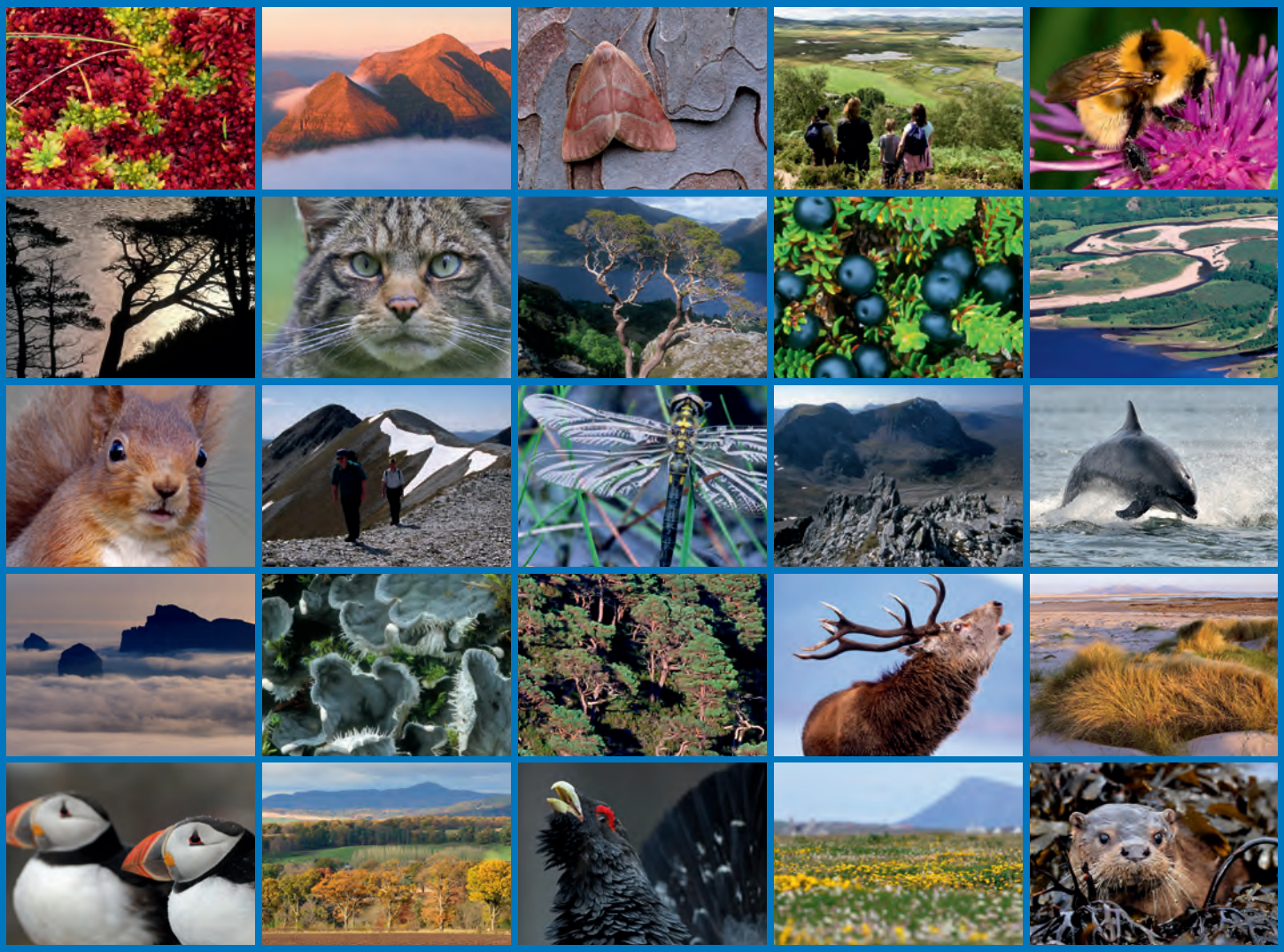
Scottish Natural Heritage
Commissioned Report No. 928

Bats and Licensing: A report on the success of maternity roost compensation measures



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COMMISSIONED REPORT

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Bats and Licensing: A report on the success of maternity roost compensation measures

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COMMISSIONED REPORT

Summary

Bats and Licensing: A report on the success of maternity roost compensation measures

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Year of publication: 2016

Keywords

Bats; mitigation; compensation; licensing; monitoring; development; maternity roost.

Background

Bats and their roosts are protected throughout the EU as a result of historical declines. As many species roost in buildings there can be conflict between development and bat protection legislation. If a development project meets legal requirements, a licence can be issued to allow bats to be disturbed and their roosts damaged or destroyed as part of works.

One of the requirements for a licence is that the project must have no negative impact on the conservation status of the species in question. In order to meet this obligation, compensation must be provided for any loss or damage to a roost. This usually involves replacing roosts on a "like for like" basis. There is an underlying assumption that by doing this works will not affect the local bat population. At the moment there is little evidence for the effectiveness of these compensation roosts, particularly where maternity roosts are involved. The aim of this project was to carry out monitoring of compensation roosts to increase our knowledge of their success.

Main findings

- From July 2011 to the end of December 2014 SNH issued 437 licences to permit works affecting bat roosts for development activities. Of these 67 involved maternity roosts. 28 of the maternity roost sites were monitored during this project.
- Compensation was installed as described in the species protection plans at all the sites monitored.
- 18% of sites had compensation which was being used by a maternity colony of the target species.
- 14% of sites had compensation which was being used as a non-maternity roost by the target bat species.
- 7% of sites had compensation which was being used by bats other than the target species (non-maternity roosts).
- 61% of sites had no evidence of compensation being used by bats.
- Of the five sites which had a maternity colony present, four had retained roosts and access points. Compensation at the remaining site consisted of three Schwegler 1FFH boxes mounted on an external wall, close to the original roost entrance.
- One of the sites which retained use by a maternity colony had an increased average roost count (7%) after development work had taken place, two decreased in numbers (66% and

68%), one maintained numbers and one couldn't be counted as presence was inferred from droppings.

- A predictive model showed that bat counts at sites affected by development are likely to have a reduced number of bats present in the post-development period for all types of compensation whereas counts at sites not affected by development would remain stable over the same period of time. Retained access sites were predicted to show the least reduction in bat numbers, with bat box sites showing the greatest reduction.

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Definition of Terms and Abbreviations

BCT – Bat Conservation Trust

Development – For the purpose of this report the term development follows the definition given in the Town and Country Planning (Scotland) Act 1997;

'…."development" means the carrying out of building, engineering, mining or other operations in, on, over or under land, or the making of any material change in the use of any buildings or other land.'

Building work may include demolition, modification, restoration or conversion of a building.

The 'developer' may be an individual, company or organisation who is responsible for undertaking the development activity.

Mitigation and Compensation - The terms mitigation and compensation have slightly different meanings when considered in a legislative context. Mitigation aims to reduce or eliminate negative impacts of a project and may involve the avoidance of deliberate killing, injury or disturbance of bats by altering work methods or timing. Compensatory measures aim to off-set unavoidable negative impacts and in bat work may include the creation, restoration or enhancement of roosts and/or associated habitats.

SNH – Scottish Natural Heritage

Site – The term site refers to an area impacted by development. All sites included in the study had at least one maternity roost present and may or may not have had non-maternity roosts of target or other species. This report does not consider the non-maternity roosts.

Original Roost – The maternity roost present prior to development work being undertaken.

Compensation Roost – The roost provided for bats post development. The roost may be partly or wholly artificial and may or may not be in the same location as the original roost.

Target Species – The species which made up the maternity colony present prior to development.

1. INTRODUCTION

1.1 Background

Bats are under threat globally due to loss and modification of habitat, persecution due to negative media associations, pesticide use, chemical timber treatments, disease, exploitation as a food resource, and a general lack of understanding of species ecology and distribution (Mickleburgh et al.,, 2002). The biggest threats to bats in Britain are fragmentation and loss of suitable habitat, intensification of agriculture, conflict with people and development (Anon, 2014; Battersby, 2005; Wickramasinghe et al.,, 2004).

As a result of historical declines throughout Europe (Stebbings and Griffith, 1986) all bats and bat roosts present in the UK are protected under the EC Habitats Directive, transposed in Scotland through the Conservation (Natural Habitat &c) Regulations 1994 (as amended).

Many bat species have adopted man-made structures such as houses, bridges, tunnels, barns and steadings as roost sites. The preference for some species to use man-made structures brings them into increased contact with people which can result in conflict, especially when development proposals are made for buildings used as roosts. To compound the issue, some species are typically associated with older buildings (Entwistle et al.,, 1997) which are more likely to be subjected to development works.

Throughout the year bats have different roosting requirements. They hibernate through winter, and look for structures that are cool, moist and have stable temperatures and humidity such as caves, tunnels, ice houses and mines. In summer male bats and non-breeding females tend to roost singly or in small groups and will use buildings, tree crevices and other structures such as bridges. They typically use a variety of roosts throughout the spring, summer and autumn seasons.

Female bats form maternity colonies in summer (May-August) to give birth to and rear young. The size of a maternity colony will vary depending on species and site suitability, but numbers can range from tens of bats to over a thousand. More than one roost may be used during the course of the maternity season. Frequency of roost switching varies with species and roost type and can be influenced by climatic factors as well as disturbance, parasite build-up, predation and foraging availability (Lewis, 1995).

In Britain, soprano pipistrelle (*Pipistrellus pygmaues)*, maternity colonies tend to inhabit one main roost alongside a number of smaller satellite roosts between which they move frequently (Stone et al.,, 2015). Daubenton's (*Myotis daubentonii*) and Natterer's (*Myotis nattereri*) can switch roosts every few days but are loyal to an area and return to the same group of roosts year on year (Ngamprasertwong et al.,, 2014; Smith and Racey, 2005). Brown long-eared bats (*Plecotus auritus*) are often loyal to one roost throughout the maternity season as well as returning to the same one each year (Entwistle et al.,, 2000).

Bats roosting within buildings tend have high levels of fidelity to their roost site (Ngamprasertwong et al.,, 2014; Trousdale *et al.,* 2008). It has been suggested that fidelity is related to the availability and longevity of roosts, with scarcer and more permanent roosts leading to greater roost loyalty (Chaverri et al.,, 2007; Trousdale et al.,, 2008; Norquay et al.,, 2013).

Roost size may also play a part in fidelity as larger roosts have a greater spread of climatic conditions which bats can move around in depending on their requirements (Entwistle, 2000; Palmeirim and Rodrigues, 1995).

Temperature is particularly important for maternity colonies as they require warm stable environments due to the energy demands of pregnancy and lactation (Sedgeley, 2001; Kerth et al.,, 2001). Roosts within buildings have been shown to warm more slowly during the day and retain heat longer at night than rock crevice roosts (Lausen and Barclay, 2006; Zahn, 1999). Roosts in buildings are also warmer than tree crevice roosts. A study in the north east of Scotland showed that maternity roosts in buildings were an average of 6.3^{o}c warmer than ambient temperature, whereas roosts in trees were only 0.5^{o}c higher (Ngamprasertwong et al.,, 2014). Increased temperatures are correlated with less torpor in lactating females, earlier births and increased juvenile growth and may lead to greater reproductive success in the colony (Hoying and Kunz, 1998; Lausen and Barclay, 2006; Racey and Swift, 1981).

If bats are forced to move roosts (e.g. because of a development) this may disrupt social bonds, and place increased energy demands on individuals when finding new roosts and foraging sites (Lewis, 1995). Due to the energy costs involved in finding new roosts, the loss of a maternity roost site can have a high impact on local bat populations (Mitchell-Jones, 2004). This impact will be even greater where alternative roosts are of inferior quality and could lead to reduced reproductive output. Even where alternative roosts are of equal quality the surrounding habitat may be of inferior quality for foraging, or foraging areas may be at a greater commuting distance which could lead to reduced individual fitness and reduce the long term viability of the population.

1.2 Development and Bat Licencing

Where development projects affect bats and/or their roosts, Scottish Natural Heritage has the authority to grant licences for activities which would otherwise be an offence under the existing legislation. For licences to be granted three strict tests must be met.

Test 1: The reason for the licence must relate to one of several specified purposes listed in Regulation 44(2) of the Conservation (Natural Habitats &c.) Regulations 1994 (as amended).

Test 2: There must be no satisfactory alternative.

Test 3: The proposed action must not be detrimental to the maintenance of the species at 'favourable conservation status'.

Since taking over licencing responsibilities from Scottish Government in 2011, SNH have issued 437 licences (up to the end of 2014) relating to bats and development. The issuing of bat licences can be complex with many applications involving more than one species and/or multiple roost types.

