these areas in comparison with more urban sites. The distance of both actual nest sites and random points from areas of greenspace increased significantly from Stratum A to Stratum C, although this effect was strongest for actual nest sites than for the random points (Figure 2). The mean distance of greenspace from actual or potential nest sites overall was less than 500 m across all levels of urban stratification, suggesting that greenspace was accessible for most birds. However, of the House Sparrows or potential sites that were within 2 km of greenspace, only those in the least urban areas (Stratum A) were within 100 m of greenspace, on average.

The distance of nests from areas containing animals increased significantly more than the distance of randomly generated points from the same feature as the percentage of human cover increased (Figure 2). As a consequence, actual nest sites were closer on average than random points to areas containing animals in grid squares classified as Stratum A, and further away on average from animals than the random points in Stratum C. In each urban stratum, however, the mean distance to areas containing animals was over 300 m and, therefore, outside the usual foraging range of a nesting House Sparrow. There was no difference between the 2003 and 2004 surveys in the distance of nest sites from areas containing animals.

Figure 3. The differences in the distance (m) of randomly generated points (blue bars), actual House Sparrow nest sites in 2003 (white bars) and 2004 (red bars) from allotments according to urban stratum where A = 25–49.9% human cover, B = 50–74.9% human cover and C => 75% human cover.

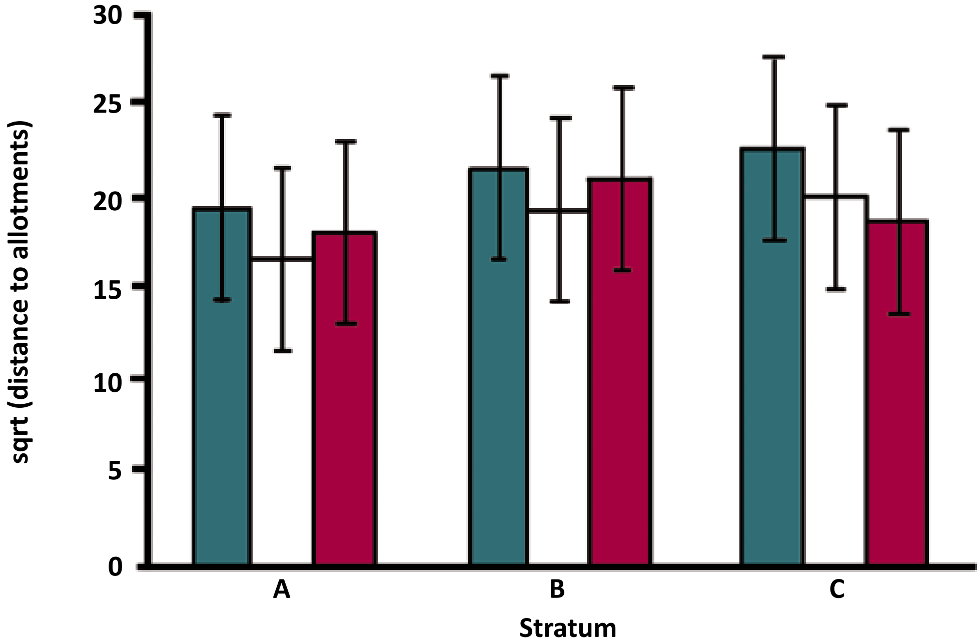
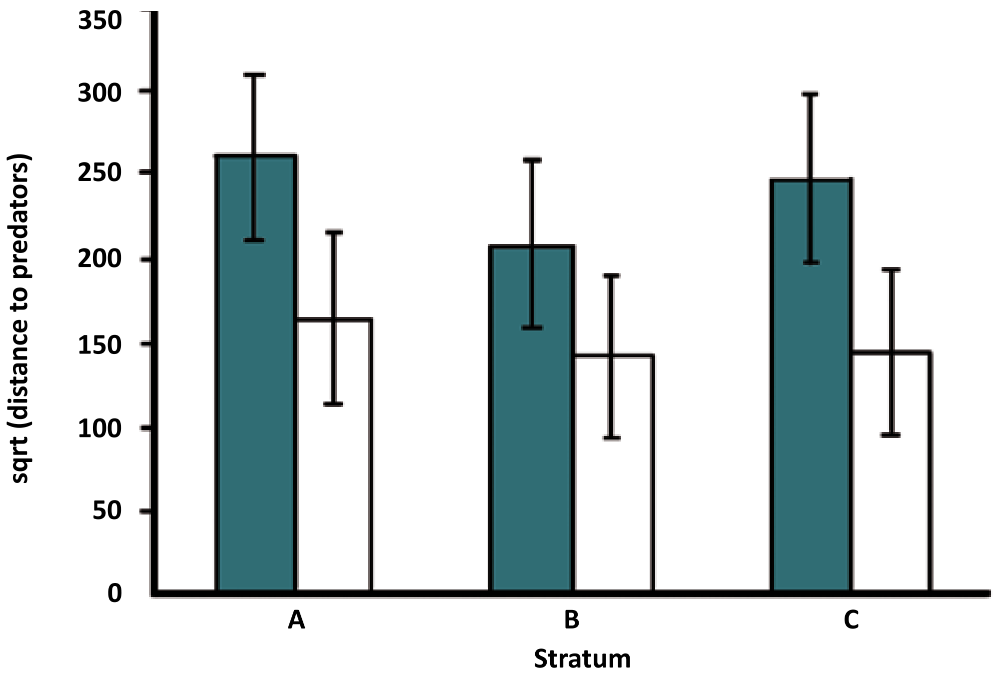


