Characteristics of woods used recently and historically by Lesser Spotted Woodpeckers 

*Dendrocopos minor* in England

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Lesser Spotted Woodpecker *Dendrocopos minor* numbers have declined greatly in England since the early 1980s for reasons that are not yet fully understood. It has been suggested that the species’ decline may be linked to the increase in Great Spotted Woodpeckers *Dendrocopos major*, changes in woodland habitat quality (such as deadwood abundance) and landscape-scale changes in tree abundance. We tested some of these hypotheses by comparing the characteristics of woods in southern England where the species is still relatively numerous with those of woods used in the 1980s before the major decline. In each time period, habitat, predator and landscape information from woods known to be occupied by Lesser Spotted Woodpeckers was compared with those found to be unoccupied during surveys. Before the main period of decline, Lesser Spotted Woodpeckers used oak-dominated, mature, open woods with a large amount of standing deadwood. Habitat use assessed from recent data was very similar, the species being present in mature, open, oak-dominated woodlands. There was a strong relationship between wood use probability and the extent of woodland within a 3-km radius, suggesting selection for more heavily wooded landscapes. In recent surveys, there was no difference in deadwood abundance or potential predator densities between occupied and unoccupied woods. Habitat management should focus on creating and maintaining networks of connected woodlands in areas of mature, open woods. Finer-scale habitat selection by Lesser Spotted Woodpecker within woodlands should be assessed to aid development of beneficial management actions.

Keywords: conservation, habitat, landscape, population declines, woodland birds, woodland structure.
epidemic spread of Dutch elm disease (Osborne 1982). UK monitoring schemes show a decline of 73% in BTO Common Birds Census indices from 1974 to 1999, but the species is now too rare to be monitored adequately by the BTO/JNCC/RSPB Breeding Bird Survey. Because of these declines, the species is included in the UK Biodiversity Action Plan priority species list as well as on the UK Red List. Numbers may have fallen more widely across Europe (Mikusinski & Angelstam 1998, PECBM 2006) in recent years.

Various aspects of the Lesser Spotted Woodpecker’s breeding ecology have been studied in Europe, such as reproductive success (Rossmanith et al. 2007), parental care and social mating (Wiktander et al. 2000), nesting diet (Rossmanith et al. 2007), foraging routines (Olsson et al. 2000, 2001) and home-range size (Wiktander et al. 2001). Habitat preferences have also been widely studied. Olsson et al. (1992) found that the species preferred stands with many snags (standing dead trees) and older stands in Sweden, and it was hypothesised that the loss and degradation of this preferred habitat through logging could, in part, explain the decline there. A Belgian study (Delahaye et al. 2002) suggested that the species required the presence of high tree species diversity, a high density of dead trees and stands with a basal area of more than 15 m²/ha. A study comparing occupied and unoccupied woods in central Europe found that forests were most likely to be occupied if more softwoods but fewer snags (diameter at breast height (dbh) > 15 cm) per area were available, where the distance to lakes and rivers was small and the elevation was low (Miranda & Pasinelli 2001).

In Britain, an analysis of nest record cards up to 1989 described nesting preferences at the nest tree scale and basic breeding ecology in the period before the decline in population (Glue & Boswell 1994). There is evidence that the species has declined more in woods where there was a current high density of Grey Squirrels Sciurus carolinensis (Amar et al. 2006). Smith (2007) describes the use of dead wood for foraging and nesting by woodpeckers in four woods in Hertfordshire alongside changes in the deadwood resource over a period of more than 20 years, suggesting that stand and deadwood dynamics are likely to provide habitats more favourable to Great Spotted Woodpecker Dendrocopos major. With these few exceptions, there have been no quantitative studies of Lesser Spotted Woodpecker habitat use at a scale wider than nest locations in England. Furthermore, the birds in Britain are the subspecies cominitus (endemic to England and Wales), which may show differing habitat requirements to its European counterparts.

