Monitoring Irish Woodland Bats: 2023 Pilot

Tina Aughney, David Clarke, Steve Langton, & Niamh Roche

BAT CONSERVATION IRELAND

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1.0 INTRODUCTION

1.1 WOODLAND BATS IN IRELAND

Irish bats are protected under domestic and EU legislation. The EU Habitats Directive (92/43/EEC) lists all Irish bat species in Annex IV and one Irish species, the lesser horseshoe bat (*Rhinolophus hipposideros*), in Annex II. Annex II includes species of community interest whose conservation requires the designation of Special Areas of Conservation (SACs) because they are, for example, endangered, rare, vulnerable or endemic. Annex IV lists various species that require strict protection. Article 11 of the Habitats Directive requires member states to monitor all species listed in the Habitats Directive and Article 17 requires States to report to the EU on the findings of monitoring schemes.

Surveillance and monitoring need to be scientifically rigorous and require well-planned methodologies to achieve statistically defensible results (Battersby, 2010). However, bats are difficult to monitor because they are nocturnal and difficult to identify when flying. In addition, individual species differ in their detectability (using bat detectors) and in their foraging and roosting strategies. Therefore, appropriate methods need to be used for specific species of bat (Battersby, 2010) and the most appropriate method should be chosen based on a general understanding of roosting habitats, foraging behaviour, seasonal movements and the influence of environmental factors on local abundance and distribution (Kunz, 2003; Warren & Witter, 2002). Methods used to determine trends in bat populations can include foot-based bat detector surveys (e.g. BCT, 2012), car-based surveys (e.g. Roche et al., 2011) or roost counts either at summer roosts (Warren & Witter, 2002) or hibernacula (Tuttle, 2003; Van der Meij et al., 2015) and multiple passive surveillance sites using full spectrum detectors (Newson, 2017; Newson et al., 2015).

1.1 WOODLAND BAT MONITORING TRIALS IN IRELAND

1.1.2 Walked Transects 2016-2017

There is currently no standardized monitoring scheme in Ireland to track trends in whiskered bats (*Myotis mystacinus*) or Natterer's bats (*M. nattereri*). A number of studies have been undertaken to determine the feasibility of different approaches, one of which was carried out in 2016 and 2017 using Elekon Batloggers (Boston et al., 2017). This is the same bat detector currently used for the car-based bat monitoring scheme as part of the Irish Bat Monitoring Programme (Aughney et al., 2022b). The Boston et al (2017) study aimed to determine the feasibility of applying a standardised repeatable acoustic survey method (i.e. walking transect coupled with five stationary recording points) to monitor trends in whiskered bats and Natterer's bats in Irish woodlands. This study was, in turn, based on earlier work by Scott and Altringham (Scott & Altringham, 2014) which was among the first detector-based trials in woodland habitats in the UK that aimed to devise methods to monitor populations of the woodland-specialist bat species there.

The data collected by Boston et al. in 2016 and 2017 was used to determine the probability of detection and occupancy of each species in an Irish context and then, through power analysis, calculate the number of woodland sites that would need to be surveyed annually across Ireland to make this a statistically robust monitoring scheme. This occupancy-based approach was compared to a traditional activity-based approach to monitoring trends using the same dataset. Results confirmed that it would be possible to monitor trends of the two target species in Irish woodlands, but that it may be more suitable for whiskered bats than Natterer's bats. 50-60 woodland sites were recommended to be surveyed three times over the summer period in order to achieve robust power to monitor Natterer's bats. This would require a large volunteer force and considerable investment in equipment. At the time, the cost of purchasing the large number of Batlogger M detectors required was considered quite prohibitive hence the scheme did not progress.

1.1.3 AudioMoth Static Detectors 2021

Following Boston's 2016-2017 work, an alternative approach was then examined using the Bat Conservation Trust (BCT) AudioMoth woodland survey methodology (Boughey et al., 2019). The field work for this pilot was carried out in 2021 to determine if the deployment of static AudioMoths, coupled with auto-id by the BCT could provide a more cost-effective means to monitor Irish woodland bat species. The results show that the recordings made by the AudioMoths were not of sufficiently high resolution to allow accurate identification of Natterer's bat and whiskered bat calls. As of 2021/22 the auto-id system was not suitable to distinguish clearly between the different *Myotis* species bat calls recorded in Irish woodlands by AudioMoth detectors (Aughney et al., 2022a).

1.1.4 Testing Detectors and Walked vs Static Surveys 2022

An additional piece of work was also carried out in Autumn 2022. Several full spectrum bat detectors were trialled in walked transects in a woodland to determine which models showed optimum microphone sensitivity combined with cost-effectiveness. This was done because full spectrum detectors have become more widely available and lower in cost since the Boston et al. trials in 2016 and 2017. The primary goal of this autumn study was to determine if a cheaper full spectrum bat detector was comparable to the Batlogger M. The 2022 Autumn Trials demonstrated that the Anabat Scout full spectrum bat detector is on par with, or may even exceed, the sensitivity of the Batlogger M full spectrum bat detector for recording *Myotis* spp. and therefore offers a cheaper but equally sensitive bat detector suitable for a woodland walking transect survey. However, this was based on a small dataset and the survey was undertaken outside the main bat activity survey season and as a result, the level of *Myotis* species activity was low.

The Bat Conservation Ireland Council expressed concerns that introducing a new national monitoring survey that would require volunteers to complete night-time walking transects in woodlands could prove a health and safety issue for insurers and possibly result in volunteer burnout. The Council indicated they would like to trial a passive static unit monitoring programme for the two target woodland bat species. As a result, static units were also deployed during the Autumn Trials, but the data recorded was of limited value as it targeted only one woodland and one survey period that was outside the main bat survey season.

The introduction of a monitoring scheme that deploys static detectors units may be beneficial in that it reduces health & safety risks for volunteers as units can be deployed during the daytime. However, since each minibat costs€1000/unit, the units need to be deployed at height to reduce the possibility of vandalism or theft. This, in turn, means carrying a ladder into a woodland and working at height.

The results of the Autumn Trials demonstrated that the location of the static unit greatly influences the level of bat activity recorded and that a number of static units would need to be deployed for each woodland. Therefore, it would be essential to further explore the parameters required to determine the best location of static units in order to effectively monitor woodlands for the target bat species.

1.1.5 What We Needed to Address in 2023

There is a trade-off between static units and walked transects regarding the chance recording of bat species and "saturation" recording of bat species (Limpens et al., 2016) leading to certain bat species being over estimated or underrepresented. Walking transects means a lower chance of recording bats but less vulnerability to "saturation". Saturation may occur in relation to static units left in-situ because bat echolocation calls recorded are not statistically independent since they may come from the same individual (Lucas et al., 2015). A walking surveyor reduces this possibility.

The 2016/2017 Woodland Pilot Study monitored occupancy of both whiskered and Natterer's bats in Irish woodlands (Boston et al., 2017). An alternative programme using static units would also provide information on occupancy but further work would be required to determine the number of static units needed per woodland, the number of nights of deployment and the temporal deployment of statics during the bat activity season. Law et al. (2015) reported that a minimum of 3 static units deployed for a minimum of 2 nights (>6 nights did not provide any additional data) during the main bat activity season was required to monitor forest bats in Australia and to detect a 30% decline within 10 years with 90% power for target bat species. With statics, there is an opportunity to record a larger dataset over a longer period of time (at least a full night of surveillance) compared to a walking transect which is completed for a maximum of two hours at the start of the night. While this may not increase the value of the data for "occupancy" monitoring, there may be an opportunity to investigate bat activity levels and the temporal use of target woodlands by Natterer's bats and whiskered bats.

As reported by Boston et al. (2017) the estimates of power demonstrated that occupancy modelling is a more efficient method to detect decline in these species than more traditional bat pass estimates in this instance but that occupancy estimates do have limitations. For example, the power calculations assessed the likelihood of detecting a 25% or 50% reduction over 25 years in the proportion of woodlands with bats which doesn't necessarily equate to an equivalent reduction in the population itself. The model reduces quantitative information on numbers of counts to a single presence/absence assessment on each walking transect visit and discards potentially useful information. The theoretical formula used ignores some of the complexities of real data, particularly spatial and temporal variation in occupancy and detectability. It may therefore over-estimate the true power. Furthermore, in the Boston study, since the initial occupancy was close to 1.0, particularly for whiskered bats, the survey methodology will have almost no ability to detect increases in occupancy. This is a major disadvantage of using occupancy modelling to detect trends, when occupancy is high in the survey area or targeted woodlands. As such, the method may be reasonably robust for detecting declines but not population change per se. A larger dataset, as a result of static unit deployment, may provide the data needed to assess potential increases in a population as a result of examining bat activity levels.

There is also a trade-off regarding sonogram analysis of data collected by a short walking transect versus full night data recorded by static units. The advantage of all-night recording is that you have sampled the bat activity for a given night and have a complete record of activity on each sampled night. The disadvantage of recording all night activity is that for full-spectrum direct recordings, this equates to larger memory and storage requirements as well as greater power consumption (Frick, 2013).

In addition, static surveillance does not necessarily include direct and close experience of bats, which may be less attractive to volunteers.

The walking transect protocol has already been tested and is ready to be deployed and rolled out as a monitoring survey, using the cheaper but equally effective Anabat Scout detectors. However, given the range of unknowns surrounding static detector deployment and its usefulness as a monitoring technique, we determined that surveys using static units would need additional pilot survey work during the principal bat activity season and that these should be operated concurrently with the walking transect methodology according to Boston et al. (2017). We also planned to include some minor changes to the methodology to increase the chance of recording Natterer's bats in the Irish landscape. This would allow direct comparisons between the two methodologies (walked vs static) and also determine if there are benefits to be gained by recording a full night of bat activity versus partial night surveys.

In 2023, funding was secured from the National Parks and Wildlife Service (NPWS) and four local authorities (Meath Co. Co., Cavan Co. Co., Kildare Co. Co. and Wicklow Co. Co.) to undertake surveys of 10 woodlands distributed in four counties: Meath, Cavan, Kildare and Wicklow. In order to complete proposed surveys, NPWS Regional Staff and local bat groups were teamed with BCIreland staff.

2.0 METHODS

2.1 WOODLAND SELECTION

Woodlands were selected on the basis of the availability of suitable survey teams along with history of prior involvement in earlier iterations of pilot woodland bat monitoring schemes. The selected woodlands are presented in the Table and Figure below.

Table 2.1: Proposed Woodlands & Survey Teams.

