Swift Ecology

Myotismart Ltd

GALLOWAY FOREST PINE MARTEN PROJECT 2017-2019

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CONTENTS

SUMMARY

- This report describes fieldwork on pine martens in the Fleet Basin Red Squirrel Stronghold, which is a part of Galloway Forest Park, during September and October 2017.

- The aims of the exercise were to gather information so as to repeat a non-invasive pine marten population estimate for the Fleet Basin (first undertaken in 2014), with 'ground-truthing' provided on this occasion by live-trapping; and to undertake a study of pine marten activity in relation to variations in forest structure.

- After a 2-week period of pre-baiting, live-trapping of pine martens was conducted in two phases over a total of eight nights. 48 captures of 24 pine martens were recorded; each animal was colour-marked on its first capture and a small sample of hairs removed for genotyping.

- 99 hair tubes were installed at an even spacing (approximately 1 tube per km square) and checked weekly on five occasions to replace bait and remove hairs for genotyping. The number of tubes visited by pine martens increased over the five visits from nine to 70. In total 158 possible hair samples were recovered and sent to the Waterford Institute of Technology.

- Scat surveys were repeated on 21 1 km transects along forest tracks surveyed in September 2014 and 2015. These were a subset of a wider effort to record the distribution of pine marten scats in the Fleet Basin. 75.8 km of forest tracks were searched for scats, with survey effort (distance searched) recorded for each of the 86 monads covered. 280 pine marten scats were recorded at 171 sites at a mean density of 3.7 scats per kilometre searched. Scat density varied across the 86 monads from 0 to 28.9 per kilometre.

- 103 fresh probable marten scats were collected and sent to the Waterford Institute of Technology for genotyping.

- The 50 'Galloway Lite' pine marten den boxes, first installed in 2014, were checked for evidence of recent (since the previous check in May 2017) occupancy by pine martens; 24 boxes (48%) showed signs of use; each box was classed as well-used, lightly-used or unused.

- In connection with the study of pine marten activity and forest structure, forest structure characteristics were recorded for a 100 m radius around each trap site, hair tube site, Galloway Lite den box site and each scat site (recorded on systematic surveys of forest tracks).

- The involvement of a small number of volunteers made a substantial contribution to the success of this exercise.

1 INTRODUCTION

1.1 Background

This second interim report on the Galloway Forest Pine Marten Project 2017-2019 describes fieldwork undertaken in the Fleet Basin Red Squirrel Stronghold (part of Galloway Forest Park) during September and October 2017. The project is a collaborative partnership between Forest Enterprise Scotland (FES), Swift Ecology and Myotismart. The fieldwork was designed to gather information for use in answering some of the key questions posed by the project, which has the following over-riding objectives:

Investigate the influence that forest structure has on pine marten populations and activity in commercial forests to inform future forest management; investigate how breeding females respond to harvesting operations to gain evidence for suitable protective buffer zones; determine the most cost effective and ethical way for FES to monitor and estimate pine marten abundance in commercial forestry, with regard to future density assessments for red squirrel conservation through the suppression of grey squirrel invasion.

This project is defined by the following aims and questions:

Aims: To gain robust evidence to inform management of commercial forestry around the protection and conservation of pine martens, and how pine marten abundance can be accurately and ethically measured for application in red squirrel conservation.

This will be done by answering the three following questions through licensed survey, research and practical habitat manipulation within a three year project timescale from May 2017 to December 2019.

Q1. How does forest structure influence the number and activity of pine martens in commercial forests?

Q2. How do breeding female pine martens respond to commercial forestry operations affecting the locality of their natal dens during the breeding season?

Q3. What is the most cost-effective and ethical way to determine pine marten abundance in commercial forests?

1.2 Objectives during autumn 2017

This second phase of the project, involving fieldwork in the Fleet Basin in September and October 2017, focussed upon two elements: a pine marten population estimate to repeat one undertaken in autumn 2014 (Birks, 2016; Croose, 2016); and a study of pine marten activity in relation to forest structure. These two elements determined the nature of the fieldwork undertaken, which comprised the following tasks:

- Systematic and wide-scale live-trapping to provide hair samples for genotyping (for population estimate) and to provide simple information on

patterns of pine marten activity (e.g. differences in numbers of captures and individuals at each trap site);
- Deployment and servicing of hair tubes to gather hair samples for genotyping (for population estimate) and to provide simple information on patterns of pine marten activity (e.g. differences in numbers of pine marten visits and individuals recorded at each hair tube site);
- Systematic searches for pine marten scats to provide information on patterns of pine marten activity (e.g. differences in scat density across monads in the study area);
- Collection of fresh scats for genotyping (for population estimate);
- Monitoring of *Galloway Lite* den boxes to determine levels of use by pine martens to provide information on patterns of activity;
- Recording details of forest structure in relation to the measures of pine marten activity identified above;
- Recording the main costs associated with the different elements of the 2017 pine marten population assessment, to inform decisions about the most cost-effective way of assessing pine marten abundance.

1.3 Purpose of this Report

This interim report provides a record of work done, information gathered and samples collected during September and October 2017. Although full descriptions of methodology are presented, full analysis and evaluation of results will be presented in the final report at the end of the project.

1.4 Personnel

Fieldwork during autumn 2017 was led by Johnny Birks (JB) of Swift Ecology and John Martin (JM) of Myotismart with considerable assistance from Shirley Martin (also of Myotismart). JM and JB have collaborated with FCS/FES over studies of pine martens in Galloway Forest since 2003, initially with The Vincent Wildlife Trust (VWT). JB and JM both hold a licence from Scottish Natural Heritage to disturb and live-trap pine martens.

This phase of the project benefited from assistance by volunteers, notably Gareth Ventress of Forest Enterprise Scotland (FES), who gave a very substantial amount of his free time to undertake pre-baiting of trap sites prior to live-trapping and to assist with live-trapping, scat surveys and monitoring of den boxes. Other voluntary assistance was provided by Shirley Martin, Trina Barratt, Jenni Mouat, Kevin Heywood, Sammy Gray and Jacob Graham.

1.5 Acknowledgements

For their generous assistance with fieldwork in this phase of the project we thank Gareth Ventress, Shirley Martin, Trina Barratt, Jenni Mouat, Kevin Heywood, Sammy Gray and Jacob Graham; we also thank Gareth Ventress for advice on forest structure recording, production of maps for fieldwork, subsequent mapping of scats, live trapping and hair tube data and for ongoing support and local information.

2 METHODS

2.1 Live-trapping

2.1.1 Distribution and density of traps

Twenty humane live-traps (Havahart Large 1-door collapsible traps, model: 1089, supplied by Woodstream Europe Ltd, Fencing House, 8 Lands End Way, Oakham, Rutland, LE15 6RF) were available for deployment in the Fleet Basin.

Given the 10,000 hectare extent of the study area, it was decided to deploy the traps in two phases, so 40 trap sites were selected. Site selection involved a compromise between the need to maximise coverage of the site (so that all pine martens present would have an opportunity to encounter at least one trap), and the need to check traps efficiently by locating them along routes providing safe vehicular access. The locations of the 40 trap sites are shown in Figure 1. This shows that phase 1 covered the north-eastern half of the study area and phase 2 the south-western half.

2.1.2 Pre-baiting

Pre-baiting commenced in late August, 2.5 weeks before traps were set. A small 'cairn' of forestry brash was used to construct a sheltered site in which a quantity (approximately a serving spoonful) of mixed honey, peanuts and raisins was placed, together with a fresh hen's egg; in addition, a small dab of marten lure (Hawbakers Marten Lure; F & T Fur Harvester's Trading Post: https://www.fntpost.com/Products/Hawbaker's+Marten+Lure+(1+oz.)) was placed on a tree above the cairn. Trap sites were revisited subsequently at descending intervals of between five and three days, with any bait removed being replaced, and a note made of whether the hen's egg had been removed (experience with trapping pine martens in the Scottish Highlands and camera trapping of the phase 1 pre-baiting sites suggests that egg removal is a reliable indicator of marten visits to a site).

2.1.3 Trap-setting and baiting

Each trap was set on level ground in a sheltered location. Wherever possible the trap was oriented so that the entrance was visible from many metres away by a person approaching from the nearest forest track; this was so as to minimise time spent checking traps and also to reduce the amount of human scent left close to the trap site.

Traps were covered first with dry hay and then with local vegetation such as sheets of moss; the purpose of this hay and moss covering was to provide shelter and protection to any trapped animal, as well as providing a soft material for trapped animals to pull at with their teeth to avoid the risk of damage to their teeth. Finally, a quantity of brash was placed over the trap to deter animals from attempting to access the bait from the rear or sides of the trap.

Traps were baited with the same honey, peanut and raisin mixture used in pre-baiting, as well as a single fresh hen's egg placed carefully at the rear of the trap well behind the treadle.

