

## **Urban development reduces fledging success of Barn Owls in British Columbia, Canada**

Author(s): Sofi Hindmarch, Elizabeth A. Krebs, John Elliott, and David J. Green

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al. 2006) and the loss of agricultural land to urbanization (Filippi-Codaccioni et al. 2008, Ludwig et al. 2009). The value of agricultural land as wildlife habitat is degraded when small fields with rotational crop practices and hedgerows are converted to large, intensively utilized fields with monocultures (Fuller et al. 1995, Wilson et al. 2005). In addition to habitat loss, urbanization creates road networks that fragment habitat and expose wildlife to traffic (Underhill and Angold 2000, Borda-de-Água et al. 2014). These changes in landscape composition have been linked to the reduced reproductive output and survival of many farmland birds (Fuller et al. 1995).

Newton (2004) argued that most of the declines in populations of farmland birds in Britain (~70% of species) are associated with reduced reproductive output rather than reduced adult survival. Changes in agricultural practices can reduce the reproductive output of farmland birds in a variety of ways. Breeding habitat can be lost as a result of the drainage and conversion of grasslands for cultivation (Vickery et al. 2001, Wilson et al. 2005). Intense grazing regimes can reduce nest cover and increase nest predation rates (Chamberlain and Crick 2003). Increased herbicide and pesticide use can reduce food availability (Rands 1985, Taylor et al. 2006) and reduce the number of breeding attempts and breeding success (e.g., Browne and Aebischer 2004, 2005). Increased use of fertilizers also allows earlier and more frequent haying, which reduces the nesting success of ground-nesting birds (Green and Stowe 1993, Schekkerman et al. 2008).

Range contraction and population declines of Barn Owls (*Tyto alba*) in Europe and North America have also been attributed to changes in agricultural landscapes that reduce both adult survival and reproductive output (Bunn et al. 1982, Colvin 1985, Taylor 1994, Toms et al. 2001, Ramsden 2003). For example, increases in road networks are associated with reduced survival of Barn Owls because the owls hunt on grassy verges along roads, making them vulnerable to collisions with vehicles (Ramsden 2003, Preston and Powers 2006, Boves and Belthoff 2012, Borda-de-Água et al. 2014). Increased use of second-generation anticoagulant rodenticides, which are lethal to Barn Owls, may also contribute to population declines by poisoning adults and young (Newton et al. 1990, Albert et al. 2010). Agricultural intensification reduces the number of potential breeding sites by removing wooden barns and old trees (Taylor 1994, Ramsden 1998). Fin12oten-



sexing was conducted using the primers P2 and P8, which bind to the Z and W chromosomes (Griffiths et al. 1998). Female nestlings had a higher asymptotic mass than males (females: mean = 539.3 g, 95% confidence interval [CI]:

voles) for each year by subtracting the mean and dividing by the standard deviation for each year to remove interannual variation. For nests monitored in both years, we then used averages of these standardized estimates in subsequent analyses.

We analyzed the data in 3 steps because we had a larger sample of nests with associated landscape data ( $n = 40$  nest sites) than of nests with diet composition data ( $n = 28$  nest sites). First, we used the larger dataset to examine the



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had confidence intervals that bounded zero (Tables 3 and 4).

Brood condition (mean standardized asymptotic mass) was unrelated to the landscape composition surrounding a Barn Owl nest. The null model in this candidate model set received 1.5 $\times$  the support of the best landscape model that included the highways term (Table 3). Weighted parameter estimates of the landscape terms all bounded zero (Table 4).

Barn Owl clutches contained 2–8 eggs ( $5.4 \pm 1.6$ ,  $n = 37$ ). Clutch sizes at nests monitored in both years were similar in 2007 ( $5.5 \pm 1.6$ ) and 2008 ( $4.6 \pm 1.4$ , paired  $t$ -test,  $t_{10} = 1.02$ ,  $P = 0.33$ ). Standardized clutch size did not vary with landscape composition. The null model was the best model in the candidate model set; no models with landscape variables received strong support (Table 3). Weighted parameter estimates of the landscape terms all bounded zero (Table 4).

Brood reduction was common and, on average,  $41 \pm 25\%$  of hatched young failed to fledge ( $n = 28$  broods). Levels of brood reduction did not vary between years at nest sites monitored in both 2007 and 2008 (paired  $t$ -test,  $t_{12} = 0.06$ ,  $P = 0.95$ ). Standardized levels of brood reduction increased as the amount of urban cover increased (Figure 3). The model including the urban cover term received more than 90 $\times$  the support of the null model. The weighted parameter estimate for the urban cover term ( $2.04 \pm 0.52$ ) had 95% CIs that did not bound

zero (Tables 3 and 4). The remaining models all received less support than the null model, and weighted parameter estimates for the remaining landscape terms all bounded zero (Tables 3 and 4).

### 3

Barn Owls ate a variety of prey; a total of 17 different species were found in the 1,524 pellets collected during the study. Voles, primarily field voles (*Microtus townsendii*) but also creeping voles (*M. oregoni*), were the main prey; the proportion of prey biomass consisting of voles was  $0.70 \pm 0.16$  (range: 0.41–0.92,  $n = 40$ ). The proportion of voles in the diet was correlated between years ( $r_p = 0.58$ ,  $P < 0.05$ ,  $n = 12$ ) but was higher in 2007 ( $0.77 \pm 0.14$ ) than in 2008 ( $0.64 \pm 0.19$ ; paired  $t$ -test,  $t_{11} = 4.04$ ,  $P < 0.001$ ). Additional prey species found in pellets included rats (*Rattus rattus* and *R. norvegicus*), mice (*Peromyscus maniculatus* and *Zapus trinotatus*), shrews (*Sorex cinereus*, *S. monticolus*, and *S. vagrans*), moles (*Scapanus orarius* and *Neurotrichus gibbsii*), rabbits (*Sylvilagus floridanus*), and several bird species (including *Sturnus vulgaris*, *Colaptes auratus*, *Columba livia*, and *Calidris mauri*).

There was limited evidence that the landscape composition surrounding a nest site influenced diet composition during the breeding season. The null model received almost twice the support of the next best model, which included the urban cover term. None of the other

landscape models received strong support (Table 3). Weighted parameter estimates of all the landscape terms also had confidence intervals that bounded zero (Table 4).

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There was little evidence to indicate that landscape effects



populations than the area of grassland that provides foraging habitat.

Barn Owls could be negatively affected by the amount of residential, commercial, and industrial land within their home range because urbanization reduces the quality or quantity of prey in surrounding foraging habitat. Diet composition, specifically the proportion of prey biomass consisting of voles, has been argued to be an indicator of diet quality for Barn Owls (Fast and Ambrose 1976, Derting and Cranford 1989, Taylor 1994). In the Fraser Valley, we found that Barn Owl fledging success and levels of brood reduction were negatively affected by the amount of urban cover within their home range, but that



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