Where possible, development work should be designed to avoid or minimise impacts to bats. Where impacts cannot be avoided compensation must be provided on a like for like basis. The Bat Mitigation Guidelines (Mitchell-Jones, 2004) are used by SNH staff to help determine appropriate compensation. Typical compensation measures include the provision of bat boxes, freestanding bat lofts or retained roosts and access points (fig.1). SNH require compensation to be provided on a like-for-like basis, as far as possible, with the aim of ensuring there is no net negative impact on bats and that they have sufficient resources secured in the long term. It is expected that by providing suitable compensation for the species concerned the favourable conservation status of the population will not be affected.

Whilst monitoring of compensation is recommended for at least two years in the Bat Mitigation Guidelines (Mitchell-Jones, 2004), this is not typically secured through a licence condition. When monitoring is undertaken results are not reported to SNH. Therefore, at present there is little evidence to support the assumption that compensation will negate development related impacts on the population.

Figure 1. Examples of different types of roost compensation. From top left running clockwise; a reinstated access point for a retained roost, a Schwegler 1FFH bat box mounted on a building, a freestanding bat loft, a heated bat box, entrance to an internal bat box in new building, a Schwegler 1FS bat box mounted on a tree.

1.3 Current knowledge of artificial bat roosts

Whilst there have been several long term studies looking at the uptake of bat boxes (Tuttle and Hensley, 2000; Poulton, 2006; Flaquer et al.,, 2006) they tend to concentrate on boxes as habitat enhancement rather than compensation for a lost or damaged roost.

Some studies have investigated the success of compensation following roost damage or destruction. In 2006, SNH published a review by the Bat Conservation Trust on the success of internal bat boxes at households which had reported problems with bats. Out of nine case studies, four had no bats present and the remainder had bats but with numbers reduced compared to maximum counts before works. The report identified points of failure as: inappropriate entrance design, unsuitable temperatures, unsuccessful exclusion from other areas of the property (so bats were still able to access the original roost site), and inadequate positioning of the boxes. All of the case studies involved soprano pipistrelles with the exception of one brown long-eared bat roost.

The Snowdonia National Park Authority commissioned a report looking at the success of mitigation associated with development projects (Waring, 2011). They looked at 20 sites within the National Park. Less than half the sites had information available on how bats had used the building prior to works so determining the success of projects was difficult. Only one site was known to have a maternity roost prior to works. A quarter of the sites had no bats or signs of bats present after development work. Only one of the sites was considered to be a full success by the author's criteria (bats present in the same quantity, exhibiting the same kind of use, and mitigation was provided as described in the species protection plan), although 75% of them showed some evidence of use. The study found that 65% of the mitigation projects had not complied with conditions imposed as part of planning permission.

Stone et al.,, (2013) carried out a review of licences issued by Natural England. Due to less than a fifth of licensees providing post development impact and monitoring reports, information on mitigation success was scant. From the information that was available, they found bat lofts/barns were more successful than bat boxes with an occupancy rate of 74% and 13% respectively. The study does not say which species the lofts/barns or boxes were

provided for. They reported a reduced number of bats present at sites post-development, compared to the pre-development surveys for all species.

The Vincent Wildlife Trust published results of monitoring at bat development sites in Ireland (Aughney, 2008). Out of 12 sites, eight relied on bat box schemes for compensation. In total, 150 boxes were inspected and bats were found to be occupying 20% of them with a further 30% showing signs of previous occupation. The most common bat found in boxes was soprano pipistrelle, followed by common pipistrelle (*Pipistrellus pipistrellus*) with a small number of Leisler's (*Nyctalus leisleri*) and Daubenton's also present. The majority of occupied boxes housed less than 5 bats. The study suggested bat boxes were not likely to be suitable compensation for maternity roosts. The report also considered three sites which involved roof renovation works at brown long-eared bat maternity roosts. At each site the roosts were retained *in situ*, but only one was successful in maintaining similar numbers of bats, the second had bats present in reduced numbers and at the other, the colony had moved elsewhere within the site.

It is clear from these studies that the results of mitigation are variable. It must be considered that all of the studies have limited sample sizes and not all of them have sufficient data available to accurately assess mitigation success. Only one of the studies was conducted in Scotland and it dealt with only one type of mitigation. Due to climatic variances and differences in species assemblages, results from elsewhere in the UK may not apply to Scotland. There is therefore a significant gap in our knowledge which needs to be addressed to ensure we are meeting our legislative bat protection obligations and maintaining species at favourable conservation status.

1.4 Project Objectives

This project assesses the effectiveness of compensation incorporated into development works affecting bat maternity roosts licenced by SNH from 2011-2014. The aim of the project is to fill our knowledge gap pertaining to the success of compensation and identify areas requiring further study. The results will help inform future licensing decisions and ensure licensing requirements are proportionate and effective.

The assessment of compensation effectiveness is made through monitoring sites which were granted licences and comparing current use by bats with pre-works survey information. The project focusses on maternity roost mitigation due to the high impact their loss can have on local populations.

In order to determine the effectiveness of compensation roosts the following questions were asked:

- Has the Species Protection Plan (SPP) been followed?
- Are the same species still present in the roost?
- Is the roost still being used by a maternity colony?

Roost counts at the development sites are compared with counts at sites unaffected by development in the period before and after works have taken place to account for factors other than the development work, such as weather, which may affect colony numbers and retention.

The project also investigates which, if any, aspects of compensation design and placement affect the chances of bats using compensation.

1.5 Factors in roost site selection and use

There are many factors which influence roost selection and use, and therefore determine the probability that a compensation roost will be successful. As nocturnal creatures, bats are sensitive to changes in the lighting regime around their roost (Boldough, 2007; Zeale et al.,, 2014; Stone et al.,, 2015). Lighting regimes at development sites are prone to change, especially where development involves building conversions or the construction of new buildings. The impacts of different types of lighting vary considerably and different bat species show diverse behavioural responses which can be both positive and negative (Stone et al.,, 2015). Some species benefit from the increased abundance of insects and actively forage in lit areas, whilst others avoid them and suffer from reduced foraging space and disrupted commuting lines (Stone et al.,, 2015).

Lights near roost entrances can also affect the timing and number of bats emerging at dusk (Shirley et al.,, 2001). There have been records of roosts being abandoned after external lights were installed (Boldough, 2007). Zeale et al.,, *(*2014) found that lights shining directly on to Natterer's bat roost entrances prevented them from emerging altogether. It is likely that lighting around a compensation roost could influence whether or not the roost is used.

Temperature has been shown to influence roost selection in soprano pipistrelles (Lourenco and Palmeirim, 2004), brown long-eared bats (Entwhistle et al.,, 1997) and Bechstein's bats (Kerth et al.,, 2001). Roost temperature requirements change throughout the year depending on a bat's needs. Throughout winter, early spring and late autumn bats favour roosts with low temperatures for hibernation and periods of torpor. In summer, female bats prefer roosts with warmer temperatures. It is thought that this is due to increased energy demands associated with lactation.

It is likely that compensation roosts such as bat boxes and bat lofts will have different temperature regimes and humidity to the original roosts selected by female bats as maternity roosts. Lourenco and Palmeirim (2004) demonstrated that whilst maximum temperatures in loft spaces and external bat boxes were similar, temperature ranges in the boxes were much smaller. Even where roosts are retained *in situ*, if the use of the building has changed or the space available to bats has been altered, temperature regimes are also likely to change.

Physical aspects of artificial roosts such as the setting (building/tree/freestanding), aspect and size of the roost have been related to their chances of occupation (Flaquer et al.,,2006; Poulton, 2006) and are likely to be related to internal roost temperature and humidity.

The length of time that a bat box has been in place, type of bat box and height of bat box can also have an effect on occupancy rates, although there is a lot of variation between species (Poulton, 2006).

Another major variable which influences roost selection is adjacent habitat. Development activities generally have some impact on their surrounding environment but for most, other than large infrastructure projects, impacts will be local and small scale. Habitat within 1-1.5km is thought to be a good predictor of roost presence (Boughey et al.,, 2011; Jenkins et al.,, 1998) although bats have been shown to be sensitive to landscape composition at scales of just 50 – 100m (Hale et al.,, 2012). This means that even small scale alteration of habitat due to development may affect its suitability for bat occupation. Distance from the roost entrance to cover may also be important (White, 2004; Jenkins et al.,, 1998; McAney and Hanniffy, 2015).

2. METHODS

2.1 Site Selection

Data on all bat licences issued between the start of 2011 and the end of 2014 were extracted from SNH's licencing database. Licences issued before 2011 were not included in the data search as SNH was not the responsible licensing authority prior to this. Licences issued after 2014 were omitted as it was less likely that compensation would be completed for the project's summer survey season. Data for licences issued for reasons other than development (survey, science and research and exclusions for public health) were excluded from the search as compensation is not normally considered appropriate for these cases.

A total of 437 development licences for bats were issued between July 2011 (the month SNH took over licencing) and the end of 2014 (fig 3), 67 of which related to maternity roost sites. The breakdown of licences issued by species and licence type is shown in figure 4. The percentage of total licence applications involving maternity roosts was much higher for brown long eared bats than soprano and common pipistrelles, the other two species most regularly affected by development (26% vs 13% and 11% respectively).

The licence application and supporting documents for the maternity roost sites were checked to see if appropriate pre-development survey information had been provided and compensation was included as part of the species protection plan. Pre-development survey information was deemed appropriate if it included a reliable estimate of the number of bats in a colony (colony size) based on emergence and/or re-entry surveys or internal surveys where the surveyor was able to view and count the number of bats present. Surveys which gave estimates of colony size based on droppings alone were not included because the count accuracy would not be sufficient for statistical comparison with any new surveys of the site.

Forty eight sites fitted the criteria required for inclusion in the study and each licence holder was contacted to request access permission for surveys. Some sites which fitted the criteria for monitoring were not included for the following reasons: failure to make contact with the licence holders, on-going construction works at the site and delayed work. Two licence holders didn't give a reason for denying access and one had delayed works due to the onerous cost of the bat compensation (a bat loft for brown long-eared bats). Two sites did not have the compensation in place before the start of the breeding season. A survey was done at one of the sites where compensation had been put in later in the season. Whilst evidence of use (droppings) was found, the results are not presented here as it was considered its success could not be compared to other roosts as it was not available to bats until after the start of the maternity season. In the end access for monitoring was granted at 28 roosts across 27 sites.

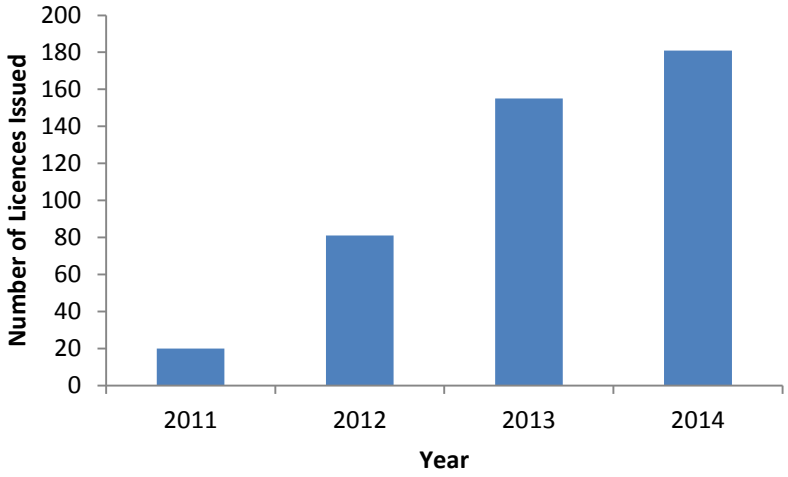

Figure 3. The number of bat development licences issued over from the period 2011 – 2014. NB: Data from 2011 is for July to December only.

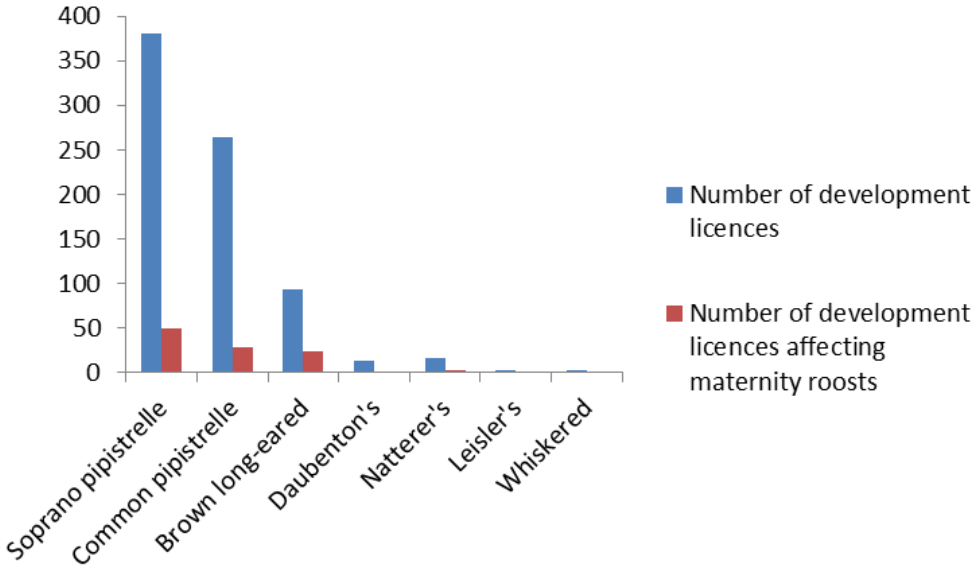

Figure 4. The number of development licences issued by species. NB: The number of licences here is greater than the total number of licences issued due to the fact one licence may cover more than one roost and/or species.

