Managing competition between birds and bats for roost boxes in small woodlands, north-east England

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SUMMARY

A total of 196 bat boxes were installed between 2005 and 2009 across 21 sites throughout the Highways Agency's (HA) 'soft estate' woodland in north-east England in support of the HA's Biodiversity Action Plan. The woodlands are typically small linear blocks (<3 ha) with trees mostly less than 40 years of age. Suitable natural cavity sites are thus very limited, hence the attractiveness of bat boxes as a conservation measure to enhance these woodland habitats. Monitoring in 2006-2007 had shown that in some areas (seven woodland sites) over 40% of bat boxes were being used by nesting passerine birds. Bird boxes were installed in an attempt to reduce bird occupancy of bat boxes. Provision of bird boxes significantly reduced bird use of bat boxes (a 50% overall reduction in occupancy) thus potentially making more bat boxes available for bat use. We also assessed if there was any relationship between the number/density of available bat boxes and level of bat occupancy to assess if there was a limit to the occupancy levels that could be achieved, thus determining an approach that could maximise benefits and cost effectiveness of box installation. Occupancy of bat boxes by bats appears not to increase above 30% utilisation with an increasing number of boxes on site after eight boxes. This suggests that, as bat boxes are installed three boxes per tree (as per best practice guidelines), the optimal number to install would generally be between nine to 12 boxes in these small woodland areas.

BACKGROUND

The Highways Agency (HA) is responsible for the maintenance of motorways and trunk roads across England. The HA Biodiversity Action Plan (HABAP) is central to the delivery of biodiversity objectives by the HA, and this current study links with three main bat (Chiroptera) related conservation objectives in the HABAP:

1) to raise awareness of bat conservation issues among HA staff, Managing Agents and consultants;
2) to maintain detailed records of known bat roosts on and close to the network;
3) to safeguard and enhance known bat populations on and close to the network.

In England, all bat species and their breeding sites or resting places (roosts), are protected under Regulation 41 of The Conservation of Habitats and Species Regulations 2010, and Section 9 of the Wildlife and Countryside Act 1981. However, more applicable to this study are the statutory requirements regarding the conservation of bats by public bodies such as the HA. Public and Local Authorities have a statutory obligation to conserve and enhance biodiversity under the Natural Environment and Rural Communities Act 2006 (NERC 2006). This Act extended the biodiversity duty set out in the Countryside and Rights of Way Act 2000 (CRoW 2000). A key element of our monitoring work is development of wildlife conservation enhancement works that are effective and cost-efficient.

This present study reports work undertaken throughout the 'soft estate' of HA Managing Agent Contract (MAC) Area 14. This comprises the main motorway and trunk roads

in Northumberland, County Durham and parts of North Yorkshire and Teesside (north-east England). Soft estate is the name given by the HA to roadside verges and associated habitats, such as small woodlands, that edge motorways and trunk roads.

The majority of the tree stock within Area 14 is generally less than 40 years old, so they are generally too young to have natural features such as deep bark cracks, crevices and rot holes that bats can use for roosting. Boxes were therefore provided as artificial alternatives to these natural features for bats in which to roost. The woodlands in the HA soft estate tend to be linear blocks and all are in rural locations. Although generally small in size (the largest being approximately 3 ha), the majority have a high level of connectivity with adjacent areas of good quality habitat and other features (e.g. rivers and hedgerows) of value to bats as, for example providing foraging areas and roosting opportunities.

A total of 196 bat boxes were installed across 21 sites in 2005-2009. Ninety-eight boxes were installed at eight sites across the network in 2005-2006. Boxes were installed in 2007 at five new sites and in 2008-2009 at a further eight. Some boxes (approximately four) were removed due to essential tree maintenance, relocated due to road improvement schemes (particularly A66 widening works), or lost through theft (approximately five). Boxes were installed following Bat Conservation Trust (2007) and Joint Nature Conservation Committee guidelines (Mitchell-Jones 2004) i.e. in sets of three per tree (to cover different aspects) at a height of at least 4 m above the ground. All boxes installed were Schwegler 'woodcrete' 2FN boxes (approx. GBP£30/box). This box design (16 cm diameter x 36 cm high and 4.3 kg in weight) has two entrances - one at the front and one at the rear (against the tree), with a domed roof. Woodcrete (a wood, concrete and clay blend) does not rot, leak or crack, and boxes purportedly last for at least 20-25 years (Schwegler-nautr website).

