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# GlasGLOW 2023

## Bat Monitoring Surveys

**Produced for itison**

**By Applied Ecology Ltd**

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# 1 Introduction

## Background

1.1 In August 2023, Applied Ecology Ltd (AEL) was commissioned by itison to provide ecological support for their autumn sound and light event known as GlasGLOW ("the Event"), to be held in October and November 2023 within the Glasgow Botanic Gardens ("the Site"), in the West End of the City of Glasgow. A plan showing the location of the Site is provided in **Figure 1.1**.

1.2 GlasGLOW has run annually within the Botanic Gardens since 2018. Although sustainability has always been a consideration in the design and planning of the Event, in 2023 itison took this further with the appointment of a dedicated sustainability specialist to advise on all stages of their event planning and delivery. In parallel with this, and as part of recognising that the Event takes place within public greenspace with its own intrinsic sensitivities, Glasgow City Council (GCC) has required itison to engage with an independent ecological consultant, to provide objective advice regarding how the 2023 GlasGLOW event could be designed and run so as to minimise its biodiversity impact.

1.3 AEL provided ecological support to itison throughout the late summer and autumn of 2023, during which a knowledge gap was identified regarding the quantity, location and type of bat activity within the parts of the Botanic Gardens in which the Event was to take place. A proposal was therefore put together for a bat monitoring study covering the late summer and pre-hibernation periods, including the nights which would be covered by the Event.

## Purpose of this report

1.4 This report provides details relating to a small-scale bat monitoring study undertaken within the Glasgow Botanic Gardens between September and November 2023. It includes an outline of the methodology and sampling strategy adopted, a description of the findings, and an evaluation of the implications of these, both in the context of the Event, and the Botanic Gardens more generally.

## Report qualification

1.5 The survey described here was undertaken in accordance with the best practice methodologies current at the time of commissioning. Site circumstances, scientific knowledge or methodological requirements can change during the course of a project, and these external factors may impact on the scope of subsequent work requirements.

1.6 All survey work and reporting were undertaken by experienced and qualified ecologists in accordance with the Code of Professional Conduct of the Chartered Institute of Ecology and Environmental Management (CIEEM), as well as guidance produced by the Bat Conservation Trust (BCT) and that contained in BS 42020:2013 (Biodiversity).

1.7 All ecological surveys have an expected validity period, owing to the tendency of the natural environment to change over time. This validity period varies from feature to

feature, and is also dependent on the degree of change in a site's management and overall landscape ecology. Where the potential for change is considered to be relevant to the Site, this is highlighted in the appropriate section.

1.8 This report does not purport to provide detailed, specialist legal advice. Where legislation is referenced, the reader should consult the original legal text, and/or the advice of a qualified environmental lawyer.

# GlasGLOW

## Site Location

Site boundary

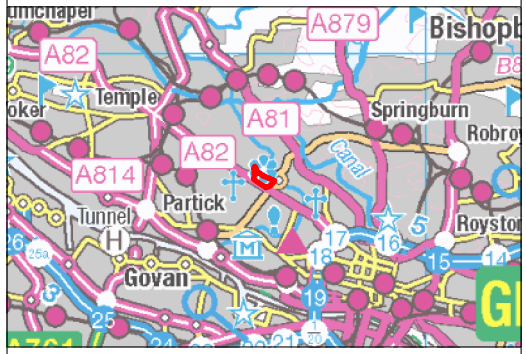


**Figure 1.1**

**Map Scale @ A4: 1:15,000**

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|---|---|
| Surveyed by: - | |
| Survey date: - | |
| Drawn by: RAH | |
| Checked by: DS | |
| Status: Final | |

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# 2 Methodology

## Site context and pre-existing data

2.1 During a Daytime Bat Walkover (DBW) of the Site undertaken in August 2023, it was noted that both structures and trees considered to have suitability for roosting bats were present within the Gardens. A large maternity-style bat box was recorded in the north-east of the Site, although no information could be provided by GCC regarding whether or not roosting bats were known to be using it. The exposed sections of the underground station within the Site were considered unlikely to support bat roosts, being well lit in daylight hours. However, the darker recesses, and the covered tunnel system would have high suitability for both summer roosts, and hibernation. Both Daubenton's bat and common pipistrelle have been recorded in flight in or close to the Site, and it was thought likely that soprano pipistrelle would also be present.

## Sampling strategy

2.2 Potential locations for the deployment of static bat detectors were searched for within the parts of the Site to be utilised for the Event. Sufficient budget was available for the use of up to five detectors, and deployment locations were selected based on:

- a need to sample a representative range of habitats within the Site;
- availability of secure fixing points to reduce the risk of theft;
- the presence of sufficient cover habitats to ensure concealment and reduce the probability of interference.

2.3 The final selected locations are shown in **Figure 2.1**, and summarised in **Table 2.1** below.

**Table 2.1: Description of detector deployment locations**

| Location | Easting | Northing | Habitat |
|---|---|---|---|
| 1 | 256795 | 667404 | Above exposed section of the old Botanic Gardens railway station. |
| 2 | 256719 | 667512 | Within rhododendron bush in area of mown lawn.[1] |
| 3 | 256615 | 667682 | On unlit edge of Gardens, under mature tree canopies. |
| 4 | 256689 | 667636 | Opposite the colony bat box, within wooded unlit edge of Gardens. |
| 5 | 256894 | 667506 | Adjacent to tea rooms, and other buildings with bat roosting suitability. |

2.4 A Permit to Use the Botanic Gardens for the study was provided by GCC for the time period between 04 September 2023 and 30 November 2023. Five Song Meter Mini Bat full spectrum detectors were used, and these were left *in situ* from the night of 04 September 2023 until they were collected in on the morning of 30 November 2023. All of the

[1] This location was more in the open than aerial imagery implies.

detectors were programmed to record from 30 mins before sunset each night, continuing until 30 mins after sunrise. They were deployed with the following settings:

- minimum frequency of 12 kHz;
- sampling rate of 256 kHz;
- trigger window of 2 secs.

2.5 In addition to the initial deployment date and final collection, there was sufficient budget for four other visits during the deployment to change over data cards and replace the batteries in the units[2]. Within the periods of time between these maintenance visits, not all of the detectors ran continuously, either because the batteries ran out, the data cards became full, or for both of these reasons. A summary of the active deployment nights for each unit is provided in **Table 2.2** below; a total of 390 recording nights was achieved.

**Table 2.2: Summary of deployment and recording periods**

| Deployment period | Sampling location and recording nights | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Period 1: 04 – 16 September 2023 (12 nights) | 7/12 (Card full) | 12/12 | 12/12 | 12/12 | 12/12 |
| Period 2: 16 September 2023 – 06 October 2023 (20 nights) | 16/20 (Card full) | 20/20 | 8/20 (Card full) | 8/20 (Card full) | 20/20 |
| Period 3: 06 – 19 October 2023 (13 nights) | 13/13 | 13/13 | 13/13 | 13/13 | 13/13 |
| Period 4a: 19 October 2023 – 02 November 2023 (14 nights) | 14/14 | 14/14 | 14/14 | 14/14 | - |
| Period 4b: 19– 30 October 2023 (11 nights) | - | - | - | - | 11/11 |
| Period 5a: 02– 23 November 2023 (21 nights) | 21/21 | 17/21 | 18/21 (Batteries empty) | 19/21 (Batteries empty) | - |
| Period 5b: 30 October 2023 – 14 November 2023 (15 nights) | - | - | - | - | 12/15 |
| Period 6a: 23 – 30 November 2023 (7 nights) | 7/7 | 7/7 | 7/7 | 7/7 | - |
| Period 6b: 14 – 30 November 2023 (16 nights) | - | - | - | - | 16/16 |
| **Total number of nights recorded** | **78** | **83** | **72** | **73** | **84** |

# Weather data

2.6 Summary weather data were also collated during the deployment period, to provide environmental context for the recorded bat activity. The parameters used were:

- the maximum and minimum temperature at midnight during each recording night[3];
- the total rainfall recorded for the 24 hour period preceding each recording night[4].

[2] SM Mini Bat detectors are marketed as having the capacity to run for 3-4 weeks without a battery change, depending on ambient temperatures and the volume of recorded activity.

[3] As taken from: https://www.timeanddate.com/weather/uk/glasgow/historic?month=9&year=2023

[4] As taken from: https://www2.sepa.org.uk/rainfall/data/index/341380 Killermont is the closest SEPA rain gauge to the Site.

# Data analysis

2.7 All sound files recorded by the static detectors were downloaded after retrieval and processed using Kaleidoscope software. An experienced bat ecologist then reviewed data in AnalookW, to classify and tag each call to species level wherever possible. This method of analysis is in line with current guidelines (Collins, 2023[5]) for data analysis, which recommends the manual checking of all non-*Pipistrellus* calls when using automated methods. Sound files labelled as noise were not reviewed. Subsequent statistical analysis was carried out using Excel and/or Minitab. For the purposes of this report, a single bat pass was defined as an echolocation call separated from other calls by a minimum of 2 secs.