2.2 Monitoring

Monitoring was carried out by SNH staff and volunteers between 1st May 2015 and 31st August 2015. Figure 2 shows the locations of monitoring sites. The details of each site can be found in Annex 1. Volunteers were recruited via local bat groups and universities and were considered competent in bat surveying. Compensation roosts were categorised as being a bat box, heated bat box, retained roost with access points or a bat loft (free standing structure with internal flight space). It is important to note that some of the licence applications involved impacts to more than one roost and multiple species in which case only compensation provided for the maternity roost was monitored. For example one site had

retained roof space for a brown long-eared maternity roost which was monitored, but several bat boxes and retained access points provided for non-breeding pipistrelle bats were not monitored.

2.2.1 External roost inspections

Compensation roosts were inspected during daylight hours for signs of bat presence such as bats, noise, droppings, scratch marks, staining from oil and/or urine, feeding remains, smell and access points clear of debris. Any evidence of bat presence was recorded and photographed. Binoculars were used for roosts which were too high to view from the ground or by ladder. If compensation roosts were on or within a building the whole perimeter was checked for evidence of bats. Building/roost interiors were inspected where access was possible with a licensed bat worker.

The roost aspect, number and height of entrances were recorded. Aspects of the roost entrances were also recorded initially but in the majority of cases they were the same as roost aspects so the results are not presented. Due to difficulties in getting direct measurements, entrance heights were categorised as: <1m, 1-2m, 3-4m, 4-5m, >5m. Where there was more than one roost entrance the minimum height was used for analysis. Compensation roosts which faced more than one aspect were recorded as having multiple aspects. Roost setting (building external, building internal, tree, post, freestanding) was noted along with the potential for other roost sites in the vicinity. Any artificial lighting which would illuminate access points or the area surrounding the roost was recorded. The type of building and development type was also noted.

Measurements of the width, depth and height of compensation structures were either taken from supplier specifications for off-the-shelf bat boxes or from specifications provided in species protection plans (SPP) for custom made compensation roosts. Actual width, depth and height were confirmed during the external roost inspections. Dimension data were not available for seven sites: four of which had retained access points and two had custom made internal bat boxes. This is because it was not possible for surveyors to access the roost to take measurements, and the SPP did not specify the compensation roost dimensions. One site had an unspecified make of bat box and measurements were not taken during the field.

Roost volume was calculated from the dimensions. The shape of compensation structures was classified as rectangular, prismatic or cylindrical and the appropriate formulae were used to find volume. Where compensation comprised of a collection of bat boxes, the combined volume was the figure used in analysis.

2.2.2 Activity surveys

The majority of sites were monitored with a dusk emergence and dawn re-entry survey. Murray, Howwood, Forth, Clatteringshaws and Doune received a second dusk emergence survey instead of the dawn re-entry survey. For the first four sites this was due to weather constraints and surveyor availability. A dawn re-entry survey was deemed inappropriate at Doune because it would have been impossible to obtain an accurate count due to the high number of bats swarming. Only one dusk emergence survey was conducted at Dalkeith A and B, Manse and Mortlach due to time and/or weather constraints. It should be noted that the weather throughout summer 2015 was generally poor. Mean temperatures were below the 1981-2010 average and rainfall was higher than average. The July rainfall in Scotland was nearly double the average level (Met Office, 2015). This meant that the number of nights suitable for activity surveys were limited.

Activity survey methodology followed that given in Hundt (2012). Dusk emergence surveys started 15 minutes prior to sunset and continued for an hour and a half to two hours after. Re-entry surveys started an hour and a half to two hours prior to sunrise and finished at sunrise. Survey times deviated from recommended survey times at some sites. At Threave and Pine Cottage this was due to poor weather conditions. SCENE, Parker Place, Bargrennan, Manse Cottage and Auchmuty had slightly reduced survey times (1 – 1.5hrs) as there had been no or very little bat activity through the duration of the survey; no evidence of bats during the external inspection and the species which had been present were pipistrelles which typically emerge 30 minutes after sunset, although sometimes earlier (Swift, 1980). It is therefore considered unlikely that the reduced survey times would be a limitation of the survey. The dawn survey timing at Invertromie was reduced due to unforeseen road closures delaying surveyor arrival time.

Surveyors were positioned so that all entrances of the compensation roost could be viewed. Where the roost was located on or in a building and there were sufficient surveyors available the whole structure was covered. Species, number of bats, time of emergence/re-entry, and location of emergence/re-entry were recorded.

A mixture of detectors and recording equipment were used (Annex 2). During the surveys bat calls were recorded using either a Bat Box Duet connected to a Rolands R-05 WAVE/MP3 recorder or the Echo Meter Touch (Wildlife Acoustics Inc. USA). Calls recorded with the Duet were analysed using BatSound real-time spectrogram analysis software, version 4.2. Calls recorded on the Echo Meter Touch were analysed using the integrated app on an ipad mini 2.

It is possible that where heterodyne and older frequency division and time expansion detectors with less sensitive microphones were used, not all bats would have been picked up. Brown long-eared bats in particular can be difficult to detect as they echolocate quietly. It is unlikely that any maternity roosts of this species were missed during monitoring though. All but one of the sites with brown long-eared bats was surveyed with the use of a new time expansion detector. External and internal inspections were also carried out prior to activity surveys so maternity roosts could be identified by signs such as droppings and feeding remains as well.

Following analysis of the results, the compensation roosts were categorised depending on the bat use recorded during monitoring. Definitions of these categories are given in table 1.

Table 1. Roost status category definitions

Category	Definition
A	Maternity colony of target species using compensation.
B	Bats of the target species are using the compensation but in low numbers, not considered to be a maternity colony.
C	Bats other than the target species are using the compensation as a maternity roost.
D	Bats other than the target species are using the compensation, not as a maternity roost.
E	No evidence of bats using the compensation.

2.3 Distance to treeline

Distance to the closest treeline was calculated from aerial photographs in geo.View.3.2 using the measure tool. The distance to the treeline from the roost entrance was measured. Where compensation had multiple entrances, the measurement was taken from the entrance closest to the treeline. Distance to treeline was also estimated in the field. Where the field and desk measurements varied the ground estimation was used as some of the photographs were taken before development work took place.

2.4 Data analysis

All statistical analysis was carried out using the R statistical programme (R Core Team, 2015).

2.4.1 Variables affecting the retention of target species

Unbalanced data, small sample sizes and a high number of zero counts meant parametric statistical tests were not viable for this part of the analysis. Sites were grouped by the presence or absence of bats in the compensation roost. Non-parametric tests were used to assess whether there were any differences between sites with and without bats using mitigation.

Fishers Exact test was used to test for independence between bat presence/absence and categorical variables. The Wilcoxon-Mann-Whitney U test was used to test for independence in the continuous variables.

To ascertain if the volume of compensation provided was proportionate to the size of maternity colony present prior to works taking place, linear regression was carried out using the maximum count before development and compensation volume. Data were log transformed due to values covering several orders of magnitude. Sites with retained access points were left out of this analysis as the size of these compensation roosts were determined by the existing structure rather than mitigation design. Compensation at all but one of the remaining sites was for pipistrelle bats. The one site for brown long-eared bats (Pines) was also removed from the analysis so that all the compensation included would be for bats with similar roost requirements.

2.4.2 Colony counts at development sites compared to sites not impacted by development

To compare colony size of compensation roosts to colony size pre-development, data were extracted from survey reports submitted alongside licence applications. Only roost counts conducted in May, June, July and August were taken forward for further analysis to ensure that surveys were concurrent with the post-development monitoring and within the recommended survey guidelines (Hundt, 2012). An exception was made for the roost at Knock as counts had only been made in September. In order to minimise the chance that differences in pre-development and post-development counts could be attributed to factors other than the development work, data from roosts unaffected by development were included in the analysis.

The Bat Conservation Trust's National Bat Monitoring Programme (NBMP) is a volunteer led roost survey scheme. Surveyors follow a standardised survey protocol at known roosts of a variety of species. Data from 2011-2015 surveys were obtained so that a comparison could be made between NBMP sites, which were unaffected by development, and the development sites surveyed for the bat mitigation project. To avoid using data on species which do not occur in Scotland, and confounding factors such as weather, only NBMP data from sites in Scotland were used in the comparison. In addition, only sites which had been surveyed in 2015 and at least once in the previous 4 years were included so that data were

comparable with those held for the mitigation sites. Data from NBMP surveys conducted outwith the main survey period, May – August were also omitted from the analysis. A search was made for the NBMP site names and locations in SNH's licencing database to confirm that they had not been subject to development.

A generalised linear mixed effect model was fitted to predict bat counts for the different compensation types (including the NBMP sites as a control) in the pre- and post-development period. In addition to bat count and compensation, species was added as a fixed effect to account for the higher numbers of soprano pipistrelles across sites, compared to other species. Site and development period were added as random effects to account for some of the natural variability between the sites and time periods which wasn't measured directly. A manual step-wise selection process using the Chi-squared test was used to select the model parameters. The model was fitted with a negative binomial distribution to allow for the high occurrence of zero count values.

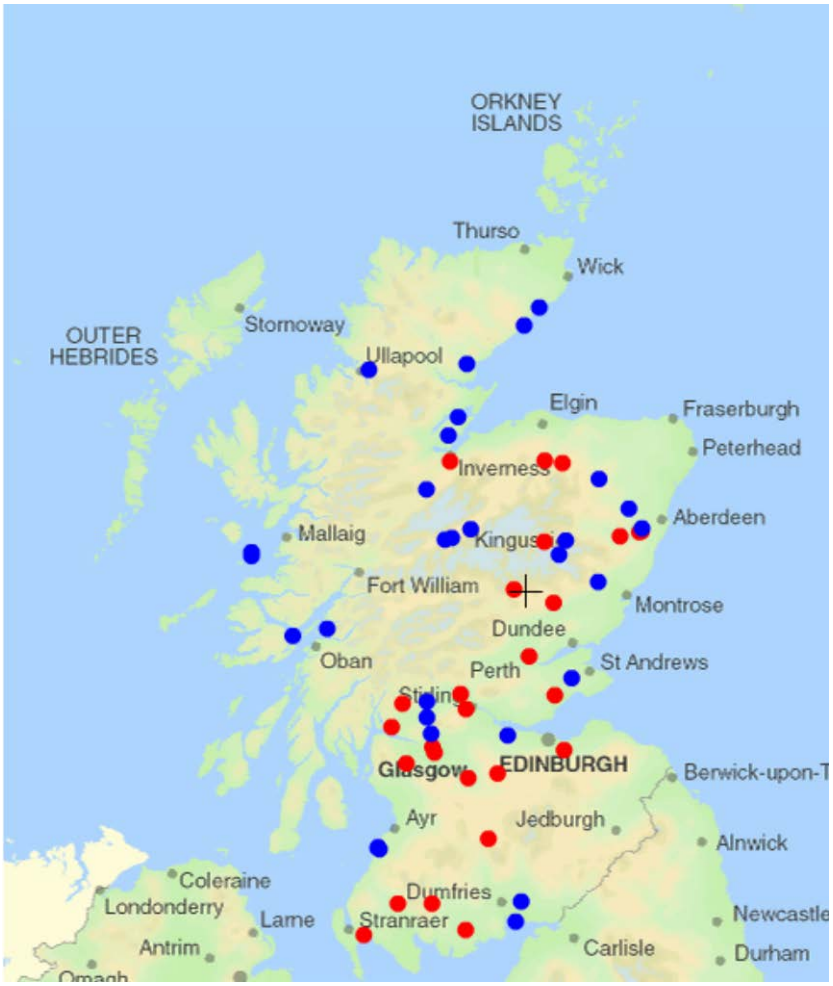

Figure 2. Map showing the locations of sites with compensation, monitored for the bat mitigation project in red and the location of NBMP colony counts sites included in the project in blue. © Crown copyright [and database rights] 2016 OS 100017908

3. RESULTS

3.1 Monitoring

3.1.1 External Surveys

All the monitored compensation was installed as described in the species protection plans submitted with licence applications. No bat boxes were found to be damaged or missing. Full results from the external surveys can be found in Annex 1.