Reasons for the decline in the UK and elsewhere in Europe are unclear, largely because despite its widespread range the species is extremely difficult to study due to its low population density and secretive behaviour. Fuller et al. (2005) proposed three potential hypotheses for the Lesser Spotted Woodpecker decline: (i) interactions, particularly in relation to nest-sites, with Great Spotted Woodpecker, which have increased greatly during the period of decline; (ii) changes in wood-scale habitat quality, especially the availability of deadwood and deadwood invertebrates; and (iii) landscape-scale changes in tree abundance. To understand factors instrumental in the decline, it is necessary to establish their requirements in areas where their populations are still relatively abundant. In addition, if a good population exists in these areas, sites are less likely to be unoccupied due to low immigration probability and more likely to be unoccupied due to other variables relating to habitat requirements.

We present the results of analyses of two data-sets describing characteristics of woods where observations were made of Lesser Spotted Woodpeckers in England. These included an intensive field project in 2007 that explicitly aimed to survey areas for Lesser Spotted Woodpeckers and measure habitat use across a wide geographical area, and data from surveys in the 1980s in southern England, which were used to describe occupied woods in the period before the major decline (Amar et al. 2006). The paper aims to identify the factors associated with wood use across England in areas where Lesser Spotted Woodpeckers are still relatively numerous and use data from the 1980s to describe factors associated with wood use in the period before or early in the decline.

METHODS

Intensive surveys, 2007

Seventy-two woods were surveyed in 2007 for Lesser Spotted Woodpeckers in three regions of England: South Yorkshire (SY; 17 woods in the area around Sheffield), Worcestershire and Shropshire (WO; 27 woods around the Wyre Forest) and the
Wiltshire/Hampshire border (HA; 28 woods including parts of the New Forest). The study areas were selected as areas where the species is still known to occur, based on accounts from county bird reports, the 1988–91 breeding atlas (Gibbons et al. 1993), the RSPB/FC/NE/BTO Bird Conservation Targeting Project (http://www.rspb.org.uk/targeting) and local knowledge through county bird recorders.

Areas of woodland 20 ha and larger (up to a maximum of 85 ha) were selected for survey within an approximate 10-km square centred on each study region. In Worcestershire, the area was increased to an approximately 15-km square to increase the sample of non-occupied woods. The National Inventory of Woodland and Trees (NIWT) (Forestry Commission 2003) was used to classify these woods, and only those that were classed as predominantly broadleaved were chosen for survey. It was not possible to survey all woodlands in each study area due to resource limitations and refused access permission.

Lesser Spotted Woodpeckers are notoriously secretive and it was necessary to devise a survey method that optimized the chances of successfully detecting birds when they were present at a site. Data from pilot studies in 2005 and 2006 showed that there is a significant relationship between survey date and the probability of hearing a bird (back-calculated once the site had been confirmed as occupied) such that there is a burst of activity between the beginning of March and mid-April. Similar seasonality has been reported by Hontsch (2004) and Miranda and Pasinelli (2001). After mid-April, the chances of detecting a Lesser Spotted Woodpecker by call appears to fall below 50%. Therefore, in this study surveys were undertaken during daylight hours between 1 March and 20 April 2007, avoiding days with heavy rain and strong wind.

Woods were surveyed by selecting a transect route that covered as much of the wood as possible. Analyses of data from three woodlands with regular visits in the pilot study showed that a 6-h period spent surveying a wood gave a 95% probability of Lesser Spotted Woodpeckers being heard or seen where they were known to be present. The three woods in the pilot study were 40, 50 and 80 ha in size. In the two smaller woodlands, there was an indication that fewer hours were necessary. In the current study, the selected woodland blocks were between 20 and 85 ha, and therefore survey duration was scaled to the size of the block as follows: < 30 ha, 3 h; 30–50 ha, 4 h; 50–70 ha, 5 h; and > 70 ha, 6 h.