Woodlands	Walking Transects	Static Surveillance
Deerpark Woodland, Virginia, Co. Cavan	Cavan Bat Group	BCIreland Woodland Team
Castle Lake Wood, Bailieboro, Co. Cavan	BCIreland Woodland Team	BCIreland Woodland Team
Killykeen Wood, Co. Cavan	BCIreland Woodland Team	BCIreland Woodland Team
Dun na Rí Forest Park, Kingscourt, Co. Cavan	BCIreland Woodland Team	BCIreland Woodland Team
Littlewood, Slane, Co. Meath	Meath Bat Group	BCIreland Woodland Team
Donadea Forest Park, Clane, Co. Kildare	Kildare Bat Group	BCIreland Woodland Team
Vale of Clara Nature Reserve, Co. Wicklow	Wicklow Woodland Team	Wicklow Woodland Team
Deputy's Pass Nature Reserve, Co. Wicklow	Wicklow Woodland Team	Wicklow Woodland Team
Glendalough, Co. Wicklow	Wicklow Woodland Team	Wicklow Woodland Team
Tomnafinogue Woodland, Co. Wicklow	Wicklow Woodland Team	Wicklow Woodland Team

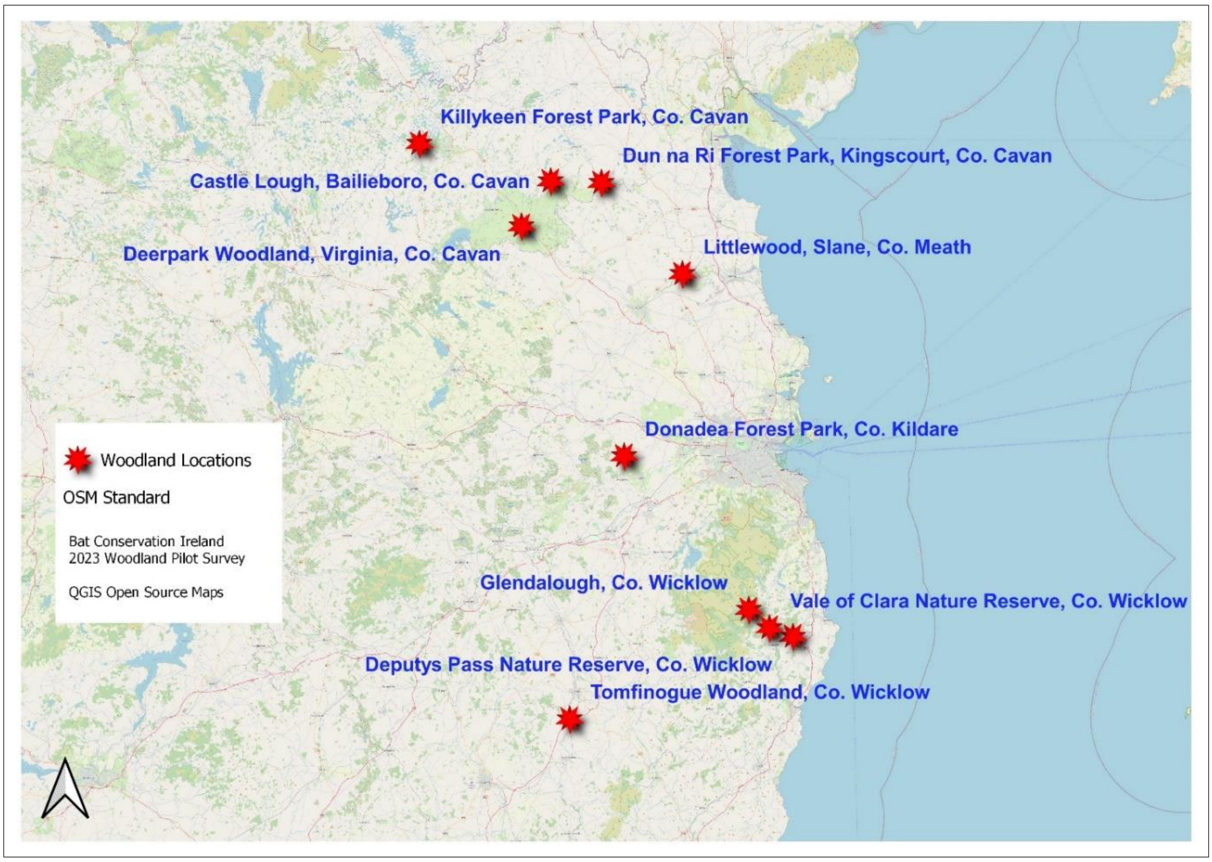

Figure 2.1: Location of woodlands sampled for the 2023 Woodland Pilot.

2.2 SURVEY SET UP

2.2.1 WALKING TRANSECTS

Walking transect routes were designed during the daytime, mapped (GPS) and habitat/management parameters noted. The survey co-ordinator designed the walking transect route (approx. 4 km) and selected the five stopping points for each woodland. Stopping points aimed to sample different habitat types present within the woodland or adjacent to the woodland (e.g. agricultural fields). At least one stopping point was located along the interface between agricultural or grassland landscape and woodland edge to increase the likelihood of detecting Natterer's bats.

The survey co-ordinator fixed a circular reflective marker on a point at eye level or as close as possible to eye level to indicate each starting and stopping point. These proved extremely useful to surveyors when walking at night under the woodland canopy.

Each route was located along accessible tracks but not always the main trails in order to include more cluttered zones.

2.2.2 STATIC SURVEILLANCE

Locations for static detectors were selected during the daytime, mapped (GPS) and habitat/ management parameters noted. Static detector locations were the same as the five stopping points for the walked transects. Static surveillance points were selected to sample different habitat types present within the woodland or adjacent to the woodland (e.g. agricultural fields). At least one static surveillance point was located at the interface between agricultural landscape and woodland edge.

The circular reflective markers that enabled surveyors locate the walking transect stopping points were also used to indicate locations for static detector deployment, so that the same location would be reused in subsequent surveys.

2.3 TRAINING

A training course was carried out for NPWS Regional Staff and Local Authority Biodiversity Officers on 31st May 2023. This was held in the NPWS Offices in Trooperstown, Kilafin, Co. Wicklow. Training included correct use of the detectors and a field-based discussion of the method for both walked and static surveys.

2.4 SURVEY METHODOLOGY

2.4.1 WALKING TRANSECTS

The methodology for walking transects was similar to that presented in Boston *et al.* (2017) with some slight modifications. Anabat Scout full spectrum bat detectors were used instead of Batlogger M detectors.

1. Surveys commenced 40 minutes after sunset

2. Surveys were carried out in ‘good weather’ where temperature at the start of the survey was >10°C, wind <20km/h and no rain. Weather conditions were recorded at the start of the survey.
3. Three transects were completed, one each during the months of June, July and August
4. Surveyors commenced at the designated starting point with their detectors switched on, walked to the first stopping point at a slow walking pace of approximately 3.4km/hr
5. Time was noted when each stationary position was reached. At the stopping point, surveyors recorded for 5 minutes while rotating the detector around to face in different directions
6. The surveyors then resumed walking to the next stopping point and so on until the transect was completed
7. Each walking transect took approximately 1.5hrs to complete
8. Following the completion of the surveys, data was downloaded from Anabat Scout SD cards and shared with the survey coordinator via a cloud sharing platform, or the survey coordinator physically collected the data from surveyors (in the case of NPWS staff 3rd party cloud sharing facilities are not available).

2.4.2 Methodology – Static Surveillance

1. Surveillance was completed using a Wildlife Acoustics Mini Bat full spectrum bat detector.
2. Five of these detectors were deployed per woodland
3. The detectors were located along the mapped walking transect with the five locations representing different habitat types.
4. Surveillance was set up for a minimum of five nights and coincided the walking transect
5. The statics units were set to record from sunset to sunrise.
6. Static surveillance was completed for three periods during each of the summer months of June, July and August.
7. Following the completion of the surveys, data was downloaded from Minibat SD cards to a dedicated hard drive by the survey coordinator. No attempt was made to use cloud sharing platforms due to the large number and size of datafiles.

2.5 DATA ANALYSIS METHODOLOGY

2.5.1 Walking Transects

Analysis was undertaken using Kaleidoscope Pro. Auto-identification was used to reduce time required for analysis. However, to ensure accuracy, the following steps were then taken manually:

- All SPECIES IDENTIFIED files for *Myoti*s species and *Plecotus* species were manually confirmed.
- All UNIDENTIFIED audio files were manually checked.

- All NOISE audio files were manually checked.
- Quick manual checking of all other bat species, to check if there were Myotis calls present that could be reassigned.

2.5.2 Static Surveillance

Due to the much greater number of audio files recorded by static surveillance, it was not possible to manually analyse the data to the same level as the walking transects. Following auto-analysis using Kaleidoscope Pro the following steps were taken manually:

- All SPECIES IDENTIFIED files for *Myotis* species (i.e. identified to species level for the three *Myotis* species) were accepted.
- All files AutoID as *Plecotus* were manually checked.
- All UNIDENTIFIED audio files were manually checked.
- Depending on the number of NOISE audio files, a selection was manually checked for *Myotis* and *Plecotus* audio files.
- Only occasional manual checking of all other bat species was undertaken. The degree of checking depended on the amount of audio files within the folder.

2.6 CALLS LIBRARY

Known roosts (or foraging areas) for all of Ireland's bat species were visited during the summer months in 2023 and calls of emerging bats were recorded using three full spectrum bat detectors: Anabat Scout, Anabat Walkabout and Wildlife Acoustics MiniBat. These calls will be used by Chris Scott to update the bat auto-identification software BatClassifyIreland.

The development of BatClassifyIreland will allow BCIreland to provide an Irish auto-id software free to any potential user that collects full spectrum bat audio files. This is important as it has been shown that there are regional differences in the echolocation calls of bat species (i.e. regional accents) which can make European bat analysis software less suitable for individual countries. Therefore, BCIreland has partnered with the original IT coder that designed BatClassifyIreland in 2016 to update the opensource code to provide a more robust and user-friendly programme. In order to do this, the AI will require further training with library calls from established bat roosts for all nine bat species resident in Ireland.

3. RESULTS

3.1 SURVEY COMPLETION

3.1.1 Walking Transects

Twenty nine walking transects were successfully completed in all 10 woodlands. Analysis of these recordings were undertaken using Wildlife Acoustics Kaleidoscope Pro software.

Table 3.1: Walking transect survey dates in 2023.

Woodlands	June	July	August
Deerpark Woodland, Virginia, Co. Cavan	3/6/2023	19/7/2023	15/8/2023
Castle Lough Wood, Bailieboro, Co. Cavan	3/6/2023	3/7/2023	19/8/2023
Killykeen Forest Park, Co. Cavan	10/6/2023	1/7/2023	15/8/2023
Dun na Ri Forest Park, Kingscourt, Co. Cavan	15/6/2023	20/7/2023	7/8/2023
Littlewood, Slane, Co. Meath	9/6/2023	20/7/2023	8/8/2023
Donadea Forest Park, Clane, Co. Kildare	15/6/2023	5/7/2023	21/8/2023
Vale of Clara Nature Reserve, Co. Wicklow	5/6/2023	12/7/2023	Unit failed to record
Deputy's Pass Nature Reserve, Co. Wicklow	13/6/2023	25/7/2023	29/8/2023
Glendalough, Co. Wicklow	8/6/2023	20/7/2023	15/8/2023
Tomfinogue Woodland, Co. Wicklow	8/6/2023	24/7/2023	22/8/2023

3.1.2 Static Surveillance

Five static detectors were set to record for at least five nights for each woodland during the three static surveillance periods. Due to poor weather conditions in July and August, walking transects were delayed for some woodlands which meant the recording was extended to include surveillance on the night of the walking transect. However, occasionally this resulted in some static units losing battery power by the time the walking transect was undertaken. Therefore, there are some missing nights of static surveillance. A total of 1,484 nights of surveillance was completed for the 10 woodlands. Analysis of these recordings was undertaken using Wildlife Acoustics Kaleidoscope Pro software.

Table 3.2: Static surveillance dates completed in 2023.