Compensation at the majority of sites (61%) took the form of bat boxes, a third of which were heated. Unheated bat boxes were largely fitted externally to buildings (55%), with some inside buildings (27%) and the rest fitted on trees (18%). No bat boxes were mounted on poles. One of the heated bat boxes was fitted inside a building with the rest placed on building exteriors. Only two sites (7%) had bat lofts and 32% of sites had retained roosts. According to the Fishers Exact test, compensation type and setting were not significantly different at sites with bats compared to sites with no bats (Table 2.).

All the sites with bat boxes and heated bat boxes had common or soprano pipistrelles as their target species. One of the bat lofts was for brown long-eared bats and one was for a large (500+) mixed pipistrelle roost. The retained access sites were aimed at a range of species including brown long-eared, common and soprano pipistrelles and whiskered bats (*Myotis mystacinus*).

The volume of compensation roosts provided for bats ranged from 0.02 - 257 m^3. The mean volume of roosts provided at sites with bats using compensation was 100m^3 whilst sites without bats were significantly smaller with a mean volume of 8.4 m^3 (Table 3). Linear regression showed that there was no relationship between the number of bats present in a colony prior to works and the volume of bat box or loft provided for them (r^2 =0.159, f_{df} =2.458 13, p=0.141).

There was a greater number of compensation features put in place in the second half of the study period than in the first which is probably a reflection of the greater number of licences being granted during that period. The distribution of compensation ages can be seen in figure 5. Length of time compensation had been available to bats did not differ between sites with bats present and those with bats absent (Table 2).

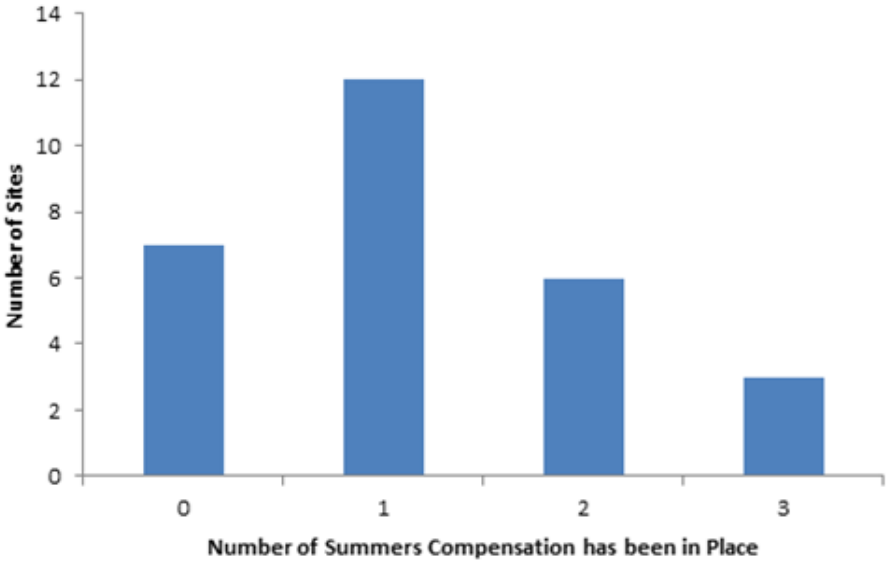

Figure 5. The age distribution of compensation roosts.

The majority of compensation roosts (57%) had entrances which were higher than 5m. Six roosts had entrances between 3-4m, six at 4-5m (both 18%) and two were in the lowest height range of 2-3m (7%). Entrance heights were different at sites with and without bats (Table 2). This may be due to the fact that there was a greater spread of entrance heights across the 19 sites which didn't have bats present compared to the 9 sites which did, rather than a reflection of bats preferences for entrance heights.

A wide variety of roost aspects were recorded. Most of the compensation (39%) consisted of a collection of boxes or complex structures which were open on multiple aspects. A further 36% faced south, south east or south west. The remaining 25% of sites faced north, west and east. According the Fishers Exact test, there was no difference in aspect at sites which had bats compared to those which didn't (Table 2).

No artificial lights near roost entrances were recorded at 22 sites. One site had a security light positioned within 2m of the compensation roost entrance which appeared to be permanently on. Two compensation roosts had lights positioned nearby but were in the same position in relation to the roost entrance as they had been before development works took place so were unlikely to alter bat behaviour. Three sites did not have lights near roost entrances but did have artificial lights which shone on potential flight paths between compensation roosts and tree cover. None of the sites which recorded lights near compensation or surrounding commuting space had roosting bats present.

All sites had other potential roost sites within their vicinity. Types of potential roost include buildings, trees and additional bat boxes. Details of the potential roosts can be seen in Annex 1.

Distances from the compensation roosts to the closest tree line ranged from 0m (where compensation roost was mounted within a stand of trees) to 87m. The average distance in occupied compensation roosts was 14 m, whereas the average distance for unoccupied compensation roosts was 19m. The results from the Mann Whitney-U test show that the difference between occupied and unoccupied sites was significantly different ($U=703$, $p=<0.001$).

Table 2. Results from the Fisher Exact tests comparing variables at sites which had the target bat species present in compensation and those which did not. Where p values are >0.05 there are no statistically significant differences in the variables for the two groups.

Variable	P value
Compensation Type	0.30
Setting	0.06
Age	0.46
Entrance height	0.03*
Aspect of Roost	0.53
Lighting	0.37

*Significant result

Table 3. Results from Mann Whitney U tests comparing variables at sites which had the target bat species present in compensation and those which did not. All p values are <0.05 indicating significant differences between the variable in the two groups.

Variable	Mean Value (±se, n) Bats Present	Mean Value (±se, n) Bats Absent	U/W value	P Value
Volume of Compensation Roost (m^3)	100 (±35,5)	8.4 (±5.8,16)	136	<0.001
Number of Entrances	5 (±1.6,9)	3 (±0.8,19)	190	<0.001
Distance to treeline	14 (±2.1,13)	19 (±3,44)	703	<0.001

3.1.2 Activity Surveys

A summary of activity survey results by site can be found in Annex 1 and the number of sites in each roost status category is given in table 4. Four sites (14%) had maternity colonies present and were classed as category A. Based on a comparison of mean counts before and after development work was undertaken; one site experienced a 7% increase in the number of bats, two sites showed a decrease of 66% and 68% respectively and one site had the same number of bats.

Another site (Dalkeith b) had no bats present during monitoring conducted in late August but had a considerable number of fresh droppings (200+) in the retained roof space. This site was considered to be successful in retaining its maternity colony and was included in category A for analysis.

Four further sites had non-maternity colonies of the target species present and were classed as category B. Three of these sites had supported common and soprano pipistrelle maternity colonies of between 16 - 530 bats before works took place. Post-development surveys found 2-5 bats present.

At Threave no whiskered bats were found during monitoring, however, weather conditions during surveys were not ideal. National Trust for Scotland staff later reported that the bats had returned to the site although it is not clear if the roost continues to function as a maternity roost (Meigas, 2015). Given the uncertainty of the roost status it was included in category B.

Compensation was not being used by the target species at 19 sites (67%). Two sites were being used by bat species other than the target species; no maternity colonies were present

though. One had a common pipistrelle roosting in a loft designed for brown long-eared bats and the other had a soprano pipistrelle using a retained roost for common pipistrelles.

A further 17 sites had no evidence of bats using the compensation roosts at all. However, one of these sites had a maternity colony of the target species present but using a different part of the building from the internal box which had been constructed as compensation. The target species was recorded during activity surveys at seven of the sites, suggesting there may be other roosts nearby. The breakdown of results by compensation type is given in Figure 6.

Table 4. The number of sites assigned to each roost status category

Category	Number of sites
A - Maternity colony of target species using compensation	5
B - Bats of the target species are using the compensation but in low numbers, not considered to be a maternity colony.	4
C - Bats other than the target species are using the compensation as a maternity roost.	0
D - Bats other than the target species are using the compensation, not as a maternity roost.	2
E - No evidence of bats using the compensation.	17

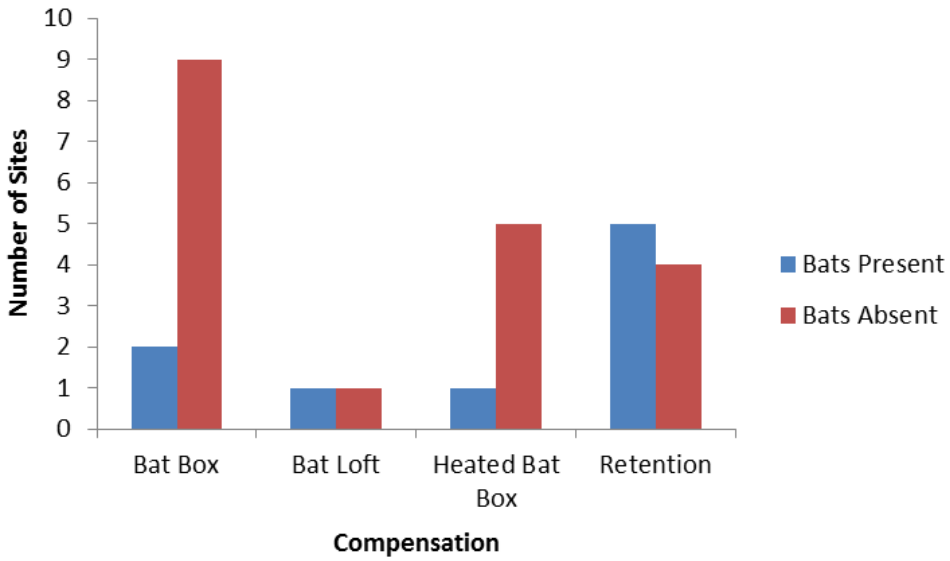

Figure 6. The number of sites with target species present (category A and B) and with target species absent (categories C, D and E) by compensation type.

3.2 Comparison of colony counts at development sites compared to sites not impacted by development

Forty Four of the NBMP sites fitted the criteria to be included within the analysis. The results of the predictive model are given in Figure 7. The model predicts that all species at all types of compensation will decline significantly in the post development period whereas control sites will have no significant change in numbers over the same period. The level of predicted decline varied between compensation measures and was as follows:

- Bat Box - 218 times fewer bats in the post-development period compared to the pre-development period (95% confidence interval: 45 to 1045 times fewer bats)

- Bat House - 119 times fewer bats in the post-development period compared to the pre-development period (95% confidence interval: 6 to 2429 times fewer bats)

- Heated bat box - 208 times fewer bats in the post-development period compared to the pre-development period (95% confidence interval: 26 to 1644 times fewer bats)

- Retained roost - 16 times fewer bats in the post-development period compared to the pre-development period (95% confidence interval: 4 to 75 times fewer bats)

In contrast to the control sites:

- 1.1 times as many bats in the post-development period compared to the pre-development period (95% confidence interval: 0.6 (so 1.6 times fewer) to 2.0 times as many bats).

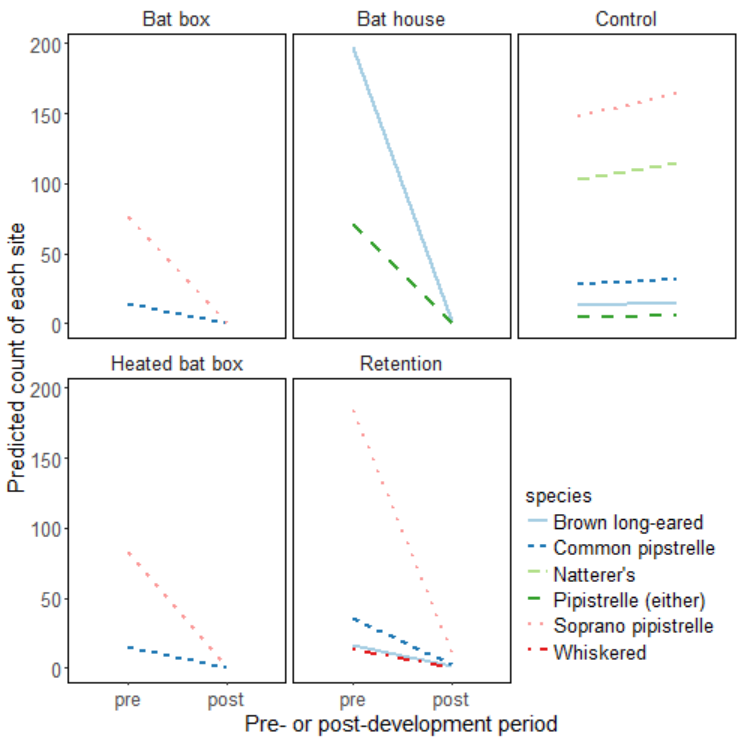

Figure 7. Graph showing the predicted counts of bats in pre- and post- development periods at sites with different compensation measures and at control sites. Each line represents the predicted counts of species at those sites. The model was a generalised mixed effect model with a negative binomial distribution, compensation type, development period and species were fixed effects. Sites and development period were added as random effects.