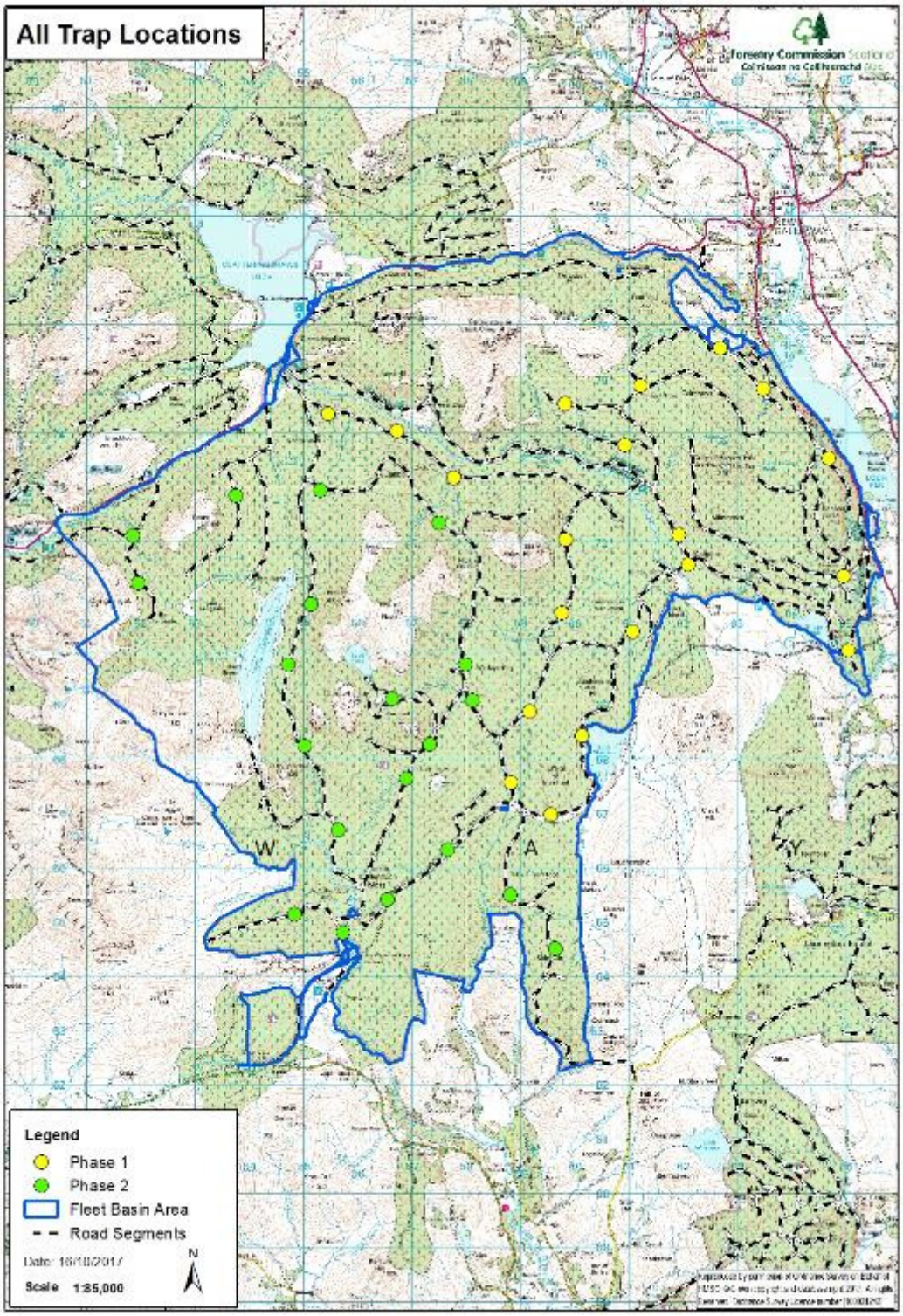

Figure 1. The location of the 40 trap sites used in the Fleet Basin during September 2017 in relation to the forest tracks used for vehicular access.

2.1.4 Trapping duration and checking protocol

Each trapping phase covered four nights as detailed in Table 1. Once trapping at the phase 1 sites was completed on 14th September 2017, all 20 traps were relocated to be reset at the phase 2 sites where the same pre-baiting schedule had been completed.

Table 1. Trapping dates, duration and total effort over the two phases.

Trapping phase	Date traps set	Date traps closed	Total no. trap nights
Phase 1	10/9/2017	14/9/2017	80
Phase 2	16/9/2017	20/9/2017	80
Total trapping effort over 2 phases			160

Because some pine marten activity is known to occur during daytime, traps were routinely checked twice per day – morning and evening - so as to avoid animals spending too long in traps. The morning trap-check typically commenced at 08:00h and the evening check at 16:00h. On the first morning (11th September 2017), trap-checking was undertaken by a single team; but the time taken to visit all 20 trap sites and process all seven pine martens caught led to the decision that all subsequent checks should involve two independent teams.

2.1.5 Processing of trapped animals

During all checks, any traps with doors closed were approached quietly and the external covering of brash, moss and hay was partly removed so as to identify the capture. Where a pine marten was caught the trap was kept covered by a thick cloth to keep the animal calm. All trapped pine martens were calmly restrained at the rear of the trap by means of a purpose-built 'comb' so that a small hair sample could be removed for genotyping and so that a colour mark could be applied to identify any subsequent recaptures. Each pine marten was 'painted' on one part of its body (either the bib, flank or back) with a small quantity of stock marker spray (Carrs Billington Stock Marker Spray 450ml) using a paintbrush (the aerosol spray was not used directly to mark the animals because of the stress response to the noise and sensation of the spray).

All pine martens trapped were assigned to a gender and age category on the basis of their size and general appearance, including tooth wear (if visible). Then animals were released at the site of capture as soon as possible, usually within five minutes of discovery. Each trap was reset and re-baited immediately.

2.2 Hair Tubes

2.2.1 Hair tube design

Following the deployment at this site in 2014 of hair tubes constructed from plastic sewage piping, a new and improved design by John Martin (JM) of Myotismart was deployed in the present study (see Plate 1). The improvements are intended to make the installation, checking and servicing of the tubes more efficient.

Each of the 100 identical hair tubes was carefully made from 100 X 100 mm plastic cable trunking (white) that is commercially available in 3 metre lengths. 300 mm lengths were cut from each length. One matching end cap was provided with each tube. Four 6 mm holes were drilled in the tube on the face opposite the removable clipped cover – the face to go against the host tree. The two lower and upper holes are to accommodate the two 2 m lengths of bale tying string. The upper two holes match two in the inner flanges of the covering lid so that it is secure and cannot be detached from the tube.

Plate 1. The new Myotismart pine marten hair tube design (on left, open for checking and servicing; on right closed for hair capture) deployed in the Fleet Basin during autumn 2017.

Bait hooks were made from 100 mm lengths of electrical cable armouring wire. A loop was formed at one end using needle-nosed pliers and the bait hook wire threaded on to the upper length of tying string inside the tube to float between the flanges to prevent it becoming detached and lost. To prevent the bait – fresh chicken wings – from hanging too low and therefore potentially being grabbed without the marten entering the tube, the wing was hung by threading it onto the wire below the wing bone at the 'elbow' and keeping the wing as high as possible in the top of the tube. After piercing the wing with the wire the end was bent upwards in the shape of a hook to give some resistance to the animal's efforts to detach the wing and prolong the time the pelage had in contact with the glue patch.

Three 40 mm diameter holes were drilled through the tree-facing elevation of the tube to assist martens with gripping the inner whilst ascending the tube to capture the bait hanging from the hook.

The clip-on cover was secured to the lid with a 100 mm length of duct tape to prevent total detachment. The tape acted as a hinge allowing the front to be detached by pulling the cover from the lower edge for hair sample removal and bait

replenishment. Sequential tube numbering using chinagraph pencil and permanent markers was done on the duct tape on the front facing elevation. The tape lasted for the five weeks and showed no signs of early failure.

The hair glue patch comprised a small square of cardboard-backed mouse capture glue designed for rodent control. This in turn was stuck to the reverse side of either the hook or loop side of a correspondingly sized square of self-adhesive backed Velcro. The mated hook and loop was then stuck inside the tube 50 mm above the lower edge of the clip on cover. As the marten entered the tube hair from its dorsal fur would become stuck to the glue patch and retrieved and replenished at weekly intervals.

2.2.2 Distribution and density of tubes

In order to ensure that results from 2017 could be compared directly with those from the similar exercise in 2014, the intention was to place the 100 hair tubes at the same locations as shown in Figure 2 at a density of approximately one tube per kilometre square. Because of recent timber harvesting activity, some hair tubes were installed on 'stobs' (fencing posts) driven into the ground in clear fell areas. Because of current felling activity one site was inaccessible, so only 99 hair tubes could be installed.

