

## Lightweight den boxes enhance habitat for pine martens *Martes martes* in a conifer plantation in south-west Scotland

Elizabeth Croose<sup>1</sup>, John Martin<sup>2</sup>, Stephanie Johnstone<sup>3</sup>, Johnny D.S. Birks<sup>4</sup>

<sup>1</sup> British Small Animal Veterinary Association (BSAVA), Woodrow House, Waterwells Business Park, Quedgeley, GL2 2AB, UK

<sup>2</sup> Myotismart Ltd, Horncop Bungalow, Heversham, Milnthorpe, Grange-over-Sands, LA7 7EB, UK

<sup>3</sup> Dumfries and Galloway Pine Marten Group, Dalbeattie, DG5 4LS, UK

<sup>4</sup> Swift Ecology Ltd, 35 Winterway, Blockley, Moreton in Marsh, GL56 9EF, UK

\*corresponding author email address: lizziecroose1@gmail.com

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### SUMMARY

The European pine marten *Martes martes* typically occupies woodland and preferentially rests and breeds in arboreal, insulated den sites, which are particularly critical for breeding females. An absence of elevated cavities may force pine martens to use suboptimal den sites, and consequently limit population distribution, abundance, and breeding success. Artificial den boxes have been designed and installed in recent years and occupied by both non-breeding and breeding pine martens. However, the large size and weight of these boxes makes them too heavy to use in young forestry plantations. We tested two smaller, lighter box designs (the Galloway Lite Mk1 ('GLMk1') and Galloway Lite Mk2 ('GLMk2')) that could be more easily deployed in commercial conifer plantations. Fifty boxes of each design were installed in Galloway Forest, south-west Scotland, and monitored for evidence of pine marten occupation and breeding. Overall, GLMk2 boxes were occupied more frequently than the GLMk1 boxes, including for breeding. The Galloway Lite boxes provide a lightweight, economical and practical option for increasing the availability of elevated den sites for pine martens and can be deployed as a conservation tool to enhance habitat conditions.

### BACKGROUND

The European pine marten *Martes martes* is a small mustelid that primarily occupies woodland habitat. Its population is currently recovering in Britain following a severe historical decline. Pine martens preferentially select den sites above ground, typically in trees, for resting and breeding. Suitable sites include tree cavities, bird nests, squirrel dreys, snagged branches, and windthrow (Zalewski 1997; Birks *et al.* 2005; Twining *et al.* 2020). This preference for arboreal den sites appears to be driven by predator avoidance (primarily red fox *Vulpes vulpes*) and to minimise energetic costs (Brainerd *et al.* 1995). Elevated, insulated den sites are particularly critical for female martens when giving birth and rearing young (Brainerd *et al.* 1995).

In human-modified habitats, such as commercial forestry plantations, an absence of insulated arboreal cavities may force pine martens to use alternative suboptimal den sites, such as burrows, rocks, tree roots, cave systems, and rocky crevices, and in man-made structures, such as buildings and stone walls (Birks *et al.* 2005; Twining *et al.* 2020). This selection of suboptimal sites has unknown consequences for the success of populations, but it has been suggested that it may limit pine marten distribution, abundance, and breeding success

(Brainerd *et al.* 1995; Birks *et al.* 2005) and affect both individual behaviour and population structure (Twining *et al.* 2020).

Pine martens were historically present in Dumfries and Galloway, south-west Scotland, but were extirpated in the late 19th century due to loss of woodland habitat and persecution, and subsequently reintroduced to Galloway Forest in 1980-1981 (Shaw & Livingstone 1992). Following observations of pine martens occupying barn owl *Tyto alba* nest boxes in the forest, an artificial den box for martens was designed and constructed in the early 2000s, to address the shortage of suitable natural den sites.

