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IRISH BAT MONITORING PROGRAMME 2018-2021

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Front cover, small photographs from top row:

Limestone pavement, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Garden Tiger** *Arctia caja*, Brian Nelson; **Fulmar** *Fulmarus glacialis*, David Tierney; **Common Newt** *Lissotriton vulgaris*, Brian Nelson; **Scots Pine** *Pinus sylvestris*, Jenni Roche; **Raised bog pool**, Derrinea Bog, Co. Roscommon, Fernando Fernandez Valverde; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

Lennart Lennuk; **Daubenton's Bat** *Myotis daubentonii*

Irish Bat Monitoring Programme 2018-2021

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Executive Summary

The Irish Bat Monitoring Programme is comprised of four schemes currently under the management of Bat Conservation Ireland. This report provides the results from these schemes from 2018-2021 along with long term trends in bat populations, where available. The surveys have been funded by the National Parks and Wildlife Service (NPWS) in the Republic of Ireland and the Northern Ireland Environment Agency (NIEA) in Northern Ireland.

Data for these schemes are collected in a standardized fashion by numerous volunteer citizen scientists, as well as professionals, across the island. The Car-based Bat Monitoring Scheme (2003-2021) collects data on common and soprano pipistrelles as well as Leisler's bat, while the All Ireland Daubenton's Bat Waterways Monitoring Scheme (2006-2021), the Brown Long-eared Bat Roost Monitoring Scheme (2007-2021) and the Lesser Horseshoe Bat Roost Monitoring Scheme are single species surveys. Different methods are used for sampling bat activity or occurrence: – the Car-based Bat Monitoring Scheme uses driven transects and full spectrum bat detectors (formerly time expansion detectors); the waterways survey for Daubenton's bat uses stationary points along walked waterway transects and heterodyne/ tuneable detectors; the brown long-eared bat is counted at summer roosts either externally using detectors during emergence or internally during daylight hours; and the lesser horseshoe bat survey is a dual season programme whereby the bats are counted in summer either externally using detectors or video cameras, or internally in the roost, and in winter in hibernacula.

The co-ordination and implementation of all schemes were impacted by the global SARS-Cov-2 pandemic in 2020 and 2021. The sudden move to online recruitment and training in spring 2020, as well as constraints associated with field surveys, meant that some targets were not fully met in that year. Despite similar constraints in 2021, however, all targets were met, with the single exception of winter hibernation counts at lesser horseshoe sites which were carried out prior to COVID-19 vaccination roll-out.

All four schemes collect sufficient data to allow detection of red or amber alert declines in their target species. Additional information for other species such as Nathusius' pipistrelle (*Pipistrellus nathusii*) and *Myotis* spp. (combined) is also gathered by the Car-based Bat Monitoring Scheme. Due to the recent changeover in detector used in this scheme the number of records for these species has increased and we have seen a corresponding decrease in the width of error bars associated with their trends.

The news for bats in Ireland over the past 12+ years has been largely positive with significant increases seen in several species such as common pipistrelle, soprano pipistrelle, Leisler's bat and the Annex II listed lesser horseshoe bat. The population trend of the brown long-eared bat appears to be currently stable. Daubenton's bat trend is also reasonably stable, with error bars that encompass the baseline for the species, but it has declined somewhat in the past four years. In addition, we now note with concern a significant decreasing trend shown in the composite *Myotis* species index derived from car-based bat monitoring surveys. While there is insufficient information to determine whether this index reflects either or both whiskered and/or Natterer's bat, and it may even include some Daubenton's bat passes, the extent of the decline observed well exceeds Red Alert levels.

As part of the monitoring schemes Bat Conservation Ireland continues to target participation by members of the public. Well-attended Daubenton's bat training courses are run by Bat Conservation Ireland every year, thus improving awareness and encouraging citizen science across the island – over 3,000 people have participated in this scheme to-date.

Equipment upgrades are ongoing, Batlogger detectors were fully phased in for the Car-based Bat Monitoring Scheme in 2020. Camcorders coupled with infra-red lamps are used to improve accuracy of brown long-eared bat counts and to provide training for new volunteer teams. Ancillary data such as records collected for other vertebrates during the Car-based Bat Monitoring Scheme are also discussed with trends in a number of roadside mammals also provided.

Acknowledgements

The Irish Bat Monitoring Programme would not be possible without the hard work, dedication and enthusiasm of the many volunteer citizen scientists and NPWS and VWT staff who contribute to the surveys. We sincerely thank you all for your commitment to biodiversity and science in Ireland. We regret that it is not possible to individually name all surveyors involved in the schemes from 2018-2022. We would also like to thank all the bat groups across the island for their continued support and participation.

Special thanks to Dawn Quinn for administrative support for the programme.

Thanks to staff at the NPWS, in particular Ferdia Marnell, Deirdre Lynn, Ed Wymer, Gemma Weir and Jakub Czarcinski for their help and advice with overall project development.

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Also, many thanks to brown long-eared bat roost owners who allowed access to surveyors or indeed contributed to the survey by carrying out their own roost counts.

Sincere thanks to Cormac Parle for ongoing technical assistance.

Finally, thanks to the Bat Conservation Ireland Council for their continuous support.

1 Introduction

Ireland is host to nine resident bat species (Roche *et al.*, 2014). Bats form almost one third of Ireland's land mammal fauna. Bats are a species rich group widely distributed throughout the range of habitat types in the Irish landscape. Due to their reliance on insect populations, specialist feeding behaviour and habitat requirements, they are considered to be valuable environmental indicators of the wider countryside (Walsh *et al.*, 2001).

Irish bats are protected under domestic and EU legislation. Under the Republic of Ireland's Wildlife Act (1976) and Wildlife (Amendment) Act (2000) it is an offence to intentionally harm a bat or disturb its resting place. Bats in Northern Ireland are similarly protected under the Wildlife (Northern Ireland) Order 1985.

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 animal 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.

Since the final report of the previous Irish Bat Monitoring contract (Aughney *et al.*, 2018) Brexit has resulted in the departure of the UK from the EU. Nonetheless, the UK as well as Ireland, are still signatories to a number of conservation agreements pertaining to bats such as the Bern and Bonn Conventions. The Agreement on the Conservation of Populations of European Bats (EUROBATS) is an agreement under the Bonn Convention. The Republic of Ireland and the UK are two of the 38 signatories. EUROBATS has an Action Plan with priorities for implementation. Best practice guidelines are also developed and published. In one such publication the standardised methods for the surveillance and monitoring of all bat species across Europe was reviewed (Battersby, 2010).

The Red List for Mammals in Ireland (Marnell *et al.*, 2019) has been updated since the last reporting round for the Irish Bat Monitoring Programme and lists all of the bat species, including common pipistrelle (*Pipistrellus pipistrellus*), soprano pipistrelle (*Pipistrellus pygmaeus*), Leisler's bat (*Nyctalus leisleri*), Daubenton's bat (*Myotis daubentonii*) and brown long-eared bat (*Plecotus auritus*) as Least Concern. In the recent Article 17 reporting to the EU by Ireland, however, (NPWS, 2019) the status of the lesser horseshoe bat has been downgraded from 'Favourable' to 'Inadequate' due to reductions in range and habitat in certain areas.

All of these species are monitored using one of the Bat Conservation Ireland (BCIreland) monitoring schemes included in the present report.

There is currently no monitoring scheme for two of the *Myotis* bat species – Natterer's bat (*Myotis nattereri*) and whiskered bat (*Myotis mystacinus*). These species have been the subject of a number of woodland pilot studies and trials, most recently in 2021 based on a Bat Conservation Trust (BCT) UK methodology. A combined trend index for *Myotis* species is, however, derived from the car-based bat monitoring scheme, and this trend index will be discussed in detail in the report below.

1.1 Alert Levels

There are no precise biological definitions of when a population becomes vulnerable to extinction but the British Trust for Ornithology (BTO) has produced Alert levels based on IUCN-developed criteria for measured population declines. Species are considered of high conservation priority (Red Alert) if their population has declined by 50% or greater over 25 years and of medium conservation priority (Amber Alert) if their populations have declined by 25-49% over 25 years (Marchant *et al.*, 1997). These Alerts are based on evidence of declines that have already occurred but if Alerts are *predicted* to occur based on existing rates of decline in a shorter time period then the species should be given the relevant Alert status e.g. if a species has declined by 2.73% per annum over a 10-year period then it is predicted to decline by 50% over 25 years and should be given Red Alert status after 10 years. Monitoring data should be of sufficient statistical sensitivity (and better, if possible) to meet these Alert levels. In addition, the data should also be able to pinpoint population increases should these occur (for more details on power analysis, i.e. assessment of how robust the data is at detecting increases or declines, see for example Roche *et al.* (2009) and Aughney *et al.* (2009, 2011).

1.2 The Irish Bat Monitoring Programme – Concept and Development to 2021

The first bat species to be regularly monitored in Ireland was the lesser horseshoe bat. While some roost counts for this species were carried out as early as 1987, regular and systematic counting at sites began in the mid-late 1990s. Counts are carried out at winter sites in January and February each year, while summer roost counts are carried out from May 23rd to July 7th. These counts are mainly conducted by staff of the NPWS and the Vincent Wildlife Trust (VWT).

The Car-based Bat Monitoring Scheme was first piloted in 2003; it targets the two most abundant pipistrelle species (common and soprano pipistrelles) and Leisler's bat (Catto *et al.*, 2004). These species are relatively easy to detect and distinguish from each other on the basis of echolocation calls. The car-based survey initially made use of a broadband (time expansion) bat detector that picked up a range of ultrasound and replayed it at a slower speed. This sound was recorded in the field using minidisc recorders (up until 2011/2012), then smart phones (2011-2019), and sound files were then analysed post-survey. From 2016 onwards, increasing numbers of full spectrum Batlogger detectors were trialled alongside the ageing time expansion detector stock each year and Batloggers were fully rolled out in 2020. Either detector method allows survey work to be carried out by individuals with little or no experience in bat identification since identification is completed post survey work.

The Car-based Bat Monitoring Scheme was followed in 2006 by the All Ireland Daubenton's Bat Waterways Monitoring Scheme (Aughney *et al.*, 2009). This scheme follows a survey methodology devised by the BCT in the UK. Narrow band, heterodyne detectors are used so volunteers who conduct the survey are trained in the identification of Daubenton's bat prior to field work. Surveyors count the number 'bat passes' of this bat species for four minutes at each of 10 fixed points on linear waterways. The onset of this scheme was a very significant development in bat monitoring in Ireland since it represented the first large-scale recruitment of members of the Irish public to bat conservation-related work.

The Car-based Bat Monitoring Scheme and All Ireland Daubenton's Bat Waterway surveys are all-Ireland schemes. Both receive funding in Northern Ireland under the Department of Agriculture, Environment and Rural Affairs (DAERA) Northern Ireland Environment Fund.

The Brown Long-eared Bat Roost Monitoring Scheme was piloted and developed in 2007 (Aughney *et al.*, 2011). This project concentrates on counts of brown long-eared bats at their roosts and is conducted by individuals with a greater level of experience in bat identification than is necessary for Daubenton's or car-based surveys. This survey protocol involves at least two counts per annum (May to September) using three potential survey methods depending on the structure, access and location of bats within, and emerging from, the roost.

Lesser horseshoe bat roost counts are carried out within the known distribution of the species, in counties along the western seaboard from Mayo to Cork. Brown Long-eared Roost Monitoring has, so far, been based in the Republic of Ireland only. Regular monitoring under BCIreland management is, therefore, in process for six bat species in the Republic of Ireland, and for four species in Northern Ireland.

Additional BCT Field Surveys are also undertaken in Northern Ireland. Data collected from those surveys feed into the BCT's UK reporting mechanisms.

1.3 Factors Impacting Measured Bat Population Trends

Many factors including climate, foraging habitat quality, roost availability, disturbance at hibernacula, landscape connectivity, artificial lighting, predation and competition, among others, combine to regulate the local and national population of a given bat species. The possibility that monitoring schemes may themselves introduce bias or error resulting in erroneous trends was discussed in a publication by Buckland & Johnston (2017) who reviewed the principles and possible pitfalls when monitoring biodiversity and determining trends in different species, including bats. The authors specified five essential components to any monitoring scheme:

1. representative sampling
2. sufficient sample size
3. sufficient detection of target species
4. representative sample of species
5. temporal sampling scheme designed to aid valid inference

We have addressed many of these issues by ensuring we carry out power analysis on data from the schemes, targeting minimum numbers of sites, random sampling where possible, carrying out counts before young are flying etc. Where we have reservations with regard to specific schemes, we address them in the relevant sections.

1.4 Weather 2018-2021

The year 2018 saw a number of extreme weather events. It began unsettled with a mainly westerly airflow and Storm Eleanor bringing strong winds on January 2nd. A cold and dry February finished with a polar continental air mass. This brought snow showers and substantial accumulations in the East and South. Storm Emma at the beginning of March caused widespread disruption and considerable snow along with snow drift conditions in a cold and changeable month. The summer of 2018 will also be remembered for heatwave and drought conditions that affected many parts of the country. The weather in May was somewhat changeable at times. While the south-west had higher than average rainfall in May, rainfall amounts in many areas that month were below LTA (long term average). Temperatures were above normal everywhere in May. June began with some intense thunderstorms but overall the first half of the month was very settled and dry. Storm Hector resulted in some wet and windy conditions in the middle of June but this was followed by dry and hot weather. All stations had above average sunshine in June 2018. July continued in a similar vein with drought and heatwave conditions experienced in most areas. Rainfall amounts were well below LTAs at all stations. Following the start of car-based bat surveying in mid-July, the end of the month saw some low pressure fronts with rain, wind and some thundery showers. August saw a split in weather experienced in the north and west compared with the south and east. Low pressure systems in the north and west resulted in rain and windy conditions at times, while the south and east experienced high pressure systems with drier sunnier weather. Overall rainfall LTAs were still below normal for the month, however.

Weather-wise 2019 began dry and cool, but the second half of January was more unsettled and changeable. A high pressure then dominated the start of February until the second week when the first storm of 2019 made landfall. Overall February was a predominantly mild and dry month, however. The summer of 2019 was changeable and wet at times. May was reasonably dry with near average temperatures. The dominant feature of the remainder of the summer was unsettled weather with low pressure. June was fairly dry and cool, although a warmer airflow moved in from the south in the final week that month. July was warm and dry overall and, again, the warmest weather was recorded at the end of the month, which worked well for many car surveyors completing their first survey in late July. August, Daubenton's and the second car survey month, began quite dry but then became unsettled and dominated by Atlantic low pressure systems. Some gusty winds and heavy rain occurred in the middle of August and caused flooding in some areas. Some areas of the west and north-west also recorded flooding towards the end of the month. Rainfall levels were above average in most places in August; 278% of the Long Term Average for rainfall for the month was recorded in Athenry, Co. Galway in 2019 although lower rainfall levels were recorded further east.

A mild and relatively dry January began the year 2020, although Storm Brendan made landfall on the 13th. February was very wet and windy with numerous storm systems coming close to and across Ireland until the start of March. The early summer was dominated by high pressure – dry and settled weather. There was some rain during this period, particularly in the south west, although it remained mostly dry elsewhere. June began relatively dry but the weather soon turned unsettled and rainfall soon began to exceed long term averages across the country. The south-west saw some particularly wet weather. July saw the Azores High briefly pushing up over Ireland between the 9th and 11th and between the 19th and 21st, when many car-based bat surveyors completed their first surveys. For most of the month Ireland was situated directly under, or on the northern side of the Jetstream, resulting in cool, wet weather. After the first week of August there were some dry pleasant days. However, slow moving fronts and thundery continental low-pressure systems kept August mostly cloudy with heavy rain at times. The final third of August brought two named storms, Storm Ellen and Storm Francis over the country with widespread gales and heavy rain causing some flooding. In combination with COVID-19 pandemic constraints, this bad weather negatively impacted some second surveys of the waterways and car-based schemes in 2020.

The start of 2021 was unsettled and wet, including Storm Christoph in January and further spells of wet weather in February. May was a cool and wet month with rainfall above average and temperatures below average. June and July, however, brought warm, dry and sunny summer with above average temperatures across all weather stations and most seeing above average sunshine and below average rainfall. July 2021 was particularly notable with widespread heatwaves and long dry spells. At least ten weather stations across Ireland reached heatwave conditions, where temperatures of at least 25°C were recorded for 5 days or more in a row. Following the heatwave which ended with some intense and thundery downpours and flash flooding, August was a month of mild and changeable weather. The mild theme continued into September, which was provisionally the warmest September on record for Ireland with temperature records broken at several stations including Phoenix Park, which had its warmest September in 122 years.

2 Car-based Bat Monitoring

The Car-based Bat Monitoring Scheme is a project funded by the National Parks and Wildlife Service (NPWS) of the Department of Housing, Local Government & Heritage, Republic of Ireland and the Northern Ireland Environment Agency (NIEA) through the Environment Fund. This scheme aims to be the primary tool for monitoring common pipistrelle, soprano pipistrelle and Leisler's bats in the Republic of Ireland and Northern Ireland.

This section of the report presents a synthesis of results for the 19 years (2003-2021) of monitoring and follows earlier reports produced by BCIreland e.g. Aughney *et al.* (2009; 2012; 2015; 2017).

2.1 Method

Training of surveyors is carried out in June and early July each year. Survey teams are provided with all equipment needed for the survey. Up until 2019 this included:

- a time expansion bat detector (Courtpan Electronic, Tranquility Transect), set to x10 time expansion and used to record continuously for 320milliseconds intervals
- HTC Android smart phone with memory card, pre-loaded with recording and spectral viewer apps.
- Purpose built adaptor leads from to connect the 3.5mm TRS jack lead from the detector into the phone's 3.5mm TRRS jack socket x 2
- pre-stamped envelopes to return the data
- instruction manuals
- recording sheets
- batteries
- flashing beacon
- thermometer and a first aid kit
- window clamp

From 2016 onwards an increasing number of teams each year were provided with an additional:

- full spectrum bat detector (Batlogger M, Elekon Electronics) and spare SD card

By 2020, time expansion detectors, smart phones and the leads to connect the two, were no longer provided to teams as we had fully swapped to Batlogger M detectors. The equipment provided from 2020 onwards included:

- full spectrum bat detector (Batlogger M, Elekon Electronics) and spare SD card
- pre-stamped envelopes to return the data
- instruction manual
- recording sheets
- flashing beacon
- thermometer and a first aid kit
- window clamp

Each year, survey teams carry out surveys of a mapped route within a defined 30km ***Survey Square***. Every route covers 15 x 1.609km (1 mile) monitoring ***Transects*** each of which is separated by a minimum distance of 3.2km (2 miles). Surveyors are asked to carry out the survey on two dates, one in mid to late July (Survey 1) and one in early to mid-August (Survey 2). Transect coverage begins 45 minutes after sundown. Each of the 1.609km transects is driven at 24km (15 miles) per hour while continuously recording from a bat detector.

The detector is clamped to the passenger door window and set to record. Those with both Batlogger and Tranquility detectors were asked to attach both devices to the same clamp and to simultaneously switch both detectors on at the start of each transect and off at the end of each transect. In that way the data from the two devices could be integrated into the species trend indices following a number of years of dual surveys.

To record time expansion detector surveys a purpose-built smart phone Android app (AudioAndLocationRecorder) was developed in 2011 based on Hertz the Wav recorder. The AudioAndLocationRecorder app simultaneously records GPS geo-locational data and sound at a 44,100Hz sampling speed. Sound is stored as .wav files. Locational data, which includes latitude, longitude, altitude, error and speed, are stored in .csv files. An additional app, Spectral Pro-Analyszer, was used by surveyors to check the detector and phone are connected correctly. This app creates a visible display of the sound being recorded by the phones in real time. It was kindly provided to Bat Conservation Ireland free of charge by its developers RadonSoft. This app is used at the beginning of each survey so that volunteers can visually check that the sound coming into the phone is correct. It cannot be used simultaneously with the AudioAndLocationRecorder, however.

Surveying with Batlogger M is more straightforward. Each Batlogger is preset with specific parameters by BCIreland. At the start of each transect surveyors switch the device to On. At the end of the transect they switch it to Off. The Batlogger automatically stores all files to an integrated SD card (dual wav files and kml files).

In 2013 three training videos were uploaded to YouTube, and to the Car monitoring Facebook page in 2015, to provide further back-up information on how to use the smart phones and apps for the survey:

- http://www.youtube.com/watch?v=0vt_KhB9IWA
- http://www.youtube.com/watch?v=BKiK8ApwXPo
- http://www.youtube.com/watch?v=lRzcjf2Kmnk

A new video was uploaded in 2020 with instructions on how to use the Batlogger M for the survey:

- https://www.youtube.com/watch?v=09_x6dyIqE8

Following survey completion, phone mini-SD cards and hard copy recording sheets are forwarded (in pre-stamped and addressed envelopes) to BCIreland or uploaded to a shared Dropbox folder following survey completion. From 2016, teams were strongly advised to make a backup copy prior to posting the SD card or to upload the data to a Dropbox folder which was provided to them for the survey. In this way, we hoped to prevent loss of survey data due to SD cards becoming corrupted or lost in the post.

2.1.1 Sound Analysis and Data Handling

Smart phone sound recordings were downloaded directly using a smart phone connected to PC. For those surveys where GPS data was successfully recorded using the Audio and Location Recorder App, a .csv file corresponding to each .wav file (transect) was also available. Csv files were also downloaded to computer.

For bat call analysis of Tranquility Detector Recordings each .wav file is opened in Bat Sound™ and calls are identified to species level where possible.

Data from Batloggers is manually analysed using Kaleidoscope Pro (Wildlife Acoustics). We do not currently use the auto-identifier results in the species trends.

Species that can be identified accurately using either Bat Sound or Kaleidoscope Pro are

- common pipistrelle
- soprano pipistrelle
- Nathusius' pipistrelle
- 'pipistrelle unknown'(i.e. pipistrelle calls with a peak in echolocation between 48kHz and 52kHz are recorded as because they could be either common or soprano pipistrelles
- Leisler's bat
- *Myotis* bats are recorded but these are noted as *Myotis* spp. since they could belong to one of a number of similar species – Daubenton's, whiskered or Natterer's.
- Social calls of brown long-eared bats are also recorded.

Various publications (Russ, 2012, 2021; Russo & Jones, 2002; Vaughan *et al.*, 1997) are used for sonogram identification reference.

For quality control purposes approximately 10% of the .wav files are forwarded each year to Dr Jon Russ for quality control analysis.

Information for each survey is entered to a tailor made MySQL database. For Tranquility data once analysis is complete, smart phone .csv files with date and time stamps, latitude and longitude are linked to the MySQL database bat records. Links are created based on the duration of the transect and the time at which each bat was recorded. It is usually possible to geo-reference each bat recorded on a smart phone survey transect that has a corresponding .csv GPS file. We also take into account the fact that GPS data and bats are not always recorded simultaneously so the programme also calculates the time difference between GPS location point and the time a bat was recorded.

For Batlogger M data, results from manual identification are lined up with latitude and longitude data from corresponding kml files. The locational data is extracted using BatClassifyIreland_04092017, a piece of software that was developed for Bat Conservation Ireland. Following cleanup of the data, results from each survey are uploaded as an individual csv file to the MySQL database.

For the purposes of providing volunteer feedback, spreadsheets listing bat species, date, time, location and accuracy are uploaded to Google Maps using Drive. Bat locations are pinned to a map for each route, with icons of differing colour and shape denoting a particular bat species.

Each year following analysis, data from the Car-based Bat Monitoring MySQL database is synchronised with the Bat Conservation Ireland Bat Records Database to ensure that the data becomes widely available when uploaded to the NDBC website.

The Facebook page (IrishCarBats) is used to communicate ongoing progress with Facebook users and surveyors. Training videos were also uploaded to this Facebook page.

2.1.2 Methodology Changes

On the first year of the survey, 2003, surveys were carried out on later dates than in the following years and the survey began 30 minutes after sunset rather than the later start time of 45 minutes after sunset. An additional change was made to the methodology in 2009; where each route had originally consisted of 20 transects, the final five transects for each route was omitted, due to safety and driver tiredness concerns. These changes to the method are taken into account in the statistical analysis.

Also, as has already been described above, there has been a gradual changeover to a new full spectrum bat detector, Batlogger M, over the past four years of the scheme.

2.1.3 Statistical Analysis

The full Generalised Additive Model (GAM) approach is used to analyse trends (Fewster *et al.*, 2000). Both Tranquility detector and Batlogger M detector data are included, with a covariate for detector to adjust for their different sensitivities. The response variable is the number of snapshots/soundfiles with the species present. The log of total survey time (based on number of 0.32s recordings per survey, sonogram length or the actual survey time) is used as an offset, which effectively does something very similar to analysing the passes per minute, but allows use of a Poisson error distribution. The analysis is completed using the first 15 mile transects only of the surveys from 2003-2008, so that results are comparable with the reduced sampling plan used from 2009.

The spline curves have five degrees of freedom, which is the default recommended by Fewster for this length of data. Surveys with less than eight one mile transects completed are excluded. In this report 2006 is used as the base year, reflecting the advice in Buckland & Johnston (2017) that it is best to select a year with more data, as this was the first year with more than 20 x 30km squares surveyed.

Smoothed trends are constructed using the GAM approach described by Fewster *et al.* (2000) with confidence limits generated by bootstrapping at the Survey Square level. A fully saturated GAM model, which is equivalent to a conventional GLM with estimates for each year, is also fitted to indicate the year-to-year variation about the smoothed curve.

For Nathusius' pipistrelle and brown long-eared bat trends, models are constructed based on a binomial distribution. This is because the species sometimes occur in the same transect on multiple occasions but there are, much more often, transects with no occurrences of these species and, therefore, a large number of zeros in the dataset. Otherwise, the same methodology is applied, with confidence limits constructed by bootstrapping at the square level.

This year we also tried modifying the 'site' variable for the analysis, so that it represented a combination of grid square and detector; for example, considering the Tranquility data for G20 as a different site to the Batlogger data for G20. This approach relies on the information in the overlapping years to stitch the trend from the two detectors together, without making such strong assumptions as the covariate approach.

2.1.3.1 Other Vertebrates: Trends

Records for vertebrates other than bats have been collected by surveyors since 2006 – during transects and between transects along the survey routes. These data do not result in high resolution georeferenced records, but since the same routes are surveyed year after year in the same manner we now have a long timeline that is suitable for further analysis, albeit with large numbers of zeroes for surveys where no specimens were recorded. This year we examined trends in:

- Cats (*Felis catus*)
- Foxes (*Vulpes vulpes*)
- Rabbits (*Oryctolagus cuniculus*)
- Hedgehogs (*Erinaceus europaeus*)
- Badgers (*Meles meles*)

These were analysed using package rtrim in r (R Core Team, 2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria (https://www.R-project.org/). The total number of each species counted in each survey square each year was calculated and the time taken to complete the surveys in each square, in hours, was included as a weighting factor (to account for the differences in time spent driving each route). For the trend analysis we used a linear model with default stepwise detection of change points. The base year for these analyses is taken as the first year of data - 2006.

2.2 Results

Seven teams participated in the 2003 car-based pilot scheme and 17 survey routes were surveyed in 2004. Twenty one squares were surveyed in 2005. An additional five squares were surveyed in 2006, bringing the total number of surveyed squares to 26 throughout the island. Equipment for 28 squares was disseminated from 2007 onwards (Figure 2.1). The survey represents a considerable input of voluntary time - taking approximately three hours to complete (mean = 181 minutes for 2017), and each team typically consists of two people.

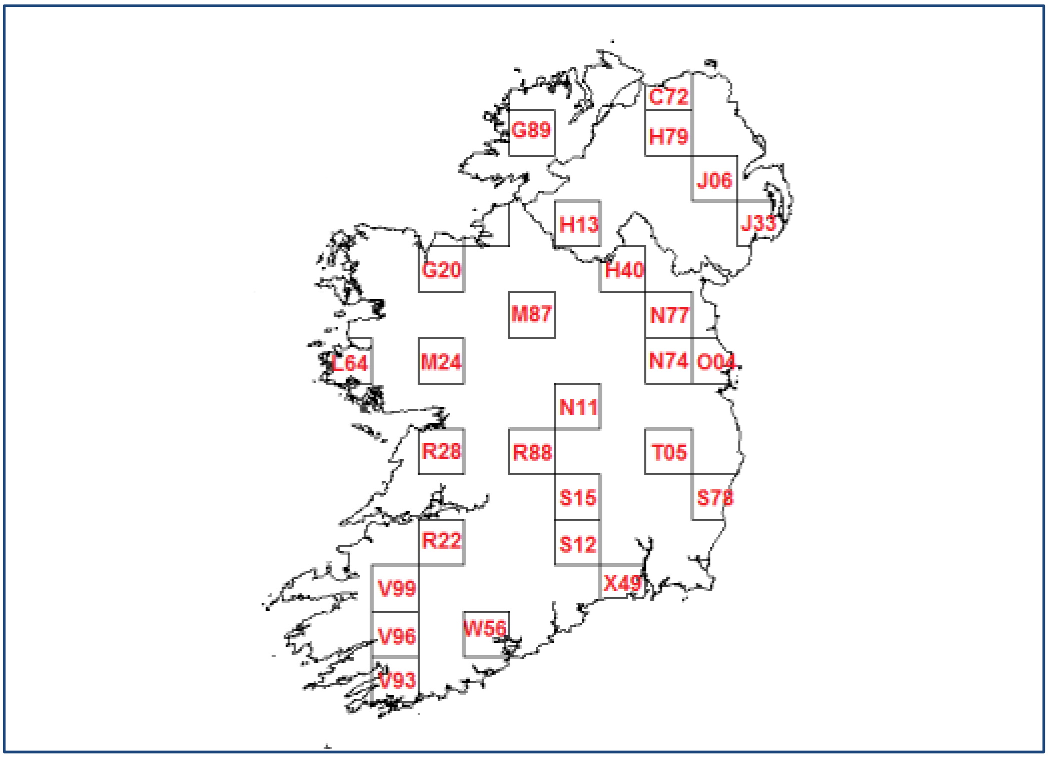

Figure 2.1 Locations of the 30km squares where surveys are carried out in both July and August each year.

Table 2.1 Numbers of squares and transects surveyed each year since 2003, along with total number of bats "passes" recorded by each of the two bat detector types.

Year	Squares	Tranquility Detector Transects (n)	Tranquility Detector Total Number of Bat "Passes"	Batlogger Detector Transects (n)	Batlogger Detector Total Number of Bat "Passes"
2003	7	180	378		
2004	17	576	2031		
2005	21	608	1691		
2006	26	887	3212		
2007	27	889	3014		
2008	27	927	3280		
2009	27	787	2147		
2010	28	816	2672		
2011	28	763	2748		
2012	28	664	2266		
2013	26	704	2529		
2014	28	754	3464		
2015	28	786	3406		
2016	28	744	3692	113	1373
2017	28	758	3945	265	3493
2018	28	790	3984	445	4920
2019	28	733	3624	636	7870
2020	26			672	9511
2021	28			809	11685
TOTAL		12,366	48,083	2,940	38,852

Just over 48,000 bat passes were recorded by Tranquility detectors until they were phased out in 2019. In the few years that Batloggers have been used and over 38,000 bat passes have been recorded by these devices.

2.2.1 Bat Dataset Generated

The Irish data has been analysed by the same person every year to produce consistent results. The following tables present raw data from the Tranquility Bat Detector (up to 2019, Table 2.2) and Batlogger Bat Detector (since 2016, Table 2.3).

Table 2.2 Tranquility Bat Detector raw bat encounter data, per 1.609km/1 mile transect, not corrected to encounters per km or per hour, Car-based Bat Monitoring Scheme 2003-2019. Average number of bats reflects the average number of bat passes observed during each 1.609km/1 mile transect travelled. Note that the detector records for just 1/11th of the time spent surveying so to determine the actual number of bat encounters per km this must be divided by 0.146 (the total distance sampled for each 1.609km transect).

Year	No. Transects	Common pipistrelle	Soprano pipistrelle	Pipistrelle unid.	Nath. pip.	Leisler's bat	Myotis spp.	Brown long-eared	Total Bats
2003	190	1.294	0.478	N/a	0	0.289	0.039	n/a	2.1
2004	577	1.905	0.695	0.443	0	0.511	0.05	n/a	3.621
2005	608	1.344	0.574	0.266	0.001	0.544	0.035	n/a	2.781
2006	887	1.701	0.652	0.271	0.033	0.892	0.029	0.024	3.62
2007	889	1.77	0.639	0.253	0.015	0.631	0.036	0.019	3.39
2008	927	1.686	0.768	0.294	0.006	0.739	0.029	0.002	3.537
2009	787	1.212	0.714	0.221	0.032	0.492	0.032	0.011	2.728
2010	816	1.442	0.668	0.241	0.069	0.809	0.023	0.012	3.275
2011	763	1.56	0.8	0.36	0.022	0.79	0.038	0.02	3.602
2012	663.5	1.399	0.799	0.353	0.048	0.754	0.027	0.026	3.415
2013	704	1.550	0.847	0.324	0.021	0.807	0.011	0.028	3.592
2014	754	1.985	1.085	0.424	0.044	1.001	0.025	0.017	4.594
2015	786	1.944	1.033	0.403	0.014	0.877	0.047	0.009	4.333
2016	744	2.141	1.227	0.555	0.040	0.952	0.027	0.009	4.962
2017	758	2.379	1.314	0.562	0.032	0.875	0.022	0.009	5.204
2018	790	2.34	1.262	0.576	0.023	0.780	0.018	0.011	5.284
2019	733	2.08	1.209	0.453	0.083	0.969	0.005	0.007	4.878
Mean Per Transect		**1.76**	**0.884**	**0.379**	**0.030**	**0.761**	**0.028**	**0.013**	**3.819**

Table 2.3 Batlogger M Bat Detector raw bat encounter data, per 1.609km/1 mile transect, not corrected to encounters per km or per hour, Car-based Bat Monitoring Scheme 2016-2021. Average number of bats reflects the average number of bat passes observed during each 1.609km/1 mile transect travelled.

Year	No. Transects	Common pipistrelle	Soprano pipistrelle	Pipistrelle unid.	Nath. Pip.	Leisler's bat	Myotis spp.	Brown long-eared	Total Bats
2016	114	4.965	4.272	1.465	0.053	1.088	0.193	0.009	12.044
2017	265	5.88	4.732	0.977	0.117	1.049	0.128	0.011	12.894
2018	445	5.26	3.497	1.097	0.022	1.097	0.072	0.011	11.056
2019	636	5.36	3.931	1.299	0.200	1.456	0.069	0.031	12.346
2020	645	6.82	4.132	1.464	0.183	1.423	0.127	0.020	14.169
2021	809	7.121	4.005	1.319	0.119	1.771	0.068	0.031	14.434
Mean Per Transect		**6.200**	**4.024**	**1.293**	**0.134**	**1.429**	**0.093**	**0.023**	**13.215**

The mean total number of bat encounters recorded using Tranquility bat detectors was 3.82 per 1.6km transect for all years of the survey until 2019. The total number of bats encountered per survey has gradually increased over the years of the survey. The changeover to Batloggers means that historical data, pre-2016, is not directly comparable.

Figure 2.2, a pie-chart, shows proportions of each species or species group encountered, from 2003 to 2019 using Tranquility detectors. The common pipistrelle is the most abundant species. Soprano pipistrelle and Leisler's bat are fairly equally represented with 20-23% each of the total bat encounters. Pipistrelle bat encounters that cannot be ascribed to either the common pipistrelle or soprano pipistrelle are recorded as 'Unknown pipistrelle'. These generally accounted for approximately 10% of the bat passes in any given year.

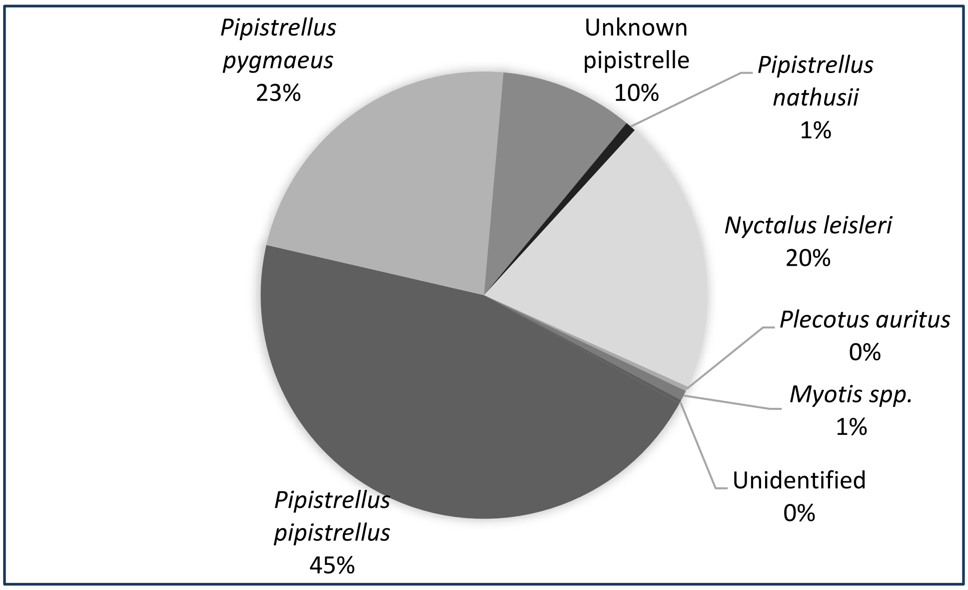

Figure 2.2 Proportions of bat species recorded during car-based bat monitoring surveys using time expansion Tranquility Detectors 2003-2019, n=48,082

M*yotis* spp., Nathusius' pipistrelles and brown long-eared bats were rarely encountered. Note that Figures 2.2 and 2.3 are not meant to give an impression of the actual relative abundance of each species along Irish roadsides since each species differs in its detectability and flight style which influences detection. Leisler's bats, for example, have loud, low frequency calls with much greater long-range detectability than either of the two pipistrelles, but would not necessarily fly close to hedgerows along roadsides, unlike the pipistrelles. So, while they are more detectable, their occurrence in the landscape would preclude detection if they had quiet short range calls. In addition, the pie-charts illustrate results of the sampled dataset with social calls of Leisler's bat and brown long-eared bats included, but excluding social calls of the pipistrelles. Pipistrelle social calls are excluded because they can be difficult to distinguish to species level with confidence.

Figure 2.3 shows proportions of each species or species group encountered, from 2016 to 2021 using Batlogger M bat detectors. Again, the common pipistrelle is the most abundant species. The proportions of calls accounted for by soprano pipistrelles and Leisler's bats have changed, however. Soprano pipistrelles account for a greater proportion, roughly 30% of total Batlogger M bat passes, while Leisler's account for just under 11% of calls.

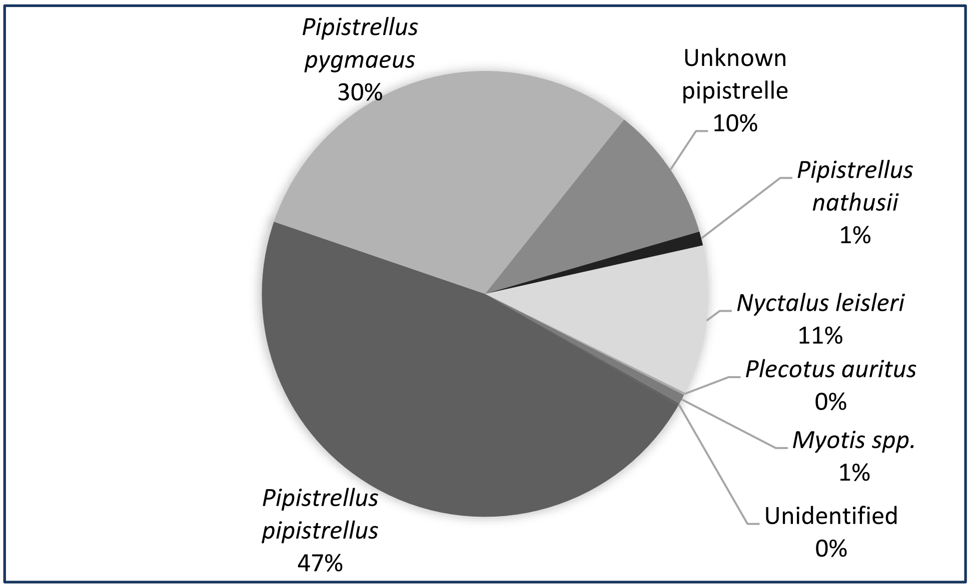

Figure 2.3 Proportions of bat species recorded during car-based bat monitoring surveys using time expansion Batlogger M Detectors 2016-2021, n=38,852

2.2.2 Alternative Trend Analysis

This year we also tried modifying the 'site' variable for the analysis, so that it represented a combination of grid square and detector; for example, considering the Tranquility data for G20 as a different site to the Batlogger data for G20. This approach relies on the information in the overlapping years to stitch the trend from the two detectors together, without making such strong assumptions as the covariate approach.

Unfortunately, this method produced confidence limits that were wider than the current approach. Therefore, for trend analysis shown in this document we have continued with the current methodology of using a covariate adjustment for combining the data from the two detectors.

2.2.3 Common pipistrelles *Pipistrellus pipistrellus*

Common pipistrelles have been the most frequently encountered species during the monitoring scheme in all survey years to-date. In L64, Connemara, common pipistrelles were confirmed for the first time in 2014 although it is still very rarely recorded within this square. The species tends to show a southern bias, occurring with greater frequency in the south and east of the country than in the north and northwest. Figure 2.4 shows the mean encounter rate for the species from Batlogger detectors for the last three years of the survey. In years prior to 2019, fewer squares were surveyed using these detectors.

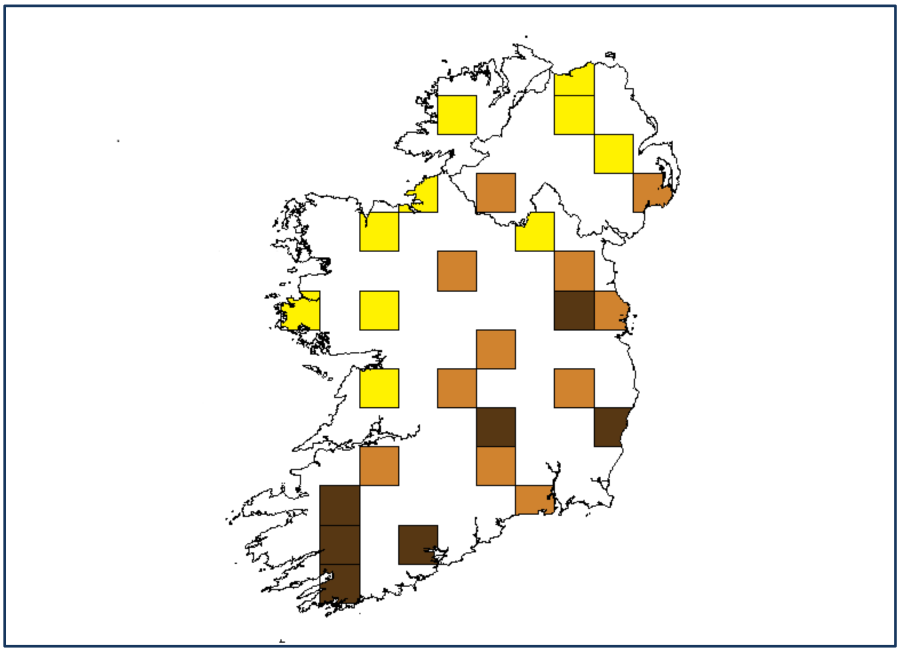

Figure 2.4 Survey squares colour coded according to mean common pipistrelle encounter rates using Batlogger detectors (per hour) from 2019-2021. The overall average rate of common pipistrelle encounters for all squares from 2019-2021 was $90hr^{-1}$.

Encounter rate $>0 \leq 60hr^{-1}$
Encounter rate $>60 \leq 120hr^{-1}$
Encounter rate $>120hr^{-1}$

2.2.3.1 Common Pipistrelle Trend

Common pipistrelles showed a significant increase from the survey start year until 2021, despite the fact that the trend levelled out a little between 2008 and 2012. The lower 95% confidence interval currently well exceeds the 2006 baseline index (Figure 2.5, Table 2.4). The highest yearly estimate for the common pipistrelle was in 2021. In the past 12 years (2010-2021) this species has increased by 69.6% in total, equivalent to a per annum increase of 4.5%. Since the start of the car survey scheme in 2003, the species' index has approximately doubled.

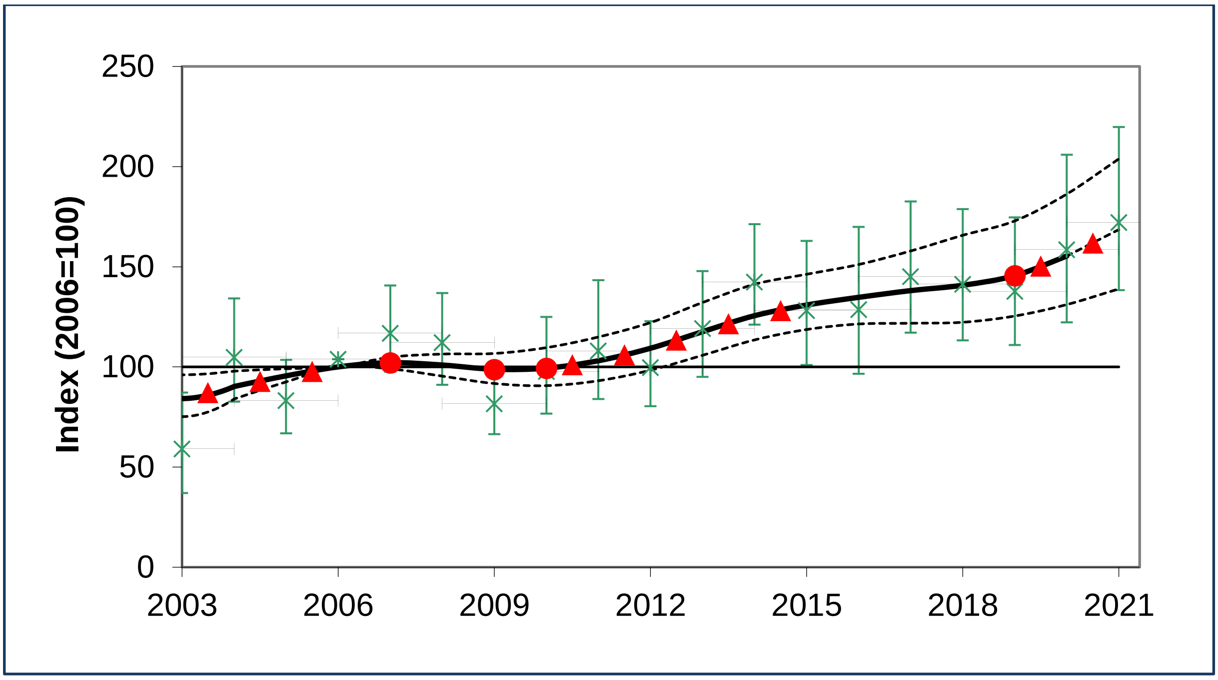

Figure 2.5 Results of the Generalised Additive Model (GAM)/Generalised Linear Model (GLM) model for common pipistrelle data. Points are estimated annual means derived from the GLM and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted GAM curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2020-2021 and the possibility that the slope will change with coming years' data. Red circles indicate significant (p<0.05) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant (p<0.05). The model is fitted with covariates for each detector to allow for different detection rates.

Table 2.4 Generalised Additive Model (GAM) results for common pipistrelles with 95% confidence limits (using first 15 transects from the 2003-2008 dataset).

Year	Sites	Surveys	Mean Passes	Smoothed (GAM) Estimate	S.E.	Conf. Interval (lower 95%)	Conf. Interval (upper 95%)	Unsmoothed Estimate	S.E.
2003	7	9	16.44	84.20	5.47	75.16	96.04	55.20	12.10
2004	17	27	24.89	90.21	3.62	83.97	97.88	100.94	13.04
2005	17	31	20.94	95.53	1.70	92.52	99.09	79.42	9.36
2006	25	45	23.13	100.00	0.00	100.00	100.00	100.00	0.00
2007	26	46	24.63	102.10	1.49	99.03	104.84	113.07	11.10
2008	23	42	24.07	100.93	2.77	95.39	106.40	108.34	11.55
2009	28	53	17.66	98.81	3.85	91.71	106.70	77.75	9.14
2010	27	53	20.55	99.37	4.85	90.63	109.61	93.91	12.74
2011	28	53	21.79	103.08	5.61	93.09	114.93	104.25	15.08
2012	27	45	19.00	109.30	6.16	98.35	122.12	95.90	10.82
2013	26	49	21.39	117.57	6.71	105.78	132.13	115.39	13.44
2014	27	49	28.86	125.56	7.10	113.45	141.24	138.64	13.27
2015	28	53	27.92	130.89	7.28	118.65	146.24	124.42	15.62
2016	28	51	30.35	134.72	7.75	121.41	151.11	124.75	18.63
2017	28	70	46.29	138.08	9.18	121.79	157.86	141.24	16.51
2018	28	81	48.30	140.76	10.86	122.28	165.70	137.44	16.79
2019	28	92	47.00	145.56	12.01	125.39	172.87	133.99	16.17
2020	25	45	97.91	155.36	13.60	131.11	186.29	154.77	20.71
2021	28	54	106.39	168.54	16.15	138.94	203.84	168.27	20.32

2.2.4 Soprano Pipistrelle

Soprano pipistrelles have been the second most frequently encountered species during the monitoring scheme in most survey years to-date. The different features of the Batlogger M means that the soprano pipistrelle encounter rate has increased relative to that of Leisler's bat.

Figure 2.6 compares the mean encounter rate per hour of the soprano pipistrelle over the past three years of the survey, 2019-2021. Abundance of this species is variable across the island. Unlike the common pipistrelle, soprano pipistrelle shows no particular southern bias.

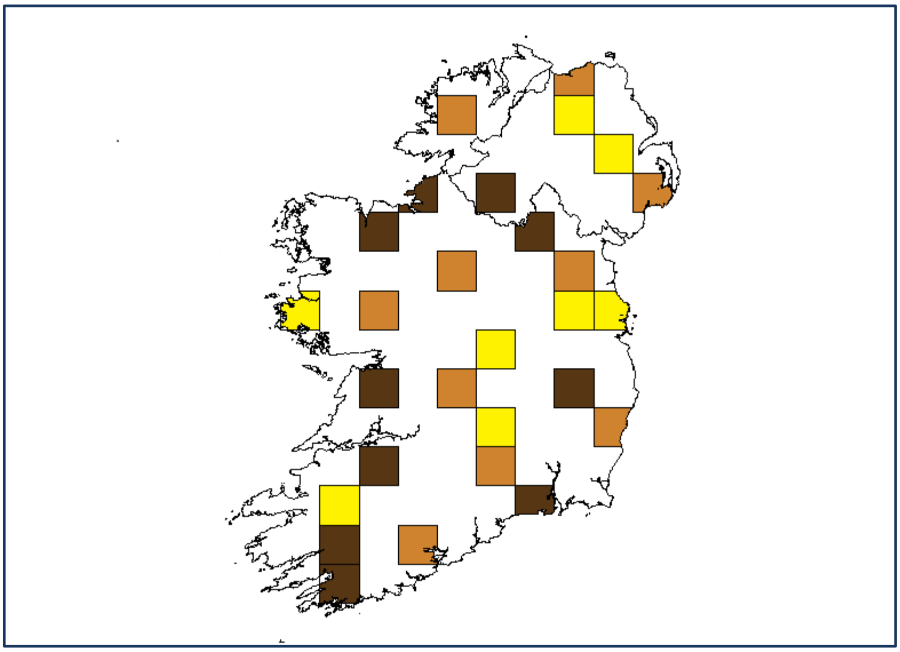

Figure 2.6 Survey squares colour coded according to mean soprano pipistrelle encounter rates using Batlogger detectors (per hour) from 2019-2021. The overall average rate of soprano pipistrelle encounters for all squares from 2019-2021 was 55.5hr^{-1}.