# Potential limitations associated with the study

## Breaks in recording

2.8 As shown in **Table 2.2** and described earlier, not all of the detectors recorded continuously. This meant that for some locations there was not a continuous timeline of data. Particular issues were experienced at Location 5 once the GlasGLOW event was up and running, when it was noticed that the data card in that detector had become full of noise files relatively early into the first during-event deployment period. It was thought likely that this was as a result of ultrasonic pulses emitting from the specific Event installation close to this location. A decision was taken to check this detector more frequently, meaning its changeover dates from that point onwards did not correspond with those at the other locations. However, there was only one night for which no data were collected (15 September 2023), and overall the longevity of the data set (ranging between 72 and 84 nights at each location) more than compensated for any gaps. It should be recognised that the standard approach to the sampling of bat activity, as per current guidelines (Collins, 2023), is based on six sampling periods each of 5 nights, within a 6 month period between May and September. The data collected far exceeded those requirements, albeit it outwith the traditional "bat active" period.

## Subjectivity of deployment locations

2.9 The locations chosen for the deployment of detectors was by definition subjective, and it is possible that detectors placed in other locations may have generated a data set with different characteristics. However, the overall patterns observed (see **Chapter 3**) were relatively consistent, and it is therefore likely that the data were reasonable representative within the logistical constraints presented by the Site and budget.

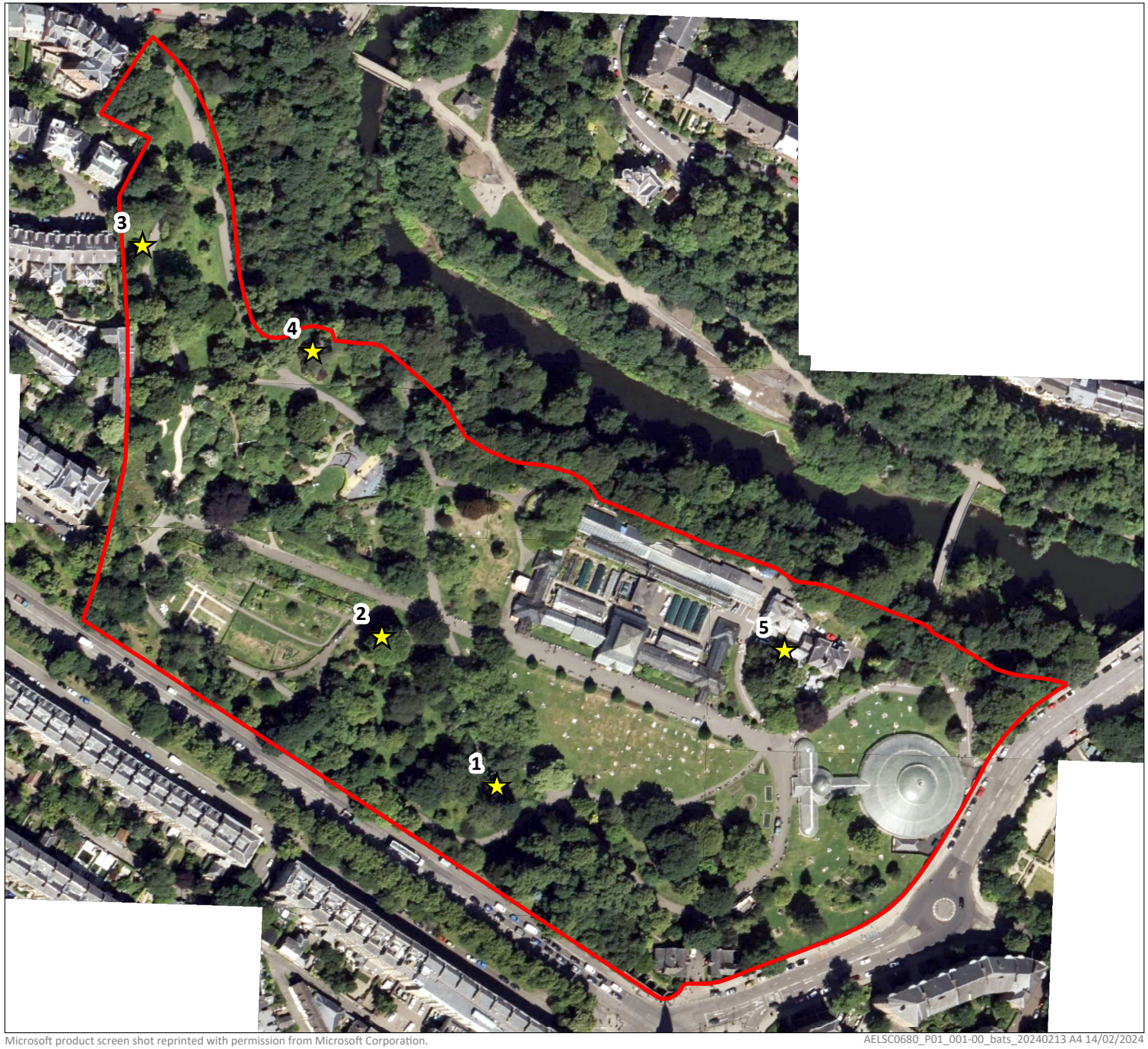
## Interpretation of calls

2.10 Caution is always required when interpreting bat calls recorded by static bat detectors. Each recorded call represents a pass of a bat within the range of the microphone. These data do not provide information about the actual number of bats present (a high number of passes could be a single bat repeatedly foraging for an extended period of time). However,

[5] **Collins, J. (2023)** *Bat Surveys for Professional Ecologists: Good Practice Guidelines, 4th Edition*. Bat Conservation Trust, September 2023.

static detector data provide invaluable information regarding relative levels of activity, and times of bat passes. Experienced operators of this equipment can use the data comparatively.

2.11 Similarly, it was not always possible to identify recorded bat calls to species level, and *Myotis* and *Nyctalus* bats were only classified to genus. However, all pipistrelle bats recorded were classified to species level.




# GlasGLOW

## Sampling Strategy

Site boundary

Static detector location

**Figure 2.1**

**Map Scale @ A4: 1:2,500**

N

| | |
|---|---|
| Surveyed by: AEL | |
| Survey date: Sept - Nov 2023 | |
| Drawn by: RAH | |
| Checked by: DS | |
| Status: Final | |

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# 3 Results

3.1 A summary of the pass data recorded by the detectors on a night-by-night basis is provided in **Appendix B**.

## Total passes and species composition

3.2 A grand total of 31,416 bat passes were recorded during the study, as summarised in **Table 3.1**. The vast majority of these (over 80 %) were at Location 1, above the disused railway station and tunnel entrances. Of these, soprano pipistrelles were the most frequently recorded species, as was the case at all locations except Location 3 where common pipistrelle was more frequently present.

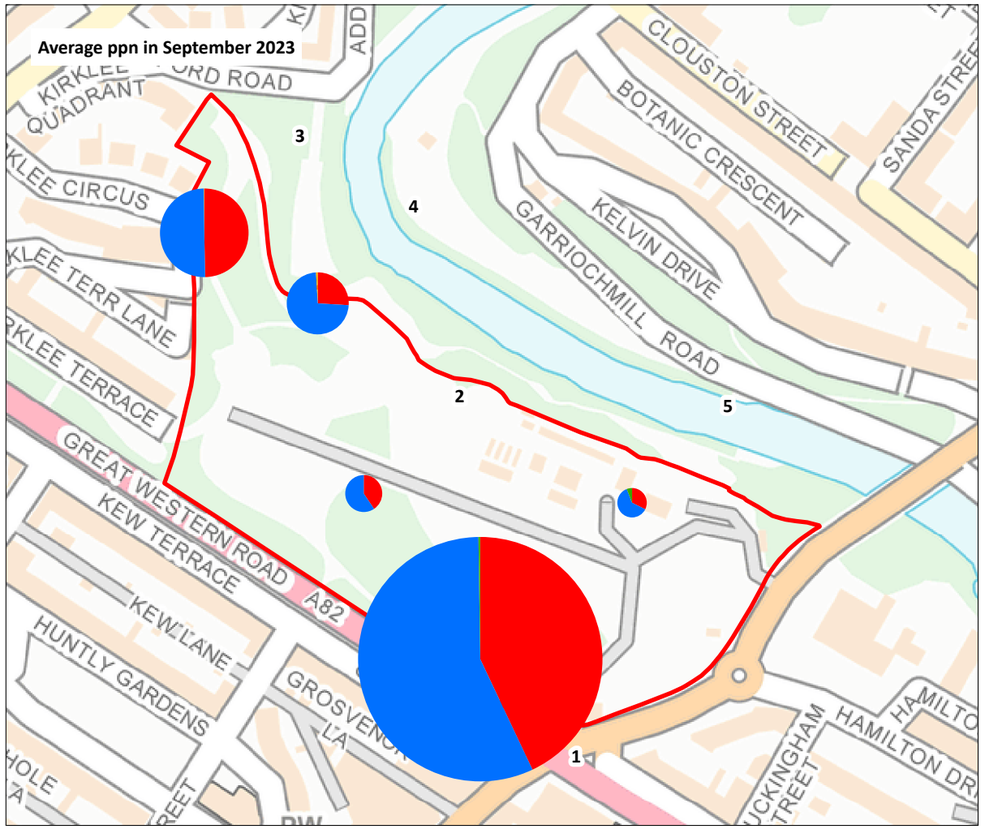
3.3 Overall, at least five species of bat were recorded during the monitoring, although nearly two-thirds of passes were made by soprano pipistrelles, and just under two-fifths by common pipistrelles. A very small number of brown long-eared (BLE) bat passes were picked up at Location 1, along with a low number of *Myotis* calls, which were also detected at Location 5. The pattern of the *Myotis* calls was indicative of these being Daubenton's bats *M. daubentonii*. Low numbers of *Nyctalus* bats were picked up at all locations except Location 2. The sonograms from these were suggestive of Leisler's bats *N. leisleri*.