Figure 4. The differences in the distance (m) of randomly generated points (grey bars) and actual House Sparrow nest sites (white bars) from predators, according to urban stratum where A = 25–49.9% human cover, B = 50–74.9% human cover and C= > 75% human cover.



House Sparrow nest sites were in significantly closer proximity to predators than random points on average (Table 4, Figure 4). This was particularly true for nests in the most urban strata (B and C), although, on average, nesting colonies at all levels of urbanisation were further than 100 m from their nearest predator.

Discussion

The high proportion of residential areas with gardens surrounding House Sparrow nest sites is unsurprising, given that these areas meet both the nesting and foraging requirements for the species. Domestic gardens have long been identified as important sources of food for many bird species throughout the year (Gaston *et al.* 2005). Houses with gardens are known to be associated with high densities of House Sparrows, although those in deprived areas appear to offer more suitable nesting and foraging opportunities than those in more affluent areas (Chamberlain *et al.* 2007, Shaw *et al*. 2008). The strong preference of House Sparrows for these areas, even in the presence of brownfield sites and allotments rich in invertebrate species (Eyre *et al.* 2003, Chamberlain *et al*. 2007), shows the importance of private gardens for nesting birds. In the case of the House Sparrow it is likely that their small foraging range obliges nesting birds to choose potential foraging areas that are as close as possible to the nest site itself; and in many cases the gardens attached to the house will be the nearest suitable site.

Moreover, private gardens often provide extra resources for adult as well as juvenile birds in the form of artificially provided supplementary food, which is estimated to be present in nearly 50% of gardens, and is known to have beneficial effects for individual birds (Robb *et al.* 2008, Davies *et al.* 2009). Many householders also provide artificial nest sites for cavity-nesting birds, whereas suitable cavities for nesting may be scarce in the vicinity of other habitats (Davies *et al.* 2009). In areas where development leads to the loss of garden habitat, particularly in less deprived areas (Pauleit *et al*. 2005), these alternative habitat types may gain in importance.

The apparent preference of nesting House Sparrows for paved areas, and the relatively low distances of sparrow nests from roads are likely to reflect the fact that buildings with gardens are often closely associated with roads and paving, rather than a preference for a habitat type with no obvious benefit in terms of nesting and foraging opportunities. Paved areas and housing are intercorrelated habitat types in urban areas (Shaw, 2009), and paved areas are therefore probably difficult to avoid for nesting birds. Busy roads, and the consequent air and noise pollution they create may however reduce the likelihood of successful nesting attempts close to these areas, and there is some evidence to suggest this may be the case (Summers-Smith 2003; Vincent, 2005). This may also explain why paved areas were less preferred in the most urban sites in this study, as pollution and traffic disruption may be highest in these areas.