Woodlands	June	July	August
Deerpark Woodland, Virginia, Co. Cavan	3^{rd} to 8^{th} June 2023	16^{th} to 21^{st} July 2023	11^{th} to 20^{th} August 2023
Total number of nights of surveillance (5 statics)	25 nights	25 nights	19 nights
Castle Lough Wood, Bailieboro, Co. Cavan	3^{rd} to 8^{th} June 2023	3^{rd} to 8^{th} July 2023	19^{th} to 24^{th} August 2023
Total number of nights of surveillance (5 statics)	25 nights	20 nights	24 nights
Killykeen Forest Park, Co. Cavan	10^{th} to 15^{th} June 2023	1^{st} to 6^{th} July 2023	15^{th} to 20^{th} August 2023
Total number of nights of surveillance (5 statics)	25 nights	25 nights	24 nights
Dun na Ri Forest Park, Kingscourt, Co. Cavan	15^{th} to 20^{th} June 2023	17^{th} to 22^{nd} July 2023	7^{th} to 12^{th} August 2023
Total number of nights of surveillance (5 statics)	25 nights	24 nights	24 nights
Littlewood, Slane, Co. Meath	5^{th} to 10^{th} June 2023	17^{th} to 22^{nd} July 2023	7^{th} to 12^{th} August 2023
Total number of nights of surveillance (5 statics)	25 nights	25 nights	25 nights
Donadea Forest Park, Clane, Co. Kildare	11^{th} to 16^{th} June 2023	3^{rd} to 8^{th} July 2023	20^{th} to 25^{th} August 2023
Total number of nights of surveillance (5 statics)	25 nights	25 nights	25 nights
Vale of Clara Nature Reserve, Co. Wicklow	2^{nd} to 7^{th} June 2023	6^{th} to 11^{th} July 2023	4^{th} to 9^{th} August 2023
Total number of nights of surveillance (5 statics)	25 nights	25 nights	25 nights
Deputy's Pass Nature Reserve, Co. Wicklow	3^{rd} to 8^{th} July 2023	23^{rd} to 28^{th} July 2023	16^{th} to 21^{st} August 2023
Total number of nights of surveillance (5 statics)	25 nights	25 nights	24 nights
Glendalough, Co. Wicklow	4^{th} to 9^{th} June 2023	16^{th} to 21^{st} July 2023	11^{th} to 20^{th} August 2023
Total number of nights of surveillance (5 statics)	25 nights	25 nights	25 nights
Tomfinogue Woodland, Co. Wicklow	8^{th} to 13^{th} June 2023	20^{th} to 25^{th} July 2023	22^{nd} to 27^{th} August 2023
Total number of nights of surveillance (5 statics)	25 nights	25 nights	25 nights

3.1.3 CALLS LIBRARY

Data was collected for all nine bat species from 26 locations across the island (24 survey nights). A greater number of survey nights were undertaken than planned to ensure that an appropriate number of audio files were collected for this study (i.e. a minimum of 2 roosts/species), see Figure 3.1 for locations. Additional recordings were also collected during routine Irish Bat Monitoring Programme roost surveys (e.g. Brown long-eared bat roost surveys).

Figure 3.1: Locations bat roosts with known species visited to record bat calls in summer 2023

All of these audio recordings were saved on to a hard drive and posted to Chris Scott to upgrade BatClassifyIreland. This graph shows the number of roosts/locations that data for each principal species was recorded from (i.e. the main species to be recorded at specific locations sampled). The majority of sites located were roosts, apart from one foraging location for Nathusius' pipistrelles (Killeshandra Town Lake, Co. Cavan), one for Leisler's bats (Pheonix Park, Co. Dublin) and three for Daubenton's bat (River Sullane, Co. Cork; Killeshandra Town Lough, Co. Cavan and River Dodder, Co. Dublin). Some of the roosts surveyed contained multiple species. Additional species were recorded commuting through the survey area during surveillance period, these are not included in the graph, Figure 3.2, below.

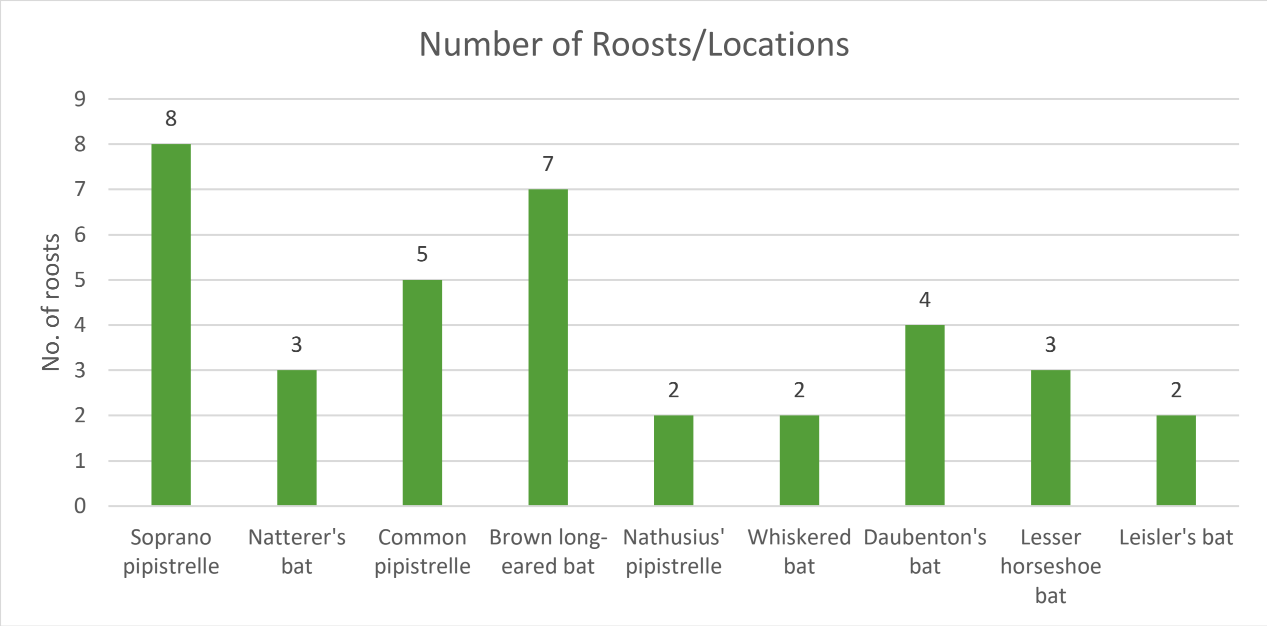

Figure 3.2: Number of roosts / locations surveyed for targeted bat species audio recordings.

3.2 STATISTICAL ANALYSIS

3.2.1 SUMMARY STATISTICS

Table 3.3 shows means for each species. For the static detectors the average number of audio files with the species present for one detector on one night is shown, but also the average total number for all five detectors over five nights. For the walked transects the mean number of audio files per transect and also the mean number of passes are shown.

Table 3.3: Summary statistics by species and month

a) Static detectors

	Mean per detector per night					**Means for 5 nights and 5 detectors**				
	daub	**natt**	**whisk**	**myotis**	**BLE**	**daub**	**natt**	**whisk**	**myotis**	**BLE**
Month										
June	10.00	1.08	6.58	1.78	3.14	250.1	27.0	164.4	44.4	78.4
July	6.75	1.23	4.60	2.08	2.35	168.6	30.8	115.0	52.0	58.7
Aug	8.01	1.31	4.67	1.89	4.16	200.3	32.8	116.7	47.2	104.1
All months	8.25	1.21	5.28	1.91	3.22	206.3	30.2	132.0	47.9	80.4

b) Walking transects

	Mean n audio files per transect					Mean n passes per transect				
	daub	**natt**	**whisk**	**myotis**	**BLE**	**daub**	**natt**	**whisk**	**myotis**	**BLE**
Month										
June	2.60	1.50	3.00	2.90	2.70	3.90	2.20	5.10	3.80	3.50
July	2.90	3.70	5.30	3.40	1.90	4.10	6.90	10.50	4.20	2.50
Aug	1.33	2.00	2.44	1.78	2.44	1.89	2.78	4.44	2.44	3.00
All months	2.31	2.41	3.62	2.72	2.34	3.34	4.00	6.76	3.52	3.00

As may be expected, the total numbers of audio files with bat presence is much higher using the static detectors (right hand side of Table 3.3a), than in the transects (left hand side of Table 3.3b). This is not surprising given that each walking transect will give perhaps 1-2 hours of recording, compared to maybe 200 hours from five detectors left for five nights.

However, it is worth noting that the ratio between the two varies considerably between species; in rough terms, at one extreme the static detectors give around 100 times the number of positive audio files as the walked transects for Daubenton's, whereas, at the other extreme, the differential for Natterer's averages around 12 times. Curiously there are also signs of a monthly difference for Daubenton's, Natterer's and whiskered, with July being higher than June or August in the walked transects, but not in the static data; this may just be a chance difference but may be worth rechecking in 2024.

Figure 3.3 shows the correlation in the walked transects between the number of audio files with a species present, and the number of passes for the two target species. The correlation is high; it is at least 0.97 for all five species or species groups. In view of this it probably does not matter much which variable is used in the analyses; while the number of passes is numerically greater, this is likely to be counteracted by its greater overdispersion relative to Poisson. The number of files with species present is easier to determine and this may help speed up analysis in the future.

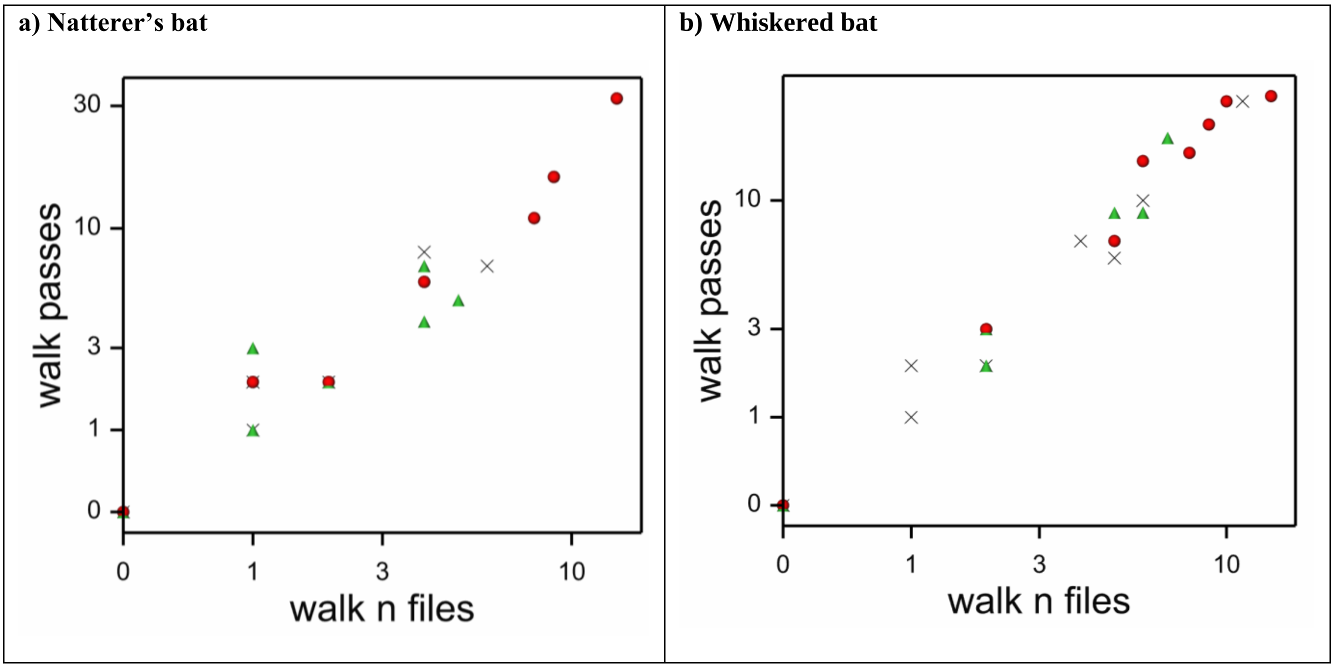

Figure 3.3. Correlations between numbers of audio files with a species and the number of passes. Each point represents one survey, crosses are June, circles July, triangles August

3.2.2 Spatial and temporal correlations between static detectors

Patterns in time and space among the static detectors are of interest because they can inform decisions on future design. Fitting a variance component model to the log-transformed number of files with bats present reveals that for all species/groups the variance between the five sampling spots is always substantially higher than the variance between the five nights of sampling.