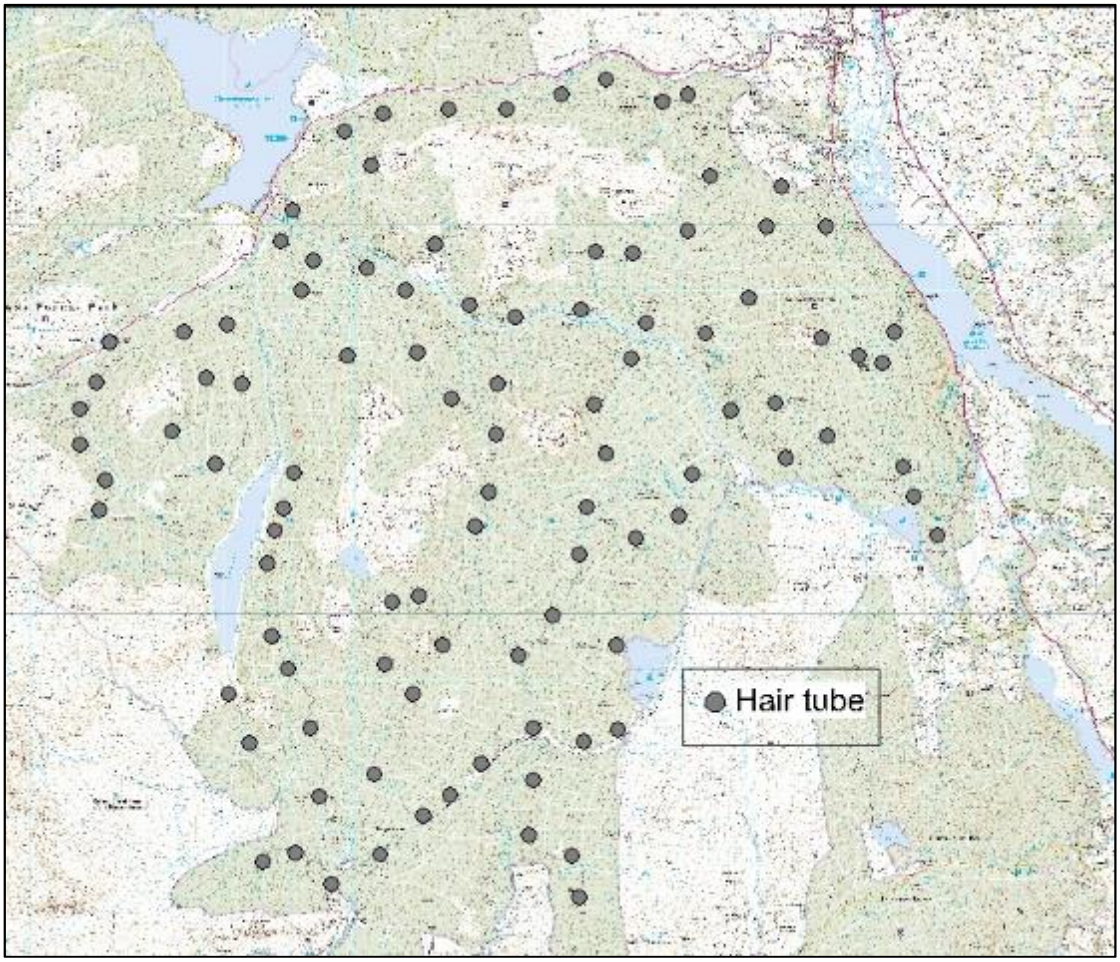

Figure 2. The distribution of the 100 pine marten hair tubes installed in The Fleet Basin during September and October 2014, which guided the installation of the 99

tubes in 2017 (Based upon Ordnance Survey material with the permission of the Controller of HMSO © Crown Copyright (2013) Licence no. 100017908).

2.2.3 Installation and servicing of tubes

99 hair tubes were installed by one team of two people (JM and SM) over two days (10-11th September 2017). Each baited and primed tube was tied to a suitable tree or stob at a minimum height of 1.5 m above ground level using bale string. If the host tree was of small diameter the 'slack' would be wound round the trunk before tying with a bow and half hitch. Tubes were normally sited within 10 m of the edge of forest tracks and, to aid relocation, the tube site was identified by coloured marker string on the edge of the forest stand.

After initial installation all tubes were subsequently serviced five times at 7-day intervals until they were removed on 14/15 October 2017 – a deployment duration of 36 days. Servicing each hair tube involved checking to determine if bait had been removed and whether any hairs had been trapped on the single sticky patch; removing any patches with hairs and storing these in plastic sample tubes labelled with tube number, checking number and date of collection; removing old chicken bait and replacing it with a fresh piece; and replacement of sticky patches, if necessary.

2.2.4 Treatment and storage of hair samples

After collection all hair samples were retained on their sticky patches and kept deep-frozen in separate sample tubes prior to delivery to the Molecular Ecology Group at the Waterford Institute of Technology (WIT) for genotyping. The same treatment was applied to hair samples from animals live-trapped during the study.

2.3 Scat surveying

2.3.1 Monad coverage

Where their populations are well-established pine martens deposit some of their scats on tracks and paths through suitable habitat as a means of communication and territory defence. Consequently, in forests with established networks of roads and tracks, non-invasive survey and monitoring information on pine martens can be gathered via the detection and identification of scats according to standard protocols. We adopted the standard protocol for pine marten scat surveys based upon searching forest tracks (see Croose *et al*., 2013).

In order to gather information on patterns of variation in pine marten activity across the study area, systematic counts were made of pine marten scats found on forest tracks over the widest possible area of the Fleet Basin study area. In order to link scatting activity to variations in forest structure, a six figure grid reference was recorded for each scat site and forest structure was recorded in the surrounding 100 m (see section 2.5 below). Furthermore, each monad was treated as a separate search unit, with a record kept of the distance of track searched and the number of scats found in each monad. This allowed the calculation of scat abundance in each

monad, expressed as the number of marten scats per kilometre searched. Fox scats were also counted.

2.3.2 Repetition of the 21 scat transects covered in 2014

As a subset of the scat surveys described above, the 21 1km transects surveyed in 2014 and 2015 were repeated in September 2017 in order to allow comparisons of the distribution of pine marten activity between the two periods. All transects were based upon lengths of forest road (see Figure 3 below).

Each transect was searched for pine marten scats once during September 2017 by one or more surveyors. A count was made of all probable pine marten scats detected on each transect. A count was also made of fox scats detected on transects.

Figure 3. The location of 21 1 km transects searched for pine marten scats in The Fleet Basin during September 2017.

2.3.3 Collection of fresh marten scats for genotyping

As in 2014, throughout our fieldwork during September and October 2017 we collected fresh marten scats on an *ad hoc* basis from many locations within the Fleet Basin in order to maximise the number and distribution of samples for genotyping.

Scats were collected during surveys of forest tracks described above, as well as during visits to live-trapping sites, den boxes and hair tubes.

2.4 Galloway Lite Den Boxes

Checks were made of levels of use by pine martens of the 50 *Galloway Lite* den boxes installed at 50 evenly-spaced locations across the Fleet Basin in September 2014. Based on the nature and extent of any marten-sized depression – if present - in the wood shavings in the interior, as well as the presence of other field signs such as scats, usage of each box was categorized as 'None', 'Slight' or 'Heavy' since the previous check of the boxes in May 2017. The distinction between the 'Slight' and 'Heavy' categories was based mainly upon the degree of compaction and/or loss of the wood shavings within the boxes: well-used den boxes tended to have a well-compacted depression and, in many such cases, the plywood base of the box was revealed. In addition to its value as part of the annual monitoring of GL box usage patterns, this information was gathered in connection with the study of pine marten activity in relation to forest structure.

2.5 Recording Forest Structure

Modern, large-scale harvesting patterns in commercial forests have a substantial impact upon pine marten habitat, with mature stands swiftly converted to large areas of open ground that may remain largely unsuitable for pine martens for several years. However, in keeping with other Scottish plantation forests established during the mid to late twentieth century, the Fleet Basin is undergoing a major phase of forest restructuring as the first cohort of trees reaches its maximum mean annual increment (MMAI), when felling normally takes place. Depending upon the MMAI, trees tend to be felled at an age of 45 to 60 years (with some thinned crops retained past the MMAI in order to diversify stand age structure in future), so biologically old trees are scarce or absent in such forests. As a consequence, we predict that pine marten activity in such forests will be distributed unevenly, with animals selecting areas of 'best' habitat and avoiding areas of 'worst' habitat. Based upon his work in commercial forests in County Leitrim, O'Mahony (2014) suggests that large areas of 'worst' habitat may appear as unoccupied gaps between the home ranges of resident pine martens, meaning that such forests support fewer pine martens than they might otherwise.

Based on advice from Gareth Ventress of FES, we recognised the five forest structure categories shown in the table below, which correspond to the advancing stages in tree growth and canopy structure between clear-fell and the next harvesting event.

Table 2. The five forest structure categories used in this study.

Structure category	Description
Open	Bare or felled ground with trees <5 years old (trees <2m tall)
Pre-thicket	Replanted ground with trees 5-15 years old prior to canopy closure (trees 2-10m tall)
Thicket	Dense young trees 15-25 years old creating a closed canopy (trees >10m tall)
Mature un-thinned	Un-thinned stands of trees >25 years old

Mature thinned	Thinned stands of trees >25 years old with a more open canopy

Forest structure was recorded within a 100 m radius around each site where an index of pine marten activity was derived (so at each trap site, GL den box, hair tube and at each location where a marten scat was found on a systematic search of a forest track): based on the proportion of the area occupied, the dominant ('primary') structure category and, if present, the 'secondary' category were recorded; in addition, the distance of the site from the nearest stand of mature trees was recorded using the four categories 0 m, <100 m, 100-200 m, and >200 m.