Our objective was to assess whether each wood was used by Lesser Spotted Woodpeckers in March and April and therefore could possibly be a breeding site. Although Lesser Spotted Woodpeckers are known to have large territories at some times of the year, in March and April they begin to focus on a smaller area for breeding (Wiktander et al. 2001). Once a bird had been observed in a wood (by sight, calling or drumming), the site was classified as ‘occupied’. Woods were re-surveyed until a bird was located or until the survey period ended, whichever was sooner. Once sites had been confirmed as ‘occupied’, they were not revisited for formal surveys during this period of fieldwork. However, subsequent records of birds in the same woods were achieved in the vast majority of cases during other phases of the project. Analysis of pilot study data suggested that the number of visits required to confirm occupancy varied between the three woods included in analyses but one visit gave on average a 49% probability, two visits 73%, three visits 91% and four visits 96%. This was independent of the size of the wood. As a compromise between covering a large number of sites and obtaining reliable detection, at least three visits were made to each wood before it was declared ‘unoccupied’ (range 3–8, mean 4.3). On repeat visits, the route taken through the wood was reversed where possible.

All occupied and unoccupied woods were surveyed for habitat from June 2007. Habitat monitoring largely followed the same protocols as the RWBS (Amar et al. 2006). Study areas were divided into 1-ha squares. Squares within the surveyed area of the wood that contained more than 25% woodland were numbered and random number tables were used to generate a set of 10 squares of 1 ha in each wood for habitat assessment. The centre of each selected square formed the centre of a 25-m-radius area in which habitat recording took place. Some measurements were recorded from the centre of the 25-m plot, and others were taken from four 5-m-radius subplots centred 12.5 m north, east, south and west of the centre of the edge of the larger plot (Fig. 1 and Table 1).

Great Spotted Woodpeckers were surveyed simultaneously with Lesser Spotted Woodpeckers. The area covered and the duration of the survey...
were used to produce an index of Great Spotted Woodpecker abundance (mean birds/ha/h) at the wood level.

Grey Squirrels were surveyed using methods described in the RWBS (Amar et al. 2006). At each site, a continuous 1000-m transect was established through the wood. At sites where this was not possible, shorter individual transects totalling 1000 m were established which were more than 100 m apart. Transects were divided in 100-m sections and walked slowly, recording all visible active dreys and their perpendicular distance from the transect line (using a laser range finder). A drey was classed as active if it was > 30 cm in diameter and little light was visible through it. Squirrel drey density estimates were then computed using the software DISTANCE (Buckland et al. 1993).

**Pre-decline bird and habitat surveys**

Full details of bird and habitat survey methods for the RWBS are given in Hewson et al. (2007) and Amar et al. (2006). For a sample of sites, habitat data were collected in the 1980s when there were still reasonable numbers of Lesser Spotted Woodpeckers present. Due to the small number of regions with Lesser Spotted Woodpeckers in the RWBS, analyses presented here were restricted to southern England where the species remained widespread in the 1980s.

The sites were surveyed in 1985 using a point count method. Point count locations were chosen at random, with no points closer than 50 m from the edge of a wood or within 100 m of each other. Points were marked onto a map, located in the field and marked with flagging tape to allow them to be relocated. Each point count lasted 5 min and was carried out during two visits to each site. First visits were in April or the first week in May, and second visits were in the last 3 weeks in May or the first half of June. Woods were classified as occupied if there was a visual or audible contact with a Lesser Spotted Woodpecker at any point during the point counts on either visit. Habitat data were collected between the middle of May and the middle of July at the same points as bird point counts. Table 1 details the variables measured in the habitat surveys.

Although RWBS surveys were carried out later in the season than the 2007 study, and so may have missed the peak time of Lesser Spotted Woodpecker activity, the species’ densities in 1985 (occupied woods: mean number of detections = 3.1, range = 1–8) may mean that detection probability was higher compared with woods with a single pair (most woods in the 2007 intensive survey).

**Statistical analysis**

Habitat variables taken at the point level were summed and divided by the number of points in a wood to produce a mean for each variable. The means were then used as potential explanatory variables in analyses to compare woods with observations of Lesser Spotted Woodpeckers and those with no observations during surveys.

We used logistic regression with a logit-link function and binomial errors to model the probability of an observation of Lesser Spotted Woodpecker in a wood (hereafter referred to as ‘probability of wood use’) in relation to its attributes. Significance was assessed using deletion likelihood-ratio tests and examining change in residual deviance using Chi-squared tests.