Boxes were originally strapped to trees, however after several seasons, trees showed signs of 'girdling' and the straps were replaced with nails. Aluminium alloy nails were used which are less damaging to saws and chipping machinery during any future management work. The tree species upon which the boxes were erected varied from site to site. All sites identified for installing bat boxes were considered to have potential benefit for bats due to the proximity of existing bat records, suitable landscape features and/or adjacent mature woodland.

Bat boxes were surveyed for evidence of bat use in November 2006, November 2007, September 2008 and October 2009 (corresponding with bat mating season) by Natural England licensed bat ecologists. Evidence for bat presence or use by roosting bats included bats occupying the box, corpses or skeletal remains, and droppings. During these surveys, bat species using boxes were pipistrelle *Pipistrellus* spp; brown long-eared *Plecotus auritus*, Natterer's *Myotis nattereri* and whiskered *M. mystacinus* /Brandt's *M. brandtii* (the latter two similar species were not identified to species to reduce disturbance).

During the 2006 survey, 37% of bat boxes across the eight sites were recorded as being used by birds (most frequently blue tit *Cyanistes* (*Parus*) *caeruleus* and great tit *Parus major*). In 2007, 30% showed evidence of bird occupancy. Birds will nest in bat boxes during spring-summer, but also use them at other times of the year for roosting. Bats are displaced by birds and the availability of roosting/breeding habitat is thus reduced. It is highly unlikely that a box could function with both nesting birds and bats using it. The birds create nests, elevating their activity to the upper areas of the box cavity where bats would roost. This places any bats sharing the box at risk of the young/adult birds interfering with them, and adult great tits are known to kill bats (Estok *et al*. 2010.).

ACTION

Additional bird nest boxes (two to15 per site) were installed in February 2008 prior to the onset of the breeding season at seven of the eight original sites where bat boxes had been installed in 2005-2006 (Table 1). The assumption was that a breeding pair of birds occupying a bird box will defend their territory, thus excluding other birds from using bat boxes present within the territory, thus retaining the availability of bat box for bats. In some cases bird boxes were already at the site, in other cases there were no existing boxes.

Table 1. Woodland study sites where bird boxes were installed in an attempt to reduce occupation of bat roost boxes by birds, summarising bat box occupancy by birds (2006-2007).

Site	County	Area	Bat box occupancy by birds (2006-2007)	Number of bat boxes (density per ha)	Number of bird boxes (density per ha)
Ellingham Lodge	Northumberland	0.7 ha	56 %	9 (13)	3 (4)
Charlton Hall	Northumberland	0.8 ha	44 %	20 (25)	15 (19)
Woodham Wood	County Durham	1.0 ha	3 %	24 (24)	11 (11)
Beech Trees	County Durham	0.9 ha	9 %	16 (18)	4 (4)
Ewebank	North Yorkshire	0.5 ha	100 %	3 (6)	2 (4)
Greta Bridge	North Yorkshire	0.6 ha	89 %	12 (20)	11 (18)
Sedbury Hall	North Yorkshire	0.8 ha	75 %	6 (8)	9 (11)

The bird boxes erected comprised approximately equal numbers with a 26 mm diameter entrance hole (designed for blue, coal *Periparus* (*Parus) ater* and marsh tits *Poecile (Parus) palustris*), and 32 mm entrance hole (suitable also for great tit, tree sparrow *Passer montanus*, house sparrow *P. domesticus* and nuthatch *Sitta europaea*). The additional bird boxes were placed so that the bat boxes were likely to fall within the territory of pairs occupying these new bird boxes (installed in February 2008 prior to the onset of the breeding season).

