

# Den boxes as a tool for pine marten *Martes martes* conservation and population monitoring in a commercial forest in Scotland

Elizabeth Croose<sup>1\*</sup>, Johnny D.S. Birks<sup>2</sup> & John Martin<sup>3</sup>

<sup>1</sup>The Vincent Wildlife Trust, 3&4 Bronsil Courtyard, Eastnor, Ledbury, Herefordshire, HR8 1EP, UK

<sup>2</sup>Swift Ecology Ltd, Glen Cottage, Lower Dingle, West Malvern, Worcestershire, WR14 4BQ, UK

<sup>3</sup>Myotismart Ltd, Horncop Bungalow, Heversham, Milnthorpe, Cumbria, LA7 7EB, UK

## SUMMARY

The pine marten *Martes martes* is a woodland specialist that favours above-ground arboreal den sites to rest and breed in. Sheltered, elevated den sites are particularly crucial for meeting the needs of breeding females and a scarcity of suitable sites may be a critical constraint upon pine marten populations. An artificial den box for pine martens was designed and 50 boxes were installed in part of Galloway Forest, southwest Scotland, in order to (a) increase the availability and diversity of suitable den sites for breeding female martens and (b) aid monitoring of the marten population. The boxes were monitored for signs of use once a year. A proportion of the boxes was occupied by martens every year and the boxes were used by breeding females to raise their young. The den boxes can be implemented as a habitat enhancement and conservation tool, particularly in commercial forests, and used to monitor marten populations and breeding success. We recommend that conservation programmes for pine martens should consider the installation of den boxes as a habitat enhancement and monitoring tool.

## BACKGROUND

The pine marten *Martes martes* is a native British mammal that is currently recovering and expanding its range following a severe population decline during the 18<sup>th</sup> and 19<sup>th</sup> centuries, to a nadir in 1915 (Langley & Yalden 1977, Croose *et al.* 2013). The pine marten is a three-dimensional habitat specialist that preferentially occupies woodland, favouring above-ground arboreal den sites to rest and breed in, including tree cavities, branches, squirrel dreys and bird nests (Birks *et al.* 2005). Sheltered, elevated den sites are particularly crucial for meeting the needs of breeding female martens (Brainerd *et al.* 1995).

A scarcity of arboreal cavities for den sites may limit pine marten distribution and abundance in forests (Brainerd *et al.* 1995). Due to the low diversity of ages and sizes of trees in most woodland in Britain and Ireland, elevated cavities suitable for martens are mostly rare or absent. A review of marten den sites in Scotland found that only 9.8% of all dens were in elevated tree cavities (Birks *et al.* 2005). During a radio-tracking study of martens in Galloway Forest, Scotland, only one tree hollow den was found of 85 dens detected (Bright & Smithson 1997). In response to a lack of above-ground den sites, martens may use alternative sites at or below ground-level, such as burrows, rocks, or tree roots, or bird boxes and buildings (Birks *et al.* 2005). This may result in negative consequences, such as an increased predation risk from red fox *Vulpes vulpes* and golden eagles *Aquila chrysaetos* (Brainerd *et al.* 1995), or disturbance or negative interactions with humans, such as exclusion from dens or persecution (Birks *et al.* 2005). The use of den sites that are assumed to be suboptimal in terms of predation risk and energetic costs may limit breeding success in some populations (Birks *et al.* 2005). This is most likely to occur in commercial

forestry plantations, where trees are too young to have developed cavities and the dominant trees species, such as Sitka spruce *Picea sitchensis*, do not develop suitable cavities. Increasing the diversity and provision of above-ground den sites that reduce predation risk and facilitate thermoregulation is likely to benefit martens and marten breeding success, particularly in commercial forests.