A three-stage filtering process was used with the aim of reducing the number of covariates entering...
the final models. First, we examined the significance of each variable alone (stage 1). At this stage, any variable not significant at the 10% level was discarded from all further analyses. We also tested for non-linear relationships in those variables where we thought the response might be non-linear (Table 1) by including both the term and its square together. Secondly, we grouped the variables describing understorey structure, field layer, tree structure, deadwood, large-scale variables and landscape variables (stage 2) and ran multivariate backwards stepwise models for each group to identify terms to be entered into a final model. Terms explaining significant variance were entered together and removed in a stepwise process if not significant at the 10% level. Finally, all variables remaining after stage 2, and those from stage 1 which did not fall into the groupings and enter stage 2, were combined and entered into a final model (stage 3). We ran the full model,

### Table 1. Descriptions of possible correlates of wood use by Lesser Spotted Woodpeckers surveyed in the 2007 intensive survey. Variables shown in bold were also surveyed in the 1980s survey. Variables shown in italics were tested for quadratic relationships in the analyses.

<table>
<thead>
<tr>
<th>Category</th>
<th>Scale (Fig. 1)</th>
<th>Measurement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood and landscape</td>
<td>Area</td>
<td>Percentage of woodland within 1, 3 and 10 km</td>
<td>Area of wood surveyed (ha)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentage of broadleaved woodland within 1, 3 and 10 km</td>
<td>Percentages calculated from the National Inventory of Woodlands and Trees (NIWT) using a grid reference at the centre of the study wood as reference</td>
</tr>
<tr>
<td>Understorey</td>
<td>Subplot</td>
<td>Horizontal visibility</td>
<td>A 2.4-m pole marked with alternate black and orange sections was placed in the centre of the plot and viewed from each of the subplots. The number of orange bands at least 50% visible through the vegetation from each subplot was recorded (Wilson et al. 2005)</td>
</tr>
<tr>
<td></td>
<td>Plot/subplot</td>
<td>Vegetation cover 0.5–2 m, 2–4 m and 4–10 m</td>
<td>Percentage of cover in height band estimated visually as if viewed from above</td>
</tr>
<tr>
<td>Tree size</td>
<td>Plot/subplot</td>
<td>Canopy cover</td>
<td>Percentage of cover estimated visually using a standardized method. The number of 2-cm squares in a 4 x 4 wire grid that were at least 50% covered by canopy foliage when viewed directly from below were counted and converted to %. Canopy was defined as foliage at least 10 m high</td>
</tr>
<tr>
<td></td>
<td>Plot</td>
<td>Basal area</td>
<td>Scored according to a standardized reloscope when viewed from the centre of the plot (Hamilton 1975)</td>
</tr>
<tr>
<td>Field layer</td>
<td>Plot/subplot</td>
<td>Maximum diameter at breast height (dbh)</td>
<td>dbh of the largest tree in the plot (cm)</td>
</tr>
<tr>
<td></td>
<td>Plot</td>
<td>Maximum height</td>
<td>Height of the tallest tree in the plot (cm)</td>
</tr>
<tr>
<td>Deadwood</td>
<td>Plot</td>
<td>Dead trees</td>
<td>Count of all dead trees</td>
</tr>
<tr>
<td></td>
<td>Plot/subplot</td>
<td>Dead limbs</td>
<td>Count of the number of dead limbs attached to trees &gt; 20 cm in diameter</td>
</tr>
<tr>
<td></td>
<td>Subplot</td>
<td>Ground deadwood</td>
<td>Count of pieces of ground deadwood &gt; 10 cm in diameter and 1 m in length</td>
</tr>
<tr>
<td>Other habitat</td>
<td>Plot</td>
<td>Dominant tree</td>
<td>Three-level factor – oak, beech, birch. The most numerous tree species in the plot</td>
</tr>
<tr>
<td></td>
<td>Plot</td>
<td>Water features</td>
<td>Two-level factor. Presence/absence of wet feature (stream, bog, flush, pond)</td>
</tr>
<tr>
<td>Predators and competitors</td>
<td>Plot</td>
<td>Slope</td>
<td>Estimation of ground slope. Measured in degrees</td>
</tr>
<tr>
<td></td>
<td>Plot</td>
<td>Altitude</td>
<td>Recorded from maps (m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Great Spotted Woodpecker abundance</td>
<td>See text for details</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey Squirrel density</td>
<td>See text for details</td>
</tr>
</tbody>
</table>
removing terms using backwards stepwise deletion until only variables significant at the 5% level remained. These variables then formed our chosen model. Given the number of potential explanatory variables, a degree of co-linearity between variables is expected. To partially account for this, we selected a backwards approach, as this is more appropriate in situations where explanatory variables may be mutually correlated, as the variable that explains the greater amount of deviance is usually retained in the final model (Crawley 2002). Stepwise modelling approaches have been criticized (e.g. Whittingham et al. 2006, Mundry & Nunn 2009) although there is also suggestion that final models vary little between modelling procedures (Murtaugh 2009). Given the large number of explanatory variables and the exploratory nature of the study, we considered the method appropriate. A benefit of the modelling approach we have chosen is that significant univariate relationships are apparent, which may be useful in the discussion stage, especially where significant variables are considered proxies of other effects. Furthermore, where multivariate models are run within groups of similar variables, the most important variable from that group (if any) is identified and taken forward to the final model (thereby reducing potential co-linearity in the data). Creating a cut-off at the 10% level rather than at the 5% level at stages 1 and 2 also means that marginally non-significant variables are included in the final modelling stage.