Encounter rate >0≤40hr^{-1}

Encounter rate >40≤60hr^{-1}

Encounter rate >60hr^{-1}

2.2.4.1 Soprano Pipistrelle Trend

Soprano pipistrelles have significantly increased from 2003 to 2021. The lower 95% confidence interval around the smoothed trend well exceeds the 2006 baseline index (Figure 2.7, Table 2.5). The highest yearly estimate in the trend series was in 2017 (Figure 2.7) but 2021 saw a similarly high yearly estimate. In the past twelve years (2010-2021) this species has increased by 79% in total, equivalent to a per annum increase of 4.97%, see Table 2.4. Since the start of the car survey scheme in 2003, the species' index has increased by 176%.

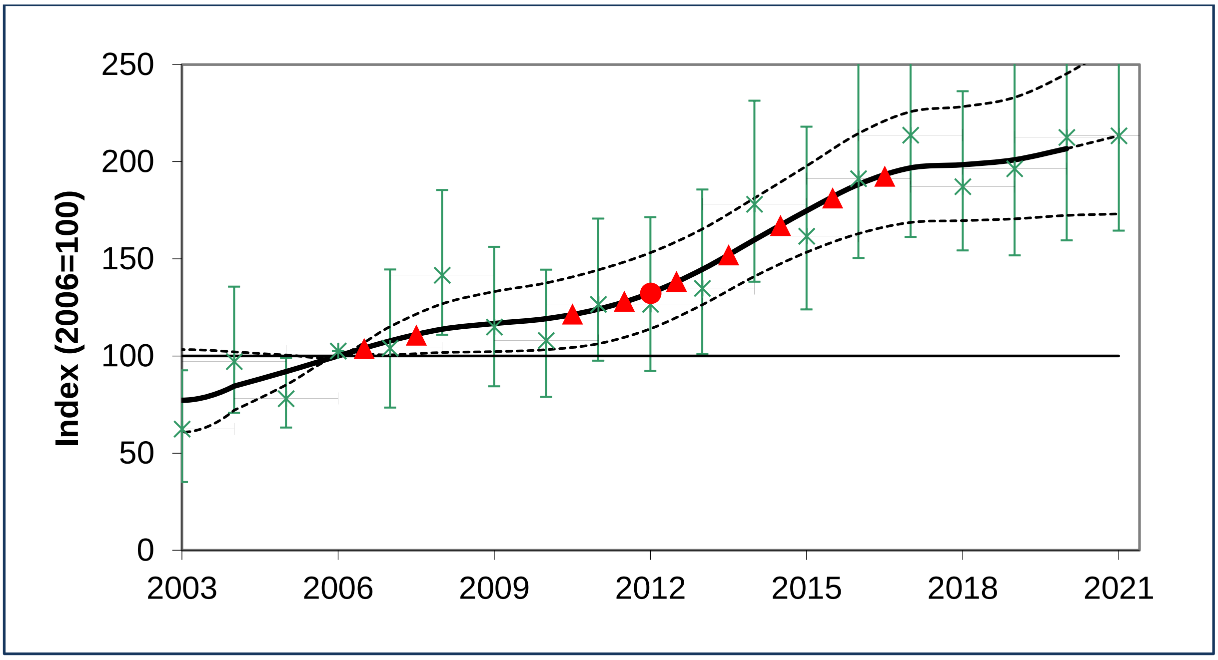

Figure 2.7 Results of the Generalised Additive Model (GAM)/Generalised Linear Model (GLM) model for soprano pipistrelle data. Points are estimated annual means derived from the GLM and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted GAM curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2020-2021 and the possibility that the slope will change with coming years' data. Red circles indicate significant ($p<0.05$) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant ($p<0.05$). The model is fitted with covariates for each detector to allow for different detection rates.

Table 2.5 Generalised Additive Model (GAM) results for soprano pipistrelles with 95% confidence limits (using first 15 transects from the 2003-2008 dataset).

Year	Sites	Surveys	Mean Passes	Smoothed (GAM) Estimate	S.E.	Conf. Interval (lower 95%)	Conf. Interval (upper 95%)	Unsmoothed Estimate	S.E.
2003	7	9	6.78	77.18	10.76	60.76	103.28	59.90	15.00
2004	17	27	9.96	84.44	7.60	72.04	102.09	94.64	16.92
2005	17	31	7.52	91.95	3.89	85.06	100.51	75.59	8.97
2006	25	45	9.51	100.00	0.00	100.00	100.00	100.00	0.00
2007	26	46	8.96	107.76	3.67	100.55	115.11	101.48	18.44
2008	23	42	11.98	113.78	6.38	101.79	126.82	139.09	19.26
2009	28	53	10.34	116.71	7.91	102.24	133.12	112.37	18.12
2010	27	53	9.79	119.18	8.91	103.23	137.60	105.49	17.24
2011	28	53	11.11	124.11	9.71	106.30	144.30	124.04	19.06
2012	27	45	11.27	132.37	10.10	113.99	153.15	124.14	19.85
2013	26	49	11.78	144.57	10.06	126.37	165.34	132.29	21.15
2014	27	49	15.65	159.76	10.12	140.94	181.25	175.61	23.93
2015	28	53	14.68	174.70	11.09	153.35	197.76	159.09	24.07
2016	28	51	17.57	188.34	13.00	162.97	214.54	188.80	25.29
2017	28	70	30.87	196.82	14.67	168.74	225.73	211.27	33.09
2018	28	81	29.85	198.45	14.93	169.65	228.35	184.68	20.53
2019	28	92	32.54	200.99	15.84	170.59	233.10	193.87	28.14
2020	25	45	59.31	206.73	18.43	172.36	245.30	209.99	36.44
2021	28	54	59.26	213.37	22.42	173.12	261.47	210.86	31.64

2.2.5 Leisler's Bat

Leisler's bats have been the third most frequently encountered species during the monitoring scheme in most survey years to-date. Like the common pipistrelle, this species tends to show some southern bias in its abundance; more squares with high numbers of passes are found in the south and east. Figure 2.8 compares the mean Batlogger M encounter rate per hour for Leisler's bat for each square from 2019-2021.

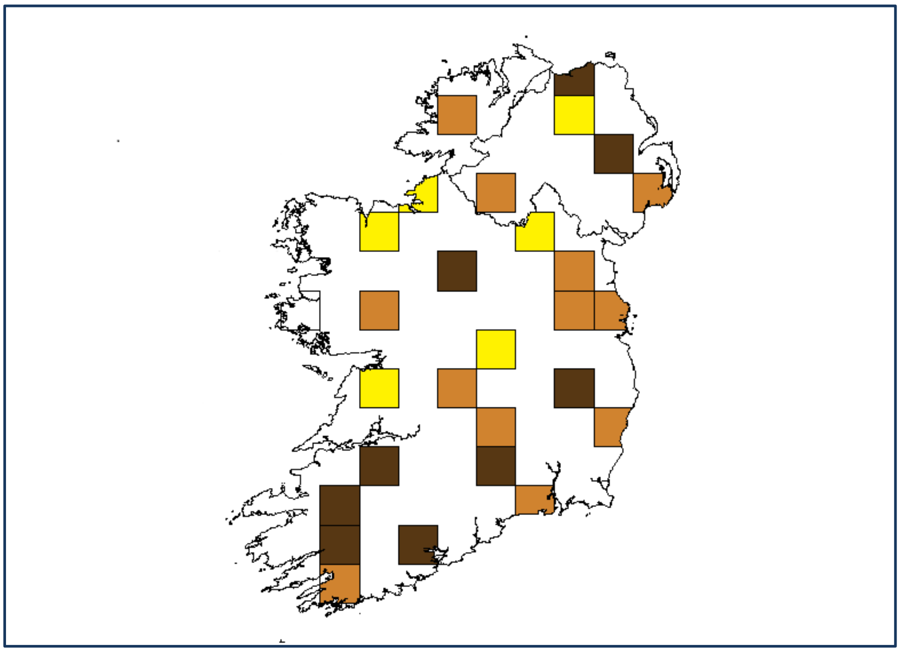

Figure 2.8 Survey squares colour coded according to mean Leisler's bat encounter rates from Batlogger detectors (per hour) from 2019-2021. The overall average rate of Leisler's bat encounters for all squares from 2019-2021 was 22.3hr^{-1}.

Encounter rate >0≤12hr^{-1}

Encounter rate >12≤24hr^{-1}

Encounter rate >24hr^{-1}

2.2.5.1 Leisler's Bat Trend

Leisler's bat showed a significant increase from the survey start year until 2014 when the trend turned downwards. The trend direction changed around 2017/2018 and began to increase again. The lower 95% confidence interval around the smoothed trend currently sits above the 2006 baseline index (Figure 2.9, Table 2.6). The highest yearly estimate in the trend series was in 2021 (Figure 2.9). In the past twelve years (2010-2021) this species has increased by 50.6% in total, equivalent to a per annum increase of 3.5%. Since the start of the car survey scheme in 2003, the species' index has increased by 166%.

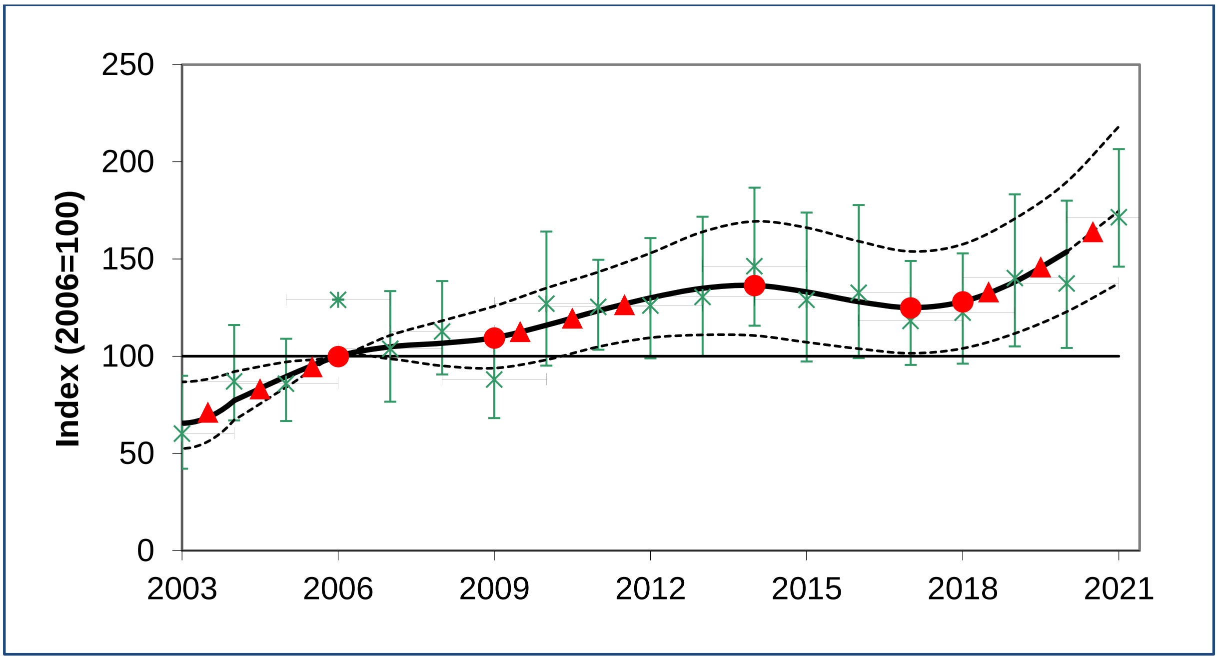

Figure 2.9 Results of the Generalised Additive Model (GAM)/ Generalised Linear Model (GLM) model for Leisler's bat data. Points are estimated annual means derived from the GLM and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted GAM curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2020-2021 and the possibility that the slope will change with coming years' data. Red circles indicate significant ($p<0.05$) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant ($p<0.05$). The model is fitted with covariates for each detector to allow for different detection rates.

Table 2.6 Generalised Additive Model (GAM) results for Leisler's bat with 95% confidence limits (using first 15 transects from the 2003-2008 dataset).

Year	Sites	Surveys	Mean Passes	Smoothed (GAM) Estimate	S.E.	Conf. Interval (lower 95%)	Conf. Interval (upper 95%)	Unsmoothed Estimate	S.E.
2003	7	9	5.11	65.55	8.77	52.54	86.81	31.17	12.58
2004	17	27	7.67	77.19	6.40	67.20	92.09	57.96	12.45
2005	17	31	7.68	89.52	3.30	84.04	97.04	56.94	10.98
2006	25	45	13.09	100.00	0.00	100.00	100.00	100.00	0.00
2007	26	46	8.93	104.86	3.22	98.64	110.74	74.82	14.45
2008	23	42	9.90	106.72	6.04	95.06	118.26	83.72	12.41
2009	28	53	7.13	109.49	8.21	93.89	125.75	59.09	11.63
2010	27	53	11.91	115.97	9.56	98.14	135.06	98.09	18.09
2011	28	53	11.08	123.39	9.97	104.88	143.35	96.37	12.17
2012	27	45	11.02	130.01	11.13	109.52	153.02	97.07	15.89
2013	26	49	11.04	134.95	13.29	110.98	163.96	101.53	18.18
2014	27	49	14.24	136.43	14.93	110.63	169.36	117.33	18.20
2015	28	53	12.55	133.09	15.00	107.19	166.13	100.02	20.24
2016	28	51	13.55	128.06	14.04	103.88	159.15	103.60	20.23
2017	28	70	13.01	125.00	13.01	101.53	153.91	89.08	13.40
2018	28	81	13.06	128.13	13.22	104.02	157.60	93.34	14.46
2019	28	92	15.77	138.27	14.92	111.70	170.72	111.13	19.83
2020	25	45	20.40	153.72	16.87	122.91	189.69	108.42	19.46
2021	28	54	26.44	174.70	20.22	137.52	218.14	142.47	15.29

2.2.6 Nathusius' Pipistrelle

Nathusius' pipistrelle remains one of the least encountered species from the survey. Over the past three years (2019-2021), however, encounter rates have increased due to the roll out of Batlogger detectors. Figure 2.10 shows squares where the species was encountered using Batloggers, graded according to the rate of passes per hour. The mean encounter rate from square J06, east of Lough Neagh, at $27hr^{-1}$, is more than ten times the mean of all squares combined. While no Nathusius' bats were encountered in C72 in the three years using Batlogger detectors, just two surveys were carried out there with these detectors in that timeframe.

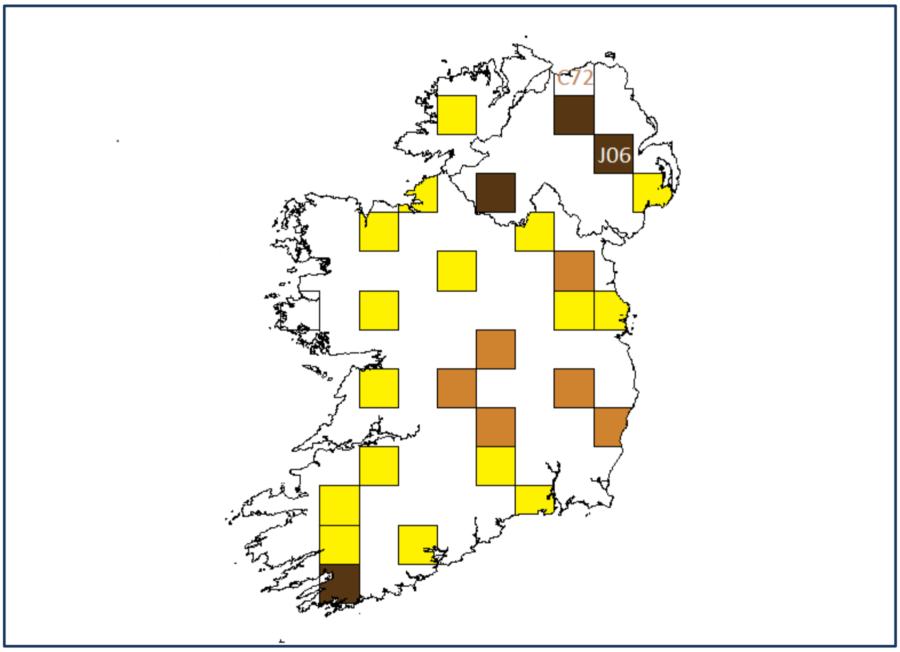

Figure 2.10 Survey squares colour coded according to mean Nathusius' pipistrelle encounter rates from Batlogger detectors (per hour) from 2019-2021. The overall average rate of Nathusius' bat encounters for all squares from 2019-2021 was $2.2hr^{-1}$.

Encounter rate $>0\leq1.5hr^{-1}$

Encounter rate $>1.5\leq3hr^{-1}$

Encounter rate $>3hr^{-1}$

2.2.6.1 Nathusius' Pipistrelle Trend

Due to its rarity there is considerable uncertainty about the trend for this species, as indicated by the very wide confidence intervals (Figure 2.11, Table 2.7). However, as far as can be determined at present, the species is likely to be slightly increasing. Interpretation of trends should be treated with caution due to the very large variability between years and wide error bars.

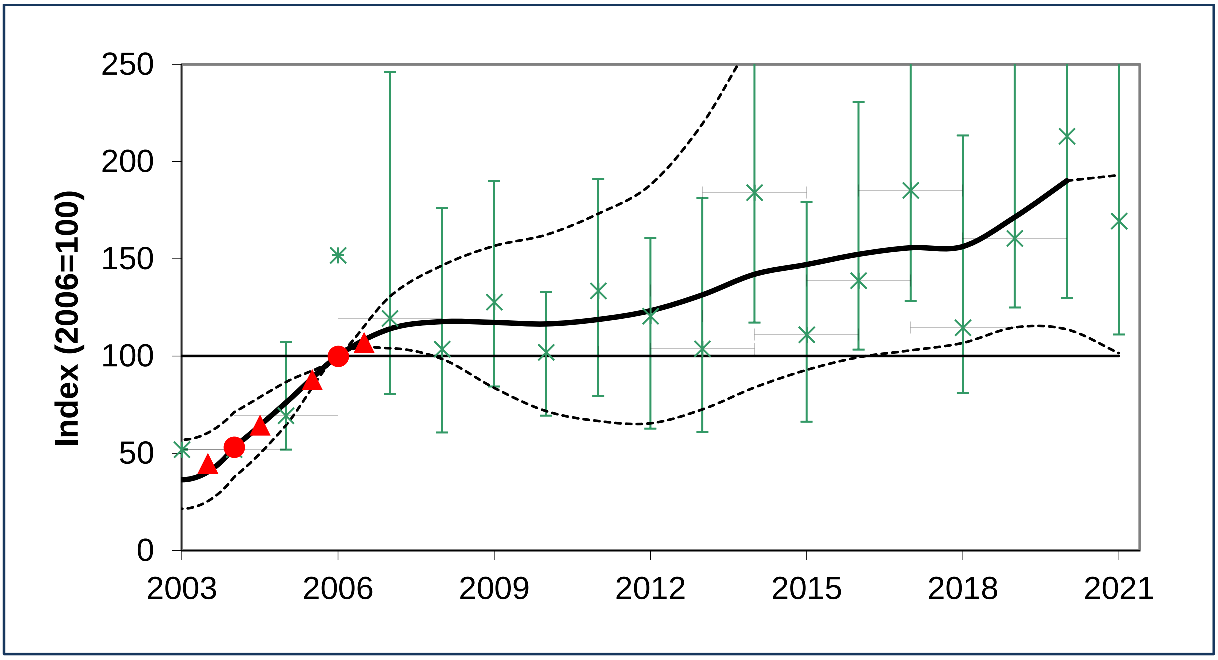

Figure 2.11 Results of the Generalised Additive Model (GAM)/Generalised Linear Model (GLM) model for Nathusius' pipistrelle data. Points are estimated annual means derived from the GLM and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted GAM curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2020-2021 and the possibility that the slope will change with coming years' data. Red circles indicate significant ($p<0.05$) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant ($p<0.05$). The model is fitted with covariates for each detector to allow for different detection rates.

Table 2.7 Generalised Additive Model (GAM) results for Nathusius' pipistrelle bat with 95% confidence limits (using first 15 transects from the 2003-2008 dataset).

Year	Sites	Surveys	Mean Passes	Smoothed (GAM) Estimate	S.E.	Conf. Interval (lower 95%)	Conf. Interval (upper 95%)	Unsmoothed Estimate	S.E.
2003	7	9	0.00	36.34	9.19	21.40	56.92	0.07	0.05
2004	17	28	0.00	53.20	8.62	37.61	70.99	0.10	0.07
2005	17	31	0.00	75.98	5.80	64.36	86.58	17.60	17.20
2006	25	45	0.02	100.00	0.00	100.00	100.00	100.00	0.00
2007	26	46	0.02	113.95	6.69	103.96	130.63	67.58	46.16
2008	23	42	0.01	117.67	12.15	98.47	146.55	51.76	31.31
2009	28	53	0.01	117.26	18.05	83.59	156.60	76.00	28.07
2010	27	53	0.01	116.48	22.84	71.65	162.35	50.19	16.18
2011	28	53	0.02	118.78	26.90	66.54	173.18	81.77	27.08
2012	27	45	0.02	123.28	31.08	65.38	188.00	68.68	27.47
2013	26	49	0.01	131.44	38.38	72.53	219.40	51.86	31.59
2014	27	49	0.03	142.02	47.38	83.79	263.13	132.20	66.35
2015	28	53	0.01	147.03	51.96	92.81	291.93	59.17	28.90
2016	28	51	0.02	152.31	56.03	99.34	310.86	86.93	35.17
2017	28	70	0.03	155.68	57.78	102.88	314.76	133.38	65.06
2018	28	81	0.02	156.28	54.36	106.70	308.04	62.84	34.82
2019	28	92	0.04	171.42	60.20	114.69	345.58	108.69	38.31
2020	25	45	0.09	190.15	79.12	113.66	421.63	161.32	118.81
2021	28	54	0.06	193.00	97.42	101.45	470.07	117.61	77.78

2.2.7 *Myotis* bat species

Occasional records for *Myotis* species are collected by the Car-based Bat Monitoring Scheme. These records are widespread but infrequent across the island. *Myotis* spp. bat passes could be Natterer's, Daubenton's or whiskered bats but it is not possible to definitively identify them to species level. Since 2017, Batlogger detectors have been fully rolled out and overall encounter rates with this species group have increased due to the fact that these detectors record continuously. Tranquility detectors recorded for just 1/11th of the time spent surveying. Figure 2.12 shows squares where the species group was encountered using Batloggers, graded according to the rate of passes per hour. The overall mean encounter rate 2019-2021 was 1.3hr^{-1}.

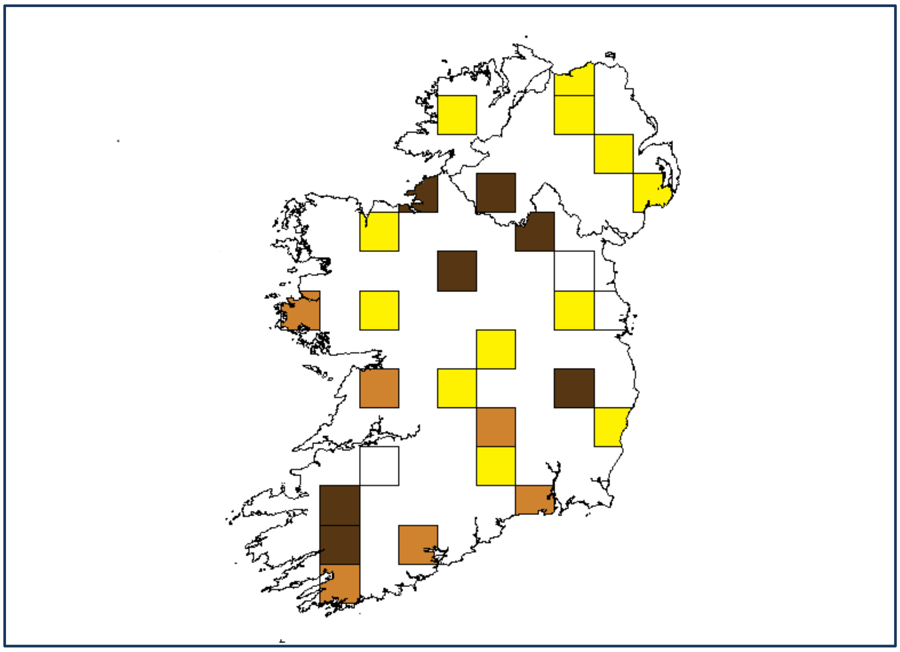

Figure 2.12 Survey squares colour coded according to mean *Myotis* spp. encounter rates from Batlogger detectors (per hour) from 2019-2021. The overall average rate of *Myotis* spp. encounters for all squares from 2019-2021 was 1.3hr^{-1}.
Encounter rate >0≤1.0hr^{-1}
Encounter rate >1.0≤2hr^{-1}
Encounter rate >2hr^{-1}

2.2.7.1 *Myotis* spp. Trend

In 2018 we reported on a possible downward trend in this group of species (Aughney *et al.*, 2018). However, we also noted that, due to the wide error bars around the trend and the fact that the index comprises a number of species, that the trend should be interpreted with caution. Despite the fact that our trend analysis now accounts for differences in detection rates between the two detectors by including co-variates for detector type, we have continued to see a concerning downward trend over the past few years. The use of Batloggers has resulted in narrower error bars, which means we can be more certain that this trend is accurate. As can be seen in Figure 2.13, the upper error bar is now significantly below the 2006 baseline. There is no obvious spatial pattern to the decline. A regression model suggests that there has been a decline from 2014 at 23 of the 28 survey squares.

The highest yearly estimate in the trend series was in the second year of the survey, 2004. In the past twelve years (2010-2021) this species group has decreased by 57% in total, equivalent to a per annum decrease of 6.8%. Since the start of the car survey scheme in 2003, the species' index has decreased by 76% with particularly steep declines in the most recent six years of the survey.

These results will be further discussed in Section 6.

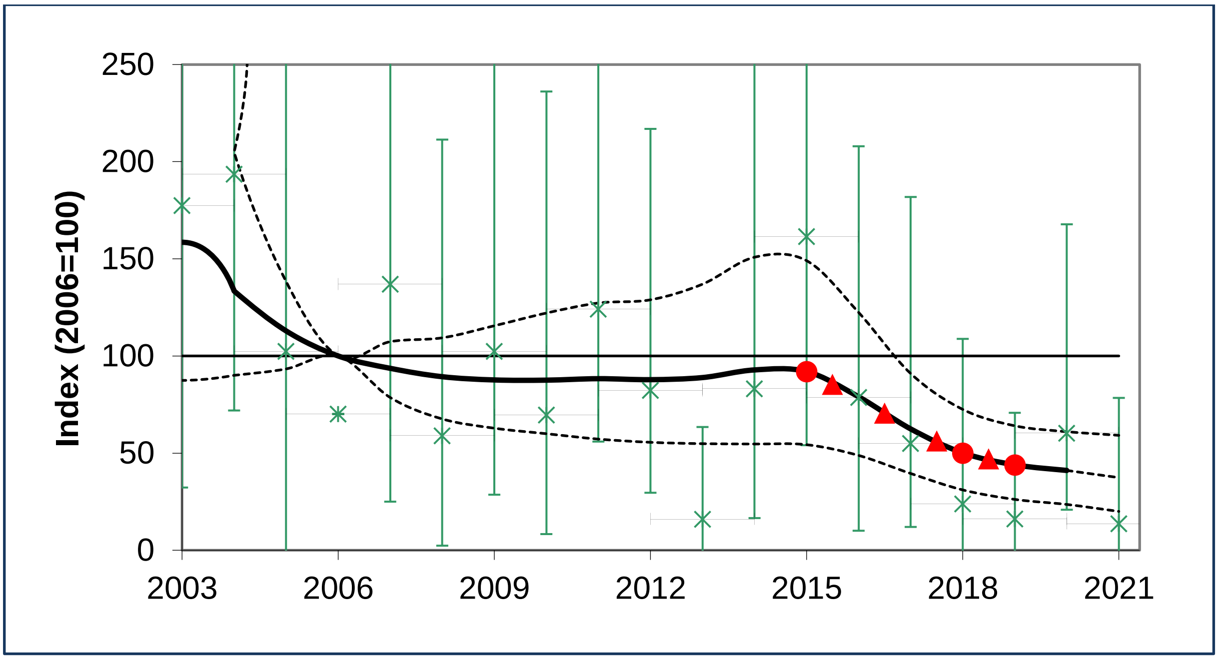

Figure 2.13 Results of the Generalised Additive Model (GAM)/Generalised Linear Model (GLM) model for *Myotis* spp. data. Points are estimated annual means derived from the GLM and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted GAM curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2020-2021 and the possibility that the slope will change with coming years' data. Red circles indicate significant (p<0.05) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant (p<0.05). The model is fitted with covariates for each detector to allow for different detection rates.

Table 2.8 Generalised Additive Model (GAM) results for *Myotis* spp. with 95% confidence limits (using first 15 transects from the 2003-2008 dataset).

Year	Sites	Surveys	Mean Passes	Smoothed (GAM) Estimate	S.E.	Conf. Interval (lower 95%)	Conf. Interval (upper 95%)	Unsmoothed Estimate	S.E.
2003	7	9	0.78	158.51	57.33	87.42	309.86	207.33	158.51
2004	17	27	0.78	133.45	29.65	90.03	204.89	223.50	133.45
2005	17	31	0.52	112.89	11.79	93.33	138.29	132.31	112.89
2006	25	45	0.38	100.00	0.00	100.00	100.00	100.00	100.00
2007	26	46	0.59	93.65	7.42	78.60	107.36	166.85	93.65
2008	23	42	0.31	89.31	10.67	67.57	109.35	88.85	89.31
2009	28	53	0.47	87.65	13.60	62.82	115.54	132.36	87.65
2010	27	53	0.36	87.55	16.11	59.98	122.10	99.49	87.55
2011	28	53	0.53	88.30	17.85	57.21	127.26	154.09	88.30
2012	27	45	0.40	87.80	18.61	55.55	128.91	112.15	87.80
2013	26	49	0.16	88.88	20.33	54.84	136.95	45.93	88.88
2014	27	49	0.39	92.81	23.67	54.68	150.83	112.99	92.81
2015	28	53	0.70	91.98	24.39	54.32	149.05	191.34	91.98
2016	28	51	0.39	78.99	18.82	48.79	122.39	108.56	78.99
2017	28	70	0.70	62.45	13.38	39.50	90.96	84.89	62.45
2018	28	81	0.54	50.12	10.63	31.05	72.50	53.73	50.12
2019	28	92	0.47	43.95	9.41	26.16	64.05	46.06	43.95
2020	25	45	1.82	41.07	9.47	23.57	61.03	90.20	41.07
2021	28	54	0.93	37.38	9.83	19.98	59.14	43.64	37.38

2.2.8 Brown Long-eared Bat

This species was encountered for the first time by the Car-based Bat Monitoring Scheme in 2007. It is largely undetectable during the car surveys due to its quiet echolocation calls. However, it does occasionally produce social calls of higher amplitude (loudness) that may be recorded.

Figure 2.14 shows squares where the species was encountered using Batloggers, graded according to the rate of passes per hour. The overall mean encounter rate 2019-2021 is the lowest of all the species/species groups detected at $0.3hr^{-1}$.

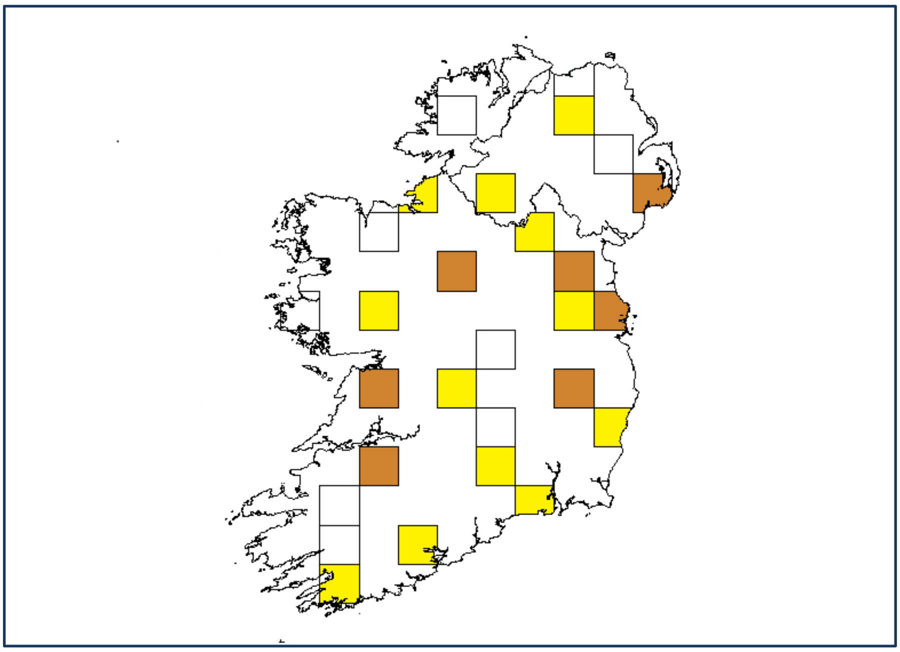

Figure 2.14 Survey squares colour coded according to mean brown long eared bat encounter rates from Batlogger detectors (per hour) from 2019-2021. The overall average rate of brown long eared bat encounters for all squares from 2019-2021 was $0.3hr^{-1}$.

Encounter rate $>0\leq0.5hr^{-1}$

Encounter rate $>0.5hr^{-1}$

2.2.8.1 Brown Long-eared Bat Trend (Car-based Monitoring)

The limited data for this species gathered by the car-based scheme shows a fluctuating trend (Figure 2.15, Table 2.9). The index currently encompasses the 2010 baseline and shows little significant change since 2007. Despite some large fluctuations, in the past twelve years (2010-2021) this species has remained relatively stable with just a -0.1% annual change. The highest yearly estimate in the trend series was in 2013. It is interesting to compare results from this scheme with the more robust Brown Long-eared Bat Roost Monitoring Scheme where the current trend for this species is also stable with a slight downward trend compared to 2020 (Section 4, Table 4.5 and Figure 4.5). Overall the smoothed index using the model with covariates for the roost monitoring scheme is currently 6.37% above the 2009 base year value which is equivalent to an average 0.52% annual increase.

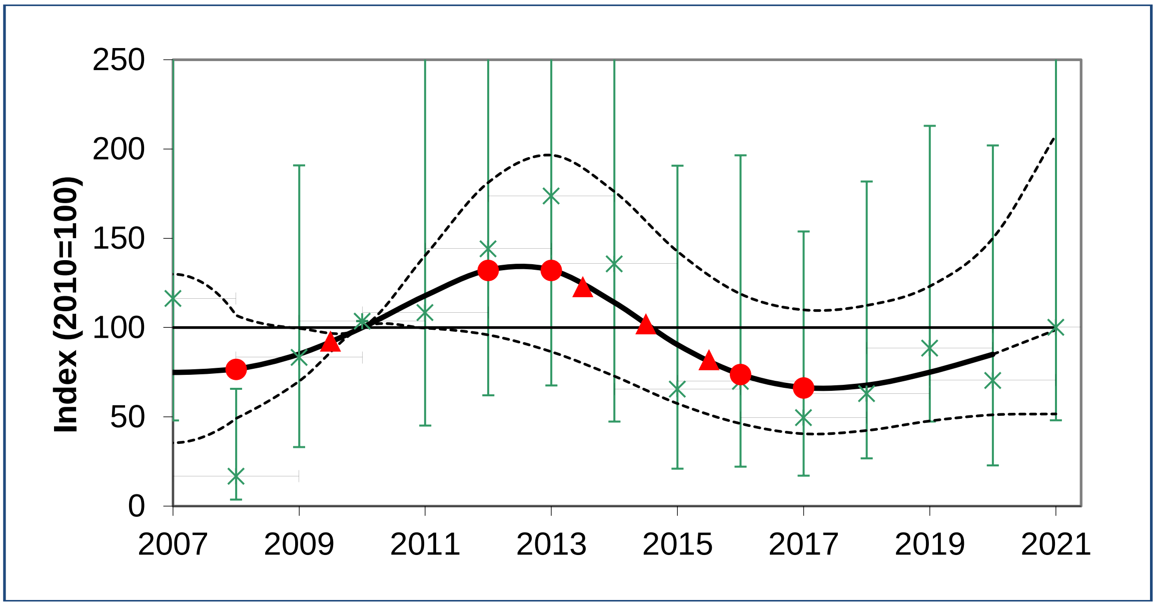

Figure 2.15 Results of the Generalised Additive Model (GAM)/Generalised Linear Model (GLM) model for brown long-eared bat data. Points are estimated annual means derived from the GLM and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted GAM curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2020-2021 and the possibility that the slope will change with coming years' data. Red circles indicate significant ($p<0.05$) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant ($p<0.05$). The model is fitted with covariates for each detector to allow for different detection rates.

Table 2.9 Generalised Additive Model (GAM) results for brown long-eared bat with 95% confidence limits (using first 15 transects from the 2003-2008 dataset).

Year	Sites	Surveys	Mean Passes	Smoothed (GAM) Estimate	S.E.	Conf. Interval (lower 95%)	Conf. Interval (upper 95%)	Unsmoothed Estimate	S.E.
2007	26	46	0.01	74.90	24.55	35.44	129.90	112.75	71.61
2008	23	42	0.00	76.74	14.89	49.09	106.87	13.26	20.70
2009	28	53	0.01	85.15	7.58	69.97	99.51	79.69	45.96
2010	27	53	0.01	100.00	0.00	100.00	100.00	100.00	0.00
2011	28	53	0.01	117.87	10.19	99.71	140.44	104.85	65.84
2012	27	45	0.02	132.25	21.75	95.87	181.26	140.52	100.95
2013	26	49	0.02	132.19	28.61	86.45	196.55	170.23	126.84
2014	27	49	0.02	114.01	26.92	72.77	176.12	132.15	91.10
2015	28	53	0.01	90.40	21.77	57.44	142.62	62.00	53.18
2016	28	51	0.01	73.82	18.62	46.21	118.82	66.36	54.03
2017	28	70	0.01	66.42	17.48	40.52	109.91	46.03	41.06
2018	28	81	0.01	67.73	17.70	42.36	112.39	59.46	47.03
2019	28	92	0.02	75.00	19.15	47.68	123.13	84.88	51.85
2020	25	45	0.02	85.00	25.39	51.13	149.98	66.93	50.69
2021	28	54	0.03	98.72	41.45	51.62	207.88	96.68	68.18

2.2.9 National Distribution of Bats

2.2.9.1 Common Pipistrelle

A total of 15,004 common pipistrelle bat records are currently available for mapping (2010 to 2021 dataset). This dataset consists primarily of records from the Car-based Bat Monitoring surveys (n=12,312 records, 82%). The following table provides a breakdown of the sources of the records; they are distributed in all counties across the country.

Table 2.10 Sources of common pipistrelle bat records on the Bat Conservation Ireland database

Source of Records	No. of Records
Car-based Bat Monitoring Scheme	12,312
Brown long-eared bat Roost Monitoring Scheme	18
All Ireland Daubenton's Bat Waterways Survey	103
BATLAS 2020	1,539
Pilot Woodland Monitoring 2016-2017	54
BCIreland Neighbourhood Bats Survey	338
Ecological Consultancy Records	588
NPWS Related Sources	4
Other Sources	47

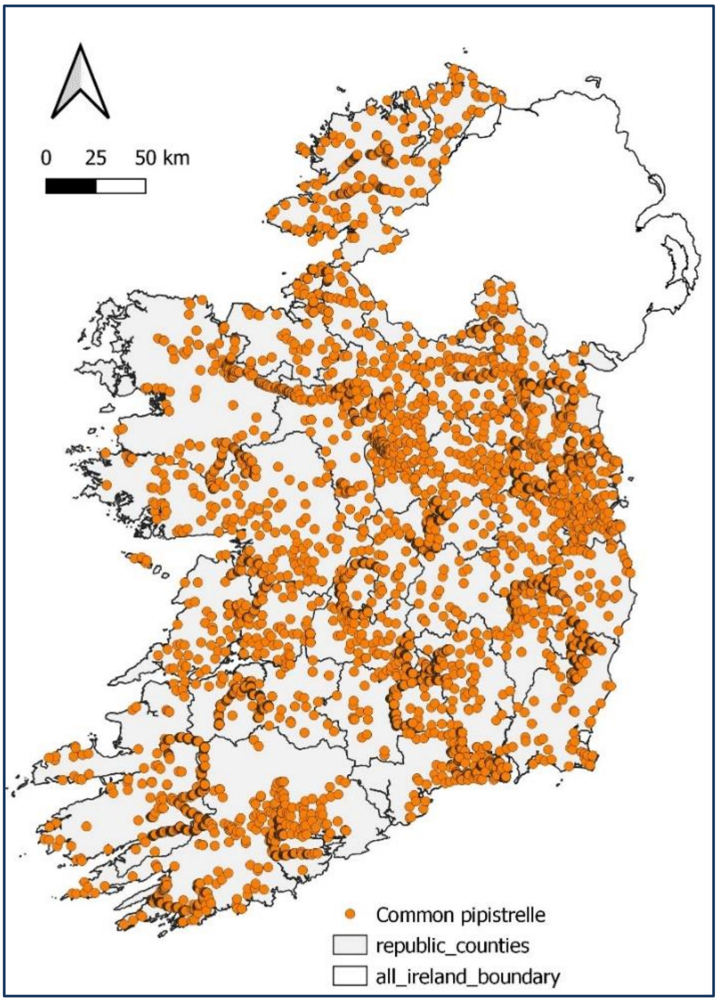

Figure 2.16 Common pipistrelle bat distribution in Ireland (BCIreland database 2010-2021).

2.2.9.2 Soprano Pipistrelle

A total of 9,636 soprano pipistrelle bat records are currently available for mapping (2010 to 2021 dataset). This dataset consists primarily of records from the Car-based Bat Monitoring surveys (n=6,475 records, 67%). The following table provides a breakdown of the sources of the records; they are distributed in all counties across the country.

Table 2.11 Sources of soprano pipistrelle bat records on the Bat Conservation Ireland database

Source of Records	No. of Records
Car-based Bat Monitoring Scheme	6,475
Brown long-eared bat Roost Monitoring Scheme	18
All Ireland Daubenton's Bat Waterways Survey	160
BATLAS 2020	1,991
Pilot Woodland Monitoring 2016-2017	54
BCIreland Neighbourhood Bats Survey	324
Ecological Consultancy Records	579
NPWS Related Sources	6
Other Sources	29

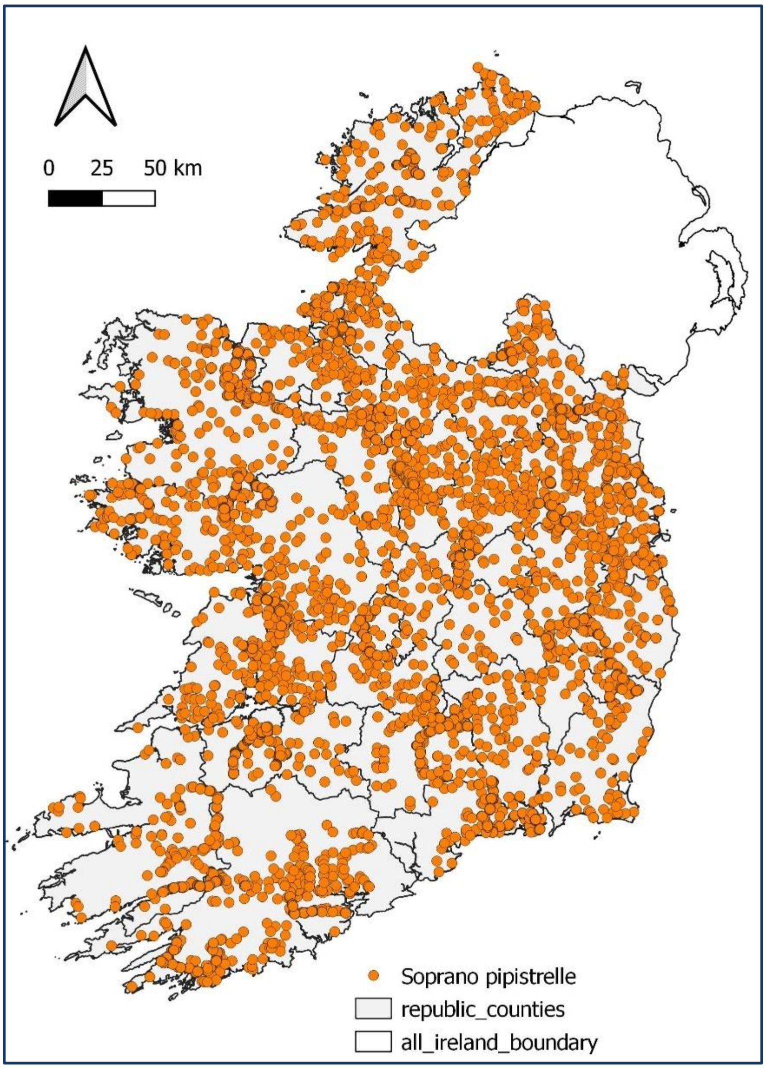

Figure 2.17 Soprano pipistrelle bat distribution in Ireland (BCIreland database 2010-2021).

2.2.9.3 Leisler's bat

A total of 7,180 Leisler's bat records are currently available for mapping (2010 to 2021 dataset). This dataset consists primarily of records from the Car-based Bat Monitoring surveys (n=5,220 records, 72.7%). The following table provides a breakdown of the sources of the records; they are distributed in all counties across the country.

Table 2.12 Sources of Leisler's bat records on the Bat Conservation Ireland database

Source of Records	No. of Records
Car-based Bat Monitoring Scheme	5,220
Brown long-eared bat Roost Monitoring Scheme	12
All Ireland Daubenton's Bat Waterways Survey	168
BATLAS 2020	947
Pilot Woodland Monitoring 2016-2017	50
BCIreland Neighbourhood Bats Survey	336
Ecological Consultancy Records	407
NPWS Related Sources	3
Other Sources	36

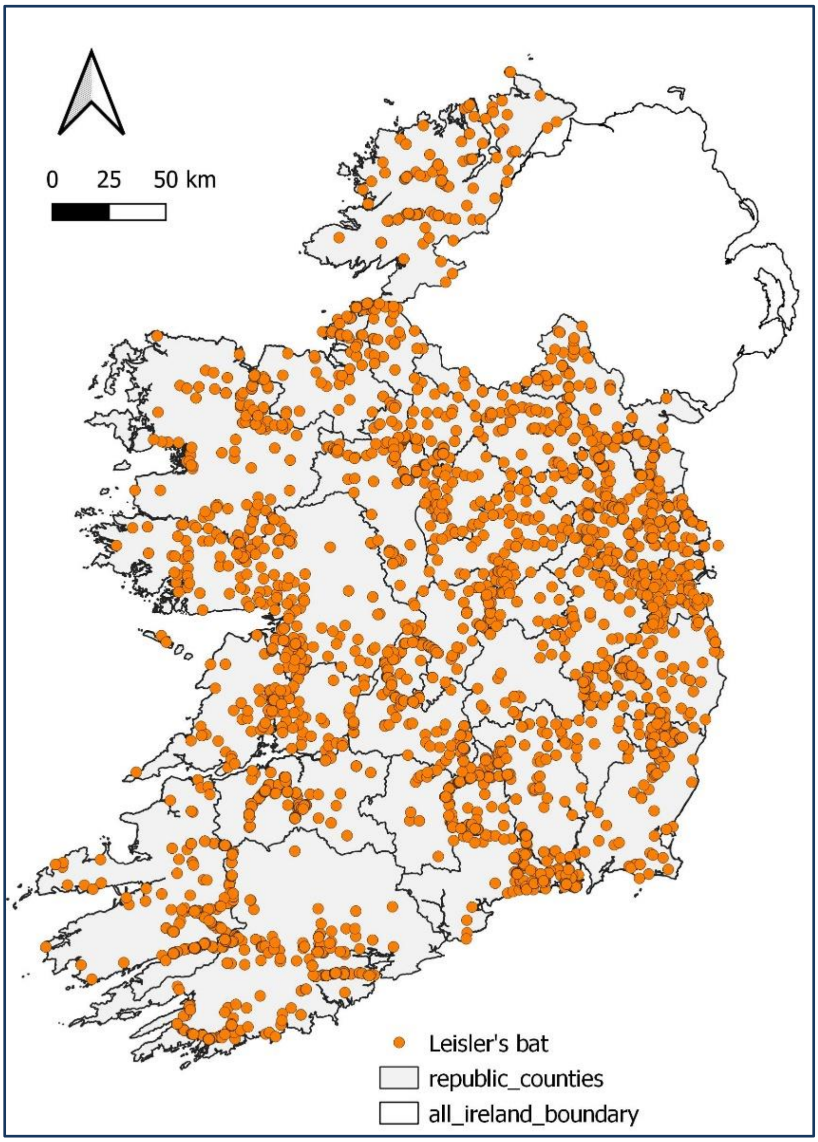

Figure 2.18 Leisler's bat distribution in Ireland (BCIreland database 2010-2021).

2.2.9.4 Nathusius' pipistrelle

A total of 148 Nathusius' pipistrelle bat records are currently available for mapping (2010 to 2021 dataset). This dataset consists primarily of records from the Car-based Bat Monitoring surveys (n=58 records, 39%). The following table provides a breakdown of the sources of the records; they are distributed in all counties across the country, albeit in low numbers.

Table 2.13 Sources of Nathusius' pipistrelle bat records on the Bat Conservation Ireland database

Source of Records	No. of Records
Car-based Bat Monitoring Scheme	58
All Ireland Daubenton's Bat Waterways Survey	3
BATLAS 2020	29
Pilot Woodland Monitoring 2016-2017	3
BCIreland Neighbourhood Bats Survey	34
Ecological Consultancy Records	19
Other Sources	2

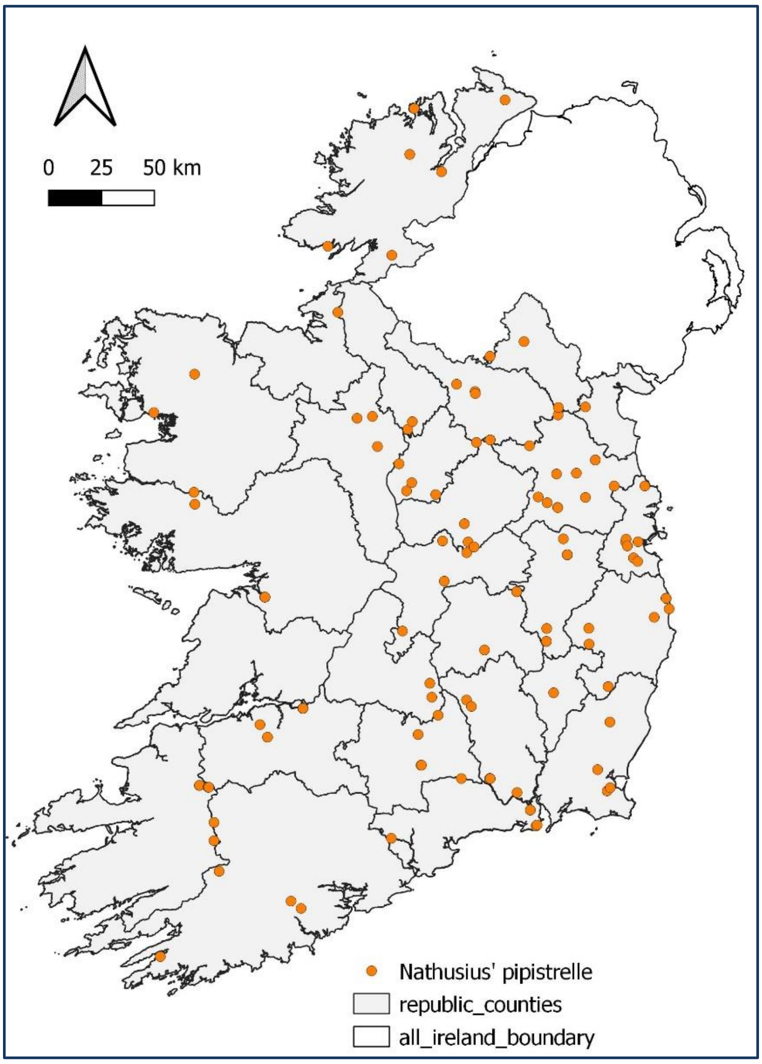

Figure 2.19 Nathusius' pipistrelle bat distribution in Ireland (BCIreland database 2010-2021).