4. DISCUSSION OF RESULTS

It is important to bear in mind when considering the results of this project that they only provide a snapshot of information from a small sample of the different compensation types. Typically development sites have counts from just one season before and after development works taking place and a limited number of counts in each survey period. In post survey monitoring sites were surveyed a maximum of two times (with the exception of Doune, which was monitored throughout the summer). The limited number of surveys means that the presence of false negatives cannot be ruled out of the results. The choice to carry out two surveys per site was made so that it would be possible to include more sites within the survey period. Whilst compensation with regular use, or used by a large number of bats might be expected to have some evidence of bats present even if they are not occupied at the time of survey; evidence at compensation used occasionally and/or by a small number of bats is less likely to be detected. It is also worth considering that weather during the monitoring period was colder and wetter than normal so bats may have been displaying atypical behaviour, and evidence such as droppings would have been washed away regularly.

4.1 Number and type of licences issued

There has been a marked increase in the number of bat development licences issued by SNH since 2011. Scottish Government show there has been no similar increase in new houses being built, demolished or converted (Scottish Government, 2015). Whilst there are other types of development that can affect bats, it is likely that increased licence demand is due to better awareness of protected species rather than increased development pressure.

Overall, works affecting maternity roosts make up a small percentage of the licences issued for bat development work. Given the relatively low number of roosts involved, it could be argued that the licencing of works involving maternity roosts will have little impact on the conservation status of bats in Scotland regardless of whether compensation for lost or damaged roosts is used. It is unrealistic to consider the impacts of development on maternity roosts in isolation though and the gravity of impact will vary from case to case depending on the location and size of the roost as well as the species involved. The conservation impact of licensed development involving maternity roosts must be considered alongside other factors affecting bat populations (including both licensed and unlicensed activities).

The relative number of licence applications for each species is broadly reflective of population numbers in Scotland (Harris et al., 1995) and the species' roosting habits. Both widespread pipistrelle species and brown long-eared bats have wide distributions and are more likely to form maternity roosts in man-made structures such as houses, steadings and barns which are subject to development, than other species present in Scotland (Altringham, 2003).

There may also be an element of bias towards finding brown long-eared bats and pipistrelles roosts during pre-development surveys. This is especially the case for maternity roots as pipistrelles and brown long-eared bats tend to be loyal to one or two roosts and return to the same site each year. Other species such as Daubenton's and Natterer's, which may roost in man-made structures, switch roosts every few days (Ngamprasertwong *et al.,* 2014 and Smith and Racey, 2005) so roosts can be harder to identify during surveys.

The lack of licence applications for rarer species means that there has been little chance to evaluate mitigation for these species which, arguably, may be more crucial to get right; particularly where they are present in low numbers or at the edge of their ranges.

The higher proportion of brown long-eared maternity roosts affected by development compared to pipistrelles is likely due to differences in roosting behaviour. Single males and non-breeding female brown long-eared bats often share roosts with maternity colonies whereas this is less frequent in both pipistrelle species. This means pipistrelles will have a higher proportion of non-breeding roosts separate from maternity roosts.

4.2 Species protection plans

One measure of mitigation success this project aimed to address is whether species protection plans are being adhered to. Results from mitigation monitoring in other parts of the UK found that this wasn't always the case. In the Snowdonia National Park study only 35% of sites complied with conditions regarding mitigation. The study only had access to planning conditions rather than licence conditions though. The author, Waring (2011), points out that there is often a discrepancy between planning conditions and licence conditions, particularly if there is a delay between planning consent being given and licence applications being submitted. It is possible that mitigation was more in line with licence conditions. Aughney's (2008) study in Ireland reported a large number of absent and damaged bat boxes. One of their sites had not erected any of the bat boxes which ought to have been put in.

In comparison, all the sites monitored in this study had mitigation installed as described in the species protection plans and so can be considered compliant in this respect. Although, two potential sites were not included in monitoring as they failed to put mitigation in place by the date set out in the species protection plan and were not available to bats by the start of the maternity season.

It is important to note that this study just looked at whether the compensation design put in the species protection plan had been followed. There are many aspects of a species protection plan, such as timing and methods of works which we were unable to assess. Failure to follow any of these may have affected the likelihood of bats returning to the sites.

4.3 Compensation uptake

The use of compensation roosts by maternity colonies was low. Less than 20% of sites had evidence that they had been used by a maternity colony and 60% of sites displayed no evidence of use by bats at all. Sites unaffected by development did not show the same decrease in occupancy. This indicates that the absence of bats at compensation sites is due to an effect of the development rather than natural colony movements or roost switching due to poor weather.

4.4 Factors in compensation uptake

4.4.1 Compensation Type

The proportion of compensation types included in monitoring, bat boxes being the most frequent, is similar to that found in a review of mitigation in England (Stone *et al.,* 2013). Popularity of the various mitigation methods is probably a broad reflection of the needs of species most affected by development, the costs associated with different compensation designs and the ease of installing them.

Whilst the predicted model showed that all compensation types were likely to experience a decrease in the number of bats, the severity of the decrease varied. Despite being the most popular type of compensation, bat boxes were largely unsuccessful in retaining maternity colonies in this study. From our model, sites with bat boxes are also predicted to have the largest decrease in bat counts following development.

The only successful bat box site had a group of three Schwegler 1FFH's which housed a small (max count 25) soprano pipistrelle maternity colony. This was the largest type of bat box monitored during the study. Measurements for the roost these boxes replaced were not available so we cannot compare space available to the bats before and after the development work took place.

The Vincent Wildlife Trust's review of bat box schemes in Ireland found that the smaller version of this model, the 1FF was preferred by pipistrelle bats, whilst the round 2FN box was preferred by brown long-ear bats (McAney and Hanniffy, 2015). They suggested the 1FF recreated a natural crevice type roost better than the 2FN which more closely resembled a tree hole. Swift (2004) found that 'flat shaped' box designs like the 1FF and 1FFH had better heat retention than other shapes of box (2F, 2FN and 1FD) which may be a contributing factor to their greater uptake.

Given the lack of bat box success in the study we should be cautious about over-reliance on them as a compensation method, particularly for maternity colonies. Mitchell-Jones (2004) states that bat boxes should only be used as replacement for roosts of low conservation significance and that they do not constitute 'like for like' replacement for significant roosts in buildings. Loss of maternity roosts of common species such as common and soprano pipistrelles is considered to be of medium to low conservation significance and therefore should have more or less 'like for like' compensation (Mitchell-Jones, 2004). Other studies have also recorded low uptake of bat boxes by maternity colonies and suggest they are not suitable maternity roosts replacements (Swift, 2004; White, 2004; McAney and Hanniffy, 2015).

In Swift's (2004) review of bat boxes, it was found that heated bat boxes were the only type which came close to replicating conditions of roosts in buildings and therefore might be used by maternity colonies. During Swift's (2004) review five sites with heated bat boxes were monitored. One site was successful and two were partially successful. In contrast, none of the heated bat boxes in our study retained maternity colonies and only one out of six sites had any use. They are predicted to have the second lowest decrease in bat numbers out of the compensation types included in this study.

It was assumed that heated bat boxes were on and functioning as they should. Access to building interiors was limited in many sites and heated bat boxes were often located above accessible heights. It is possible that heating elements were not all on and that lack of heat contributed towards the absence of bats. Any future studies looking at the success of heated bat boxes should ascertain that they are on, working and set to a suitable temperature.

It is also possible that the lack of bats in the heated boxes was due to inappropriate positioning in relation to commuting corridors and/or a lack of desirable habitat features in the surrounding area. At least two of the sites had a considerable amount of artificial lighting around the boxes which can disrupt emergence and make bats more visible to predators.

The majority of sites successful in keeping maternity colonies had retained the original roosting space and retained and/or reinstated access points. Retained sites were predicted to have the lowest decrease in bats post-development. More than half of the sites monitored had some use by the target bat species and one site was being used by a different species. Two out of the three retained roosts which did not have any bats had building work continuing throughout the summer which could have disturbed returning bats.

Where roosts cannot be retained and incorporating roost space within a new development is not possible, free-standing bat lofts are thought to provide the next best thing in terms of 'like for like' roost replacement. They structurally resemble a typical building which might house

bats and features can be incorporated to make them suitable for a variety of species, however, they may struggle to replicate temperature regimes of roosts in occupied buildings. The cost of bat lofts can also be prohibitive with estimated costs between £10,000 and £30,000 depending on required size and construction materials (figures taken from informal discussions with consultants and Stone *et al.,* 2013). The cost may be reduced or made more palatable by incorporating a duel function to the construction, as was done in the two examples monitored in this study. In these cases they doubled up as a car port and storage shed.

Whilst neither of the bat lofts monitored were fully successful, both had some use by bats and were both well positioned close to water and tree cover. Both lofts were constructed from material similar or the same as the original roost and the loft at Imperial had insulation from the original roost transplanted in to it. The loft at Imperial had small numbers of soprano pipistrelle bats which were one of the target species (it had been a mixed pipistrelle roost). One pipistrelle bat was found at the Pines on both visits, although it was intended to replace a brown long-eared maternity roost. The Imperial loft had been in place for two summers prior to monitoring and the Pines had just been erected so it is possible bats have not had sufficient time to find the new structures. Stone *et al.,* (2013) reported that 74% of bat lofts in their study had bats present but it was not clear how numbers or use compared to the original roosts so it is difficult to assess the success rate in comparison with the study sites.

4.4.2 Roost volume

Sites with bats present had significantly greater volume than sites with no bats. White (2004) also found that occupied artificial roosts had a higher average volume compared to unoccupied roosts although the difference was not significant. The result may be a reflection of the fact that successful sites tended to have retained roosts in large roof spaces compared to unsuccessful sites which were in the main part smaller bat boxes. The result might, therefore, be influenced by factors associated with the different compensation types rather than volume itself. This result could also be linked to the fact that in a large area bats have a greater variety of microclimates to move around in and regulate themselves appropriately.

Linear regression results show that the volume of compensation provided was not proportionate to the number of bats present in the colony prior to works taking place. Some sites had a comparatively large number of bat boxes and therefore a large volume of compensation provided for small maternity colonies and vice versa. Tuttle and Hensley (2000) found that boxes in clusters of three or more were more likely to be occupied as the higher number of boxes offered a range of conditions for the bats to move around in. Whilst increasing the number of bat boxes may increase the chances of bats using them, up to a point; excessive number of boxes can drive up project costs.

4.4.3 Treeline

Although statistical analysis indicated that distance to the treeline was significantly different in sites with bats and those without, the difference between the two groups was not great. There was only 5m difference between the means of the two groups. Nonetheless, the importance of tree cover in roost uptake has been shown in several other studies (White, 2004; Jenkins *et al.,* 1998; McAney and Hanniffy, 2015). Jenkins *et al.,* (1998) and McAney and Hanniffy (2015) both suggest that tree cover could shelter roosts from environmental extremes resulting in a more stable environment within the roost. The result could also be down to reduced exposure to predators upon emergence. High densities of insect prey are also found round the edge of treelines (Downs and Racey, 2006). None of the research on compensation uptake reviewed in this study investigated how the importance of cover might vary with species and what the impacts of different types of cover are.

4.4.4 Age

McAney and Hanniffy (2015) and Poulton (2006) both found that uptake of bat boxes increased with time suggesting bats need a period to find and/or become accustomed to new roosting opportunities. No relationship was found between age of compensation and uptake from bats in this study, however, the majority of replacement roosts had been in place for less than two summers prior to monitoring and the oldest for three summers. The McAney and Hanniffy (2015) study took place over 16 years and the Poulton (2006) study for 20 years so our dataset may not cover a period long enough to pick up trends in age and occupation. Re-visiting the same sites in 5 – 10 years could provide a greater insight in the role compensation age plays in the likelihood of uptake.

5. RECOMMENDATIONS

5.1 Establish long term impacts of roost closure and forced movement

Recent evidence suggests that populations of most of Scotland's bat species are either stable or increasing in the context of historical declines (Barlow *et al.,* 2015; BCT, 2015). To continue this positive trend we need to address the impacts of current pressures on bat populations. Development and related issues are considered to be the main pressures facing bats in the UK (Anon, 2014), with pressure only likely to increase with increased urbanisation and housing demands from a growing population. Whilst little is known about the long term impacts of development, it has been shown that even widespread species capable of adapting to the urban environment, such as the common pipistrelle, respond negatively to high levels of urbanisation (Lintott *et al*., 2016).