In the 2007 Lesser Spotted Woodpecker survey dataset, locality (SY, WO or HA) was retained in the models at all times as a fixed effect. This was to control to some degree the possible effects of spatial autocorrelation, accounting for geographical variation in occupancy. Therefore, the effect of any covariate will be identified over and above any gross differences accounted for by locality. We accept that when these effects are fixed, the final models will be conservative. However, given the number of variables tested and the exploratory nature of the analyses we considered this appropriate. Analyses were carried out using R version 2.5.1.

RESULTS

Intensive studies, 2007

Lesser Spotted Woodpeckers were recorded in 40 of the 72 woods surveyed (SY – 5/17 sites occupied, WO – 20/27, HA – 15/28). At the univariate stage, 10 variables were significant (at 10% level) in predicting wood use by Lesser Spotted Woodpeckers (Table 2). Figure 2 shows effects significant (5% level) at stage 2 and those that remained to stage 3. At stage 2, Lesser Spotted Woodpeckers were more likely to occur in woods with a generally open structure (Fig. 2a), dominated by oak, with low herbaceous cover in the field layer (Fig. 2b), and woods in a highly wooded landscape (Fig. 2c). The final model contained locality (a fixed effect in all models), horizontal visibility and the proportion of land within 3 km that is wooded.

The relationship with horizontal visibility suggests an effect of the ‘openness’ of the wood, Lesser Spotted Woodpeckers having a > 50% probability of occupancy from values of around eight on the horizontal visibility scale. A mature, tall woodland with a closed canopy is likely to have a poor shrub understorey layer through shading. This process could also lead to the negative relationship with herbaceous cover, which is also shaded in closed-canopy woodland. The relationships with wood ‘openness’ and herbaceous cover are therefore likely to be proxy measures of the species’ use of mature, closed-canopy woodland.

There was a > 50% probability of wood occupancy where the proportion of woodland in the surrounding landscape (at 3-km radius) was > 30%, equating to around 800 ha of woodland in the vicinity. There was no significant relationship between wood occupancy and the amount of woodland within a 10-km radius. As our survey woods were within a restricted area, there was a large degree of overlap in woodland area at that scale between woods. This is likely to have resulted in a small amount of variation in values and so any effect of wooded area at that scale may have been lost.

Pre-decline bird and habitat surveys

Sixteen of the 34 woods were occupied during the 1985 survey. Five of the measured habitat variables were associated univariately with woods used by Lesser Spotted Woodpeckers in the 1980s: dominant species, maximum height, cover at 4–10 m, water features and the number of dead limbs > 20 cm (Table 3). Lesser Spotted Woodpeckers were significantly more likely to be present in woods with tall trees dominated by oak, with more
water features, a greater number of dead limbs < 20 cm on live trees and high cover at 4–10 m. Figure 3 shows effects significant (0.05 level) at stage 2 and those that remained to stage 3. The final model retained dead limbs and oak as the most significant variables.