Between 2003-2013, fifty large wooden den boxes designed for pine martens (termed the 'VWT (Vincent Wildlife Trust) box') were installed in Galloway Forest and monitored annually (see full details in Croose *et al.* 2016a). Between 30% and 70% of boxes were occupied each year and used by both non-breeding and breeding animals (Croose *et al.* 2016a). Elsewhere, den boxes of various designs have been installed to address habitat constraints and used by pine martens in other parts of Scotland, and in Wales, England, Ireland and France, in both private and state woodlands (Vincent Wildlife Trust, unpublished data).

Despite the high uptake by martens of the VWT box, a key limitation is its large size and heavy weight (13 kg), which prohibits installation on small or young trees and makes the boxes unsuitable for wide scale use in commercial forests where sufficiently large trees are scarce or unevenly distributed. To address this limitation, two new smaller, lightweight designs of box, termed the 'Galloway Lite Mk1' and 'Galloway Lite Mk2' were produced and deployed in succession.

The aim of this study was to test the success of the two boxes measured by their use for resting and breeding by pine martens.

**ACTION**

This study took place in Galloway Forest Park, a large conifer plantation located in Dumfries and Galloway in south-west Scotland, covering approximately 800 km<sup>2</sup> (Figure 1). The forest was established in the early 1930s and is a multiple-use forest, managed for timber production (mainly Sitka spruce *Picea sitchensis* with coverage of other coniferous species), human recreation, wildlife conservation and as a Dark Sky Park.

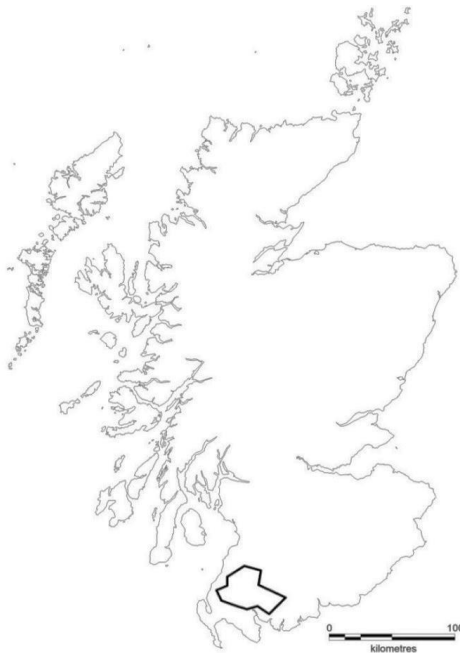


Figure 1. Study location in Galloway Forest, Scotland.

**Den box designs**

The Galloway Lite box is constructed from an adapted 30-litre polyethylene (recyclable high-density polyethylene) jerry can. A plywood box sits inside the jerry can, creating a durable and weatherproof exterior, and is fastened to a wooden

Oriented Strand Board (OSB) (a type of engineered wood sheet) base. An access hole, partly sheltered by a projecting flap above, is incorporated into the back of the box, which is fitted against the tree, enabling martens to enter the hole by climbing up the tree trunk (Figures 2 - 5). Two vertical lengths of plank (wooden battens) are fitted either side of the hole to protect the access hole against the weather, stabilise the box against the tree and give access space for martens. Rope is passed through a hole in each batten and under the projecting flap to secure the box to the tree. The boxes weighed 3.5kg. Softwood shavings were put into each inner plywood box to a depth of 5cm to provide bedding for the martens. All boxes were designed and constructed by John Martin.

An initial design of the box - the 'Galloway Lite Mk1' (hereafter termed 'GLMk1') - was produced in 2014, and subsequently subtly modified to create an updated version - the 'Galloway Lite Mk2' (hereafter termed 'GLMk2') - in 2018. The GLMk2 design was constructed from jerry cans of the same volume capacity as the GLMk1s, but of a different manufacture and moulding, which determined the dimensions of the inner plywood box. The key difference is the inner plywood box of the GLMk2 is 8 cm taller, with slightly narrower side elevations (see Table 1).

Table 1. Dimensions of the two Galloway Lite box designs.