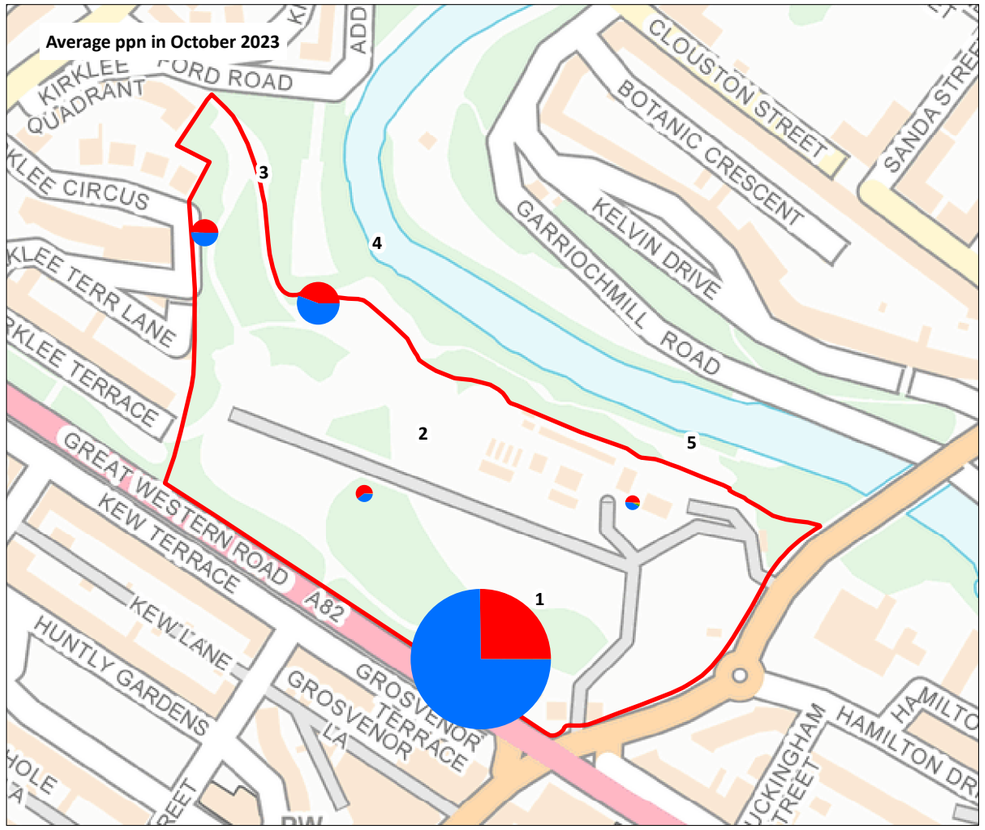
**Table 3.1: Summary of species composition of all recorded passes by location**

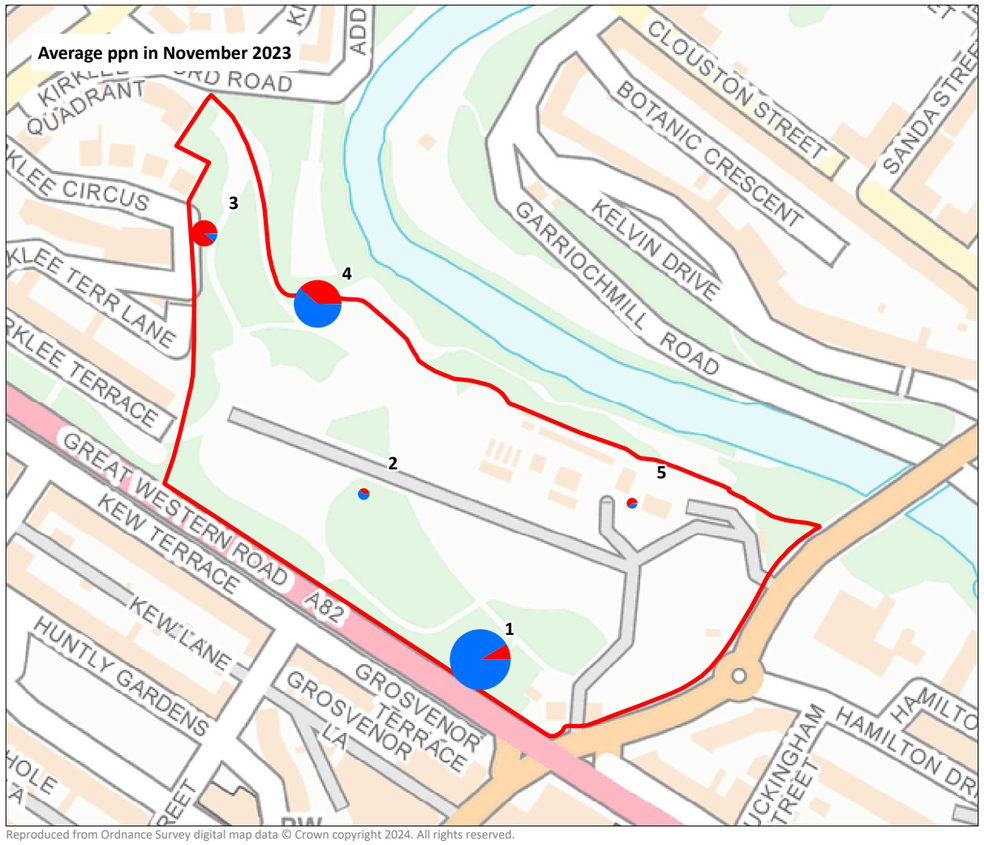
| Detector location | Common pipistrelle | Soprano pipistrelle | Brown long-eared bat | *Myotis* sp. | *Nyctalus* sp. | Total | % of all passes |
|---|---|---|---|---|---|---|---|
| 1 | 9238 | 16146 | 4 | 40 | 2 | 25430 | 80.9 |
| 2 | 283 | 359 | 0 | 0 | 0 | 642 | 2.0 |
| 3 | 1341 | 1184 | 0 | 0 | 2 | 2527 | 8.0 |
| 4 | 831 | 1552 | 0 | 0 | 7 | 2390 | 7.6 |
| 5 | 165 | 239 | 0 | 22 | 1 | 427 | 1.4 |
| **Total** | **11858** | **19480** | **4** | **62** | **12** | **31416** | **100.0** |
| % of all passes | 37.7 | 62.0 | < 0.1 | 0.2 | < 0.1 | 100.0 | - |