Figure 3.4 shows temporal correlations for Whiskered and Natterer's bats. The whiskered results are more typical, with a strong correlation, averaging around 0.7, between counts 1-4 days apart, falling to around 0.35 for counts two months apart. Correlations are lower for Natterer's (lower than any of the other species) but are still around 0.4 for counts in the same five day period.

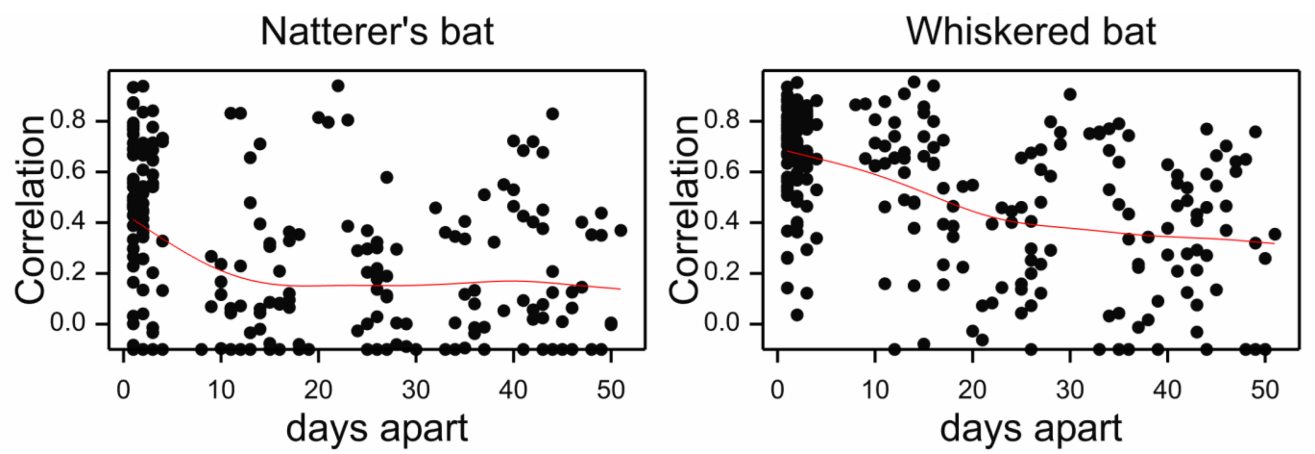

Figure 3.4: Temporal correlations in the static bat dataset (numbers of files with bats). The red line is a smoothed curve to show the trend with time.

By contrast Figure 3.5 shows the pattern of temporal correlations within sites, or rather the lack of pattern; correlations are much lower, regardless of the distance between detectors.

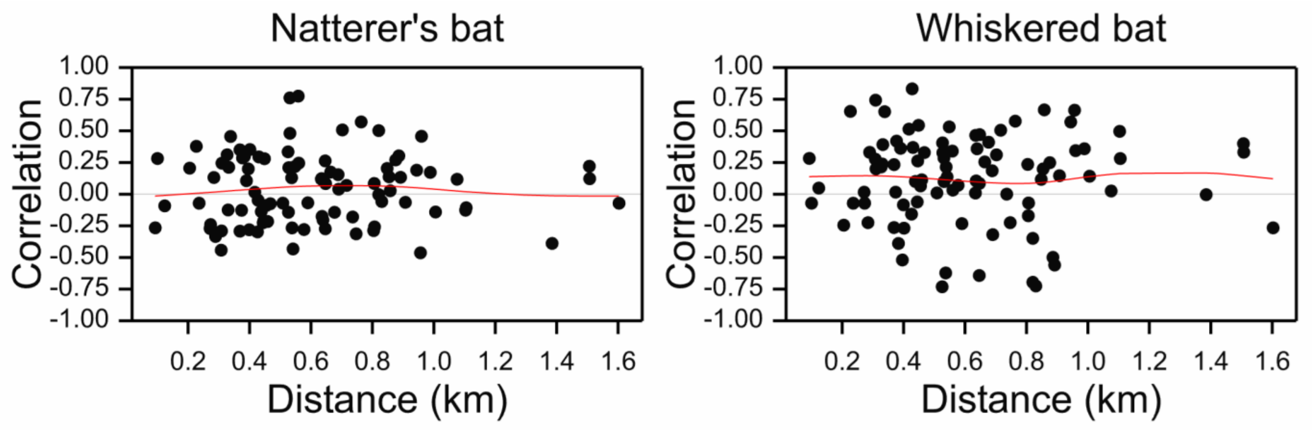

Figure 3.5: Spatial correlations in the static bat dataset (numbers of files with bats). The red line is a smoothed curve to show the trend with distance apart.

These results suggest that the most effective way to sample a woodland is to use more sampling points and fewer nights; for example, five detectors left out for three nights, should produce more information than three detectors left out for five nights. If the cost of detectors is an issue, there could be a case for moving them within the wood; perhaps changing location after two days.

3.2.3 Power analyses

The power analyses described below use a simulation approach, broadly based on that used to estimate the power of car-based monitoring in Ireland (Roche et al., 2011) and NBMP surveys in Great Britain (Barlow et al., 2015). This involves calculating the variance of the (transformed) data, then using these variances to produce a large number of simulated datasets with a variety of levels of change over a 25 year period (in this case red and amber alert levels). A Poisson GAM model is then fitted to each dataset using the method described by Fewster et al. (2000), changing the number of sites and years considered in order to determine the numbers required to detect change with 80% power.

A complication of this project is that we do not have an estimate of the year x site random variance; i.e. the degree to which there is random variation between sites in the annual pattern of change. The site.year variability is therefore estimated as being equal to half the site.month variability in the data; this value seems reasonable based on other studies in Ireland and Great Britain. Note that in the 2017 analysis, different criterion was used, based on a proportion of the site variance, but given that the site.month variance has a temporal component, this approximation seemed more sensible for the current dataset.

Results are shown as the number of years to achieve 80% power for red and amber alert declines (50% or 25% decline over 25 years) for walked transects in Table 3.4 and for static detectors in Table 3.5. Both tables refer to the designs used in the 2023 data; i.e. one transect walked in each of three months for the walked transects, and five detectors for five nights in each of three months for the static detectors.

Comparing the tables, it can be seen that, with the effort used in 2023, fewer sites are needed to achieve the same level of power using the static detectors, particularly for Natterer's. As always with power analyses, results should be treated with caution, as they will depend critically on the assumptions made, particularly in this case the assumption about the site.year variation. They are best regarded as a general indication of whether a particular design has a realistic chance of detecting trends of biological importance.

Table 3.4: Number of years taken for walked transects to detect change with 80% power using various numbers of sites. 'Amber' refers to a decline of 1.41% p.a. (25% over 25 years), 'red' to 2.73% p.a. (50% over 25 years). Three replicate surveys per site per year.

Species	**Natterer's bat**		**Whiskered bat**	
Change	**amber**	**red**	**amber**	**red**
Nsites				
10	>25	>25	>25	23
20	>25	18	>25	15
50	>25	13	22	11
75	24	12	17	9
100	20	11	15	8

Table 3.5: Number of years taken for static detectors to detect change with 80% power using various numbers of sites. 'Amber' refers to a decline of 1.41% p.a. (25% over 25 years), 'red' to 2.73% p.a. (50% over 25 years). Three replicate surveys with five detectors for five nights per site per year.

species	**Natterer's bat**		**Whiskered bat**	
change	**amber**	**red**	**amber**	**red**
nsites				
10	>25	18	>25	20
20	>25	14	>25	14
50	18	9	18	10
75	15	9	15	9
100	14	8	14	8

In order to determine the minimum number of nights that the static detectors would need to be put out we used an approach of exploring the impact on the residual variance of reducing the number of nights. Results vary between species and there is a lot of uncertainty (estimating variances is always tricky with a relatively small dataset), but the best estimate is that reducing to two nights might increase the variance by 35%. Rerunning the power simulations with Natterer's produces the following results (existing results shown on left for comparison).

species	**Natterer's bat 5 nights**		**Natterer's bat 2 nights**	
change	**amber**	**red**	**Amber**	**red**
nsites				
10	>25	18	>25	25
20	>25	14	>25	16
50	18	9	24	11
75	15	9	21	10
100	14	8	17	10

Reducing the number of nights does take quite a bit longer to reach 80% power, which must be weighed against the 60% saving in data processing costs.

We also examined whether we would need to put out the statics for all three surveillance periods or, whether just two surveillance periods would suffice. Repeating a couple of power simulations with just two months for Natterer's it would take around 10% longer to detect a decline, for Whiskered nearer to 20%. So there is a penalty to reducing to two months, but this could be offset by doing more sites.

The results above suggest that both methods are viable. Comparing five nights with five detectors with the walked transects, the statics perform slightly better in terms of time taken to achieve 80% power, but if we reduced to five detectors and two nights the walked transects are probably slightly better; i.e. which is better depends on the numbers of detectors and nights used. This means that considerations of practical mobilisation and costs are important factors in deciding which method we will proceed with.

3.2.4 Costs

This costing assumes that we will eventually include 60 sites with the walking transects or 50 sites with the static detectors. This will be the number of sites targeted to be surveyed annually across Ireland and Northern Ireland (combined) once the scheme is fully underway. These are the numbers of sites using either methodology that are required to achieve roughly comparable levels of statistical power.

Other costs associated with the project such as management and administration, training of volunteers, statistical analysis ***are not included*** in this breakdown. This costing is simply to compare the relevant financial differences between walked and static surveys.

In addition, another factor to consider is the input required from volunteers. This would be greatest for Option 3 (three statics + moving locations) since they would need to visit the site nine times per season (for each survey - once to place detectors, second to move them and third to collect), volunteers would need to visit and walk the woods six times for Option 2 (five statics not moved, one visit to place statics and return visit to collect for each survey period) and three times (albeit at night) for Option 1 (walking transects).

Option 1 – Walking Transects

This method consists of carrying out one walking transect per site, repeated three times at each site (i.e. one transect walked at each site during the months of June, July and August respectively).