Table 4 compares the results from the 1980s study and the intensive study. Cross-referencing of important variables between the two surveys at each stage of the analyses showed very similar key variables, suggesting that habitat associations have remained consistent throughout the period of decline. Although some of the specific variables are different, they generally describe mature open woodland with a preference for oak and a possible relationship with wet features.

### DISCUSSION

We describe broad-scale habitat characteristics of woods containing Lesser Spotted Woodpeckers in England. Woods with an open structure at least up to 2.4 m and set within a heavily wooded landscape are more likely to be used by the species during the March and April pre-breeding stage. Woods were more likely to be used if they were oak-dominated and had a higher abundance of dead limbs. Cross-referencing suggested that habitat associations have remained largely consistent throughout the period of decline with the use of mature, open woodland with a preference for oak and a possible relationship with wet features. Furthermore, with the recent dataset we have been able to establish...
the importance of the extent of woodland in the wider landscape.

The RWBS (Amar et al. 2006) documented changes in woodland structure between the early 1980s and the early 2000s, during which time there was an increase in sub-canopy cover at 2–10 m, low vegetation cover (below 2 m), canopy height and deadwood. If Lesser Spotted Woodpeckers are selecting open woods, this change may have created sub-optimal conditions and may be related to the observed change in population. However, wood openness could be a product of

The RWBS (Amar et al. 2006) documented changes in woodland structure between the early 1980s and the early 2000s, during which time there was an increase in sub-canopy cover at 2–
mature woodland with high canopy cover which has the effect of over-shading and therefore creating an open horizontal structure. Lesser Spotted Woodpeckers spend most of their time foraging in the canopy (our obs.) and it seems plausible that this variable acts as a proxy for the species’ selection of mature stands with high canopy cover. Further work is required at a finer scale to establish the relationship between canopy requirements for Lesser Spotted Woodpeckers and wood openness.

The results do not suggest that understorey should be cleared in woodlands to assist Lesser Spotted Woodpeckers, as that would be to the detriment of other species and the effect will not alter the layer the species forages in.

Lesser Spotted Woodpeckers favoured oak-dominated woodlands. Oak is an important tree species for foraging and nesting. From autumn to early spring, Lesser Spotted Woodpeckers feed almost exclusively on wood-living insect larvae extracted

### Table 4. Comparison of significant results from the 1980s survey and the 2007 survey.

<table>
<thead>
<tr>
<th>Category</th>
<th>1980s RWBS data</th>
<th>Intensive survey 2007</th>
<th>Agreement between two time periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field layer</td>
<td>No correlations</td>
<td>More likely to be found during surveys in woods with low herbaceous cover</td>
<td>No</td>
</tr>
<tr>
<td>Understorey</td>
<td>More likely in woods with high cover at 4–10 m</td>
<td>More likely in woods with low cover below 2.4 m</td>
<td>Yes</td>
</tr>
<tr>
<td>Tree size</td>
<td>More likely in woods with tall trees</td>
<td>More likely in woods with tall trees</td>
<td>Yes</td>
</tr>
<tr>
<td>Deadwood</td>
<td>More likely in woods with more dead limbs</td>
<td>No correlations with deadwood</td>
<td>No. Needs further testing at finer scale</td>
</tr>
<tr>
<td>Landscape</td>
<td>Landscape not tested</td>
<td>More likely to occur within a wooded landscape</td>
<td>n/a</td>
</tr>
<tr>
<td>Other habitat</td>
<td>More likely in oak woods</td>
<td>More likely in oak woods</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>More likely in woods with a greater proportion of wet features</td>
<td>No association with wet features</td>
<td>No. Needs further research</td>
</tr>
</tbody>
</table>