The strong aversion of nesting House Sparrows to greenspace is, perhaps, surprising. Greenspaces are heavily utilised by breeding sparrows in European towns and cities, where private gardens are less common (*e.g.* Murgui 2009), but greenspaces in the UK tend to be more open and homogeneous in character than elsewhere in Europe and may lack the foraging opportunities that the birds need. It is possible that, here in the UK, most greenspace is only used when other foraging resources are unavailable, or by non-breeding individuals that are able to travel longer distances to find better quality greenspace whilst foraging. The relative popularity of greenspace in the most densely populated areas suggests that, to some extent, this might be the case, as does the relatively long average distance from greenspace to nests.

Relatively heterogeneous habitat, such as pasture grazed by livestock, may provide more foraging opportunities than open countryside, and this study provides some evidence to suggest that in areas where gardens are less readily available (*i.e.* in the least populated areas studied here) greenspace, brownfield sites, allotments and land containing animals are a useful substitute for nesting birds. This may account for the relatively high densities of House Sparrows that have been recorded at these sites (Chamberlain *et* *al*. 2007). The scarcity of these habitat types overall, however, may limit their use by colonies as a regular foraging habitat in comparison with residential areas.

The apparent preference of nesting House Sparrows for 'other' habitats in the most urbanised areas may be due to the presence of useful foraging habitat along urban river banks, and the presence of patches of urban greenspace along flood plains. However, the lack of these habitats in the immediate vicinity of House Sparrow nests suggests that these areas are constrained by a lack of suitable nest sites. In this case, creating potential nest sites in areas where House Sparrows utilise urban greenspace, allotments and brownfield sites as foraging areas, may mitigate the effects of development in nearby areas of housing. This may be particularly the case in more urban areas, where allotments appear to be relatively under-utilised at present (Shaw 2009).

The close proximity of nesting House Sparrows to predators, particularly in densely populated areas suggests that nesting birds are usually forced to forage in areas where predators are present. Predators are likely to have a relatively large range in relation to nesting birds, and although they may not be able to access nest sites directly, they may contribute to high mortality rates amongst parent birds and juveniles, particularly where foraging costs are high. Studies suggest that domestic cats can have a detrimental effect on House Sparrow populations and, whilst neither they nor Sparrowhawks are thought to have a large enough impact to account for the scale of House Sparrow population declines, they may have a large enough impact in areas where the population is already under stress to cause local extinctions of colonies (Baker *et al*. 2005; Chamberlain *et al.* 2009b, Shaw 2009).

This study emphasises the importance of residential areas with gardens as the preferred habitat for House Sparrow populations. Although other habitats, such as brownfield sites and allotments, are useful for nesting birds, they are only utilised heavily in areas where houses with gardens are relatively scarce. Neither the presence of neither roads nor predators appears to have a negative effect on House Sparrows when choosing the location of a colony, but it is likely that the ubiquitous nature of both within urban habitats renders discrimination against either very difficult, even if they have a negative effect on some populations. Mitigation measures to preserve House Sparrow populations should, therefore, concentrate on improving existing garden habitats wherever possible, including the limitation of development in areas where sparrows are present. However, attention should be paid to preserving good quality greenspace and brownfield sites, particularly in relatively rural areas.

Acknowledgements

We would first like to extend our sincere gratitude to all participants of the BTO's House Sparrow Survey. We would also like to thank Viola Kimmel and Su Gough for GIS support, and Rosie Cleary-McHarg for coordinating the House Sparrow Survey. This work was funded through the BTO House Sparrow Appeal; an appeal to BTO supporters and, in particular, the John Spedan Lewis Charitable Trust, Leslie Mary Carter Charitable Trust, Salter Charitable Trust, Elsie Mary Elkes Charitable Trust and the BTO's Young Scientist Fund. Remotely-sensed land cover data were derived from the LCM2000 database provided by the Centre for Ecology and Hydrology. This project was funded by the BTO. Thank you to BTO staff who developed the urban stratification and sampling methodology, in particular Alex Banks.

References:

Aebischer, N.J., Robertson, P.A. & Kenward, R.E. 1993. Compositional analysis of habitat use from animal radio-tracking data. *Ecology* **74**(5): 1313–1325.

Baker, P. J., Bentley, A.J., Ansell, R.J. & Harris, S.. 2005. Impact of predation by domestic cats *Felix catus* in an urban area. *Mammal Review* **35**: 302–312.