CAPITAL COSTS **Equipment**	**Cost per unit**	**No. of units/site**	**No. of sites**	**Total cost**
Anabat Scout + 32GB SD card	€1,141.48	1	60	€1,141.48 x 60 = **€68,488.80**
Value of Anabat Scout units already owned by BCI (7 units)				**€7,990.36**
Total equip cost (53 units)				**€60,498.44**

ANNUAL DATA ANALYSIS COSTS **Data processing**	**Cost per hr**	**Mean no. of processing hrs/site**	**No. of sites**	**Total cost**
Time processing data (Kaleidoscope Pro + manual verification)	€33	2.5	60	€33 x 2.5 x 60 =
Data processing cost/year (150 hrs)				**€4,950.00**

Option 2 – Static Detectors (5 units per site)

This method consists of placing five static detectors at each site for a period of five days, with this method repeated three times at each site (i.e. one survey carried out at each site during the months of June, July and August respectively).

CAPITAL COSTS **Equipment**	**Cost per unit**	**No. of units/site**	**No. of sites**	**Total cost**
Song Meter Mini Bat 2 AA + 32GB SD card + Batteries	€904.62	5	50	€904.62 x 5 x 50 = **€226,155.00**
Value of Mini Bat units already owned by BCI (26 units)				**€23,520.12**
Total equip cost (224 units)				**€202,634.88**

ANNUAL DATA ANALYSIS COSTS **Data processing**	**Cost per hr**	**Mean no. of processing hrs/site**	**No. of sites**	**Total Cost**
Time processing data (Kaleidoscope Pro)	€33	13	50	€33 x 13 x 50 =
Data processing cost/year (650 hrs)				**€21,450.00**

Option 3 – Static Detectors (3 units per site)

This method consists of placing three static detectors at each site for a period of 2-3 days, then moving the same detectors to different locations for another 2-3 days. The method is repeated three times at each site (i.e. one survey carried out at each site during the months of June, July and August respectively).

CAPITAL COSTS **Equipment**	**Cost per unit**	**No. of units/site**	**No. of sites**	**Total cost**
Song Meter Mini Bat 2 AA + 32GB SD card + Batteries	€904.62	3	50	€904.62 x 3 x 50 = **€135,693.00**
Value of Mini Bat units already owned by BCI (26 units)				**€23,520.12**
Total equip cost (124 units)				**€112,172.88**
ANNUAL DATA ANALYSIS COSTS **Data processing**	**Cost per hr**	**Mean no. of processing hrs/site**	**No. of sites**	**Total Cost**
Time processing data (Kaleidoscope Pro)	€33	13	50	€33 x 13 x 50 =
Data processing cost/year (650 hrs)				**€21,450.00**

4. DISCUSSION

Considering there are only nine resident species of bats in Ireland, Natterer's bats and Whiskered bats comprise an important portion of the Irish bat fauna. These two species tend to rely on woodland habitat for roosting and foraging opportunities (Smith & Racey, 2008), with brown long-eared bats also being strongly associated with woodlands (e.g. Swift, 1998; Murphy et al., 2012). Woodland is estimated to cover just 11.6% of in the RoI (Forest Statistics Ireland, 2023) and approximately 8.7% in Northern Ireland (Northern Ireland Woodland Register and Basemap, 2020). With much of this consisting of non-native production forestry, it is likely that optimal habitat for these species in Ireland is limited. It is therefore imperative that we begin to better understand the conservation status of these species in woodland habitats in Ireland so that they can be managed effectively.

As with all other Irish bat species, Natterer's bat and Whiskered bats are protected under domestic and EU legislation and are required to be monitored in Ireland under Article 11 of the Habitats Directive. Outcomes of protected species monitoring schemes are reported to the EU under Article 17 of the Directive on a six yearly cycle. While whiskered and Natterer's bats have not yet had a dedicated monitoring scheme rolled out in Ireland as yet, given the body of work done to date on exploring the different survey options in Ireland in recent years (Aughney et al., 2022a; Boston et al., 2017), there is now enough information available to help inform the best way forward in terms of creating a viable all-Ireland monitoring scheme for these woodland bat species.

4.1.1 Methods Comparison

Based on the evidence provided in this report, we feel that using walking transects is the most viable option to use for a new All-Ireland woodland bat monitoring scheme. There are several reasons for this. Firstly, the power analysis carried out on 2023 data showed that fewer sites are needed to achieve 80% power in detecting amber and red alert declines using static detectors compared to walking transects. However, the number of additional walking transect sites required to detect similar levels of decline for the species over time is not substantial. There are only small differences in the number of survey years needed to detect amber and red alert declines for Whiskered bats between the two methods, while for Natterer's bat, the main differences in the numbers of sites only apply to the amber alert levels for Natterer's bat; the red alert detection levels are very similar between the methods. Estimating variances is always tricky when comparing methods and the numbers of sites needed when dealing with relatively small sample sizes. However, going by the power analysis results, a target of 60 sites across Ireland using the walking transect method would yield comparable trend detection levels to that using 50 sites with static detectors.

Other factors that we considered carefully when selecting a method included data analysis time involved, equipment costs, the feasibility of detector deployment and management of equipment, and volunteer time. Although the static detectors collected substantially more data than that gathered via walking transects, the analysis of the data from the static detectors took, on average, 13 hours for each site over the duration of the summer sampling, compared to 2.5 hours for the walking transects. This is a five-fold increase on the amount of time required to process data from static detectors compared to walking transects. On the basis of the similarities between the statistical power of each method in detecting species declines, we feel the walking transect method is well justified in terms of time efficiency. It is possible, in the future, that automated analysis could negate much of the time needed to process data, however the capital costs of the static monitoring are also still much higher.

The cost for purchasing the number of Anabat Scout devices needed for walking transects to cover 60 sites across Ireland is far lower than the number required for using the static detector approach (five detectors needed at each site). Therefore, we deem that the cost of purchasing the required number of static detectors to justify using this approach is inhibitory. As well as the initial capital cost, there would also be issues around the effective management and safe inventory of 250 devices that cost a considerable amount of money. Inevitably, there will always be unforeseen costs maintaining equipment such as this (e.g. repair costs and periodic servicing). Therefore, it will be far more effective for BCIreland to manage and maintain 60 Anabat Scout devices used for the walking transects.

Lastly, we will be relying on volunteers to carry out these surveys. We greatly appreciate and value the time that volunteers invest in schemes such as this one, as it would not be possible to achieve the desired outcomes without them. There have been concerns raised about the demands being placed on volunteers with regard to adopting another volunteer-based bat monitoring scheme, as well as health and safety considerations when conducting surveys at night. We acknowledge the fact that this scheme would ask more of volunteers in terms of participation in BCIreland schemes. However, the level of volunteer time required using the walking transect method is far less than that needed using the static detectors (three visits to each site for walked transects versus six visits to each site for static deployment/collection – see section 3.2.4 for more details). The amount of volunteer time using this method is similar to that required for some of the other BCIreland monitoring schemes (Aughney et al., 2022b). Moreover, we hope that a large portion of the surveys in each county will be undertaken by staff from local authorities or state bodies e.g. NPWS, County Councils, and Coillte. Therefore, this scheme presents a unique opportunity to involve and upskill staff from these authorities in bat survey methods, as well as recruiting interested members of the public or various regional bat groups.

4.1.2 Survey Rollout 2024

In the 2023 pilot, a total of ten woodland sites were surveyed across counties Cavan, Kildare, Meath and Wicklow. Based on the results from that pilot study we now plan adapt the walking transect protocol as the survey methodology of choice. In 2024, we plan to re-survey all of the sites from 2023, using walking transects carried out three times in the summer, once in each month of June, July and August. In addition, we plan to adopt new sites for inclusion in the scheme in other counties in both the Republic of Ireland and Northern Ireland. Counties that will be included in the ROI in 2024 are Longford, Sligo and Monaghan (two sites in each county) while a second site will also be added in Co. Kildare. We also plan to add up to 10 sites located in Northern Ireland to the scheme in 2024, though the locations of these are yet to be decided. The inclusion of new sites and counties will be progressed each survey year, with the aim of establishing 60 survey sites in the scheme by 2028.

In keeping with the criteria of woodlands included in the 2023 pilot, adopted woodlands will ideally contain a walking route of approximately 4km in length, with five suitable stopping points along the routes. Where possible, stopping points will represent different habitat types within the woodland or adjacent to the woodland (e.g. agricultural fields). Similarly, at least one stopping point will be positioned along the interface between agricultural or grassland landscape and woodland edge to increase the likelihood of detecting Natterer’s bats.

We will work to identify and recruit new survey teams as well as develop appropriate training materials for the scheme surveyors. We will also explore opportunities to engage with Coillte and the Forest Service in the Republic of Ireland, and the Forest Service in Northern Ireland.

Work will also continue on the development of BatClassifyIreland in 2024. High quality reference files for each recorded species are currently being isolated so that these can be used in the development of the model. Once completed, this will equip Chris with the necessary data needed to refine the model to create the auto-ID software for Irish bats.

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APPENDIX 1: DETAILED SITE INFORMATION

A1.1 Littlewood, Slane, Co. Meath

This transect starts and ends in the car park of the woodland. There is limited accessible walking tracks and as a consequence there are two small overlapping sections (e.g. in and out to Stopping Point 2).

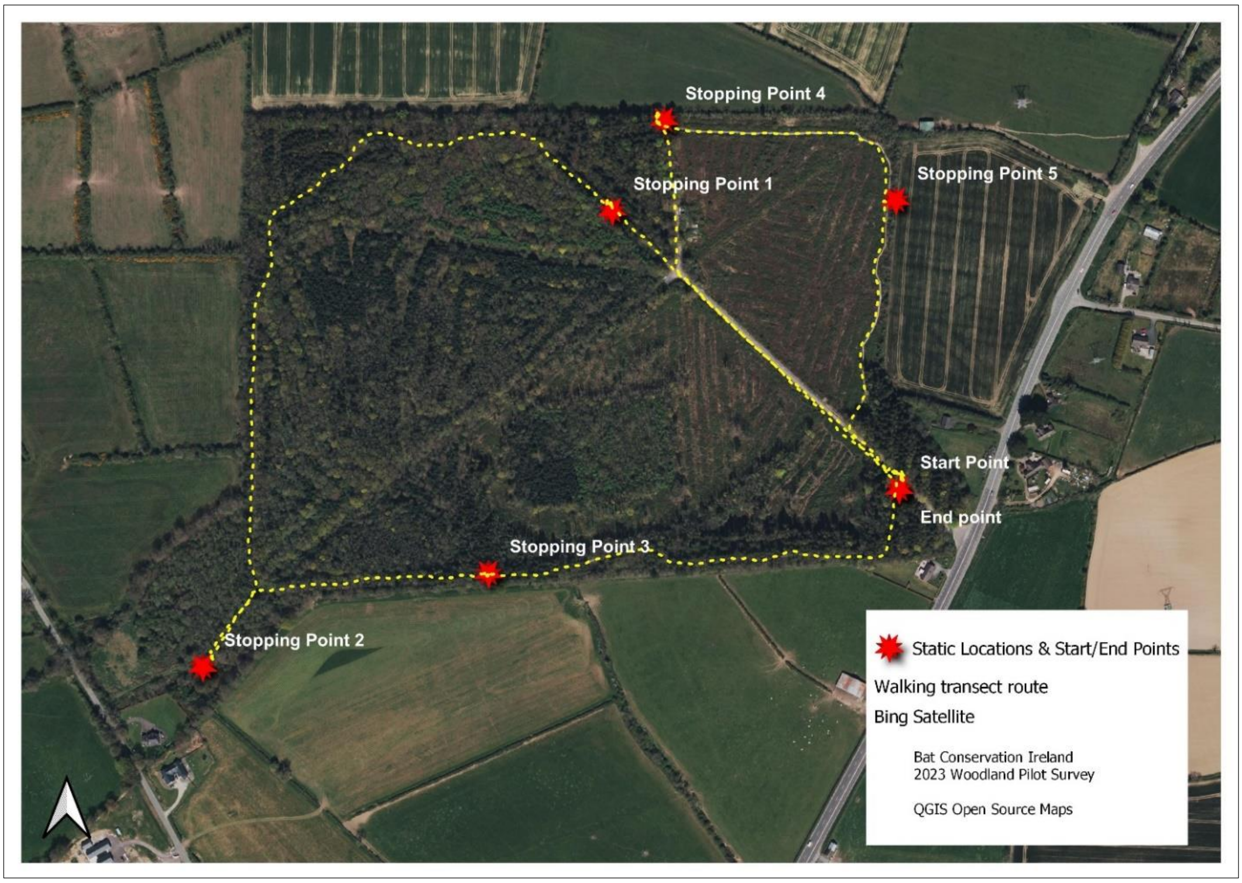

Figure A.2: Littlewood, Slane, Co. Meath – walking transect route and stopping point locations