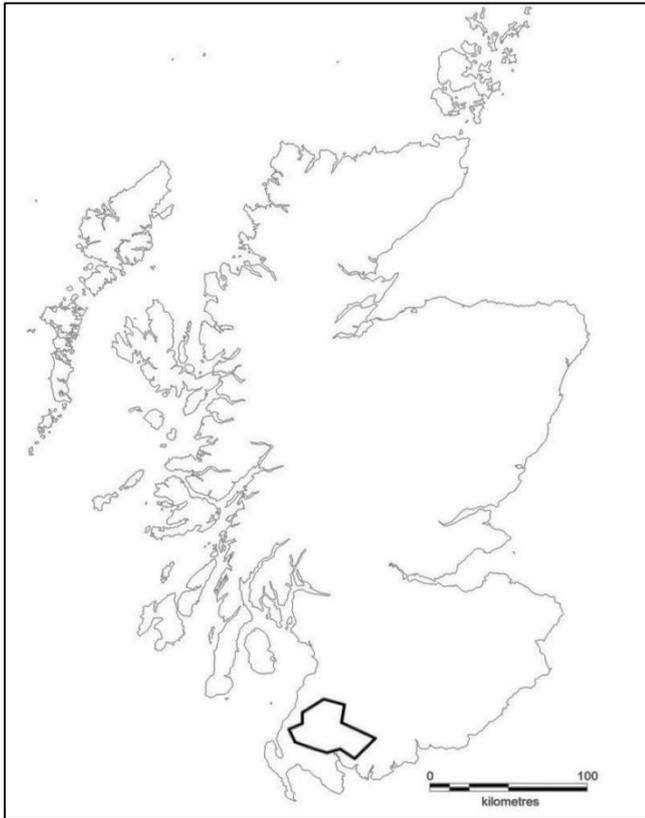
Galloway Forest is situated in Dumfries and Galloway in southwest Scotland and covers approximately 800 km<sup>2</sup> (Forestry Commission Scotland 2014, Figure 1). It was established in 1947 and is managed as a multi-use forest, combining timber production (Sitka spruce with coverage of other coniferous species), human recreation and wildlife conservation. The region has a mild climate with average temperatures ranging from 1.3 °C in winter to 19.5 °C in summer (Met Office 2013) and average annual rainfall of 1,600 mm (Forest Enterprise 2012). In 1980-1981, 12 pine martens were reintroduced into two separate areas of the forest, in order to re-establish a population in southern Scotland, from where they had been extirpated in the late 19<sup>th</sup> century (Shaw & Livingstone 1994).

During the 1990s, pine martens were observed occupying barn owl *Tyto alba* nest boxes in the forest. This stimulated the design and build of a den box for martens, of which 50 were installed in Galloway Forest in order to: (a) increase the availability and diversity of suitable den sites for breeding female martens, specifically in commercial plantations and (b) aid monitoring of the marten population.

## ACTION

**Den box design:** The design of the den box had previously been described in Messenger *et al.* (2006) and the design and installation methods have been refined over the years. The information presented here reflects the refined version.

\* To whom correspondence should be addressed: [elizabethcroose@vwt.org.uk](mailto:elizabethcroose@vwt.org.uk)



**Figure 1.** The location of Galloway Forest in Scotland.

The boxes were 55 cm (height) by 51 cm (width) by 24 cm (depth) and weighed 13 kg (Figure 2). They were constructed from 25 mm softwood and 18 mm exterior grade Water and Boil Proof (WBP) plywood. The central chamber measured 20 cm x 25 cm, with a depth of 50 cm. This matched the size of a black woodpecker *Dryocopus martius* nest chamber, which martens commonly use as den sites in continental Europe. Two internal “chimney” entrances opened into the central chamber and allowed the animal to enter and exit the box from the adjacent tree trunk. The provision of two entrances offered escape opportunities and allows ventilation. The overall design of the box provided insulation, allowed minimal heat loss and prohibited any water penetration. The lid was made of recycled plastic and was gently sloping, allowing water to run off. Two non-rust A2 stainless steel screws were used to prevent the lid



**Figure 2.** The rear (tree side) of the den box showing the two entrances and the horizontal battens.

being dislodged from the box. Two vertical, wooden, pressure treated roofing slate battens measuring 25 mm x 50 mm were fitted to horizontal battens on the rear of the box to stabilise the box on the trunk of the tree. Softwood shavings to a depth of 10 cm were placed inside the chamber of each box as bedding material. Subsequently, it was discovered that a marten-sized depression in the wood shavings indicated recent use and the contrast between the pale colour of the shavings and the relatively dark colour of the animals assisted the observation of the animals. A small camera was installed in some of the boxes to monitor their occupancy, but in several cases the camera and/or cables were damaged by martens, so the cameras were subsequently removed.

**Den box installation:** In total, 50 boxes were installed in Galloway Forest. In February 2003, 10 boxes were installed in Glen Trool in the south of Galloway Forest (55°5' N, 4°33' W). In January and March 2013, an additional 40 were installed, 10 in each of four sites: the Fleet Basin; (55°02'N, 4°16'W); Arreacleoch and Penninghame (50°05'N, 4°48'W and 55°02'N, 4°42'W); Carrick Forest (55°13'N, 4°30'W) and Glen Trool (these were an additional 10 boxes to the existing boxes at this site). By 2013, some of the original 10 boxes installed in 2003 had deteriorated or been lost or removed.

The den boxes were installed at sites where pine martens were believed to be present and in stands of long term retention, in consideration of harvesting and other operational constraints and management practices. Trees selected for box installation were concealed from public roads and had reasonable access for monitoring with ladders. The large size and weight of the den box dictated the minimum size of tree that could feasibly support the box. Finding trees of sufficient size was sometimes challenging, particularly with Sitka spruce trees.