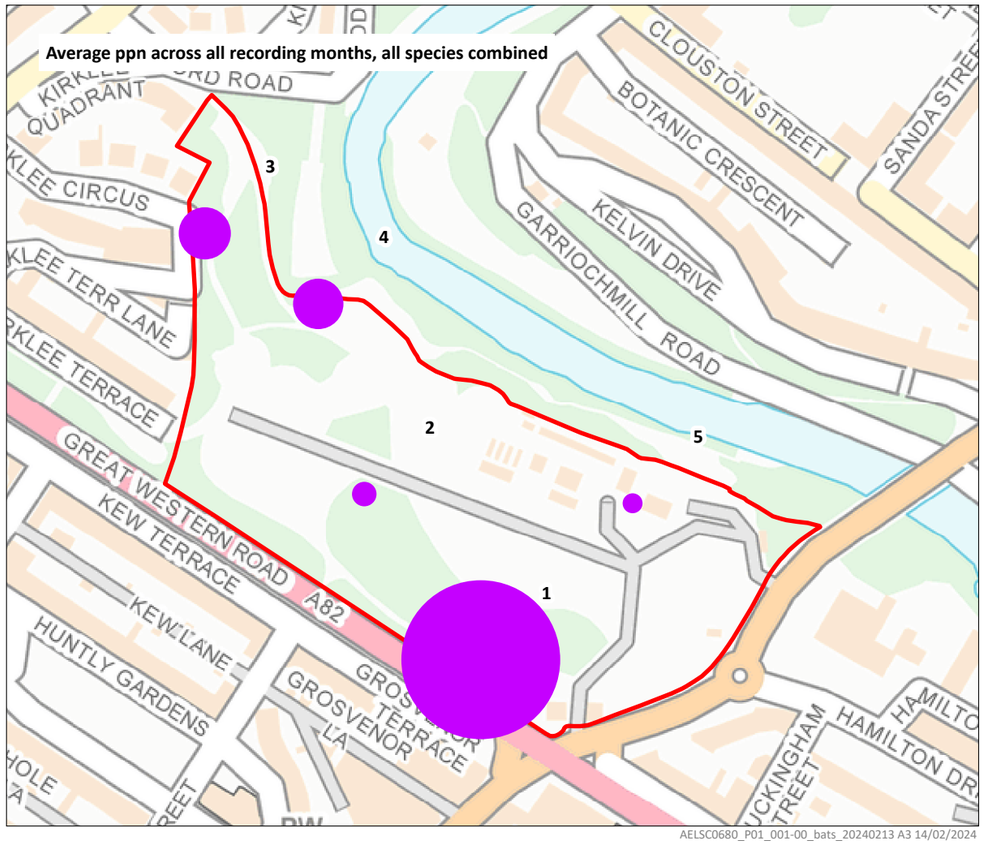
## Seasonal patterns

3.4 A summary of the species abundance and distribution for each month in which sampling occurred is presented in **Figure 3.1**, with activity levels standardised across the locations through the use of passes per night (ppn). These maps show how bat activity declined over the autumn months included in the sampling, but proportionally this was generally consistent across all of the sampling locations.



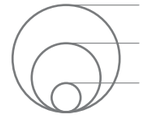




# GlasGLOW

## Passes per Night (ppn) Recorded Sept-Nov 2023

Site boundary

**Average recorded ppn:**



150
62
11

The radius of each disc shown on the maps is proportional to the total number of ppn in the displayed recording period. The radii of the discs shown here in the legend represents the given number of ppn.

- Common pipistrelle
- Soprano pipistrelle
- BLE
- Myotis sp.
- Nyctalus sp.

**Figure 3.1**

**Map Scale @ A3:** 1:4,000

N

| | |
|---|---|
| Surveyed by: AEL | |
| Survey date: Sept-Nov 2023 | |
| Drawn by: RAH | |
| Checked by: DS | |
| Status: Final | |

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3.5 More detail regarding the activity recorded at each location is provided in **Figures 3.2-3.7**. These plots show the total number of passes recorded at each location on each recording night, with a smoothed LOWESS plot (**Lo**cally **We**ighted **S**catter-plot **S**moothing) to highlight the trends shown in each plot. LOWESS plots can be particularly useful for exploring patterns in time series data. The different vertical axis scales used for these plots should also be noted.

3.6 These figures also show that bat activity decreased over the sampling period. However, they also show that at all locations, the main period of decrease was prior to a point in time between 04 October 2023 and 14 October 2023, and after this time, activity was generally very low.

## Weather data

3.7 The summary weather data used in the study has been included in **Appendix C**.

3.8 A plot of maximum and minimum temperatures at midnight over the sampling period is provided in **Figure 3.8**, and rainfall totals in **Figure 3.9**. A summary of correlation coefficients between these parameters and the number of recorded bat passes is provided in **Table 3.2**. These data show that prevailing weather conditions were relatively wet and mild up to the second week in October, after which time temperatures started to fluctuate more noticeably, with more frequent dry or relatively low rainfall periods.

3.9 There were significant correlations between the recorded number of passes of all species and both maximum and minimum recorded temperatures with the exception of BLE, because there were too few BLE passes to generate a significant result. There was no relationship however between number of bat passes and recorded rainfall for the 24 hour period preceding midnight on the recording night. The analysis was repeated for the rainfall recorded for the 24 hr period commencing at midnight of the recording night, and no significant correlations were obtained in this way, either.

**Table 3.2: Correlation coefficients between number of bat passes and weather data**

| Species/ genus | Maximum midnight temp | | Minimum midnight temp | | Rainfall | |
|---|---|---|---|---|---|---|
| | r | *P* | r | *P* | r | *P* |
| Common pipistrelle | 0.386 | < 0.001 | 0.338 | 0.001 | -0.176 | NS |
| Soprano pipistrelle | 0.385 | < 0.001 | 0.359 | 0.001 | -0.154 | NS |
| BLE | 0.036 | NS | -0.042 | NS | -0.090 | NS |
| *Myotis* sp. | 0.375 | < 0.001 | 0.334 | 0.001 | 0.125 | NS |
| *Nyctalus* sp. | 0.216 | < 0.05 | 0.216 | < 0.05 | -0.110 | NS |
| All passes | 0.409 | < 0.001 | 0.372 | < 0.001 | -0.173 | NS |