Table A.1: Littlewood, Slane, Co. Meath – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	697301	775730
Stopping Point 1	697025	775998
Stopping Point 2	696631	775559
Stopping Point 3	696906	775649
Stopping Point 4	697075	776085
Stopping Point 5	697298	776008
End point	697301	775730

A1.2 Donadea, Clane, Co. Kildare

Donadea Woodland is a large Coillte woodland with numerous tracks to choose from. However, there is no direct access to agricultural land in order to represent 20% of this landscape type.

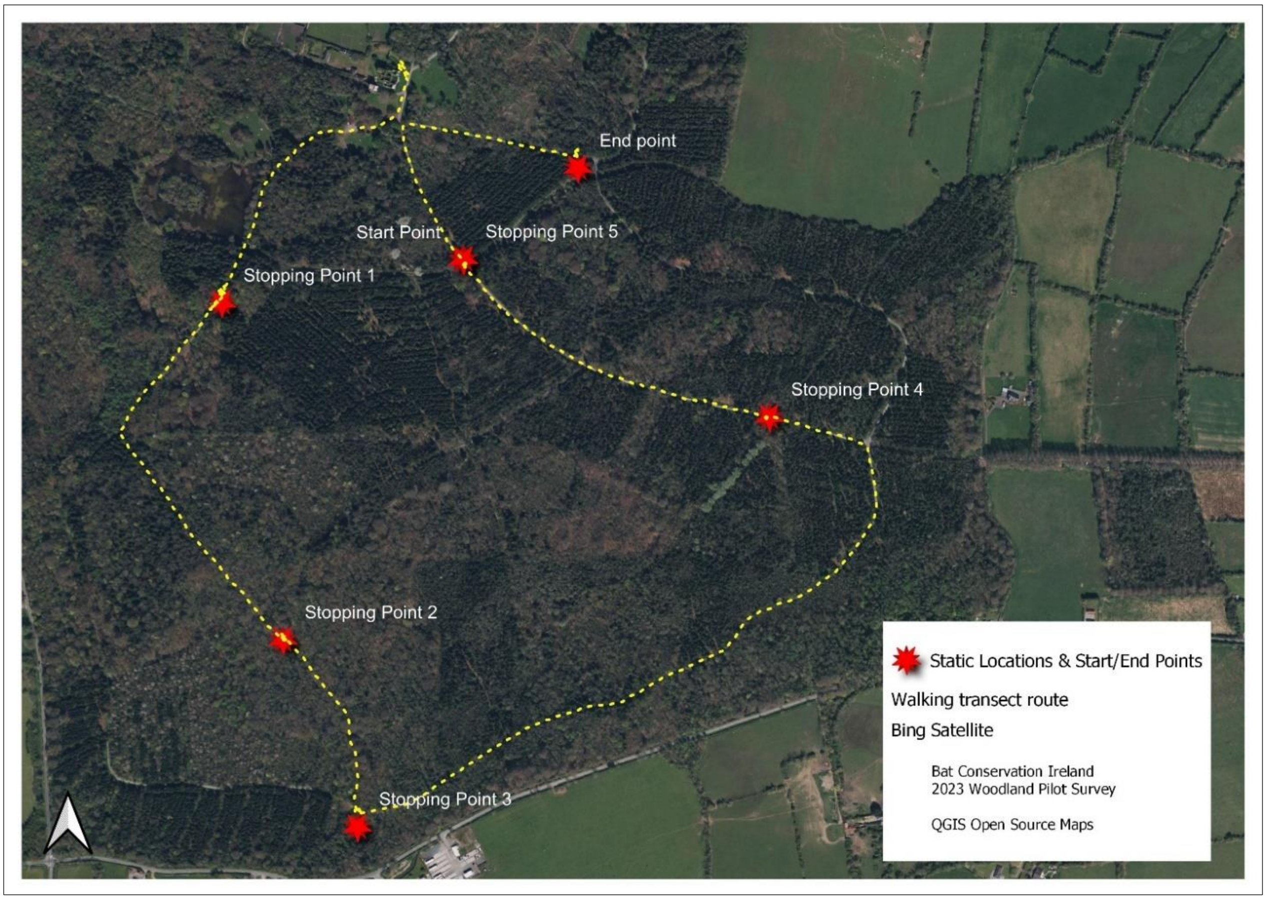

Figure A.2: Donadea Woodland, Clane, Co. Kildare – walking transect route and stopping point locations

Table A.2: Donadea Woodland, Clane, Co. Kildare – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	683562	732752
Stopping Point 1	683193	732686
Stopping Point 2	683287	732169
Stopping Point 3	683401	731882
Stopping Point 4	659730	787310
Stopping Point 5	683564	732753
End point	683739	732893

A1.3 GLENDALOUGH, CO. WICKLOW

The walking route is not a loop and is primarily located on The Green Road within the national park.

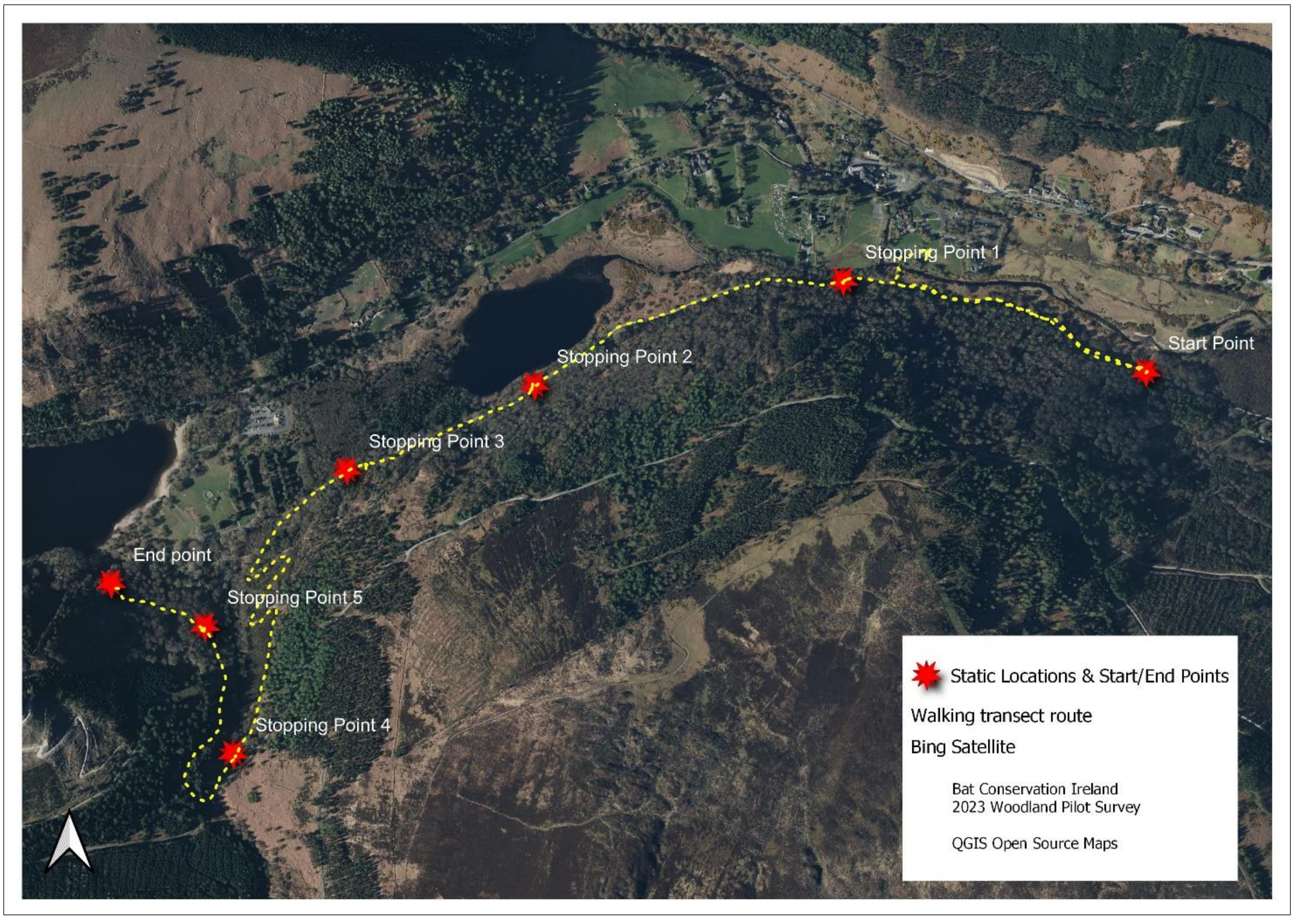

Figure A.3: Glendalough, Co. Wicklow – walking transect route and stopping point locations

Table A.3: Glendalough, Co. Wicklow – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	712953	696527
Stopping Point 1	712324	696716
Stopping Point 2	711683	696499
Stopping Point 3	711293	696323
Stopping Point 4	711057	695734
Stopping Point 5	710998	695999
End point	710803	696088

A1.4 DEPUTY’S PASS, CO. WICKLOW

This is a one loop walking transect with a small overlap to Stopping Point 3 in order to represent an agricultural landscape.