The main habitats at the seven study sites were:

1) Ellingham Lodge - 0.7 ha of broadleaved woodland dominated by beech *Fagus sylvatica*, ash *Fraxinus excelsior* and sycamore *Acer pseudoplatanus*.

2) Charlton Hall - a 0.8 ha strip of semi-natural broadleaved woodland bisected by a stream, with a small patch of conifers linking with an adjacent conifer plantation on the opposite side of the A1 trunk road.

3) Woodham Wood - 1 ha of broadleaved plantation adjacent to Woodham Burn that joins the River Skerne 50m north of the wood.

4) Beech Trees – a 0.9 ha linear belt of mixed plantation woodland adjoining the River Tees.

5) Ewebank - a narrow (approximately 15 m wide) linear 0.5 ha area of mixed plantation woodland adjacent to the A66, continuing to the River Greta to the east.

6) Greta Bridge - 0.6 ha area of broadleaved plantation (adjacent to Ewebank) with the River Greta flowing beneath the carriageway.

7) Sedbury Hall – a 0.8 ha narrow (15-20 m at widest point) broadleaved woodland within the central reservation of a newly dualled section of a trunk road.

Analysis: A 2 x 2 chi-squared contingency table (Fowler & Cohen 1990) was used to test the success of providing additional bird boxes to divert birds from nesting/ roosting in bat boxes. We compared the proportion of bat boxes used by birds before and after installation of bird boxes. As bird boxes were installed in February 2008 prior to the bird breeding season, data collected on bird occupancy in 2006 and 2007 are classed as 'before', and data collected in 2008 and 2009 are 'after' the treatment.

Our null hypothesis was that the boxes would be in the same proportions. We believe that this simple hypothesis is valid as it is unlikely that other factors could account for the change of occupancy, except for availability of suitable nest boxes. One exception could be that although management operations within the woodlands (2006-2009) were limited, some mature willow (*Salix* spp.) trees in Woodham Wood were removed (for safety reasons).

CONSEQUENCES

Results indicate that, overall, birds were using the newly installed bird boxes in preference to the bat boxes. The majority of birds nesting in bird boxes were blue tits. The number of bat boxes with evidence of bird activity each year at the seven sites between 2006 and 2009 is summarised in Figure 1.

Over this period, overall bat box occupancy by bats across all seven sites increased: 9% occupancy in 2006, 18% in 2007, 12% in 2008 and 17% in 2009. At five of the sites, use of bat boxes by birds was lower in 2008 and 2009 than in 2006 and 2007. However, there was higher use of bat boxes by birds after installation of the additional bird boxes at two sites, Ellingham Lodge and Woodham Wood. The occupancy of these boxes by birds ranged from 40 to 100% (mean 79%). It is not known why occupancy by birds increased at these sites, but, bat box use by bats at Ellingham Lodge was low throughout the study period regardless of installation of bird boxes. At Woodham Wood, although occupancy of bat boxes by birds increased in 2008 and 2009, occupancy by bats was consistent in both years. As removal of some more mature willow trees occurred at this site, perhaps this reduced the number of natural cavities available for birds, although the trees that were removed were considered small in terms of their suitability for bats. Occupancy data from the bat boxes at all seven study sites between 2006 and 2009 are summarised in Table 2. Although the increase in use of the bat boxes by bats has not increased in the same proportion as the decrease in use by birds, overall use of the bat boxes by bats increased from 7.8% to 12.8%. Bird occupancy in 2006 outnumbered bat use by about 5:1, falling to 2:1 by 2009.