2.6 Recording Population Assessment Costs

In order to answer one of the questions identified in section 1.1 above, namely

Q3. What is the most cost-effective and ethical way to determine pine marten abundance in commercial forests?

a record was kept of the main costs (person-hours, mileage and genotyping) invested in those elements of the project essential to the production of a 2017 pine marten population estimate for the Fleet Basin. These comprised the following:

- Live-trapping (including pre-baiting)
- Installation and servicing of hair tubes
- Collection of scats for genotyping
- Costs of genotyping

2.7 Constraints

The weather in Galloway during September and October 2017 was typically changeable, with bouts of wet weather separated by drier spells. The bouts of wet weather may have had some influence upon the detectability and condition (including the condition of DNA required for genotyping) of scats during surveys. The generally humid conditions also influenced the function of the hair tubes, with a significant proportion of tubes visited by martens failing to gather a hair sample due either to the softening of the cardboard backing of the mouse-glue patches (so that they adhered to the martens and were thus removed from the tubes) or due to the martens' wet guard hairs failing to stick to the glue patch. This was a particular problem during the final tube check in mid-October, when the weather was especially wet and more than half of the tubes apparently visited by martens failed to collect a hair sample.

Because the glue patches are approved for use in confined spaces devoted to food storage and preparation, it is believed that they are non-toxic in nature so do not represent a risk threat when adhering to the fur of a pine marten.

3 RESULTS

3.1 Live-trapping

Live-trapping of pine martens was completed successfully in two phases over eight nights at 40 sites across the Fleet Basin, following a period of pre-baiting, as described in section 2.1 above. 24 individual pine martens were captured on 48 occasions (so there were 24 recaptures). Hair samples were successfully taken from each pine marten on its first capture, when a temporary colour mark was applied in order to identify the animal if recaptured; all pine martens were released unharmed at the site of capture. A summary of the variations in trapping success is illustrated in Figure 4 below.

There were no captures of any non-target species; however, camera-trapping during pre-baiting at the 20 phase 1 trap sites did record red squirrel *Sciurus vulgaris*, badger *Meles meles*, fox *Vulpes vulpes* and wood mouse *Apodemus sylvaticus* feeding on the bait.

Assessments of the age and sex of trapped animals indicated that the 24 individuals comprised 10 females (of which four were juvenile/sub-adult) and 14 males (of which eight were juvenile/sub-adult). These assessments cannot be relied upon as most were based upon a non-intrusive examination; genotyping should confirm the sex of each trapped animal in due course.

Trapping success across the two phases was similar, as indicated by the summary in Table 3 below.

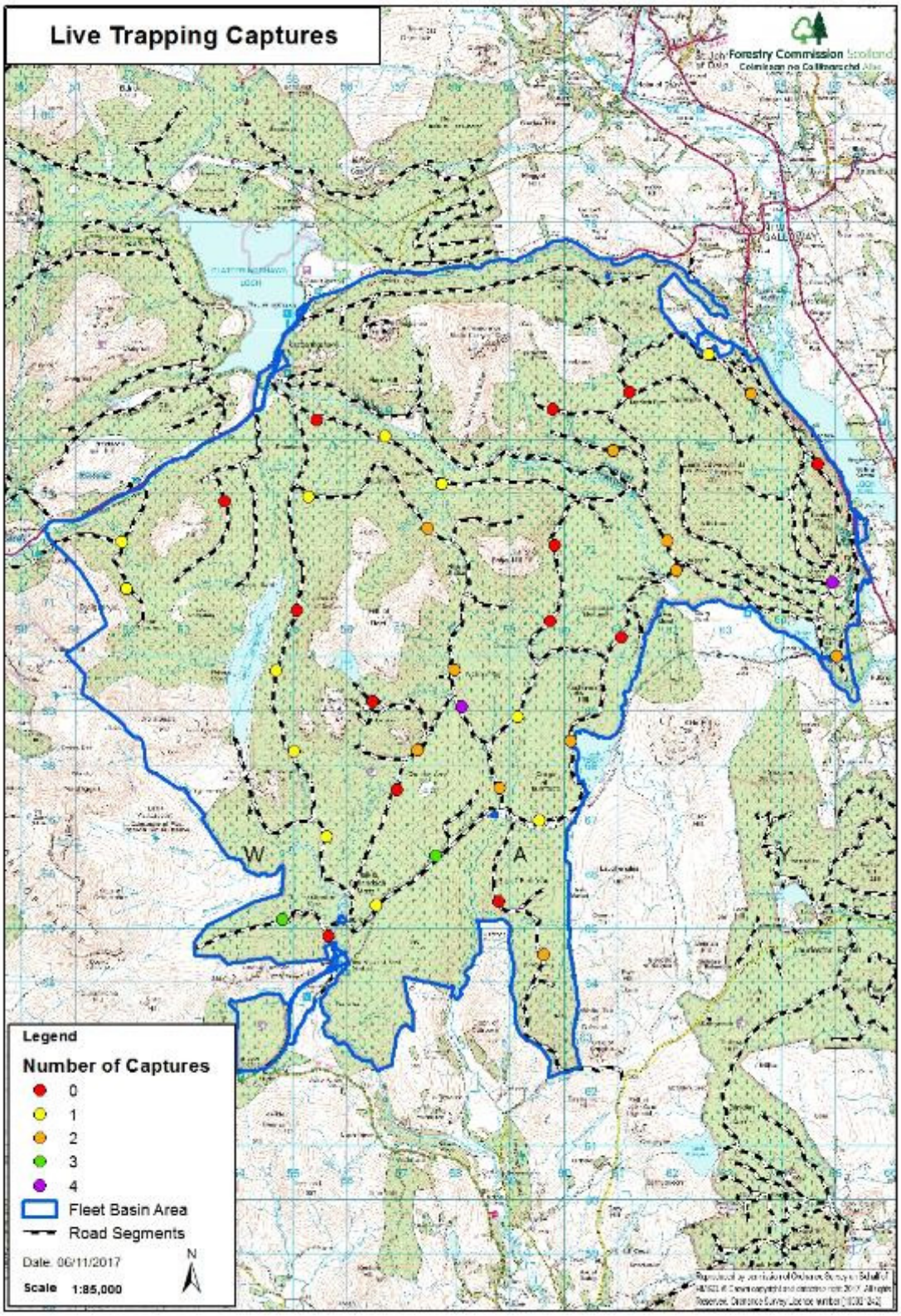

Figure 4. Variations in trapping success in the Fleet Basin in September 2017, expressed as the number of marten captures at each of the 40 trap sites.

Table 3. A comparison of trapping success across the two phases in the Fleet Basin during September 2017.

	Phase 1	Phase 2	Both phases
No. individuals caught	13	11	24
No. recaptures	10	14	24
Total captures	23	25	48

There were substantial variations in both the frequency with which individuals were captured and in the number of captures recorded at trap sites across the study area (see Figure 4). For example, one sub-adult male (FB7) was trapped five times at five different trap sites; and this wide-ranging animal was the only one to be trapped in both of the trapping phases. In contrast, nine animals were trapped once only and never recaptured. In terms of geographical variations in success, 13 out of 40 (32.5%) trap sites recorded no pine marten captures; and two traps (GL19 and GL40) recorded four captures of three and two individuals respectively. Full analyses of these results will be undertaken once genotype information is available from WIT.

3.2 Hair Tubes

The 99 hair tubes were visited and serviced five times after installation as detailed in Table 2. 63 tubes produced hair samples during the 36 days of the study, and the number of tubes apparently visited by pine martens (this includes those visits where bait was removed but no hair sample was collected) increased on each successive check from nine to 70 as the study progressed, as shown in Table 4 below. 158 hair samples were collected over the five checks, with several tubes visited by pine martens on more than one occasion.

Table 4. A summary of hair sample collection during the five visits to the 99 tubes installed in the Fleet Basin in September 2017.

Check no. (and date)	No. tubes with hair samples	Number of tubes visited by martens but no hair samples collected	Cumulative number of tubes producing hair samples
1 (16-17/9/17)	6	3	6
2 (21-22/9/17)	22	5	27
3 (30/9-1/10/17)	41	9	45
4 (7-8/10/17)	55	8	60
5 (14-15/10/17)	34	36	63

Table 4 indicates that on each check a proportion of the hair tubes had apparently been visited by pine martens (because the bait had been removed) but no hair samples were collected. This arose either because the sticky patches failed to gather hairs (sometimes due to the accumulation of flies stuck to the patches) or because the patches adhered to the pine marten as it vacated the tube. Over the first four checks the proportion of tubes affected in this way was <10%; but on the final check in very damp weather 36 tubes were visited by martens but failed to gather hair

samples. These 'no sample marten visits' to tubes were recorded separately so that they can be included in subsequent analyses of marten activity.

There were marked variations in the frequency of occurrence of visits to hair tubes, as illustrated in Figure 5. For example, considering all marten visits (i.e. including 'no sample marten visits), 28 tubes received no visits and the same number received four or five visits. This variation in tube usage will be used in subsequent analyses of pine marten activity in relation to forest structure.