Beyer, H.L. 2004. Hawth's Analysis Tools for ArcGIS. Available from: http://www.spatialecology.com/htools.

Chamberlain, D.E., Toms, M.P., Cleary-McHarg, R. & Banks, A. N. 2007. House Sparrow (*Passer domesticus*) habitat use in urbanised landscapes. *Journal of Ornithology* **148**: 453–462.

Chamberlain, D.E., Cannon, A.R., Toms, M.P., Leech, D.I., Hatchwell, B.J. & Gaston, K.J. 2009a. Avian productivity in urban landscapes: a review and meta-analysis. *Ibis* **151**: 1–18.

Chamberlain, D.E, Glue, D.E. & Toms, M. 2009b. Sparrowhawk *Accipiter nisus* presence and winter bird abundance. *Journal of Ornithology* **150**: 247–254.

Chasan, R. 2005 Multiple Minimum Distance tool for ArcGIS. Available from: http://arcscripts.esri.com/

Crick, H.Q.P., Robinson, R.A., Appleton, G.F., Clark, N.A. & Rickard, A.D. (Eds) 2002 Investigation into the causes of the decline of Starlings and House Sparrows in Great Britain. *BTO Research Report No 290*, pp 1-9. DEFRA, Bristol. Available from: http://www.bto.org/research/archive/res_report_290.htm

Davies, Z.G., Fuller R.A., Loram, A., Irvine, K.N., Sims, V. & Gaston, K.J. 2009. A national scale inventory of resource provision for biodiversity within domestic gardens. *Biological Conservation* **142**: 761–771.

Eyre, M. D., Luff, M.L. & Woodward, J.C. 2003. Beetles (Coleoptera) on brownfield sites in England: An important conservation resource? *Journal of Insect Conservation* **7**: 223.

Gaston, K.J., Smith, R., Thompson, K. & Warren, P. 2005. Urban domestic gardens (II): Experimental tests of methods for increasing biodiversity. *Biodiversity and Conservation* **14**: 395–413.

Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology* **61**: 65–71.

Marzluff, J. M., Bowman, R. & Donnelly, R. 2001. *Avian Ecology and Conservation in an Urbanizing World*. Kluwer Academic Publishers, Boston.

Murgui, E. 2005. Valencia. *in*: Kelcey, J.G., Rheinwald, G. (Eds.), *Birds in European cities*. Ginster Verlag, Germany, pp 335–358.

Pauleit, S. Ennos, R. & Golding, Y. 2005. Modelling the environmental impacts of urban land use and land cover change – a study in Merseyside, UK. *Landscape and Urban Planning* **71**: 295–310.

Peach, W.J., Vincent, K., Fowler, J.A. & Grice, P.V. 2008. Reproductive success of House Sparrows along an urban gradient. *Animal Conservation* **11**: 493–503.

Pendleton, G.W., Titus, K., DeGayner, E., Flatten, C.J. & Lowell, R.E. 1998. Compositional analysis and GIS for study of habitat selection by Goshawks in Southeast Alaska. *Journal of Agricultural, Biological and Environmental Statistics* **3**: 280–295.

R Development Core Team 2007. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, Available from: http://www.R-project.org.

Robb, G.N., McDonald, R.A., Chamberlain, D.E., Reynolds, J.S., Harrison, T.J.E. & Bearhop, S. 2008. Winter feeding of birds increases productivity in the subsequent breeding season. *Biology Letters* **4**: 220–223.

Shaw, L.M., Chamberlain, D. & Evans, M. 2008. The House Sparrow, *Passer domesticus* in urban areas: Reviewing a possible link between post-decline distribution and human socioeconomic status. *Journal of Ornithology* **149**: 293–299.

Shaw, L.M. 2009. Investigating the role of socioeconomic status in determining urban habitat quality for the House Sparrow, *Passer domesticus*. PhD thesis; University of Exeter.

Siriwardena, G.M., Robinson, R.A., Crick, H.Q.P. 2002. Status and population trends of the House Sparrow, *Passer domesticus*, in Great Britain. pp 33–51 in Crick, H.Q.P., Robinson, R.A., Appleton, G.F., Clark, N.A. & Rickard, A.D. (Eds) (2002) Investigation into the causes of the decline of Starlings and House Sparrows in Great Britain. *BTO Research Report No 290*, DEFRA, Bristol. Available from: http://www.bto.org/research/archive/res_report_290.htm.