The site at Charlton Hall is interesting in that use of the bird boxes by birds in 2009 was lowest (40%), yet the decrease in the number of bat boxes used by birds in 2008 and 2009 was also marked. Ellingham Lodge and Woodham Wood showed increases in occupancy of the bat boxes, but also showed a high occupancy of the additional bird boxes. For the Greta Bank, Sedbury and Beech Trees the increase in bat use and concurrent decrease in displacement by birds was reflected by an occupancy of the additional bird boxes of 91%, 83% and 75%, respectively.

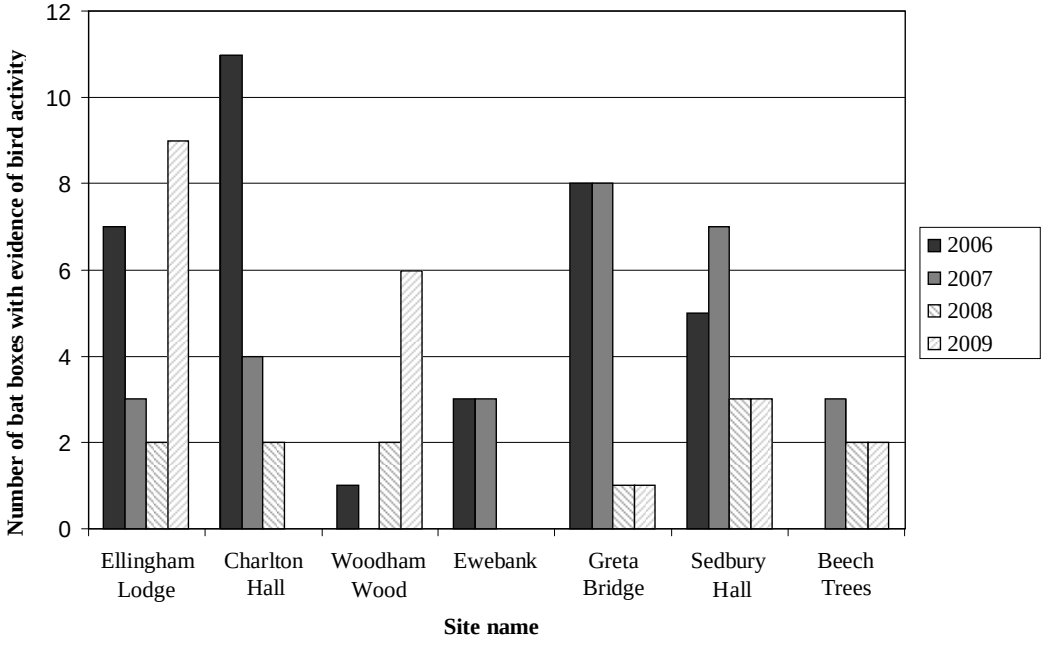

Figure 1. Number of bat boxes with evidence of bird activity in 2006 to 2009, at the seven sites where bird boxes were installed prior to the breeding season in 2008.

Table 2. Occupancy of bat boxes by birds with occupancy by bats in parenthesise. The use of the additional bird boxes provided at each of the site is shown.

Location	Bird use of bat boxes (bat occupancy in parenthesise)				Use of additional bird boxes (number of boxes available)
	2006	2007	2008	2009	2009
Ellingham Lodge	7 (1)	3 (0)	2 (1)	9 (0)	2 (3)
Charlton Hall	11 (5)	4 (7)	2 (3)	0 (3)	6 (15)
Woodham Wood	1 (1)	0 (5)	2 (5)	6 (5)	8 (11)
Ewebank	3 (0)	3 (0)	0 (1)	0 (1)	1 (2)
Greta Bridge	8 (0)	8 (0)	1 (1)	1 (0)	10 (11)
Sedbury Hall	5 (0)	7 (1)	3 (1)	3 (0)	5 (6)
Beech Trees	0 (0)	3 (0)	2 (1)	2 (2)	3 (4)

Occupancy of bat boxes by birds in 2006 and 2007 '*before*' adding bird boxes and occupancy of bat boxes by birds 2008 and 2009 '*after*' adding bird boxes was significantly different ($X^2_1 = 17.37$, $P<0.0001$). This suggests that overall, a reduction in occupancy of bat boxes by birds can be affected through the provision of bird boxes, thus reducing displacement of bats. In terms of overall occupancy of bat boxes by birds, this was reduced from 38% before the addition of nest boxes to 17% after (Figs. 2a and 2b).