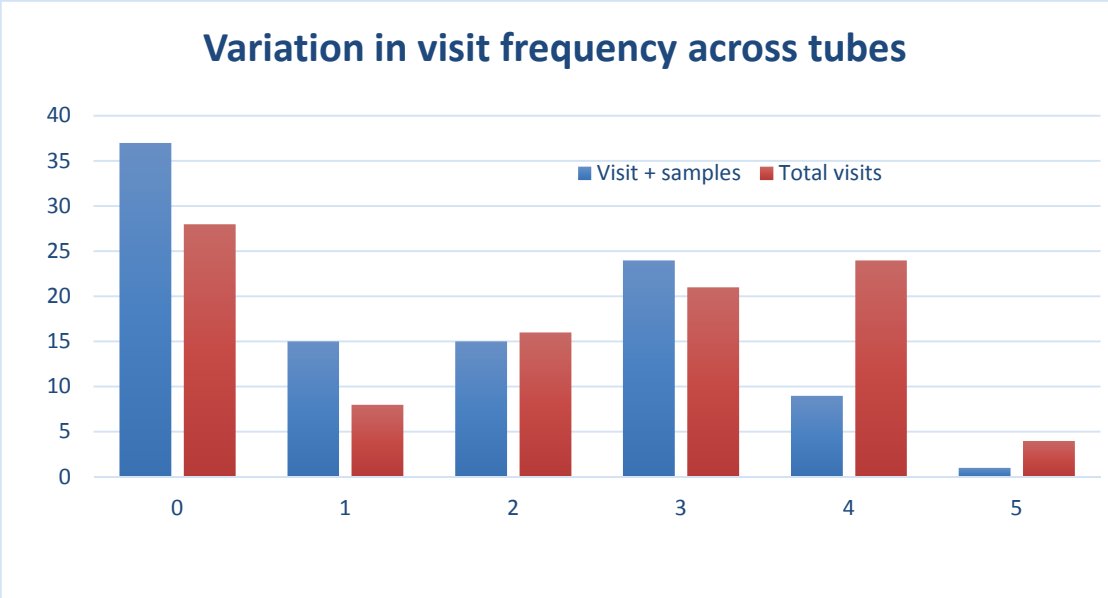

Figure 5. Variations in the frequency of occurrence of hair tubes receiving zero to five visits by pine martens (shown both as visits producing hair samples and total visits).

3.3 Scat Surveying

3.3.1 Monad coverage

The extent of forest tracks surveyed for pine marten scats in the Fleet Basin during September 2017 is shown in Figure 6 below. Surveying involved a combination of professional and experienced volunteer surveyors, with less experienced volunteers shadowing the professional ones on occasions. A total of 75.8 km of forest tracks was searched for scats, with survey effort (distance searched) recorded for each of the 86 monads covered; this represents 72% of the candidate monads in the study area. 280 pine marten scats were recorded at 171 sites (see Figure 7) at a mean density of 3.7 scats per kilometre searched. Scat density varied across the 86 monads covered from 0 to 28.9 per kilometre.

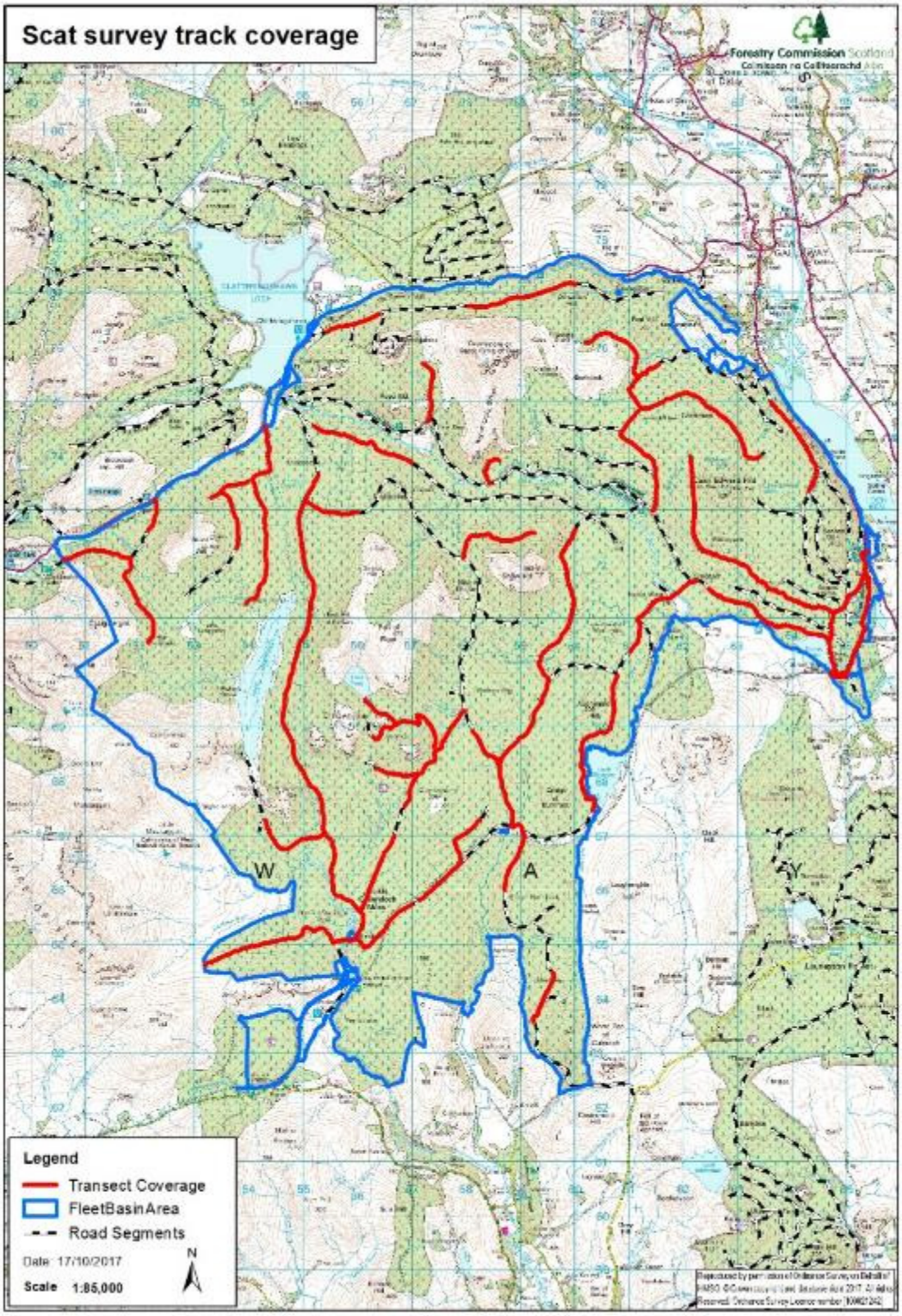

Figure 6. The extent of scat survey coverage along forest tracks in the Fleet Basin during September 2017.

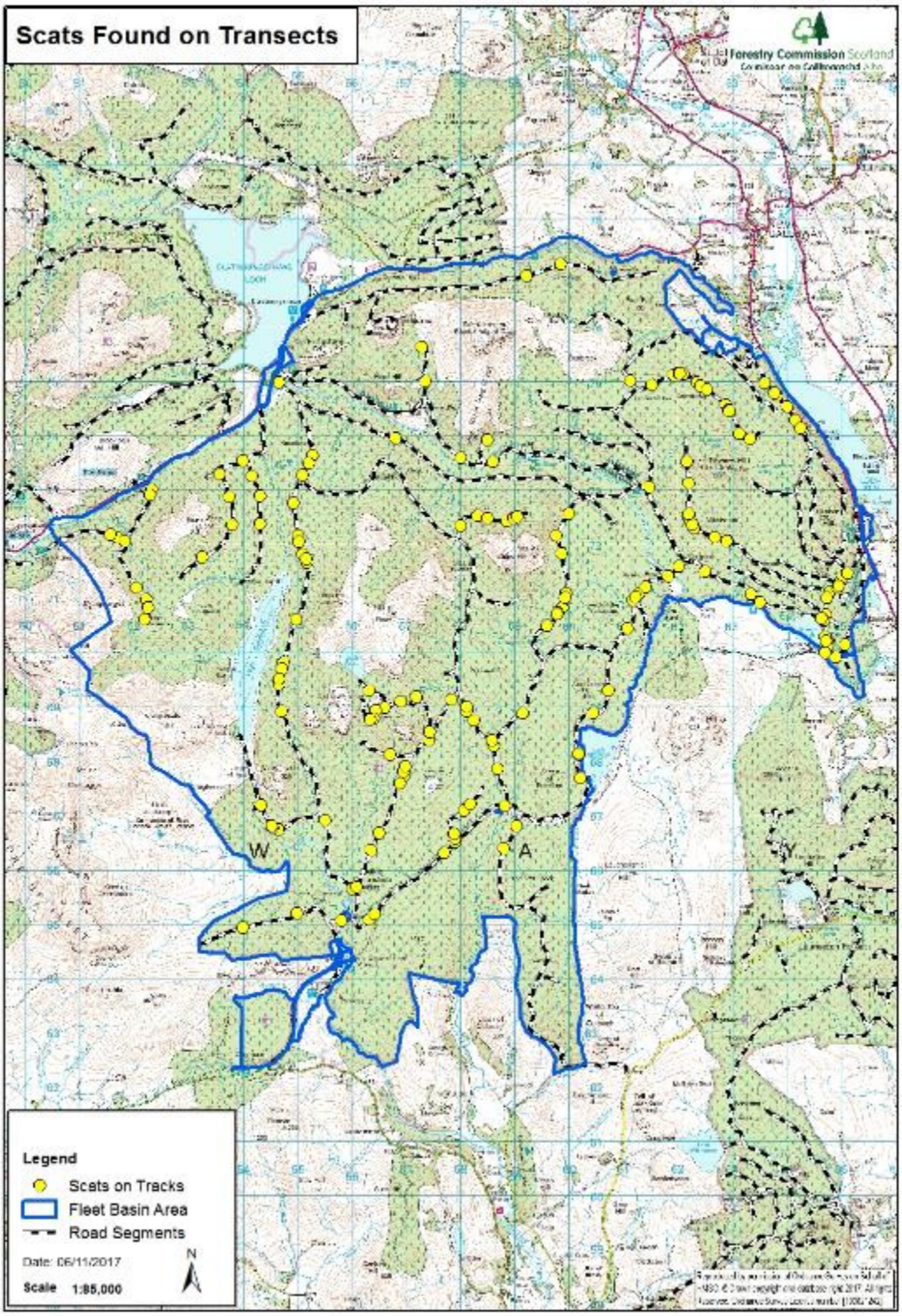

Figure 7. The location of all scats recorded during systematic searches of forest tracks shown in Figure 5.