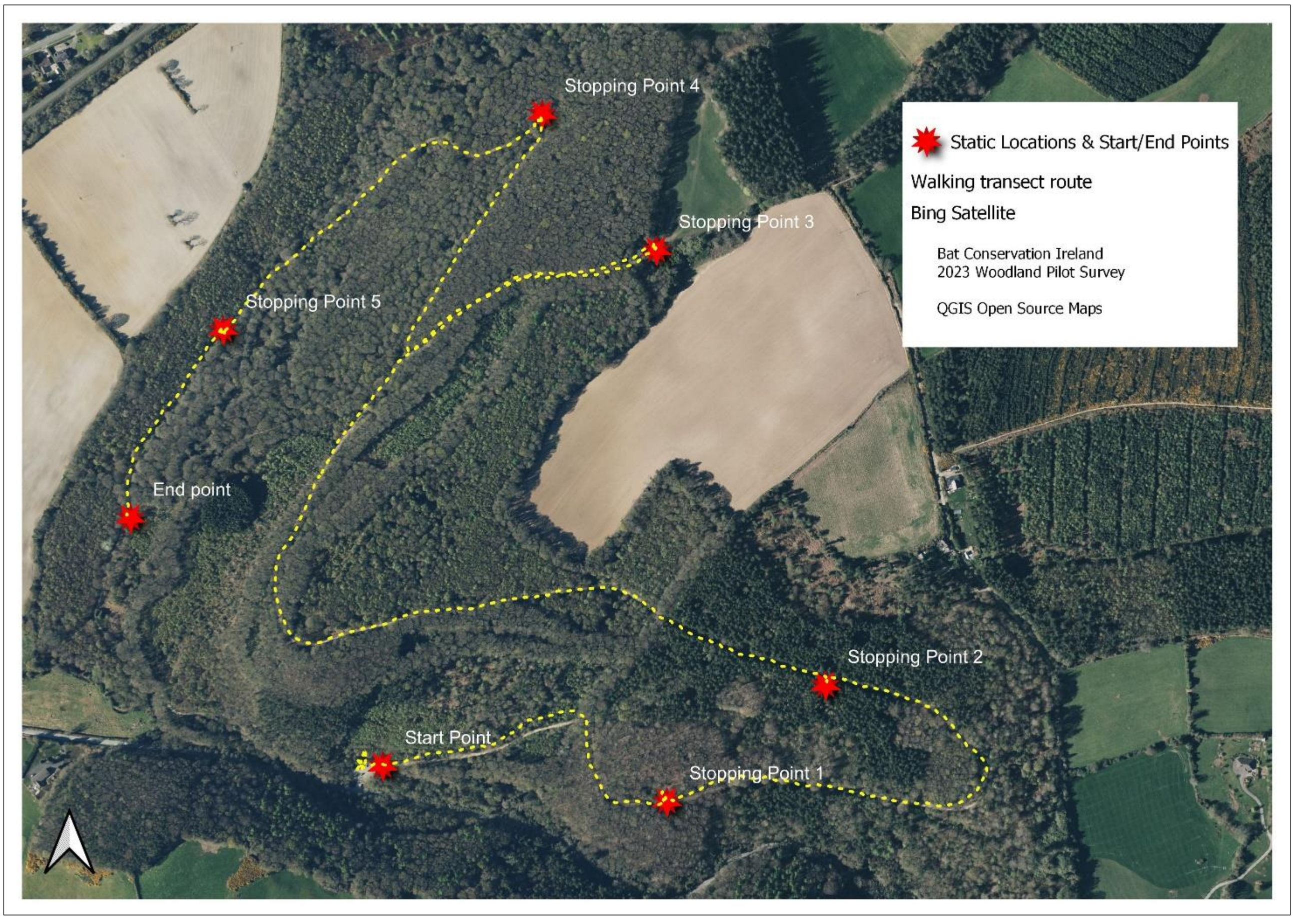

Figure A.4: Deputy’s Pass, Co. Wicklow – walking transect route and stopping point locations

Table A.4: Deputy’s Pass, Co. Wicklow – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	723396	690187
Stopping Point 1	723724	690146
Stopping Point 2	723907	690280
Stopping Point 3	723712	690782
Stopping Point 4	723580	690939
Stopping Point 5	723212	690690
End point	723105	690473

A1.5 VALE OF CLARA NATURE RESERVE, CO. WICKLOW

This is a one loop walking transect along the trails of the nature reserve starting in one car park and ending in another one.

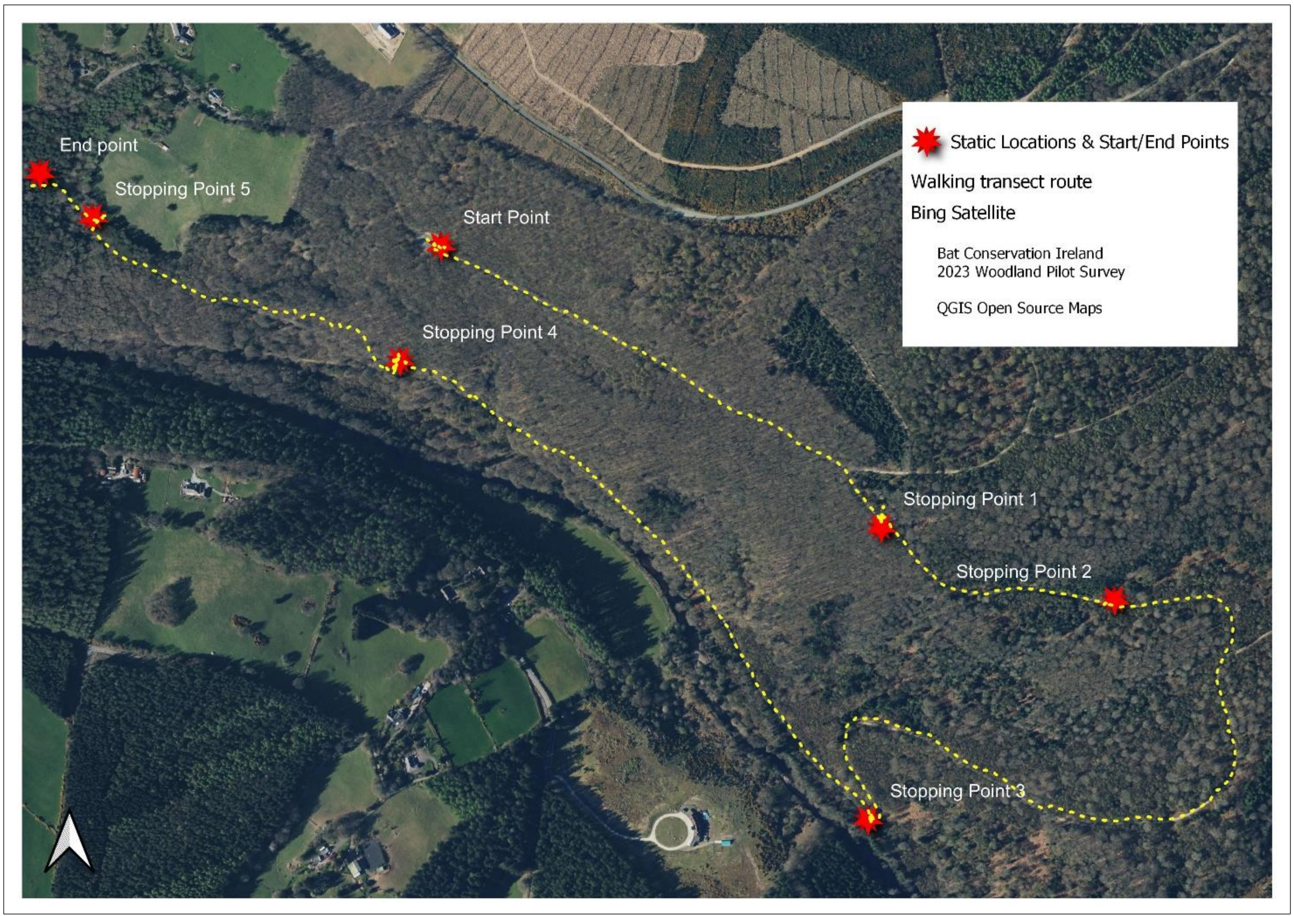

Figure A.5: Vale of Clara Nature Reserve, Co. Wicklow – walking transect route and stopping point locations

Table A.5: Vale of Clara Nature Reserve, Co. Wicklow – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	717828	692185
Stopping Point 1	718387	691827
Stopping Point 2	718683	691735
Stopping Point 3	718370	691456
Stopping Point 4	717776	692039
Stopping Point 5	717386	692221
End point	717319	692277

A1.6 TOMFINOGUE WOODLAND, CO. WICKLOW

This is a single loop walking transect along the trails of the woodland starting at the public car park. Stopping Point 2 represents a small detour from the main woodland trail to the boundary in order to sample adjacent agricultural land.

Figure A.6: Tomfinogue Woodland, Co. Wicklow – walking transect route and stopping point locations

Table A.6: Tomfinogue Woodland, Co. Wicklow – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	670700	670700
Stopping Point 1	702108	670447
Stopping Point 2	702160	669802
Stopping Point 3	701668	669525
Stopping Point 4	701641	669669
Stopping Point 5	701965	670147
End point	702147	670413

A1.7 DEERPARK WOODS, VIRGINIA, CO. CAVAN

This transect starts at the Boat House in Deerpark Woodland (Coillte) and ends at the public car park of Lough Ramor lakeshore (Virginia, Co. Cavan) after it follows the right of way through Virginia Golf Course towards the car park.

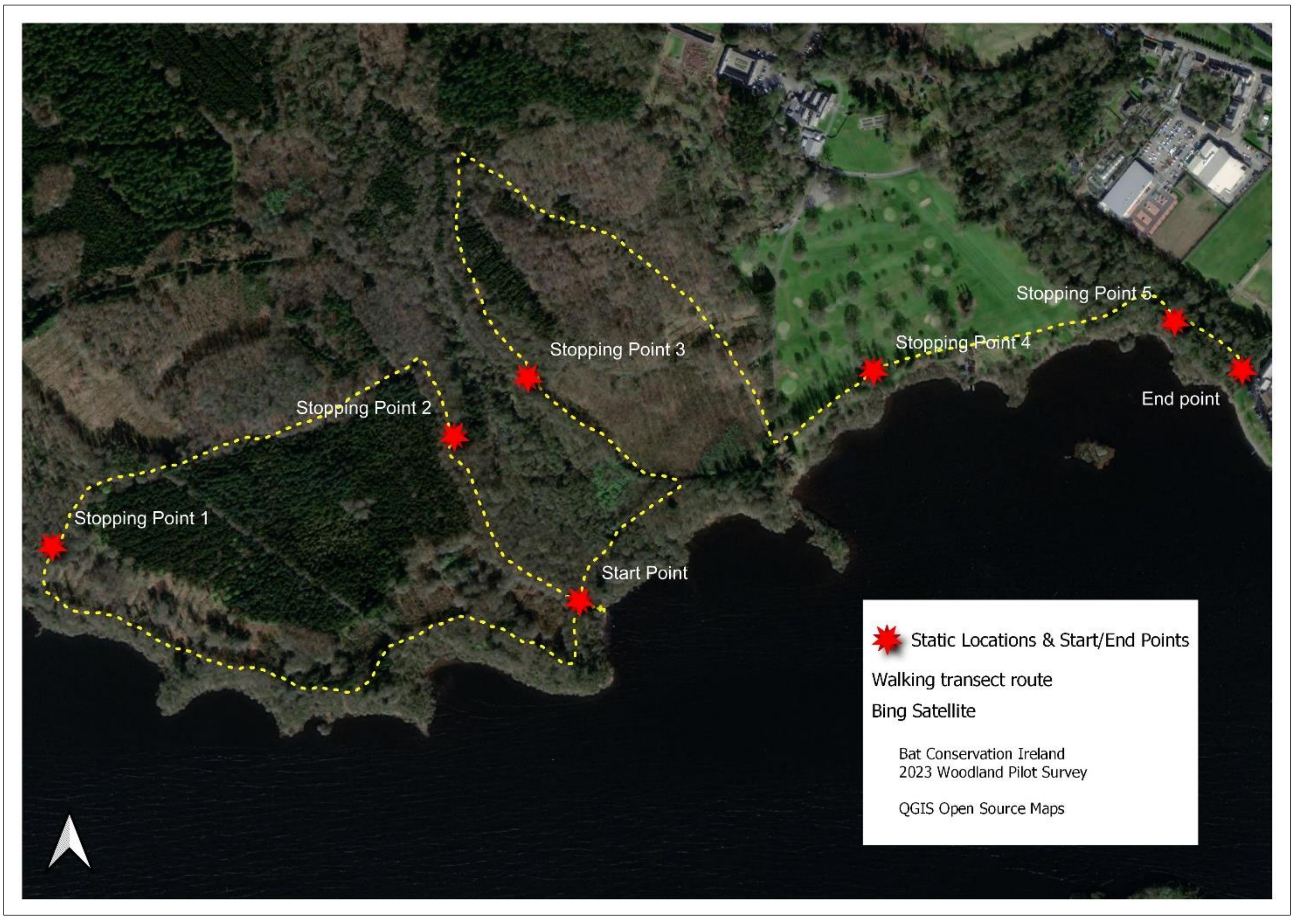

Figure A.7: Deerpark Woodland, Virginia, Co. Cavan – walking transect route and stopping point locations