As part of the wider assessment of the efficacy of bat box provision, we considered whether there is a relationship between bat use and number of bat boxes or, a diminishing benefit once an 'optimum' number has been achieved. For the purposes we analysed data from a total of 196 bat boxes installed across all 21 sites (between 2005 and 2009) within Area 14.

We looked at the number of bat boxes used by bats at each site, for the whole survey period 2006-2009 and compared this to the number of bat boxes installed (Fig. 3). Spearman's rank correlation shows a weak but statistically significant positive correlation ($r_s = 0.26$, $p = 0.04$, $n = 50$) between the number of bat boxes used and the number installed. This shows that, as the number of boxes installed at a site increases, so does the number of bat boxes used by bats. The highest proportion occupied was seven boxes utilised with 26 boxes (27%) installed at a site.

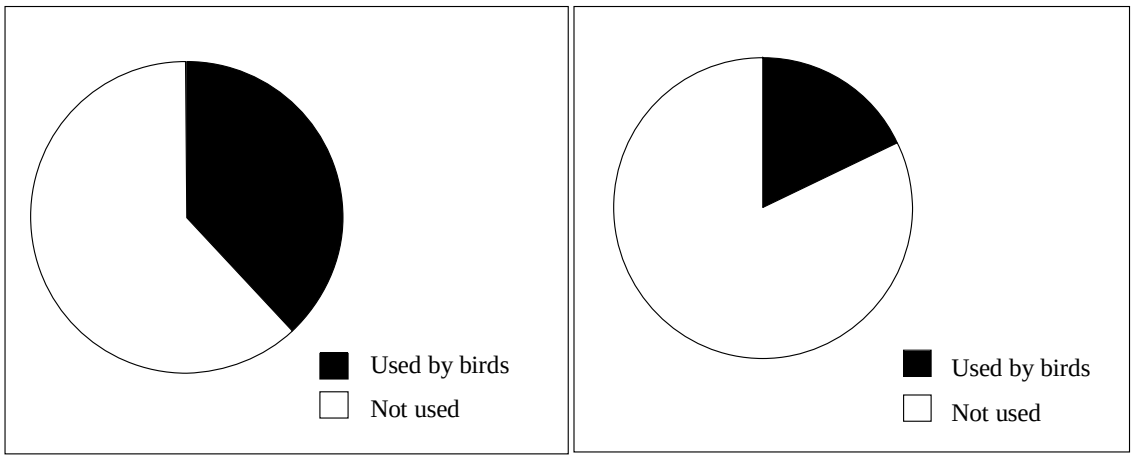

Figure 2a. Occupancy of bat boxes by birds in 2006 and 2007 '*before*' adding bird boxes (left) and **2b**: occupancy of bat boxes by birds 2008 and 2009 '*after*' adding bird boxes (right).

When comparing the proportion of boxes used by bats with the number installed (Fig. 4), Spearman's rank correlation shows that there is a weak, though not statistically significant, negative correlation (r_s=-0.24, p=0.15). Although occupation of bat boxes may increase initially overtime our data suggest that the proportion of bat boxes occupied in relation to the number of boxes installed increases up to five boxes, and then levels off at around 30% utilisation when there are eight boxes installed at a site.