3.3.2 Repetition of the 21 scat transects covered in 2014 and 2015

All 21 transects were surveyed successfully during September 2017, with scat abundance ranging from zero to 18 per kilometre. The transects are shown in Figure

3 and the results are summarised in Figure 8 below, with the results from 2014 and 2015 also shown for comparison. A count of more than ten marten scats was recorded on only two transects (numbers 3 and 9) in 2017, and these coincided with two of only three transects on which more than ten scats were recorded in September 2015 (see Figure 8).

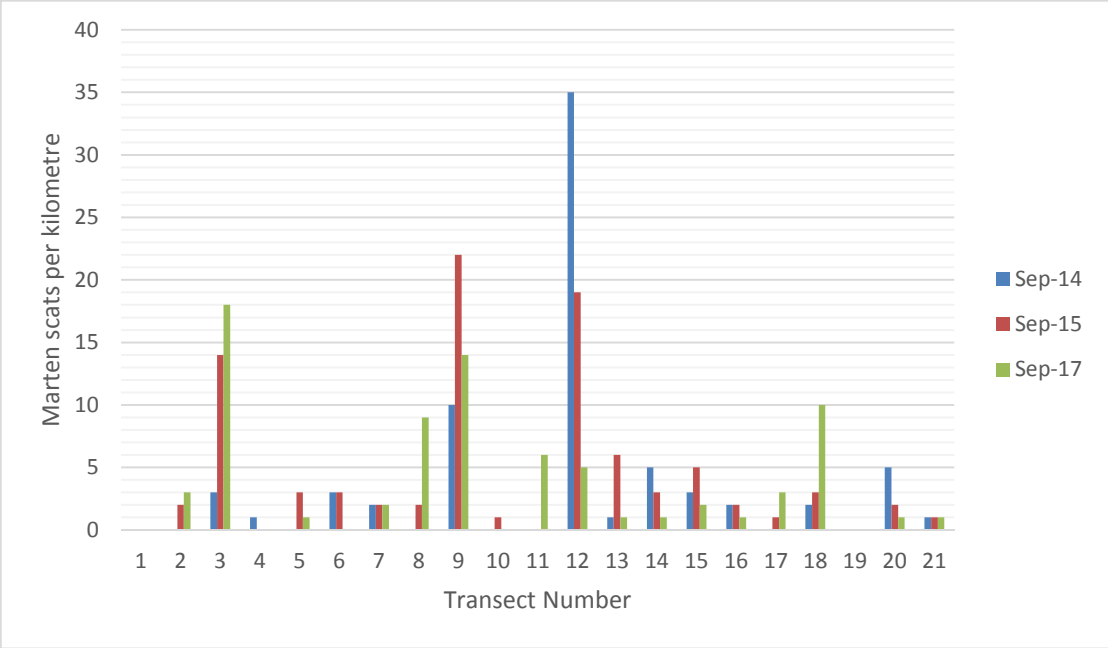

Figure 8. Variations in the abundance of pine marten scats recorded on the 21 1kilometre transects in the Fleet Basin across three monitoring years.

3.3.3 Collection of fresh marten scats for genotyping

103 probable fresh pine marten scats were collected during September and October 2017, stored deep-frozen and sent to WIT for genotyping. The scats were collected from many locations (see Figure 9) across the Fleet Basin during systematic scat surveys and during targeted visits to sites during the course of work involving hair tubes, live-trapping and den box checks.

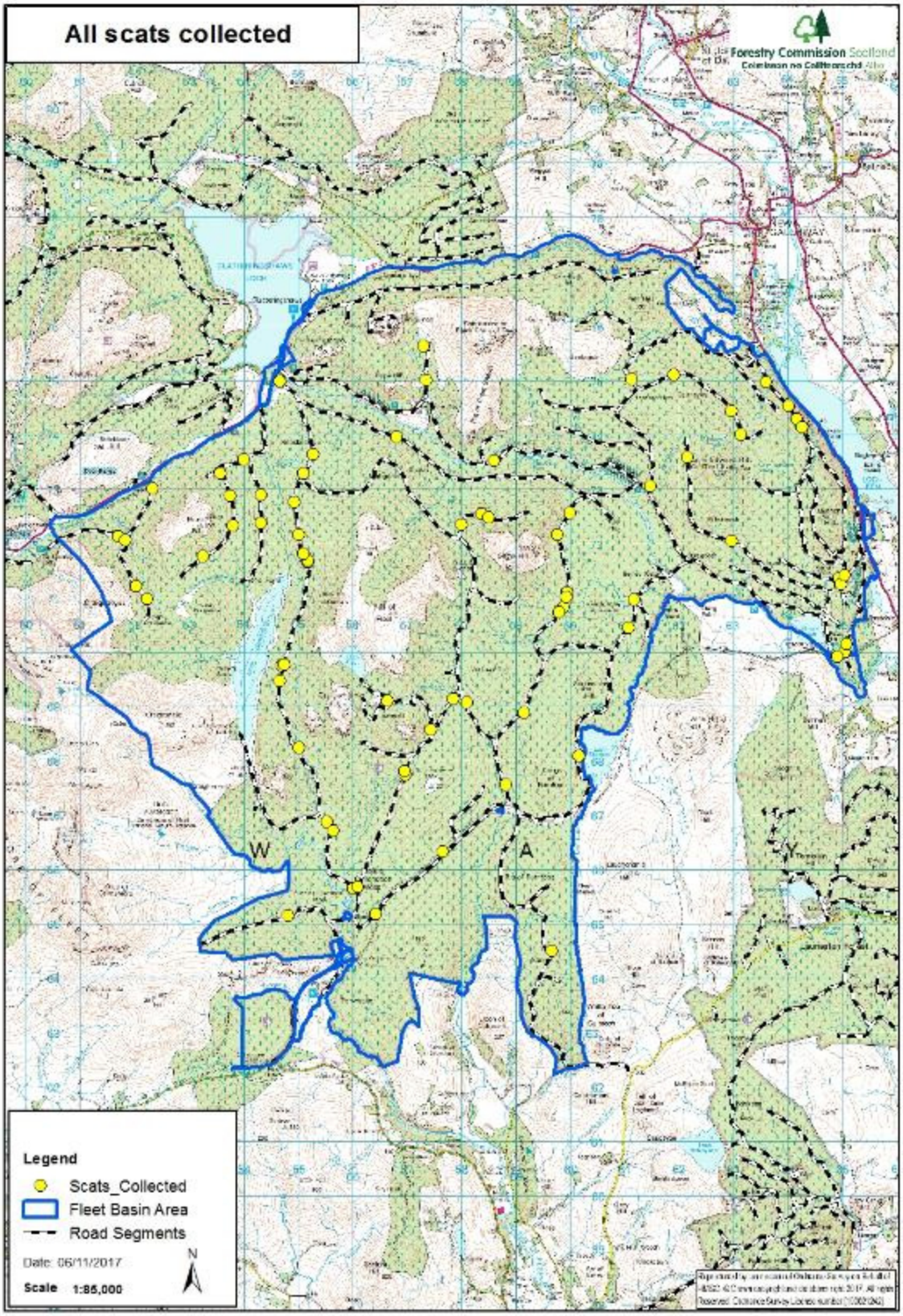

Figure 9. The locations of the 103 fresh marten scats collected for genotyping in September and October 2017.

3.4 Galloway Lite den Boxes

The 50 *Galloway Lite* den boxes installed in the Fleet Basin in 2014 were checked on 21st and 22nd September and 5th October 2017 for evidence of recent use by pine martens. Of the 50 boxes checked 24 (48%) showed evidence of use by a pine marten since the previous check in May 2017; 10 of these showed signs of 'Slight' use and 14 showed signs of 'Heavy' use.

Table 6. Levels of use by pine martens of the Galloway Lite den boxes in Sept/Oct 2017

Level of use	None	Slight	Heavy
No. boxes	26	10	14

Since their installation in September 2014, 42 of the boxes have shown evidence of use by martens, representing a cumulative occupancy rate of 84% over three years (see Figure 10). Figure 10 indicates that on each check since May 2015, evidence of use by pine martens has been recorded at 38-52% of boxes.