Figure 3. Relationships between variables significant at stage 2 of the analyses and the probability of Lesser Spotted Woodpeckers being detected during surveys in the 1980s in woods in southeast England. Solid line shows the modelled relationship and circles show the mean figure per site. (a) Percentage of vegetation cover at 4–10 m; (b) maximum height; (c) water features in a wood; (d) the number of dead limbs > 20 cm on live trees.
from small-diameter dead branches on living trees (Cramp 1985, Olsson 1998). From bud-burst and through the breeding season a high proportion of their diet comprises surface-living insects such as aphids and caterpillars and bark-dwelling invertebrates, which are gleaned from the bark and leaves (Wiktander et al. 1994, Olsson 1998). Aphids and especially caterpillars also make up the vast majority of the food given to nestlings (Wiktander et al. 1994). Breeding has been reported to coincide with oak bud-burst (Wiktander et al. 1994, Olsson 1998). Aphids and especially caterpillars also make up the vast majority of the food given to nestlings (Wiktander et al. 1994). Breeding has been reported to coincide with oak bud-burst (Wiktander et al. 1992, 2001). Furthermore, laying date has been found to be strongly influenced by the availability of food in deadwood more than a month before laying (Olsson et al. 1999). An alternative explanation of a preference for oak stands is that areas dominated by oak contain other favoured species for nesting and foraging. In southern Sweden, Lime Tilia cordata is a preferred species and forest stands are selected on this basis. However, these stands are also dominated by oak (Olsson 1998). Finer-scale work on habitat selection will establish any preferences such as these in Britain.

The relationship found with the amount of woodland at the landscape level is supported by several studies from continental Europe. Wiktander et al. (1992) found that the frequency of occurrence of Lesser Spotted Woodpeckers in large (200-ha) census areas increased with the total area of deciduous woodland. Where there was < 17 ha, the frequency of occurrence was 24%, rising to 62% where there was 17–38 ha, and those areas with more than 38 ha had a frequency of Lesser Spotted Woodpecker occurrence of 80%. Opdam et al. (1985) suggested that isolation of woodlots in The Netherlands may be a factor determining the distribution of Lesser Spotted Woodpeckers in the landscape. They found a weak correlation between the presence of the species and the area of forest within a 3-km radius.

This requirement for a wooded landscape is also supported by the species’ large home-range. Hontsch (2004) found that Lesser Spotted Woodpecker home-range averaged 211 ha in winter, 131 ha in the pre-breeding season and 27 ha in the breeding season. Wiktander et al. (2001) found similarly large territories in the winter: 742 ha, reducing to 355 ha in early spring, 103 ha in late spring and 43 ha during nesting. The reasons for this seasonal variation in home-range size are not fully understood, but it has been proposed that it may relate to territorial behaviour and be a trade-off between energy demand and predation risk (Wiktander et al. 2001). Olsson and Wiktander (unpubl. data) report that in winter in Sweden, Lesser Spotted Woodpeckers spend more time foraging in spruce, possibly because energy demands are lower at this time (Wiktander 1998). This allows the species to select habitats of greater safety (e.g. no defoliation in spruce forests) rather than energetic profitability (Olsson 1998); therefore they select a large territory encompassing this habitat type and minimize their predation risk as a result.

Woodland cover in Britain has undergone considerable changes over time. Results from the latest Countryside Survey (Carey et al. 2008) show that whilst woodland cover is increasing currently in England (5.8% increase between 1998 and 2007 and 10.6% between 1990 and 2007), this is largely due to new plantings, which are unlikely to be suitable for Lesser Spotted Woodpecker at the current time. There is some evidence from the same survey that woodland quality is decreasing, as there has been a long-term decrease in plant species richness in broadleaved woodland of 19% between 1990 and 2007 in the areas targeted by the Countryside Survey for their botanical interest. Furthermore, connectivity of woodlands may have decreased over time, with the woodland resource becoming increasingly fragmented. The total length of woody linear features deceased by 1.4% in England between 1998 and 2007, following an increase between 1990 and 1998, and a decrease between 1984 and 1990. The length of ‘managed’ hedgerows decreased by 6.1% between 1998 and 2007, with a large proportion of ‘managed’ hedges turning into lines of trees or relict hedges due to lack of management. For a species with a requirement of a large amount of wooded area across a large area, this trend may be of concern. Lesser Spotted Woodpecker populations may be surviving in heavily wooded parts of the country where it is possible for them to retain their large territories and cover large areas, making use of hedgerows and other types of woodland.