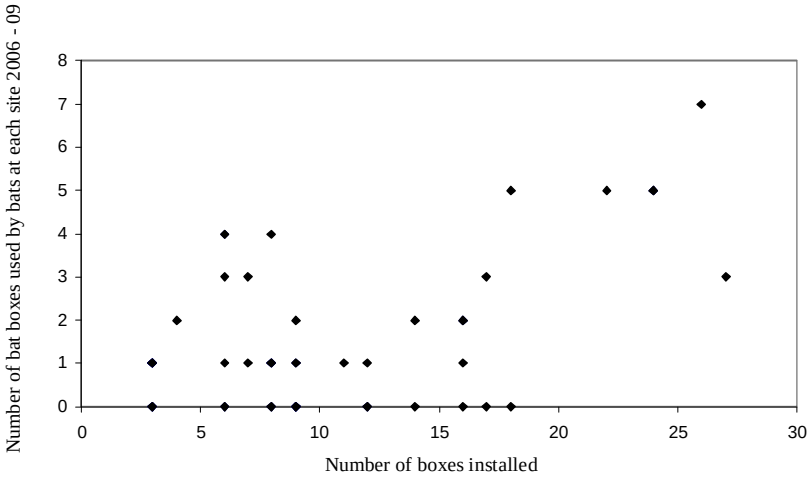

Figure 3. Number of bat boxes used compared with number of bat boxes installed from 2006-2009.

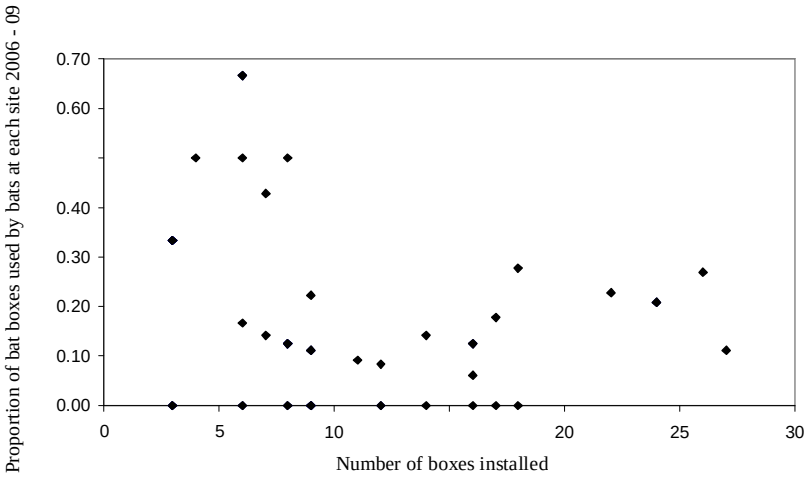

Figure 4. Proportion of bat boxes used by bats compared with number of bat boxes installed between 2006- 2009.

Conclusions and discussion: In the seven woodland study sites (trees predominantly less than 40 years of age) encouragingly, bat boxes were used by bats as roost sites in otherwise habitat of marginal suitability due to the lack of natural breeding/roost sites. Displacement of bats from bat boxes by birds (primarily for nesting but also roosting) was identified as a problem. Subsequent to installation of bird boxes at sites where displacement of bats was considered high (i.e. above 40%), overall, bird use of bat boxes was significantly reduced, whilst bat use increased. It is thus recommended that consideration be made regarding provision of bird boxes in addition to bat boxes to improve the likelihood of uptake of bat boxes by bats. Annual maintenance (e.g. removal of old bird nests from bat boxes) will help potential availability of roosting opportunities for bats (by providing roosting space), and help maintain a hygienic environment by removing potential parasites present in nest material or other accumulated debris. Studies by Estok *et al*. (2010.) have shown that great tits may search for, capture, kill and eat hibernating bats and maintaining old nest sites within bat boxes may increase this risk.

Our results suggests that (but bearing in mind the mostly linear nature of the Highways Agency soft estate woodlands) as bat boxes are installed three boxes per tree (as per best practice guidelines), the optimal number of boxes to install would generally be between nine to 12 boxes in our 21 small (<3 ha) Highways Agency woodland sites. Information gained from this study has additionally provided a greater understanding of bat distribution within the Area 14 network. Knowledge gained from this study will be used to further manage and enhance additional soft estate woodlands for bat conservation.

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