Table A.7: Deerpark Woodland, Virginia, Co. Cavan – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	659343	787007
Stopping Point 1	658649	787079
Stopping Point 2	659178	787224
Stopping Point 3	659275	787301
Stopping Point 4	659730	787310
Stopping Point 5	660126	787375
End point	660215	787311

A1.8 KILLYKEEN FOREST PARK, CO. CAVAN

This transect was designed in order to access the forest park at night-time. The main car park is near to the Start Point but the car park is closed prior to sunset (barrier near Stopping Point 5). The nearest safe parking area is adjacent the End Point.

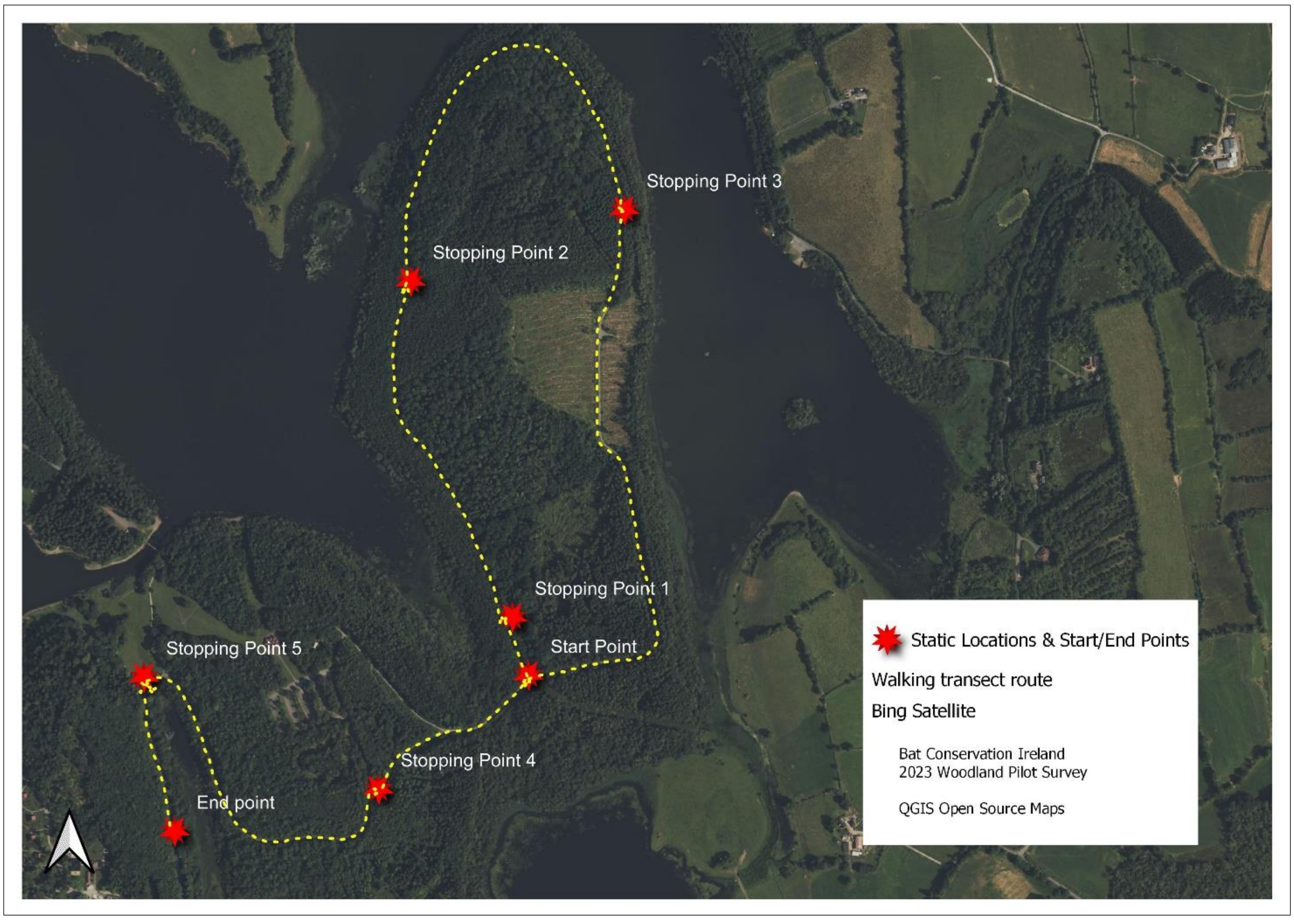

Figure A.8: Killykeen Forest Park, Co. Cavan – walking transect route and stopping point locations

Table A.8: Killykeen Forest Park, Co. Cavan – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	635259	806454
Stopping Point 1	635235	806541
Stopping Point 2	635082	807045
Stopping Point 3	635403	807152
Stopping Point 4	635034	806283
Stopping Point 5	634682	806451
End point	634728	806220

A1.9 CASTLE LOUGH, BAILIEBORO, CO. CAVAN

This transect was designed along trails within the woodland while avoiding the main lake loop trail (to reduce the potential recording of Daubenton's bats). These is one small section that overlaps (before Stopping Point 2).

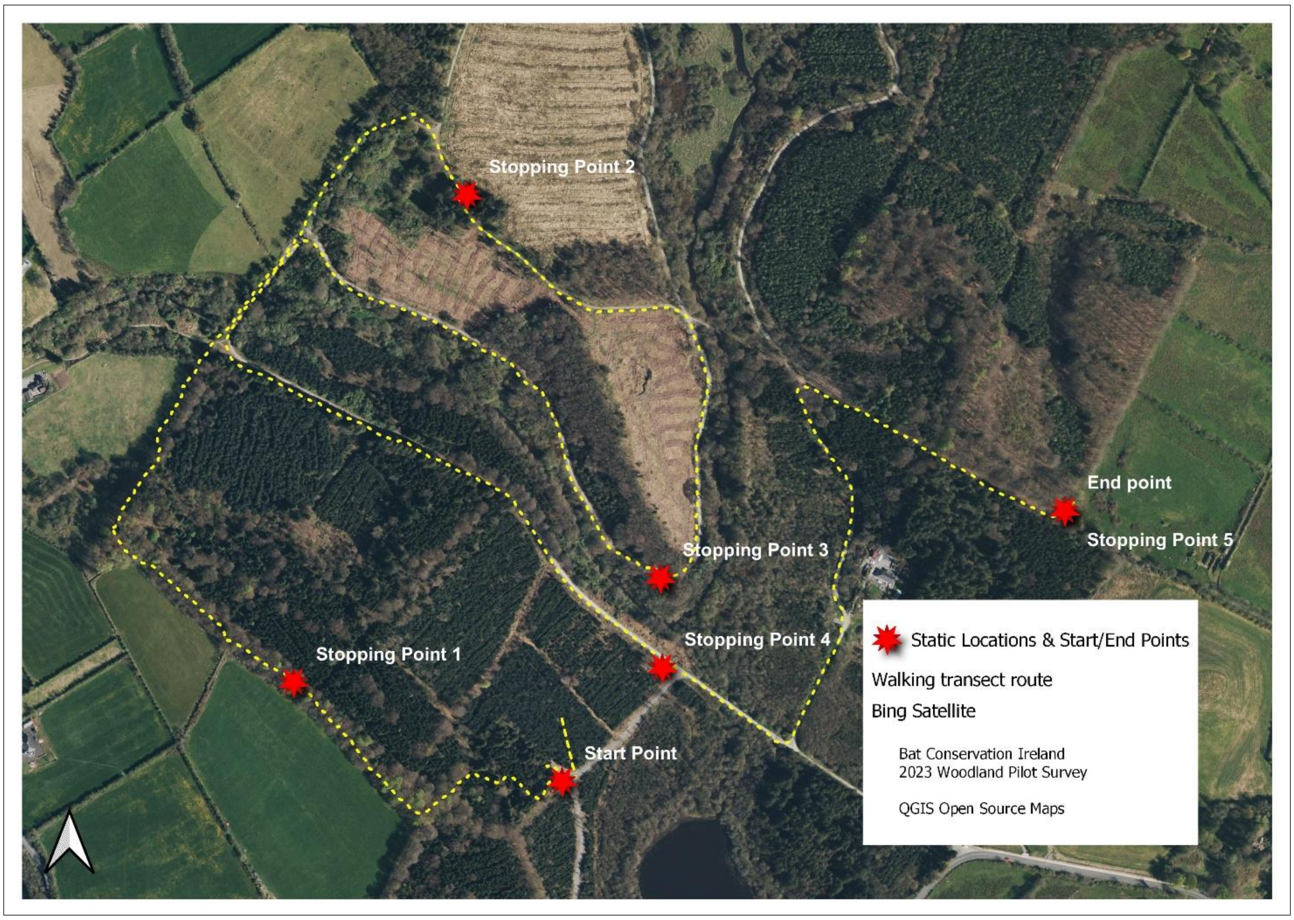

Figure A.9. Castle Lough Woods, Bailieboro, Co. Cavan – walking transect route and stopping point locations

Table A.9: Castle Lough Woods, Bailieboro, Co. Cavan – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	666242	797635
Stopping Point 1	665963	797738
Stopping Point 2	666143	798244
Stopping Point 3	666344	797846
Stopping Point 4	666346	797753
Stopping Point 5	666764	797916
End point	666764	797916

A1.10 DUN NA RÍ FOREST PARK, KINGSCOURT, CO. CAVAN

This walking transect starts at the main entrance barrier to the Coillte woodland and follows the main trails through the woodland.

Figure A.10: Castle Lough Woods, Bailieboro, Co. Cavan – walking transect route and stopping point locations

Table A.10 Castle Lough Woods, Bailieboro, Co. Cavan – transect and stopping point co-ordinates.

Name	ITM Easting	ITM Northing
Start Point	678206	797248
Stopping Point 1	678803	797260
Stopping Point 2	679262	797252
Stopping Point 3	679052	797477
Stopping Point 4	678680	797516
Stopping Point 5	678387	797292
End point	678200	797247

Please Note: walking transects are mapped using .GPX files saved on SD card by the Anabat Scout during official walking transect surveys. Some spurious GPS co-ordinates may occur, depending on reliability of satellite connections during surveys.