	GLMk1	GLMk2
Inner plywood box height (roof to base internal distance)	22 cm	27 cm
Inner plywood box width (side to side internal distance)	24 cm	22 cm
Inner plywood box depth (front to rear internal distance)	22 cm	24 cm
Internal volume	11.6 L	14.3 L
Internal distance between box base and lower edge of access hole	8 cm	16 cm
Access hole radius and shape	100 × 100 mm square	79 mm circular

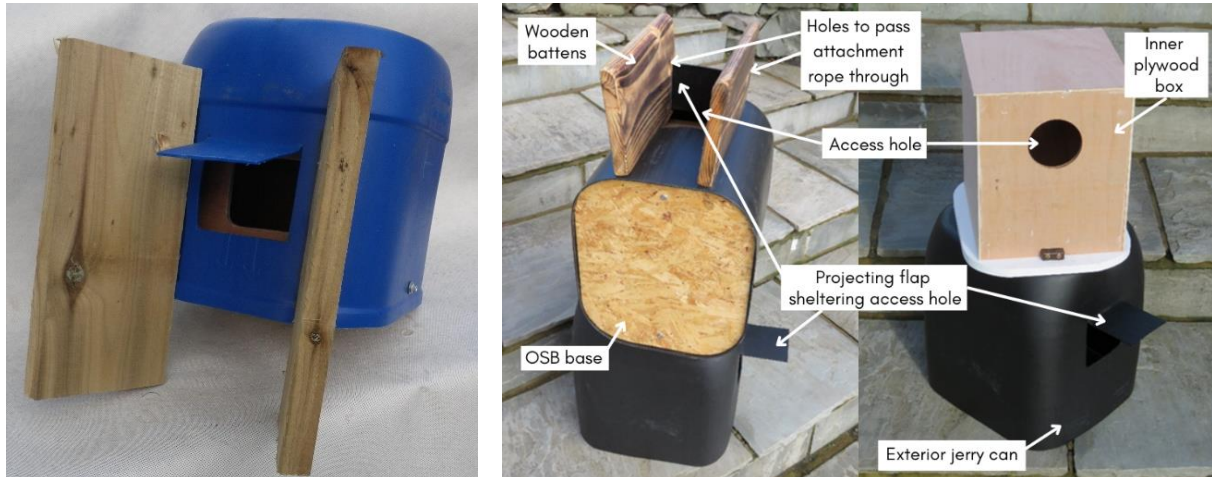


Figure 2 (left). The Galloway Lite Mk1 box design, showing the exterior jerry can, access hole to the inner plywood box, projecting flap and wooden battens.

Figure 3 (right). The Galloway Lite Mk2 box design, during construction, with the key features indicated.

### Den box installation

During September 2014, 50 GLMk1 den boxes were installed in the Fleet Basin, a conifer plantation of approximately 100 km<sup>2</sup> in the south-eastern part of Galloway Forest Park. To ensure an even distribution, a single box was installed in each alternate 1 km x 1 km square of the Ordnance Survey grid, resulting in a density of one den box per 2 km<sup>2</sup> across the study area. This choice of den box density was guided by adult female pine marten home range size derived from radio-tracking in Galloway Forest: estimated to be 4.52 km<sup>2</sup> in mixed conifer plantations and 10.61 km<sup>2</sup> in upland spruce plantations (Bright & Smithson, 1997). The aim was to ensure that the smallest typical home range would likely contain a minimum of two den boxes. A previous study indicated a minimum of 15 pine martens at a population of 0.13 individuals/km<sup>2</sup> in the study area (Croose *et al.* 2016b).

Within each selected grid square and in consultation with the landowner Forestry Commission Scotland (now Forestry and Land Scotland) a stand of conifers was selected with the following characteristics:

- Trees >15 years old, large enough to support a den box;
- Stand not proposed for felling/harvesting in the next five years;
- Stand safely accessible from forestry roads.