2.2.9.5 *Myotis* species

The Car-based Bat Monitoring Scheme does not identify *Myotis* records to species level. Records are presented below firstly for records of *Myotis* species that have not been distinguished to species level and then separately for validated Natterer's bat and Whiskered bat records. Distribution records for confirmed Daubenton's bat are presented in Section 3.

A total of 560 *Myotis* bat records are currently available for mapping (2010 to 2021 dataset). This dataset consists of records from a number of surveys, but the highest proportion of records is derived from BATLAS 2020 surveys (n=216 records, 39%). The following table provides a breakdown of the sources of the records; they are distributed in all counties across the country, albeit in low numbers.

Table 2.14 Sources of *Myotis* bat records on the Bat Conservation Ireland database

Source of Records	No. of Records
Car-based Bat Monitoring Scheme	158
All Ireland Daubenton's Bat Waterways Survey	5
BATLAS 2020	216
Brown long-eared Roost Monitoring Scheme	1
Pilot Woodland Monitoring 2016-2017	1
BCIreland Neighbourhood Bats Survey	51
Ecological Consultancy Records	114
Other Sources	14

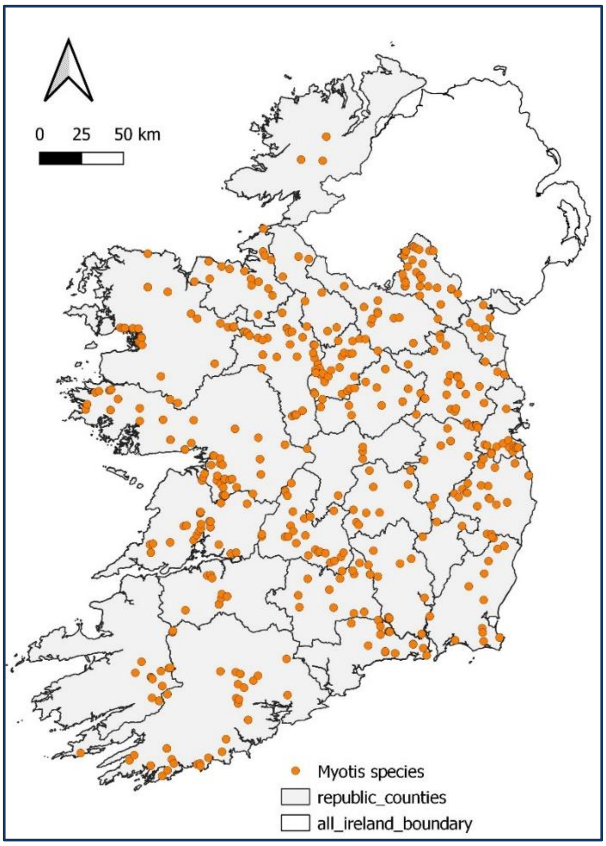

Figure 2.20 *Myotis* bat distribution in Ireland (BCIreland database 2010-2021).

A total of 246 validated Natterer's bat records are currently available for mapping (2010 to 2021 dataset). This dataset consists of records from a number of surveys, but the highest proportion of records has been collected by Ecological Consultancy surveys (n=102 records, 41%). The following table provides a breakdown of the sources of the records; they are distributed in all counties across the country, albeit in low numbers.

Table 2.15 Sources of validated Natterer's bat records on the Bat Conservation Ireland database

Source of Records	No. of Records
All Ireland Daubenton's Bat Waterways Survey	6
BATLAS 2020	63
Brown long-eared Roost Monitoring Scheme	4
Pilot Woodland Monitoring 2016-2017	26
BCIreland Neighbourhood Bats Survey	35
Ecological Consultancy Records	102
Other Sources	10

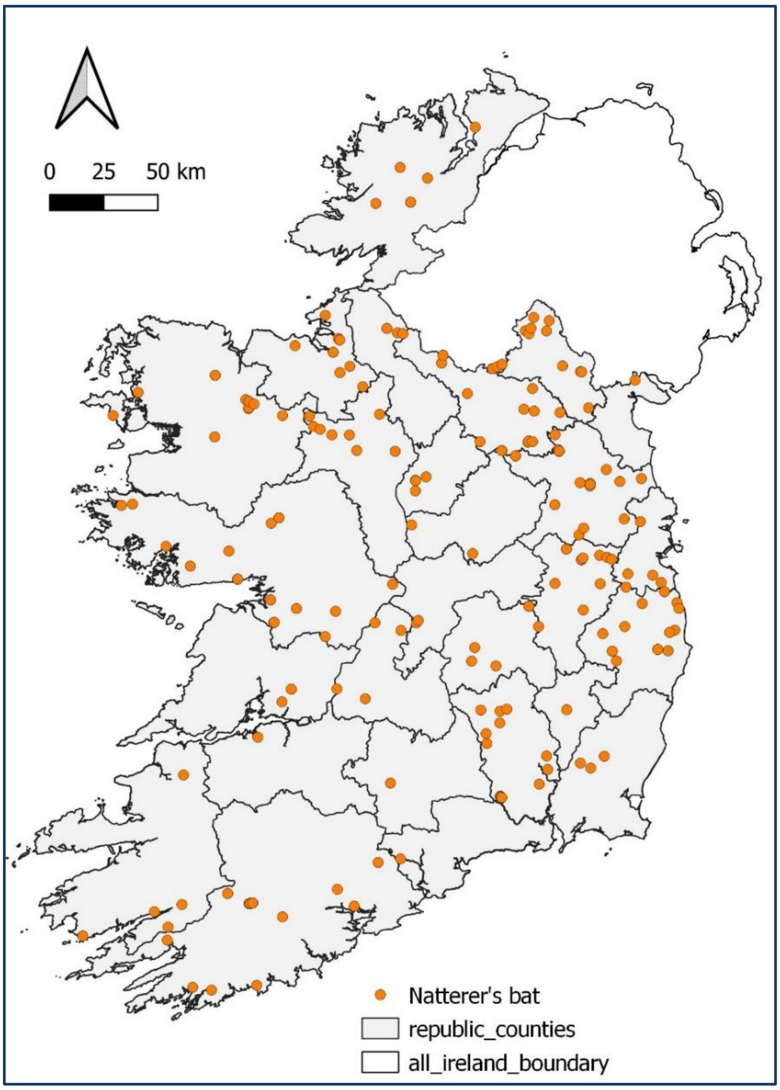

Figure 2.21 Natterer's bat distribution in Ireland (BCIreland database 2010-2021).

A total of 120 whiskered bat records are currently available for mapping (2010 to 2021 dataset). This dataset consists of records collected during a number of different surveys, but the highest proportion of records was collected from Pilot Woodland Monitoring 2016-2017 surveys (n=46 records, 38%). The following table provides a breakdown of the sources of the records; they are distributed across 24 counties in the country, albeit in low numbers. There are currently no records in the database for Counties Offaly and Kerry for the 2010 to 2021 dataset.

Table 2.16 Sources of whiskered bat records on the Bat Conservation Ireland database

Source of Records	No. of Records
All Ireland Daubenton's Bat Waterways Survey	1
BATLAS 2020	27
Brown long-eared Roost Monitoring Scheme	2
Pilot Woodland Monitoring 2016-2017	46
BCIreland Neighbourhood Bats Survey	17
Ecological Consultancy Records	25
Other Sources	2

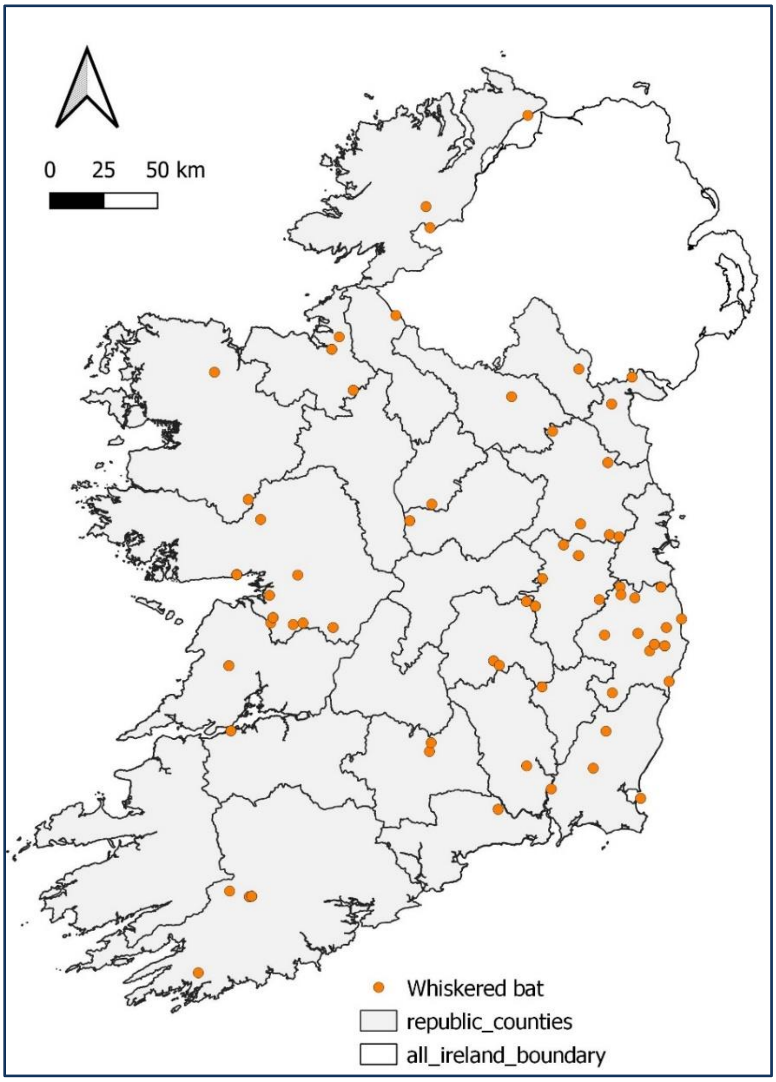

Figure 2.22 Whiskered bat distribution in Ireland (BCIreland database 2010-2021).

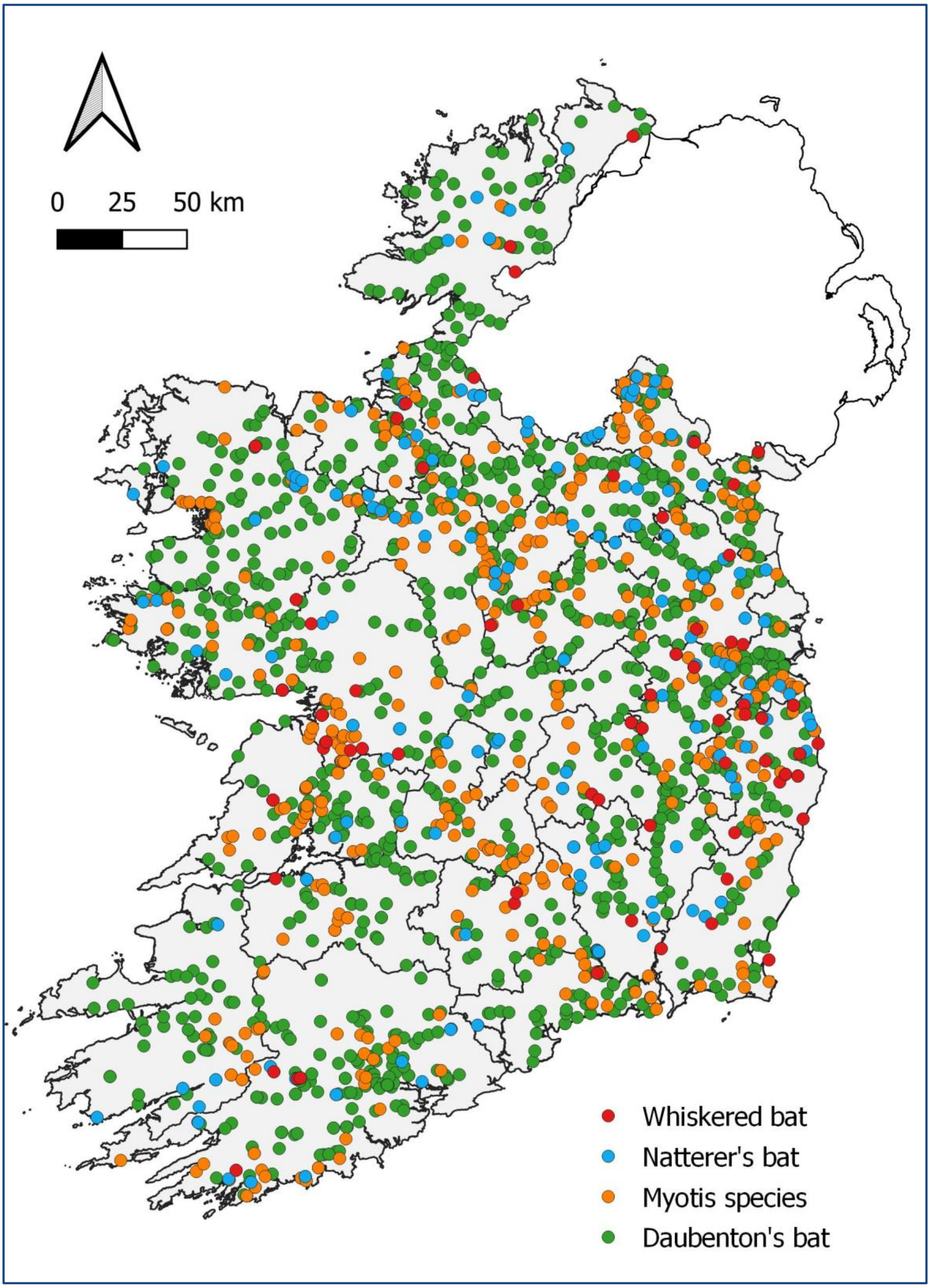

Figure 2.23 All *Myotis* species bat distribution in Ireland (BCIreland database 2010-2021).

2.2.10 Other Vertebrates

Surveyors are asked to record living and dead vertebrates that they encounter during the car-based bat surveys, within and between transects. This resulted in the collection of 5,122 records of living vertebrates (apart from bats) from 2006 to 2021. Figure 2.24 is a pie chart illustrating proportions of living vertebrate records attributed to species or species groups. In all survey years, records for living vertebrates have been dominated by cats. In most years, these accounted for over 50% of the records collected. Dogs and rabbits are the second most frequently encountered species with 482 and 486 records collected, respectively. Foxes are the next most common species (443 records). A number of species of conservation interest have been recorded by surveyors including otter, pine marten and owls.

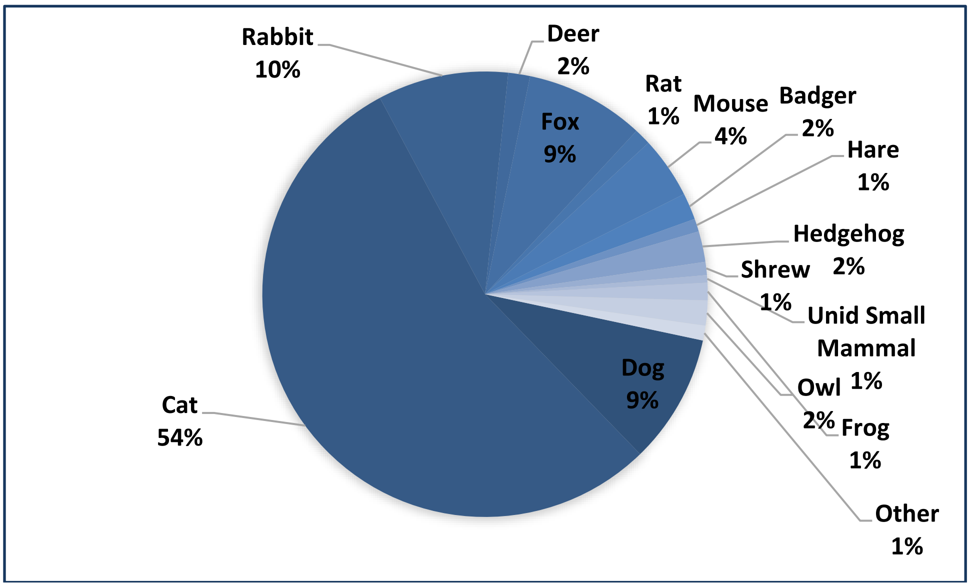

Figure 2.24 Living vertebrates, other than bats, recorded 2006-2021, n=5122

Records for living cats, foxes, rabbits, hedgehogs and badgers were analysed further using package rtrim in r (R Core Team, 2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/).

It is important to note, however, that these 'other vertebrate' data are not central to the Car-based Bat Monitoring Scheme and the survey was not designed with collection of these data in mind. Detection of cats, or any other non-Chiropteran species, is not necessarily standardised across the dataset so the trends reported below may be subject to error. In addition, the datasets for hedgehogs and badgers, in particular, include very high numbers of zeros which further reduces the reliability of the trend results.

2.2.10.1 Roadside Cats

All cat data from 2006-2021 for each survey square was tallied and divided by the total number of hours spent surveying that square. From this we derived raw data on cat occurrence per hour spent surveying and graded these data according to low, medium and high occurrence squares, see Figure 2.25 below.

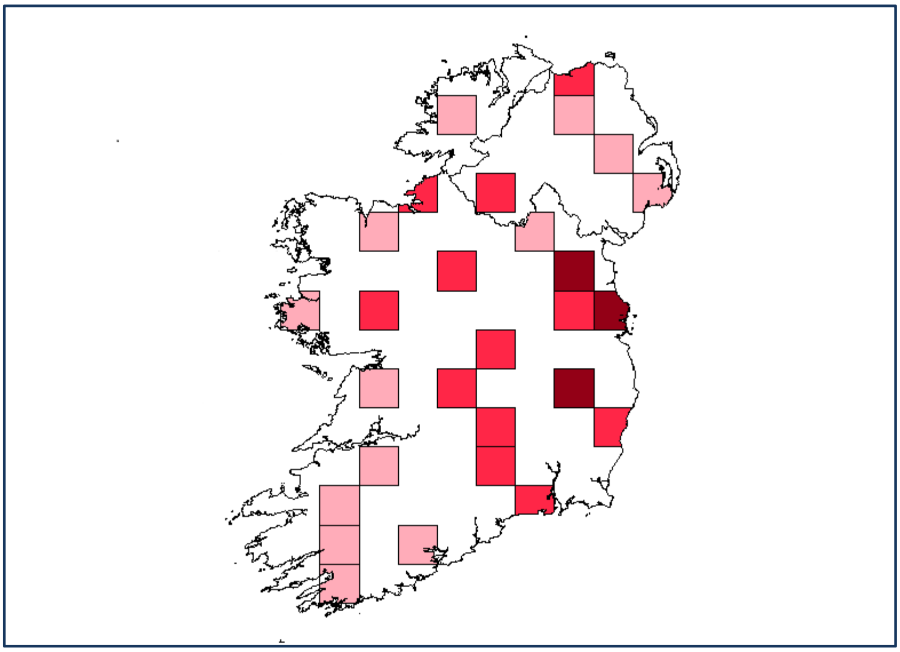

Figure 2.25 Survey squares colour coded according to mean cat encounter rates (per hour) from 2006-2021. The overall average rate of cat encounters for all squares from 2006-2021 was 1.09hr^{-1}.

Encounter rate = 0hr^{-1}
Encounter rate >0≤1.0hr^{-1}
Encounter rate >1.0≤2.0hr^{-1}
Encounter rate >2.0hr^{-1}

Cats increased in the first three years of the time series, 2006-2008, followed by a subsequent decrease and stabilisation. Overall, Figure 2.26 indicates that roadside cat trends are relatively stable as the upper error bars now encompass the 2006 baseline.

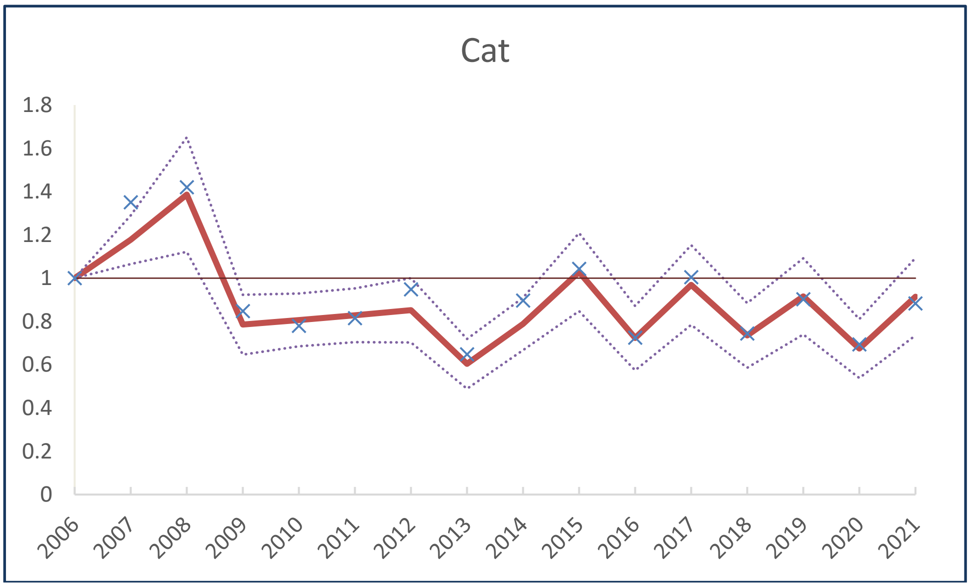

Figure 2.26 Yearly roadside cat trends analysed using rtrim. Blue points indicate yearly estimates with imputations for missing data. The red line shows modelled trend based on a piecewise loglinear model with 95% error bars (dotted lines). The baseline year was taken as 2006, time spent surveying was included as a weighting factor.

2.2.10.2 Roadside Foxes

All fox data from 2006-2021 for each survey square was tallied and divided by the total number of hours spent surveying that square. From this we derived raw data on fox occurrence per hour spent surveying and graded these data according to low, medium and high occurrence squares, see Figure 2.27 below.

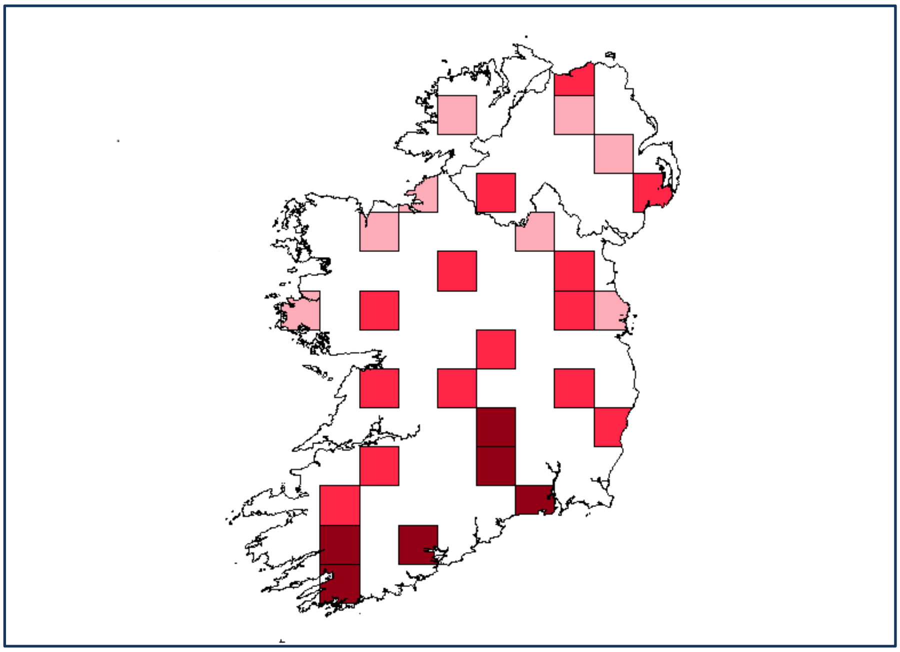

Figure 2.27 Survey squares colour coded according to mean fox encounter rates (per hour) from 2006-2021. The overall average rate of fox encounters for all squares from 2006-2021 was $0.17hr^{-1}$.

- Encounter rate = $0hr^{-1}$
- Encounter rate $>0\leq0.15hr^{-1}$
- Encounter rate $>0.15\leq0.25hr^{-1}$
- Encounter rate $>0.25hr^{-1}$

Fox numbers increased in the second year of the time series (2007) but subsequently decreased for several years to 2013. That decline has recently been offset by an increase from 2019 to present. Overall, Figure 2.28 indicates that, while roadside fox trends have fluctuated, they appear to have now recovered from low yearly estimates recorded from 2011-2018. The lower error bars currently encompass the 2006 baseline.

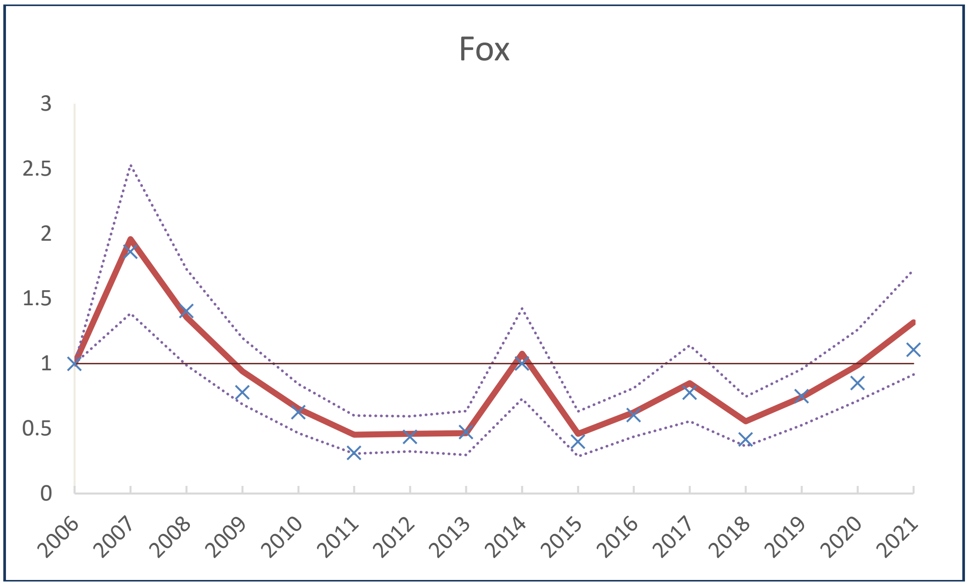

Figure 2.28 Yearly roadside fox trends analysed using rtrim. Blue points indicate yearly estimates with imputations for missing data. The red line shows modelled trend based on a piecewise loglinear model with 95% error bars (dotted lines). The baseline year was taken as 2006, time spent surveying was included as a weighting factor.

2.2.10.3 Roadside Rabbits

All rabbit data from 2006-2021 for each survey square was tallied and divided by the total number of hours spent surveying that square. From this we derived raw data on rabbit occurrence per hour spent surveying and graded these data according to low, medium and high occurrence squares, see Figure 2.29 below.

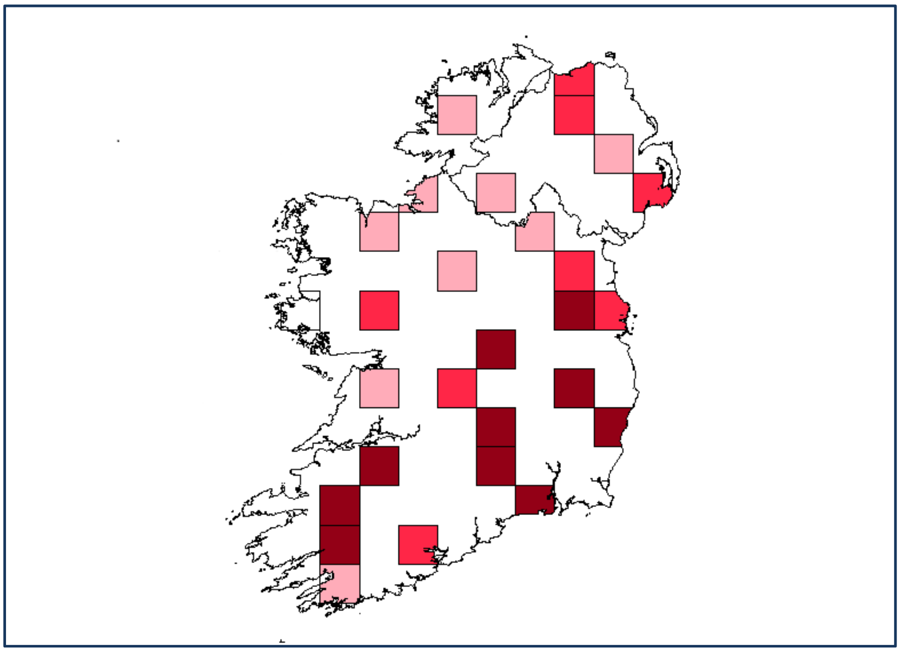

Figure 2.29 Survey squares colour coded according to mean rabbit encounter rates (per hour) from 2006-2021. The overall average rate of rabbit encounters for all squares from 2006-2021 was 0.196hr^{-1}.

Encounter rate = 0hr^{-1}
Encounter rate >0≤0.1hr^{-1}
Encounter rate >0.1≤0.2hr^{-1}
Encounter rate >0.2hr^{-1}

Rabbit numbers increased in the second year of the time series (2007) but subsequently decreased for several years to 2012. Since that time, the trend has fluctuated but the upper error bar remains below the baseline, thus indicating that roadside rabbits have significantly declined from 2006 to 2021, see Figure 2.30.

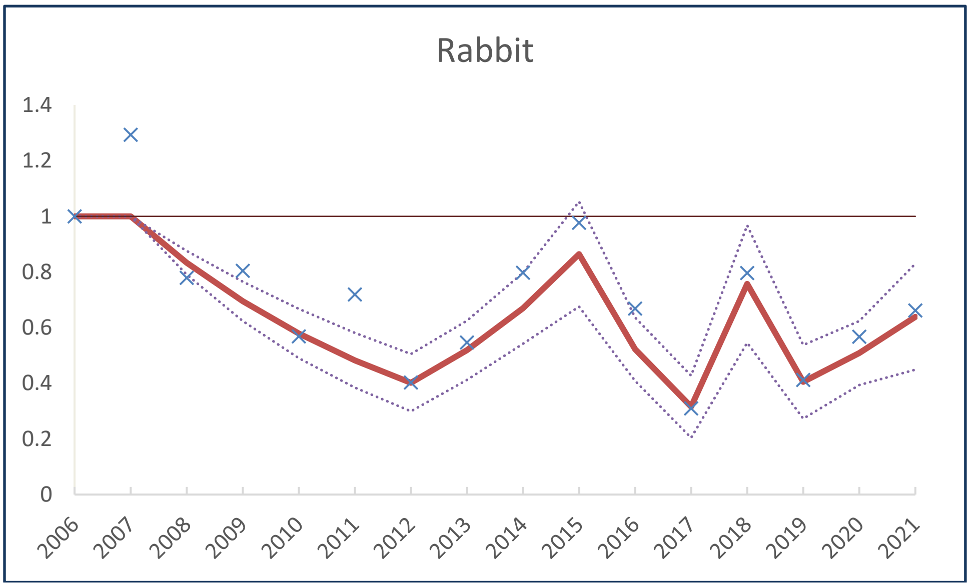

Figure 2.30 Yearly roadside rabbit trends analysed using rtrim. Blue points indicate yearly estimates with imputations for missing data. The red line shows modelled trend based on a piecewise loglinear model with 95% error bars (dotted lines). The baseline year was taken as 2006, time spent surveying was included as a weighting factor.

2.2.10.4 Roadside Hedgehogs

All hedgehog data from 2006-2021 for each survey square was totalled and divided by the number of hours spent surveying that square. From this, we derived raw data on hedgehog occurrence per hour spent surveying and graded these data according to low, medium and high occurrence squares, see Figure 2.31 below. Hedgehogs have not been recorded from surveys in four squares to date – two in Northern Ireland and two squares in the west. Highest encounter rate squares are mainly located in the southern half of the island.

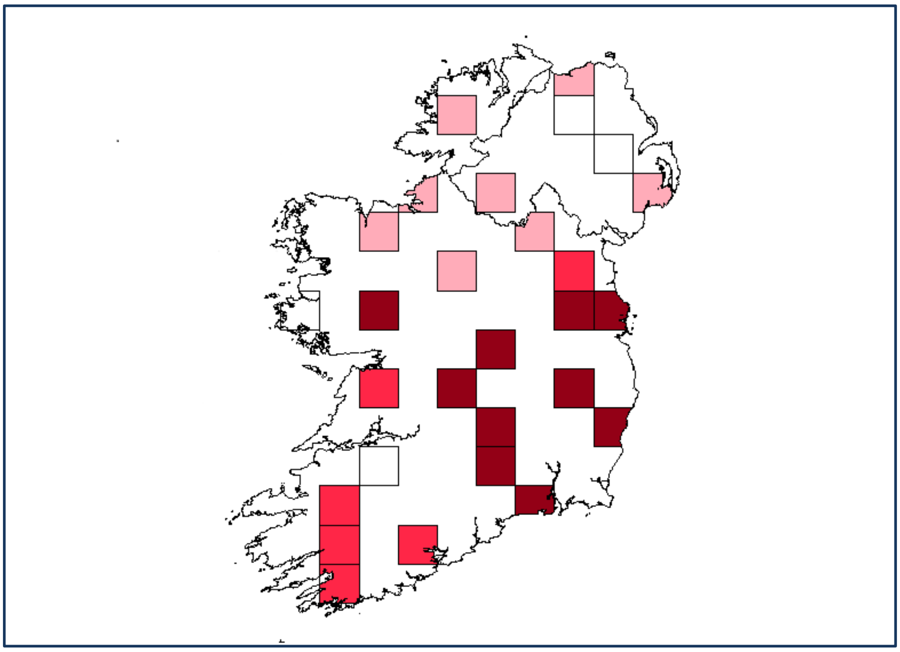

Figure 2.31 Survey squares colour coded according to mean hedgehog encounter rates (per hour) from 2006-2021. The overall average rate of hedgehog encounters for all squares from 2006-2021 was 0.47hr^{-1}.

Encounter rate = 0hr^{-1}
Encounter rate >0.001≤0.049hr^{-1}
Encounter rate >0.050≤0.089hr^{-1}
Encounter rate >0.09hr^{-1}

Similar to rabbits, cats and foxes, hedgehog numbers increased in the second year of the time series (2007). Numbers then decreased for the subsequent two years. The trend fluctuated from 2009 to 2011 but then gradually increased so upper error bars are currently above the baseline. This indicates that roadside hedgehogs have, overall, stayed reasonably stable since 2006, see Figure 2.32.

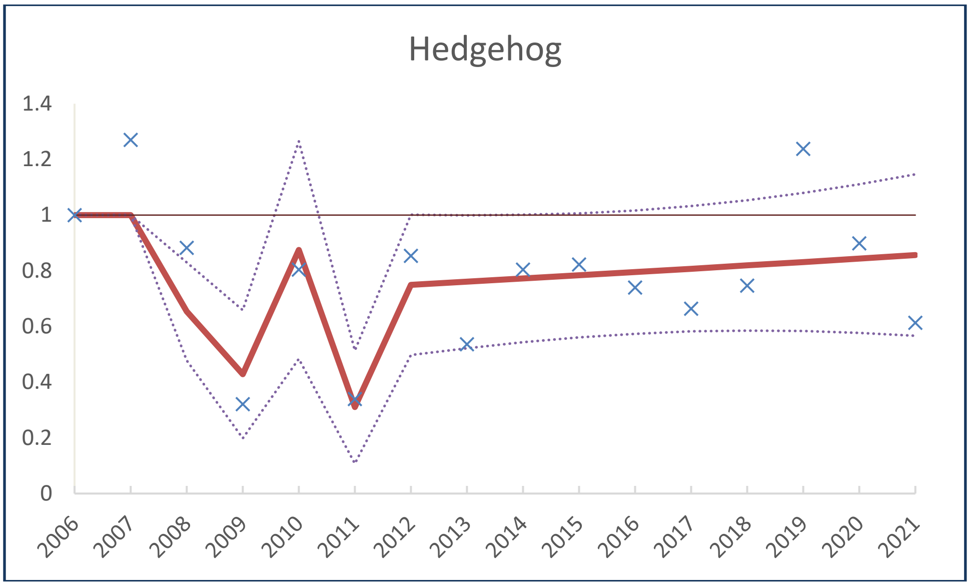

Figure 2.32 Yearly roadside hedgehog trends analysed using rtrim. Blue points indicate yearly estimates with imputations for missing data. The red line shows modelled trend based on a piecewise loglinear model with 95% error bars (dotted lines). The baseline year was taken as 2006, time spent surveying was included as a weighting factor.

2.2.10.5 Roadside Badgers

All badger data from 2006-2021 for each survey square was tallied and divided by the total number of hours spent surveying that square. From this, we derived raw data on badger occurrence per hour spent surveying and graded these data according to low, medium and high occurrence squares, see Figure 2.33 below.

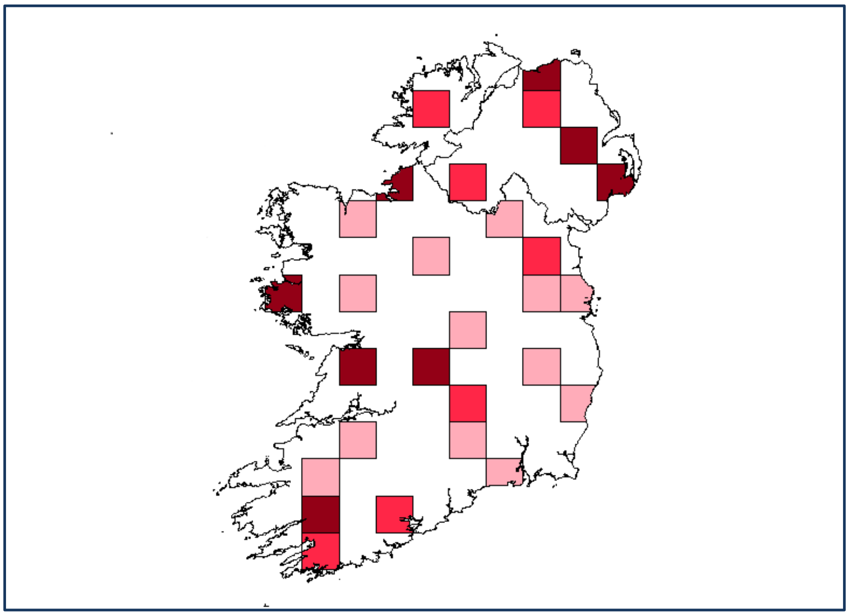

Figure 2.33 Survey squares colour coded according to mean badger encounter rates (per hour) from 2006-2021. The overall average rate of badger encounters for all squares from 2006-2021 was 0.041hr^{-1}.

- Encounter rate = 0hr^{-1}
- Encounter rate >0.001≤0.025hr^{-1}
- Encounter rate >0.025≤0.050hr^{-1}
- Encounter rate >0.050hr^{-1}

Unlike the previous four species, badger numbers did not increase in the second year of the time series (2007). Instead, yearly estimates dropped for three years to 2009 and, following a brief increase in 2010, dropped again to 2012. Since then, numbers have gradually increased and the 2021 yearly estimate matched that of 2006. Since the error bars encompass the baseline it appears that there has been no significant change to roadside badger trends in the 16 years of the time series (Figure 2.34).

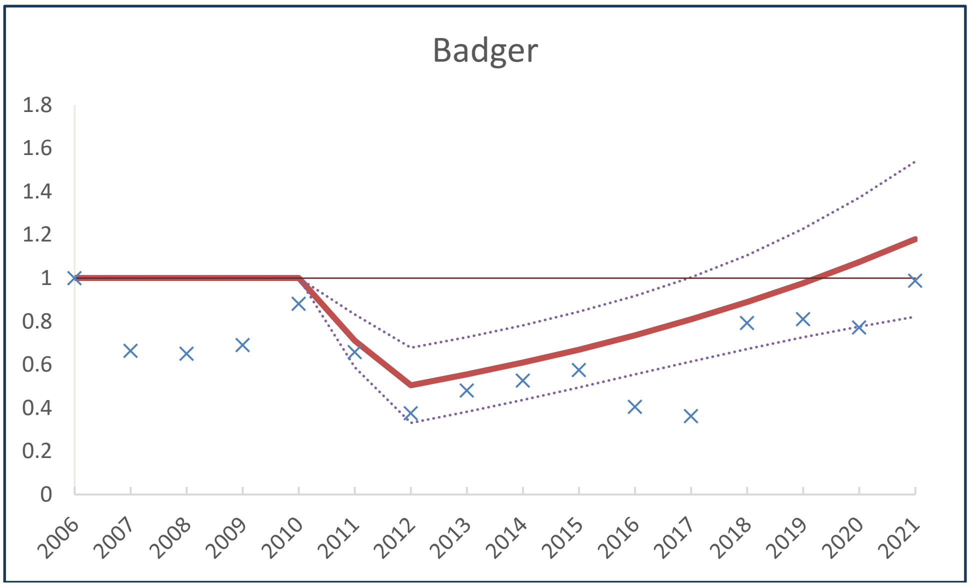

Figure 2.34 Yearly roadside badger trends analysed using rtrim. Blue points indicate yearly estimates with imputations for missing data. The red line shows modelled trend based on a piecewise loglinear model with 95% error bars (dotted lines). The baseline year was taken as 2006, time spent surveying was included as a weighting factor.

2.2.10.6 Other Vertebrates: Dead

Dead vertebrates tend to be recorded in different proportions to live ones (see Figure 2.35). Three hundred and twenty five dead vertebrates other than bats were recorded by surveyors from 2006 to 2021. The most frequently recorded dead species is the rabbit, while rats, hedgehogs, badgers and foxes are observed less often. Despite the high numbers of living cats observed during the car surveys, cats are infrequently observed as road kill, relative to the proportion of live sightings, but still constitute a frequently recorded dead vertebrate species.

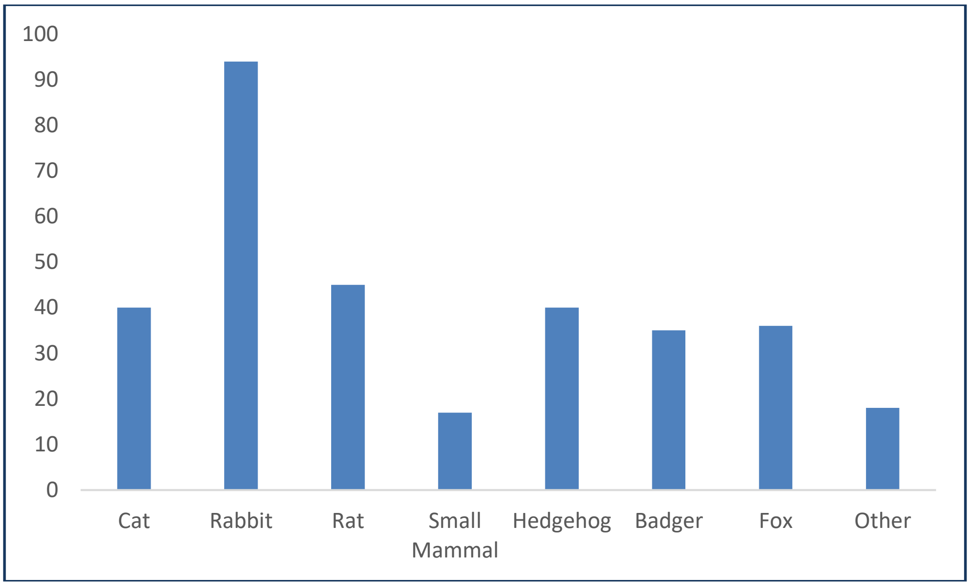

Figure 2.35 Number of records of dead vertebrates collected during car-based bat monitoring surveys 2006-2021. N=325.

2.2.11 Oral and Poster Presentations & Scientific Papers

Conference attendance was curtailed in 2020 and 2021 due to the COVID-19 pandemic.

The following conference presentations were completed using data from the Car-based Bat Monitoring Surveys:

- AIMS: All Ireland Mammal Symposium, November 2019
- Oral Presentation Title: The Impact of Climate on Trends in Common Bat Species

The following peer reviewed publications results from analyses of the Car-based Bat Monitoring Survey data:

1. Roche et al (2020) Elucidating the consequences of a warming climate for common bat species in north-western Europe. Acta Chiropterologica, 21: 359-373.
2. McGowan E. *et al.* (2021). Testing consistency of modelled predictions of the impact of climate change on bats. Climate Change Ecology, 2: 1-12.

3 All Ireland Daubenton's Bat Waterways Survey

The All Ireland Daubenton's Bat Waterway Survey is a project funded by the National Parks and Wildlife Service (NPWS) of the Department of Housing, Local Government and Heritage, Republic of Ireland and the Northern Ireland Environment Agency (NIEA) through the Environment Fund. This scheme aims to be the primary tool for monitoring Daubenton's bats in the Republic of Ireland and Northern Ireland. This monitoring protocol was devised by the BCT in 1997 and introduced in Ireland by BCIreland in 2006. It has been managed by BCIreland since then.

This section of the report presents a synthesis of results for the sixteen years (2006-2021) of monitoring in the Republic of Ireland and Northern Ireland and follows earlier reports produced by BCIreland e.g. Aughney *et al.* (2009; 2012; 2015; 2017).

3.1 Method

The All-Ireland Daubenton's Bat Waterway Monitoring Survey methodology is based on that currently used in the UK National Bat Monitoring Programme (NBMP) by the BCT (Anon, 2004).

Newly recruited surveyors are provided with a list of "Free" waterway sites from which to choose a suitable waterway site (i.e. one that is within their choose survey area). However, if there are no suitable waterway sites, the option is given to allow the survey team to choose their preferred site, often using a bridge point as the source of the identifying a new transect.

Surveyors undertake a daytime survey of their allocated site to determine its safety and suitability for surveying. At the chosen site, ten points (i.e. survey spots) approximately 100m apart are marked out along a 1km stretch of waterway. The surveyors then revisit the site on two evenings in August and start surveying 40 minutes after sunset. At each of the ten survey spots, the surveyor records Daubenton's bat activity as bat passes for four minutes using a heterodyne bat detector and torchlight (Walsh *et al.*, 2001).

Bat passes are either identified as 'Sure' Daubenton's bat passes or 'Unsure' Daubenton's bat passes. A 'Sure' Daubenton's bat pass is where the surveyor, using a heterodyne detector, has heard the typical rapid clicking echolocation calls of a *Myotis* species and has also clearly seen the bat skimming the water surface. Bats that are heard and sound like *Myotis* species but are not seen skimming the water surface may be another *Myotis* species. Therefore, these bat passes are identified as 'Unsure'. The number of times a bat passes the surveyor is counted for the duration of the four minutes. The number of bat passes is a measure of bat activity and results are quoted as 'the number of bat passes per survey period' (No. of bat passes/40 minutes).

Surveyors also record a number of parameters including air temperature, weather data and waterway characteristics, such as width and smoothness. Surveyors are asked to undertake the survey on two dates, one between the dates of 1st to 15th August (Survey 1, S1) and the repeat survey between the dates of 16th to 30th August (Survey 2, S2). On completion of surveys, survey forms are returned to BCIreland for analysis and reporting.

All data is entered on to a dedicated online MySQL waterways database and converted to Access for further querying and statistical analysis. The online MySQL waterways database is synchronised with BCIreland's National Bat Database on a yearly basis. Prior to 2011 data was entered in Excel spreadsheets.

3.1.1 Volunteer Recruitment

The All Ireland Daubenton's Bat Waterway Survey relies on the participation of volunteers to survey the large number of waterway sites required to detect Red and Amber Alert declines and to calculate population trends. A recruitment drive is undertaken annually. An on-line registration system was set up on the BCIreland website to facilitate volunteer participation. BCIreland also works closely with Heritage Officers and Biodiversity Officers in local authorities to facilitate development of local volunteer networks.

Prior to the allocation of sites, all surveyors were contacted by email to determine their willingness to participate in the coming year's surveys. In non-pandemic years all newly recruited surveyors are invited to attend an evening training course organised for the months of June and July. These training courses are advertised through social media, BCIreland website (events section) and by email. Local training course hosts are provided with posters to advertise in their area. The course consists of a one hour PowerPoint presentation followed by a discussion of potential survey areas. An outdoor practical session on a local river or canal to demonstrate the survey methodology is then completed. An information pack consisting of a detailed description of the methodology, maps, survey forms and online training facilities are provided for each survey team. Heterodyne bat detectors are also available on loan for the duration of the summer months.

Due to COVID-19, no in-person training courses were organised in 2020 and 2021. Instead, BCIreland produced a new suite of online training videos and these videos were uploaded to the BCIreland YouTube channel. In addition, Zoom training dates were undertaken during the month of July in 2020 and 2021and new volunteers were invited to attend. These Zoom sessions were 1.5 hrs long and replicated the traditional evening training courses. The online videos provided additional training to replicate the in-field training section of traditional evening courses with specific training videos designed to show volunteers how to use a bat detector and the different bat detector models.

All registered volunteers receive an email prior to the month of August with the following information:

- Digital copies of survey sheets, survey methodology, Landowner Letter and sunset times;
- Web links to video clips of foraging Daubenton's bats;
- BCIreland's bat echolocation call audio library;
- Training video clips.

Volunteers receive regular updates by email and through newsletters on the progress of the monitoring scheme. A word document for each waterway site, detailing the history of the survey as well as results and the trend for the individual site compared to the All-Ireland trend, is emailed to the relevant survey teams. Thus, detailed feedback is provided ensuring that participants are kept fully informed of their contribution to the survey.

3.1.2 Statistical Analysis

For statistical analysis, a log-transformation is carried out on data at the ten individual points within each survey; this effectively calculates the mean of passes for the survey and helps to reduce the influence of the very high counts sometimes recorded due to one or two bats repeatedly passing the observation point. In previous years bat pass counts were used in a Restricted Maximum Likelihood (REML) model (log-transformed) to investigate the potential relationships with collected variables. Since 2010, the dataset (2006-2019) has been entered into a model looking at the impact of the various covariates on the probability of observing bats at a given spot i.e. a binomial model (Binomial Generalised Linear Mixed Model (GLMM)/GAM model).

Analyses are based on data from dates between day numbers 205-250 (i.e. 24th July and 7th September, if not a leap year) which is designed to give approximately one week either side of the official survey period to maximise the amount of data available. The majority of submitted surveys are included in the model as only a few surveys from the second week in September are excluded.

For analyses based on bat passes, both counts excluding and including 'Unsure' Daubenton's bat passes were used. For binomial analyses, the presence of both 'Sure' and 'Unsure' Daubenton's bat passes at each survey spot were used. Surveys where no bat passes were recorded are also included in the analysis.

To assess trends, two different methods are used. One is a Generalised Linear Model (GLM) with a Poisson error distribution which is applied to the entire dataset (i.e. 2006-2019) and the other is a GLM with a binomial distribution. The first is undertaken in order to compare the trends with the BCT waterways survey (Barlow *et al.*, 2015) while the latter is also reported since presence/absence models such as this are considered to more effectively deal with the issue of multiple encounters with the same individual bats, a problem common to static detector surveys.

The trend datasets only include waterway sites surveyed for two or more years as waterway sites surveyed in a single year do not contribute to information on trends.

For the GLM with Poisson distribution Daubenton's bat activity per annum was modelled using four different measures ('Sure' passes only, 'Unsure' and 'Sure' passes combined, a maximum of 48 passes per survey, a maximum of 48 passes with covariates included in the model). The model with the maximum number of bat passes per survey spot is set to 48 passes (both Sure and Unsure) (i.e. one pass per 5 seconds) because it is considered that volunteers differ greatly in how they record continuous activity and this truncation reduces the uncertainty associated with higher counts. This approach is similar to the approach used for assessing Daubenton's trend in Britain in the National Bat Monitoring Programme (NBMP) undertaken by the BCT and also for trends in bird populations.