Hontsch (2004) recommended that conservation strategies for Lesser Spotted Woodpecker should focus on creating and maintaining networks of suitable habitats rather than large patches of uniform habitat, as the species probably tolerates a certain amount of fragmentation in its home-range. Miranda and Pasinelli (2001) concluded that the distribution of Lesser Spotted Woodpecker was
affected by variables associated with forest structure and the relative position within the landscape and, like Hontsch (2004), habitat connectivity was suggested as a conservation measure.

The importance of deadwood was only suggested in the 1980s analyses. Deadwood of the sort measured in this study has increased over time (Amar et al. 2006), and therefore lack of correlations in the recent dataset do not necessarily mean a lack of importance. All the woods in the intensive survey had higher levels of deadwood than the 1980s surveyed woods. The deadwood variables measured in this and the 1980s study were dead trees, ground deadwood over 10 cm diameter and 1 m in length, and dead limbs > 20 cm in diameter on live trees. Lesser Spotted Woodpeckers forage on small-diameter dead branches in live trees (Smith 2007) and nest in dead trees or areas of deadwood on live trees (Smith 2007, Kosinski & Kempa 2007), so the deadwood we measured may not have been the correct sort to establish an association. It is also possible that Lesser Spotted Woodpeckers may be selecting areas of deadwood at a scale finer than the wood level.

There is a suggestion that Lesser Spotted Woodpeckers prefer damp woodlands (Cramp 1985). Indeed, Wiklander et al. (1992) suggested that a possible cause of the Lesser Spotted Woodpecker decline in Sweden could be due to the large-scale felling of riparian woodland. Miranda and Pasinelli (2001) also found a positive association between Lesser Spotted Woodpecker occurrence and distance to water features. In this study, the species was found to have a relationship with wet features in the 1980s data. This relationship was not apparent in the 2007 dataset, although there was a positive trend between soil wetness and Lesser Spotted Woodpecker occurrence in a small sample of woods. Soil moisture has been found to be associated with wood occupancy in the Willow Tit Poecile montanus, another declining woodland species (Lewis et al. 2007, 2009a,b). We suggest that this factor needs careful consideration in the decline of the Lesser Spotted Woodpecker and further research is required.

Fuller et al. (2005) proposed three hypotheses to explain the decline: interactions with Great Spotted Woodpecker, changes in wood-scale habitat (especially deadwood and deadwood invertebrates), and landscape-scale changes in tree abundance. There was no evidence from the intensive studies that Lesser Spotted Woodpecker occurrence in a wood is related to Great Spotted Woodpecker abundance. There was also no supporting evidence that Grey Squirrel density had a negative effect on Lesser Spotted Woodpeckers. It is therefore suggested that the correlation found in the RWBS is likely to be a product of a relationship with another variable. There was also little suggestion that deadwood of the type measured and at the scale reported here is related to Lesser Spotted Woodpecker occurrence within a wood, although as already discussed, we suspect that there may be associations at a finer scale. We know that deadwood has generally increased over time but the resources used by Lesser Spotted Woodpeckers may have declined. Furthermore, we have no information about deadwood invertebrates in the study woods and how they have changed. The final hypothesis was that there may have been landscape-scale changes which have impacted the Lesser Spotted Woodpecker. Currently, due to what we know regarding connectivity of woodlands and the suitability of new plantings, this may be the most plausible hypothesis for influences on Lesser Spotted Woodpecker populations. However, this study has not been exhaustive and other potential limiting factors remain untested.

Management recommendations

If our findings are representative of the British range of the Lesser Spotted Woodpecker, habitat management for the species needs to focus on maintaining a network of connected woodlands within an area of around 3-km radius of mature woodlands. The relationship with landscape should be used to target remaining well-wooded areas within the species current range for finer-scale habitat manipulations, and there should be measures to encourage habitat connectivity in areas where Lesser Spotted Woodpeckers remain. Further work is required to establish the role of wet features, deadwood and finer-scale habitat selection, such as that required for breeding territories and specific foraging requirements, as well as other factors potentially limiting populations.

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