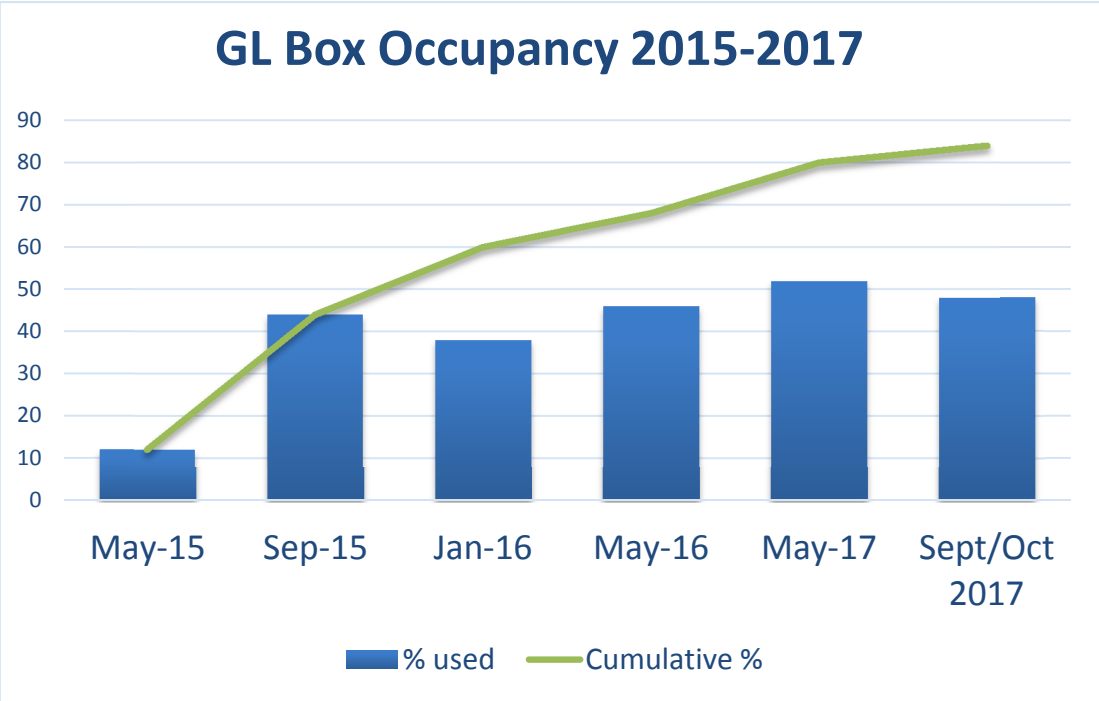

Figure 10. Patterns of occupancy by pine martens of the 50 Galloway Lite den boxes during 2015 to 2017.

3.5 Recording Forest Structure

Forest structure details were recorded successfully at all 171 sites where scats were found during systematic searches along forest tracks, along transects in each monad surveyed for scats, and also at every site where a live-trap, hair tube or Galloway Lite den box was deployed. These data will be used in due course in analyses of pine marten activity in relation to forest structure.

3.6 Recording Population Assessment Costs

The main costs associated with the elements of the pine marten population assessment, both invasive (live-trapping) and non-invasive, were recorded. These are presented in tables 7 and 8 below. At this stage material costs are not included, but these will be built in to the final report at the end of the project - together with information from genotyping – so that a fair comparison of the cost-effectiveness of each approach can be made. At this stage, a comparison of the totals presented in tables 7 and 8 below suggests that the invasive approach to population assessment (based upon live-trapping and genotyping) involves labour and travel costs of less than half those associated with the non-invasive approach (based on genotyping samples from hair traps and scats).

Table 7. The main costs associated with the invasive elements of the 2017 Fleet Basin pine marten population assessment

Project element	**Person-hours @ £37.5 per hour**	**Mileage @ 50p per mile**	**Other**	**Grand total**
Pre-baiting of 2 x 20 trap sites	58h = £2,175	794 = £397		
Setting and checking of 20 traps over 8 nights	222h = £8,325	875m = £437.50		
Genotyping of 24 hair samples @ £30 per sample			£720	
Totals	**£10,500.00**	**£834.50**	**£720.00**	**£12,054.50**

Table 8. The main costs associated with the non-invasive elements of the 2017 Fleet Basin pine marten population assessment

Project element	**Person-hours @ £37.5 per hour**	**Mileage @ 50p per mile**	**Other**	**Grand total**
Installation and servicing of 99 hair tubes	456h = £17,100	2174 = £1087		
Genotyping of 158 hair samples @ £30 per sample			£4740	
Collection of 103 scats	20h = £750	200m = £100		
Genotyping of 103 scat samples			£3090	
Totals	**£17,950.00**	**£1187.00**	**£7830.00**	**£26,967.00**

4 EVALUATION AND CONCLUSIONS

4.1 Summary

4.1.1 Live-trapping

Live-trapping was very successful, although extremely time-consuming due to the dispersed nature of the trap sites and the need to check traps twice per day; this necessitated deployment of two independent teams to ensure that no animals were left in traps for an unacceptable period. Nevertheless, no martens appeared to have suffered and no non-target species were caught. Cost-effectiveness could be improved in future by making use of available technology to indicate remotely whether traps have been triggered.

The number of animals trapped over the eight nights of trapping (24) exceeded expectations, which were based upon the 2014 maximum population estimate of 15-18 individual pine martens in the Fleet Basin study area. Although the assessment of age and sex of trapped animals involved some uncertainties, the population did not seem to be dominated by juveniles born in 2017, which would have been one explanation for the unexpected abundance of animals present. 12 of the 24 martens were classed as either juvenile or sub-adult (meaning <3 years old).

Also, it should be noted that trapping effort did not cover the entirety of the study area, so it is feasible that some individuals were present but not trapped, either because they did not encounter a trap or because they were trap-shy. For example, camera trap evidence during the pre-baiting of phase 1 traps recorded one or more pine martens making multiple visits to four trap sites that did not record any captures when traps were set later.

4.1.2 Scat surveys

Substantial effort was invested in maximising systematic scat survey coverage of forest tracks and recording survey effort across monads in the Fleet Basin. This generated a large amount of data on variations in scat abundance across the study area, which will be of great benefit in the assessment of pine marten activity in relation to forest structure. Surveys also contributed to the collection of 103 fresh scats for genotyping as part of the non-invasive population assessment (114 scats were collected in 2014).

4.1.3 Hair tubes

The tubes worked well for the five-week deployment. However, some glue patches failed due to accumulations of flies preventing surface contact with animal hair, some due to the cardboard backing becoming wet and the glue detaching from it as the animal left the tube, and some probably due to the wet coated animal fur not sticking to the glue.

Compared with the near-identical exercise in autumn 2014, the 2017 study revealed much higher levels of pine marten activity at hair tubes. For example, the current study produced three times as many samples for genotyping (158 compared with 52

in 2014) and the number of hair tubes producing hair samples was higher (63 compared with 26 in 2014).

In future deployments it is suggested that a larger section of Velcro is used, with the glue patch remaining at 20mm square, allowing more hook & loop connections so as to reduce the risks of the glue patch becoming detached as a marten leaves the hair tube. Also, if possible, avoidance of using hair tubes during periods of wet and humid weather might reduce the risk of a glue patch become detached when a marten vacates a tube.

4.1.4 Galloway Lite boxes

The September/October 2017 checks revealed that the GL boxes continue to be used by pine martens, with further boxes used for the first time so that cumulative usage now stands at 84%. The most recent data will be of use as one index of pine marten activity in the forest structure study. The information on box use between May 2015 and Sept/Oct 2017 presented in Figure 10 does not suggest that any clear seasonal pattern exists. However, this may be a consequence of the low frequency of box checks (typically twice per year). In future, consideration should be given to more frequent monitoring (perhaps semi-automated) so as to better detect any seasonal patterns in box occupancy.

4.1.5 Recording forest structure

A substantial body of data has been gathered on the forest structure characteristics of sites linked to pine marten activity indices (scat sites, traps, hair tubes and GL boxes). Much of this information still needs to be organised and entered onto spreadsheets for analysis.

The intention is that data will also be organised on a monad basis, using FES stock maps to categorise each monad on the basis of its forest structure, for comparison with indices of pine marten activity. One complication is that some monads will be 'richer' in pine marten activity data than others: for example, in autumn 2017 some Fleet Basin monads contained a trap site, hair tube and a GL den box, as well as generating scat abundance information from surveys; in contrast, other monads lacked one or more of the above. The most data-rich monads are the 40 containing a trap site, as these are likely to have all the other components; so monad analysis should perhaps be based upon these, so long as it is statistically robust.

4.1.6 Recording population assessment costs

Although incomplete at this stage, there is now some basis for comparing the costs of assessing pine marten abundance in ways that are either invasive (e.g. live-trapping) or non-invasive (genotyping of hair and scat samples). This element will be explored further in the final report on this project.

4.2 Future Work

The following is a summary of future work that flows directly from the fieldwork completed in September/October 2017:

- Genotyping of 2017 Fleet Basin hair and scat samples by WIT
- Mapping of pine marten genotypes and plotting of 'recorded ranges'
- Calculation of population estimates for invasive and non-invasive methods
- Comparison of 2017 population estimates with the 2014 estimate
- Entry and organisation of forest structure data
- Analysis of forest structure 100 m radius data against pine marten activity data at scat, trap, hair tube and GL den box sites – what relationships are apparent?
- Construction of pine marten activity indices for each monad (based on patterns of scat abundance, live-trapping success, hair tube and GL den box usage)
- Use of FES stock maps to categorise each monad on basis of forest structure for 2014 and 2017
- Analysis of relationships between forest structure and pine marten activity indices at monad scale
- Further analysis of the cost-benefit and welfare comparisons of invasive and non-invasive approaches and their relative contributions to the final population estimate.

The intention is to involve MSc student Rhiannon Taylor in some of the above analyses, as well as staff at the VWT such as Lizzie Croose, who is willing to assist with preparing information for publication.