Snow, D. W. & Perrins, C. M. *et al*;. 1998. *The Birds of the Western Palearctic*. Oxford University Press, UK.

Summers-Smith, J.D. 2003. The decline of the House Sparrow: a review. *British Birds* **95**: 143–146.

Vincent, K. E. 2005. Investigating the causes of the decline of the urban House Sparrow *Passer domesticus* population in Britain. Leicester, De Montfort University. PhD: 303. Available from: www.katevincent.org.

Appendix A

T statistics and P values comparing habitat selection by House Sparrows as determined by compositional habitat analysis, relative to the availability of the six main habitat types for each House Sparrow Survey visit. The results are divided by urban stratum, where Stratum A = 25–49.5% human cover; Strata B = 50–74.5% human cover and Stratum C = 75–100% urban cover. Preference rankings for each habitat type are shown, with 0 = least preferred. The reference habitat type used was paving.

a) Summer 2003, visit 1 - Stratum A

Habitat type	Greenspace	Buildings	Gardens	Brownfield	Other	Paving	Rank
Greenspace	-	-2.44	-7.75	-1.62	-0.41	-5.32	0
	-	0.015	0.001	0.092	0.691	0.001	
Buildings		-	-6.48	0.88	2.05	-2.80	3
		-	0.001	0.379	0.040	0.011	
Gardens			-	7.57	8.47	3.94	5
			-	0.001	0.001	0.001	
Brownfield sites				-	1.19	-3.61	2
				-	0.237	0.002	
Other					-	-4.50	1
					-	0.001	
Paving						-	4

b) Summer 2003, visit 2 - Stratum A

Habitat type	Greenspace	Buildings	Gardens	Brownfield	Other	Paving	Rank
Greenspace	-	-1.33	-9.70	-3.01	-2.89	-5.35	0
	-	0.190	0.001	0.071	0.156	0.001	
Buildings		-	-9.22	-1.82	-1.48	-4.14	1
		-	0.001	0.071	0.156	0.001	
Gardens			-	7.91	8.26	5.62	5
			-	0.001	0.001	0.001	
Brownfield sites				-	0.29	-2.39	3
				-	0.758	0.020	
Other					-	-2.81	2
					-	0.007	
Paving						-	4

c) Summer 2004, Stratum A

Habitat type	Greenspace	Buildings	Gardens	Brownfield	Other	Paving	Rank
Greenspace	-	0.08	-6.83	-1.16	-2.25	-3.99	1
	-	0.950	0.001	0.258	0.032	0.001	
Buildings		-	-7.75	-1.24	-2.27	-4.53	0
		-	0.001	0.221	0.018	0.001	
Gardens			-	6.44	5.40	3.20	5
			-	0.001	0.001	0.002	
Brownfield sites				-	-0.93	-3.51	2
				-	0.326	0.001	
Other					-	-2.16	3
					-	0.028	
Paving						-	4

d) Summer 2003, visit 1 - Stratum B

Habitat type	Greenspace	Buildings	Gardens	Brownfield	Other	Paving	Rank
Greenspace	-	-1.43	-12.58	-2.65	-4.26	-4.16	0
	-	0.150	0.001	0.012	0.001	0.002	
Buildings		-	-11.73	-1.21	-2.87	-3.22	1
		-	0.001	0.209	0.004	0.003	
Gardens			-	10.91	9.24	8.94	5
			-	0.001	0.001	0.001	
Brownfield sites				-	-1.65	-1.71	2
				-	0.108	0.109	
Other					-	-0.00	3
					-	1.00	
Paving						-	4

e) Summer 2003, visit 2 - Stratum B

Habitat type	Greenspace	Buildings	Gardens	Brownfield	Other	Paving	Rank
Greenspace	-	-0.52	-12.23	-4.49	-3.99	-4.21	0
	-	0.618	0.001	0.001	0.001	0.001	
Buildings		-	-12.43	-4.10	-3.43	-3.86	1
		-	0.001	0.002	0.001	0.001	
Gardens			-	8.38	8.86	8.97	5
			-	0.001	0.001	0.001	
Brownfield sites				-	0.57	0.61	4
				-	0.579	0.574	
Other					-	-0.00	2
					-	0.996	
Paving						-	3