**Figure 3.2: Number of passes per night recorded at Location 1, with associated LOWESS plot**

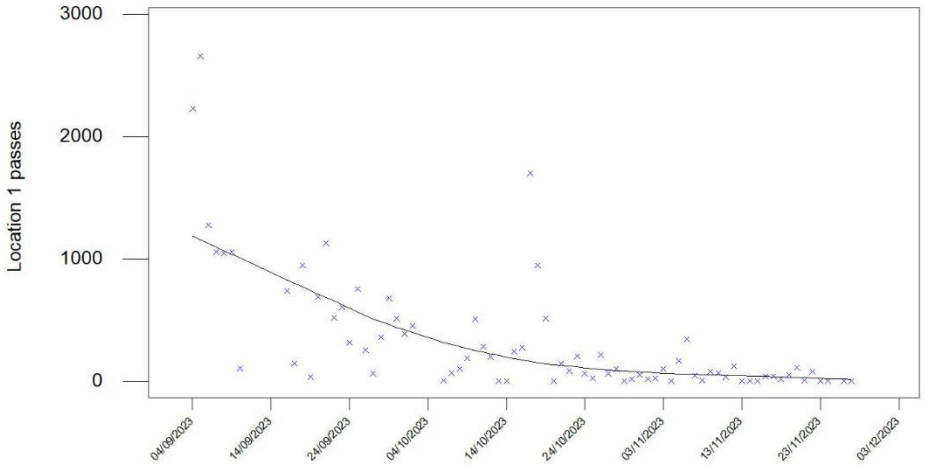



**Figure 3.3: Number of passes per night recorded at Location 2, with associated LOWESS plot**

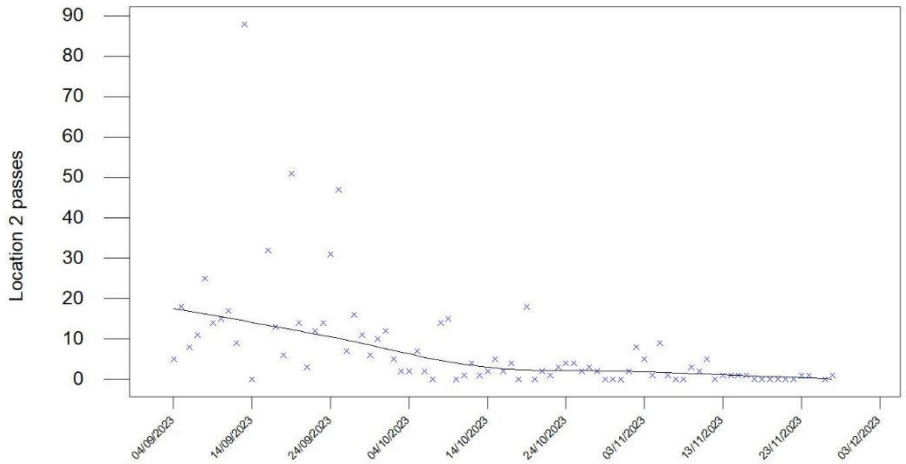



**Figure 3.4: Number of passes per night recorded at Location 3, with associated LOWESS plot**

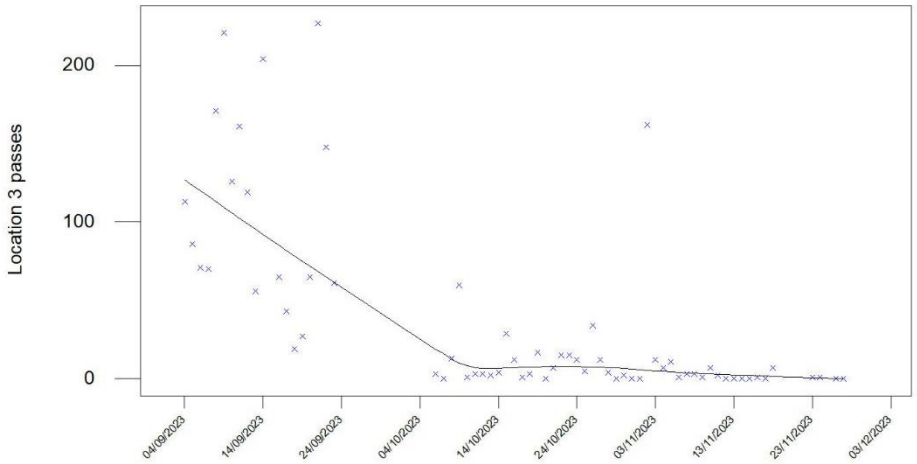


**Figure 3.5: Number of passes per night recorded at Location 4, with associated LOWESS plot**

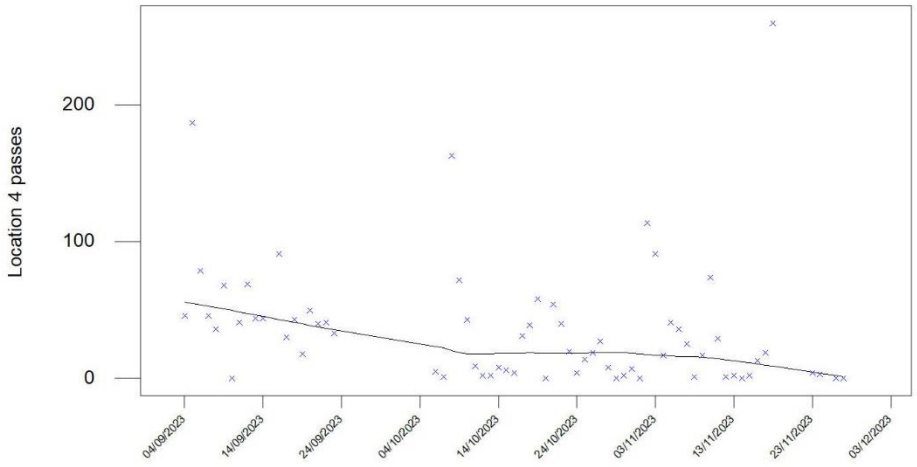



**Figure 3.6: Number of passes per night recorded at Location 5, with associated LOWESS plot**

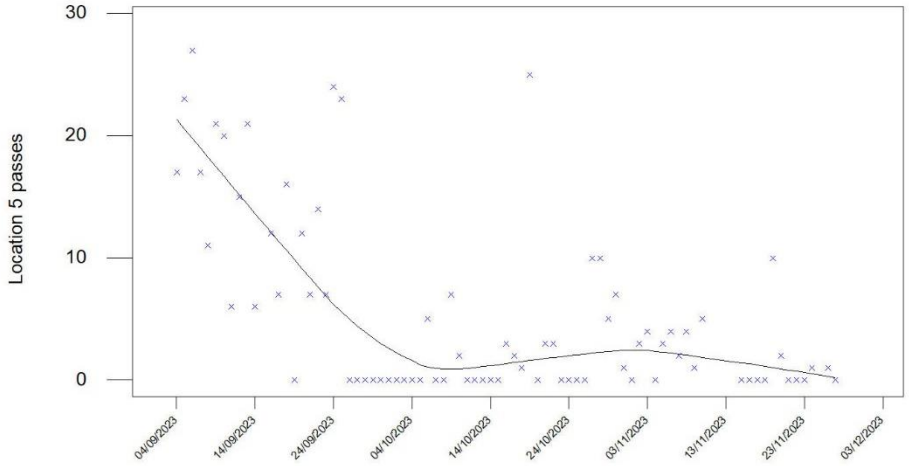



**Figure 3.7: Total number of passes per night recorded at all locations, with associated LOWESS plot**

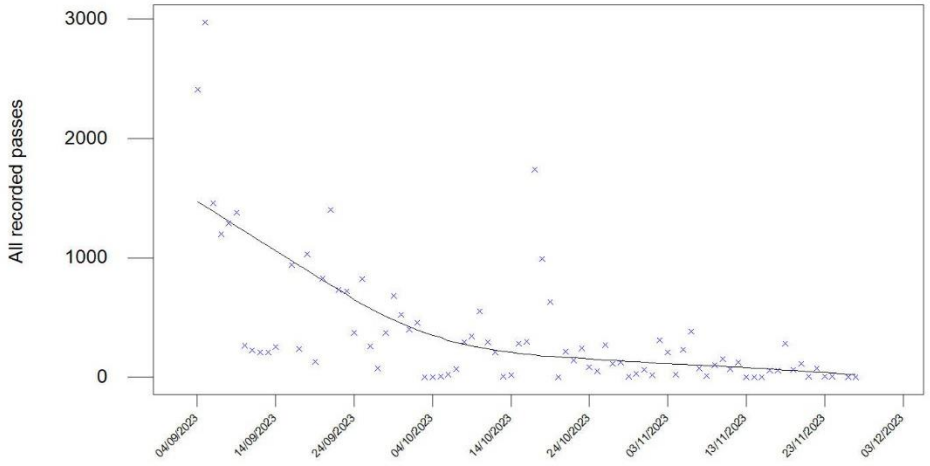


**Figure 3.8: Maximum and minimum recorded temperatures at midnight on each recording night**

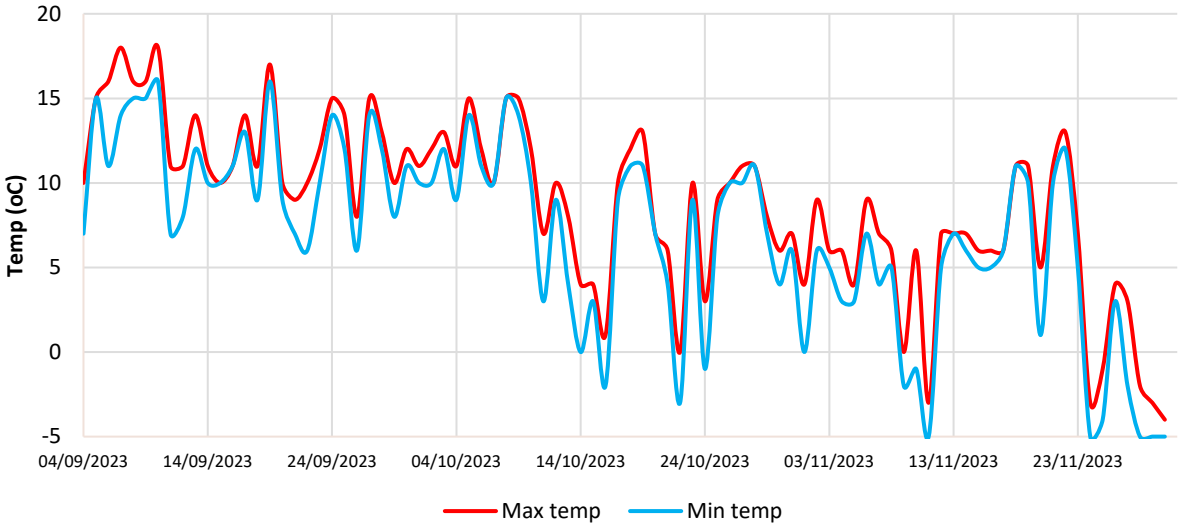
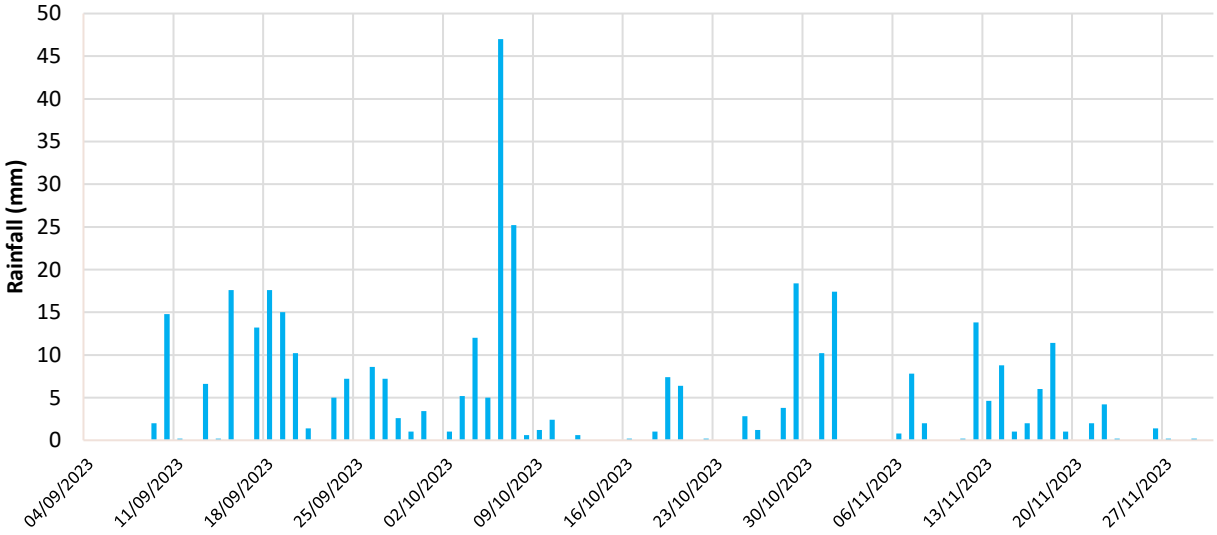



**Figure 3.9: Total rainfall for 24 hr period preceding recording night**



# 4 Discussion

## Species composition

4.1 The sampling reported here has confirmed that a wider range of bat species utilise the Site during autumn and early winter than previously known. The most active species appeared to be soprano pipistrelle, rather than the common pipistrelle recorded by other users of the Gardens.