Ideally, the vertical battens on the rear of the box were fixed at a width to fit the curve of the tree trunk, in order to stabilise the box. The circumference of the tree needed to be no greater than the arm span of the person fixing the box (assuming only one person is fixing it), enabling a chain and fixing rope to be passed around the trunk to facilitate fixing. Trees with branches on the lower part of the trunk, beneath the box, were selected, as branches provide a climbing structure for martens.

Each box was fitted to a tree at a height of approximately 4 m, to avoid disturbance by people and ground predators (e.g. foxes). Prior to fixing the box in place, some minor branches were removed if necessary, to facilitate placement of the box against the trunk. The boxes usually faced the prevailing wind, thereby sheltering the two entrances against the tree trunk. The box was hoisted into position in the tree by two people (a ‘hauler’ and a ‘fixer’) using a pulley system and a ladder. A small pulley was attached to a chain around the trunk above the final position of the box. The chain circumference was adjusted by means of a carabine hook. A rope was attached to the box and run through the pulley and down to the ‘hauler’ on the ground. As the ‘hauler’ pulled the rope, the box was guided into position by the ‘fixer’ on the ladder. The box was attached to the trunk using 8 mm rope. The fastening method was refined and subsequently the rope was passed between the vertical battens and the back of the box rather than around the tree and box. The rope was tied and finished with a reef knot between the battens and box, allowing easy adjustment to accommodate increased tree girth and avoid damage to the box

or tree. When the weight of the box was released, it hung against the trunk and the pulley system was removed.

A narrow strip of adhesive material ('mouse glue': Pest Control Supermarket, <http://www.pestcontrolsupermarket.com>) was pinned to the upper edge of the box entrances to collect hair from martens for genetic analysis.

A risk assessment and method statement were produced in agreement with Forestry Commission Scotland. When installing and monitoring the boxes, personal protective equipment was used by surveyors, including a helmet, safety glasses, hi-visibility vests and gloves. Surveyors accessing the boxes had completed ladder training.

**Monitoring:** Den boxes were monitored, under licence from Scottish Natural Heritage, once per year in May, when breeding females are occupying natal den sites with their dependent kits (born during March and April). The boxes were monitored from 2004 to 2016, except for 2013 when there was no systematic monitoring due to resourcing constraints, so there are no data for this year.

Boxes were initially checked for signs of use by observing them from a distance using binoculars. Typically, boxes occupied by breeding females have scats (faeces) on the lid of the box; however, an absence of scats on the lid is not always an indication that a box is unoccupied. Following an initial inspection, a licensed surveyor accessed the box using a ladder. Surveyors kept quiet and calm and limited the number of people visiting the box in order to minimise disturbance and human scent. The lid of the box was carefully lifted in order to ascertain occupancy. Where possible, the information detailed in Table 1 was recorded. A box was classed as occupied or having been occupied either when a marten(s) was observed in the box, or when other signs of use were present (see Table 1). Breeding was confirmed when marten kits (with or without an adult female marten present) were observed in the box.

When an adult female was occupying the box with kits, no further action was taken in order to minimise disturbance. When kits were present in a box without an adult female, because she was out foraging or resting at another den site, the kits were carefully removed from the box and transferred to a cloth holding bag. Surveyors handled kits with gloves in order to avoid transferring scent or infection. Kits were handled by

**Table 1.** Evidence of pine marten use of den boxes.

External evidence of pine marten use	Internal evidence of pine marten use
Scats on the lid of the box (taking account of number and age of scats; fresh to old)	Marten(s) present
Scats on the ground underneath the box	Marten-sized depression in the wood shavings
Vocalisations from the box (growling adult or squeaking kits)	Prey remains and prey caches
Smoothing on the upper surfaces of side branches	Hairs in the box and/or on the entrances
Claw marks on tree trunk and branches	Staining of the wood on the inside of the box