f) Summer 2004, Stratum B

Habitat type	Greenspace	Buildings	Gardens	Brownfield	Other	Paving	Rank
Greenspace	-	-0.85	-11.24	-3.15	-3.99	-4.22	0
	-	0.399	0.001	0.001	0.001	0.001	
Buildings		-	-11.30	-2.09	-3.06	-3.64	1
		-	0.001	0.051	0.004	0.001	
Gardens			-	9.67	8.92	8.33	5
			-	0.001	0.001	0.001	
Brownfield sites				-	-1.01	-1.53	2
				-	0.301	0.119	
Other					-	-0.46	3
					-	0.632	
Paving						-	4

g) Summer 2003, visit 1 - Stratum C

Habitat type	Greenspace	Buildings	Gardens	Brownfield	Other	Paving	Rank
Greenspace	-	-0.04	-12.40	-3.41	-7.27	-2.07	0
	-	0.966	0.001	0.001	0.001	0.044	
Buildings		-	-12.24	-3/39	-6.95	-2.11	1
		-	0.001	0.001	0.001	0.043	
Gardens			-	10.20	6.44	10.77	5
			-	0.001	0.001	0.001	
Brownfield sites				-	-3.77	1.50	3
				-	0.001	0.132	
Other					-	4.94	4
					-	0.001	
Paving						-	2

h) Summer 2003, visit 2 - Stratum C

Habitat type	Greenspace	Buildings	Gardens	Brownfield	Other	Paving	Rank
Greenspace	-	0.10	-12.87	-3.66	-7.34	-2.56	1
	-	0.924	0.001	0.001	0.001	0.012	
Buildings		-	-13.35	-3.70	-6.60	-2.74	0
		-	0.001	0.001	0.001	0.005	
Gardens			-	10.08	7.11	11.31	5
			-	0.001	0.001	0.001	
Brownfield sites				-	-3.40	1.06	3
				-	0.003	0.249	
Other					-	4.16	4
					-	0.001	
Paving						-	2

i) Summer 2004, Stratum C

Habitat type	Greenspace	Buildings	Gardens	Brownfield	Other	Paving	Rank
Greenspace	-	-2.08	-12.96	-4.96	-6.66	-3.41	0
	-	0.038	0.001	0.001	0.001	0.002	
Buildings		-	-11.28	-3.27	-4.18	-1.60	1
		-	0.001	0.003	0.001	0.122	
Gardens			-	8.38	7.39	9.10	5
			-	0.001	0.001	0.001	
Brownfield sites				-	-1.21	1.51	3
				-	0.235	0.136	
Other					-	2.45	4
					-	0.015	
Paving						-	2

BTO Research Report No. 599

Lorna M Shaw, Dan Chamberlain, Greg J Conway & Mike Toms

Spatial distribution and habitat preferences of the House Sparrow, *Passer domesticus* in urbanised landscapes.

The House Sparrow *Passer domesticus* has declined in urban areas across Europe since the late 1970s and is now listed as a species of conservation concern. Recent research into the causes of decline suggests that breeding adults may be influenced by a number of urban habitat features. These include pollution levels, insect abundance, nest site availability and the presence of predators.

Here we test for the presence of these habitat features in relation to House Sparrow colonies by comparing the distance of actual nest sites and randomly generated points to the features of interest. We then test the preferences of House Sparrows for a number of habitat types using compositional habitat analysis.

We found that houses with gardens are strongly preferred to any other habitat type, although in more rural areas allotments and green space may provide useful alternatives to urban gardens. Predators and roads are not avoided, probably due more to their ubiquitous nature than any lack of a detrimental impact.

Mitigation measures to prevent House Sparrow colony loss should, therefore, concentrate on the habitat quality of urban gardens, particularly in the most densely populated areas.

British Trust for Ornithology
The Nunnery
Thetford
Norfolk
IP24 2PU

(+44) 1842-750050
info@bto.org
www.bto.org

BTO Looking out for birds

978–1–906204–97–6