4.2 Soprano pipistrelle bats tend to be more frequent in this part of Scotland than common pipistrelles, and therefore this finding is not unexpected. Both species are common and widespread, and they are classified as Not Threatened (Hutson 1993[6]). In 2013, population estimates in Scotland[7] were 352,000 for common pipistrelle and 198,000 for soprano pipistrelle. It is accepted that this is likely significantly lower than the true figure. They are crevice roosters, and as such have adapted to finding roosting spaces in built features, and are potentially less affected by environmental constraints of urban areas, such as street-lighting. Pipistrelles are fast-flying species and there is some evidence to suggest that they congregate around artificial lighting to hawk insects attracted to the lights.

4.3 Of the three other species/genus of bats which were recorded in much lower numbers than the pipistrelles, *Myotis* bats were the most frequent. The sonograms recorded were suggestive of these being Daubenton's bats, and these have previously been recorded in the Gardens. They were only recorded at Location 5 in closest proximity to the River Kelvin, and at Location 1 at the railway tunnels. Daubenton's are well adapted to hunting over water surfaces and this is probably the reason why they are associated with the River Kelvin corridor. It is possible that the railway tunnels represent a roost location for this species, and further analysis of the first and last pass times could provide more information regarding this.

4.4 With regards to the BLE passes, it is useful to have it confirmed that this species is occasionally present in the general location of the Site, but as the Site and its environs do not represent preferred habitat for either roosting or foraging for this species, it is not unexpected that so few passes were recorded. BLE is typically a species which roosts in older buildings, barns, churches and trees, preferring cavities rather than crevices, and preferably a "warm up" space for use immediately prior to commencing and evening's hunting. Preferred foraging habitats are open deciduous and coniferous woodlands, parkland and gardens, and in combination these roosting and foraging habitats are not commonplace around the Site.

4.5 The *Nyctalus* passes recorded are interesting, as these species are thought to be at their northernmost limit in Scotland, although their distribution is becoming better known through the use of static detector studies such as this. In the UK, Leisler's bats are classed as Vulnerable: scarce (except in Ireland) and with a poorly known conservation status

[6] **Hutson, A.M. (1993).** *Action plan for the conservation of bats in the United Kingdom*. Bat Conservation Trust, London

[7] **JNCC (2013).** *Individual Species Reports* - 3rd UK Habitats Directive Reporting 2013.

(Hutson, 1993). However, a study in 2017[8] stated that the population of Leisler's bat in Scotland may actually be in the region of many thousands. *Nyctalus* species are early emerging bats, typically leaving a roost 0-30 mins after sunset and sometimes even earlier. They are able to fly long distances (up to 20 km) quickly after emerging (Jones *et al.*, 2009)[9]. It is thought unlikely that a *Nyctalus* roost is present in close proximity to the Site, but closer analysis of first- and last-pass times may provide greater insight into this.

## Frequency of bat activity

4.6 ECOBAT[10] is a UK-wide database and analysis platform which enables temporal and spatial comparisons of bat activity recorded by static detectors, relative to reference datasets already entered into the platform. It is usually possible to enter new datasets into ECOBAT to generate an objective evaluation of a site's bat activity relative to the datasets already contained within the platform. At the time of writing, ECOBAT was in a prolonged period of outage to enable a rebuild, and therefore no comparisons via that platform were possible. Without ECOBAT, the general levels of activity recorded, when expressed as passes per night, are difficult to compare with activity recorded elsewhere, as the study here focussed on a time period which is not typically covered by longer running static bat detector surveys. The late autumn and early winter bat activity periods are much less well studied, and therefore direct comparisons cannot be easily made.

4.7 The closest pre-existing dataset to the Site held by AEL and for which ECOBAT analysis was undertaken was located c. 23 km to the north-west. This was however for a peri-urban location within the Loch Lomond and the Trossachs National Park; the environmental context is not at all comparable to the Site. However, a subjective comparison between the two datasets suggests that at least during some nights in September, bat activity within the Botanic Gardens may be classifiable as being "high", if the data were to be passed through ECOBAT. This would not be unexpected given that the Gardens represent a notable area of greenspace within a predominantly urban environment, and is well connected via the River Kelvin to potential roosting locations and other foraging habitats. It is possible that bats commute to forage here from roost locations at some distance away, as well as from roosts in close vicinity.

4.8 However, bat activity levels did vary greatly between locations and over time. Peaks and troughs were clearly identifiable, including as expected lower activity at times of lower temperatures, and higher activity on milder nights, and nights following sub-optimal foraging weather.

## Trends in activity

4.9 The data collected during this study show clearly how bat activity tails off during the autumn, in the weeks leading up to hibernation. Activity was most notably reduced after

[8] **Newson, S.E., Evans, H.E., Gillings, S., Jarrett, D. & Wilson, M.W. (2017)**. *A survey of high risk bat species across southern Scotland*. Scottish Natural Heritage Commissioned Report No. 1008.

[9] **Jones, G., Cooper-Bohannon, R., Barlow, K. and Parsons, K. (2009).** *Scoping and Method Development Report: Determining the potential ecological impact of wind turbines on bat populations in Britain*. University of Bristol and Bat Conservation Trust.

[10] https://www.mammal.org.uk/science-research/ecostat/ecobat/ Not currently available.

the first week in October, which corresponded with the first sub-zero air temperatures for this part of Glasgow. A lack of a relationship between bat activity and rainfall was interesting, as it may be that, to a certain extent, bats in the West of Scotland are habituated to some level of night time precipitation given the prevailing weather conditions in this part of the UK. However, it may also be because the rainfall data used here were not at a sufficiently fine resolution to allow within-night correlations.

4.10 The trend lines for the whole data set, and those derived for each individual recording location, all show the drop off in activity as plateauing in mid October 2023. The GlasGLOW event commenced on 27 October 2023, and lasted until 12 November 2023, and although the datasets are noisy (as is characteristically the case for sampling within real world natural environments where it is not possible to control all potential variables), none of the trend lines showed an accelerated decrease in activity within the time period of the Event.

## Roosting bats

4.11 The high level of bat activity at Location 1 is likely to confirm the hypothesis that the railway tunnel system contains roosting locations, at least for common and soprano pipistrelles. Nearly 400 passes of bats recorded at this location were exceptionally early, and timed *before* sunrise; approximately a quarter of these were during the Event. It is not possible to determine from these data the size of these roosts, whether they are summer or hibernation roosts or both, and/or whether any of the activity recorded may represent an autumn swarming pre-hibernation location for pipistrelles. These could all be areas for further study.

## Aspects for further investigation

4.12 The data presented here are interesting because they have focussed on a time period of bat activity which is less well studied. Due to budget (i.e. time) constraints, it has not been possible to undertake all of the potential analyses which the data offer, and further work, particularly on between-species comparisons of activity and first- and last-pass timings could be undertaken if the opportunity presented itself. Other routes to enquiry could include *inter alia*:

- liaison with the University of Glasgow regarding use of the existing dataset by a BSc, MSc or MRes student as part of a dissertation or thesis;
- manual surveys with observers at the railway tunnels, to add qualitative data regarding bat behaviour to the quantitative data collected during this investigation;
- completion of additional 3 month recording periods (e.g. Dec-Feb, May-July) for a fuller understanding of bat usage of the Gardens;
- completion of similar studies for other events which take place in the Botanic Gardens, in particular those occurring in the summer months.

4.13 Following advice given by AEL to itison prior to the commencement of the 2023 GlasGLOW event, some changes to the sound and light installations were made, to take into consideration potential impacts on bats. There are no historical data which could be used to determine whether or not the bat activity recorded during the Event period differed to that seen in previous years, but the analyses presented here do not appear to indicate any

detectable effect on bat activity that might be attributable to anthropogenic sourced disturbance. However, it would be prudent for the biodiversity recommendations made for the 2023 event to be carried forward for future events.

# 5 Summary and Conclusions

5.1 Throughout late autumn and early winter 2023, bat activity monitoring was undertaken within the Glasgow Botanic Gardens. Within the study period, the GlasGLOW event took place in the gardens, comprising 17 nights of a sound and light installation.

5.2 The monitoring data revealed at least five species of bat were using the Gardens, and at least three of these had not previously been formally recorded there. Bat activity was concentrated in the area in the vicinity the former Botanics railway station and it was thought likely that this was the entry location to a well-used roost of common and soprano pipistrelle bats. The nature of this roost, and whether or not this included hibernaculae, could not be determined.