An individual tree was selected within each stand that was:

- Located within 30-50 m of (but not easily visible from) the forestry road;

- Species, size and conformation suitable for installation of a den box (usually a Sitka or Norway spruce *Picea abies*, lodgepole pine *Pinus contorta* or Scots pine *Pinus sylvestris*, and a trunk circumference at 3 m above ground level of between 80 cm and 1.5 m);
- With abundant side branches on lower trunk;
- Safe access by ladder.

Having selected a suitable tree, a space 2-4 m above ground level on the south-western face of the trunk was chosen for siting the box, so that the access hole would face away from the prevailing wind direction to reduce ingress of draughts. Where necessary, side branches were removed with a pruning saw to facilitate ladder placement for box installation. Wherever possible, the box was located 10-20 cm above a whorl of side branches to enable easy marten access to the box (such whorls are typically found on immature spruce and pine trees). Each box was attached to the tree trunk with a 1.8 m length of UV-resistant polypropylene rope wrapped around the trunk and secured with a reef knot. Surplus rope length was retained to allow loosening in response to tree growth in future.

In September 2018, fifty GLMk2 boxes were each installed, using the same method, on a separate tree <10 m from each existing GLM1 box, all of which were retained *in-situ*. The installation method for the GLMk2 boxes was identical to that for the GLMk1 boxes. Thereafter, each location hosted two den boxes of a different design (Figure 5).



Figure 4 (left). The Galloway Lite Mk2 box design installed on a tree. The box access hole is between the two wooden battens. The rope to secure the battens and box to the tree can be seen passing through the battens.

Figure 5 (centre). An example of both Galloway Lite box designs (GLMk1 left, GLMk2 right) installed at one location.

Figure 6 (right). A Galloway Lite Mk1 box with a large pile of fresh pine marten scats on the lid; evidence that the box is or has recently been occupied by a marten.

### Monitoring

Following installation, all boxes were checked at least once per year for evidence of recent or current occupancy by pine martens over the period 2015-2021 (except 2020, due to COVID-19 restrictions). Annual checks normally took place in the first two weeks of May to coincide with the period when marten litters would be present in boxes used for breeding. Where no martens were present, a close inspection for evidence of recent occupancy of boxes over winter or early spring was carried out. In some years, the boxes were also checked in other months, for example when maintaining the boxes in the autumn. All monitoring was carried out by a licensed person under Disturbance Licences from Scottish Natural Heritage (now NatureScot, Scotland's Statutory Nature Conservation Organisation).

The boxes were checked using the following methods:

- Quiet approach and observation through binoculars from a distance of >20 m to look for marten scats on top of the box (Figure 6);
- Once closer, listen for sounds of movement and vocalisations by animals inside the box;
- Search of the ground under the box tree for marten field signs, including scats and prey remains, and claw marks and fresh polishing on branches beneath box (see Table 2);
- Ascent of ladder placed against box tree by a licensed person who lifts box gently to assess presence or absence of marten(s) based on weight and any sound and smell (adult martens typically growl when the box is approached closely, and a box with natal use typically has a

scent similar to burnt honey). Count and assess the age/freshness of any marten scats on box roof;

- If no adult marten is present, the box is moved slightly away from the tree to feel inside the box with a gloved hand for presence of kits or other contents (e.g. prey items). If kits are present, the number and approximate age is noted;
- If no kits are present the interior of the box is checked using a torch, and the inside the box is checked manually for evidence of recent occupancy. The main evidence of use is a depression in the wood shavings, often down to the base of the box if heavily used. Marten hairs may also be attached to the rough plywood around the box access hole (see Table 2).

Table 2. Evidence of pine marten occupation of Galloway Lite boxes.

Internal evidence of pine marten use	External evidence of pine marten use
Pine marten(s) present	Marten scats and/or prey on the lid of the box (Figure 6)
Depression in the wood shavings	Marten scats and/or prey on the ground, underneath the box
Marten hair in the entrance to the box	Vocalisations from adults or kits within the box (growling or squeaking) or audible movement inside the box; and marten scent
Prey remains and caches in the box	Claw marks and/or 'polishing' on branches beneath the box



## CONSEQUENCES

A small proportion (12%) of GLMk1 boxes were occupied by pine martens within the first year after installation, with their use increasing year-on-year to a peak 78% of boxes showing evidence of use in 2018 (see Table 3). This increased use of boxes in 2018 is likely due to a prolonged period of cold temperatures and heavy snow (known as ‘the Beast from the East’), meaning martens were likely to have been more dependent on insulated den sites.