The binomial (presence/absence) model uses the proportion of survey spots with bats present at each waterway site (e.g. 0.7 if Daubenton's bats were observed at seven of the ten survey spots). Bootstrapping is used to find standard errors using logistic regression (a GLM with a logit link function) (Fewster *et al.*, 2000). A smoothed GAM trend is also fitted to the results without co-variates to give a general indication of the trend.

3.1.3 National Distribution of Daubenton's bats

In preparation for Article 17 Reporting in 2025 BCIreland will provide information relating to the distribution of all Irish bat species. As part of the preparation for this, all bat records for the period 2010 to 2021 were downloaded from the Bat Conservation Ireland database. Daubenton's bat records collated by the monitoring scheme and all other incidental records for this species were extracted and prepared for mapping. Mapping was completed using QGIS (3.16 Hannover) and projected (ITM Co-ordinates) to prepare a distribution map.

3.2 Results

3.2.1 Volunteer Participation

On average, 182 volunteer survey teams have annually participated in the All Ireland Daubenton's Bat Waterway Monitoring Scheme since 2006. A small number of teams have surveyed more than one site annually but the majority of the teams survey one waterway site.

Table 3.1 Total number of survey teams that participated for the duration of the monitoring scheme 2006-2021.

Year	Total Waterways	No. of Volunteer Teams
2006	134	127
2007	202	190
2008	182	161
2009	209	187
2010	214	182
2011	230	213
2012	220	188
2013	228	188
2014	255	208
2015	250	194
2016	245	193
2017	229	173
2018	243	175
2019	237	176
2020	232	172
2021	227	181

There is a high turnover of survey teams with approximately 30 new survey teams are recruited annually (except for 2020 when there was less volunteers recruited due to COVID-19 restrictions). Thirteen new survey teams participated in 2020 surveying 14 waterway sites while 32 new volunteer teams surveyed 36 sites in 2021. Since 2006, 901 different survey teams have participated. The majority of the survey teams have only participated for one year (48.3%) while 100 teams (11%) have contributed to the scheme for 8 years or more. One hundred and fifty survey teams (16.6%) have surveyed 2 or more waterway sites.

3.2.2 Volunteer Recruitment, Training & Support

The training schedule consists of annual evening training courses. During the current contract period, 12 and 14 evening training courses were completed in 2018 and 2019, respectively. The courses are usually organised in conjunction with Heritage Officers, Biodiversity Officers, NPWS education units, National Parks, local environmental and community groups and other government agencies (e.g. NPWS and NIEA staff). The training evenings have developed into a regular feature of the summer event calendar of Heritage Officers and Biodiversity Officers' education programmes. Since 2006, a total of 193 training courses have been organized and these have provided training for over 3,000 people. Due to COVID-19 no in-person training courses were organised in 2020 and 2021. BCIreland produced new online training videos in 2020 and these training course videos were made available on the BCIreland YouTube channel. The online video resources were coupled with online Zoom sessions for new survey teams. Additional online training in relation to using bat detectors was also prepared to assist volunteers new to bat surveying. While online course attendance was low in 2020, the 2021 online training (5x Zoom sessions) was attended by 63 people, 32 of which successfully completed surveys. This reduced the amount of time required for training in 2020 and 2021 and allowed the scheme co-ordinator to undertake extra surveys to reduce the number of single surveyed waterway sites. This offset, to some extent, the slightly lower number of volunteer teams that participated during these years particularly in 2020.

The BCIreland Facebook page and website were used to communicate training courses, training dates and ongoing progress with Facebook users and surveyors.

Heterodyne bat detectors are loaned to volunteers teams, where required. Since 2006, 230 bat detectors have been purchased by BCIreland for volunteer teams participating in the All Ireland Daubenton's Bat Waterways Scheme. The models purchased by BCIreland tend to be cheaper models available on the market (e.g. Magenta 4 heterodyne bat detector). In 2021 60 bat detectors were loaned to volunteer surveyors (33% of participating surveyors in 2021).

3.2.3 Bat Detector Models

Volunteer teams are asked to provide details of the type of bat detector they use during the waterways survey. Detector models have changed considerably since 2006 (Table 3.2). In the early years BCIreland purchased Magenta III detectors while detectors more recently purchased for this scheme are Magenta 4 models. The detector models most frequently used by volunteer teams tend to be those loaned out by BCIreland. Therefore, in the early years, Magenta Mark III was the most used bat detector model but this was replaced by Magenta Bat 4 detector from 2011 onwards, while Stag Electronics Bat Box III detector or Bat Box 3D detector (in later years) have been consistently used throughout the monitoring period.

Table 3.2 The different detector model type used by survey teams during a selection of years for the All Ireland Daubenton's Bat Waterways Survey 2006-2021.

Survey Year	2006	2009	2012	2015	2016	2017	2018	2019	2020	2021
Detector Type										
Magenta Mk II	5	1	4	3	3	3	3	2	4	4
Magenta Mk III	31	26	10	7	6	3	5	5	5	7
Bat Box III	47	48	36	35	33	28	20	20	23	19
Pettersson D100	10	23	15	18	12	11	14	12	16	10
Pettersson D200	10	9	15	34	33	36	42	34	15	12
Bat Box Duet	6	24	21	9	16	13	17	10	11	11
Petersson D230	3	1	2	2	3	2	1	1	1	1
Petersson D240x	5	6	5	1	3	4	3	1	2	2
Sky SBR 2100	2	0	0	0	0	0	0	0	0	0
Mini-3	4	8	6	0	1	1	0	1	1	1
Magenta Bat 4	0	26	59	93	95	85	77	87	85	87
Not noted	11	10	1	5	1	3	3	3	3	8
U30 Bat detector	0	0	0	0	0	0	0	0	0	0
Bat Box IIId	0	10	17	12	11	8	21	18	12	14
Magenta Bat 5	0	13	18	17	14	23	22	27	22	25
Ciel Electronics	0	3	9	17	14	12	8	7	12	7
Anabat	0	1	0	0	0	1	7	9	18	19

3.2.4 Waterway Sites Surveyed

A total of 642 waterway sites were surveyed across the island from 2006 to 2021 (Table 3.3, see Appendix 2 for a full list of all of the waterway sites surveyed to-date). One hundred and four of the sites are located in Northern Ireland and the remaining 538 are located in the Republic of Ireland (Figure 3.1). The province with the greatest number of waterway sites surveyed over the 16 years is Leinster (n=252), while the county with the highest number of waterway sites is found in County Cork (n=51) (Figure 3.2).

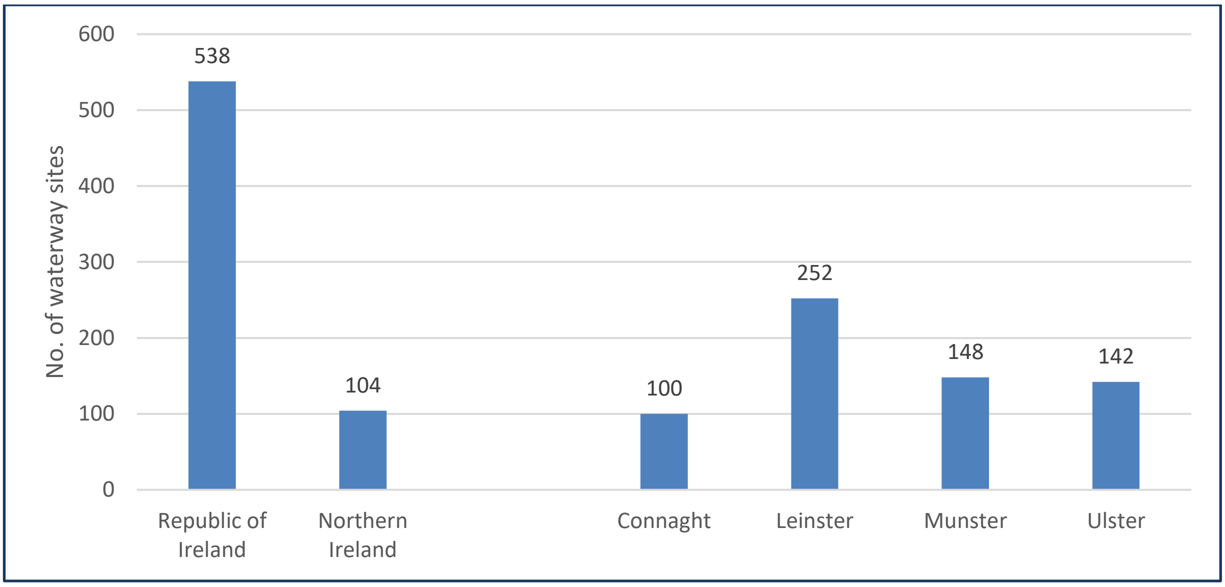

Figure 3.1 Total number of waterway sites surveyed in 2006-2021 in each country and province.

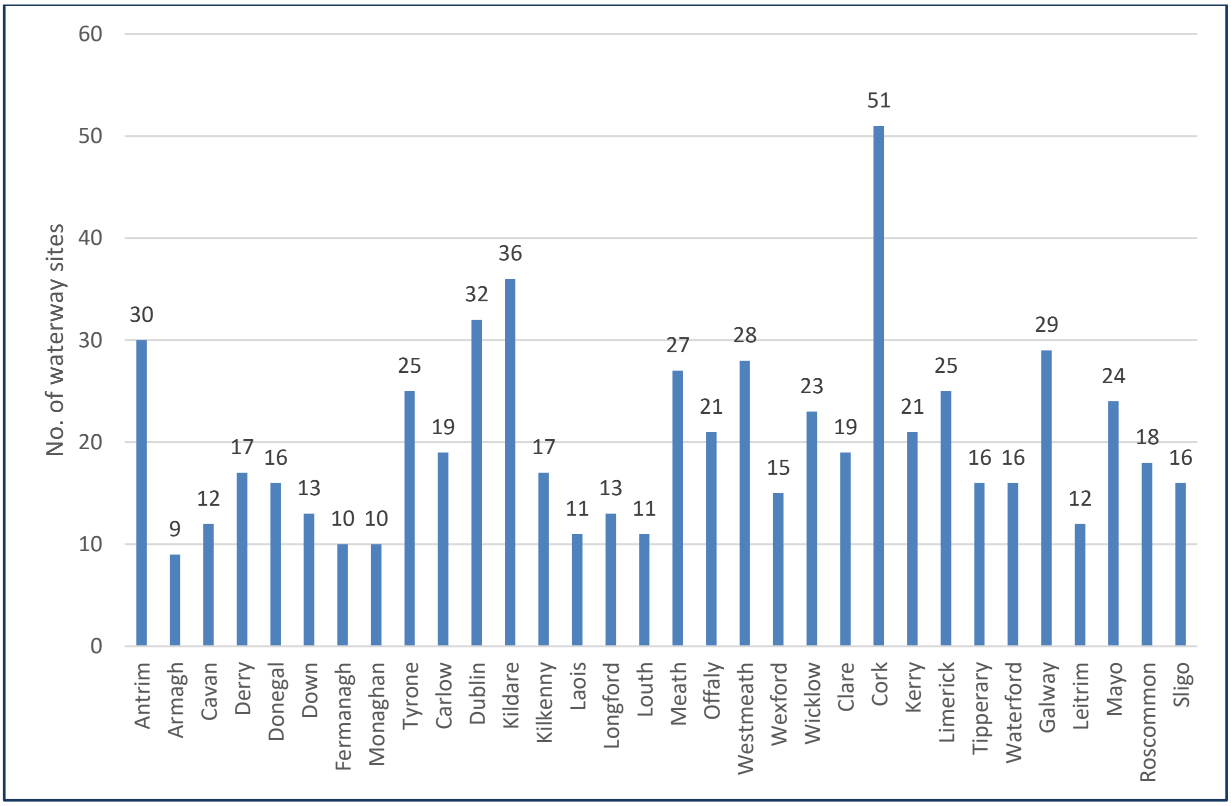

Figure 3.2 Total number of waterway sites surveyed in 2006-2021 in each county across the island.

Table 3.3 Total number of waterway sites surveyed per year according to province and country for the duration of the monitoring scheme 2006-2021.

Year	Connaught	Munster	Leinster	Ulster	Northern Ireland	Republic of Ireland	Total
2006	27	35	53	19	14	120	134
2007	31	42	103	26	20	182	202
2008	29	38	77	38	32	150	182
2009	30	46	89	44	35	174	209
2010	30	40	96	48	36	178	214
2011	33	48	97	52	44	186	230
2012	31	46	94	47	36	184	218
2013	26	46	109	47	34	194	228
2014	36	45	113	60	36	218	254
2015	40	57	104	52	37	216	253
2016	36	56	103	50	32	213	245
2017	29	54	101	44	34	199	233
2018	33	54	100	56	36	207	243
2019	37	97	51	54	36	203	239
2020	31	93	52	56	33	199	232
2021	32	94	48	53	31	196	227

A total of 91 waterway sites are along canals, four waterway sites are along channels and 547 waterway sites are along rivers (Figure 3.3). Lake shores and coastlines are not included in this monitoring scheme. Waterway sites are located along 324 discrete waterways; 21 canals, 4 channels and 299 rivers. Multiple sites may be situated at different locations along the same waterway. For example, the Royal Canal and Grand Canal have 29 and 31 surveyed waterway sites, respectively, while the rivers Shannon and Barrow have 16 waterway sites each.

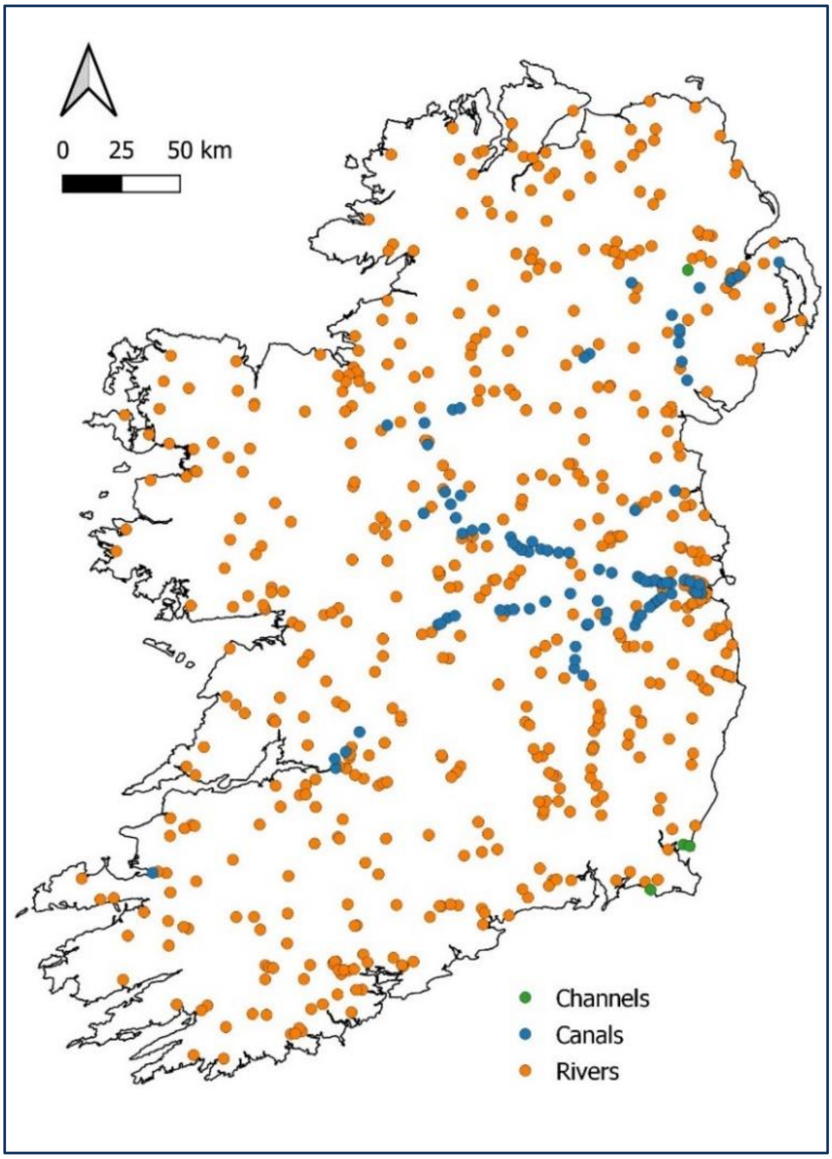

Figure 3.3 Location of waterway sites surveyed in 2006-2021 according to type of waterway.

The highest number of waterways sites surveyed in any one year for Northern Ireland was in 2011 (n=44) and for Republic of Ireland was in 2014 (n=219). Overall, the highest number of waterway sites surveyed in a particular year was in 2014 (n=255).

Of the 642 waterway sites surveyed, only 2.2% (n=14) were surveyed for all sixteen years while 19.8% (n=127) of waterway sites were surveyed only once (Figure 3.4). This latter figure has decreased since 2017 when there were 154 waterway sites (26.4% of the total of n=599) with only one year of surveys. Only a total of five new waterway sites were set up by volunteer teams in 2020 and 2021 while the remaining new volunteer teams (n=40) surveyed existing waterway sites that did not have a volunteer team. This contrasts with 15 and 24 new waterways sites set up in 2018 and 2019 respectively.

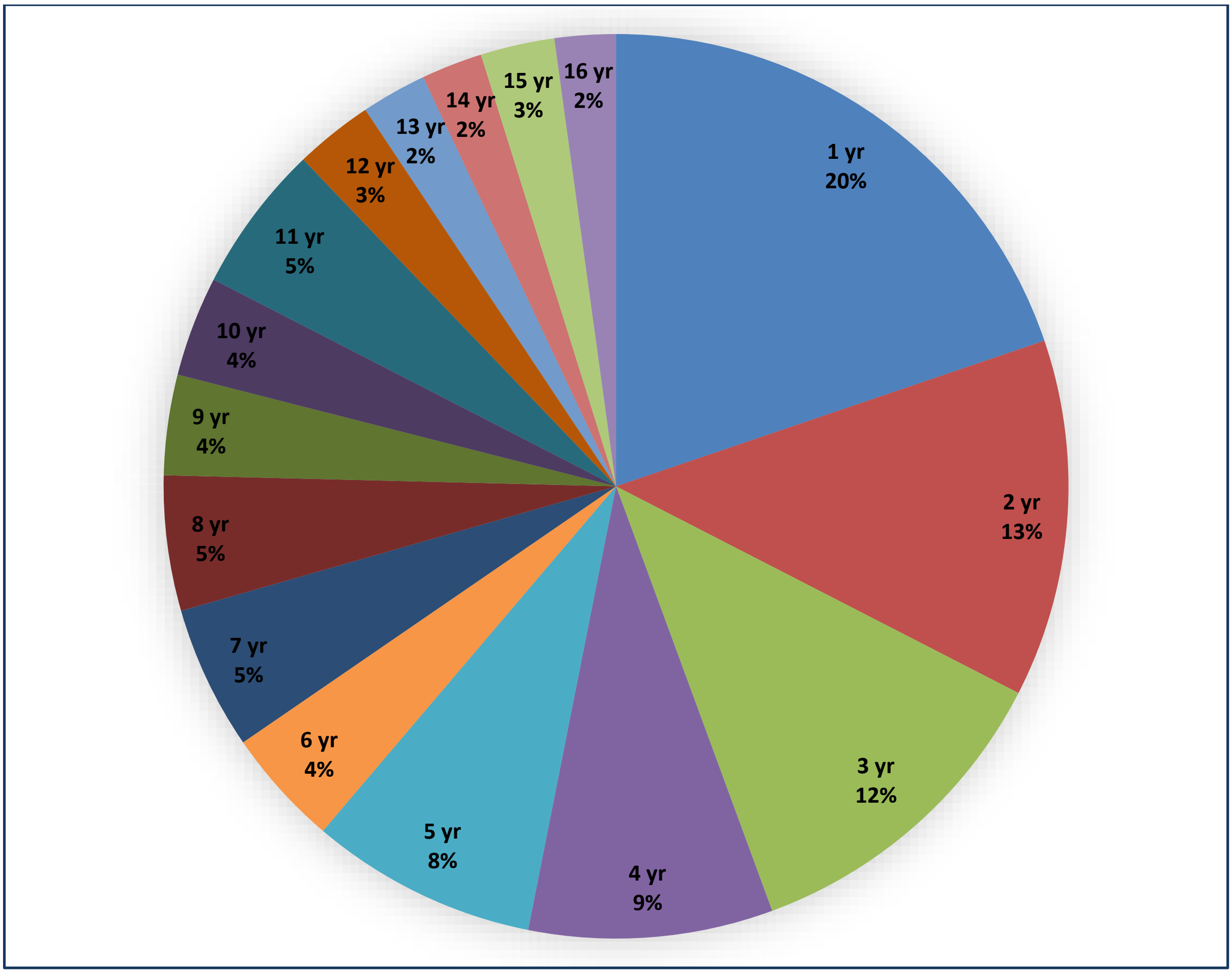

Figure 3.4 Number of years each waterway site was surveyed in 2006-2021 monitoring period, n=642.

During the sixteen years of monitoring, Daubenton's bat 'passes' were recorded along 93.3% (n=599) of the waterways sites (Figure 3.5). This is an increase in Daubenton's presences compared to the previous report (Aughney *et al*., 2018) at twelve years of monitoring (2006-2017), when Daubenton's bat 'passes' were only recorded on 85.5% (n=512) of the waterways sites surveyed. The 43 waterway sites with no Daubenton's bat 'passes' are 35 rivers, 7 canals and 1 channel.

Of the 512 sites positive for Daubenton's bats, 101 (15.7%) were only surveyed for one year during the monitoring period (see Table 3.4). For those waterway sites positive for Daubenton's bats and surveyed for two years or more, 140 waterway sites had at least one survey year where Daubenton's bat 'passes' were not recorded, while 358 waterways sites (55.8% of total waterway sites surveyed) surveyed for two years or more, had Daubenton's bats recorded consistently during each survey year.

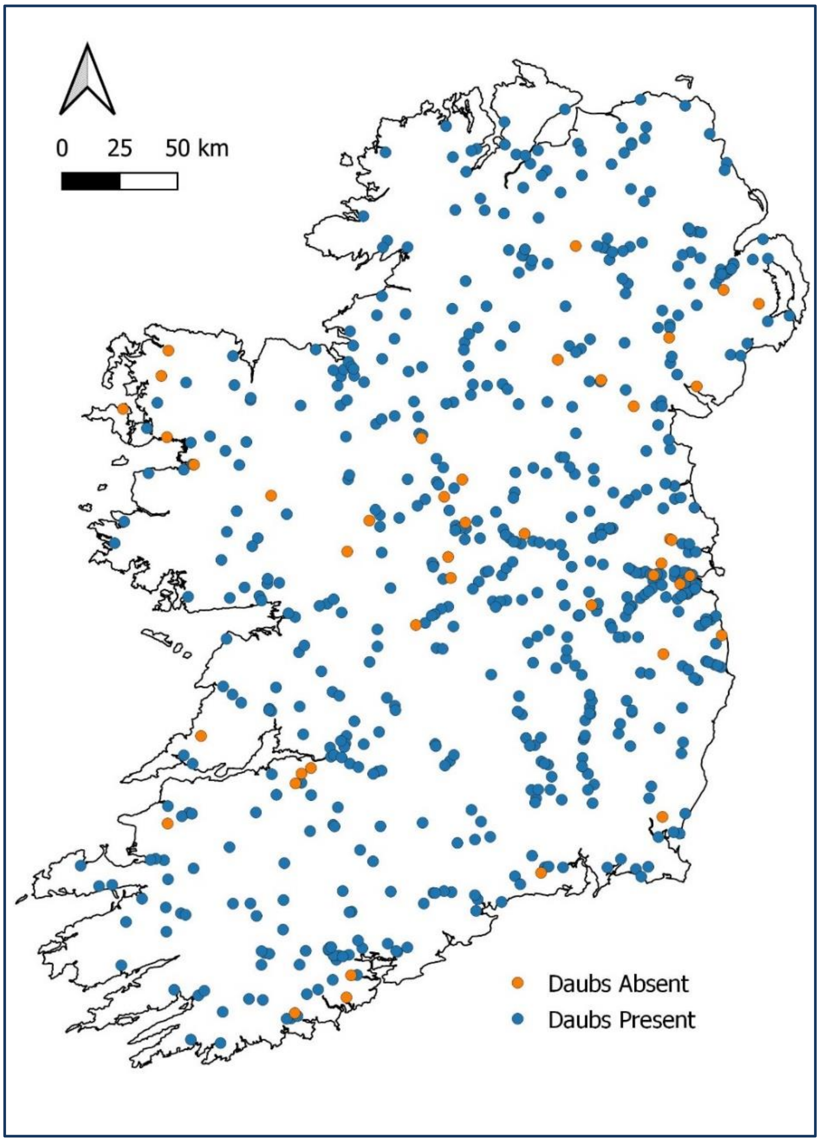

Figure 3.5 Location of waterway sites surveyed in 2006-2021 in each county and according to type of waterway.

Table 3.4 Total number of different survey teams that have surveyed waterway sites for the duration of the monitoring scheme 2006-2021.

Group	No. of Waterway Sites
Daubenton's bat 'passes' absent some survey years (2 or more years of surveying)	140
Daubenton's bat 'passes' present all survey years (2 or more years of surveying)	358
Daubenton's bat 'passes' present for sites surveyed for 1 year only	101
Daubenton's bat 'passes' absent in all survey years	43

3.2.5 Number of Completed Surveys

The highest number of surveys were completed in 2014 (n=473 surveys) (Table 3.5). Overall, 6,453 surveys have been returned to BCIreland for the 2006-2021 monitoring period and this amounts to 4,302 hours of observation time (four minutes per survey spot, 10 survey spots= 40 minutes per survey). Survey teams were requested to complete two surveys, if possible, per year as this provides more robust data for monitoring. The month of August is split into two sampling periods: Survey 1 (1st August to 15th August) and Survey 2 (16th August to 31st August). Of the completed surveys, 2,926 were repeats (i.e. both Survey 1 and Survey 2 were completed - 90.7%). The year with the highest proportion of repeat surveys was 2007 (95% of waterway sites with repeat surveys for that year).

Table 3.5 Total number of completed surveys for the duration of the monitoring scheme 2006-2021.

Year	S1 & S2	Single Survey	TOTAL
2006	122	12	256
2007	185	17	387
2008	133	47	313
2009	171	37	379
2010	193	19	405
2011	179	51	409
2012	183	37	403
2013	187	40	414
2014	221	31	473
2015	213	37	463
2016	197	48	442
2017	181	48	410
2018	184	58	426
2019	196	42	434
2020	188	43	419
2021	193	34	420

In total, 331,893 bat passes were recorded from all completed surveys submitted from 2006-2021, 83.1% of which were noted as 'Sure' Daubenton's bat passes (Table 3.6). The proportion of 'Unsure' Daubenton's bat passes was highest in 2006 (33%) when the scheme first started and lowest in 2020 (13.6%) which coincided with COVID-19 restrictions and thereby the lowest uptake of new volunteers since the start of the monitoring programme in 2006. On average, the mean percentage of 'Unsure' Daubenton's bat passes was 16.9%.

The mean number of 'Sure' Daubenton's bat passes recorded for all 16 years was 43.7 per survey with the highest mean recorded in 2010 (51.7 'Sure' Daubenton's bat passes per survey). The province of Connaught shows a consistently high mean number of 'Sure' Daubenton's bat passes (All years: 54.2 'Sure' Daubenton's bat passes per survey) (Figure 3.8). Overall, 91% of all surveys completed recorded bat 'passes'. Munster had the highest percentage of surveys with bat passes (All years: 92.8%) compared to all other provinces. The mean percentage of survey spots with bats (10 survey spots per waterways transect) was 55.7% while Connaught had the highest percentage of survey spots with bats at 56.2%. A full breakdown of these statistics is presented in Appendix 2.

Table 3.6 Total number of bat passes recorded for the duration of the monitoring scheme 2006-2021.

Year	Sure Daubenton's bat pass	Unsure Daubenton's bat pass	TOTAL	% of Unsure of Total No. of bat passes
2006	11,985	5,916	17,901	33%
2007	15,951	3,971	19,922	20%
2008	11,735	2,173	13,908	15.6%
2009	17,018	2,998	20,016	15%
2010	20,775	3,731	24,506	15.2%
2011	20,828	3,899	24,727	15.8%
2012	17,866	3,922	21,788	18%
2013	17,409	3,426	20,835	16.4%
2014	18,508	3,844	22,352	17.2%
2015	19,558	3,452	23,010	15%
2016	20,635	3,826	24,461	15.6%
2017	19,492	3,558	23,050	15.4%
2018	15,884	2,925	18,809	15.55%
2019	16,213	2,951	19,164	15.40%
2020	16,102	2,530	18,635	13.60%
2021	15,884	2,925	18,809	15.55%

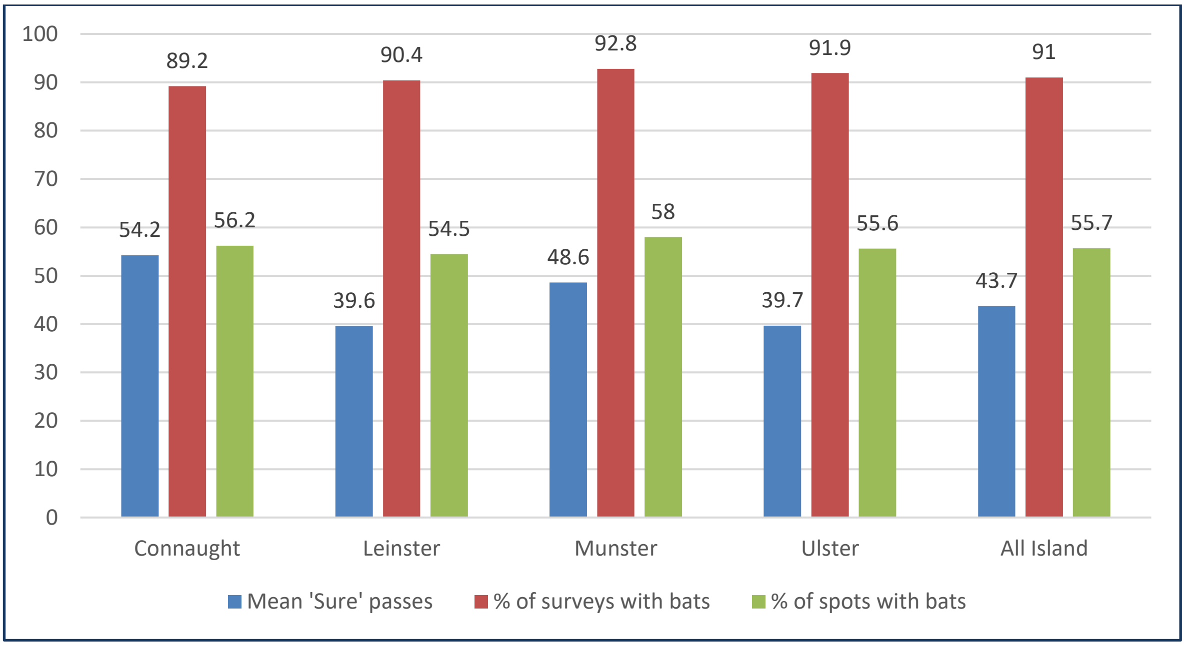

Figure 3.6 Mean number of 'Sure' Daubenton's bat passes per survey in each province and for the island and percentage of surveys with bats and percentage of survey spots with bats in the 2006-2021 monitoring period.

3.2.6 Trend Analysis 2006-2021

To assess trends, a Poisson Generalised Linear Model (GLM) was applied to the data with the results expressed as an index and 2007 used as the base year. Just one of the models is reported here, the model that includes both sure and unsure passes and with the maximum number of passes set to 48 with covariates. This particular model is chosen to facilitate comparison with British data from the BCT. Data from waterway sites that were surveyed for two years or more were included in this analysis. Waterway sites only surveyed for one year do not contribute to information on trends and are therefore omitted.

Bat counts (bat passes) were relatively low from 2012 to 2014, with the result that a downward trend first noted in 2011 continued till 2014. However, a recovery was then noted in 2015. Results for the Poisson GAM models confirmed that the upward trend reported in 2015 continued in 2016 and 2017. Since 2018 there has been a slight downward trend and 2021 counts were reasonable without being exceptional. The trendlines show a somewhat reduced downward slope compared to the trend presented in 2020 (Aughney *et al.*, 2021).

Based on the Poisson model with covariates, Daubenton's bat trend has fluctuated over the duration of the monitoring scheme. The smoothed trend indicates a total increase of 0.52%, which represents a yearly increase of 0.04% (baseline year is 2007). But there is no significant difference from the baseline year while there is a very obvious sinusoidal pattern to the trend overall (Figure 3.7).

Figure 3.7 All Ireland results of Poisson Generalised Additive Model (GAM) model (max 48 'sure' and 'unsure' passes), with covariates (survey start time, surveyor skills and degree of smooth water as recorded by survey teams), shown with 95% confidence limits. Green points are estimated annual means and are shown to illustrate the variation about the fitted line.

Table 3.7 Poisson Generalised Additive Model (GAM) results with 95% confidence limits for Daubenton's bats (2006-2021). Covariates include survey start time, surveyor skills and degree of smooth water as recorded by survey teams.

Index 2007 = 100

		Smoothed		95% conf limits		Unsmoothed		95% conf limits	
Year	Sites	Index	s.e.	Lower	Upper	Fitted	s.e.	Lower	Upper
2006	109	100.27	3.39	93.34	107.20	107.83	10.61	88.21	129.00
2007	170	100.00	0.00	100.00	100.00	100.00	0.00	100.00	100.00
2008	170	101.77	2.49	97.07	106.92	91.07	5.87	80.36	102.62
2009	183	105.98	4.09	98.49	114.83	111.96	7.07	98.50	125.71
2010	203	109.11	5.03	100.36	120.08	117.23	8.16	102.81	136.15
2011	213	108.54	5.46	99.25	120.83	113.92	7.63	101.30	131.05
2012	212	105.66	5.73	95.48	118.04	104.40	7.21	91.62	119.73
2013	217	103.81	6.12	92.71	117.04	103.30	7.19	90.58	119.04
2014	238	104.64	6.62	92.91	118.85	100.86	8.20	86.53	118.79
2015	238	107.62	7.05	94.95	123.28	115.70	8.89	100.84	134.70
2016	237	109.76	7.36	96.69	125.87	110.59	8.13	96.45	128.49
2017	219	110.02	7.68	95.92	126.44	115.56	10.08	97.89	137.42
2018	223	107.90	7.70	93.67	124.14	112.60	9.65	93.57	132.94
2019	220	104.55	7.47	90.36	119.79	101.93	8.76	85.53	119.80
2020	224	102.04	7.55	87.68	117.50	102.39	9.18	85.84	121.83
2021	217	100.52	8.34	84.75	117.46	104.30	9.34	86.93	124.16
TOTAL	506								

The trend analysis was completed for data from the Republic of Ireland and Northern Ireland separately using the Poisson model with covariates. For the Republic of Ireland data, the smoothed trend indicates a slight decrease of 1.53%, which represents a yearly decrease of 0.11% (baseline year is 2007) (Figure 3.8, Table 3.8). For Northern Ireland the smoothed trend indicates an increase of 34.1%, which represents a yearly increase of 2.12% (baseline year is 2007) (Figure 3.9, Table 3.9). Although the index value is greater for Northern Ireland, the confidence limits are wide due to the relatively small sample size and therefore values are not significantly different using a randomisation test (P=0.290).

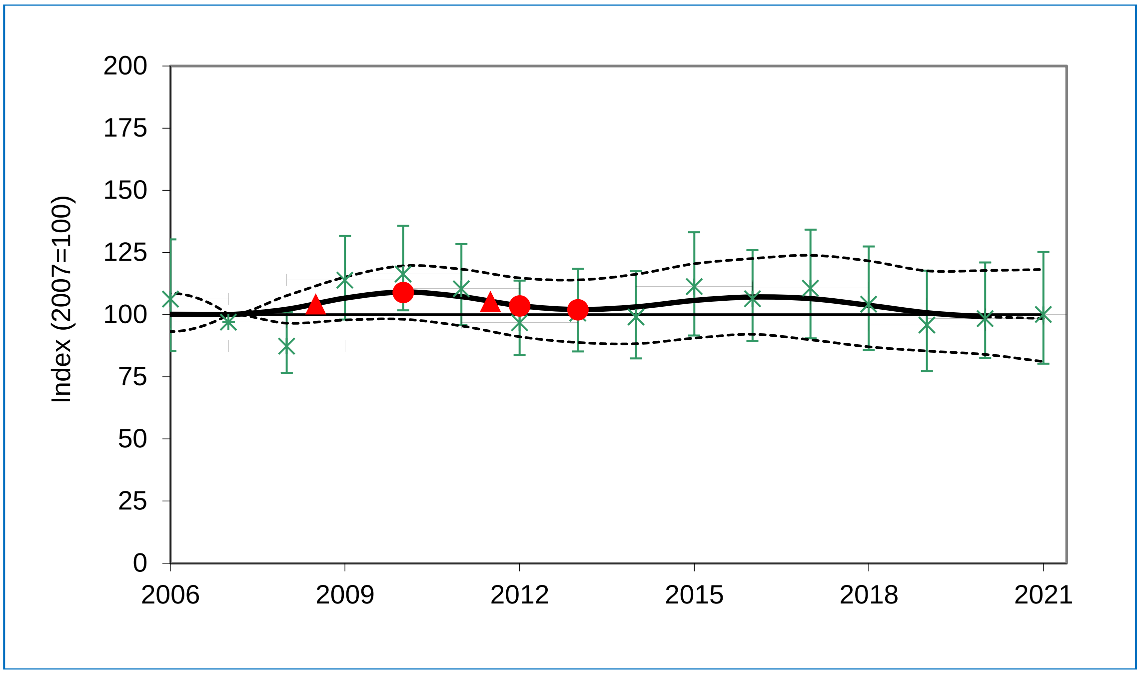

Figure 3.8 Republic of Ireland results of Poisson Generalised Additive Model (GAM) model (max 48 'sure' and 'unsure' passes), with covariates (survey start time, surveyor skills and degree of smooth water as recorded by survey teams), shown with 95% confidence limits. Green points are estimated annual means and are shown to illustrate the variation about the fitted line.

Table 3.8 Republic of Ireland Poisson Generalised Additive Model (GAM) results with 95% confidence limits for Daubenton's bats (2006-2021). Covariates include survey start time, surveyor skills and degree of smooth water as recorded by survey teams.

		Index 2007 = 100							
		Smoothed		95% conf limits		Unsmoothed		95% conf limits	
Year	Sites	Index	s.e.	Lower	Upper	Fitted	s.e.	Lower	Upper
2006	99	100.13	3.83	93.18	108.60	109.34	11.74	88.33	133.27
2007	157	100.00	0.00	100.00	100.00	100.00	0.00	100.00	100.00
2008	143	102.15	2.81	96.57	107.65	90.32	6.30	79.61	104.05
2009	153	106.65	4.66	97.82	115.10	116.88	8.42	101.02	134.61
2010	168	109.09	5.67	98.15	119.63	119.34	8.83	104.73	138.73
2011	173	107.24	5.97	95.46	118.28	113.46	8.66	98.81	131.35
2012	179	103.61	6.03	91.13	114.76	99.83	7.46	86.71	116.67
2013	187	102.03	6.31	88.80	113.96	103.69	8.01	88.18	121.47
2014	204	103.12	6.76	88.31	116.24	102.16	8.54	85.39	120.44
2015	203	105.71	7.24	90.54	120.47	114.35	9.68	94.59	136.12
2016	205	107.09	7.73	92.10	122.56	109.44	9.58	92.46	128.90
2017	188	106.45	8.23	89.88	123.87	113.65	11.47	93.46	137.18
2018	191	103.75	8.33	87.05	121.61	107.26	10.83	88.74	130.41
2019	188	100.74	8.14	85.37	117.62	98.86	10.06	80.27	120.69
2020	190	99.09	8.23	83.98	117.75	101.42	9.96	85.64	123.97
2021	189	98.47	9.10	81.12	118.16	103.11	10.62	83.26	128.17
TOTAL	**423**								

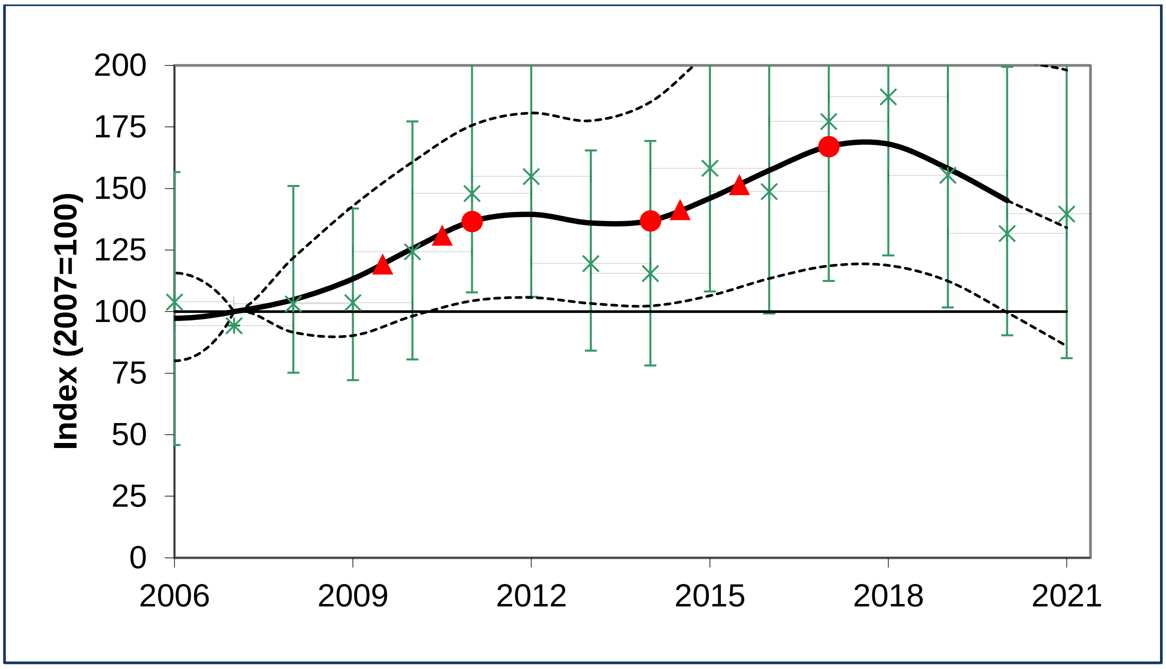

Figure 3.9 Northern Ireland results of Poisson Generalised Additive Model (GAM) model (max 48 'sure' and 'unsure' passes), with covariates (survey start time, surveyor skills and degree of smooth water as recorded by survey teams), shown with 95% confidence limits. Green points are estimated annual means and are shown to illustrate the variation about the fitted line.

Table 3.9 Northern Ireland Poisson Generalised Additive Model (GAM) results with 95% confidence limits for Daubenton's bats (2006-2021). Covariates include survey start time, surveyor skills and degree of smooth water as recorded by survey teams.

		Index 2007 = 100							
		Smoothed		95% conf limits		Unsmoothed		95% conf limits	
Year	Sites	Index	s.e.	Lower	Upper	Fitted	s.e.	Lower	Upper
2006	10	97.29	9.44	80.02	115.67	109.60	28.53	51.46	162.32
2007	13	100.00	0.00	100.00	100.00	100.00	0.00	100.00	100.00
2008	28	104.86	7.79	91.58	121.89	108.84	18.91	80.83	156.67
2009	30	113.30	13.06	90.27	142.92	109.32	17.88	77.81	147.54
2010	35	125.57	16.06	98.17	160.76	130.03	24.01	86.22	182.90
2011	40	136.65	17.44	104.35	175.63	153.72	23.79	113.46	210.43
2012	33	139.49	18.18	105.71	180.65	160.50	26.82	111.66	216.21
2013	30	136.00	18.38	103.31	177.53	125.24	20.29	89.78	171.11
2014	34	136.95	20.14	102.31	185.09	121.13	23.91	83.77	174.95
2015	35	146.03	23.71	106.45	205.50	163.95	35.56	113.85	253.46
2016	32	157.35	27.71	113.44	221.63	154.43	28.03	104.89	215.28
2017	33	167.10	31.74	118.56	245.65	182.94	43.72	118.11	291.33
2018	32	168.06	32.02	118.76	244.17	192.92	38.35	128.47	278.00
2019	33	158.17	28.65	112.43	227.91	161.02	34.07	107.35	238.36
2020	34	145.12	26.48	99.63	204.87	137.42	27.66	96.03	205.07
2021	28	134.10	28.99	86.03	198.07	145.31	34.18	86.74	222.70
TOTAL	**83**								

3.2.7 National Distribution of Daubenton's bats

BCIreland hosts a separate database for the waterways survey. This is annually synchronised with the main BCIreland database. For each of the 10 survey spots along every 1km transect, both 'Sure' and 'Unsure' Daubenton's bat passes are recorded, resulting in 20 records per transect per survey. In total, there were more than 19,000 records from the All Ireland Daubenton's Bat Waterways Survey for the 2010-2021 download period. This large volume of records was replaced with one discrete geo-referenced record per waterway site where Daubenton's bats were recorded during monitoring transects for the 2010-2021 period. The final dataset used for mapping consists of 1,645 Daubenton's bat records. This includes records from a number of surveys including BATLAS 2020 (n=838 records, 51%). The following table provides a breakdown of the records currently available. Records are distributed in all counties across the country.

Table 3.10 Sources of Daubenton's bat records on the Bat Conservation Ireland database

Source of Records	No. of Records
All Ireland Daubenton's Bat Waterways Survey	496
BATLAS 2020	838
Brown long-eared Bat Roost Monitoring Scheme	2
Pilot Woodland Monitoring 2016-2017	29
BCIreland Neighbourhood Bats Survey	146
Ecological Consultancy Records	120
Other Sources	14

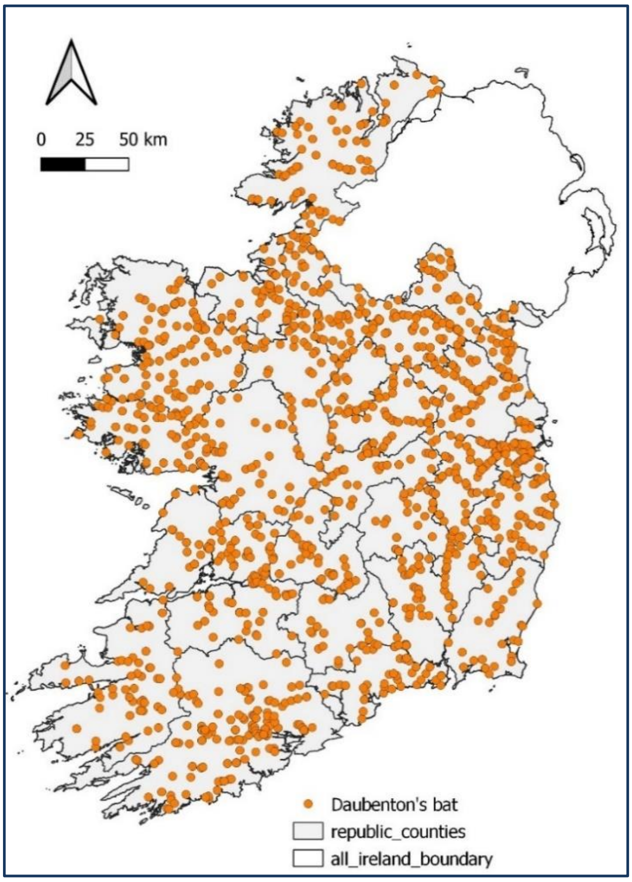

Figure 3.10 Daubenton's bat distribution in Ireland (BCIreland database 2010-2021).

4 Brown Long-eared Bat Roost Monitoring Scheme

The Brown Long-eared Roost Monitoring Scheme is a project funded by The National Parks and Wildlife Service (NPWS) of the Department of Housing, Local Government and Heritage, Republic of Ireland. This scheme aims to be the primary tool for monitoring brown long-eared bats in the Republic of Ireland. This monitoring protocol was devised and piloted by BCIreland in 2007 and has been managed by BCIreland since then.

This report presents results for the first fifteen years (2007-2021) of brown long-eared bat (*Plecotus auritus*) monitoring and follows earlier reports produced by BCIreland (Aughney *et al.*, 2011, 2017).

4.1 Methods

The Brown Long-eared Roost Monitoring Scheme methodology was designed by BCIreland. For a full description of the Preliminary Roost Assessment and Survey Methodology see Aughney *et al.* (2011).

4.1.1 Survey Methods

Roosts deemed suitable for the monitoring scheme are monitored yearly by either Internal counts (2 counts) or External Emergence Dusk Counts (2-3 counts) during the specified survey periods (see Appendix 3). In general, buildings with no access to the roof space are surveyed by Emergence Dusk Counts only. Buildings with exit points too high to clearly see emerging bats (i.e. greater than two floors high) are monitored using Internal Counts if the roof space is accessible. Not all individual brown long-eared bats leave the roost site every night, especially during poor weather conditions (Entwistle, Racey, & Speakman, 1996) therefore internal validation is completed post emergence survey, where possible. Buildings with both access to roof space and visible exit points are assessed by whichever method can be used with greatest ease and that results in reliable roost numbers.

Dates for survey periods are as follows: Survey 1: 16th May to 15th June; Survey 2: 16th June to 31st July & Survey Period 3: 1st August to 30th August. Volunteer survey teams are encouraged to adhere to these survey dates, where possible. Internal counts are undertaken by a licensed surveyor and counts are completed during the day using a red-light torch. The entire internal space of the roost is examined and individual brown long-eared bats are counted. Emergence Dusk Surveys are completed using bat detectors with surveyors located at all known exit points from the roost. Surveys begin 20 minutes after sunset and continue until no bats exit the building for a full ten minutes of surveying. A survey form is provided and surveyors are requested to fill out all sections of the form (see Appendices). Information required includes weather data (Temperature, cloud cover (3-point scale), wind (3-point scale) and rain (3-point scale), bat count, emergence time of first bat, start and finish times and details of survey team. On completion of surveys, survey forms are returned to BCIreland for analysis and reporting.

4.1.2 Methodology Changes

For the first four years of the scheme, surveys began 30 minutes after sunset. As a result of statistical analysis and surveyor feedback expressing the likelihood of missing early emerging bats, the start time was changed to 20 minutes after sunset from 2011 onwards. This change to the survey methodology is taken into account in the statistical analysis.

Surveyors were requested to record the time of the first emerging bats from 2011 onwards. To increase the accuracy of the start times in relation to sunset, a sunset time table was generated for each individual roost in relation to Longitude and Latitude co-ordinates. The sunset table for each individual roost was issued to all surveyors as part of the survey pack.

Due to the COVID-19 pandemic we asked surveyors not to carry out counts inside roosts in 2020 and 2021 unless they could keep >1m distance between themselves and the bats. This was to minimise the chance of humans transmitting the SARS-CoV-2 virus to the bats. We also asked surveyors to wear masks during all internal surveys.

4.1.3 Additional Technology

Sony HandyCam FDR-AX33 and FDR-AX53 cameras with night-shot capability along with infrared illuminators (30° and 60° spread, two of each type) were deployed to assist with a small selection of emergence surveys since 2016. The camcorder was positioned on a tripod (1.5m high) while the IR illuminators were erected on a separate tripod (1m high, two per roost site). Illuminators (2 units per survey) were shone onto the building in the general vicinity of known exit points. Filming started 20 minutes after sunset and the 10 minute intervals were marked by vocalising "10 minutes" during recording session to aid counting post filming with reference to Emergence Count surveys undertaken simultaneously. Recordings were saved on SD Cards (64MB) and filming was completed in high resolution to aid counting. Recordings were analysed post surveying.