5.3 In general, the levels of recorded bat activity varied significantly between sampling locations and over time, and appeared to be determined by ambient temperatures rather than rainfall. Activity decreased throughout the autumn, levelling off in the first two weeks of October. No discernible effect of the Event could be detected in the data.

5.4 This was a snapshot study which has provided useful insights into a less well studied period of the bat annual cycle, despite a number of difficulties associated with sampling “real world” environments where a range of variables cannot be controlled. Potential further lines of enquiry have been highlighted, and recommendations made regarding best practice mitigation for biodiversity features that should be incorporated into strategies for events in the Gardens.

# Appendix A

## List of Initialisms, Acronyms and Abbreviations Used in this Report

| Short form | Full terminology |
|---|---|
| AEL | Applied Ecology Ltd |
| BCT | Bat Conservation Trust |
| BLE | Brown long-eared bat |
| BRS | Bat Roost Suitability |
| CIEEM | Chartered Institute of Ecology and Environmental Management |
| DBW | Daytime Bat Walkover |
| EPS | European Protected Species |
| GCC | Glasgow City Council |
| LOWESS | Locally Weighted Scatter-plot Smoothing |
| PEA | Preliminary Ecological Appraisal |

# Appendix B

## Summary Bat Activity Data (September – November 2023)

| Night start date | Total number of passes recorded | | | | | |
|---|---|---|---|---|---|---|
| | Common pipistrelle | Soprano pipistrelle | Brown long-eared bat | *Myotis* sp. | *Nyctalus* sp. | Total |
| 04/09/2023 | 1506 | 899 | 0 | 6 | 1 | 2412 |
| 05/09/2023 | 1305 | 1659 | 0 | 5 | 3 | 2973 |
| 06/09/2023 | 708 | 747 | 2 | 5 | 0 | 1462 |
| 07/09/2023 | 588 | 613 | 0 | 2 | 0 | 1203 |
| 08/09/2023 | 614 | 670 | 0 | 1 | 4 | 1289 |
| 09/09/2023 | 526 | 850 | 0 | 3 | 2 | 1381 |
| 10/09/2023 | 120 | 146 | 0 | 0 | 0 | 266 |
| 11/09/2023 | 92 | 132 | 0 | 0 | 0 | 224 |
| 12/09/2023 | 108 | 104 | 0 | 0 | 0 | 212 |
| 13/09/2023 | 51 | 157 | 0 | 1 | 0 | 209 |
| 14/09/2023 | 77 | 177 | 0 | 0 | 0 | 254 |
| 15/09/2023 | * | * | * | * | * | * |
| 16/09/2023 | 501 | 439 | 0 | 1 | 0 | 941 |
| 17/09/2023 | 134 | 105 | 0 | 2 | 0 | 241 |
| 18/09/2023 | 283 | 744 | 0 | 4 | 0 | 1031 |
| 19/09/2023 | 49 | 84 | 0 | 0 | 0 | 133 |
| 20/09/2023 | 322 | 501 | 0 | 6 | 0 | 829 |
| 21/09/2023 | 327 | 1077 | 0 | 1 | 0 | 1405 |
| 22/09/2023 | 266 | 466 | 0 | 2 | 0 | 734 |
| 23/09/2023 | 136 | 586 | 0 | 3 | 0 | 725 |
| 24/09/2023 | 104 | 265 | 0 | 2 | 0 | 371 |
| 25/09/2023 | 473 | 346 | 0 | 5 | 0 | 824 |
| 26/09/2023 | 121 | 139 | 0 | 2 | 0 | 262 |
| 27/09/2023 | 43 | 34 | 0 | 0 | 0 | 77 |
| 28/09/2023 | 173 | 198 | 0 | 1 | 0 | 372 |
| 29/09/2023 | 205 | 480 | 0 | 0 | 0 | 685 |
| 30/09/2023 | 132 | 388 | 0 | 3 | 0 | 523 |
| 01/10/2023 | 113 | 286 | 0 | 2 | 0 | 401 |
| 02/10/2023 | 144 | 312 | 0 | 0 | 0 | 456 |
| 03/10/2023 | 0 | 2 | 0 | 0 | 0 | 2 |
| 04/10/2023 | 0 | 2 | 0 | 0 | 0 | 2 |
| 05/10/2023 | 1 | 6 | 0 | 0 | 0 | 7 |
| 06/10/2023 | 5 | 16 | 0 | 3 | 0 | 24 |
| 07/10/2023 | 1 | 67 | 0 | 0 | 0 | 68 |
| 08/10/2023 | 187 | 104 | 0 | 1 | 0 | 292 |
| 09/10/2023 | 168 | 175 | 0 | 0 | 0 | 343 |
| 10/10/2023 | 226 | 329 | 0 | 1 | 0 | 556 |
| 11/10/2023 | 117 | 177 | 0 | 0 | 0 | 294 |
| 12/10/2023 | 51 | 160 | 0 | 0 | 0 | 211 |
| 13/10/2023 | 3 | 5 | 0 | 0 | 0 | 8 |
| 14/10/2023 | 7 | 8 | 2 | 0 | 0 | 17 |
| 15/10/2023 | 62 | 224 | 0 | 0 | 0 | 286 |

| Night start date | Total number of passes recorded | | | | | |
|---|---|---|---|---|---|---|
| | Common pipistrelle | Soprano pipistrelle | Brown long-eared bat | *Myotis* sp. | *Nyctalus* sp. | Total |
| 16/10/2023 | 30 | 268 | 0 | 0 | 0 | 298 |
| 17/10/2023 | 325 | 1415 | 0 | 0 | 0 | 1740 |
| 18/10/2023 | 172 | 821 | 0 | 0 | 0 | 993 |
| 19/10/2023 | 130 | 504 | 0 | 0 | 0 | 634 |
| 20/10/2023 | 0 | 1 | 0 | 0 | 0 | 1 |
| 21/10/2023 | 29 | 184 | 0 | 0 | 0 | 213 |
| 22/10/2023 | 52 | 92 | 0 | 0 | 0 | 144 |
| 23/10/2023 | 61 | 182 | 0 | 0 | 0 | 243 |
| 24/10/2023 | 31 | 53 | 0 | 0 | 0 | 84 |
| 25/10/2023 | 38 | 11 | 0 | 0 | 0 | 49 |
| 26/10/2023 | 144 | 127 | 0 | 0 | 0 | 271 |
| 27/10/2023 | 41 | 73 | 0 | 0 | 0 | 114 |
| 28/10/2023 | 38 | 85 | 0 | 0 | 0 | 123 |
| 29/10/2023 | 3 | 3 | 0 | 0 | 0 | 6 |
| 30/10/2023 | 23 | 5 | 0 | 0 | 1 | 29 |
| 31/10/2023 | 52 | 9 | 0 | 0 | 0 | 61 |
| 01/11/2023 | 3 | 16 | 0 | 0 | 0 | 19 |
| 02/11/2023 | 278 | 31 | 0 | 0 | 0 | 309 |
| 03/11/2023 | 85 | 126 | 0 | 0 | 0 | 211 |
| 04/11/2023 | 14 | 12 | 0 | 0 | 0 | 26 |
| 05/11/2023 | 41 | 190 | 0 | 0 | 0 | 231 |
| 06/11/2023 | 6 | 380 | 0 | 0 | 0 | 386 |
| 07/11/2023 | 32 | 43 | 0 | 0 | 0 | 75 |
| 08/11/2023 | 8 | 6 | 0 | 0 | 0 | 14 |
| 09/11/2023 | 11 | 90 | 0 | 0 | 0 | 101 |
| 10/11/2023 | 75 | 79 | 0 | 0 | 0 | 154 |
| 11/11/2023 | 17 | 54 | 0 | 0 | 0 | 71 |
| 12/11/2023 | 24 | 101 | 0 | 0 | 0 | 125 |
| 13/11/2023 | 0 | 3 | 0 | 0 | 0 | 3 |
| 14/11/2023 | 2 | 1 | 0 | 0 | 0 | 3 |
| 15/11/2023 | 1 | 2 | 0 | 0 | 0 | 3 |
| 16/11/2023 | 3 | 54 | 0 | 0 | 1 | 58 |
| 17/11/2023 | 0 | 59 | 0 | 0 | 0 | 59 |
| 18/11/2023 | 3 | 282 | 0 | 0 | 0 | 285 |
| 19/11/2023 | 14 | 48 | 0 | 0 | 0 | 62 |
| 20/11/2023 | 12 | 100 | 0 | 0 | 0 | 112 |
| 21/11/2023 | 0 | 9 | 0 | 0 | 0 | 9 |
| 22/11/2023 | 0 | 77 | 0 | 0 | 0 | 77 |
| 23/11/2023 | 5 | 1 | 0 | 0 | 0 | 6 |
| 24/11/2023 | 5 | 3 | 0 | 0 | 0 | 8 |
| 25/11/2023 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26/11/2023 | 1 | 0 | 0 | 0 | 0 | 1 |

| Night start date | Total number of passes recorded | | | | | |
|---|---|---|---|---|---|---|
| | Common pipistrelle | Soprano pipistrelle | Brown long-eared bat | *Myotis* sp. | *Nyctalus* sp. | Total |
| 27/11/2023 | 0 | 1 | 0 | 0 | 0 | 1 |
| 28/11/2023 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29/11/2023 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30/11/2023 | 0 | 0 | 0 | 0 | 0 | 0 |