Our results show that many of the artificial roosts designed to compensate for roosts lost due to development are not being used by maternity colonies, at least in the short term. This means that many developments involving maternity roosts are leading to a loss of roosting opportunities which could have an impact on the health and survival of individuals and reproductive success of the colony. Even when compensation is successful, with the exception of retained roosts, bats are forced to switch roosts which may also have an effect on fitness and reproduction (Lewis, 1995).

A study in Canada found big brown bats (Eptesicus fuscus), which are loyal to one maternity site, had reproductive success reduced by more than half compared to control colonies when excluded from roosts prior to parturition (Bringham and Fenton, 1986). Stone *et al.,* (2015) found that soprano pipistrelles, which use multiple roost sites, were able to adapt to the loss of a main maternity roost by moving to alternative roosts, already in use by the colony. The study did not directly measure reproductive success in the displaced colonies but modelling suggested that reduction in individual survival would have a greater impact on population stability than reduced reproductive success. No behavioural changes likely to reduce an individual's fitness were recorded within the week following the exclusion.

Loss of a roost, through development works and failure of associated compensation, is therefore likely to impact species differently depending on their behaviour, roost requirements and the availability of alternative roosts. Species like brown long-eared bats which use one roost throughout the maternity period may be less resilient to the loss of a roost than species like soprano pipistrelle which use a variety of roosts. For many of the rarer bat species in Scotland we don't have enough knowledge of maternity roost requirements to judge how roost destruction might impact on the population.

Further research into successful compensation designs and the specific roosting requirements of individual species should be first and foremost in order to reduce the

impacts from roost losses. However, greater knowledge on the longer term population effects of roost destruction (should compensation not be successful) and movement will allow licencing authorities to make better informed decisions on the ability of a development application to meet the favourable conservation status licencing test. This may also be dependent on a better understanding of the key factors affecting bat populations and the relative impacts of regulated activities on them. It would also allow greater proportionality to be applied when requiring compensation.

The provision of compensation, other than retained roosts can add considerable costs to a development project. Bat boxes cost anywhere from £15 for a small wooden bat box to £890 for a programmable heated box (NHBS, 2015). More complex structures such as a freestanding bat loft can run into tens of thousands of pounds (Stone et al.,, 2013). The cost of installing compensation can be disproportionate to the total development budget, particularly for small projects. This can be off-putting to developers. At least one case was discovered whilst carrying out this project where a proposed building conversion had to be delayed until further notice as the developer could not afford the required compensation. The high cost of compensation, coupled with a low success rate (for maternity roosts, based on the results of this study) could cause developers to lose confidence in regulatory requirements for bat conservation and form pessimistic views of wider sustainable development issues. The high cost of compensation can also lead to negative press stories and low public opinion of bat conservation (e.g. Sutherland, 2015). Retained roosts can be more cost effective and have a greater chance of positive results so should be recommended where possible to negate negative attitudes towards bat conservation related to added project costs. Where retention is not possible, expensive structures such bat lofts should only be recommended where the ecologist considers there to be a high chance of success, for example, where the new structure will be situated in good habitat and closely replicate internal conditions of the original roost. Designing bat lofts so that they have another function and are therefore of value to the developer outside of the provision of a bat roost should help decrease the risk of bad feelings if the compensation is unsuccessful.

A better understanding of the long term population impacts of roost closure could give licencing authorities and ecological consultants' greater confidence in asserting the need for a particular level of compensation. Or, in certain situations, to make the decision that not providing compensation, or providing a lower level of compensation, would be of little consequence to the long term survival of the colony. Greater flexibility in compensation provision, based on predicted population impacts could allow SNH and consultants to build closer relationships with developers with a positive result for attitudes towards bat conservation.

Consideration also needs to be given to the cumulative impacts development may have on population viability. The destruction of one roost in an area relatively free from development may not have an impact on the local bat population. However, in an area with high levels of development a single colony could be moved from year to year, foraging ground could be lost or become fragmented and available alternative roosts could dwindle leading to a reduced population. At present when an application for a bat development licence is assessed there is no way to check what other licences have been issued in that area. This is something which SNH are seeking to address.

5.2 Improve knowledge of compensation successes and failures

Issues related to population viability due to roost closure and negative opinion of compensation could be countered by ensuring compensation has a greater chance of success. Our study has shown that for maternity colonies, the compensation currently provided is not often used. Unfortunately, we do not have enough data or a large enough sample size to pinpoint why uptake has been so low. To answer this question a longer term

monitoring programme which captures more detailed information on the conditions inside the roost and its surrounding habitat prior to development is required so comparisons can be made between with the original and compensation roosts, and factors influencing compensation uptake can be better identified.

We know that lighting, habitat surrounding the roost, temperature, humidity and roost size are important for maternity roost selection. This kind of roost information is not essential for licences to be issued though, and was seldom available in pre-development survey reports. Comparison of these variables between original and compensation roosts could, therefore, not be made in this study.

Any future studies trying to understand compensation success and failures should engage ecological consultants and developers at an early stage to identify sites for monitoring. Identifying sites before development work is carried out would allow a surveyor to visit the site and record data such as; roost temperature, humidity, volume, habitat, particularly the presence and placement of vegetation cover and water in relation to the roost and artificial lighting near the roost entrance, foraging and commuting areas. These data could also be collected by a consultant if they are carrying out work on site anyway. If meaningful comparisons are to be made between original roosts and compensation and trends are to be looked at across multiple sites, a standard protocol for recording data would be helpful.

Regardless of any future studies, it would be good practice for consultants to include greater information in licence applications on how conditions inside and outside the roost are likely to change after development. This kind of detail was lacking in many of the licence applications reviewed during the project. Stone *et al.,* (2013) also identified this as an issue in their review of bat mitigation in England. Inclusion of greater detail in survey reports would make it easier for licencing staff to judge if compensation is appropriate.

An effort also needs to be made to create a long term monitoring dataset. This would allow us to answer questions about the effect of age on success rate and to rule out the possibility of false negative results. Monitoring could continue in a similar fashion to that carried out in this project with SNH connecting volunteers with developers and site owners/occupiers willing to participate. As the work has already been put in place it would make sense to at least continue to monitor the sites which were included in this project with the existing network of volunteers. Inclusion of more sites, particularly for underrepresented compensation types such as bat lofts, would help address the issue of small sample size.

5.3 Consideration of development and compensation within the wider landscape

At present efforts to compensate for lost roosts focus on replicating the lost or damaged structure with little attention paid to the habitat surrounding the roost. It is well established that habitat is an important factor for both natural and artificial roost selection (e.g. Boughey, 2011; Entwistle et al., 1997; Jenkins et al.,, 1998; Tuttle and Hensley, 2000). Female bats in particular need good foraging habitat within close proximity of the maternity roost due to pregnancy and lactation demands (Lintott, 2014). It is therefore reasonable to assume that the continued availability of suitable habitat for foraging, cover and commuting is likely to have a strong influence on the success of compensation roosts yet these features are rarely mentioned in species protection plans.

Surrounding habitat may not feature in protection plans for multiple reasons. Part of the issue is related to lack of communication between developers and consultants. This concern was raised by attendees at a workshop on mitigation ran by SNH for the BCT's Scottish Bat Conference in November 2015. It was felt that developers did not provide consultants with post-development details such as lighting and landscaping which could affect compensation and little opportunity was given for them to provide input on design of post-development

features. Greater communication between consultants and developers could avoid situations where compensation fails due to inappropriate lighting or lack of vegetation cover near the entrance of a roost. Many developments have a relatively small footprint though and it is often the wider habitat which developers, consultants and licencing authorities have no control over, which will influence the long term success of compensation.

The ability to provide long term secured habitat for bats, and other wildlife lies with local planning authorities. There has been a push in more recent years to consider conservation efforts at the landscape scale and to include green space within urban areas. Given that habitat has been shown to be a good predictor of bat activity and roost presence it should be possible to create a model of habitat suitability for bats (Bellamy and Altringham, 2015). Spatial models could be used by planning departments and environmental groups to identify priority areas for bat conservation and ensure that core habitats and connecting corridors are secured for future use. This information could also be used by developers and consultants when creating species protection plans and ensure that compensation is positioned in the optimum location. It is worth noting though that the habitat needs of even seemingly similar species can be quite different (e.g. common and soprano pipistrelles; Lintott *et al.*, 2016) and the specific habitat requirements of our less common species have yet to be identified.

6. CONCLUSION

The results of this study show that the majority of roosts provided for maternity colonies as compensation for loss and/or damage of a roost through development work are not being used (at least in the short-term). This has implications for the assumption that if compensation is provided the impact on a species favourable conservation status will be negated. The results of this study indicate that retained roosts are most likely to be occupied by maternity colonies but further long-term studies with increased sample sizes and improved detail are needed to determine why some roosts are used and not others. The impact of not providing compensation for lost roosts also needs to be investigated, to determine if it is cost effective in terms of the conservation return for bats and to help answer the question of impacts on favourable conservation status. Finally, it may be beneficial to take some of the focus away from the impacts of individual development projects and look at securing habitat for bats in the wider landscape.

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ANNEX 1: SITE DESCRIPTIONS AND SURVEY RESULTS

Site Description - Auchmuty					
Species:	Common pipistrelle	*Property Type:*	School	*Development:*	Demolition for new building
Details of Compensation:	External MAB heated bat box mounted on vehicle shed next to treeline.				
External survey results					
Compensation Type (n if boxes):	Heated bat box (1)	*Setting:*	Building external	*Evidence of Bats:*	None
Roost Aspect:	North-West	*No. Entrances:*	1	*Height (m):*	4-5
Volume(m^3):	0.04	*No. summers in place:*	2	*Other roosting potential nearby:*	Yes (housing)
Artificial lights on or near entrance:	Yes. Security lighting all around the box, none directly on the entrance. Dark scrub corridor within 2m of box entrance.				

Activity survey results								
Pre-Development	*Min count:*	1	*Max count:*	13	*Mean count:*	5	*No. of surveys:*	3
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	No bats recorded during either dusk or dawn survey.							

Site Description - Bargrennan					
Species:	Soprano pipistrelle	*Property Type:*	Private Residence	*Development:*	Demolition for new building
Details of Compensation:	Internal bat box				
External survey results					
Compensation Type (n if boxes):	Bat box (1)	*Setting:*	Building internal	*Evidence of Bats:*	Droppings
Roost Aspect:	South-West	*No. Entrances:*	1	*Height (m):*	3-4
Volume(m^3):	Unknown	*No. summers in place:*	0	*Other roosting potential nearby:*	Yes (housing)
Artificial lights on or near entrance:	No				

Activity survey results								
Pre-Development	*Min count:*	3	*Max count:*	17	*Mean count:*	11	*No. of surveys:*	3
Post-Development	*Min count:*	0	*Max count:*	2	*Mean count:*	1	*No. of surveys:*	2
Survey notes:	One further soprano pipistrelle was found using a Schwegler 1FF placed within 1m of the internal bat box as additional compensation.							

Site Description - Clatteringshaw					
Species:	Soprano pipistrelle	*Property Type:*	Visitor Centre	*Development:*	Renovation
Details of Compensation:	3 x Schwegler 1FFH mounted externally				

External survey results					
Compensation Type (n if boxes):	Bat box (3)	*Setting:*	Building internal	*Evidence of Bats:*	Droppings and staining around entrances
Roost Aspect:	North-East	*No. Entrances:*	3	*Height (m):*	3-4
Volume(m^3):	0.12	*No. summers in place:*	2	*Other roosting potential nearby:*	Yes (housing)

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	49	*Max count:*	74	*Mean count:*	62	*No. of surveys:*	2
Post-Development	*Min count:*	14	*Max count:*	25	*Mean count:*	20	*No. of surveys:*	2
Survey notes:	The colony was concentrated in the southern most box; with a couple of individuals emerging from the other two.							

Site Description - Colgrain					
Species:	Common pipistrelle	*Property Type:*	School	*Development:*	Demolition of Building
Details of Compensation:	Heated bat box, make unknown, on roof of nearby building (350m).				

External survey results					
Compensation Type (n if boxes):	Heated bat box (1)	*Setting:*	Building external	*Evidence of Bats:*	None
Roost Aspect:	South-east	*No. Entrances:*	1	*Height (m):*	>5
Volume(m^3):	Unknown	*No. summers in place:*	3	*Other roosting potential nearby:*	Yes (housing)

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	0	*Max count:*	40	*Mean count:*	13	*No. of surveys:*	5
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	1
Survey notes:	No bats recorded throughout survey.							