To determine whether the use of IR increases accuracy of survey counts IR aided filming was specifically investigated in 2020 using count data from four roosts. These sites were surveyed by both IR technology and a surveyor simultaneously.

Guide Tracker Pro19 Thermal Imagery scope was deployed in 2021 and this was also mounted on a tripod (1.5m high). Film footage was examined post-surveying.

4.1.4 Statistical Analysis

The effects of Northings and Eastings, day number (i.e. survey date), weather data, building type, start time, and internal/external counts were examined using a Generalised Linear Mixed Model (GLMM).

To assess trends a Generalised Linear Model (GLM), with confidence limits based on bootstrapping at the site level, was applied to the 2007-2021 data. Data from all sites counted in two or more years are included in the trend dataset.

The trend was smoothed using Generalised Additive Model (GAM) smoothing and the yearly estimates were expressed as an index with 2008 as the base year. The models use a negative binomial distribution, rather than the Poisson distribution previously used (and as used for the GLMM), as it fits the data better and gives slightly more precise results.

The models were completed with and without covariates for drizzle/rain, for internal counts before mid-May and for external counts after mid-September, factors that were significant from GLMM models.

4.1.5 Habitat Mapping & Roost Profiles

The locations of all roosts currently monitored were digitised and concentric circles were created at 0.5 km radius from the roost using QGIS (3.16 Hannover) to determine the extent of woodland cover within each radius. Information from the NPWS Native Woodland Inventory (NWI) was examined to determine if woodlands mapped by this project were located within 0.5km of a roost. This data includes areas of native woodland >1ha. In addition, within 0.5 km radius of the roosts, tall vegetation (treelines, small woodlands, forestry and parkland trees) were digitised using aerial photographs (Bing Satellite) to determine the total cover of trees (hectares) within each 0.5km buffer zone. This mapping did not include hedgerows.

Information was also collated in relation to the structure of the roosts including age, wall construction, roofing material etc. Together with the broad habitat information, a roost profile was compiled for 44 roosts. This data was also subjected to statistical analysis using R.

4.1.6 Ecosystems Services Research

Bat Conservation Ireland is collaborating with the BatLab, University College Dublin on a project '***Bats and Ecosystem Services'***. This is being carried out by PhD student Gwenaëlle Hurpy, with funding from the Irish Research Council and NPWS.

This project aims to estimate the positive role that bats play within the Irish ecosystem in limiting and reducing pests (e.g. mosquitos, biting midges/insects and agricultural crop pests). As part of the project, insects that bats eat will be identified using DNA analysis of the insect remains in bat droppings. The research is focusing on three bat species: brown long-eared bats and common and soprano pipistrelles, across different habitats throughout Ireland. A selection of brown long-eared bat roosts from the monitoring scheme are included in this research. Bat Conservation Ireland provided a list of suitable building where access to collect bat droppings was possible. The scheme co-ordinator also assisted with dropping collection and liaison with roosts owners/managers. A total of thirteen brown long-eared roosts are included in this research.

To aid collection of bat droppings, newspaper was laid down inside roosts for two days and any fresh brown long-eared droppings were collected. The BatLab provided containers with silicon beads to store bat droppings and gloves and tweezers to collect bat droppings. This dropping collection was undertaken three times over the summer months to coincide with the three roost count periods of the survey methodology.

4.1.7 National Distribution of Brown long-eared bats

In preparation for Article 17 Reporting in 2025 BCIreland will provide information relating to the distribution of all Irish bat species. As part of the preparation for this, all bat records for the period 2010 to 2021 was downloaded from the Bat Conservation Ireland database. Brown long-eared bat roost data collated by the monitoring scheme and all other incidental records for this species were extracted and prepared for mapping. Mapping was completed using QGIS (3.16 Hannover) and projected (ITM Co-ordinates) to prepare a distribution map.

4.2 Results

4.2.1 Volunteer Participation 2007-2021

Volunteer teams are a vital component of the monitoring scheme and support is provided by on-site training whereby the scheme co-ordinator and new volunteer teams complete the first count together. Bat detectors and torches are also provided by BCIreland, where required. In addition, the co-ordinator accompanied some volunteer team counts during the first survey of each new monitoring year to provide continued support, when requested. The number of volunteer teams participating annually varied from year to year. For example, 45 building roosts were surveyed in 2020, 31 of which were monitored solely by volunteer teams and/or roost owners. The coordinator assisted surveying of three additional roosts with volunteer teams. In total, 51 volunteers, including three roost owners, participated in the monitoring scheme in 2020.

The following bat groups participate in the surveys: Kildare Bat Group, Waterford Bat Group, Clare Bat Group, Cork County Bat Group, Wicklow Bat Group, Cavan Bat Group, Midlands Bat Group and the Galway Bat Group. Four roost owners have participated in the scheme in the last four years.

For the purposes of providing volunteer feedback, a graph is annually prepared for each roost site detailing the survey history and results. This is emailed to each individual survey team in preparation for the next survey season.

4.2.2 Monitored Roosts 2007-2021

The Brown Long-eared Bat Roost Monitoring Scheme was introduced in 2007 and continued until 2010. There was no funding available in 2011 to implement the scheme, but during this survey season, volunteer teams undertook a minimum of one survey at 34 roosts to ensure continuity in the data until additional funding was available. The scheme was reinstated in 2012.

The 2007-2021 dataset consists of sixty-four brown long-eared roosts distributed in 21 counties in the Republic of Ireland. The highest number of roosts was located in County Cork (n=9) (Figure 4.1). The buildings surveyed were categorised into the following types: churches, houses, agricultural barns, large buildings/mansions and a category named "other" to represent two medieval towers and a 12th century stone structure. The majority of the buildings surveyed over the duration of the monitoring scheme have been churches (n=28, 45.3%: Table 4.1).

Over the 15 years, a total of 64 buildings were monitored while an additional 78 buildings were assessed and 76 were deemed unsuitable for monitoring. The remaining two roosts were deemed suitable to be assessed in 2022 (Counties Limerick and Offaly) for their inclusion in the monitoring scheme.

The highest number of roosts monitored in one year was in 2013 (n=49). During the 2018-2021contract period, 48 buildings were monitored and these were located across 20 counties (Figure 4.1). While only six roosts have been counted for each of the 15 years the scheme has been in operation, 34 roosts (53%) have 10 or more years of survey data (Table 4.2). In general, the majority of roosts in the dataset have been consistently surveyed from year to year, see Table 4.3. For example, 43 roost sites were monitored in 2021 and 42 of these roost sites were also monitored in 2017.

Some buildings are no longer being monitored due to roost abandonment, roost renovation works and/or changes to the habitat adjacent to the building (e.g. removal of hedgerow preventing bats from commuting to/from the building) or no access to structure. There are currently 44 structures on the database that are suitable for monitoring going forward and five additional structures that are recommended to be reassessed. Three additional roosts surveyed in 2018-2021 survey period have yielded reductions in numbers below the threshold minimum (i.e. a minimum of 8 individuals) but monitoring will continue of these building, where possible, to further investigate potential reasons for these reductions.

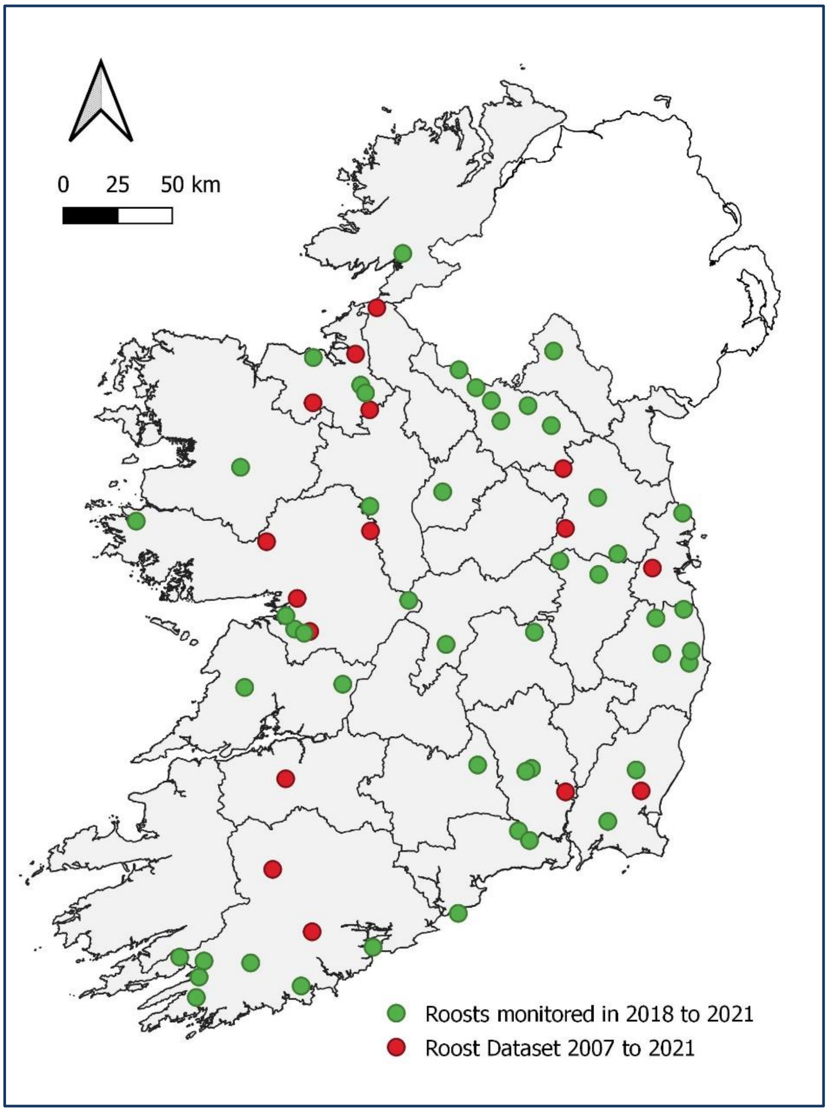

Figure 4.1 Location of all structures monitored as part of the Brown Long-eared Roost Monitoring Scheme 2007-2021.

Table 4.1 The number of roost types surveyed per year for the duration of the Brown Long-eared Roost Monitoring Scheme 2007-2021.

Survey Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	All
Structure Type																
Barn	0	2	2	2	2	2	4	3	3	2	1	1	1	1	1	4
Church	5	11	19	18	16	19	24	24	26	26	26	25	24	26	24	29
House	3	5	5	7	3	6	7	7	7	8	8	7	6	7	7	11
Large Building	6	11	8	12	12	12	12	11	8	8	9	9	9	8	8	17
Other	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3
All Types	16	31	36	41	35	41	49	48	47	47	47	45	43	45	43	64

Table 4.2 The number of years each roost has been surveyed for the duration of the Brown Long-eared Roost Monitoring Scheme 2007-2021.

Number of years	Number of roosts	% of total	Cumulative %
2	5	7.8	7.8
3	1	1.6	9.4
4	6	9.4	18.8
5	3	4.7	23.4
6	2	3.1	26.6
7	4	6.2	32.8
8	3	4.7	37.5
9	6	9.4	46.9
10	3	4.7	51.6
11	3	4.7	56.2
12	5	7.8	64.1
13	7	10.9	75
14	10	15.6	90.6
15	6	9.4	100

Table 4.3 The number of years each roost has been surveyed for the duration of the Brown Long-eared Roost Monitoring Scheme 2007-2021.

Survey Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2007	*16*														
2008	16	*31*													
2009	11	24	*36*												
2010	13	26	35	*41*											
2011	11	22	31	34	*35*										
2012	10	22	32	34	33	*41*									
2013	11	25	33	36	34	40	*49*								
2014	10	22	31	33	32	40	46	*48*							
2015	9	20	29	31	29	37	43	45	*47*						
2016	10	20	29	30	28	36	42	44	45	*47*					
2017	10	20	29	30	28	36	41	43	44	46	*47*				
2018	10	19	27	28	26	33	38	40	41	43	44	*45*			
2019	9	18	25	26	24	31	36	38	39	41	42	42	*43*		
2020	9	19	27	28	26	33	38	40	41	43	44	42	42	*45*	
2021	9	18	25	26	24	31	36	38	39	41	42	40	40	42	43
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021

In 2020, a total of 1,854 individual bats were counted in 45 roosts. This is the highest total over the fifteen years of the scheme. The mean number of bats per roost in 2020 was 32.53 individuals and the median count was 29 individuals (Table 4.4). The highest Mean Roost Count was recorded in 2016 (n=34.1) and the Median value in this year was 30 bats.

Table 4.4 The number of roosts surveyed per year, and surveyed again in subsequent years, for the duration of the monitoring scheme 2007-2021.

Survey Year	No. of individuals	Mean Roost Count	Median Roost Count
2007	342	18.32	18
2008	644	18.6	15
2009	1062	25.6	21
2010	1455	31.7	29
2011	1089	31.1	26
2012	1523	32.3	29
2013	1716	29.5	26
2014	1648	29.63	23
2015	1665	30.2	28.5
2016	1772	34.1	30
2017	1823	33.4	29
2018	1703	32.95	26
2019	1624	32.53	29
2020	1854	32.53	29
2021	1586	31.11	28

4.2.3 Completed Surveys 2007-2021

A total of 1,371 monitoring surveys have been undertaken to-date with the highest number of surveys completed in 2021 (n=116 surveys) (see Table 4.5). Depending on the roost, monitoring is either completed by Internal Count or by an Emergence Count (dusk survey). Some roosts over the duration of the monitoring scheme were surveyed using a combination of these two methods. The majority of surveys completed were Emergence Count (n=1,079 surveys, 78%). Emergence Counts are the preferred method of survey as this was shown by statistical analysis to be a more reliable method for this monitoring scheme (Aughney *et al.*, 2011). The proportion of roosts monitored by Internal Counts has reduced from year to year. In 2007, for example, 46% of surveys completed were Internal Counts compared to 18% in 2017. However, some roost sites can only be accurately monitored by internal counts. An exception to this was in 2021 when a number of additional internal counts were completed as a result of the Ecosystems Survey project. A table is presented in Appendix 3 detailing all of the surveys completed for each roost and the recommended survey method for future monitoring at each site.

Table 4.5 The number of surveys completed per year for the duration of the monitoring scheme 2007-2021.

Survey Year	Internal count	Emergence count	Total no. of surveys	Total no. of roosts
2007	12	13	25	16
2008	26	25	51	31
2009	24	49	73	36
2010	25	62	87	41
2011	7	29	36	35
2012	24	67	91	41
2013	25	86	111	49
2014	27	85	112	48
2015	18	90	108	47
2016	20	95	115	47
2017	18	93	111	47
2018	17	93	110	45
2019	15	95	110	43
2020	9	106	115	45
2021	29	91	116	43

4.2.4 Statistical Analysis of the 2007-2021 Dataset

The effects of Northings and Eastings, day number (i.e. survey date), weather data, start time, type of building (different construction parameters) and Internal Counts/external Dusk Emergence Counts are examined annually using a Generalised Linear Mixed Model (GLMM). From analysis of the 2007-2021 dataset, three terms were statistically significant; rain, roost type and day number. This is similar to the results of analysis completed in 2019 and 2020. In previous years, terms that were significant included survey period, start time and type of survey (internal versus external roost counts), but these parameters are having less of an influence as the monitoring scheme progresses and surveys are surveyed in a more standardised manner (e.g. strictly adhering to completing surveys in the three set survey periods).

Type of building remains significant, with higher average counts in churches. Surveyor's recorded weather data and rain is still significant with higher numbers, as would be expected, recorded in drier conditions. The interaction term between internal counts and day number is again very highly significant ($F=15.31$ with 1 and 910 d.f., $P<0.001$) whereby external counts tend to be higher than internal counts early in the season, but internal to be higher than external later in the year. This trend continues for the 2007-2021 dataset. This pattern has been evident (although not always statistically significant) for many years, and we already allow for it in the GAM model using a covariate.

Day Number continues to have a significant influence on the counts (quadratic trend peaking in July/August). Felt is no longer significant (i.e. the presence of roofing felt), as noted in 2020 ($F=2.35$ with 2 and 57 d.f., $P=0.105$).

Additional statistical analysis was undertaken to investigate the mean time the first bat emerged during external surveys in previous years and this was repeated in 2021. As the survey protocol requires surveyors to start surveys 20 minutes after sunset, it is important to determine that the survey protocol is correct (i.e. appropriate start time). This dataset included surveys completed during 2012-2021 (n=741 surveys relating to 34 roosts with a minimum of five years of emergence survey data), as surveyors were requested to record the time of the first emerging bat since 2011 going forward. From the onset of the monitoring survey, surveyors were asked to count the number of bats during emergence according to ten minute survey blocks. The ten minute block data was used to calculate the approximate mean emergence time (based on treating bats as if they all emerged at the mid-point of the block) and a time of last emergence, to the nearest 10 minute survey block. In relation to the time of the first emerging bat, the Mean time was 30.3 minutes after sunset (Table 4.6) while the last bat tended to emerge 68.1 minutes after sunset. On average it takes 45.8 minutes for the colony to emerge but this is influenced, as to be expected, by the size of the colony (note – surveyors end the survey once there is a full 10 minute block where no bats have emerged).

Table 4.6 Mean and standard errors (minutes after sunset) of First Emergence Time, Mean Emergence Time and Last Emergence Time for external survey completed the duration of the monitoring scheme 2007-2021. Note: Observations more than 20 minutes from the expected time and first emergence times not tallying with the start time were removed from the dataset. Last emergence times are taken as the end of the 10 minute block.

	Mean (minutes after sunset)	S.E.
First Emergence Time	30.3	0.33
Mean Emergence Time	45.8	0.34
Last Emergence Time	68.1	0.49

Firstly looking at the relationship with total counts, based on a GLMM:

- **First emergence**: total counts tend to be lower when the time of first bat to emerge is later relative to sunset time (NOTE: survey starts 20 minutes after sunset) ($F= 43.29$ with 1 and 613 d.f., $P<0.001$)
- **Mean emergence time**: whilst there are signs of a negative relationship between the number of bats emerging and the mean emergence time, this is not quite statistically significant ($F=3.44$ with 1 and 615 d.f., $P=0.064$).
- **Last emergence time**: when counts are high, the time of last emergence is later relative to sunset time (NOTE: survey starts 20 minutes after sunset) ($F=10.79$ with 1 and 612 d.f., $P=0.001$).

These relationships are shown graphically in Figure 4.2, which plots all the data, expressing each count as a proportion of the average count for the roost.

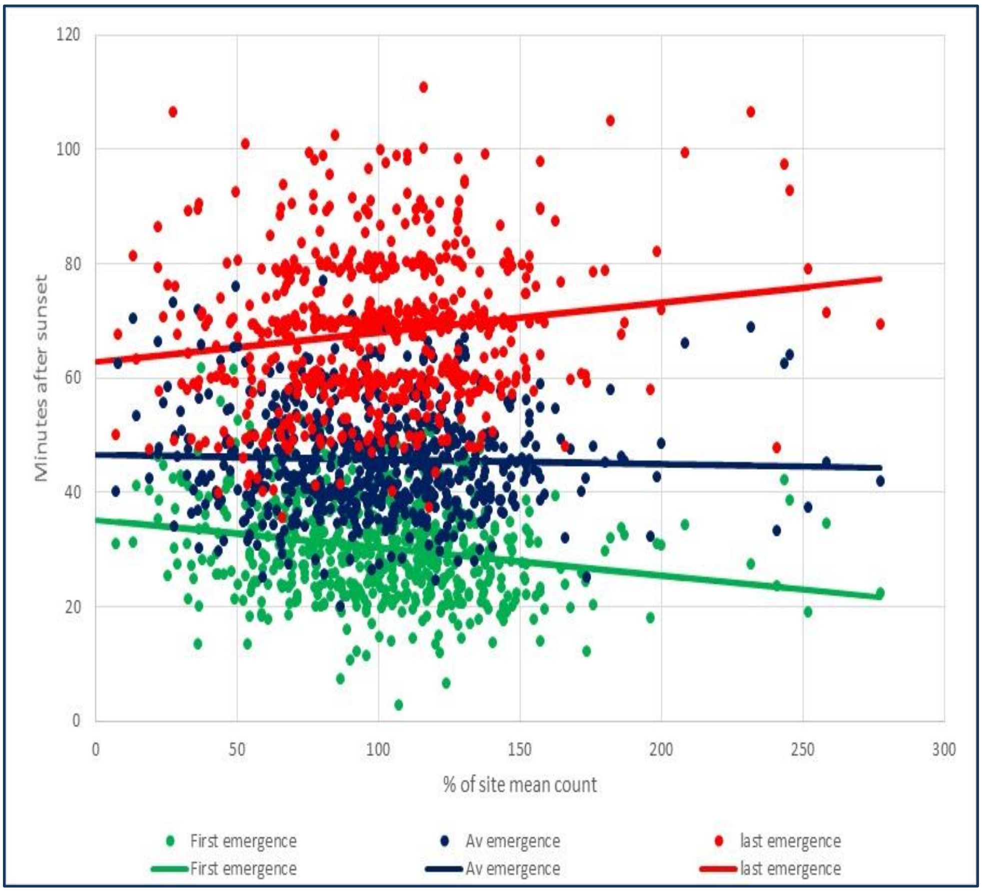

Figure 4.2 First, Mean and Last Emergence Times plotted against counts as a proportion of the site mean count. (Note: Last Emergence Times are only known to the nearest ten minute block). Lines are linear regression lines.

Analysis of external counts was undertaken to determine if weather data collated by surveyors influenced the three emergence times. The results are as follows:

- First emergence times were around 3 minutes earlier in cloudy conditions (i.e. full cloud cover) (F=10.33 with 2 and 620 d.f., P<0.001, Figure 2), but were 3 minutes later when it was breezy (F=6.42 with 2 and 628 d.f., P=0.002). First emergence times also tend to be slightly earlier relative to sunset later in the season (F=22.23 with 1 and 462 d.f., P<0.001 for the linear effect of day number), with a change of around one minute per month.
- Cloud also has a highly significant impact on mean emergence times (F=7.35 with 2 and 655 d.f., P=0.001), with emergence times in full cloud around 2.5 minutes earlier than on a clear night. The mean time was 3.5 minutes later in breezy conditions, compared to a calm night (F=7.20 with 2 and 660 d.f., P=0.001). There is also a significant relationship with day number and with earlier emergence relative to sunset later in the survey season (F=28.50 with 1 and 482 d.f. P<0.001)
- Last emergence times (based on the last block with bats) are not significantly related to cloud (F=1.09 with 2 and 662 d.f., P=0.337), but the relationship with wind is close to statistical significance (F=2.93 with 2 and 664 d.f., P=0.054). The linear effect of day number is significant (F=10.02 with 1 and 492 d.f., P=0.002), with the time of the last bat getting earlier relative to sunset by just over 1 minute per month.

The relationships with cloud conditions (Clear sky, Partial Cloud Cover and Full Cloud Cover) is shown in Figure 4.3 and that with wind conditions (Calm, Light Wind and Breezy) in Figure 4.4.

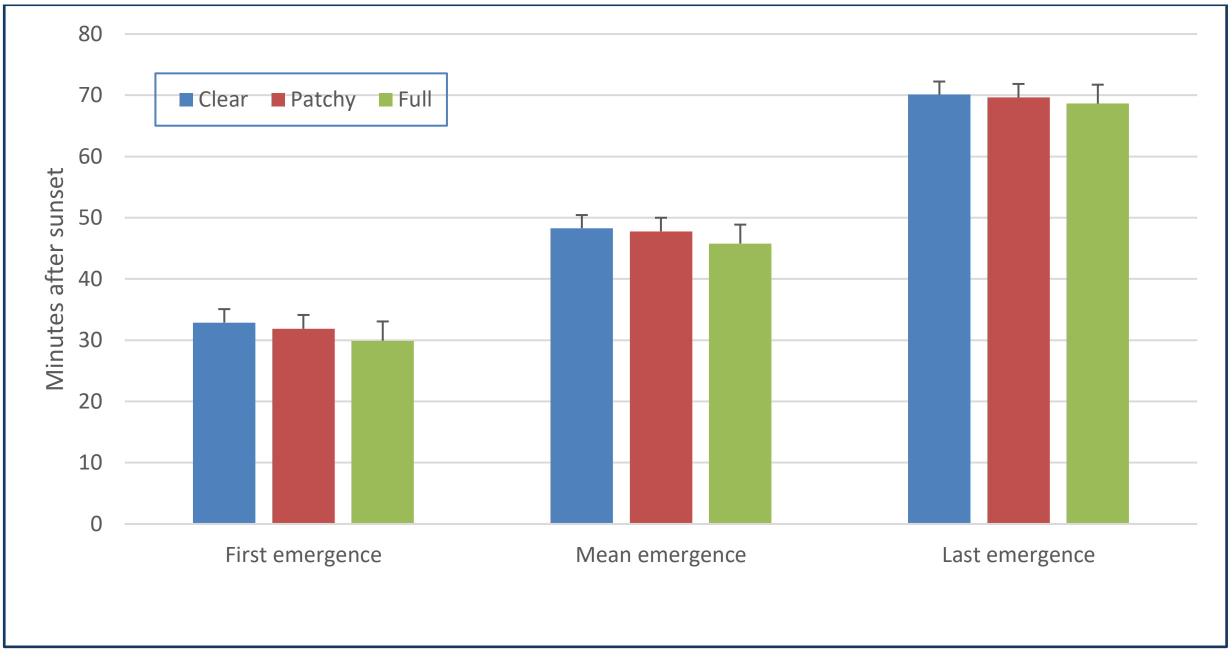

Figure 4.3 Emergence times in different cloud conditions (Clear sky, Partial Cloud Cover and Full Cloud Cover). Bars show estimates from REML models with 95% confidence limits, after adjusting for the effect of day number and wind conditions.

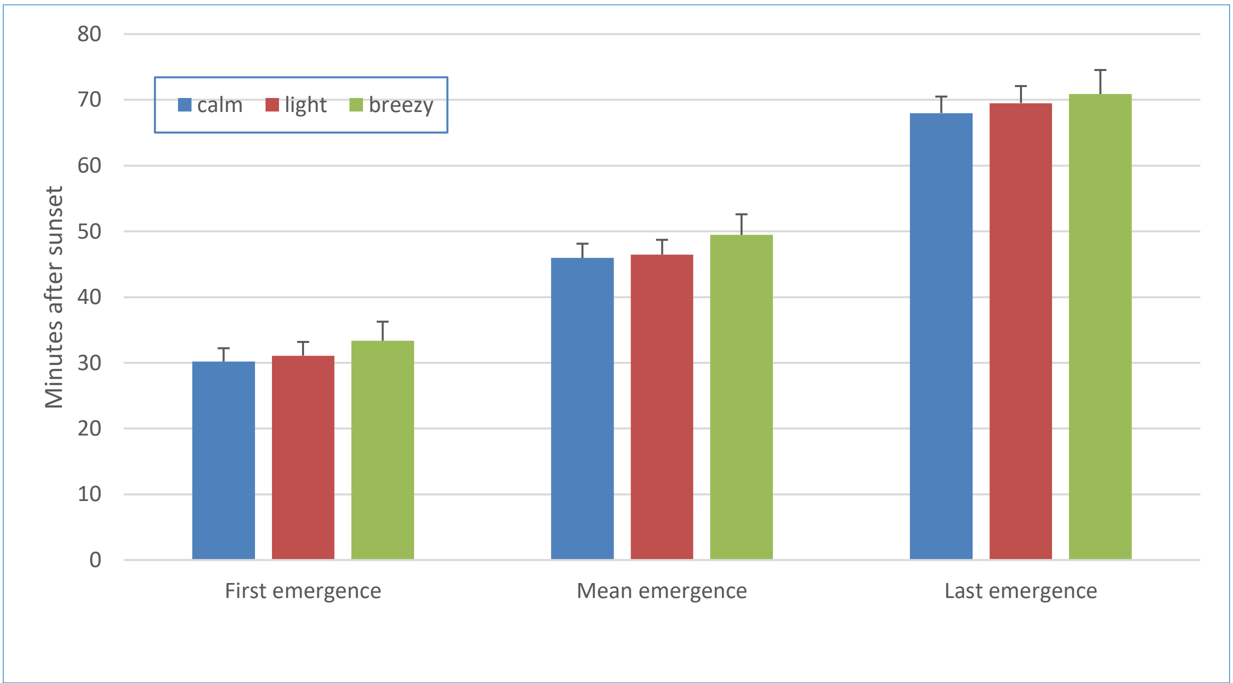

Figure 4.4 Emergence times in different wind conditions (Calm, Light Wind and Breezy). Bars show estimates from REML models with 95% confidence limits, after adjusting for the effect of day number and cloud conditions.

This analysis provides mean values across a large array of roost types. The earliest First Emergence Time was 2.9 minutes after sunset (Site Code 2013, survey date 27/8/2020, weather conditions: clear sky, calm and dry) while the range of First Emergence Time was 2.9 minutes to 62.5 minutes after sunset. When the dataset is examined, there were three surveys where First Emergence Time was 60 minutes after sunset: Site Code 2021 (Survey date: 1/7/2018, weather conditions: 16°C, partial cloud, breezy and dry); Site Code 2024 (Survey date 15/8/2020, weather conditions: 17°C, full cloud, calm and dry) and Site Code 2055 (Survey date: 27/6/2018, weather conditions: 18°C, clear sky, dry and calm). Two of these roosts (Site Codes 2021 and 2024) have reported dwindling roost numbers since 2018 which may account for the late First Emergence Times. On the date of the survey for the third roost, a full moon occurred on 28/6/2018 (i.e. one night later) and therefore given that “clear sky” was noted on the 27/6/2018, it is likely that the brightness of the moon may have resulted in a later First Emergence Time for this particular survey. While it is also worth noting that there is a considerable amount of roost to roost variation in the emergence times, as well as some signs of year to year variation within roosts (maybe due to factors such as levels of shading by trees), there is no sign of a consistent year to year pattern across all roosts.

4.2.5 Trend Analysis 2007-2021

Results from a GAM model, expressing the trend as an index with 2009 as the base year, is shown in Figure 4.5 and Table 4.7. While previous years trend analysis had used the 2008 as the base year, investigations in 2019 showed that using 2009 as the base year provides a more stable and accurate population trend. Therefore, going forward, 2009 will be used as the base year. The models use a negative binomial distribution, rather than the Poisson distribution used previously (and as used for the GLMM), as this seemed to fit the data better and gave slightly more precise results.

The models have been fitted with and without covariates for drizzle/rain, for Internal Counts before mid-May and for external Dusk Emergence Counts after mid-September. The model with covariates is slightly more precise (i.e. narrower confidence limits). Other than the slight difference in precision, results are similar with and without covariates, with an initial increase followed by stable results for the last couple of years. The index is currently above the baseline value for 2009 but there is a noticeable drift downwards towards the baseline compared to the trend line as reported in 2020.

Overall the smoothed index using the model with covariates is currently 6.37% above the 2009 base year value which is equivalent to an average 0.52% annual increase.

In previous years the brown long-eared bat trend from the Irish roost monitoring surveys was similar to that derived from Car-based Bat Monitoring Scheme data. That index currently encompasses its 2010 baseline and shows little significant change since 2007 (see Figure 2.15). Despite some large fluctuations, in the past twelve years (2010-2021) this species has remained relatively stable with just a -0.1% annual change. Error bars are much wider for Car-based Bat Monitoring data, however, since this scheme only picks up social calls of relatively few brown long-eared bats during July and August roadside surveys. By way of comparison, just seven brown long-eared bat passes were recorded from 790 x 1.6km transects across Ireland in 2015, compared with over 1600 individuals counted from 46 roosts during the Brown Long-eared Bat Roost Monitoring Scheme in the same year.

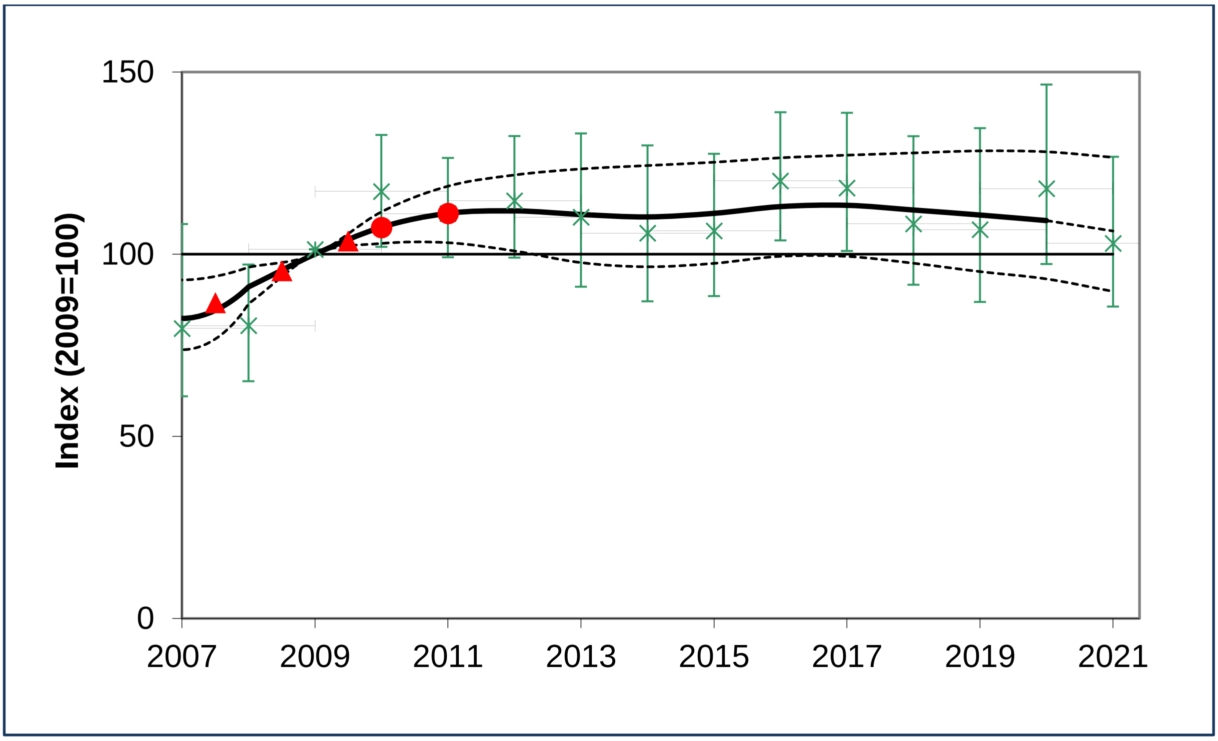

Figure 4.5 Results of Binomial GAM model with 95% confidence limits for the Brown Long-eared Roost Monitoring Scheme 2007-2021. Green points are estimated annual means and are shown to illustrate the variation about the fitted line.

Table 4.7 Binomial GAM results with 95% confidence limits for Brown Long-eared Roost Monitoring Scheme (2007-2021). Covariates include drizzle/rain, for internal counts before mid-May and for external counts after mid-September.

		Index 2009 = 100							
		Smoothed		95% conf limits		Unsmoothed		95% conf limits	
Year	Sites	Index	s.e.	Lower	Upper	Fitted	s.e.	Lower	Upper
2007	16	82.36	4.84	73.77	92.93	78.29	12.29	59.66	106.94
2008	31	91.01	2.50	86.39	96.42	79.06	8.27	63.80	95.83
2009	36	100.00	0.00	100.00	100.00	100.00	0.00	100.00	100.00
2010	41	107.39	2.19	102.94	111.61	115.87	7.88	100.69	131.40
2011	35	111.21	3.89	103.15	118.66	109.81	6.70	97.83	125.10
2012	41	111.90	5.39	100.89	121.73	113.38	8.63	97.71	131.10
2013	49	110.90	6.53	97.69	123.39	108.82	10.63	89.73	131.82
2014	48	110.23	7.05	96.54	124.34	104.49	10.96	85.73	128.54
2015	47	111.21	7.11	97.47	125.24	105.09	9.89	87.17	126.23
2016	47	113.06	7.07	99.42	126.46	118.76	8.90	102.46	137.65
2017	46	113.41	7.26	99.40	127.18	116.88	9.49	99.56	137.48
2018	45	112.13	7.80	97.51	127.79	106.99	10.22	90.28	131.06
2019	43	110.75	8.47	95.22	128.36	105.40	12.27	85.56	133.28
2020	45	109.23	8.94	93.21	128.11	116.70	12.48	95.97	145.23
2021	43	106.37	9.31	89.79	126.58	101.64	10.64	84.29	125.41
TOTAL	64								

4.2.6 Habitat Mapping & Roost Profiles

The locations of all roosts currently monitored (n=44) were digitised and concentric circles were created at a 0.5 km radius from the roost using QGIS (3.16 Hannover) to determine the extent of woodland cover within each buffer zone. While woodland information from the NPWS Native Woodland Inventory (NWI) was projected, only a small proportion of the roost buffers (n=7 roosts) contained woodlands from this project. Therefore, it was necessary to digitise, within 0.5 km radius of the roosts, all "Tall Vegetation" (treelines, small woodlands, forestry and parkland trees) using aerial photographs (Bing Satellite) to determine the total cover of trees (hectares) within each 0.5km buffer zone.

A 0.5km buffer encompasses 77.28 hectares of land. The total amount of "Tall Vegetation" was calculated for each of the 44 brown long-eared roosts from digitised polygons. On average, 17.46 hectares (22.59%) of the buffer was deemed "Tall Vegetation", ranging from as low as 3.96 hectares (5.12%) to 66.91 hectares (86.58%). The roost with the least tall vegetation cover is Site Code 2090 which is located at the foothills of an upland area in west Co. Sligo, while the roost with the most cover is Site Code 2023 which is located adjacent to Glengarriff Nature Reserve, Co. Cork (shown in Figure 4.6 as an example).

Figure 4.6 Aerial image (OpenSource Maps) of digitised "Tall Vegetation" (Yellow hatched area) within the 0.5km buffer for Site Code 2023 and also depicting the NPWS Native Woodland Inventory (NWI) (shown in Red).

This habitat data was added to the "Roost Profile" (i.e. age of building, construction of building material, roof material and location) and an investigation was completed to determine if there is any relationship between roost counts and these factors. A summary of the "Roost Profile" data is presented in Table 4.6. The majority of the buildings are churches (57%), have a natural slate roof (87%), >100 years old (68%), with a natural stone wall construction (86%) and are located in a rural area (70%).

Table 4.8 Summary of Roost Profile parameters of Brown long-eared bat roosts.

Parameters					
Building Type	Church	House	Agricultural Building	Large Building / Mansion	Other
	25	6	1	9	3
Roof Material	Natural Slate	Modern Slate	Thatch	Lead	
	39	3	1	1	
Age	>100 years	<100 years			
	30	14			
Wall Construction	Natural Stone	Concrete	Mix		
	38	5	1		
Location	Rural	Urban Edge	Urban		
	31	13	0		

The average roost count for the last five years (2017 to 2021) was calculated for each of the 44 brown long-eared roosts. Mean number of bats was 32 individuals (Range: 6 individuals to 87 individuals). Generalised Linear Modelling was undertaken with mean count per roost for the years 2017-2021 and included as possible explanatory variables were Eastings, Northings and percent "Tall Vegetation" cover. GLM with poisson distribution results showed a significant positive association between mean roost count with both presence of "Tall Vegetation" (i.e. % cover within a 0.5km radius) and Northing co-ordinates. The χ^2 statistic of the model is 35.77 with 2 degrees of freedom which has an overall p value of <0.000 which suggests that the model is highly useful as a predictor of roost size. In this case the model indicates that roost size increases with both habitat coverage in the immediate area surrounding the roost, as well as at more northerly latitudes (see Figures 4.7 and 4.8). A roost profile is available for each of the 44 roosts proposed to be monitored during the 2022-2025.

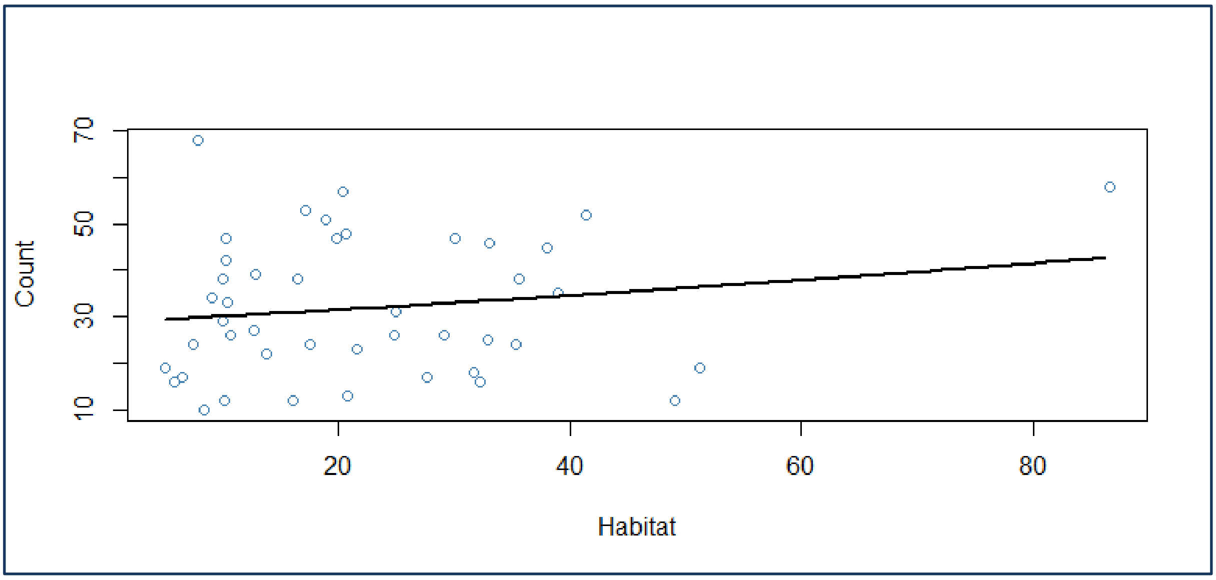

Figure 4.7 Regression line indicating the relationship between "Tall Vegetation" cover within 0.5km radius of each roosts (n-44) and mean roost counts from 2017-2021.

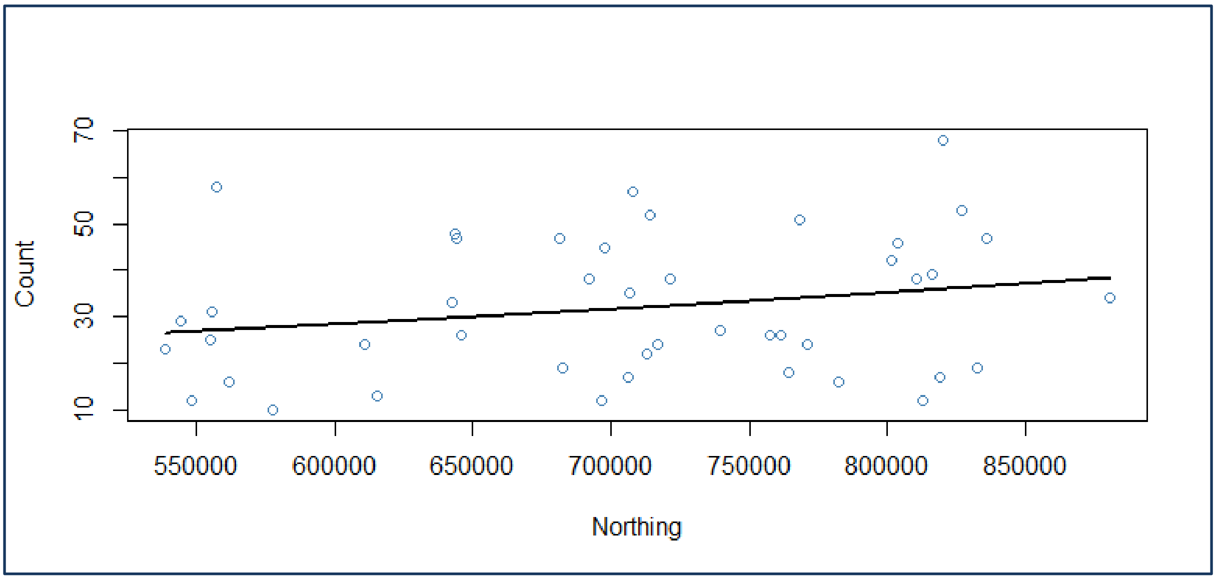

Figure 4.8 Regression line indicating the relationship between roost locations (ITM Northing) and mean roost counts from 2017-2021.

4.2.7 Additional Technology

Due to the difficulty of detecting brown long-eared bats emerging from some roosts, filming with the aid of infra-red illuminators were deployed. The use of IR aided filming was investigated in 2020 using count data from four roosts surveyed by both IR technology and a surveyor simultaneously to determine if the use of IR increases accuracy of survey counts. This dataset is a small one and includes one roost that is being investigated as the roost numbers have been low for a number of years (Site Code 2064 – X on Figure 5.10). Excluding Site Code 2064, counts using the IR camera are significantly higher ($F=14.61$ with 1 and 14 d.f., $P=0.002$) compared to counts completed by the surveyor at the specified roosts.

Sony HandyCam FDR-AX33 and FDR-AX53 with night-shot capability along with infrared illuminators are now routinely deployed at specific roosts. In 2020 they were used at six roosts, providing more reliable counts for each site. It was also used to confirm roost exit point(s) (e.g. Site Code 2022), as an additional surveyor for Sites Codes 2045, 2100 and 2138 and used as a training tool for the surveying of Site Codes 2122 and 2066. In 2021 they were used at eight roosts, providing more reliable counts for each site. It was used as the main survey tool for Site Codes 2022, 2066 and 2129, as an additional surveyor for Sites Codes 2045, 2100, 2122, 2124 and 2138 and used as a training tool for the surveying of Site Codes 2133, 2131 and 2006.

Due to the precautionary measure of reducing survey access to internal spaces of roosts previously surveyed by internal counts during COVID-19 restrictions, additional roosts were surveyed by filming. One such roost is Site Code 2001. The exit points for this roost are approximately 20m high and therefore difficult to pin-point. The IR illuminators deployed were not “bright” enough to illuminate potential exits points during surveys in 2020. Therefore, thermal imagery was used during the 2021 emergence surveys. This technology successfully filmed bats emerging from high exit points. This technology was also used to pin-point exit points for Site Code 2006, a building where exits points have been noted to change seasonally.

4.2.8 Ecosystems Services Research

Bat droppings were collected from a total of 13 buildings currently monitored for brown long-eared bats under the roost survey scheme. The following map was produced by Ph.D. student Gwenaëlle Hurpy-Rochon. Dropping collection was completed by two roost owners, two volunteer surveyors (n=3 roosts) and the scheme co-ordinator (n= 4 roosts). The remainder were collected by Ms. Hurpy-Rochon. A separate progress report has been prepared by Ms. Hurpy-Rochon for NPWS.

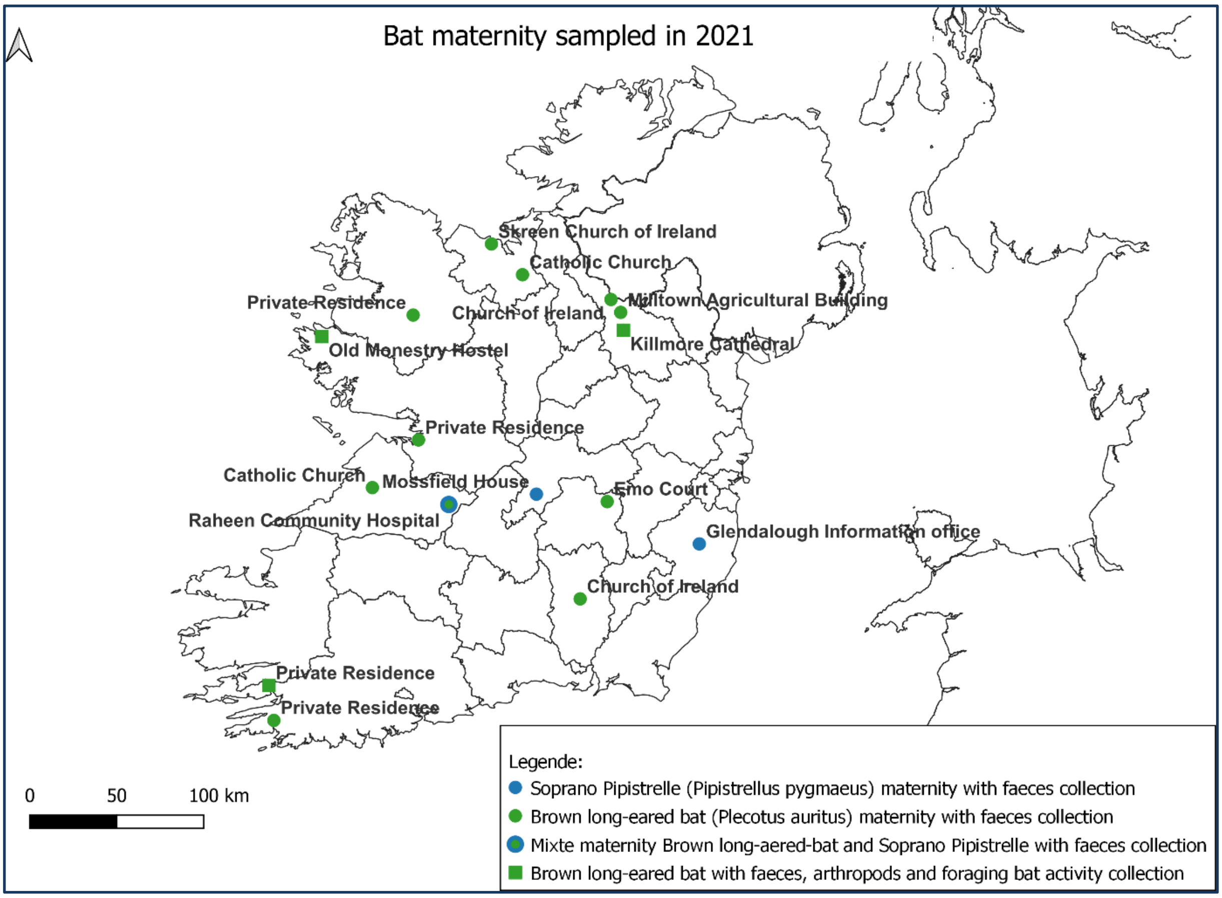

Figure 4.9 Roosts sampled in 2021 (Source: BatLab, UCD).

4.2.9 National Distribution of Brown long-eared bats

A total of 1,427 brown long-eared bat records are currently available (2010 to 2021 dataset). This dataset is consists primarily of records from the roost monitoring surveys (n=863 records, 60%). The following table provides a breakdown of the sources of the records; they are distributed in all counties across the country.