In comparison, the GLMk2 boxes were immediately occupied at a much higher rate than the GLMk1 boxes following installation: 61% in the first spring following installation, rising to 80% in 2021. The swift uptake of the GLMk2 boxes is unsurprising because each was located close to an existing GLMk1 box, so pine martens could find them quickly. Nevertheless, the higher GLMk2 occupancy rate suggests a preference over the GLMk1 boxes. Overall, pine martens occupied the GLMk2 boxes more frequently than the GLMk1 boxes ( $\chi^2 = 8.74$ ,  $d.f. = 1$ ,  $p < 0.01$ ).

Whilst the GLMk1 boxes were readily used by pine martens for resting, no evidence of breeding was recorded in the boxes. This might have been due to the shallow depth of the inner box beneath the access hole, which didn’t offer sufficient protection to marten kits inside, and this was altered in the design of the GLMk2 box. In contrast, the GLMk2 boxes have been used for breeding every year since they were installed in 2018 (although this is unknown for 2020 as no monitoring took place that year) (see Table 3).

## COSTS

The cost of materials to produce a Galloway Lite box (either Mk1 or Mk2) is estimated at £25 (January 2024), not including labour.

Box checking was carried out on a voluntary basis so there were no labour costs for the monitoring. It took approximately 15 minutes to check a box, comprising time to carry and assemble the ladder and put on personal protective equipment (a harness and hard hat) before climbing the ladder and checking the box for signs of use. As the boxes were checked only once per year, to obtain evidence of breeding or current or recent occupancy by martens, the monitoring using either method was not time-consuming overall.

Table 3. Percentage of den boxes with evidence of recent pine marten use (and percentage used for breeding) in Galloway Forest, from 2015 to 2021. The GLMk1 boxes were installed in 2014, the Mk2 boxes were installed in 2018. Monitoring did not take place in 2020 due to COVID-19 restrictions.

Year	Box design	
	GLMk1 % used (% breeding use)	GLMk2 % used (% breeding use)
2015	12% (0)	-
2016	45% (0)	-
2017	49% (0)	-
2018	78% (0)	-
2019	38% (0)	61% (2%)
2020	-	-
2021	58% (0)	80% (2%)

## DISCUSSION

High levels of non-breeding use by pine martens across the Fleet Basin study area suggest that both Galloway Lite box designs effectively mitigate the absence of elevated, insulated resting sites in commercial conifer plantations. The low levels of use for breeding are not surprising given the high density of boxes and the low population density of pine martens at this study site. After the 50 GLMk1 boxes had been in place for three years, a new population estimate indicated that the pine marten population had increased by 78% between 2014 and 2019; a causal link between this increase and den box provision was suspected but not confirmed (Croose *et al.* 2019).

The lack of any confirmed breeding in the GLMk1 boxes before the modified GLMk2 boxes were installed indicates that box design is critical for breeding female martens. We conclude that, compared with the GLMk1 box, the greater internal distance between the access hole and base in the GLMk2 box better meets the requirements of breeding female martens. This is likely because of the reduced risks of exposure to weather, and kits being predated or falling out of the box once they become mobile.

In summary, the Galloway Lite boxes provide a lightweight, economical and practical option for increasing the availability of elevated, insulated den sites for pine martens, particularly in commercial conifer plantations where natural elevated tree cavities are typically absent. As the pine marten

population in Britain continues to expand its range, including into areas with suboptimal habitat, these boxes can be deployed as a conservation tool to provide suitable den sites and enhance habitat conditions for martens. They also have a role in population monitoring and can provide information on pine marten distribution and breeding success.

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