# Appendix C
## Collated Weather Data

| Night start date | Max temperature at midnight (°C) | Min temperature at midnight (°C) | Rainfall (past 24 hrs) | Time of sunrise | Time of sunset |
|---|---|---|---|---|---|
| 04/09/2023 | 10 | 7 | 0 | 06:26 | 20:04 |
| 05/09/2023 | 15 | 15 | 0 | 06:28 | 20:02 |
| 06/09/2023 | 16 | 11 | 0 | 06:30 | 19:59 |
| 07/09/2023 | 18 | 14 | 0 | 06:32 | 19:56 |
| 08/09/2023 | 16 | 15 | 0 | 06:34 | 19:54 |
| 09/09/2023 | 16 | 15 | 2 | 06:36 | 19:51 |
| 10/09/2023 | 18 | 16 | 14.8 | 06:38 | 19:49 |
| 11/09/2023 | 11 | 7 | 0.2 | 06:40 | 19:46 |
| 12/09/2023 | 11 | 8 | 0 | 06:42 | 19:44 |
| 13/09/2023 | 14 | 12 | 6.6 | 06:44 | 19:41 |
| 14/09/2023 | 11 | 10 | 0.2 | 06:46 | 19:38 |
| 15/09/2023 | 10 | 10 | 17.6 | 06:48 | 19:36 |
| 16/09/2023 | 11 | 11 | 0 | 06:49 | 19:32 |
| 17/09/2023 | 14 | 13 | 13.2 | 06:51 | 19:30 |
| 18/09/2023 | 11 | 9 | 17.6 | 06:53 | 19:27 |
| 19/09/2023 | 17 | 16 | 15 | 06:55 | 19:24 |
| 20/09/2023 | 10 | 9 | 10.2 | 06:57 | 19:22 |
| 21/09/2023 | 9 | 7 | 1.4 | 06:59 | 19:19 |
| 22/09/2023 | 10 | 6 | 0 | 07:01 | 19:16 |
| 23/09/2023 | 12 | 10 | 5 | 07:03 | 19:14 |
| 24/09/2023 | 15 | 14 | 7.2 | 07:05 | 19:11 |
| 25/09/2023 | 14 | 12 | 0 | 07:07 | 19:08 |
| 26/09/2023 | 8 | 6 | 8.6 | 07:09 | 19:06 |
| 27/09/2023 | 15 | 14 | 7.2 | 07:11 | 19:03 |
| 28/09/2023 | 13 | 12 | 2.6 | 07:13 | 19:01 |
| 29/09/2023 | 10 | 8 | 1 | 07:15 | 18:58 |
| 30/09/2023 | 12 | 11 | 3.4 | 07:17 | 18:55 |
| 01/10/2023 | 11 | 10 | 0 | 07:19 | 18:53 |
| 02/10/2023 | 12 | 10 | 1 | 07:21 | 18:50 |
| 03/10/2023 | 13 | 12 | 5.2 | 07:23 | 18:47 |
| 04/10/2023 | 11 | 9 | 12 | 07:25 | 18:45 |
| 05/10/2023 | 15 | 14 | 5 | 07:27 | 18:42 |
| 06/10/2023 | 12 | 11 | 47 | 07:29 | 18:40 |
| 07/10/2023 | 10 | 10 | 25.2 | 07:31 | 18:37 |
| 08/10/2023 | 15 | 15 | 0.6 | 07:33 | 18:35 |
| 09/10/2023 | 15 | 14 | 1.2 | 07:35 | 18:32 |
| 10/10/2023 | 12 | 10 | 2.4 | 07:37 | 18:29 |
| 11/10/2023 | 7 | 3 | 0 | 07:39 | 18:27 |
| 12/10/2023 | 10 | 9 | 0.6 | 07:41 | 18:24 |
| 13/10/2023 | 8 | 4 | 0 | 07:43 | 18:22 |
| 14/10/2023 | 4 | 0 | 0 | 07:45 | 18:19 |
| 15/10/2023 | 4 | 3 | 0 | 07:47 | 18:17 |

| Night start date | Max temperature at midnight (°C) | Min temperature at midnight (°C) | Rainfall (past 24 hrs) | Time of sunrise | Time of sunset |
|---|---|---|---|---|---|
| 16/10/2023 | 1 | -2 | 0.2 | 07:49 | 18:14 |
| 17/10/2023 | 10 | 9 | 0 | 07:51 | 18:12 |
| 18/10/2023 | 12 | 11 | 1 | 07:53 | 18:09 |
| 19/10/2023 | 13 | 11 | 7.4 | 07:55 | 18:07 |
| 20/10/2023 | 7 | 7 | 6.4 | 07:57 | 18:05 |
| 21/10/2023 | 6 | 4 | 0 | 07:59 | 18:02 |
| 22/10/2023 | 0 | -3 | 0.2 | 08:01 | 18:00 |
| 23/10/2023 | 10 | 9 | 0 | 08:03 | 17:57 |
| 24/10/2023 | 3 | -1 | 0 | 08:05 | 17:55 |
| 25/10/2023 | 9 | 8 | 2.8 | 08:08 | 17:53 |
| 26/10/2023 | 10 | 10 | 1.2 | 08:10 | 17:50 |
| 27/10/2023 | 11 | 10 | 0 | 08:12 | 17:48 |
| 28/10/2023 | 11 | 11 | 3.8 | 08:14 | 17:46 |
| 29/10/2023 | 8 | 7 | 18.4 | 07:16 | 16:44 |
| 30/10/2023 | 6 | 4 | 0 | 07:18 | 16:41 |
| 31/10/2023 | 7 | 6 | 10.2 | 07:20 | 16:39 |
| 01/11/2023 | 4 | 0 | 17.4 | 07:22 | 16:37 |
| 02/11/2023 | 9 | 6 | 0 | 07:24 | 16:35 |
| 03/11/2023 | 6 | 5 | 0 | 07:27 | 16:33 |
| 04/11/2023 | 6 | 3 | 0 | 07:29 | 16:31 |
| 05/11/2023 | 4 | 3 | 0 | 07:31 | 16:29 |
| 06/11/2023 | 9 | 7 | 0.8 | 07:33 | 16:27 |
| 07/11/2023 | 7 | 4 | 7.8 | 07:35 | 16:25 |
| 08/11/2023 | 6 | 5 | 2 | 07:37 | 16:23 |
| 09/11/2023 | 0 | -2 | 0 | 07:39 | 16:21 |
| 10/11/2023 | 6 | -1 | 0 | 07:41 | 16:19 |
| 11/11/2023 | -3 | -5 | 0.2 | 07:43 | 16:17 |
| 12/11/2023 | 7 | 5 | 13.8 | 07:46 | 16:15 |
| 13/11/2023 | 7 | 7 | 4.6 | 07:48 | 16:13 |
| 14/11/2023 | 7 | 6 | 8.8 | 07:50 | 16:11 |
| 15/11/2023 | 6 | 5 | 1 | 07:52 | 16:10 |
| 16/11/2023 | 6 | 5 | 2 | 07:54 | 16:08 |
| 17/11/2023 | 6 | 6 | 6 | 07:56 | 16:06 |
| 18/11/2023 | 11 | 11 | 11.4 | 07:58 | 16:05 |
| 19/11/2023 | 11 | 10 | 1 | 08:00 | 16:03 |
| 20/11/2023 | 5 | 1 | 0 | 08:02 | 16:02 |
| 21/11/2023 | 11 | 10 | 2 | 08:04 | 16:00 |
| 22/11/2023 | 13 | 12 | 4.2 | 08:06 | 15:59 |
| 23/11/2023 | 7 | 5 | 0.2 | 08:08 | 15:57 |
| 24/11/2023 | -3 | -5 | 0 | 08:10 | 15:56 |
| 25/11/2023 | -1 | -4 | 0 | 08:11 | 15:55 |
| 26/11/2023 | 4 | 3 | 1.4 | 08:13 | 15:54 |

| Night start date | Max temperature at midnight (°C) | Min temperature at midnight (°C) | Rainfall (past 24 hrs) | Time of sunrise | Time of sunset |
|---|---|---|---|---|---|
| 27/11/2023 | 3 | -2 | 0.2 | 08:15 | 15:53 |
| 28/11/2023 | -2 | -5 | 0 | 08:17 | 15:51 |
| 29/11/2023 | -3 | -5 | 0.2 | 08:19 | 15:50 |
| 30/11/2023 | -4 | -5 | 0 | 08:20 | 15:49 |