Table 4.9 Sources of Brown long-eared Bat Records on the Bat Conservation Ireland Database

Source of Records	No. of Records
Brown long-eared bat Roost Monitoring Scheme	863
All Ireland Daubenton's Bat Waterways Survey	9
Car-based Bat Monitoring Scheme	88
BATLAS 2020	122
Pilot Woodland Monitoring 2016-2017	29
BCIreland Neighbourhood Bats Survey	154
Ecological Consultancy Records	151
Other Sources	11

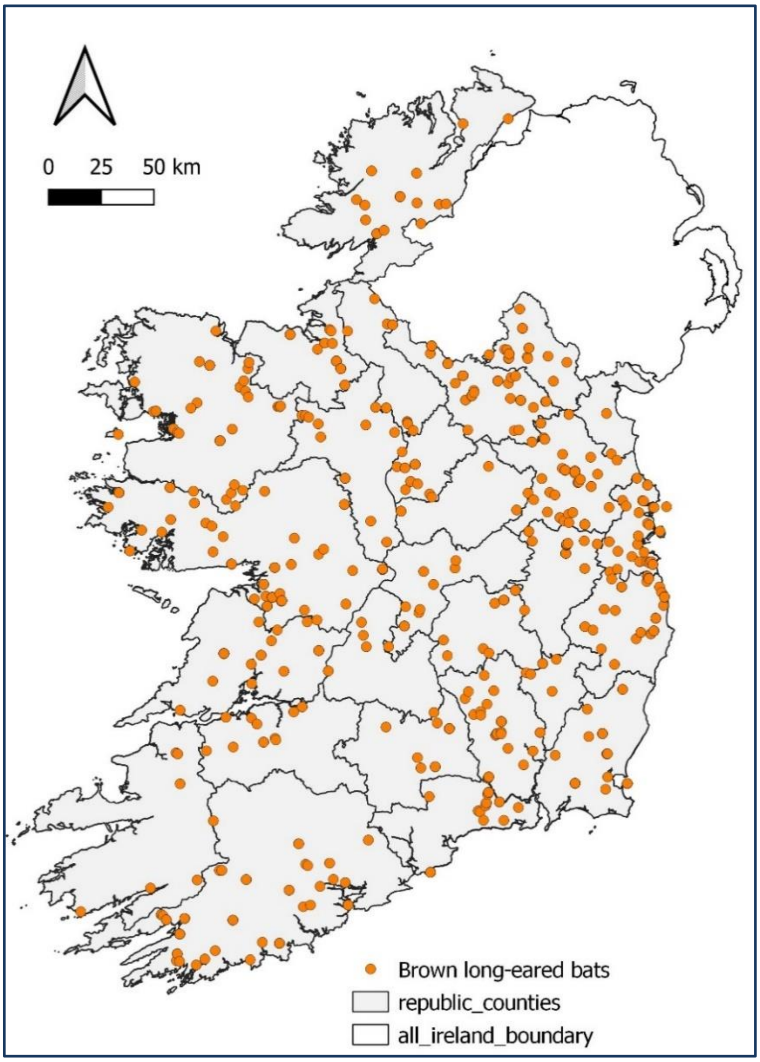

Figure 4.10 Brown long-eared bat distribution in Ireland (BCIreland database 2010-2021).

5 Lesser Horseshoe Bat Roost Monitoring

The lesser horseshoe bat (*Rhinolophus hipposideros*) is mainly found in counties on Ireland's western seaboard - Mayo, Galway, Clare, Limerick, Kerry and Cork - with strongholds in Kerry/west Cork and in Clare. The lesser horseshoe bat is Ireland's only Annex II-listed bat species (as per EU Habitats Directive [92/43/EU]). This means that its population requires special protection measures and the designation of Special Areas of Conservation within the Natura 2000 network. These designations are usually roost or hibernacula-centred and focus on large roosting sites for the species, usually with >50 individuals in winter or >100 individuals in summer.

BCIreland carried out analysis of the Lesser Horseshoe Bat database in 2012, see Roche *et al.* (2012). Initial results were encouraging and indicated that the species has increased for much of the duration of its monitoring scheme. However, concerns have been expressed about the state of deterioration of many of its roosting sites e.g. Roche, Aughney, & Langton (2015) and McAney (2014) as well as the finding that there are genetically distinct clusters within the Irish population (Dool *et al.*, 2013; Harrington, 2018) that are likely to have arisen due to landscape connectivity constraints. Further work on landscape connectivity for the species was carried out more recently and this identified issues with high levels of artificial light at night (ALAN) that act as barriers in the landscape for the species around Galway and Limerick cities (Finch & McAney, 2020).

The present report details the ongoing seasonal monitoring of lesser horseshoe bat summer and winter sites by National Parks and Wildlife Staff, staff of the Vincent Wildlife Trust and various independent ecological consultants. Using the summer roost and hibernacula count data we have analysed population trends for the species to winter and summer 2021.

5.1 Method

BCIreland's involvement in the scheme began in November 2013 when the MS Access database listing known roosts and roost records was provided by the NPWS.

Surveyors were trained in survey methodology prior to the handover. New NPWS conservation rangers are typically trained-in by other members of staff from their region. Surveyors are provided with equipment needed for the survey by the NPWS or Vincent Wildlife Trust (VWT) to complete surveys of specific sites within their district each year. While some summer counts are carried out by counting emerging bats at dusk (emergence counts), many sites are counted internally during daylight hours. Emergence counts are generally carried out using bat detectors, with the Vincent Wildlife Trust also using video camera footage to ensure accuracy. The dates for surveying in summer are May 23rd to July 7th, although counts outside these dates are included in the overall trend series. This is considered necessary because the sample size within the specified survey dates would result in a low sample size for the early years of the time series should counts outside those dates be omitted. Winter surveys in hibernacula are carried out in January and February each year. For some of the larger hibernacula photographs of the hibernating bats are taken and are then counted ex situ to ensure accuracy of counts and reduce potential disturbance to hibernating bats.

During the current contract, data was provided in Excel spreadsheets by NPWS regional staff from summer 2018 to summer 2021. These data were cleaned, queried (where necessary) and imported to the database using the Excel to Access Import function in MS Access.

Due to the COVID-19 pandemic we asked surveyors not to carry out counts in sites in summer and winter 2021 unless they could keep >1m distance between themselves and the bats. This was to minimise the chance of humans transmitting the SARS-CoV-2 virus to the bats. We also asked surveyors to wear masks during all surveys.

5.1.1 Statistical Analysis

For overall yearly trends, a Generalised Linear Model (GLM) with a Poisson error distribution was applied to the data. Confidence intervals are generated by bootstrapping (Fewster *et al.*, 2000), as used in Generalised Additive Model (GAM) analysis. Generalised Additive Models (GAMs) have been fitted to the annual means to give a visual impression of the trend over time. Curved trend lines have been applied to the data.

5.1.1.1 Hibernation counts

The analysis includes data from December 24th to 7th March from 1986 to 2021 but the number of sites is very low in some years, particularly between 1989 and 1991. The y-variate is the count of bats present. Sites with no bats in any year in the survey period are excluded and sites with a record for only one year are also excluded because these contribute no information on trends. The winter 2022 dataset was not included in the time series as all data had not been received at the time of analysis.

Roche *et al.* (2012) highlighted the effect of day number during the survey period on mean winter counts with numbers falling off towards spring. In order to account for this, day number in the survey period is used as a covariate in the analysis. Data from surveys conducted between 26th December and 7th March are used, i.e. January and February ±1week.

Constraints due to the COVID-19 pandemic meant that a number of winter sites could not be accessed for surveying in winter 2021.

5.1.1.2 Summer counts

The analysis includes data from May to August from 1992 to 2021 but the number of sites is very low in some years, particularly 1996 and early in the time series. The y-variate is the count of bats present. Sites with no bats in any year in the survey period are excluded and sites with a record for only one year are also excluded because these contribute no information on trends. There are a number of pairs of sites that are grouped for the analysis because the same bats use the two sites, for example the stables and cellars at Curragh Chase, Co. Limerick. Day number in the survey period is used as a covariate in the analysis. A review of data to 2017 showed that counts conducted internally differ substantially from those conducted during evening emergence (Aughney *et al.*, 2018), with counts carried out of emerging bats resulting in higher numbers than internal counts. Since then, trend analysis of summer sites has included a covariate for internal counts to account for those differences.

5.1.1.3 Population trends and the influence of weather

In 2022 we also examined relationships between lesser horseshoe bat population trends and weather conditions. The lesser horseshoe summer data (within day numbers 137-194) was used for calculating annual growth rate. We used the time period from 2006 to 2021 as numbers of counts are a lot lower before this. Monthly rainfall and temperature data provided by Met Éireann was downloaded from data.gov.ie.

Since the number of met stations close to roosts is small, particularly for the temperature data, we concentrated on investigating impacts of weather on population change over time, i.e. temporal trends, rather than spatial trends. We used methods similar to those described in Froidevaux *et al.* (2017), correlating growth rates with met data for the period 2007-2021.

Two weather variables were examined, temperature and rainfall. For temperature, mean monthly temperatures were extracted for the seven stations shown with large red dots in Figure 5.1 which all had at least ten years of temperature data and were within 10km of counted roosts.

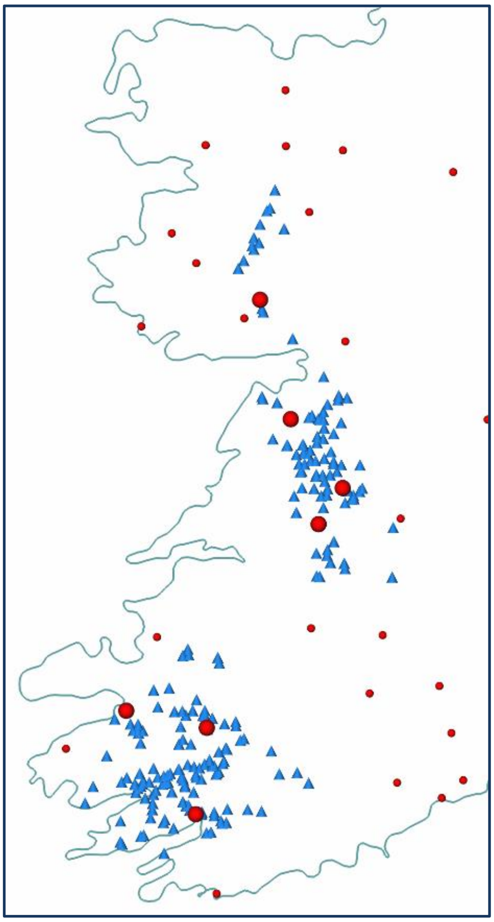

Figure 5.1 Locations of roosts (blue triangles) and weather stations (red circles) with temperature data. Larger red circles are the ones used, based on their length of met data and proximity to the roosts.

A complete matrix of temperatures for all months and years was obtained by imputing for missing values from a model fitting station and the interaction of year and month. The minimum of these monthly averages was then taken for each station in each quarter of each year. Before averaging over stations to get a single figure for each quarter of each year. The quarters were taken as Jan-March, April-June, July-Sept and Oct-Dec, as in Froidevaux *et al.* (2017), rather than the Dec-Feb, March-May, etc definition often used with met data.

Rainfall was more straightforward, with an average being taken over all stations and all months in each quarter of each year. Twenty stations were used, as there were more met stations with decent runs of rain data that were sufficiently close to the roost sites.

Two approaches were investigated for calculating growth rates. For the first method we used a similar approach to Froidevaux *et al.* (2017) 31 roosts were selected which each had counts for at least 12 years (between days 137 and 194) and averaged at least 25 bats. Growth rates were then calculated for each colony in each year, using equation 1 in Froidevaux *et al.* (2017)- which investigated the annual fluctuations in colony size by calculating the annual growth rate (r_t) for each colony:

$$r_t = (N_t - N_{t-1})/(N_{t-1}) * 100$$

where N is the number of individuals of a given colony at years t or t - 1.

We took median counts for each year, on the grounds that the big fluctuation in counts produces a skew distribution of growth rates, so the median should be a better estimator of overall change.

We also examined the relationship between weather and growth rate using unsmoothed trend estimates. This has the advantage that it makes full use of all data, weighting them appropriately for the number of bats, whereas the above method weights all roosts equally regardless of size. This was done with trend data (May-August counts) and using the shorter period we used to use (days 137-194).

5.1.2 National distribution of lesser horseshoe bats

In preparation for Article 17 Reporting in 2025 BCIreland will provide information relating to the distribution of all Irish bat species. As part of the preparation for this, all bat records for the period 2010 to 2021 was downloaded from the Bat Conservation Ireland database. Lesser horseshoe bat roost data collated by the monitoring scheme (Please note the vast majority of records from the roost monitoring is held by NPWS) and all other incidental records for this species were extracted and prepared for mapping. Mapping was completed using QGIS (3.16 Hannover) and projected (ITM Co-ordinates) to prepare a distribution map.

5.2 Results

5.2.1 Records submitted for 2018-2021

The number of roost/hibernacula count records on the lesser horseshoe database currently stands at 5,841 but this includes some records for other species and data that cannot be used in trend analysis due, for example, to insufficient information in the Date field.

Table 5.1 Number of lesser horseshoe bat records imported to Access database 2018-2021

Year	Winter	Summer
2018	137 (111 sites)	135 (104 sites)
2019	129 (119 sites)	169 (148 sites)
2020	120 (108 sites)	153 (136 sites)
2021	55 (48 sites)	149 (134 sites)

These records include some null counts where no access was possible, multiple counts in the same season at some sites, and some records for species other than the lesser horseshoe bat. Some additional records outside the main survey dates or recently discovered historical records were also imported to the Access database.

Winter seasons counts were carried out at between 48 and 111 sites in each winter season from 2018 to 2021. The number of sites counted in January-February 2021 was the lowest for many years due to COVID-19 constraints. The sum of maximum counts for all sites from winter 2018 to winter 2021 ranged from a low of 5090 (winter 2021) to a high of 9373 (winter 2020, pre-pandemic).

Table 5.2 Raw data for each season in the current reporting period. Total Bats = sum of maximum counts within the survey periods (2018-2021 inclusive).

Year	Season	Total Bats	Mean count	Single Site Max Count	Median
2018	Summer	10,007 (n=104)	96.2	525	50
2019	Summer	10,733 (n=148)	72.0	526	22
2020	Summer	10,851 (n=136)	79.8	580	34.5
2021	Summer	11,307 (n=129)	87.7	515	41
2018	Winter	9,307 (n=111)	83.8	1090	24
2019	Winter	8,494 (n=119)	71.4	1110	9
2020	Winter	9,373 (n=108)	86.8	902	18
2021	Winter	5,090 (n=48)	106.0	828	39.5

Each summer from 2018 to 2021 counts were carried out at 104 to 137 sites. The sum of maximum counts for these sites ranged from 10,007 bats in summer 2018 to 11,307 bats in summer 2021.

From summer 2018 to summer 2021 counts were carried out by 72 individuals including staff of NPWS and VWT, ecological consultants, and their assistants.

5.2.2 Winter trends

Counts at 156 sites contribute to the winter trend analysis. The trend has been increasing since the start of the survey with the exception of a five year period between 2007 and 2011 when numbers were stable. Between 1988 and 2021 the smoothed trend index increased by 321%. Over the past 20 years (2002-2021), the trend index increased by 81.5%, which is equivalent to a 3% annual increase. In the short term (2016-2021) the trend index has remained at a 3% per annum increase.

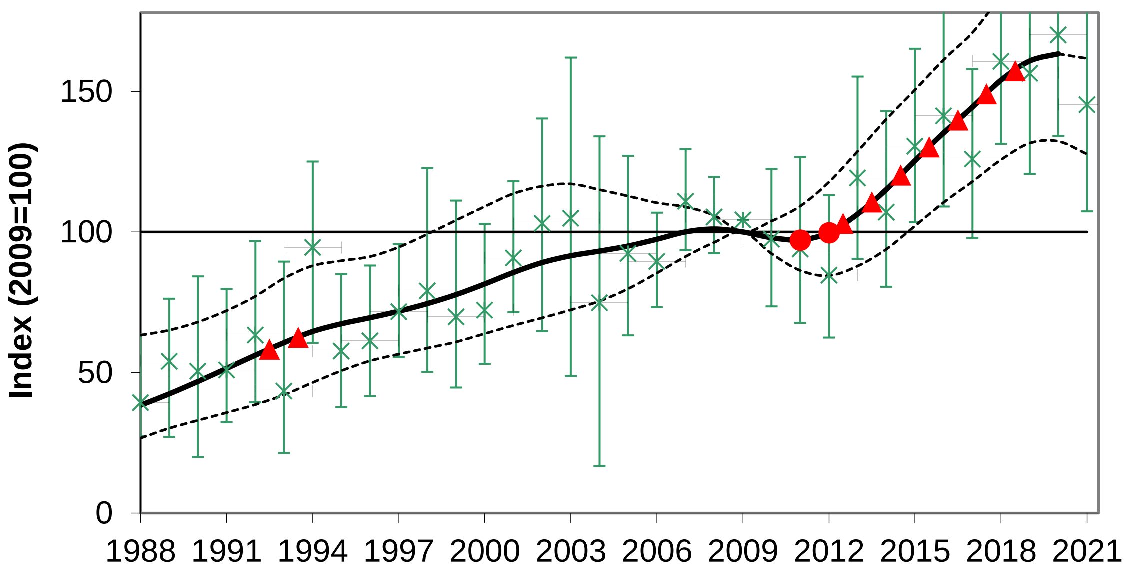

Figure 5.2 Results of the Generalised Additive Model (GAM)/Generalised Linear Model (GLM) model for lesser horseshoe hibernation data. Points are estimated annual means derived from the GLM and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted GAM curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2020-2021 and the possibility that the slope will change with coming years' data. Red circles indicate significant ($p<0.05$) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant ($p<0.05$).

5.2.3 Summer trends

The results presented here use the full May to August period, with two covariates, one to adjust for the linear effect of day number in the year and another for internal counts. The results are shown in Figure 5.3. Similar to the increasing trend in hibernation counts, there has been a significant increase in lesser horseshoe bats in summer. Between 1992 and 2021 the index increased by 98%. Over the past 20 years the index has increased by 2.98% per annum which is very similar to the 3% increase seen in the hibernation sites. Over the past six years the annual increase in summer has been 2.1%, which is slightly lower than that seen in winter sites.

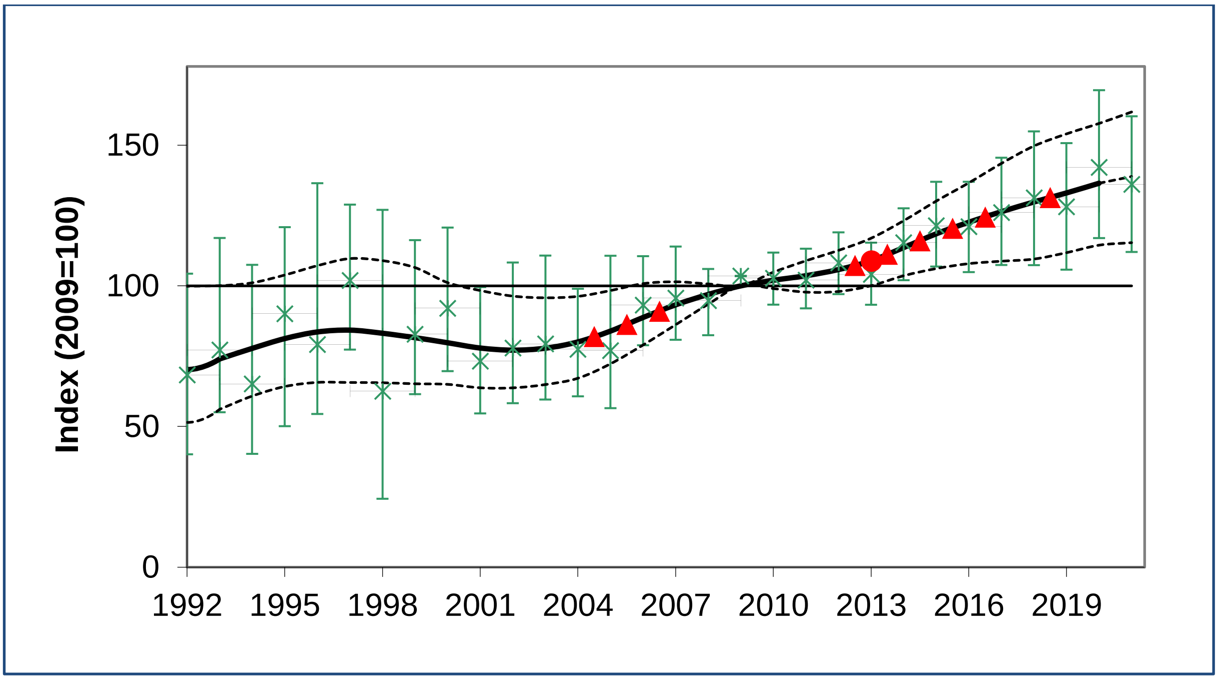

Figure 5.3 Results of the Generalised Additive Model (GAM)/Generalised Linear Model (GLM) model for lesser horseshoe summer data with day number and internal counts as co-variates. Points are estimated annual means derived from the GLM and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted GAM curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2016-2017 and the possibility that the slope will change with coming years' data. Red circles indicate significant ($p<0.05$) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant ($p<0.05$).

5.2.3 Lesser horseshoe bats and weather

Table 5.3 shows the correlation coefficients between growth rates and the meteorological variables, including lagged versions. Only one value is nominally significant at the 5% level, which is no better than would be expected by chance since the table contains 48 correlations. It is also noticeable that, whilst there are some similarities between the results from the three different methods of calculating the growth rates, there are also some clear differences. This suggests that the findings are not that robust. Also, not shown in the table are correlations between summer counts and met data in the third and fourth quarters of the survey year, since the weather clearly cannot influence earlier counts. However, if these are calculated, the largest is 0.453, indicating that quite large correlations are possible by chance alone.

Table 5.3 Pearson correlations between measures of colony growth and quarterly met data. * indicates nominally significant at P<0.05. 'Short trend' indicates growth rate based on unsmoothed index using days 137-194. 'Full trend' is based on the usual unsmoothed index using May-August counts. 'Froidevaux' uses the method described in Froidevaux *et al*. 2017..

		Temperature			Rainfall		
		Short trend	Full trend	Froidevaux	Short trend	Full trend	Froidevaux
Survey Year	Apr-June	0.213	0.166	0.579*	0.271	0.083	-0.176
Survey Year	Jan-March	0.494	0.261	0.146	0.381	0.100	0.280
Previous Year	Oct-Dec	0.162	0.080	0.042	-0.256	-0.213	0.062
Previous Year	July-Sept	0.192	0.333	0.469	-0.344	-0.289	-0.507
Previous Year	Apr-June	-0.026	-0.128	0.166	-0.020	0.199	-0.094
Previous Year	Jan-March	-0.066	0.025	-0.300	0.137	-0.062	0.295

However, the one nominally significant result is between spring temperatures and the growth rate using the Froidevaux approach to growth rate, which is one of the significant relationships also found for greater horseshoe bats in Britain. Figure 5.4 shows the relationship; the correlation looks rather stronger in recent years and weak before 2012. Note that whilst some counts will be made before the end of the quarter, since the minimum of the three monthly means is taken, this will almost certainly relate to weather in the early part of the quarter, before the count is undertaken. We also tried using the March-May period instead of April-June, but using the mean rather than the minimum, and the correlation with growth rate was then 0.586 (i.e. slightly higher than the value of 0.579 in Table 5.3), again suggesting that it is the earlier spring weather that is driving this.

Figure 5.4 Growth rate (median of values calculated as in paper) and spring temperature plotted against year. Spring temperature is the mean of minimum of the monthly average temperatures for April-June for each station.

5.2.4 Other work on the lesser horseshoe database

A body of work is currently underway to clean and export data from the lesser horseshoe bat database to an Arc GIS Online (AGOL) system for the use of NPWS staff. This work is well advanced and ongoing.

Bat Conservation Ireland liaised with the Vincent Wildlife Trust in 2021/2022 to carry out comparisons of summer trends between VWT sites and non-VWT sites in Ireland. VWT reserves provide summer roosting sites for approximately 30% of the Irish lesser horseshoe bat population and are an extremely important and well-managed conservation resource for the species here.

There were 12 VWT sites and 168 non-VWT sites included in the analyses. We found that there was no significant difference in the growth rate at non-VWT summer sites compared with summer sites that are owned or managed by the VWT, although VWT sites have grown at a slightly faster rate in the past few years. From 2009-2021, non-VWT sites increased by a mean of 2.42% per annum compared with 2.9% per annum at VWT sites in the same time period. We also looked at sites of equivalent size to VWT reserves (which tend to have large numbers (>150) of bats in summer) and found that an analysis of 16 of these sites showed an even larger per annum increase (3.2%).

VWT's own analysis of the same dataset is due to be included in a peer-reviewed publication.

5.2.5 National distribution of lesser horseshoe bats

The National Bat Database is owned and managed by Bat Conservation Ireland. A total of 178 lesser horseshoe bat records are currently available for mapping on the National Bat Database (2010 to 2021 dataset). This dataset includes records from an early version of the NPWS roost monitoring surveys database (n=123 records, 69%). The following table provides a breakdown of the sources of the records;

these are distributed in the six counties where this species is known to reside. This dataset will be combined with the greater body of data held by NPWS relating to the NPWS Roost Monitoring Scheme.

Table 5.4 Sources of lesser horseshoe bat records on the Bat Conservation Ireland database

Source of Records	No. of Records
NPWS Roost Monitoring Scheme	123
Brown long-eared bat Roost Monitoring Scheme	2
BATLAS 2020	14
Ecological Consultancy Records	39

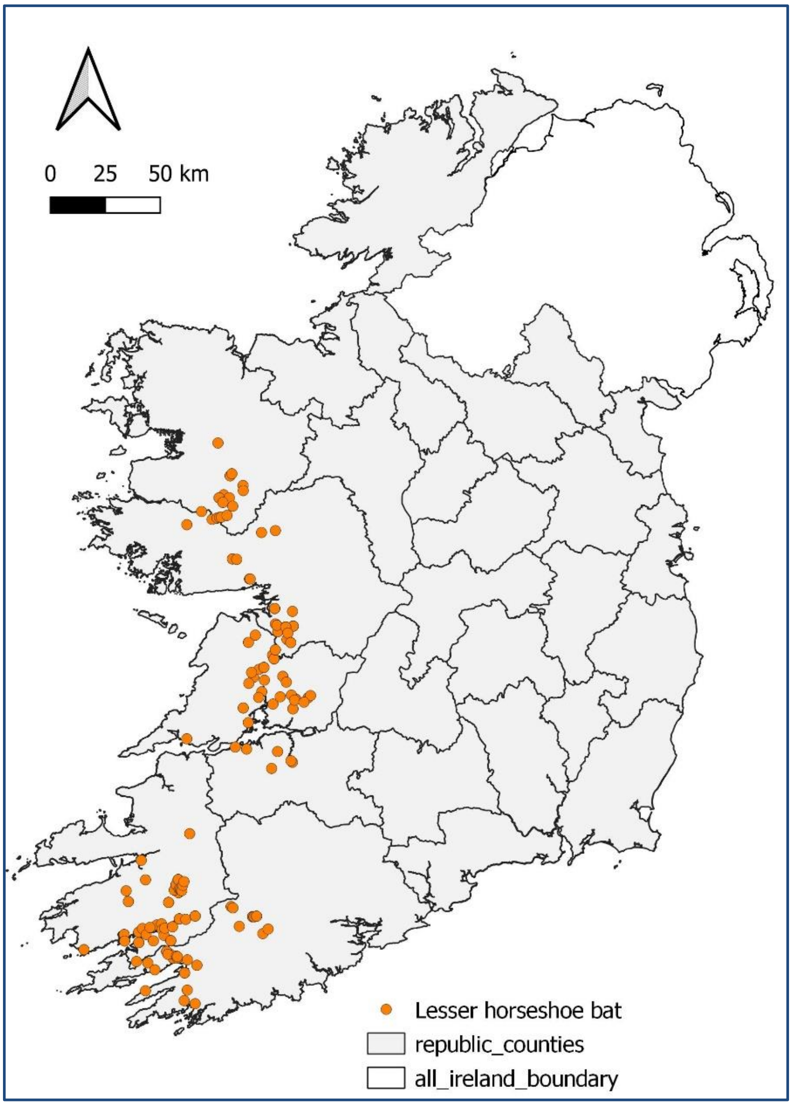

Figure 5.5 Lesser horseshoe bat distribution in Ireland (BCIreland database 2010-2021).

6 Discussion

6.1 Volunteer Participation

Much of Irish Bat Monitoring Programme involves participation by citizen scientists. There are a number of benefits gained from participation in citizen science programmes by members of the public. These include increased scientific knowledge and involvement in local issues (C. C. Conrad & Hilchey, 2011) as well as a reduction in costs associated with large scale survey efforts.

Car-based Bat Monitoring continued to run successfully from 2018 to 2021 with considerable input from volunteer citizen scientists. Without their expertise and time input it would not be possible to run the scheme. From 2016 onwards, increasing numbers of teams were asked to carry out the survey with two pieces of equipment – both the Tranquility/smartphone and Batlogger M detectors - clamped to the window. The dual equipment set up was difficult for surveyors, particularly those who carried out surveys with both sets of equipment for a number of years. Nonetheless, Batlogger M detectors were fully phased in by 2020, despite the considerable constraints imposed that year by the COVID-19 pandemic. While in general, the turnover of volunteers on this scheme is quite low, eight new volunteer teams were recruited in 2021. All of these teams were trained in via Zoom and all successfully completed two surveys of their route. The use of just the new Batlogger M detectors made training and surveying a little simpler for new teams.

The All Ireland Daubenton's Bat Waterway Monitoring Scheme was the first large-scale recruitment programme of the Irish public to bat conservation-related work (Roche *et al.*, 2014). In exchange for training and equipment, members of the public are encouraged to survey their local waterway for Daubenton's bats. Over the sixteen years of the scheme, 901 teams - more than 1,800 people - have carried out the survey. The waterways survey is a very valuable tool for raising awareness about the conservation needs of Irish bats but it also demonstrates the considerable volunteer force that exists in Ireland. Building on this positive result, additional citizen science bat-related programmes have been rolled out including BATLAS 2010 and 2020.

However, 48% of the waterways survey teams have only participated for one year which means that there is a need for an annual recruitment drive since a certain percentage of volunteers are lost every year. Pre-pandemic, this involved approximately 13 training courses per year along with providing on-going support for volunteer teams in the form of bat detectors, training aids and feedback. A considerable amount of work is involved in organising and running courses. When these are run in conjunction with local heritage or biodiversity officers in individual counties, the effort required on the part of BCIreland staff is greatly reduced and the benefit of running the event as part of the county heritage forum greatly increases their value for positive promotion of bats and wildlife conservation in local areas. COVID-19 restrictions in 2020 and 2021 changed the training experience with no face-to-face training completed. All training was undertaken on-line coupled with You Tube training videos that were produced specifically to support Zoom training sessions. The recruitment, and therefore participation, of new volunteer teams was lower in these pandemic years particularly in 2020, but this can be attributed to restrictions of people's movements during the summer of 2020. A more successful recruitment drive was completed in 2021 but some volunteers were unable to participate due to contracting COVID-19 during the month of August.

The move online provided BCIreland with an opportunity to explore this format for training and to consider rolling out a blended in-person and online training programme for the future. The benefits of a blended training programme include providing varied training opportunities for future volunteers, reduced organisation time and reduced amount of time spent (and carbon emitted) while travelling for both BCIreland staff and attendees, as well as increased bat conservation awareness resulting from a greater online presence. The reduced the amount of time required to organise and provide training in 2020 and 2021 allowed the scheme co-ordinator to undertake extra surveys. Waterway sites that had only been surveyed once were particularly targeted so they could then be added to the trend dataset. This benefit offset, to some extent, the slightly lower number of volunteer teams that participated in 2020 and 2021.

A minimum of 180 waterways need to be surveyed twice annually in order to monitor Daubenton's bats effectively; without the large number of participating volunteer teams, this would be very difficult to achieve. Therefore, the managing body (i.e. BCIreland and the scheme co-ordinator) needs to continue to encourage volunteers to participate for more than one year. Retaining volunteers and keeping them interested is a challenge for citizen science programmes (Conrad & Daoust, 2008). There is genuine interest and willingness on behalf of the public to be involved (Miller-Rushing *et al.*, 2012) but the scheme managers need to demonstrate that each volunteer's contribution is valued. In feedback to BCIreland, volunteer teams have requested greater explanation of how their data is used and how important it is. In addition, more training tools and opportunities to increase skill sets have also been requested. A communication plan is one of the recommended steps to feeding back results and managing recommendations for citizen science programmes (Conrad & Daoust, 2008).

For trend population models, only waterways sites surveyed for two or more years are used. Therefore it is important to ensure that waterways sites are surveyed as often as possible when survey teams are available. It is also preferable that the same survey team surveys the same waterway site from year to year. While BCIreland encourages new team members to take on "old" waterways sites, many new teams prefer to have their "local waterway" to survey. Further work needs to go into showing the benefits of taking on "old" waterway sites and repeating surveys. In addition, survey teams are disappointed if they survey waterways where there are no Daubenton's bats. While we do explain that these "null" waterway sites are important, to retain volunteer teams, it may be more important to offer a different waterway site where Daubenton's bats have been previously recorded and that the scheme co-ordinator surveys the "null" sites where possible. One of the benefits of on-line training meant that it was easier to encourage new volunteers to select their potential waterway sites from the existing list instead of creating a new transect. Only a total of five new waterway sites were set up by new volunteer teams in 2020 and 2021 while the remaining 40 teams surveyed existing waterway sites that did not have a volunteer team. This contrasts with 15 and 24 new waterways sites set up in 2018 and 2019 respectively. There was also greater time available for the co-ordinator to complete additional surveys. As a consequence, the number of waterway sites with just one years of data has been reduced to 127 waterway sites (18.8%).

For the Brown Long-eared Roost Monitoring Scheme volunteers need to have some experience in identifying bats using bat detectors. There is a smaller potential pool of volunteers within the country with sufficient expertise available to participate in the scheme, compared with Daubenton's waterways surveys, for example. However, the majority of the roosts in the scheme are now monitored by volunteer survey teams. To-date, teams have carried out the counts very successfully, especially when they have been trained in situ by the co-ordinator and a team leader is assigned to organise survey dates, collate survey results and return datasheets to BCIreland. The majority of teams participating in the scheme have done so since 2007, and this has greatly increased the robustness of the data. Working closely with local bat groups has also proven to be very effective and should continue for any future monitoring of brown long-eared bats. The participation of roost owners in the monitoring scheme has also proven to be a very successful way of gathering data. It encourages roost owners to take a greater interest in their bat roosts and to contribute to the conservation of this species. It has also provided BCIreland with a valuable opportunity to answer queries with regard to bats roosting in housing. BCIreland will continue to encourage and assist roost owners with monitoring of their own roosts, support current teams and any new teams that enter the programme from 2022 onwards. We will also continue to ensure that volunteers seeking to upgrade their bat detection skills are provided the opportunity to do so. Building on the success of the current YouTube video, additional videos will be produced to provide training and support. Using video filming technology at specific roosts allowed us to accurately pinpoint exit points thereby providing confidence for the surveyors. This was also successfully used as a training tool for new volunteer teams. The continued success of the scheme is also reflected by the participation of all 13 roosts selected for inclusion in the UCD BatLab Ecosystems Services study, including two roost owners who collect dropping three times per summer for the research and access to the other eleven roosts to facilitate droppings collected (a total of six visits per roost per summer).

6.2 Survey Coverage

Very good coverage was achieved by all four monitoring schemes over the four years of the current contract.

The car-based bat monitoring survey continued in all 28 squares across the island with at least 50 successful survey returns provided each year from 2018 to 2021, with the exception of 2020 when 23 squares had available survey data. Constraints due to the COVID-19 pandemic meant that slightly fewer squares were surveyed in that year.

The fact that there is a very long time series already available for these schemes means that the slight dip in coverage in 2020 due to the pandemic will not impact greatly on the error associated with trends.

Buckland and Johnston (2017) consider that the monitoring of roosts is inherently biased from the start because sites are usually selected based on known colonies. This was the case for the brown long-eared roost monitoring programme and continues to be the situation as new sites are added when BCIreland is alerted to a colony being identified. Over the years, colonies that have become abandoned are still included in the dataset but are no longer being surveyed. As a result, this can lead to negatively biased estimates in population trend models. Roost faithful species such as brown long-eared bats, tend not to be such a problem. While it is more of a concern for bat species that are known “roost switchers” such *Pipistrellus* species, to reduce any negative bias, it is recommended that roosts previously surveyed for the scheme but not included should be reassessed for future inclusion in the survey scheme. Five such roosts have been identified and are listed in Appendix 3.

A consistently high number of completed surveys were achieved in 2018-2021 survey period for the brown long-eared bat. Currently, there are roosts being monitored in 20 counties across the country. Two roosts are proposed to be assessed in 2022 (Counties Limerick and Offaly) and BCIreland also aims to reassess roosts previously surveyed in Counties Limerick, Galway, Cavan and Kildare. Using the results of the Roost Profile analysis, churches in Counties Westmeath, Monaghan, Meath and Louth will be investigated using aerial photographs and church websites. This will potentially increase coverage to 23 counties. However, three counties are still not represented in the national distribution and this should be addressed in the next monitoring period. While some roosts become unfavourable to monitor or to access, more than half the roosts in the current dataset have been monitored for at least ten years. Of the 43 roosts surveyed in 2021, 26 were also surveyed in the baseline year of 2009. This is an important factor in ensuring robust population trend analysis. There are currently 44 structures on the database that are suitable for monitoring going forward and five structures that are recommended for reassessment.

For the lesser horseshoe bat a very high number of surveys were completed in the summer survey seasons 2018-2021 with more than 130 count records provided from at least 104 sites each season. The number of counts carried out each winter was similarly high, with over 120 counts from at least 108 sites each year. An exception was January and February 2021 when COVID-19 restrictions were in force and only 55 counts were carried out at 48 sites.

The count data stretches across the distribution range for the species and accounts for well over three quarters of the entire population on the island (NPWS, 2019) each summer and usually more than half the population in winter. NPWS and VWT staff members are highly dedicated, visiting and reviewing the sites in their areas, providing count information, feedback and information on any new sites that come to light.

This year we carried out a piece of work to examine factors that may be responsible for increasing lesser horseshoe bat trends. We used Met Eireann weather data and analysed yearly population change in this species. Just one weather variable, minimum spring temperature, was positively and significantly correlated with growth. Although there is a possibility that this correlation arose by chance, it is also one of the significant weather variables associated with population change in greater horseshoe bats in Britain (Froidevaux *et al.*, 2017). There is good reason to suspect that this kind of weather variable could affect summer roost numbers. We suggest that further work on landscape change and weather should be carried out to examine their impacts on lesser horseshoe bat populations.

6.3 Possible Sources of Bias

For the Daubenton's survey an array of bat detector models is used by participating volunteer teams. Many of the volunteer teams also borrow a bat detector from BCIreland for the duration of the survey. Ten bat detector models have regularly been used by volunteer teams. However bat detector models have changed considerably since 2006. In the early years, Magenta Mark III was favoured but this was replaced by Magenta Bat 4 detector from 2011 onwards, while Stag Electronics Bat Box III detector or Bat Box 3D detector (in later years) has been frequently used throughout the monitoring period. As different bat detector models have different microphones, the capacity of the model to pick up different bat species can vary. Cheaper models tend to have poorer quality microphones and bat echolocation calls can often sound different from one model to another. Buckland and Johnston (2017) highlight the technological advances in bat detectors as one potential bias in bat monitoring schemes. One method to reduce to bias is to include a covariate for type of detector in the models of trends. While the potential impact of bat detector model has always been included in the Daubenton's trend model, closer consideration of this potential bias is required as a precaution. BCIreland purchases the cheaper bat detector models for the waterways survey, principally because the detector is not the main tool for identification of Daubenton's bats. It can be considered a tool to alert the volunteer team to bats nearing their survey spot. A positive recording of a Daubenton's bat is confirmed by seeing the bat as it flies across the surface of the waterway through the beam of torch light. As a consequence, the potential bias of changing bat detectors is not as much of a problem in this survey scheme as for other bat monitoring schemes that rely solely on bat detectors. Nonetheless, BCIreland recommends the continued documentation of bat detector model type on survey forms and to continue to use it as covariate in statistical analysis.

Discussions with regard to bias arising from the use of different bat detector models in the waterways survey has highlighted the need to closely look at this for other monitoring schemes, including the brown long-eared bat roost counts. BCIreland have a pool of heterodyne bat detectors that are loaned to volunteer teams when requested. Due to the fact that this species is quieter and more difficult to detect, the models loaned to volunteers are of higher quality compared to those used by the waterway surveyors (e.g. Pettersson D200 and Bat Box Duet models compared to Magenta 4 for waterway surveys). In addition, volunteer teams are requested to use particular models of detectors for the roost surveys, many of whom are using broad spectrum bat detectors to improve accuracy. On the positive side, it may be considered that the potential bias of changing bat detectors or using different models is not as much of a problem during roost emergence as for some bat monitoring schemes that rely solely on bat detectors because there is a visual element involved in the emergence counts and that there is no bias in relation to internal counts. Volunteers, more often than not, use the bat detectors as an audio alert to the presence of bats but a visual verification is more often used. This emphasises the importance of filming technology, see below. BCIreland recommends the continued documentation of bat detector model type on survey forms from 2022 onwards.

The type of detector used during car-based bat monitoring was overhauled over the past five years. We have now completely switched to full spectrum detectors. The changeover was gradual and many surveys were carried out over a four year period (2016-2019) with both sets of equipment used simultaneously. In this way, we ensured that trends derived from the two detector types could be integrated. We have carried out various statistical analyses of the dual data and currently consider that including a covariate for detector type in the trend models is the most accurate means of accounting for differences between the two. We have also kept the old Tranquility detector units in storage in case we need to run further checks in the future.

The accuracy of roost counts can also be increased by the use of filming. While this is an expensive option and cannot be used for all emergence surveys, BCIreland have two high quality camcorders with night-shot capability and filming has been successfully deployed in 2018-2021 at a small number of roosts. The use of filming has also resulted in more accurate identification of exit points. Structures can change over time and as a result, the usage of the structure by bats changes; the deployment of cameras periodically at roosts will help ensure that roosts are surveyed correctly. It can also boost confidence for volunteer survey teams and has also proved as a useful training tool. Therefore, it is recommended that for the next survey period, the deployment of cameras is undertaken at all brown long-eared bat roosts where the exit point is <4m high, at least once, as part of a validation protocol. This validation is also an important process for citizen science programmes (Conrad & Hilchey, 2011) and for trend analysis (Buckland & Johnston, 2017). As a consequence, additional units are recommended to be purchased and distributed among volunteer survey teams.

6.4 Bat Species Trends

6.4.1 The Good News

Common pipistrelle trends have fluctuated somewhat but highest encounters to date were recorded in 2021. Overall, the trend has been upwards. In the past 12 years (2010-2021) this species has increased by 69.6% in total, equivalent to a per annum increase of 4.5%. Since the start of the car survey scheme in 2003, the species' index has approximately doubled.

In Britain, an increase was recorded for the same species from foot-based field surveys carried out by the BCT from 1999 to 2020, with an average increase of 3.5% per annum in that time period (BCT & JNCC, 2021).

High soprano pipistrelle encounter rates were recorded by the Car-based Bat Monitoring Scheme in 2017, 2020 and 2021. In the past twelve years (2010-2021) this species has increased by 79% in total, equivalent to a per annum increase of 4.97%, although there has been a slight levelling out of the trend since 2017. Overall, since the start of the car survey scheme in 2003, the species' index has increased by 176%.

In Britain this species increased to between 1999 and 2020, albeit at a slower rate than its sibling species. The average annual rate of increase for soprano pipistrelle in Britain is 2.1% (BCT & JNCC, 2021).

The highest yearly estimate in the trend series for Leisler's bat was in 2021. In the past twelve years (2010-2021) this species has increased by 50.6% in total, equivalent to a per annum increase of 3.5%. Since the start of the car survey scheme in 2003, the species' index has increased by 166%.

A binomial analysis of Nathusius' pipistrelle tentatively indicates that the species remains stable or may be slightly increasing. The records collected for this species from Car-based Bat Monitoring Scheme confirm that the species is a summer resident within the Republic of Ireland, as well as Northern Ireland. In the past three years the species was recorded from a higher number of survey squares than the previous three years of the scheme, which lends further credence to the suggestion that it is currently increasing on the island.

The all-Ireland Daubenton's bat trend has fluctuated over the duration of the monitoring scheme. Overall, the smoothed trend indicates a total increase of 0.52% since 2007, which represents a very slight yearly increase of 0.04%, but there is no significant difference from the baseline year indicating that the species is currently stable. From similar waterways surveys carried out in the UK, the population of Daubenton's bat there is also currently considered to be stable (1999-2020) (BCT & JNCC, 2021). For the Republic of Ireland data, the smoothed trend indicates a slight decrease of 1.53%, which represents a yearly decrease of 0.11% while an increase of 34.1%, which represents a yearly increase of 2.12% was recorded for Northern Ireland. However, the confidence limits are wide for the Northern Ireland dataset due to the relatively small sample size while the confidence limits are narrow for the Republic of Ireland dataset set, reflecting a greater and more robust dataset.

The brown long-eared bat trend index for Republic of Ireland is currently 6.37% above the 2009 base year value which is equivalent to an average 0.52% annual increase since that time. This does not, however, constitute a significant increase since the error bars for this species also encompass the baseline. Data from equivalent roost counts in Britain show a very similar increase of 0.7% per annum (since 2001), but this increase is also not considered significant (BCT & JNCC, 2021).

The lesser horseshoe bat increased significantly from the early years of the survey in the early 1990s. While some caution is needed when interpreting trends from early years due to low sample sizes, we can be reassured by the fact that summer and winter trends continue to converge, increasing up to the early 2000s, levelling out somewhat in the mid-2000s and more recently increasing again. Overall in Ireland over the past 20 years (2002-2021) the summer and winter trends for the species have been very similar – with a total increase of 81.5% in winter and 80% in summer. The UK NBMP reports a difference in the extent of increase recorded by winter versus summer counts (BCT & JNCC, 2021). Between 1999 and 2020, population change in the UK was +183% in winter counts and +84% from summer counts. We also noted a similar disparity between winter and summer trends in our previous report (Aughney *et al.*, 2018). The convergence of the two indices noted in the present report may reflect the fact that increasing number of winter sites that are counted here every year which results in a more robust trend index.

Initial examination of lesser horseshoe trends in relation to weather data indicates that population change may be correlated with spring temperatures, which tallies with findings in the UK for Greater Horseshoe Bat (Froidevaux *et al.*, 2017).

6.4.2 The Bad News

A number of pilot studies have been carried out to trial monitoring scheme methodologies for Natterer's and whiskered bats (e.g. Boston *et al.*, 2017; Roche & Aughney, 2007). A trial using Audiomoth detectors in woodlands was also carried out in 2021, the results from BCT are not yet available due to technical difficulty with the auto-id programme (T. Aughney *pers.comm.*). In addition, several years of research were carried out into Natterer's and whiskered bats in Ireland by the team at the Centre for Irish Bat Research (e.g. Boston *et al.*, 2010, 2014; Buckley *et al.*, 2013).

Thus far, due to the relative rarity of these species and difficulties discriminating between the *Myotis* species using bat detectors, it has not been possible to determine a cost-effective method of monitoring the two species in Ireland. The 2016-2017 trial using Batlogger M detectors in selected, mainly broadleaved or mixed woodland sites, showed that both species were present in all sampled sites, but that detecting population changes would require very large numbers of sites to be sampled (60 sites or more for Natterer's bats) with these, relatively expensive, bat detectors.

A national bat distribution survey BATLAS 2020 was carried out in the latter half of the last decade (2016-2019) (Pickett *et al.*, 2019). This was a point-based bat detector survey carried out by trained volunteers along with Bat Conservation Ireland staff and contractors. We found that non-Daubenton's *Myotis* species presence per site was lower during BATLAS 2020 compared with BATLAS 2010, a similar survey that had been carried out ten years earlier. Unidentified *Myotis* spp. were present in 17.1% of sites during BATLAS 2010 compared with 6% of sites during BATLAS 2020. Confirmed Natterer's bat occurrences declined from 4% of sites during BATLAS 2010 to 2.2% of sites during BATLAS 2020. Whiskered bat presence dropped from 1.2% to 0.9%. While BATLAS surveys are prone to a high degree of error for these species due to differences in detector type, observer experience and overall low detection rates, the data nonetheless portray a concerning picture about the trends of *Myotis* species over the past twenty years in Ireland, in particular outside of woodland settings. In addition to this, latest data from the car-based bat monitoring scheme now appears to tally with the results of BATLAS 2020. While the roll out of Batlogger detectors has resulted in increased confidence regarding the accuracy of the *Myotis* spp. trend, this species group has declined in 23 out of 28 car survey squares.

The common picture from these two schemes provides strong evidence that the roadside populations of either Natterer's bat or whiskered bat, or quite possibly both species combined, are undergoing continuing and substantial declines. Declines that exceed 2.73% per annum are considered Red Alert declines and the car-based bat monitoring *Myotis* species index has reduced by almost 7% per annum since 2010. Corresponding Daubenton's data from the All Ireland Waterways Survey (Section 3) has shown a relatively stable trend and it seems unlikely that the declines we see here are due to changes in Daubenton's bat populations.

No parallel decline in whiskered or Natterer's bats have been noted in Britain in the same time frame. Natterer's bat has had an increasing trend across Britain since 1999 (BCT & JNCC, 2021) while the combined index for whiskered and Brandt's bat (*Myotis brandtii*) has remained stable. Both trend indices are derived from winter hibernation counts.

It is possible that declines in these two species in Ireland, if they are occurring, may be outside of their ideal habitat, broadleaved woodland, since in 2016 Natterer's and whiskered bats were recorded in all woodlands in which pilot surveys were carried out (Boston *et al.*, 2017). BATLAS surveys are carried out in surveyor-selected locations, often at bridges along roads, and car-based surveys are carried out in habitats that may not be ideal for either species. There may, therefore, be merit in ensuring that a wide pool of habitat types, not just woodlands, are surveyed-for when a *Myotis* species monitoring scheme *is* rolled out, since a decline in less favoured habitats may well precede any declines in ideal habitats such as broadleaved woodland.

6.5 National Dataset

The large number of bat records generated by the monitoring schemes will feed into Article 17 reporting for Ireland in the coming months and has also been used for various publications such as the Atlas of Mammals in Ireland (Lysaght & Marnell, 2016).

BCIreland hosts over 100,000 bat records on the National Bat Database, and the 2010-2021 dataset provides good distribution coverage of individual bat species across Ireland. While many of the records held on the database pertain to the Irish Bat Monitoring Programme, additional records have been collated from ecological surveys, bat group surveys and BATLAS 2020. These records add greatly to our distribution knowledge as they are from areas not annually surveyed by the individual monitoring schemes.

The publication "Irish Bats in the 21st Century" (Roche *et al.*, 2014) examined the 2000 to 2009 bat dataset for the whole of the island. There is an opportunity now to compare this dataset to the 2010 to 2019 one, but this should only be completed when other potential data sources have been added to the BCIreland database. This will provide more accurate distribution maps and therefore provide more accurate maps for Article 17 reporting in 2025.

6.6 Ancillary Data

6.6.1 Other Vertebrates - Car-based Bat Monitoring

The data for vertebrates other than bats are not collected in a standardised fashion during the Car-based Bat Monitoring Survey and may be influenced by factors such as driving speed (which is variable between transects), car headlight beam intensity, and roadside verge vegetation density and height among others. We have no available estimates of detectability for vertebrates that are recorded during the car-based survey. Nonetheless, since there are now 15 years of other vertebrate data we carried out some basic trend and other analyses on the data.

6.6.1.1 Cats

Occurrence of cats appears to be lower along the extreme western seaboard and particularly high in some areas surrounding Dublin. Higher numbers of cats may be expected to occur in association with higher densities of human habitation.

Cat numbers along roadsides at night (per hour of surveying) have not changed significantly since 2006.

6.6.1.2 Foxes

Data from the car-based bat monitoring scheme implies that there is a gradient in fox abundance across Ireland, with higher numbers (per survey hour) found in the south and south-east of the country and lower numbers in the north-west. This gradient has not been observed in the most recently published atlas of the species in Ireland where occurrences are usually based on randomly observed records for the species (Lysaght & Marnell, 2016).

Following some fluctuations from 2006-2009, the roadside fox population has remained relatively stable to 2021. Trend error bars for the species currently encompass the 2006 index.

6.6.1.3 Rabbits

Similar to foxes, data from the car-based bat monitoring scheme implies that there is a gradient in rabbit abundance across Ireland, with higher numbers (per survey hour) found in the south and south-east of the country and lower numbers in the north-west. This gradient was also observed in the most recently published atlas of the species in Ireland where occurrences are based on randomly observed records for the species (Marnell & Lysaght, 2016).

Following some fluctuations from 2006-2009, the roadside rabbit trend index has remained below the 2006 baseline. This implies that there has been a moderate but significant decrease in roadside counts of the species (per hour of surveying) since 2006. It is of note that fluctuations in yearly estimates of rabbit numbers closely mirror those of foxes, although foxes do not appear to have undergone any decline in the same period.