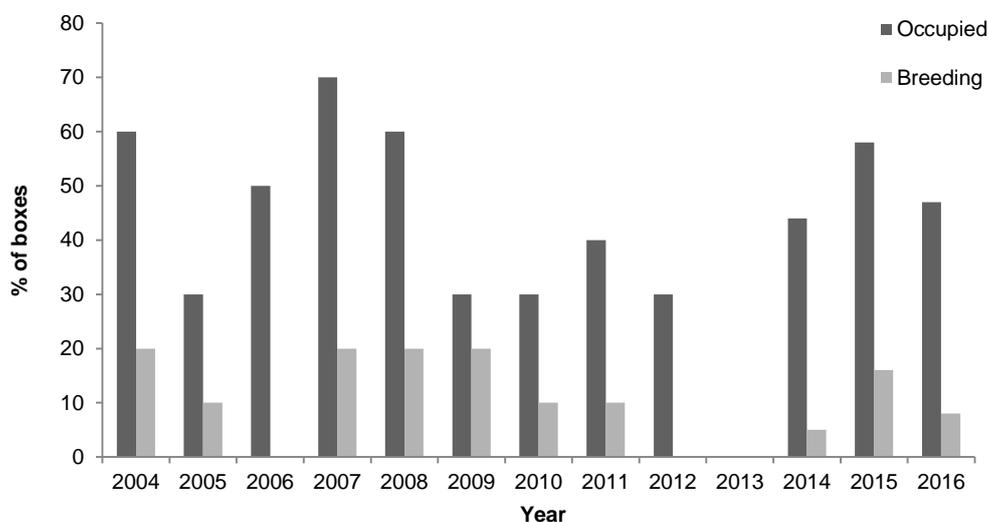
gripping the loose skin on the nape of the neck between finger and thumb, which results in them becoming placid. Gender and weight of the kits were recorded, and hair samples were taken from the back of the animal for genetic analysis before the kits were placed back in the box.

Where scats were present on the lid of the box, these were collected for genetic analysis in order to identify the genotype of the animal occupying the box, and archived for future dietary studies.

As the boxes were monitored only once per year, this was not time consuming. In addition to the monitoring, ongoing maintenance of the boxes was required, particularly as they aged and deteriorated, and some boxes needed relocating in response to harvesting operations or windthrow. The cost of purchasing boxes commercially is £120; the cost of the materials to produce each box is estimated at £25.

## CONSEQUENCES

A proportion of the boxes has been occupied by pine martens every year since installation (Figure 3) and breeding has been confirmed in the boxes in most years (Figures 3 and



**Figure 3.** Percentages of den boxes occupied and used for confirmed breeding by pine martens across four sites in Galloway Forest. The data for 2004-2012 refer to 10 den boxes, the data for 2014-2016 refer to 40 den boxes. The boxes installed in 2003 were not monitored from 2012 onwards, as many had been lost or removed. The boxes were not systematically monitored in 2013, so no data are shown for this year.



**Figure 4.** Three pine marten kits, aged 6-7 weeks, in a den box in Galloway Forest.

4). Some of the boxes were first used by martens in the year following their installation; thus the boxes were found and occupied by martens fairly readily. In the boxes in which the number of kits was confirmed ( $n = 8$ ), the mean number of kits was 1.83 (range 1-3).

## DISCUSSION

The den boxes were occupied readily by pine martens and provided elevated, sheltered resting and denning sites in forests where natural arboreal den sites are scarce. Thus, the den boxes can be implemented as a habitat enhancement tool, particularly in commercial forests. Den boxes were used by breeding females to raise kits. Consequently, the availability of boxes is likely to contribute to marten breeding success and over-winter survival, although this is yet to be substantiated. Furthermore, the boxes can be used as a tool to monitor breeding success in marten populations and gather genetic samples (in the form of scats or hairs collected from the box) for population assessment. Whilst the results are not included here, we are aware that this design of den box has also been used by breeding martens elsewhere in Scotland, and in Wales and Ireland.

The occupancy of boxes and use by breeding females is likely to be affected by several factors, including availability of other den sites, harvesting and management operations in the forest and marten population density. Notably, occupancy of the boxes and marten breeding success could vary between years according to fluctuations in the abundance of field voles *Microtus agrestis*, the marten's favoured prey in Scotland. Elsewhere in Europe, a link between marten litter size and rodent abundance has been documented (Kleef & Wijsman 2015), but there are not currently enough data to examine any trends in Galloway Forest.

A limitation of the use of the den boxes is their weight, which prohibits installation on small or young trees. Some boxes had to be moved prior to, or were lost during, harvesting operations, or were grounded by windthrow. The design of the box and materials used have been refined over the years. Specifically, the plywood elements of the boxes tended to fail due to delamination; notably, WBP plywood appears to delaminate faster than Marine Grade plywood. Consequently, some elements (e.g. lids) were replaced with heavy duty

recycled plastic. Also, steel screws failed due to rust so were replaced with non-rust screws.

A new design of box which is lighter than the current design, and can therefore be installed on younger and smaller trees, and is considerably cheaper to manufacture, is also currently being trialled in Galloway Forest.

As the pine marten population recovers and expands its range in Britain and Ireland, the need to provide adequate den sites in managed woodlands will become more widespread. We recommend conservation programmes for pine martens should consider the installation of den boxes as a habitat enhancement and monitoring tool. The number and density of den boxes in a forest should be guided by the population density of martens. Ideally, each marten home range should include at least one den box. In a commercial conifer forest, this is likely to equate to approximately 1-2 boxes per 2 km<sup>2</sup>.

## ACKNOWLEDGEMENTS

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