Site Description - Dalkeith A					
Species:	Soprano Pipistrelle	*Property Type:*	Stable Block	*Development:*	Conversion
Details of Compensation:	Retention of roost with access via “chutes”				

External survey results					
Compensation Type (n if boxes):	Retention	*Setting:*	Building internal	*Evidence of Bats:*	None
Roost Aspect:	Multiple	*No. Entrances:*	3	*Height (m):*	>5
Volume(m^3):	172.5	*No. summers in place:*	0	*Other roosting potential nearby:*	Yes (other estate buildings)

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	75	*Max count:*	876	*Mean count:*	476	*No. of surveys:*	2
Post-Development	*Min count:*	507	*Max count:*	507	*Mean count:*	507	*No. of surveys:*	1
Survey notes:	N/A							

Site Description - Dalkeith B					
Species:	Brown long-ear	*Property Type:*	Stable Block	*Development:*	Conversion
Details of Compensation:	Retention of roost with access via bat slates				

External survey results					
Compensation Type (n if boxes):	Retention	*Setting:*	Building internal	*Evidence of Bats:*	Droppings
Roost Aspect:	Multiple	*No. Entrances:*	3	*Height (m):*	>5
Volume(m^3):	105	*No. summers in place:*	0	*Other roosting potential nearby:*	Yes (other estate buildings)

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	10	*Max count:*	10	*Mean count:*	10	*No. of surveys:*	1
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	1
Survey notes:	No brown long-eared bats encountered during the survey but the presence of 200+ droppings which had not been present at the start of the season suggest that the maternity colony did return.							

Site Description - Doune							
Species:	Soprano pipistrelle	*Property Type:*	Telephone Exchange	*Development:*	Repair		
Details of Compensation:	Retention of roost with access points reinstated.						

External survey results							
Compensation Type (n if boxes):	Retention	*Setting:*	Building internal	*Evidence of Bats:*	Staining around entrances and droppings		
Roost Aspect:	Multiple	*No. Entrances:*	7	*Height (m):*	3-4		
Volume(m^3):	Unknown	*No. summers in place:*	3	*Other roosting potential nearby:*	Yes (housing)		

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	49	*Max count:*	814	*Mean count:*	341	*No. of surveys:*	6
Post-Development	*Min count:*	27	*Max count:*	320	*Mean count:*	208	*No. of surveys:*	7
Survey notes:								

Site Description - Drumcom							
Species:	Brown long-ear	*Property Type:*	Community Hall	*Development:*	Conversion		
Details of Compensation:	Roost partially retained with access via ridge tiles.						

External survey results							
Compensation Type (n if boxes):	Retention	*Setting:*	Building internal	*Evidence of Bats:*	None		
Roost Aspect:	South	*No. Entrances:*	3	*Height (m):*	>5		
Volume(m^3):	13.1	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing, trees)		

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	30	*Max count:*	57	*Mean count:*	44	*No. of surveys:*	2
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:								

Site Description - Elms					
Species:	Common pipistrelle	*Property Type:*	Garage	*Development:*	Repair
Details of Compensation:	Retention of roost with access point reinstated.				

External survey results					
Compensation Type (n if boxes):	Retention	*Setting:*	Building internal	*Evidence of Bats:*	None
Roost Aspect:	South-East	*No. Entrances:*	1	*Height (m):*	2-3
Volume(m^3):	Unknown	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing, trees)
Artificial lights on or near entrance:	Security light 2m from entrance but was in place prior to repairs.				

Activity survey results							
Pre-Development	*Min count:*	100	*Max count:*	100	*Mean count:*	100	*No. of surveys:* 1
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:* 2
Survey notes:	Up to 4 common pipistrelles recorded foraging throughout the survey, along with soprano pipistrelles and Nyctalus sp.						

Site Description - Forth					
Species:	Common pipistrelle	*Property Type:*	School	*Development:*	Demolition for new building
Details of Compensation:	4 x Habibat Concrete bat boxes, 7 x Schwegler 2FR tubes, all mounted externally on new building				

External survey results					
Compensation Type (n if boxes):	Bat box (11)	*Setting:*	Building external	*Evidence of Bats:*	None
Roost Aspect:	Multiple	*No. Entrances:*	11	*Height (m):*	>5
Volume(m^3):	3.9	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing)
Artificial lights on or near entrance:	No				

Activity survey results							
Pre-Development	*Min count:*	1	*Max count:*	24	*Mean count:*	12	*No. of surveys:* 3
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:* 1
Survey notes:	Common pipistrelle were recorded during the survey but none using compensation						

Site Description - Glasgow					
Species:	Soprano pipistrelle	*Property Type:*	University	*Development:*	N/A - Exclusion
Details of Compensation:	Nest Box Company heated bat box, mounted externally on nearby building.				

External survey results					
Compensation Type (n if boxes):	Heated bat box (2)	*Setting:*	Building external	*Evidence of Bats:*	None
Roost Aspect:	South	*No. Entrances:*	2	*Height (m):*	>5
Volume(m^3):	0.26	*No. summers in place:*	0	*Other roosting potential nearby:*	Yes (housing)

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	0	*Max count:*	200	*Mean count:*	69	*No. of surveys:*	3
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	Soprano pipistrelles were recorded during the survey but not using compensation.							

Site Description - Howwood					
Species:	Soprano pipistrelle	*Property Type:*	School	*Development:*	Repair
Details of Compensation:	Bat box mounted externally, make unknown.				

External survey results					
Compensation Type (n if boxes):	Bat box (1)	*Setting:*	Building external	*Evidence of Bats:*	None
Roost Aspect:	South	*No. Entrances:*	1	*Height (m):*	3-4
Volume(m^3):	0.02	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing)

Artificial lights on or near entrance: Yes. Not on roost entrance but new lights shine on previous commuting routes.

Activity survey results								
Pre-Development	*Min count:*	15	*Max count:*	330	*Mean count:*	205	*No. of surveys:*	16
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	Soprano pipistrelles were recorded during the survey but not using compensation.							

Site Description - Imperial					
Species:	Mixed pipistrelles (majority soprano)	*Property Type:*	Distillery	*Development:*	Demolition for new building
Details of Compensation:		Purpose built bat loft/storage shed.			

External survey results					
Compensation Type (n if boxes):	Bat house (1)	*Setting:*	Freestanding	*Evidence of Bats:*	None
Roost Aspect:	Multiple	*No. Entrances:*	7	*Height (m):*	>5
Volume(m^3):	15.2	*No. summers in place:*	2	*Other roosting potential nearby:*	Yes (housing, trees)
Artificial lights on or near entrance:	No				

Activity survey results							
Pre-Development	*Min count:*	415	*Max count:*	530	*Mean count:*	480	*No. of surveys:* 3
Post-Development	*Min count:*	2	*Max count:*	4	*Mean count:*	3	*No. of surveys:* 2
Survey notes:	1 x pipistrelle (species unknown) and a second unidentified bat emerged during the dusk survey. 4 x soprano pipistrelles observed entering during dawn survey.						

Site Description - Invertromie					
Species:	Brown long-ear	*Property Type:*	Steading	*Development:*	Conversion
Details of Compensation:		Retention of roost with access via bat slates.			

External survey results					
Compensation Type (n if boxes):	Retention	*Setting:*	Building internal	*Evidence of Bats*	None
Roost Aspect:	Multiple	*No. Entrances:*	7	*Height (m):*	>5
Volume(m^3):	100.8	*No. summers in place:*	0	*Other roosting potential nearby:*	Yes (housing)
Artificial lights on or near entrance:	No				

Activity survey results							
Pre-Development	*Min count:*	0	*Max count:*	8	*Mean count:*	5	*No. of surveys:* 4
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:* 2
Survey notes:	No brown long-eared bats recorded during the survey. A single common pipistrelle was found to be using a wall gap which was compensation for a non-maternity pipistrelle roost.						

Site Description - Kelvin					
Species:	Soprano pipistrelle	*Property Type:*	Conference centre	*Development:*	N/A – Exclusion
Details of Compensation:	Nest Box Company partially heated bat box mounted externally				
External survey results					
Compensation Type (n if boxes):	Heated bat box (1)	*Setting:*	Building external	*Evidence of Bats:*	None
Roost Aspect:	North-east	*No. Entrances:*	1	*Height (m):*	4-5
Volume(m^3):	0.03	*No. summers in place:*	0	*Other roosting potential nearby:*	Yes (housing)
Artificial lights on or near entrance:	Yes but it was present prior to development works				

Activity survey results								
Pre-Development	*Min count:*	116	*Max count:*	116	*Mean count:*	116	*No. of surveys:*	1
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	Swarming and wall touching associated with old roost entrance observed during dawn re-entry survey							

Site Description - Knock					
Species:	Brown long-ear	*Property Type:*	Steading	*Development:*	Partial Demolition
Details of Compensation:	Roost partially retained with original access and a 1FE Schwegler Bat Access Panel				
External survey results					
Compensation Type (n if boxes):	Retention	*Setting:*	Building internal	*Evidence of Bats:*	Droppings and feeding remains
Roost Aspect:	Multiple	*No. Entrances:*	15	*Height (m):*	3-4
Volume(m^3):	257.3	*No. summers in place:*	2	*Other roosting potential nearby:*	Yes (housing + farm buildings)
Artificial lights on or near entrance:	Some security lighting round the building but many possible entrances. 2/4 sides of the building are not lit.				

Activity survey results								
Pre-Development	*Min count:*	0	*Max count:*	2	*Mean count:*	1	*No. of surveys:*	7
Post-Development	*Min count:*	2	*Max count:*	2	*Mean count:*	2	*No. of surveys:*	2
Survey notes:	2 x brown long-eared bats found during internal inspection on both monitoring visits. 1 x soprano pipistrelle entered/exited roof apex just above access panel on both visits. Unidentified pipistrelle emerged from the south gable end on first visit.							

Site Description - Leadhills							
Species:	Common pipistrelle		*Property Type:*	School	*Development:*	Repairs	
Details of Compensation:	2 x internal heated bat boxes with access at gable apex, make unknown						
External survey results							
Compensation Type (n if boxes):	Heated bat box (2)		*Setting:*	Building internal	*Evidence of Bats:*	None	
Roost Aspect:	West		*No. Entrances:*	2	*Height (m):*	>5	
Volume(m^3):	Unknown		*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing)	
Artificial lights on or near entrance:	None						
Activity survey results							
Pre-Development	*Min count:*	11	*Max count:*	16	*Mean count:*	14	*No. of surveys:* 3
Post-Development	*Min count:*	0	*Max count:*	5	*Mean count:*	3	*No. of surveys:* 2
Survey notes:	It was not clear from the ground where the entrances for the bat boxes were. There did not appear to be any artificial entrance. Bats were seen emerging and re-entering from the Southernmost gable entrance, it was assumed this was from the heated bat box.						

Site Description - Manse							
Species:	Soprano pipistrelle		*Property Type:*	Private Residence	*Development:*	Demolition for new building	
Details of Compensation:	1 x Schwegler 1FS Large colony box plus 4 x Schwegler 2F in trees						
External survey results							
Compensation Type (n if boxes):	Bat box (1)		*Setting:*	Tree	*Evidence of Bats:*	None	
Roost Aspect:	South-East		*No. Entrances:*	1	*Height (m):*	4-5	
Volume(m^3):	0.04		*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing, trees)	
Artificial lights on or near entrance:	No						
Activity survey results							
Pre-Development	*Min count:*	142	*Max count:*	142	*Mean count:*	142	*No. of surveys:* 1
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:* 1
Survey notes:	Soprano and common pipistrelles were both recorded foraging in the site during the survey						

Site Description - Mortlach					
Species:	Soprano pipistrelle	*Property Type:*	Distillery	*Development:*	Demolition for new building
Details of Compensation:	External heated bat box, make unknown				

External survey results					
Compensation Type (n if boxes):	Bat box (1)	*Setting:*	Building external	*Evidence of Bats:*	None
Roost Aspect:	South-East	*No. Entrances:*	1	*Height (m):*	>5
Volume(m^3):	0.03	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing, trees, small bat boxes in trees)

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	28	*Max count:*	45	*Mean count:*	36	*No. of surveys:*	3
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	No bats recorded during the survey							

Site Description - Murray					
Species:	Common pipistrelle	*Property Type:*	Hospital	*Development:*	Demolition for new buildings
Details of Compensation:	15 x Schwegler 1FQ mounted externally on new building				

External survey results					
Compensation Type (n if boxes):	Bat box (15)	*Setting:*	Building external	*Evidence of Bats:*	None
Roost Aspect:	Multiple	*No. Entrances:*	15	*Height (m):*	>5
Volume(m^3):	3	*No. summers in place:*	2	*Other roosting potential nearby:*	Yes (housing, small bat boxes in trees)

Artificial lights on or near entrance: The area around the hospital is brightly lit. There are lights near to compensation boxes but no light directly on entrances.

Activity survey results								
Pre-Development	*Min count:*	1	*Max count:*	28	*Mean count:*	11	*No. of surveys:*	3
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	No bats observed using the Schwegler 1FQ on the buildings but 29x soprano pipistrelles found in the 25 Schwegler 1FD's in nearby trees during surveys conducted by Tayside bat group.							