6.6.1.4 Hedgehogs

According to car-based bat monitoring survey data, hedgehog occurrence (per hour of surveying) is highest in survey squares in the southern half of the island. Hedgehogs were not recorded during any surveys in four squares, two in Northern Ireland and two on the western seaboard. While the L64 square, Connemara is unlikely to support large numbers of hedgehogs due to the predominance of blanket bog habitat there, there is no particular reason why the mixed agricultural landscape of R22, Limerick, or the two squares in Northern Ireland should not support hedgehogs. In fact the species was recorded at a number of 10km squares in Limerick from 2010-2015 (Lysaght & Marnell, 2016) so its absence from the car monitoring data may simply be an outlier.

The dataset gathered by car monitoring volunteers implies that hedgehogs have not undergone any serious declines in Ireland since 2006, unlike Britain in the same time period (Wembridge *et al.*, 2022). While there were fluctuations in the early years of the survey (2006-2011) the trend has stabilised over recent years and error bars encompass the 2006 baseline. It is possible, however, that the species has undergone range reductions due to habitat loss that are not apparent from the poorly resolved car-based bat monitoring data.

6.6.1.5 Badgers

Badger occurrence per hour of road-based surveying does not change across a north/south gradient, unlike some of the other vertebrates recorded during the car survey (foxes, rabbits and hedgehogs).

Trends in roadside badger occurrences across Ireland have remained relatively stable throughout the survey period; a dip from 2012-2017 was recently offset by an increase and the trend error bars currently encompass the 2006 baseline. This suggests badger populations in Ireland are overall relatively stable at present. Comparative information is not available for the same time period from the UK although evidence suggests that badger populations increased substantially in England and Wales between the 1980s and 2011–2013 (Judge *et al.*, 2017).

7 Recommendations

7.1 Car-based Bat Monitoring

Recommendation 1	Continue to survey the 28 Survey Squares across the Republic of Ireland and Northern Ireland using the present survey protocol. Sites should continue to be surveyed twice per annum within the specified date ranges (see Appendix 1 for list of Squares and transect start and stop points)
Recommendation 2	Facilitate continued cooperation between agencies in Northern Ireland and the Republic of Ireland
Recommendation 3	Continue to ensure equipment is fit for purpose by comprehensive testing in advance of dissemination in the summer. Also, ensure survey teams are provided with sufficient training and support to carry out the surveys.
Recommendation 4	Continue to provide "cloud-based" data sharing system such as Dropbox to facilitate online uploading of results.
Recommendation 5	Provide detailed feedback to surveyors in the form of overall bat numbers per survey, as well as detailed maps of bat records where sufficient GPS data is available.
Recommendation 6	Continue to share Republic of Ireland data with NBDC, and Northern Irish data with CEDaR and BCT and 3rd level researchers.
Recommendation 7	Continue to employ a professional statistician with experience of bat data interpretation to carry out analysis of the data.
Recommendation 8	Continue to carry out research based on the car monitoring dataset and publish research in peer-reviewed scientific journals, as well as presenting data at national and international scientific conferences.
Recommendation 9	Continue to carry out analysis of other vertebrate data and share with relevant agencies / researchers.
Recommendation 10	Consider some means of celebrating the 20th birthday of the Car-based Bat Monitoring Scheme, for example with a seminar, talk or special publication.

7.2 Daubenton's Bat Waterways Monitoring

Recommendation 1	Continue to survey Daubenton's bats using the current methodology. Sites should continue to be surveyed twice in the month of August and start time should remain at 40 minutes after sunset.
Recommendation 2	Waterway sites surveyed in previous years should be re-surveyed from year to year to increase the robustness of the data.
Recommendation 3	Aim to survey a minimum of 200 sites, 170 in the Republic of Ireland and 30 in Northern Ireland. Aim to survey at least 80% of these twice annually. (See Appendix 2 for list of sites surveyed since 2006)
Recommendation 4	Strive to survey a minimum of 5 waterway sites per county with an aim of 50 waterway sites per province to allow for regional differences to be investigated.
Recommendation 5	Continue to provide annual training courses as a means to recruit new volunteers and as a means to provide education on the conservation of bats in general. Where necessary to ensure continuity of waterway sites, new volunteers should be deployed to cover waterway sites previously surveyed.
Recommendation 6	Continue to provide technical support and survey videos for volunteers. Continue to provide volunteer support by email, Daubenton's bat newsletters and training programmes. Consider the adoption of an online system for volunteers to return their survey forms. Continue to maintain a library of bat detectors for loan to volunteer teams.
Recommendation 7	Continue to utilise regional paid-surveyors to ensure that core sites are surveyed twice annually.
Recommendation 8	Continue to employ a professional statistician with experience of bat data interpretation to carry out analysis of the data.
Recommendation 9	Undertake the monitoring scheme on an all-island basis with continued cooperation between agencies in Northern Ireland and the Republic of Ireland. Encourage and sustain the involvement of NPWS and NIEA Regional Staff, Local Authorities' Heritage and Biodiversity Officers and Waterways Ireland in the organization of training courses and the surveying of waterway sites.
Recommendation 10	Continue to share data with BCT, UK, CeDAR, Northern Ireland and NBDC, Republic of Ireland.

7.3 Brown Long-eared Roost Monitoring

Recommendation 1	Brown long-eared roost monitoring should continue with 2-3 counts completed for each monitored roost annually according to roost survey methodology (See Appendix 3, Table A3.1).
Recommendation 2	A minimum of 40 roosts should be monitored twice annually. Dates for survey periods should be changed to the following dates: Survey 1: 16th May to 15th June; Survey 2: 16th June to 31st July & Survey Period 3: 1st August to 30th August. (See Appendix 3, Table A3.2 for a list of sites recommended for monitoring in next monitoring period). Ensure that roosts are surveyed according to recommended survey method and that internal counts are completed by a licensed bat worker.
Recommendation 3	Continue to investigate potential roosts in counties not represented by the current dataset in 2022-2025 to increase regional representation. All new sites should be assessed using the preliminary roost survey methodology (See Appendix 3, Table A3.1).
Recommendation 4	Continue to carry out volunteer recruitment with the aim of having greater than 70% of roosts monitored annually by volunteer teams and roost owners. Volunteers participating in other monitoring schemes and people who have attended bat detector workshops should be contacted to determine their interest in joining a local team to monitor a roost within their county. This will help ensure that the scheme can continue sustainably and cost effectively.
Recommendation 5	Continue to encourage and assist roost owners with monitoring of their own roosts.
Recommendation 6	Continue to keep in close communication with volunteers and to encourage those who are unable to carry out counts to inform us well in advance of the field season.
Recommendation 7	Continue to encourage volunteer surveyors to collect data in a standardised manner. Survey start time should continue to be 20 minutes after sunset. Provide volunteers with sunset time tables specific to their roosts to ensure that volunteer teams start surveys at an accurate time. Continue to emphasise the important of completing surveys on nights where the weather is forecasted to remain dry for the entire survey.
Recommendation 8	Change survey sheets to require volunteer survey teams to note the bat detector model used.
Recommendation 9	Continue to use support technology (i.e. filming) for specific brown long-eared roosts to increase accuracy of emergence counts. Utilise filming to provide training support for new volunteer teams.
Recommendation 10	Continue to employ a professional statistician with experience of bat data interpretation to carry out analysis of the data.
Recommendation 11	Reassess five roost sites previously monitored and recommended for re-surveying (See Appendix 3, Table A3.2 for details).

7.4 Lesser Horseshoe Bat Roost Monitoring

Recommendation 1	Lesser horseshoe bat roost and hibernacula monitoring should continue with counts completed annually in winter and summer.
Recommendation 2	A minimum of 70 roosts should be monitored annually in winter. While, for sufficient power just 50 core sites need to be counted in summer, ongoing deterioration of many summer sites means that problems are detected sooner when annual counts are carried out.
Recommendation 3	Selection of sites for monitoring should be based on the data available in the Lesser Horseshoe Bat MS Access Database in consultation with regional NPWS and VWT staff.
Recommendation 3	Dates for surveys: January and February for hibernacula, May 23rd to July 7th for summer sites.
Recommendation 4	The subject of climate impacts, in combination with landscape change, should be further investigated with regard to the LHB dataset.
Recommendation 5	Continue to keep in close communication with NPWS and VWT staff.
Recommendation 6	Continue to encourage and assist NPWS staff with site visits.
Recommendation 7	Continue to encourage surveyors to collect data in a standardised manner.
Recommendation 8	Communicate the need to record whether sites have been surveyed using internal or external emergence counts, due to the impact this has on trend estimation error.
Recommendation 9	Continue to employ a professional statistician with experience of bat data interpretation to carry out analysis of the data.
Recommendation 10	Ensure yearly importation of site counts and site records to the Lesser Horseshoe Bat MS Access Database. Continue to execute a data transfer to a GIS-based database in collaboration with NPWS GIS team.

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Appendix 1 Car-based Bat Monitoring

Table A.1 Locations of Car-based Bat Monitoring Scheme Transects (2012 onwards)

SurveySquare	TransectNumber	Grid Ref	Point	X	Y
C72	1	C989247	Finish	298900	424700
C72	2	C9260028500	Finish	292600	428500
C72	3	C9070025000	Finish	290700	425000
C72	4	C9350021700	Finish	293500	421700
C72	5	C8683919995	Finish	286839	419995
C72	6	C8430027100	Finish	284300	427100
C72	7	C8100026300	Finish	281000	426300
C72	8	C7350022500	Finish	273500	422500
C72	9	C7250026500	Finish	272500	426500
C72	10	C7470030500	Finish	274700	430500
C72	11	C7300034900	Finish	273000	434900
C72	12	C7760032400	Finish	277600	432400
C72	13	C8050029100	Finish	280500	429100
C72	14	C8300033300	Finish	283000	433300
C72	15	C8671130204	Finish	286711	430204
C72	1	C982261	Start	298200	426100
C72	2	C9360027000	Start	293600	427000
C72	3	C8970026600	Start	289700	426600
C72	4	C9560021900	Start	295600	421900
C72	5	C8808521262	Start	288085	421262
C72	6	C8550026200	Start	285500	426200
C72	7	C8000025000	Start	280000	425000
C72	8	C7330020600	Start	273300	420600
C72	9	C7130025600	Start	271300	425600
C72	10	C7450028900	Start	274500	428900
C72	11	C7170034100	Start	271700	434100
C72	12	C7840033800	Start	278400	433800
C72	13	C8010030600	Start	280100	430600
C72	14	C8170034400	Start	281700	434400
C72	15	C8552331053	Start	285523	431053
G20	1	G2296205204	Finish	122962	305204
G20	2	G2238408965	Finish	122384	308965
G20	3	G2054412525	Finish	120544	312525

G20	4	G2130516798	Finish	121305	316798
G20	5	G2575721619	Finish	125757	321619
G20	6	G2694225914	Finish	126942	325914
G20	7	G3164823879	Finish	131648	323879
G20	8	G3273919317	Finish	132739	319317
G20	9	G3195114782	Finish	131951	314782
G20	10	G3010810225	Finish	130108	310225
G20	11	G2921006284	Finish	129210	306284
G20	12	G3260904555	Finish	132609	304555
G20	13	G3580303486	Finish	135803	303486
G20	14	G3934905050	Finish	139349	305050
G20	15	G4078409862	Finish	140784	309862
G20	1	G2150504895	Start	121505	304895
G20	2	G2297407907	Start	122974	307907
G20	3	G2037610851	Start	120376	310851
G20	4	G2055616258	Start	120556	316258
G20	5	G2547019773	Start	125470	319773
G20	6	G2633124533	Start	126331	324533
G20	7	G2991324108	Start	129913	324108
G20	8	G3251420927	Start	132514	320927
G20	9	G3220616373	Start	132206	316373
G20	10	G3064811719	Start	130648	311719
G20	11	G2822607930	Start	128226	307930
G20	12	G3237602981	Start	132376	302981
G20	13	G3450603992	Start	134506	303992
G20	14	G3885903985	Start	138859	303985
G20	15	G4051108229	Start	140511	308229
G53	1	G6434443955	Finish	164344	343955
G53	2	G6012044439	Finish	160120	344439
G53	3	G6426548671	Finish	164265	348671
G53	4	G6957251405	Finish	169572	351405
G53	5	G7245656058	Finish	172456	356058
G53	6	G7690157581	Finish	176901	357581
G53	7	G7957254838	Finish	179572	354838
G53	8	G7879149723	Finish	178791	349723
G53	9	G7822642477	Finish	178226	342477
G53	10	G7338343132	Finish	173383	343132

G53	11	G7352539674	Finish	173525	339674
G53	12	G7612735886	Finish	176127	335886
G53	13	G7888333940	Finish	178883	333940
G53	14	G7828830371	Finish	178288	330371
G53	15	NULL	Finish		
G53	1	G6752243409	Start	165697	343431
G53	2	G6106945154	Start	161069	345154
G53	3	G6317347808	Start	163173	347808
G53	4	G6823250713	Start	168232	350713
G53	5	G7105455708	Start	171054	355708
G53	6	G7558457003	Start	175584	357003
G53	7	G7819454614	Start	178194	354614
G53	8	G7926951108	Start	179269	351108
G53	9	G7939741838	Start	179397	341838
G53	10	G7463643612	Start	174636	343612
G53	11	G7207439546	Start	172074	339546
G53	12	G7588837295	Start	175888	337295
G53	13	G7944734912	Start	179447	334912
G53	14	G7963230992	Start	179632	330992
G53	15	G741303	Start	174100	330300
G89	1	G82799289	End	182790	392890
G89	2	G86829401	End	186820	394010
G89	3	G91109531	End	191100	395310
G89	4	G95169683	End	195160	396830
G89	5	G9958597011	End	199585	397011
G89	6	H09289626	End	209289	389626
G89	7	C10300995	End	210300	409950
G89	8	C09321216	End	209320	412160
G89	9	C09971650	End	209970	416500
G89	10	C07241849	End	207240	418490
G89	11	C04491453	End	204490	414530
G89	12	C00451383	End	200450	413830
G89	13	B96561550	End	196560	415500
G89	14	B92951240	End	192950	412400
G89	15	B8957809171	End	189578	409171
G89	1	G8150093446	Start	181500	393446
G89	2	G85249393	Start	185240	393930

G89	3	G89719437	Start	189710	394370
G89	4	G93809699	Start	193800	396990
G89	5	G9806196714	Start	198061	396714
G89	6	H0669896354	Start	206698	396354
G89	7	C11610914	Start	211610	409140
G89	8	C08881072	Start	208880	410720
G89	9	C09241507	Start	209240	415070
G89	10	C08531836	Start	208530	418360
G89	11	C05951587	Start	205950	415870
G89	12	C02061344	Start	202060	413440
G89	13	B97911543	Start	197910	415430
G89	14	B94111356	Start	194110	413560
G89	15	B9092810230	Start	190928	410230
H13	1	H1169354820	Finish	211693	354820
H13	2	H1034551711	Finish	210345	351711
H13	3	H10184766	Finish	210180	347660
H13	4	H1108043184	Finish	211080	343184
H13	5	H1159239435	Finish	211592	339435
H13	6	H1159633650	Finish	211596	333650
H13	7	H2008230983	Finish	220082	330983
H13	8	H2817831032	Finish	228178	331032
H13	9	H3413933624	Finish	234139	333624
H13	10	H3933330479	Finish	239333	330479
H13	11	H384343	Finish	238400	334300
H13	12	H383403	Finish	238300	340300
H13	13	H387466	Finish	238700	346600
H13	14	H389522	Finish	238900	352200
H13	15	H3874157977	Finish	238741	357977
H13	1	H1098856297	Start	210988	356297
H13	2	H1169751985	Start	211697	351985
H13	3	H1120547467	Start	211205	347467
H13	4	H1235843947	Start	212358	343947
H13	5	H1002839359	Start	210028	339359
H13	6	H1027034280	Start	210270	334280
H13	7	H1991032562	Start	219910	332562
H13	8	H2673531038	Start	226735	331038
H13	9	H3551834742	Start	235518	334742

H13	10	H3808831278	Start	238088	331278
H13	11	H397355	Start	239700	335500
H13	12	H378387	Start	237800	338700
H13	13	H387450	Start	238700	345000
H13	14	H379509	Start	237900	350900
H13	15	H399569	Start	239900	356900
H40	1	H462018	Finish	246200	301800
H40	2	H504023	Finish	250400	302300
H40	3	H528023	Finish	252800	302300
H40	4	H569014	Finish	256900	301400
H40	5	H601031	Finish	260100	303100
H40	6	H643043	Finish	264300	304300
H40	7	H632083	Finish	263200	308300
H40	8	H615126	Finish	261500	312600
H40	9	H661164	Finish	266100	316400
H40	10	H648218	Finish	264800	321800
H40	11	H647275	Finish	264700	327500
H40	12	H617293	Finish	261700	329300
H40	13	H583266	Finish	258300	326600
H40	14	H540255	Finish	254000	325500
H40	15	H509235	Finish	250900	323500
H40	1	H445019	Start	244500	301900
H40	2	H492022	Start	249200	302200
H40	3	H515023	Start	251500	302300
H40	4	H555008	Start	255500	300800
H40	5	H587037	Start	258700	303700
H40	6	H628041	Start	262800	304100
H40	7	H631068	Start	263100	306800
H40	8	H623111	Start	262300	311100
H40	9	H647156	Start	264700	315600
H40	10	H653204	Start	265300	320400
H40	11	H656262	Start	265600	326200
H40	12	H626297	Start	262600	329700
H40	13	H596273	Start	259600	327300
H40	14	H554252	Start	255400	325200
H40	15	H516244	Start	251600	324400
H79	1	H7479097441	End	274790	397441

H79	2	H7810394838	End	278103	394838
H79	3	H8221496736	End	282214	396736
H79	4	H8450793531	End	284507	393531
H79	5	H8827491036	End	288274	391036
H79	6	H9197392934	End	291973	392934
H79	7	H9565094929	End	295650	394929
H79	8	H9345499120	End	293454	399120
H79	9	C9348402832	End	293484	402832
H79	10	C9546005564	End	295460	405564
H79	11	C9427510179	End	294275	410179
H79	12	C9090013233	End	290900	413233
H79	13	C8232716810	End	282327	416810
H79	14	C8137516359	End	281375	416359
H79	15	C7791216081	End	277912	416081
H79	1	H7385798756	Start	273857	398756
H79	2	H7694895498	Start	276948	395498
H79	3	H8066196677	Start	280661	396677
H79	4	H8378594847	Start	283785	394847
H79	5	H8669391407	Start	286693	391407
H79	6	H9086791922	Start	290867	391922
H79	7	H9510093896	Start	295100	393896
H79	8	H9439597686	Start	294395	397686
H79	9	C9239702748	Start	292397	402748
H79	10	C9527104354	Start	295271	404354
H79	11	C9468208610	Start	294682	408610
H79	12	C9208912577	Start	292089	412577
H79	13	C8640414753	Start	286404	414753
H79	14	C8232716810	Start	282327	416810
H79	15	C7949416140	Start	279494	416140
J06	1	J2525182316	Finish	325251	382316
J06	2	J2300085800	Finish	323000	385800
J06	3	J1950087300	Finish	319500	387300
J06	4	J1580089300	Finish	315800	389300
J06	5	J1330087400	Finish	313300	387400
J06	6	J1670085400	Finish	316700	385400
J06	7	J1720080900	Finish	317200	380900
J06	8	J1590076900	Finish	315900	376900

J06	9	J1400073800	Finish	314000	373800
J06	10	J1320068700	Finish	313200	368700
J06	11	J0970066700	Finish	309700	366700
J06	12	J0870064500	Finish	308700	364500
J06	13	J1290862794	Finish	312908	362794
J06	14	J1590061200	Finish	315900	361200
J06	15	J2020061300	Finish	320200	361300
J06	1	J2522281294	Start	325222	381294
J06	2	J2400085000	Start	324000	385000
J06	3	J2110087200	Start	321100	387200
J06	4	J1750089000	Start	317500	389000
J06	5	J1210088500	Start	312100	388500
J06	6	J1520085900	Start	315200	385900
J06	7	J1720082300	Start	317200	382300
J06	8	J1680078300	Start	316800	378300
J06	9	J1490074900	Start	314900	374900
J06	10	J1340070500	Start	313400	370500
J06	11	J1120067100	Start	311200	367100
J06	12	J0790065800	Start	307900	365800
J06	13	J1090062900	Start	310900	362900
J06	14	J1470061400	Start	314700	361400
J06	15	J1900061500	Start	319000	361500
J33	1	J3670041700	Finish	336700	341700
J33	2	J3660047500	Finish	336600	347500
J33	3	J4060054600	Finish	340600	354600
J33	4	J3760057900	Finish	337600	357900
J33	5	J3060056700	Finish	330600	356700
J33	6	J2550056300	Finish	325500	356300
J33	7	J2840051500	Finish	328400	351500
J33	8	J2730046000	Finish	327300	346000
J33	9	J2490039600	Finish	324900	339600
J33	10	J2380037000	Finish	323800	337000
J33	11	J3030034300	Finish	330300	334300
J33	12	J3890035300	Finish	338900	335300
J33	13	J4260041100	Finish	342600	341100
J33	14	J4560038000	Finish	345600	338000
J33	15	J5230034600	Finish	352300	334600

J33	1	J3573339994	Start	335733	339994
J33	2	J3730045500	Start	337300	345500
J33	3	J4130053200	Start	341300	353200
J33	4	J3890058300	Start	338900	358300
J33	5	J3170057400	Start	331700	357400
J33	6	J2610057800	Start	326100	357800
J33	7	J2760052700	Start	327600	352700
J33	8	J2820047600	Start	328200	347600
J33	9	J2580040900	Start	325800	340900
J33	10	J2240037600	Start	322400	337600
J33	11	J2880034600	Start	328800	334600
J33	12	J3760034500	Start	337600	334500
J33	13	J4120040600	Start	341200	340600
J33	14	J4570039700	Start	345700	339700
J33	15	J5140035700	Start	351400	335700
L64	1	L7014060091	Finish	70140	260091
L64	2	L7285062547	Finish	72850	262547
L64	3	L7689463240	Finish	76894	263240
L64	4	L8067860864	Finish	80678	260864
L64	5	L7917258908	Finish	79172	258908
L64	6	L8201556177	Finish	82015	256177
L64	7	L8504752677	Finish	85047	252677
L64	8	L8404448273	Finish	84044	248273
L64	9	L7992047290	Finish	79920	247290
L64	10	L7592346317	Finish	75923	246317
L64	11	L6520940384	Finish	65209	240384
L64	12	L6228343990	Finish	62283	243990
L64	13	L6500047481	Finish	65000	247481
L64	14	L6189649813	Finish	61896	249813
L64	15	L6594247763	Finish	65942	247763
L64	1	L7010258626	Start	70102	258626
L64	2	L7142562474	Start	71425	262474
L64	3	L7555263760	Start	75552	263760
L64	4	L7933361361	Start	79333	261361
L64	5	L8044659616	Start	80446	259616
L64	6	L8081857164	Start	80818	257164
L64	7	L8430854042	Start	84308	254042

L64	8	L8454149744	Start	84541	249744
L64	9	L8120246962	Start	81202	246962
L64	10	L7718046694	Start	77180	246694
L64	11	L6673340195	Start	66733	240195
L64	12	L6329642651	Start	63296	242651
L64	13	L6358046897	Start	63580	246897
L64	14	L6238148727	Start	62381	248727
L64	15	L6470248424	Start	64702	248424
M24	1	M215453	Finish	121500	245300
M24	2	M207486	Finish	120700	248600
M24	3	M202525	Finish	120200	252500
M24	4	M221557	Finish	122100	255700
M24	5	M252587	Finish	125200	258700
M24	6	M260629	Finish	126000	262900
M24	7	M264673	Finish	126400	267300
M24	8	M292682	Finish	129200	268200
M24	9	M325656	Finish	132500	265600
M24	10	M357618	Finish	135700	261800
M24	11	M393613	Finish	139300	261300
M24	12	M402583	Finish	140200	258300
M24	13	M424541	Finish	142400	254100
M24	14	M419526	Finish	141900	252600
M24	15	M375531	Finish	137500	253100
M24	1	M226462	Start	122600	246200
M24	2	M208472	Start	120800	247200
M24	3	M204512	Start	120400	251200
M24	4	M219542	Start	121900	254200
M24	5	M243574	Start	124300	257400
M24	6	M258613	Start	125800	261300
M24	7	M270659	Start	127000	265900
M24	8	M278688	Start	127800	268800
M24	9	M317662	Start	131700	266200
M24	10	M345633	Start	134500	263300
M24	11	M379613	Start	137900	261300
M24	12	M412594	Start	141200	259400
M24	13	M430553	Start	143000	255300
M24	14	M430517	Start	143000	251700

M24	15	M388534	Start	138800	253400
M87	1	N070826	End	207000	282600
M87	2	N055892	End	205500	289200
M87	3	N077920	End	207700	292000
M87	4	N104905	End	210400	290500
M87	5	N006862	End	200600	286200
M87	6	M976824	End	197600	282400
M87	7	M933800	End	193300	280000
M87	8	M915844	End	191500	284400
M87	9	M884876	End	188400	287600
M87	10	M892907	End	189200	290700
M87	11	M913948	End	191300	294800
M87	12	M930988	End	193000	298800
M87	13	M886921	End	188600	292100
M87	14	M847959	End	184700	295900
M87	15	M836933	End	183600	293300
M87	1	N082837	Start	208200	283700
M87	2	N054872	Start	205400	287200
M87	3	N081902	Start	208100	290200
M87	4	N095926	Start	209500	292600
M87	5	N021864	Start	202100	286400
M87	6	M984840	Start	198400	284000
M87	7	M947795	Start	194700	279500
M87	8	M924832	Start	192400	283200
M87	9	M898867	Start	189800	286700
M87	10	M882897	Start	188200	289700
M87	11	M903936	Start	190300	293600
M87	12	M925973	Start	192500	297300
M87	13	M902984	Start	190200	298400
M87	14	M857966	Start	185700	296600
M87	15	M833946	Start	183300	294600
N11	1	N3270039500	Finish	232700	239500
N11	2	N3330036400	Finish	233300	236400
N11	3	N3740034800	Finish	237400	234800
N11	4	N3890031900	Finish	238900	231900
N11	5	N3470029700	Finish	234700	229700
N11	6	N3100030300	Finish	231000	230300

N11	7	N2900027400	Finish	229000	227400
N11	8	N2950025000	Finish	229500	225000
N11	9	N3080020900	Finish	230800	220900
N11	10	N3170017900	Finish	231700	217900
N11	11	N3340015200	Finish	233400	215200
N11	12	N2950012700	Finish	229500	212700
N11	13	N2570015400	Finish	225700	215400
N11	14	N2510018700	Finish	225100	218700
N11	15	N2060022700	Finish	220600	222700
N11	1	N3440039300	Start	234400	239300
N11	2	N3250037400	Start	232500	237400
N11	3	N3570034700	Start	235700	234700
N11	4	N3980032900	Start	239800	232900
N11	5	N3630029800	Start	236300	229800
N11	6	N3130028700	Start	231300	228700
N11	7	N2910029000	Start	229100	229000
N11	8	N3090025400	Start	230900	225400
N11	9	N3060022500	Start	230600	222500
N11	10	N3000018600	Start	230000	218600
N11	11	N3420016500	Start	234200	216500
N11	12	N3070011600	Start	230700	211600
N11	13	N2730015000	Start	227300	215000
N11	14	N2380017400	Start	223800	217400
N11	15	N2030020900	Start	220300	220900
N74	1	N8372567918	Finish	283725	267918
N74	2	N7748167575	Finish	277481	267575
N74	3	N7339569390	Finish	273395	269390
N74	4	N7416162923	Finish	274161	262923
N74	5	N7305056178	Finish	273050	256178
N74	6	N7495453408	Finish	274954	253408
N74	7	N7874850695	Finish	278748	250695
N74	8	N7419048631	Finish	274190	248631
N74	9	N7401744007	Finish	274017	244007
N74	10	N8118345584	Finish	281183	245584
N74	11	N8475143102	Finish	284751	243102
N74	12	N8666647440	Finish	286666	247440
N74	13	N9250346917	Finish	292503	246917

N74	14	NULL	Finish		
N74	15	N9245957100	Finish	292459	257100
N74	1	N8533467628	Start	285334	267628
N74	2	N7904667407	Start	279046	267407
N74	3	N7473069181	Start	274730	269181
N74	4	N7357764382	Start	273577	264382
N74	5	N7327557662	Start	273275	257662
N74	6	N7332753266	Start	273327	253266
N74	7	N7758751343	Start	277587	251343
N74	8	N7559147955	Start	275591	247955
N74	9	N7273944501	Start	272739	244501
N74	10	N7962145702	Start	279621	245702
N74	11	N8389744378	Start	283897	244378
N74	12	N8562246404	Start	285622	246404
N74	13	N9328645525	Start	293286	245525
N74	14	N9391951701	Start	293919	251701
N74	15	N9166655757	Start	291666	255757
N77	1	N9593282437	Finish	295932	282437
N77	2	O0165482573	Finish	301654	282573
N77	3	O0095187002	Finish	300951	287002
N77	4	O0305890912	Finish	303058	290912
N77	5	O0213195540	Finish	302131	295540
N77	6	N9768596741	Finish	297685	296741
N77	7	N9437499650	Finish	294374	299650
N77	8	N9028497853	Finish	290284	297853
N77	9	N8632898074	Finish	286328	298074
N77	10	N8387295189	Finish	283872	295189
N77	11	N8079898753	Finish	280798	298753
N77	12	N7766498817	Finish	277664	298817
N77	13	N7869193046	Finish	278691	293046
N77	14	N7874588704	Finish	278745	288704
N77	15	N8114384759	Finish	281143	284759
N77	1	N9729381613	Start	297293	281613
N77	2	O0045182026	Start	300451	282026
N77	3	O0140185403	Start	301401	285403
N77	4	O0243989410	Start	302439	289410
N77	5	O0271494253	Start	302714	294253

N77	6	N9934596781	Start	299345	296781
N77	7	N9580699680	Start	295806	299680
N77	8	N9161298734	Start	291612	298734
N77	9	N8782898425	Start	287828	298425
N77	10	N8542894039	Start	285428	294039
N77	11	N8171597389	Start	281715	297389
N77	12	N7937398229	Start	279373	298229
N77	13	N7876394783	Start	278763	294783
N77	14	N7868590328	Start	278685	290328
N77	15	N8029286274	Start	280292	286274
O04	1	O2259	Finish	322000	259000
O04	2	O187616	Finish	318700	261600
O04	3	O171657	Finish	317100	265700
O04	4	O1368	Finish	313000	268000
O04	5	O087689	Finish	308700	268900
O04	6	O009694	Finish	300900	269400
O04	7	O0065	Finish	300000	265000
O04	8	O010598	Finish	301000	259800
O04	9	O067619	Finish	306700	261900
O04	10	O1162	Finish	311000	262000
O04	11	O115576	Finish	311500	257600
O04	12	O0558	Finish	305000	258000
O04	13	O024575	Finish	302400	257500
O04	14	O026540	Finish	302600	254000
O04	15	O0349	Finish	303000	249000
O04	1	O237594	Start	323700	259400
O04	2	O198613	Start	319800	261300
O04	3	O177643	Start	317700	264300
O04	4	O153685	Start	315300	268500
O04	5	O093676	Start	309300	267600
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O04	8	O003614	Start	300300	261400
O04	9	O053613	Start	305300	261300
O04	10	O104614	Start	310400	261400
O04	11	O118593	Start	311800	259300
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O04	13	O009583	Start	300900	258300
O04	14	O008542	Start	300800	254200
O04	15	O0351	Start	303000	251000
R22	1	R246279	End	124600	127900
R22	2	R243325	End	124300	132500
R22	3	R253368	End	125300	136800
R22	4	R293401	End	129300	140100
R22	5	R322431	End	132200	143100
R22	6	R341452	End	134100	145200
R22	7	R381467	End	138100	146700
R22	8	R409484	End	140900	148400
R22	9	R406455	End	140600	145500
R22	10	R422418	End	142200	141800
R22	11	R455401	End	145500	140100
R22	12	R464358	End	146400	135800
R22	13	R496356	End	149600	135600
R22	14	R457344	End	145700	134400
R22	15	R438303	End	143800	130300
R22	1	R244265	Start	124400	126500
R22	2	R245310	Start	124500	131000
R22	3	R255357	Start	125500	135700
R22	4	R282388	Start	128200	138800
R22	5	R310421	Start	131000	142100
R22	6	R331448	Start	133100	144800
R22	7	R374452	Start	137400	145200
R22	8	R399486	Start	139900	148600
R22	9	R406468	Start	140600	146800
R22	10	R412424	Start	141200	142400
R22	11	R450415	Start	145000	141500
R22	12	R464373	Start	146400	137300
R22	13	R489362	Start	148900	136200
R22	14	R474348	Start	147400	134800
R22	15	R447311	Start	144700	131100
R28	1	R302867	Finish	130200	186700
R28	2	R335854	Finish	133500	185400
R28	3	R357823	Finish	135700	182300
R28	4	R396805	Finish	139600	180500

R28	5	R425844	Finish	142500	184400
R28	6	R439887	Finish	143900	188700
R28	7	R462926	Finish	146200	192600
R28	8	R483962	Finish	148300	196200
R28	9	M496004	Finish	149600	200400
R28	10	M462043	Finish	146200	204300
R28	11	M437076	Finish	143700	207600
R28	12	M392092	Finish	139200	209200
R28	13	M357082	Finish	135700	208200
R28	14	M340026	Finish	134000	202600
R28	15	M303020	Finish	130300	202000
R28	1	R287873	Start	128700	187300
R28	2	R334869	Start	133400	186900
R28	3	R345827	Start	134500	182700
R28	4	R385805	Start	138500	180500
R28	5	R418830	Start	141800	183000
R28	6	R434873	Start	143400	187300
R28	7	R456912	Start	145600	191200
R28	8	R470963	Start	147000	196300
R28	9	R490991	Start	149000	199100
R28	10	M467030	Start	146700	203000
R28	11	M448073	Start	144800	207300
R28	12	M407085	Start	140700	208500
R28	13	M360096	Start	136000	209600
R28	14	M346052	Start	134600	205200
R28	15	M315026	Start	131500	202600
R88	1	N034066	Finish	203400	206600
R88	2	N004068	Finish	200400	206800
R88	3	M964082	Finish	196400	208200
R88	4	M926068	Finish	192600	206800
R88	5	M905027	Finish	190500	202700
R88	6	M876006	Finish	187600	200600
R88	7	R845984	Finish	184500	198400
R88	8	R848954	Finish	184800	195400
R88	9	R866923	Finish	186600	192300
R88	10	R870892	Finish	187000	189200
R88	11	R864855	Finish	186400	185500

R88	12	R889834	Finish	188900	183400
R88	13	R927824	Finish	192700	182400
R88	14	R969818	Finish	196900	181800
R88	15	R988849	Finish	198800	184900
R88	1	N046057	Start	204600	205700
R88	2	N008083	Start	200800	208300
R88	3	M979078	Start	197900	207800
R88	4	M935077	Start	193500	207700
R88	5	M914038	Start	191400	203800
R88	6	M889008	Start	188900	200800
R88	7	R845997	Start	184500	199700
R88	8	R863961	Start	186300	196100
R88	9	R849929	Start	184900	192900
R88	10	R873907	Start	187300	190700
R88	11	R858869	Start	185800	186900
R88	12	R883847	Start	188300	184700
R88	13	R914827	Start	191400	182700
R88	14	R957824	Start	195700	182400
R88	15	R993834	Start	199300	183400
S12	1	S377496	Finish	237700	149600
S12	2	S336494	Finish	233600	149400
S12	3	S296490	Finish	229600	149000
S12	4	S254492	Finish	225400	149200
S12	5	S211477	Finish	221100	147700
S12	6	S164461	Finish	216400	146100
S12	7	S125429	Finish	212500	142900
S12	8	S122399	Finish	212200	139900
S12	9	S124354	Finish	212400	135400
S12	10	S122316	Finish	212200	131600
S12	11	S129285	Finish	212900	128500
S12	12	S145271	Finish	214500	127100
S12	13	S185265	Finish	218500	126500
S12	14	S224277	Finish	222400	127700
S12	15	S252257	Finish	225200	125700
S12	1	S3936549954	Start	239365	149954
S12	2	S3521649021	Start	235216	149021
S12	3	S3086448520	Start	230864	148520

S12	4	S2684149223	Start	226841	149223
S12	5	S2248248585	Start	222482	148585
S12	6	S1781546755	Start	217815	146755
S12	7	S1306544297	Start	213065	144297
S12	8	S1065739913	Start	210657	139913
S12	9	S1258137199	Start	212581	137199
S12	10	S1366932201	Start	213669	132201
S12	11	S1406529038	Start	214065	129038
S12	12	S1369226197	Start	213692	126197
S12	13	S1764226017	Start	217642	126017
S12	14	S2112827563	Start	221128	127563
S12	15	S2394325933	Start	223943	125933
S15	1	S386635	Finish	238600	163500
S15	2	S344620	Finish	234400	162000
S15	3	S358592	Finish	235800	159200
S15	4	S333577	Finish	233300	157700
S15	5	S336545	Finish	233600	154500
S15	6	S310545	Finish	231000	154500
S15	7	S286553	Finish	228600	155300
S15	8	S285513	Finish	228500	151300
S15	9	S247514	Finish	224700	151400
S15	10	S207532	Finish	220700	153200
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S15	14	S182684	Finish	218200	168400
S15	15	S205718	Finish	220500	171800
S15	1	S393647	Start	239300	164700
S15	2	S354628	Start	235400	162800
S15	3	S354600	Start	235400	160000
S15	4	S345582	Start	234500	158200
S15	5	S350552	Start	235000	155200
S15	6	S306532	Start	230600	153200
S15	7	S286571	Start	228600	157100
S15	8	S280531	Start	228000	153100
S15	9	S253505	Start	225300	150500
S15	10	S220526	Start	222000	152600

S15	11	S189552	Start	218900	155200
S15	12	S190612	Start	219000	161200
S15	13	S153622	Start	215300	162200
S15	14	S174669	Start	217400	166900
S15	15	S191711	Start	219100	171100
S78	1	S744815	Finish	274400	181500
S78	2	S737846	Finish	273700	184600
S78	3	S721879	Finish	272100	187900
S78	4	S729910	Finish	272900	191000
S78	5	S737939	Finish	273700	193900
S78	6	S741970	Finish	274100	197000
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S78	8	S823979	Finish	282300	197900
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S78	10	S886967	Finish	288600	196700
S78	11	S909997	Finish	290900	199700
S78	12	S928964	Finish	292800	196400
S78	13	S937938	Finish	293700	193800
S78	14	S974918	Finish	297400	191800
S78	15	S994885	Finish	299400	188500
S78	1	S749804	Start	274900	180400
S78	2	S749839	Start	274900	183900
S78	3	S734876	Start	273400	187600
S78	4	S716903	Start	271600	190300
S78	5	S736927	Start	273600	192700
S78	6	S734963	Start	273400	196300
S78	7	S774966	Start	277400	196600
S78	8	S808977	Start	280800	197700
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S78	10	S879953	Start	287900	195300
S78	11	S896996	Start	289600	199600
S78	12	S930977	Start	293000	197700
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S78	14	S960924	Start	296000	192400
S78	15	S991898	Start	299100	189800
T05	1	T030790	Finish	303000	179000
T05	2	T060764	Finish	306000	176400

T05	3	T054727	Finish	305400	172700
T05	4	T088706	Finish	308800	170600
T05	5	T122676	Finish	312200	167600
T05	6	T138654	Finish	313800	165400
T05	7	T096644	Finish	309600	164400
T05	8	T063671	Finish	306300	167100
T05	9	T015659	Finish	301500	165900
T05	10	T016616	Finish	301600	161600
T05	11	T044596	Finish	304400	159600
T05	12	T081589	Finish	308100	158900
T05	13	T049559	Finish	304900	155900
T05	14	T017514	Finish	301700	151400
T05	15	T045503	Finish	304500	150300
T05	1	T018788	Start	301800	178800
T05	2	T053772	Start	305300	177200
T05	3	T053737	Start	305300	173700
T05	4	T077717	Start	307700	171700
T05	5	T111687	Start	311100	168700
T05	6	T153661	Start	315300	166100
T05	7	T112643	Start	311200	164300
T05	8	T076664	Start	307600	166400
T05	9	T030663	Start	303000	166300
T05	10	T016630	Start	301600	163000
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T05	14	T017528	Start	301700	152800
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V93	1	W180479	Finish	118000	47900
V93	2	W136465	Finish	113600	46500
V93	3	W147438	Finish	114700	43800
V93	4	W184422	Finish	118400	42200
V93	5	W165388	Finish	116500	38800
V93	6	W137354	Finish	113700	35400
V93	7	W106338	Finish	110600	33800
V93	8	W062329	Finish	106200	32900
V93	9	W025347	Finish	102500	34700

V93	10	V984354	Finish	98400	35400
V93	11	V945374	Finish	94500	37400
V93	12	V904382	Finish	90400	38200
V93	13	V939407	Finish	93900	40700
V93	14	V969438	Finish	96900	43800
V93	15	V978473	Finish	97800	47300
V93	1	W194488	Start	119400	48800
V93	2	W150469	Start	115000	46900
V93	3	W136449	Start	113600	44900
V93	4	W169425	Start	116900	42500
V93	5	W167403	Start	116700	40300
V93	6	W146366	Start	114600	36600
V93	7	W119337	Start	111900	33700
V93	8	W077335	Start	107700	33500
V93	9	W039347	Start	103900	34700
V93	10	V998352	Start	99800	35200
V93	11	V958369	Start	95800	36900
V93	12	V917374	Start	91700	37400
V93	13	V926398	Start	92600	39800
V93	14	V954433	Start	95400	43300
V93	15	V984460	Start	98400	46000
V96	1	W0109288464	Finish	101092	88464
V96	2	W0514486283	Finish	105144	86283
V96	3	W0838083085	Finish	108380	83085
V96	4	W1213381995	Finish	112133	81995
V96	5	W152794	Finish	115200	79400
V96	6	W1952977674	Finish	119529	77674
V96	7	W163757	Finish	116300	75700
V96	8	W140760	Finish	114000	76000
V96	9	W1158473385	Finish	111584	73385
V96	10	W076740	Finish	107600	74000
V96	11	W042745	Finish	104200	74500
V96	12	V999733	Finish	99900	73300
V96	13	V955724	Finish	95500	72400
V96	14	V912707	Finish	91200	70700
V96	15	V9142380395	Finish	91423	80395
V96	1	W002898	Start	100200	89800

V96	2	W040876	Start	104000	87600
V96	3	W075844	Start	107500	84400
V96	4	W112826	Start	111200	82600
V96	5	W142801	Start	114200	80100
V96	6	W183788	Start	118300	78800
V96	7	W177763	Start	117700	76300
V96	8	W139774	Start	113900	77400
V96	9	W130738	Start	113000	73800
V96	10	W089734	Start	108900	73400
V96	11	W051754	Start	105100	75400
V96	12	W015735	Start	101500	73500
V96	13	V968728	Start	96800	72800
V96	14	V926716	Start	92600	71600
V96	15	V902804	Start	90200	80400
W56	1	W7684061298	Finish	176840	61298
W56	2	W7257062125	Finish	172570	62125
W56	3	W6836561344	Finish	168365	61344
W56	4	W6595262741	Finish	165952	62741
W56	5	W6135261747	Finish	161352	61747
W56	6	W5688661278	Finish	156886	61278
W56	7	W5209061187	Finish	152090	61187
W56	8	W5221365493	Finish	152213	65493
W56	9	W5120068841	Finish	151200	68841
W56	10	W5154271172	Finish	151542	71172
W56	11	W5562671786	Finish	155626	71786
W56	12	W5599572063	Finish	155995	72063
W56	13	W5463575580	Finish	154635	75580
W56	14	W5565079580	Finish	155650	79580
W56	15	W5613784083	Finish	156137	84083
W56	1	W7814861380	Start	178148	61380
W56	2	W7398262175	Start	173982	62175
W56	3	W6974261868	Start	169742	61868
W56	4	W6618661559	Start	166186	61559
W56	5	W6285762305	Start	162857	62305
W56	6	W5853561113	Start	158535	61113
W56	7	W5390560804	Start	153905	60804
W56	8	W5265363954	Start	152653	63954

W56	9	W5086167396	Start	150861	67396
W56	10	W5020170701	Start	150201	70701
W56	11	W5404171385	Start	154041	71385
W56	12	W5710571286	Start	157105	71286
W56	13	W5576274531	Start	155762	74531
W56	14	W5499278092	Start	154992	78092
W56	15	W5610482525	Start	156104	82525
X49	1	S470183	End	247000	118300
X49	2	S453151	End	245300	115100
X49	3	S425124	End	242500	112400
X49	4	S449085	End	244900	108500
X49	5	S429056	End	242900	105600
X49	6	S442015	End	244200	101500
X49	7	S464005	End	246400	100500
X49	8	S501017	End	250100	101700
X49	9	S545032	End	254500	103200
X49	10	S571072	End	257100	107200
X49	11	S609067	End	260900	106700
X49	12	S642013	End	264200	101300
X49	13	S675097	End	267500	109700
X49	14	S669056	End	266900	105600
X49	15	S644086	End	264400	108600
X49	1	S465197	Start	246500	119700
X49	2	S467147	Start	246700	114700
X49	3	S412131	Start	241200	113100
X49	4	S454104	Start	245400	110400
X49	5	S414067	Start	241400	106700
X49	6	S440030	Start	244000	103000
X49	7	X466990	Start	246600	99000
X49	8	S491027	Start	249100	102700
X49	9	S537021	Start	253700	102100
X49	10	S562060	Start	256200	106000
X49	11	S606082	Start	260600	108200
X49	12	S636025	Start	263600	102500
X49	13	S688007	Start	268800	100700
X49	14	S663041	Start	266300	104100
X49	15	S656078	Start	265600	107800

V99	1	W0064389816	Start	100643	89816
V99	2	W0609890220	Start	106098	90220
V99	3	W1049291274	Start	110492	91274
V99	4	W1478792932	Start	114787	92932
V99	5	W1731295862	Start	117312	95862
V99	6	R1557901008	Start	115579	101008
V99	7	R1640005100	Start	116400	105100
V99	8	R1701809907	Start	117018	109907
V99	9	R1693214456	Start	116932	114456
V99	10	R1412818391	Start	114128	118391
V99	11	R0890919424	Start	108909	119424
V99	12	R0595920519	Start	105959	120519
V99	13	R0004519451	Start	100045	119451
V99	14	Q9702816633	Start	97028	116633
V99	15	Q9897712228	Start	98977	112228
V99	1	W0217589654	End	102175	89654
V99	2	W0764890605	End	107648	90605
V99	3	W1206991703	End	112069	91703
V99	4	W1624493153	End	116244	93153
V99	5	W1720197406	End	117201	97406
V99	6	R1595202481	End	115952	102481
V99	7	R1755706079	End	117557	106079
V99	8	R1663811076	End	116638	111076
V99	9	R1727915767	End	117279	115767
V99	10	R1262518508	End	112625	118508
V99	11	R0834320080	End	108343	120080
V99	12	R0447420237	End	104474	120237
V99	13	Q9851419153	End	98514	119153
V99	14	Q9734515170	End	97345	115170
V99	15	Q9950210840	End	99502	110840

Appendix 2 All Ireland Daubenton's Bat Waterways Survey

Table A.2 Locations of All Ireland Daubenton's Bat Waterway Sites

Site Code	Waterway	Site Name	Grid Ref	County
1001	River Boyne	Slane Bridge	N9639673641	Meath
1002	River Blackwater (L)	O'Dalys Bridge	N6524780344	Meath
1003	Borora River	Moynalty Bridge	N7338482669	Meath
1004	Ward River	Bridge nth of Killeek	O1452146385	Dublin
1005	Vartry River	Newrath Bridge	T2861396699	Wicklow
1006	Kings River	Ballinagree Bridge	O0361002384	Wicklow
1007	Avonmore River	Ballard Bridge	T1440195648	Wicklow
1008	Glencullen River	Glencullen Bridge	O2258617414	Wicklow
1009	Vartry River	Nun's Cross	T2573997807	Wicklow
1010	River Ow	Roddenagh Bridge	T1174279106	Wicklow
1011	Camlin River	The Mall Bridge	N0622375767	Longford
1012	River Dargle	Bray Bridge	O2633618868	Wicklow
1013	River Slaney	Seskin Bridge	S9767493842	Wicklow
1014	Streamstown River	Interpretative Centre	M4816106102	Galway
1015	Clarinbridge River	Clarin Bridge	M4125920049	Galway
1016	Black River	Moyne Bridge	M2558849084	Galway
1017	Lough Kip River	Dr. Chlaidhdi	M2228631268	Galway
1018	Owenriff River	Glan Road Bridge	M1224443146	Galway
1019	River Corrib	Salmon Weir Bridge	M2960825521	Galway
1020	Kilcolgan River	Dunkellin Bridge	M4420218423	Galway
1021	Cregg River	Addergoole Bridge	M3231534989	Galway
1022	Clare River	Claregalway Bridge	M3729433236	Galway
1023	Royal Canal	Aghnaskea Bridge	N0871770472	Longford
1024	Inny River	Newcastle Bridge	N1821456903	Longford
1025	Inagh River	Inagh Bridge	R2082081290	Clare
1026	Inagh River	Moananagh Bridge	R1703984873	Clare
1027	Mulkear River	Bridge Nth of Coolruntha	R8053868653	Tipperary
1028	River Moy	Mount Falcon Fisheries S1	G2494413324	Mayo
1029	River Boyne	Ramparts	N8735367941	Meath
1030	River Blackwater (L)	Donaghpatrick Bridge	N8194072310	Meath
1031	Athboy River	Athboy Bridge	N7169064260	Meath
1032	Brosna River	Ballinagore Bridge	N3567239671	Westmeath
1033	Coalisland Canal	Moor Bridge	H8584964920	Tyrone
1034	Inny River	Ballymanhon Bridge	N1581956876	Longford
1035	Delvin River	Gormanstown Bridge	O1707665774	Dublin
1036	River Liffey	Leixlip Bridge	O0075035810	Kildare
1037	Tolka River	Cardiff Bridge	O1241137745	Dublin
1038	Tolka River	Dunboyne-Loughsallagh Br	O0279241654	Meath
1039	Tolka River	Abbotstown Bridge	O0913338443	Dublin

1040	River Dodder	Oldbawn Bridge	O0975026300	Dublin
1041	River Dodder	Bridge on Spring Avenue	O1361028910	Dublin
1042	Grand Canal	Henry Bridge	N9560028200	Kildare
1043	Rafford River	Ratty's Bridge	M5470723255	Galway
1044	Royal Canal	Farranyoogan	N1300074200	Longford
1045	River Rinn	Cloonart Bridge	N0831883154	Longford
1046	Royal Canal	Collins Bridge	O0273836789	Dublin
1047	Royal Canal	Granard Bridge, Castleknock	O0847638072	Dublin
1048	Grand Canal	Kilmainham Section	O1283233158	Dublin
1049	River Lee	Bannon Bridge	W6090171883	Cork
1050	Martin River	Bawnafinny Bridge	W5979575446	Cork
1051	Unshin River	Colloney	G6796926532	Sligo
1052	Owenboy River (Mun)	Priests Bar	W6045561309	Cork
1053	River Foherish	Carrigaphooca Bridge	W2964573728	Cork
1054	Glashaboy River	Upper Glanmire Bridge	W7140578374	Cork
1055	Shournagh River	Tower Bridge	W5858874646	Cork
1056	Laney River	Carrigagulla Bridge	W3892783062	Cork
1057	Bride River	Coolmucky Bridge	W4607367866	Cork
1058	River Lee	Drumcarra Bridge	W2955867786	Cork
1059	River Sullane	Linnamilla Bridge	W3117072810	Cork
1060	River Blackwater (M)	Charles bridge	W2481194404	Cork
1061	Argideen River	Lisselane Bridge	W4052244437	Cork
1062	Owenreagh River	Gearhamnen	V8842982150	Kerry
1063	River Suir	Knocklofty Bridge	S1443820561	Tipperary
1064	River Suir	Thurles Bridge	S1291158676	Tipperary
1065	River Feale	Racecourse Footbridge	Q9816333625	Kerry
1066	Flesk	Flesk Bridge	V9672589468	Kerry
1067	River Fane	Stephenstown Bridge	J0135201565	Louth
1068	River Nanny	Dardistown Bridge	O1116570164	Meath
1069	Nenagh River	Tyone Bridge	R87589780 92	Tipperary
1070	Moyola River	Curran Bridge	H95Yes9500	Derry
1071	River Sow	Poulsack Bridge	T0477627051	Wexford
1072	River Suir	Kilsheelan Bridge	S2862023234	Tipperary
1073	River Suir	Cabragh Bridge	S1119956062	Tipperary
1074	Tintern Abbey Stream	Tintern Abbey	S7938609979	Wexford
1075	Whelan's Br River	Whelan's Bridge	S5225710042	Waterford
1076	River Shannon	Banagher Bridge	N0052515880	Offaly
1077	River Sow	Kilmallock Bridge	T0322931865	Wexford
1078	River Nore	Knockanore	S5469143670	Kilkenny
1079	River Nore	NE of Warrington	S5373654466	Kilkenny
1080	River Nore	Threecastles Bridge	S4582162709	Kilkenny
1081	River Barrow	St Mullins	S7295037800	Carlow
1082	River Barrow	Graiguenamanagh Bridge	S7099143606	Kilkenny
1083	Avonmore River	Clara Bridge	T1690092100	Wicklow