5 RELEVANT LITERATURE

Birks, J.D.S. (2016). *Fleet Basin Pine Marten Project Final Report*. Unpublished report to Forestry Commission Scotland and the People's Trust for Endangered Species by Swift Ecology, Waterford Institute of Technology and Myotismart.

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Mowat, G. and Paetkau,D. (2002). Estimating marten population size using hair capture and genetic tagging. *Wildlife Biology*, 8, 201-209.

Mullins, J., Statham, M.S.J., Roche, T., Turner, P.D. and O'Reilly, C. (2010). Remotely plucked hair genotyping: a reliable and non-invasive method for censusing pine marten (*Martes martes, L*. 1758) populations. *European Journal of Wildlife Research*. 56, 443-453.

O'Mahony, D.T. (2014). Socio-spatial ecology of pine marten (*Martes martes*) in conifer forests, Ireland. *Acta Theriol.* 59: 251-256.

APPENDIX 1 September/October 2017 Work Log

JB = Johnny Birks, JM = John Martin, SM = Shirley Martin, GV = Gareth Ventress, TB = Trina Barratt.
Note that prior to this fieldwork session there had been much heavy rain in Galloway, during which GV established 40 pre-baiting sites prior to our live-trapping in the Fleet Basin. Also, on 9th September, the Fleet Basin was used for the 'Galloway Hills Rally', which introduced some disturbance into the forest the day before we set out our hair tubes and traps. Heavy vehicular use of some tracks must have destroyed some of the scats that we might otherwise have encountered during our transect surveys.

9th September (heavy rain showers)
a.m. JB drove from West Malvern to Horncop, South Cumbria, whence JB, JM and SM drove to Dalry p.m., pausing for supplies in Dumfries.
7pm all met up with GV and TB in the Clachan Inn, Dalry for a planning meeting.

10th September (more heavy rain, turning to gusty showers pm and clearing in the evening; temp 11–13.5°C)
All met at 8.30 a.m. at Clatteringshaws depot to collect traps and other essential equipment. JM and SM spent the day setting out 50 hair tubes in the Fleet Basin at locations based on the identical September 2014 exercise (although this time a new design of *Myotismart* hair tube was used). 1 fresh scat collected.
JB, GV and TB set out 20 cage traps in the eastern half of the Fleet Basin (phase 1). Much fresh evidence of marten activity at trap sites; 5 fresh scats collected.

11th September (showers and sunny intervals, turning windy later; 11.5-15°C)
JM and SM continued with setting out hair tubes. JB, GV and TB checked 20 traps between 0830 and 1400h. 7 martens caught and marked, with last animal released at 1300h, so need a swifter approach in future! Evening check of last ten traps 1630-1900h produced one new animal and one recapture. So 9 captures of 8 individuals on the first day's trapping.

12th September (showers plus sunny intervals, turning to longer spells of heavy rain in the evening; 9.5-14°C)
Morning trap-checking 0830-12 noon in two teams 'leap-frogging' around the circuits and coordinated by radio contact: 3 recaptures and 2 new captures.
Some scat survey work done. GV did pre-baiting of Phase 2 traps.
Evening round 1600-1900h in 2 teams: 2 new captures.

13th September (sunshine and showers all day; 9-13°C)
Two trap-check teams now operating independently (JM and GV doing the 10 traps SW of river, JB, SM and TB doing the 10 traps NE of the river). 4 recaptures on NE side of river, none on SW side. Traps all checked by about 11am.
More scat surveys.
Evening trap check – 1 recapture on SW side of river.

14th September (sunny, cool and breezy; 9-15.5°C)

Traps checked a.m. in two independent teams, and all traps removed using JM's trailer.
One new capture and 1 recapture. Most traps relocated to Phase 2 sites by JM and GV, with final pre-baiting done also.
JB, SM and TB did further scat surveys NE of the river. Good signs of marten activity but patchy.
TB departed.

15th September (sun and minor showers later; 11-15.5°C)
JM and SM started first check of hair tubes. Not much evidence of visits so the martens have yet to find them.
JB and GV set out final three traps.
JB and GV did further scat surveys. Data analysis in the evening suggests that we have scat abundance data from at least 33 monads in the Fleet Basin, with a mean marten scat density of 3.8 scats per km searched.

16th September (mostly sunny and dry; 7-12.5°C)
GV away on course in Edinburgh.
JM and SM continued with hair-tube checking and servicing: 8 tubes in total visited by martens but some problems with flies preventing collection of good hair samples (best hair samples from sites out in open locations).
JB met Jenni Mouat and set 20 Phase 2 traps in SE of Fleet Basin. Also did scat transect work in NW corner and towards Grannoch Lodge.
JB and J Mo checked two traps late afternoon and one contained a male marten.

17th September (sunny and dry; 8.5-16.5°C)
Checked Phase 2 traps in two teams doing 10 traps each: JM and GV entered via Laurieston Road entrance and caught 3 new animals; JB, SM and J Mo entered from north end and caught 5 new animals, making a total of 9 new animals on the first night of Phase 2, bringing total marked to 22. Then all did further scat surveys in different parts of Fleet Basin.
J Mouat left for home about 6pm.
To date we have surveyed 45 monads (out of 118 possible monad candidates) for scats, covering 33.75km, recording 130 marten scats at a mean density of 3.96 per kilometre.

18th September (overcast, calm and dry; 9.5-14°C)
Morning trap-checking in two teams again: JB and GV did the trap circuit starting in the south at the Laurieston entrance, while JM and SM did the NW circuit. This produced 5 recaptures, one of which was also caught again later in the day on the evening check. In between times GV and JB had to change wheels on their vehicles following punctures near the southern end of the forest; JM and SM completed further scat surveys in two areas; and GV and JB did scat surveys in a further area. So far we have completed 19 of the 21 1km transects; and for the monad study we had completed over 43 kilometres of scat-searching across 57 monads, with a mean density of 4.3 marten scats found per 1km searched.

19th September (Sunny intervals, dry; 6.5-14.5°C)
Morning trap-checking in two teams produced 4 recaptures and two new animals, bringing the cumulative total to 24 individuals marked in the study area. The evening trap check produced no daytime captures. In between checks we split up and did more 1km scat transects (all 21 completed now) and general scat surveys to maximise monad coverage. Currently we have completed over 64 km of surveys in 77 monads, with 241 marten scats recorded.

20th September (Drizzly and grey, turning to serious heavy rain after 11am; 14.5-15°C)
Trap-checking and removal in two teams, with 4 recaptures in total. This brought to an end an extremely successful two phases of trapping over a total of 8 nights, with 48 captures of 24 individuals across the Fleet Basin.
For the last bit of trap-checking we were joined by ecological consultants Jon Kendrew and Victoria Chanin. We showed them Galloway Lite boxes, a VWT box and hair tubes, then did some scat survey work around Bennan Hill in heavy rain, with some success.

21st September (Heavy overnight rain but clearing in morning to give a mainly calm, sunny day; 10-15°C)
JM and SM started the second check of the hair tubes, producing 14 hair samples from 53 tubes checked.
GV and JB started the checks of marten activity at GL boxes: of 21 boxes checked 12 (57%) showed some evidence of occupancy by pine martens. Further scats were collected. JB and GV did further scat surveys, bringing the total distance covered to 71.4km over 82 monads, with 274 scats recorded. Total scats collected stands currently at 93.

22nd September (Cool morning with light rain, turning to heavy rain all afternoon; 9-12°C)
JM and SM continued checking and servicing hair tubes, with 8 tubes visited by martens (making a total of 22 on this check).
JB and GV continued checking the Galloway Lite boxes, completing >40.
Two fresh scats collected, bring the total collected to 95.

23rd September
All returned home.

29th September-1st October (mixed weather – heavy rain on 1st October)
JM returned to Fleet Basin (with assistant Kevin Heywood of Simply Ecology) to undertake third check of the 99 hair tubes. Good weather on 30th September – 65 tubes checked – but heavy rain on 1st October when final 35 tubes checked. Overall 50 of the tubes had been visited by probable martens, with hair samples recovered from 41 tubes (remainder had failed due to damp affecting the strength of the cardboard backing or flies dominating the sticky patches).

5th October
GV and assistant to check the final 8 GL boxes in the Fleet Basin. 2 of the 8 had been heavily used; also medium use of GL12, where a marten had apparently gathered hay from the recent trap site nearby and imported it into the box.

6th to 8th October (mixed weather again – very wet on 7th)
JM and assistant Samantha Gray of Simply Ecology returned to Fleet Basin to undertake 4th check of 99 hair tubes. Wet weather on 7th October – 75 hair tubes checked; better weather on 8th October – 25 samples checked. 63 tubes visited by martens (including some tubes visited for first time) and 51 hair samples gathered. 12 tubes had either glue patch missing or bait taken and no hair sample due to mass of flies on glue patch. Cardboard backing on glue patch gets very damp and glue will separate from it on contact with marten fur.

14/15th October (generally damp conditions, with rain showers and drizzle)
JM and SM made 5th and final visit to recover all hair tubes and collect samples for genotyping (their trip was affected by puncture problems once again as well as traffic delays). 72 out of 99 tubes showed signs of visits by martens (bait removed), but only 34 produced hair samples due to very damp conditions affecting the function of the sticky patches (and more problems with flies). All hair tubes and stobs were recovered and stored at Clatteringshaws depot.