Site Description - Parkerplace					
Species:	Common pipistrelle	*Property Type:*	Sheltered Housing	*Development:*	Repair
Details of Compensation:	Wooden bat box make unknown mounted externally				

External survey results					
Compensation Type (n if boxes):	Bat box (1)	*Setting:*	Building external	*Evidence of Bats:*	None
Roost Aspect:	South-west	*No. Entrances:*	1	*Height (m):*	>5
Volume(m^3):	0.02	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing)

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	4	*Max count:*	4	*Mean count:*	4	*No. of surveys:*	1
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	1 x common pipistrelle was seen entering/exiting from another area of the building during both surveys							

Site Description - Pines					
Species:	Brown long-ears	*Property Type:*	Private Residence	*Development:*	Demolition for new building
Details of Compensation:	Purpose built bat loft/car port located next to treeline and water				

External survey results					
Compensation Type (n if boxes):	Bat house (1)	*Setting:*	Freestanding	*Evidence of Bats:*	Droppings
Roost Aspect:	Multiple	*No. Entrances:*	9	*Height (m):*	4-5
Volume(m^3):	13.9	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing, trees)

Artificial lights on or near entrance: No

Activity survey results								
Pre-Development	*Min count:*	15	*Max count:*	15	*Mean count:*	15	*No. of surveys:*	2
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	1 x common pipistrelle bat seen emerging from and returning to compensation during the dusk and dawn surveys							

Site Description - Pitmudie							
Species:	Soprano pipistrelle		*Property Type:*	Private Residence	*Development:*	N/A - Exclusion	
Details of Compensation:			Purpose built internal bat box				
External survey results							
Compensation Type (n if boxes):	Bat box (1)		*Setting:*	Building internal	*Evidence of Bats:*	None	
Roost Aspect:	Multiple		*No. Entrances:*	1	*Height (m):*	>5	
Volume(m^3):	0.7		*No. summers in place:*	0	*Other roosting potential nearby:*	Yes (housing)	
Artificial lights on or near entrance:	No						
Activity survey results							
Pre-Development	*Min count:*	152	*Max count:*	152	*Mean count:*	152	*No. of surveys:* 1
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:* 2
Survey notes:	No soprano pipistrelles were recorded during the survey.						

Site Description - SCENE							
Species:	Soprano pipistrelle		*Property Type:*	Research Station	*Development:*	Demolition for new building	
Details of Compensation:			2 x heated bat box mounted externally, make unknown				
External survey results							
Compensation Type (n if boxes):	Heated bat box (2)		*Setting:*	Building external	*Evidence of Bats:*	None	
Roost Aspect:	North-west		*No. Entrances:*	2	*Height (m):*	2-3	
Volume(m^3):	0.2		*No. summers in place:*	3	*Other roosting potential nearby:*	Yes (small bat boxes in trees)	
Artificial lights on or near entrance:	Yes, security light mounted within 2m of boxes which shone on entrances. Considerable lighting of the surrounding area including flight path from the roost to wooded area.						
Activity survey results							
Pre-Development	*Min count:*	15	*Max count:*	373	*Mean count:*	167	*No. of surveys:* 3
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:* 2
Survey notes:	3 x soprano pipistrelles seen entering areas of the building other than compensation during the dawn survey.						

Site Description - Stables							
Species:	Common pipistrelle	*Property Type:*	Private Residence	*Development:*	Repair		
Details of Compensation:	Roost retained with access points reinstated						

External survey results							
Compensation Type (n if boxes):	Retention	*Setting:*	Building internal	*Evidence of Bats:*	None		
Roost Aspect:	North-east	*No. Entrances:*	4	*Height (m):*	4-5		
Volume(m^3):	Unknown	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing, trees)		
Artificial lights on or near entrance: No							

Activity survey results							
Pre-Development	*Min count:*	6	*Max count:*	24	*Mean count:*	17	*No. of surveys:* 3
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:* 2
Survey notes:	1 x soprano pipistrelle seen entering the retained access points during the dawn survey. A second soprano pipistrelle was observed swarming and wall touching but did not enter.						

Site Description - Straloch							
Species:	Common pipistrelle	*Property Type:*	Private Residence	*Development:*	Demolition for new building		
Details of Compensation:	1FS Large colony box						

External survey results							
Compensation Type (n if boxes):	Bat box (1)	*Setting:*	Tree	*Evidence of Bats:*	None		
Roost Aspect:	South	*No. Entrances:*	1	*Height (m):*	4-5		
Volume(m^3):	0.04	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing, trees and small boxes in trees)		
Artificial lights on or near entrance: No							

Activity survey results							
Pre-Development	*Min count:*	7	*Max count:*	7	*Mean count:*	7	*No. of surveys:* 3
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:* 2
Survey notes:	There is a maternity roost, C. 70 common pipistrelles, in a nearby building. Based on pre-development surveys and information from the owner, it's likely this was always the main roost and the destroyed roost was a satellite.						

Site Description - Threave					
Species:	Whiskered	*Property Type:*	Countryside Centre	*Development:*	Repairs
Details of Compensation:	Retention of roost with access points reinstated				

External survey results					
Compensation Type (n if boxes):	Retention	*Setting:*	Building internal	*Evidence of Bats:*	None
Roost Aspect:	South-east	*No. Entrances:*	Unknown	*Height (m):*	>5
Volume(m^3):	Unknown	*No. summers in place:*	1	*Other roosting potential nearby:*	Yes (housing, trees)
Artificial lights on or near entrance:	No				

Activity survey results								
Pre-Development	*Min count:*	40	*Max count:*	40	*Mean count:*	40	*No. of surveys:*	1
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	No target bats observed during monitoring but information from National Trust Scotland staff suggests that whiskered bats are using the retained access points but roost status is unknown.							

Site Description - Touch					
Species:	Soprano pipistrelle	*Property Type:*	Business Centre	*Development:*	N/A - Exclusion
Details of Compensation:	Purpose built internal bat box with access via bat slate				

External survey results					
Compensation Type (n if boxes):	Bat box (1)	*Setting:*	Building internal	*Evidence of Bats:*	None
Roost Aspect:	East	*No. Entrances:*	1	*Height (m):*	>5
Volume(m^3):	9	*No. summers in place:*	2	*Other roosting potential nearby:*	Yes (housing)
Artificial lights on or near entrance:	No				

Activity survey results								
Pre-Development	*Min count:*	17	*Max count:*	734	*Mean count:*	284	*No. of surveys:*	3
Post-Development	*Min count:*	0	*Max count:*	0	*Mean count:*	0	*No. of surveys:*	2
Survey notes:	Maternity colony of c.60 soprano pipistrelles observed swarming and re-entering in to a roost in the same building as the compensation but in a different area. One dead juvenille bat found under entrance to maternity roost. Several smaller groups of bats >10 seen emerging/re-entering roosts elsewhere in the building. This was a complex building and it would seem that attempts to exclude bats from areas other than the compensation were not entirely successful.							

ANNEX 2: SURVEY INFORMATION

Site	Date	Survey Start	Survey Finish	Temperature	Detectors Used	Weather				Number of Surveyors
						Cloud	Wind	Rain	Visibility	
Auchmuty	20/08/2015	20:20	21:30	17	EchoMeter Touch (EMT)	High	Light	Drizzle	Good	1
	25/08/2015	04:30	06:00	11	EMT	Med	Breezy	None	Good	1
Bargrennan	13/07/2015	21:45	23:00	14	EMT	Med	Calm	None	Good	1
	30/07/2015	03:30	05:15	7	EMT	Low	Calm	None	Good	1
Clatteringshaw	15/07/2015	21:30	23:15	12	EMT	Low	Calm	None	Good	1
	29/07/2015	21:15	22:40	13	EMT	Low	Light	None	Good	1
Colgrain	Unknown*	Unknown*	Unknown*	Unknown*	Unknown*	Unknown*	Unknown*	Unknown*	Unknown*	Unknown*
Dalkeith A	25/08/2015	20:10	21:40	16	Bat Box Duet	Med	Calm	None	Good	2
Dalkeith B	25/08/2015	20:10	21:40	16	Bat Box Duet	Med	Calm	None	Good	1
Doune	08/06/2015	21:38	22:40	15	Bat Box Duet	Low	Calm	None	Good	3
	16/06/2015	21:41	22:16	15	Bat Box Duet	Low	Calm	None	Good	2
Drumcom	18/06/2015	22:00	23:45	11.5	EMT, Bat Box Duet, Magenta	High	Light	None	Good	4
	18/08/2015	03:50	05:45	11	EMT, Magenta	High	Light	None	Moderate	3
Elms	14/07/2015	21:40	11:15	13.5	EMT	Low	Calm	None	Good	1
	29/07/2015	03:15	05:15	9	EMT	Low	Calm	None	Good	1
Forth	2/07/2015	21:26	23:30	16	Anabat SD2	Low	Calm	None	Good	3

	31/08/2015	19:45	21:45	12	Anabat SD2	High	Calm	Drizzle	Moderate	3
Glasgow	09/08/2015	20:45	22:20	18	Bat Box Duet	High	Light	None	Good	1
	22/08/2015	04:45	06:00	14	Bat Box Duet	High	Light	None	Moderate	1
Howwood	06/06/2015	21:34	22:30	12	Bat Box Duet	Low	Light	None	Good	1
	17/06/2015	22:05	21:50	9	Bat Box Duet	Unknown*	Breezy	None	Good	1
Imperial	13/06/2015	22:00	23:20	10.5	Bat Box Duet	High	Calm	None	Moderate	2
	20/07/2015	03:34	05:00	10	EMT	High	Calm	None	Moderate	1
Invertromie	03/06/2015	22:03	23:35	12	Bat Box Duet, Bat Box III	Low	Calm	None	Good	3
	14/08/2015	04:39	05:40	13	Bat Box Duet, EMT	High	Calm	None	Good	2
Kelvin	14/08/2015	04:00	05:46	15	Bat Box Duet	High	Calm	None	Good	2
	21/08/2015	20:15	22:10	17	Bat Box Duet	High	Light	None	Good	2
Knock	09/07/2015	22:00	23:39	13.5	EMT, Bat Box III, Bat Box Duet	Low	Calm	None	Good	4
	28/08/2015	04:40	06:08	11	EMT, Bat Box Duet	High	Calm	None	Good	2
Leadhills	18/05/2015	03:00	05:00	6	Anabat	High	Calm	Drizzle	Moderate	2
	02/07/2015	22:00	23:59	12	Anabat	Low	Light	None	Good	2
Manse	05/08/2015	21:10	22:15	15	EMT	High	Calm	None	Moderate	1

Mortlach	17/08/2015	20:30	22:30	13	EMT	High	Calm	None	Good	1
Murray	14/05/2015	21:10	22:30	9	Bat Box Duet, Bat Box III, Magenta, Petterson D240	High	Calm	None	Good	8
	04/06/2015	21:50	23:20	14	Bat Box Duet, Bat Box III, EMT, Magenta, Petterson D240	Med	Calm	None	Good	6
Parkerplace	12/06/2015	21:50	23:00	13.5	Bat Box Duet	High	Light	None	Moderate	1
	24/07/2015	03:00	05:05	10	EMT	High	Calm	None	Good	1
Pines	18/07/2015	21:40	23:20	11	Bat Box Duet, EMT	Low	Light	None	Good	2
	19/08/2015	04:40	05:45	13	EMT	High	Light	None	Moderate	1
Pitmudie	09/07/2015	21:30	23:05	11	Petterson D420	High	Light	None	Good	3
	22/07/2015	03:00	04:57	6	Petterson D420	High	Calm	None	Good	2
SCENE	11/06/2015	22:00	23:05	16	Bat Box Duet, Bat Box III	Low	Calm	None	Good	3
	23/07/2015	03:30	05:05	11	Bat Box Duet, Bat Box III, EMT	High	Light	None	Good	3
Stables	05/06/2015	22:00	23:30	14	Bat Box Duet, Magenta	Low	Calm	None	Good	3
	31/08/2015	04:10	06:15	13	EMT	Med	Calm	None	Good	1

Straloch	04/08/2015	21:10	22:40	15	EMT, Bat Box Duet	High	Calm	Drizzle	Moderate	2
	26/08/2015	04:30	06:00	12	EMT, Bat Box Duet	Med	Calm	Drizzle	Good	2
Threave	16/07/2015	21:30	22:35	16	EMT	High	Breezy	Drizzle	Moderate	1
	31/07/2015	03:50	05:20	Unknown*	EMT	High	Calm	Drizzle	Moderate	1
Touch	10/06/2015	21:51	23:28	17	Bat Box Duet	Low	Light	None	Good	2
	22/07/2015	03:00	05:00	11	Bat Box Duet, Bat Box III, EMT	High	Calm	None	Good	3

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