1084	Owennashad River	Br u/s Blackwater R. confl.	X0482098940	Waterford
1085	Clashawley River	Fethard	S2050034900	Tipperary
1086	Royal Canal	Bellmount Bridge	N3950051100	Westmeath
1087	Dripsey River	Dripsey Bridge Lower	W4613579659	Cork
1088	River Brosna	Newell's Bridge	N3830042300	Westmeath
1089	Aherlow River	Cappa Old Bridge	R9935429318	Tipperary
1090	Derry River	Tomnafinoge Wood	T0190070300	Wicklow
1091	Glengarrif River	Footbridge NW of Glengarrif	V9181357002	Cork
1092	River Shannon	Lusmagh	M9648214956	Offaly
1093	Tributray of River Boyne	Ballivor Road Bridge	N6030345270	Westmeath
1094	River Dodder	Newbridge Firhouse	O1145027750	Dublin
1095	Cartron River	Carran	F8001100176	Mayo
1096	River Feale	Finuge Bridge	Q9514932139	Kerry
1097	Sneem River	Br u/s Ardsheelhane R. confl.	V6893067563	Kerry
1098	River Moy	Mount Falcon Fisheries S2	G2484212404	Mayo
1099	River Blackwater (M)	Careyville	W8558399508	Cork
1100	Inny River	Shrule Bridge	N1350055866	Longford
1101	Arigideen River	Kilmaloda Bridge	W4519245605	Cork
1102	River Lagan	Shaws Bridge	J3250069000	Antrim
1103	Maigue River	Fort Bridge	R5062825677	Limerick
1104	Mascosquin River	Ree Bridge	C8980223646	Derry
1105	River Roe	Dog Leap	C6792920302	Derry
1106	River Roe	Dungiven Bridge	C6829609777	Derry
1107	Whelan's Br River	Br West of Carrickduston	S5068107653	Waterford
1108	Glenarm River	Glenarm Estate	D3012511916	Antrim
1109	Cusher River	Clare Glen Bridge	J0129543745	Armagh
1110	Bann (Newry) Canal	Moneypennys Lock	J0309851157	Armagh
1111	Bann (Newry) Canal	Scarva Heritage Centre	J0637343671	Armagh
1112	Moneycarragh River	Moneylane	J3992836890	Down
1113	Ravernet River	Legacurry Bridge	J2967960067	Down
1114	Owenmore River	Rathmullan Big Bridge	G6661312353	Sligo
1115	Drowse River	Lennox's Bridge	G8176957360	Leitrim
1116	Grand Canal	Spencer Bridge	N6685218922	Kildare
1117	River Suir	Suir Valley Railway	S5391310362	Waterford
1118	Owenmore River	Templehouse Bridge	G6254718531	Sligo
1119	Drumcliff River	Ford 500m u/s Drumcliff Bridge	G6791942172	Sligo
1120	North Slob Channel	Channel - Wildfowl Reserve	T0799925260	Wexford
1121	Duff River	Bridge at Drumacolla	G7960049100	Leitrim
1122	Boyle River	Knockvicar Bridge	G8725405497	Roscommon
1123	River Lee	Kennel's to Weir Stream	W5870071400	Cork
1124	Manulla River	Belcarra Walkway	M1997684271	Mayo
1125	Grand Canal	Corbally Line/Limerick Bridge	N8734918727	Kildare
1126	River Liffey	Kilcullen Bridge	N8417309703	Kildare
1127	River Liffey	Connell Ford	N8135013680	Kildare

1128	Royal Canal	Deey Bridge	N9793036948	Kildare
1129	River Brosna	Ballycumber Bridge	N2110730605	Offaly
1130	Royal Canal	Smullen Bridge	N9400237410	Kildare
1131	River Dodder	Milltown Bridge	O1683130308	Dublin
1132	River Blackwater (L)	Mabe's Bridge	N7361077290	Meath
1133	River Blackwater (L)	Nine Eyes Bridge	N6304083380	Cavan
1134	River Blackwater (Monaghan)	New Mills, Cornahoe	H7188138758	Monaghan
1135	Errina-plassey Canal	Errina Bridge	R6400064800	Clare
1136	Greanagh River	Coolah Bridge	R4434946357	Limerick
1137	Claureen River	Claureen Bridge	R3285978100	Clare
1138	River Fergus	Drehidnagower	R3302878713	Clare
1139	River Barnakyle	Old Forge Bridge	R5103853043	Limerick
1140	River Shannon	Burgess Park, Athlone	N0410041000	Westmeath
1141	River Blackwater (U)	Killryan Bridge	H2029114588	Cavan
1142	Grand Canal	Milltown Bridge	S6536297394	Kildare
1143	Grand Canal	Ayimer Bridge	N9720029488	Kildare
1144	Diffagher River	Cloonemeohe Bridge	G9328624777	Leitrim
1145	River Shannon	Dowra Bridge	G9910026700	Leitrim
1146	River Shannon	Mahanagh Bridge	G9560811715	Roscommon
1147	River Suck	Castlecoote Bridge	M8086362621	Roscommon
1148	Owenea River	Owenea Bridge	G7370992012	Donegal
1149	River Deele (U)	Milltown Bridge	H2437899626	Donegal
1150	Owenwee River	Belclare Bridge	L9594282187	Mayo
1151	St. John's River	Kilbarry Walkway	S6015010000	Waterford
1152	River Unshin	Ballygrania Bridge	G6948125932	Sligo
1153	Feale River	Listowel Bridge	Q9950033250	Kerry
1154	Mulkear River	Annacotty Bridge	R6428157651	Limerick
1155	Owenocarney River	Annagore Bridge	R4769067627	Clare
1156	Bilboa River	Gortnagarde Bridge	R7800050500	Limerick
1157	Boyle Canal	Boyle Canal	G8161804138	Roscommon
1158	Lung River	Br u/s Lough Gara	M6615996542	Roscommon
1159	River Bann (Leinster)	Margerry's Bridge	T1144159337	Wexford
1160	Rafford River	Rafford House	M6085526108	Galway
1161	River Slaney	Scarawalsh Bridge	S9837545068	Wexford
1162	Colligan River	Colligan Bridge	X2201797991	Waterford
1163	Douglas River	Cunaberry Bridge	S8422067950	Carlow
1164	Crana River	Crana Park	C3479732831	Donegal
1165	River Liffey	Ballymore Eustace Bridge	N9264309729	Kildare
1166	River Fergus	Dromore Wood	R3588787940	Clare
1167	River Blickey	Twomile Bridge	X2252691187	Waterford
1168	Kesh River	Kesh	H1798963906	Fermanagh
1169	River Erne	Enniskillen	H2700053000	Fermanagh
1170	Colebrook River	Ballindarragh Bridge	H3312935981	Fermanagh
1171	River Robe	Crossboyne Bridge	M3377970999	Mayo

1172	Grand Canal	Srah Castle	N3291725164	Offaly
1173	Boor River	Kilbillaghan Townland	N1157035349	Westmeath
1174	Grand Canal	Griffith Bridge/Shannon Harbour	N0331819049	Offaly
1175	Lagan Canal	Hilden Bridge	J2810065500	Antrim
1176	Clooneen River	Bridge NW of Kilavil	G6374710049	Sligo
1177	Grand Canal	Hazelhatch Bridge	N9875130726	Dublin
1178	Feale River	Mount Colums Creamery	R1576518754	Limerick
1179	River Erkina	Footbridge 0.5km u/s Durrow	S4050077500	Laois
1180	River Suck	Ballyforan Bridge	M8165046331	Galway
1181	River Nore	Waterloo Bridge	S4110184127	Laois
1182	Owenass River	Bridge Nth of Irishtown Hs	S4500007300	Laois
1183	Delour River	Annagh Bridge	S2907093502	Laois
1184	River Barrow	Clashganey Lock	S7360945865	Carlow
1185	Dinin River	Dinin Bridge	S4791662897	Kilkenny
1186	River Nore	Fennessys Mill	S5212054971	Kilkenny
1187	Owenboy River (Mun)	Ballea Bridge	W7097663371	Cork
1188	Woodford River	Ballyconnell Bridge	H2729118609	Cavan
1189	Cladagh River	Swanlinbar Church of Irl	H1930827094	Cavan
1190	Owengarve River	Rosgalive Bridge	L8866096312	Mayo
1191	Carrowbeg River	2nd br u/s lake, Westport Hs	L9975284551	Mayo
1192	River Bush	Bush Golf Course	C9366542459	Antrim
1193	Broadmeadow River	Swords Golf Course	O1485450059	Dublin
1194	Unshin River	Riverstown Riverstown	G7399720147	Sligo
1195	Gort River	Castletown Mill	M4583303174	Galway
1196	River Barrow	Portnahinch Bridge	N4905110046	Laois
1197	River Dereen	Acaun Bridge	S8997977969	Carlow
1198	Castlebar River	Castlebar Town	M1401390382	Mayo
1199	Vicarstown Canal	Vicarstown	N6150000500	Laois
1200	Dalligan River	Ballyvoyle Bridge	X3357895023	Waterford
1201	Lacey's Canal	Butler's Bridge	N4197950177	Westmeath
1202	River Nore	Dysart	S5960039300	Kilkenny
1203	Royal Canal	County Meath Bridge	N8860039600	Kildare
1204	River Boyne	2km d/s Blackwater confl.	N8852069110	Meath
1205	River Knock	Knockadrohid Bridge	M1587926695	Galway
1206	River Lee	Lee Fields	W6484371393	Cork
1207	Clodiagh River	Muchlagh Bridge	N3100022800	Offaly
1208	Dripsey River	Dripsey Bridge	W4876073864	Cork
1209	Brosna River	Mill Race Coola Mills	N3374536474	Westmeath
1210	Silver River	Wooden Bridge	N1273014351	Offaly
1211	Castletown River	Toberona/St John's Bridge	J0300009700	Louth
1212	Kilcurry River	Bridge near Lurgankeel	J0272811980	Louth
1213	River Dereen	Ballykilduff Townland	S8999777183	Carlow
1214	River Dee	Bridge in Ardee	N9623890328	Louth
1215	River Dee	Drumcar Bridge	O0655891105	Louth

1216	Scarrif River	Cooleen Bridge	R6033186045	Clare
1217	River Dodder	Castlekelly Bridge	O1015220776	Dublin
1218	Scarrif River	1km u/s Scarrif Bridge	R6330084315	Clare
1219	Rye Water	Rye Bridge	O0043235834	Dublin
1220	Boyne Canal	Oldbridge	O0452476191	Louth
1221	River Boyne	Kilnagross Bridge	N7705556675	Meath
1222	River Glyde	Castlebellingham	O0595495145	Louth
1223	Bann (Newry) Canal	Victoria Lock	J0960023400	Armagh
1224	The Quoile	Quoile Pondage	J4878046424	Down
1225	River Boyne	Beaulieu Bridge	O0842675139	Louth
1226	Emlagh River	Bridge west of Emlagh townland	Q6496602437	Kerry
1227	River Dargle	Ballinagee Bridge	O2040914752	Wicklow
1228	Stradbally River	Stradbally Bridge	S57Yes6300	Laois
1229	Glenarm River	Glenarm Castle	D3100015100	Antrim
1230	Camowen River	Lover's Retreat Picnic Site	H4680072900	Tyrone
1231	River Lagan	Drum Bridge	J3058267050	Antrim
1232	Inny River	Coolnagon Bridge	N3872470037	Westmeath
1233	River Bride	Tallow Bridge	W9989294367	Waterford
1234	Breensford River	Unknown	N1042844431	Westmeath
1235	Fairy Water	Downstream of Poe's Bridge	H4250075000	Tyrone
1236	Inny River	Ballycorkey Bridge	N3113563923	Westmeath
1237	Mahon River	Aughshemus Bridge	S4167402690	Waterford
1238	Glory River	Monachunna Townland	S4810038100	Kilkenny
1239	Kings River	Ballycloven	S4850039888	Kilkenny
1240	Royal Canal	Chambers Bridge	N9001538751	Kildare
1241	River Bush	Conagher Bridge	C9618230530	Antrim
1242	Mountain River	Ballycoppigan Bridge	S7096350443	Carlow
1243	Camowen River	Bracky Bridge	H5351971478	Tyrone
1244	River Faughan	Park Bridge	C5912202283	Derry
1245	Sixmile Water	Loughshore Park	J14779865553	Antrim
1246	Lower Bann	The Cuts	C8560030300	Derry
1247	Glenelly River	Drumaspar	H4960091300	Tyrone
1248	Annalee River	Rathkenny Bridge	H5334011556	Cavan
1249	Tolka River	Violet Hill Drive, Finglas	O1408237523	Dublin
1250	Grand Canal	Ponsonby Bridge	N9363426625	Kildare
1251	Broadmeadow River	Milltown Bridge	O0721051770	Meath
1252	River Dargle	Tinehinch Bridge	O2212516160	Wicklow
1253	Aghadowney River	Agivey Bridge	C8980022900	Derry
1254	River Slaney	Enniscorthy Bridge	S9742239898	Wexford
1255	Vartry River	Ashford Bridge	T2704797405	Wicklow
1256	River Liffey	New Bridge	N8704009850	Kildare
1257	Royal Canal	Ballinea Bridge	N3876851029	Westmeath
1258	River Slaney	Kilcarry Bridge	S8928162507	Carlow
1259	River Barrow	Ballyteiglea Br (Lock)	S7096450450	Carlow

1260	Sixmile Water	Millrace Trail	J1535585458	Antrim
1261	Ulster Canal	Monaghan Town	H6792934654	Monaghan
1262	River Corrib	Quincentennial Bridge	M2928726328	Galway
1263	River Laune	1/2km below Beaufort Bridge	V8816692633	Kerry
1264	River Strule	Stone Bridge	H4370077600	Tyrone
1265	River Sillees	Glencunny Bridge	H1952840979	Fermanagh
1266	River Lagan	Stranmillsweir to Lagan Meadows	J3410070900	Antrim
1267	Sixmile Water	Castlefarm Bridge	J1440086800	Antrim
1268	River Bann (Ulster)	Lawcencetown	J0999849080	Down
1269	River Nore	Threecastles Bridge d/s	S4581262685	Kilkenny
1270	Dawros River	Derryinver Bridge	L7019459744	Galway
1271	River Dodder	Clonskeagh Bridge	O1742530664	Dublin
1272	River Roe	Roe Road Bridge	C6665423398	Derry
1273	Annalee River	Butler's Bridge	H4089710577	Cavan
1274	Glencullen River	Knocksink Bridge	O2203117563	Wicklow
1275	Avonmore River	Clara Vale Site 1	T1845591104	Wicklow
1276	Blennerville Canal	Blenerville	Q8154813229	Kerry
1277	Lackagh River	Lackagh Bridge	C0951231005	Donegal
1278	Crawsfordsburn River	Crawsfordsburn Country Park	J4672282042	Down
1279	River Shrule	Stone Bridge u/s	H4369577631	Tyrone
1280	River Faughan	Faughan Bridge u/s	C4927620536	Derry
1281	Agivey River	Errigal Bridge	C8115014505	Derry
1282	Fairy Water	Omagh	H4308874897	Tyrone
1283	River Boyne	Trim Walkway	N8050056535	Meath
1284	River Boyne	Trim Castle	N8015856895	Meath
1285	Glencullen River	Glencullen/Dargle confluence	O2430017200	Wicklow
1286	Vartry River	Annagolan Bridge	T2210399247	Wicklow
1287	Kings River	Kells Bridge	S4941543690	Kilkenny
1288	Drumragh River	Lissan Bridge	H4614370728	Tyrone
1289	River Lagan	Wolfden's Bridge	J2844168907	Antrim
1290	Agivey River	Moneycarrie Bridge	C8667019435	Derry
1291	Lagan Canal	Ballyskeagh High Bridge	J2882766888	Antrim
1292	Enler River	Dundonald	J4230073200	Down
1293	Royal Canal	Sli na Canala, Enfield	N7742341203	Meath
1294	Bann Upper	Laraheen	T1216064158	Wexford
1295	Upper Inny River	Jobson's Bridge	N5295480707	Meath
1296	Upper Inny River	Roos Bridge	N4729183034	Meath
1297	Clarebane River	Clarebane Bridge	H8734016771	Monaghan
1298	Owenascaul River	Anascaul Bridge	Q5927301880	Kerry
1299	Camlin River	Carrigglass Bridge	N1654377942	Longford
1300	River Boyne	Derryingdaly Bridge	N7667353936	Meath
1301	River Liffey	War Memorial Gardens	O1170034150	Dublin
1302	Arney River	Brochagh Bridge	H1755537398	Fermanagh
1303	River Nore	Kilkenny City	S5078255870	Kilkenny

1304	River Nore	Bennetsbridge North	S5524349272	Kilkenny
1305	Gageborough River	John Halloway Farm	N2667037907	Offaly
1306	Royal Canal	D'Arcy's Bridge	N5916349728	Westmeath
1307	Grand Canal	Cartland Bridge	N5975932357	Offaly
1308	River Boyne	Ballyboggan Bridge	N6388640232	Meath
1309	Grand Canal	Courtwood Bridge	N6190004100	Laois
1310	River Boyne	Broadboyne Bridge	N9184471312	Meath
1311	Altidore River	Mountkennedy Wood	O2630906937	Wicklow
1312	Kilcrow River	Hearnesbrook Demesne	M7978713028	Galway
1313	River Lee (Kerry)	Ballyseedy Wood	Q8760113092	Kerry
1314	Grand Canal	Pike Bridge, Caron Gate	N9612637359	Kildare
1315	Broadmeadow River	Ashbourne	O0643552202	Meath
1316	River Shannon	O'Brien's Bridge	R6638866876	Clare
1317	Ballyteige Channels	Ballteige	S9400006000	Wexford
1318	Virginia River	Handball Alley, Virginia	N6072587566	Cavan
1319	River Finn	Drumboe Woods	H1351294675	Donegal
1320	Garvogue River	Bridge Street, Sligo	G6930935969	Sligo
1321	Kings River	Newtown	S4647043551	Kilkenny
1322	Owenmore River	Knoxpark	G6729128934	Sligo
1323	Ardnaglass River	Ardnaglass Bridge	G5309834279	Sligo
1324	Mulkear River	Rockvale Bridge	R7386763348	Tipperary
1325	River Lagan	Moores Bridge	J2621862885	Antrim
1326	River Lagan	Lock Keepers Cottage	J3307769155	Antrim
1327	Hind River	South of Roscommon Town	M8928161325	Roscommon
1328	River Maine	Castleisland	R0015109561	Kerry
1329	River Suck	Conamon Bridge	M7895064900	Roscommon
1330	River Suck	Rookwood Bridge	M8095057600	Roscommon
1331	Boyle River	Boyle Town	G7914302022	Roscommon
1332	Lecarrow Canal	Lecarrow	M9715055500	Roscommon
1333	River Suck	Cloondacarra Bridge	M6710378022	Roscommon
1334	River Shannon	Roosky	N0539787001	Roscommon
1335	River Scramogue	Carrowclogher	M9290678076	Roscommon
1336	Bleach River	Flagmount	R5555094900	Clare
1337	River Lee (Kerry)	Tralee Town	Q8377313711	Kerry
1338	Royal Canal	46th Lock	N0628875709	Longford
1339	River Shannon	Tharmonbarry	N0550076950	Roscommon
1340	Gageborough River	Ballyboughlin Bridge	N2369933776	Offaly
1341	Royal Canal	Scally's Bridge	N2300660012	Longford
1342	Mulkear River	Abington	R7157653428	Limerick
1343	Royal Canal	Ashtown Station	O1099137417	Dublin
1344	Royal Canal	Louisa Bridge	N9938336522	Kildare
1345	Butlerstown River	Glyntown Bridge	W7325075000	Cork
1346	Leannan River	Claragh Bridge	C2045020300	Donegal
1347	River Shannon	Bigmeadow, Athlone	N0391740202	Roscommon

1348	Glencree River	Wooden Bridge	O1920014700	Wicklow
1349	Killeenagarrif River	Barrington's Bridge	R6789054928	Limerick
1350	Unknown River	Castle Bridge, Baldwinstown	S9705010250	Wexford
1351	River Nore	Limaine Bridge	S4410566004	Kilkenny
1352	Dinin River	Corelttstown	S5060066200	Kilkenny
1353	River Boyne	Bellewstown	N7620055800	Meath
1354	Woodford River	George Mitchell Peace Bridge	H3395819357	Fermanagh
1355	River Erne	Erne Bridge, Belturbet	H3611317085	Cavan
1356	River Boyne	Obelisk Bridge	O04523762000	Louth
1357	River Boyne	New Bridge, Drogheda	O08426751139	Louth
1358	River Bonet	Drumlease Fileds	G8184830233	Leitrim
1359	River Blackwater (U)	Favour Royal Bridge	H6123452989	Tyrone
1360	Colebrook River	Ashbrook	H3914144098	Fermanagh
1361	Owenboy River (Mun)	Bealahareach Bridge	W6843063254	Cork
1362	Bann (Newry) Canal	Campbell's Lock	J0635845059	Down
1363	River Coyle	Stoneyford	J5822548840	Down
1364	Unknown River	Whitehouse, Ballymagrorthy	C3992118750	Derry
1365	Unshin River	Union Wood, Colloney	G6859126898	Sligo
1366	Grand Canal	Belmount	N0735921944	Offaly
1367	River Eske	Donegal Town	G9285878608	Donegal
1368	Maine River	Maine Bridge	Q8913104839	Kerry
1369	River Robe	Ballinarobe Town	M1903264544	Mayo
1370	Owenglin River	Andbear Old Bridge, Clifden	L6604250386	Galway
1371	River Nanny	Bellewstown Bridge	O0858069615	Meath
1372	Castletown River	Cort Rd Bridge	J0067009893	Louth
1373	Cashen River	Ferry Bridge	Q8908736537	Kerry
1374	Vartry River	Devils Glen	T2310098900	Wicklow
1375	River Boyne	Scurlockstown Bridge	N8158956837	Meath
1376	Newport River	Newport Town	L9900094000	Mayo
1377	River Bandon	Inisshannon Bridge	W5413057125	Cork
1378	Ballinderry River	Kildress AC	H7730078400	Tyrone
1379	Royal Canal	Atchies Bridge	N1370058000	Longford
1380	Slate River	Bridge Street, Rathangan	N6731119316	Kildare
1381	River Liffey	Liffey Park, Clane	N8794627057	Kildare
1382	Leemara River	Leemara Wood	W8426976970	Cork
1383	Lerr River	Gotham Bridge	S7262082181	Carlow
1384	Ballinderry River	Cabinwood	H8160076500	Tyrone
1385	Killymoon River	Tullylagan Manor	H8026473103	Tyrone
1386	River Barrow	Maganey Bridge	S7169384727	Carlow
1387	River Barrow	Barrow Track, Carlow	S7162776701	Carlow
1388	Crumlin River	Lennymore Blue Bridge	J1188875225	Antrim
1389	River Maigue	Ballycasey, Kildimo	R4690050600	Limerick
1390	River Barrow	Slyguff Townland	S6860057400	Carlow
1391	Ballinderry River	Scotstown Road	H9440080600	Tyrone

1392	River Barrow	Milford Bridge	S6970067100	Carlow
1393	Lagan Canal	Broadwater	J1488162783	Antrim
1394	Dungourney River	Bilberry	W9275875314	Cork
1395	Royal Canal	Jackson's Bridge	N9180037600	Kildare
1396	Lagan Canal	Gilchrest Bridge	J3172968037	Antrim
1397	Shournagh River	Shournagh Cross Roads	W5924375350	Cork
1398	River Slaney	Tullow Bridge	S8490072200	Carlow
1399	River Cloughmore	Palmerstown	G1726931449	Mayo
1400	Owenmore River (Mayo)	Bangor Erris Village	F8625922862	Mayo
1401	Deel River	Deelcastle Townland	G1789218885	Mayo
1402	Allow River	Kilberrihert Metal Bridge	R3950411839	Cork
1403	Glasswater River	Glasswater Townland	J4495054050	Down
1404	River Barrow	Barrow Br, Portarlington	N5400012700	Offaly
1405	Owenmore River (Mayo)	Bellacorick Bridge	F9697119955	Mayo
1406	River Barrow	Clogrennan Bridge	S6980073700	Carlow
1407	Sixmile Water	Dunadry Rd, Muckmore	J2003384969	Antrim
1408	River Barrow	Leighlin Bridge	S6905065450	Carlow
1409	River Barrow	Rathvinden Lock	S6947866368	Carlow
1410	Shimna River	Tollymore Forest	J3274631954	Down
1411	Ballinderry River	Coagh Village	H8907178711	Tyrone
1412	Ballinderry River	Artrea Canoe Steps	H8609076900	Tyrone
1413	Rye Water	Carton Estate	N9590038100	Kildare
1414	River Boyne	Scariff Bridge	N7338252679	Meath
1415	Kilcrow River	Ballyshrule Bridge	M7981505669	Galway
1416	Bandon River	Dunmanway	W2418053020	Cork
1417	Shannon Erne Waterway Canal	Ballyduff Bridge	H0959810845	Leitrim
1418	River Slaney	Rathvilly Bridge	S8771982181	Carlow
1419	Grand Canal	Pluckerstown	N7476220994	Kildare
1420	Dooyertha River	Clougharevaun Bridge	M5805924175	Galway
1421	Unknown River	Lisduff Townland	M6431220387	Galway
1422	Grand Canal	Killeen Bridge, Daigean	N4906528959	Offaly
1423	Camcor River	Springfield Bridge, Birr	N0803704641	Offaly
1424	Laune River	Biannconi Car Park	V7790296413	Kerry
1425	River Blackwater (M)	Killavullen Bridge	W6477299756	Cork
1426	Shimna River	Islands Park, Newcastle	J3713531546	Down
1427	Royal Supply Canal	Castlepollard Canal Bridge	N4350054500	Westmeath
1428	Grand Canal	Lock 34, McCartney Aqueduct	N0459519599	Offaly
1429	River Funshion	Killee Bridge	R7791912600	Cork
1430	River Moy	Banda	G4653310022	Sligo
1431	Bonet River	Cornstauk Bridge	G8714538932	Leitrim
1432	River Shannon	Drumsna Bridge	M9930597267	Leitrim
1433	Boor River	Kilgarvan Glebe Townland	N0830034900	Westmeath
1434	Castle Lough River	Castle Lough River	N6570398032	Cavan
1435	Maigue River	Croom Town Centre	R5114041333	Limerick

1436	River Nanny	Annesbrook, Duleek	O0355565525	Meath
1437	Grand Canal	12th Lock, Lucan Road Br	O0298032236	Dublin
1438	Tunny Cut Channel	Tunny Cut	J0990670338	Antrim
1439	Cromogue River	Monroe, Bouladuff	S0507962531	Tipperary
1440	Owenbeg River (Conn)	Kilnamonagh	G6527725618	Sligo
1441	Wee River	Madabawn Bridge	H6412209474	Cavan
1442	Rostrevor River	Rostrevor	J1799818300	Antrim
1443	Grand Canal	Lock 26 to 27, Tullamore	N3565925606	Offaly
1444	River Sillees	Derryconnelly	H1220051900	Fermanagh
1445	River Slaney	Glen of Imaal	S9391294311	Wicklow
1446	Royal Canal	Kildallan Bridge	N3433656445	Westmeath
1447	Royal Canal	Shondonagh Bridge	N3695652656	Westmeath
1448	Royal Canal	Baltrasna Bridge	N4718051300	Westmeath
1449	Deenagh River	Killarney National Park	V9473490149	Kerry
1450	Upper Caragh River	Blackstones Bridge	V7096486387	Kerry
1451	Leannan River	Dromore Bridge	C1244417620	Donegal
1452	River Suir	Holycross Village	S0903754106	Tipperary
1453	Jamestown Canal	Canal Tow Path	M9884595891	Roscommon
1454	Stoneyford River	Knockcairn Bridge	J1961073809	Antrim
1455	Crumlin River	Crumlin Glen	J1546976449	Antrim
1456	River Corrib	NUIGalway Playing Fields	M2872327513	Galway
1457	River Deele (M)	Deel Bridge, Rathkeale	R3608041430	Limerick
1458	Glendasan River	Glendasan Valley	T1190097200	Wicklow
1459	River Owenmore (Kerry)	Slievadrehid	Q5131310748	Kerry
1460	Ulster Canal	Tom Young's Wood	H6574933103	Monaghan
1461	River Stick	Blegooly Village	W6638853702	Cork
1462	Dungourney River	Middleton Heritage Centre	W8846673397	Cork
1463	Owenacurra River	Cork Bridge, Midleton	W8792573797	Cork
1464	Poll na Carraighe Dubh	River Ilen	W1281847400	Cork
1465	Manch Estate, Dunmanway	Bandon River	W3017652606	Cork
1466	Grand Canal	Portobello, Dublin	O1568532465	Dublin
1467	River Faughan	Drumahoe A6 Road Bridge	C4604414749	Derry
1468	Royal Canal	Moyvalley Bridge	N7205642641	Kildare
1469	River Burren	Mill Race, Carlow Town	S7210476508	Carlow
1470	Royal Canal	Fowlards Bridge	N1790059300	Longford
1471	Royal Canal	Cope Bridge, Leixlip	O0086737048	Kildare
1472	River Shannon	Jamestown	M9791397804	Leitrim
1473	River Blackwater (Waterford)	Castleislands, Lismore	X0400099000	Waterford
1474	Royal Canal	The Downs, Kinnegad	N5008550707	Westmeath
1475	Stoneyford River	Coxtown	N6380061678	Westmeath
1476	Royal Canal	Coolnahinch Bridge	N1091464635	Longford
1477	River Barrow	Bestfield Lock Gates	S7170079284	Carlow
1478	Grand Canal	Sallins Village Centre	N8913022897	Kildare
1479	Chimneyfield River (River Bridde Trib)	Forge Brdge (Chimneyfield Townland)	W6864990798	Cork

1480	Fergus River	Ennis Town Center	R3387377672	Clare
1481	River Clodiagh	Portlaw Bridge	S4678915054	Waterford
1482	Glenshesk River	Magheratemple Townland	D1305039800	Antrim
1483	Burntollet River	Ervey, Ness Wood	C5298211754	Derry
1484	Grand Canal	Oberstown (M7 Bridge)	N8862121718	Kildare
1485	Grand Canal	Rathangan Bridge	N6740019300	Kildare
1486	River Blackwater (U)	Deerpark Woodlands, Virginia	N5906587611	Cavan
1487	Anner River	Grangebeg Townland, Fethard	S2465429819	Tipperary
1488	Grand Canal	Bord Na Mona Factory Bridge, Lullymore	N7148129283	Kildare
1489	Bawnaknockane River	Ballydehob	V9903335463	Cork
1490	Royal Canal	Dolan Bridge (Coolnahay Harbour)	N3530253977	Westmeath
1491	River Blackwater (U)	The Argory	H8725658553	Armagh
1492	River Dodder	Rathfarnham Road (R114) Bridge	O1447529666	Dublin
1493	Sixmile Water	Summerhill Mill Section (Antrim Town)	J1836185182	Antrim
1494	Manulla River	Laghtavarry, Ballyvarry (M5)	M2305094224	Mayo
1495	Clare River	Curraghmore Bridge (N84)	M3216532853	Galway
1496	River Blackwater (Monaghan)	Ballinode Village	H6291735826	Monaghan
1497	Woodford (Aughty) River	Clonco Townland (R135)	R7641698963	Galway
1498	River Barrow	Goresbridge Town	S6841853711	Kilkenny
1499	Curragheen River	Murphy's Farm (Bishopstown))	W6200070000	Cork
1500	Finn River	Magherarny Village, Monaghan	H5788029835	Monaghan
1501	Bredagh River	Gulladuff, Moville	C6098938305	Donegal
1502	Swilly River	Milk Isle, Letterkenny (N14)	C1827811248	Donegal
1503	Owenmore River	Ardcree Bridge, SE Coolaney	G6403822638	Sligo
1504	Tolka River	Griffith Park to Drumcondra Park	O1618736725	Dublin
1505	Crolly (Gweedore) River	Crolly Bridge (NW of N56)	B8327919666	Donegal
1506	Skeoge River	Inch Widlfowl Reserve	C3500023000	Donegal
1507	Barrow Way Canal	Ballyteige Bridge	N7535124196	Kildare
1508	Castlegar River	Canavans Bridge, Mountbellew	M6671846784	Galway
1509	River Maigue	Adare Bridge, Adare Town	R4688946639	Limerick
1510	Glenaniff River	R281 Bridge, Rossinver	G9202149672	Leitrim
1511	Eany Water	Ballymacahill Bridge	G8407481394	Donegal
1512	River Liffey	Castletown Estate	N9920434119	Kildare
1513	Grand Canal	Clogheen Bridge 5th Monasteravin	N6201409766	Kildare
1514	Owenkeagh River	Mounteen Townland, Ballinascarthy	W4406446880	Cork
1515	Bessbrook River	Carrigmore Viaduct, Bessbrook	J0659928366	Armagh
1516	River Nore	Tallyho Bridge, SE Durrow	S4235776207	Laois
1517	Bann (Newry) Canal	PontzyPass, Nth Newry	J0608639391	Armagh
1518	Leannan River	Ramelton Town Centre	C2280421180	Donegal
1519	Slate River	Drumsru Townland, Rathangan	N7252023529	Kildare
1520	Inny River	Float Bridge, Coole	N3924672511	Westmeath
1521	River Lagan	Governor's Bridge, Belfast	J3385471602	Antrim
1522	Dungolman / Tang River	Galliaghstown	N1765552058	Westmeath

1523	Tributary of River Inny	Ballymacartan Townland (L5344)	N2423352547	Westmeath
1524	River Blackwater (Wexford)	Mooeny's Fields (East of Blackwater)	T1312033302	Wexford
1525	River Finn	R235 Road Bridge, Castlefinn	H2627594550	Donegal
1526	Broadmeadow River	Fieldstown (R122), Rolestown	O1174450227	Dublin
1527	Torrent River	Reenaderny Road Bridge	H8821962848	Tyrone
1528	River Lagan	Ballynaris Hill (W of Dunmore)	J1804153425	Down
1529	River Lagan	Tullynacross Rd Bridge (Lisburn)	J2795366242	Antrim
1530	Bilboa River	Blackboy Bridge	R7986551553	Limerick
1531	Bilboa River	Bilboa Bridge	R8156251902	Limerick
1532	Boyne Canal	Ramparts Foot Bridge	N8744767932	Meath
1533	Killaloe Canal	Killaloe Town Centre	R6980073300	Clare
1534	Nenagh River	Kylerarr Bridge, Lower Bir Road	R8735579977	Tipperary
1535	Carrowbeg River	East of Viaduct, Westport	M0036684399	Mayo
1536	Francis River	Castlerea Town Park	M6764879937	Roscommon
1537	Muckanagh River	Knockbaun R312 Rd Bridge	M0733496687	Mayo
1538	Ballinamore Canal	Crossycarwill Bridge	G9754905176	Leitrim
1539	Lissan Water	Lissan House, Cookstown	H7943782418	Tyrone
1540	Ballinderry River	Wellbrook Bridge, Cookstown	H7497179095	Tyrone
1541	Owenduff River	Srahboy Confluence (Shean Lodge)	F8450011200	Mayo
1542	Owvane River	Carriganass Bridge (R584)	W0484656566	Cork
1543	Ballymoney River	Riverside park, Ballymoney	C9550025700	Antrim
1544	River Shannon	Railway Bridge, Athlone	N0350041900	Westmeath
1545	River Foyle	Sainsbury, Strand Rd, Derry	C4384518292	Derry
1546	Derryhippo River	Cregg Village Walkway	M7630660204	Galway
1547	Ballinderry Upper River	Baroney Road (West of Cookstown)	H6564279066	Tyrone
1548	Glenamoy River	Glenamoy Bridge (R314)	F8931333817	Mayo
1549	Ilen River	Bridge by West Cork Hotel	W1185933916	Cork
1550	River Lee	Angler's Rest, Bandon	W6086671777	Cork
1551	River Liffey	Liffey Linear Park, Newbridge	N8060015400	Kildare
1552	Grand Canal	Lock 32 (Noggus)	N1045722884	Offaly
1553	Nenagh River	Ballyartella Bridge, Ballycommon	R8392783443	Tipperary
1554	Gageborough River	Train Station Field, Horseleap	N2789138297	Westmeath
1555	Ballinderry Upper River	Aughlish Townland	H7870978151	Tyrone
1556	River Dall	Cushendall Town Centre Bridge	D2367927620	Antrim
1557	Fane River	Blackstaff (Bridge on L3119)	H9079009691	Monaghan
1558	Inny River	Finea Village	N3952181091	Westmeath
1559	Ballinamore Canal	Ballinamore Town	H1273211448	Leitrim
1560	Canal Bank Plassey Walk	Lough Derg Way, Limerick City	R5967457917	Limerick
1561	River Glennafallid	Glenshelane River Walk	X1189799298	Waterford
1562	River Bann	Fisherman's Walk, Portglenone	C9789902575	Antrim
1563	Colligan River	Killadangan Bridge, Killadangan	X2321396144	Waterford
1564	Clare River	Milltown Bridge, Milltown Village	M4054362970	Galway
1565	Curracloe Channel	Curracloe North Slob	T1064824655	Wexford
1566	Triogue River	Portlaoise South Central	S4720098633	Laois

1567	River Blackwater (Waterford)	Kitchen Hole to Huthole (N72)	X0863799736	Waterford
1568	River Barrow	Athy Railway Bridge	S6823793403	Kildare
1569	Grand Canal	Dolphins Barn, Dublin	O1374132659	Dublin
1570	Lixnaw Canal & River Brick	Cunnigar Townland	Q8898328977	Kerry
1571	River Shannon	Universtiy of Limerick	R6102158685	Limerick
1572	Black River	Shrule Village	M2799452633	Mayo
1573	River Shannon	Castleconnel (Castleoaks Hotel)	R6545362174	Limerick
1574	Bawnboy River	Bawnboy Bridge (Keepers Inn)	H2114719111	Cavan
1575	Bunowen River	Louisburgh Town Centre	L8067880692	Mayo
1576	River Mahon	Main Street Bridge, Kilmacthomas	S3934806187	Waterford
1577	Arra River	Cullinaghmore Bridge, Newcastle West	R2721233792	Limerick
1578	River Mock	Duncormick Bridge	S9177109309	Wexford
1579	Tributary of River Corock	Wellintonbridge, Wexford	S8523213601	Wexford
1580	River Shannon	Lanesborough Town Centre	N0049269385	Roscommon
1581	Aherlow River	Ballyhoura Way	R8111627792	Limerick
1582	River Shannon	World's End, Castleconnell	R6587763590	Limerick
1583	Creegh River	Creegh Bridge	R0343266877	Clare
1584	Ward River	Wards River Valley Park, Swords	O1769346634	Dublin
1585	River Sullane	Sullane Macroom Town Park	W3295072620	Cork
1586	The Loobagh	North Bridge, Kilmallock	R6065028442	Limerick
1587	Grand Canal	29th Lock, Tullamore	N2976125234	Offaly
1588	The Loobagh	Deebert Bridge (R515), Kilmallock	R6125727758	Limerick
1589	Owvane River	Perason's Bridge	W0231554545	Cork
1590	Figile River	Clonbullogue Bridge	N6091923513	Offaly
1591	River Morningstar	Bruff Village, Limerick	R6266835993	Limerick
1592	Headrace Canal	Blackwater Bridge, Ardnacrusa (R463)	R5928761868	Clare
1593	Keale River	Darragh Bridge, Kilfinane	R7230517505	Limerick
1594	Owendoher River	Ballyboden Road, Dublin	O1420028400	Dublin
1595	River Lee	Carrigohane (Beyond Lee Fields)	W6316371800	Cork
1596	Grand Canal	Ballycommon	N4239025893	Offaly
1597	River Dodder	Herbert Park, Ballsbridge	O1788032428	Dublin
1598	River Bride	U/S from Comerboy Bridge (Mass Rock)	W6771490589	Cork
1599	River Lee	Cork City Centre	W6748172150	Cork
1600	Royal Canal	Phibsboro (Dublin)	O1509736264	Dublin
1601	River Clady / Knockoneill	Dunglady Bridge (Drumbolg Road)	C8951003749	Derry
1602	River Erne	Enniskillen Castle	H2336443794	Fermanagh
1603	Bann (Newry) Canal	Lock 9 (A27 Road)	J0726031245	Armagh
1604	Cong (Corrib) River	Cong Village	M1461455322	Mayo
1605	River Deele (M)	Akeaton Town	R3406950336	Limerick
1606	Dromore River	Peace Bridge, Ballybay	H7162420462	Monaghan
1607	Callan River	Tassagh (Keady)	H8683637171	Armagh
1608	Wood River	Vandeleur Woods (Kilrush)	Q9976954880	Clare
1609	Tributary of Dromore River	Doohamlet GFC	H7669121049	Monaghan

1610	Tributary of Dromore River	Doohamlet Community Centre	H7636720372	Monaghan
1611	Slate River	Ferrycarrig (N11)	T0148023145	Wexford
1612	Newtownards Canal	Newtownards Road Bridge	J4886873661	Down
1613	Casla River	Off Furnace Rd R336	L9783427223	Galway
1614	Larganess River	Florence Court	H1724634087	Fermanagh
1615	Unknown River, Barnynagappul Strand	Tonatanvally, Achill	F6966908522	Mayo
1616	Royal Canal	Coralstown	N5478749802	Westmeath
1617	Grand Canal	Naas Golf Course	N9003223197	Kildare
1618	Inagh River	Ennistymon River Walk	R1301088362	Clare
1619	Fairy Water	Upstream of Priest's Bridge	H3671677324	Tyrone
1620	River Cromoge	Inch House Loop Walk	S0482363421	Tipperary
1621	River Finnow	Licahane Rd (R582), Millstreet	W2745788981	Cork
1622	Ballymahatty River	Camphill Community River Walk	H4104967604	Tyrone
1623	River Lee	Bandon Town Centre	W4922955102	Cork
1624	River Dodder	Templeougue Bridge (Sth R137)	O1215228204	Dublin
1625	River Suir	R671 Road Bridge (Clonmel)	S1930022048	Tipperary
1626	Unshin River	Lisconny Bridge (Sligo)	G6974422900	Sligo
1627	Caher River	Caher Lower, Fanore Bridge (Fanore)	M1447908950	Clare
1628	River Blackwater (Kerry)	R582 Road Bridge (Nth of Rathmore)	W1724094307	Kerry
1629	Three Trouts River	Three Trouts Bridge (R761)	O2888510486	Wicklow
1630	River in Birr Castle Gardens	Birr Castle Gardens	N0538904968	Offaly
1631	Grand Canal	Grand Canal at Inchicore (Dublin)	O1085932713	Dublin
1632	River Liffey	Waterstown Park (Strawberry Fields)	O0848135923	Dublin
1633	River Mourne	Sion Mills Mourneside Walk	H3462793208	Tyrone
1634	Burn Dennet	Bridge on Duncastle Road	C4293504396	Tyrone
1635	Owenbeg River (Conn)	Coolaney River Walk	G6073925310	Sligo
1636	River Faughan	Brackfield Wood (Glenshane Rd)	C5090509606	Derry
1637	Argidean River	Ballinroher Townland Footbridge	W4244744599	Cork
1638	River Dodder	St. Lukes Hospital	O1552229787	Dublin
1639	Paulnasharry Bay	Poulnasharry Bay (N67 Bridge)	Q9594858532	Clare
1640	Inver Bridge (N56)	Eany River	G8213778486	Donegal
1641	River Suck	Ballinasloe Harbour	M8547930957	Galway
1642	Glen River	Father Murphys Bridge	W3916195872	Cork

Appendix 3 Brown Long-eared Roost Monitoring Scheme

Preliminary Roost Assessment - Methodology

All new roosts, when first considered for inclusion in the monitoring scheme, were assessed by completing a daytime check of the building. This involved a survey of the roof space and when the building was accessible, safe, and brown long-eared droppings or actual brown long-eared bats were observed, then a preliminary assessment was undertaken. The preliminary assessment involved surveying the building by using at least two of the methods listed in Table A3.1 below. Once a site was deemed suitable for inclusion in the scheme (i.e. more than eight individuals were present and it was possible to safely count bats at the site by watching emerging bats or by entering the roof space), monitoring was then completed year-on-year using the most suitable method with an aim of counting the colony at each roost twice per year.

Table A3.1: Methods of assessing the most suitable protocol for counting brown long-eared bats at each roost. The assessment is carried out using at least two of Methods A-C below. Dates for surveying: Survey 1 1st May to June 15th, Survey 2 June 16th to July 31st, Survey 3 August 1st to 31st August.

	Method A	**Method B**	**Method C**
Description	Interior daytime count	Emergence Dusk Count	Interior Post Emergence Count
No. of counts per season	2	2 or 3	2 (usually in conjunction with Method B)
Dates when counts can be conducted	Survey Period1 & Survey Period 3	Survey Period 1 (preferred), Period 2 and Period 3 (preferred)	Survey Period 1 & Survey Period 3
Surveyor	Licensed	Licence not necessary	Licensed
Method	Count of bats present in roost.	Surveyors present at all known exit points, surveying starts 20 minutes after sunset. Count in 10min blocks. Count for 60mins or stop when no bats emerge for 10mins. Note if bats are seen or just heard. Direction of flight also noted.	Enter roost at start and end of emergence. Count bats present on both occasions. Numbers of bats before and after emergence are compared with total observed emerging.
Equipment	Red-light torch	Bat detector and red-light torch	Red-light torch
Other recorded details	Internal roof details, dimensions, presence of roof felt etc.	Weather conditions.	Weather conditions
Other info	Dead bats collected	Fine weather survey only.	Only undertaken in buildings with safe access in hours of darkness.

Table A3.2 Locations of Brown Long-eared Roost Monitoring Sites recommended for next monitoring period.

Code	Name	Grid Reference	Survey Type
2001	Kilmore Cathedral, Co. Cavan	H3840003547	Internal
2003	St. Kevin's Kitchen, Co. Wicklow	T1225996784	Emergence
2005	Private Residence, Timoleague, Co. Cork	W4672144156	Internal
2006	Private Residence, Currabinny, Co. Cork	W7985461938	Emergence
2009	Glenealy Catholic Church, Co. Wicklow	T2486692334	Emergence
2010	Ardgillan Castle, Co. Dublin	O2188861214	Emergence
2012	Lydacan Castle, Gort, CO. Galway	M4374507999	Emergence
2013	Church of Ireland, Ennistage, Co. Kilkenny	S5249648995	Emergence
2014	Church of Ireland, Clone, Co. Wexford	T0051943249	Emergence
2016	Private Residence, Rathkeale, Co. Limerick	R3967039242	To be reassessed
2019	Church of Ireland, Tomregan, Co. Cavan	H2699018836	Internal
2022	Private Residence, Pearson's Bridge, Co. Cork	W0217455591	Emergence
2023	Private Residence, Glengarriff, Co. Cork	V9102357423	Internal
2024	Catholic Church, Bantry, Co. Cork	V9988748189	Emergence
2027	Private Residence, Dunmanway, Co. Cork	W2358754713	Emergence
2029	Agricultural Building, Co. Wexford	T0265033650	To be reassessed
2035	Catholic Church, Inagh, Co. Clare	R2083081244	Emergence
2038	Church of Ireland, Portlaw, Co. Waterford	S465153	Emergence
2039	Church of Ireland, Kilmeadan, Co. Waterford	S516109	Emergence
2045	Emo Court, Co. Laois	N5376306596	Internal
2055	Private Residence, Kells, Co. Kilkenny	S4992842667	Emergence
2062	Clonfert Cathedral, Co. Galway	M9615021150	Emergence
2063	Church of Ireland, Ballycormack, Co. Longfrod	N116710	Emergence
2064	Church of Ireland, Horetown, Co. Wexford	S8751719690	To be reassessed
2065	Church of Ireland, Swanlinbar, Co. Cavan	H1922627024	Emergence
2066	Catholic Church, Baileboro, Co. Cavan	H6159401409	Emergence
2067	Catholic Church, Riverstown, Co. Sligo	G7411719996	Emergence
2072	Church of Ireland, Crohan, Co. Tipperary	S2783045640	Emergence
2086	Catholic Church, Peterswell, Galway	M507069	To be reassessed
2090	Church of Ireland, Screen, Co. Sligo	G524326	Internal
2100	Private Building, Cloughballymore, Co. Galway	M3977514075	Emergence
2101	Private Residence, Castlebar, Co. Mayo	M1895882258	Internal
2116	Private Residence, Castlebaldwin, Co. Sligo	G7629316392	Emergence
2119	Private Residence, Virginia, Co. Cavan	N6705181641	To be reassessed
2120	Private Building, Milltown, Co. Cavan	H3425913074	Internal
2122	Private Residence, Ballydehob, Co. Cork	V9870038800	Emergence
2123	Church of Ireland, Ardmore, Co. Waterford	X1888977468	Emergence
2124	Church of Ireland, Dunamon, Co. Roscommon	M7900664687	Emergence
2125	St Patrick's Church of Ireland, Powerscourt, Co. Wicklow	O2239517047	Emergence
2128	Private Building, Ballynabrock, Co. Wicklow	O0960012900	Emergence
2129	Ardbraccan Church, Navan, Co. Meath	N8283668243	Emergence
2130	Clogharinka Catholic Church, Co. Kildare	N6550039200	Emergence
2131	Nuns Cross Church of Ireland, Ashford, Co. Wicklow	T2577597975	Emergence
2132	Killymard Old Roman Catholic Church, Co. Donegal	G9339480438	Emergence
2133	Drung Roman Catholic Church, Co. Cavan	H5086510577	Emergence
2135	Private Building, Letterfrack, Co. Galway	L7105857545	Emergence
2136	Raheen Community Hospital, Raheen, Co. Clare	R6586982667	Emergence
2137	Private Building, Gort, Co. Galway	M4810206109	Emergence
2138	Bellinode Church of Ireland, Bellinode, Co. Monaghan	H6263435639	Emergence

Relationship between Brown Long-eared Bat Roost Counts and Various Factors

(This relates to analysis completed for Section 4.2.6)

R Output

```
Call:
glm(formula = Count ~ Habitat + Easting + Northing, family = poisson(),
    data = BLE)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-4.919  -2.352  -0.173   1.543   5.135

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  2.183e+00  3.101e-01   7.039 1.93e-12 ***
Habitat      8.338e-03  1.774e-03   4.701 2.59e-06 ***
Easting     -1.858e-07  3.814e-07  -0.487    0.626
Northing     1.687e-06  3.267e-07   5.163 2.43e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 298.40  on 43  degrees of freedom
Residual deviance: 262.63  on 40  degrees of freedom
AIC: 499.08

Number of Fisher Scoring iterations: 4
```