BATLAS 2020 Pilot Project

BATLAS 2020 Pilot Project Report (Nov 2015)

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Daubenton's bat
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An Roinn
Ealaíon, Oidhreachta agus Gaeltachta
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1. Executive Summary

In 2008, Bat Conservation Ireland initiated Ireland’s first systematic bat distribution recording scheme, BATLAS 2010. The distributions of four target species (common pipistrelle, soprano pipistrelle, Daubenton’s bat and Leisler’s bat) were mapped in 751 10km grid squares across the island (including 647 squares in the Republic of Ireland) using a standardised acoustic bat detector survey method. BATLAS 2010 acts as a baseline against which future distributional changes in these species can be measured, and Bat Conservation Ireland plans to repeat BATLAS surveys every decade.

In September 2015, BATLAS 2020 was kick-started with a Pilot Project where experienced surveyors trialled the proposed BATLAS 2020 methods. The proposed methodology is similar to that of BATLAS 2010, except that in addition to re-surveying the previous BATLAS 2010 sites, additional survey sites are selected in order to systematically survey each of the four 5km x 5km quadrants within a 10km x 10km square. As a consequence, this higher resolution data will provide more detailed distribution maps and will be compatible with the 5km resolution of Bat Conservation Ireland's Bat Landscape Model. The surveys will also help to eliminate gaps in survey coverage and give insight into potential changes in the distributions of the target bat species on the island. In addition to recording habitat types during BATLAS 2020, surveyors will also record information on artificial lighting and hedgerow types as these may influence bat activity.

A minimum of 50 10km squares to be surveyed for the four targeted bat species was set as the target for the 2015 BATLAS 2020 Pilot Project. Bat distribution maps at this early stage of the overall project were not a main objective given the limited and non-systematic survey coverage. Trialling of the new BATLAS 2020 methodology with volunteers, and exploring the data collected in preparation for BATLAS 2020 from 2016 onwards were the main objectives. Volunteers who were already confident in identifying the four target bat species using a bat detector were sought for participation in the 2015 BATLAS 2020 Pilot Project. Training of new volunteers to carry out BATLAS 2020 bat surveys will be part of the scheme in future years.

Forty-seven surveyors participated in the Pilot Project and conducted bat surveys at 548 survey sites in 68 10km squares throughout the island. 23.7% of the sites surveyed during the Pilot Project were previously surveyed during BATLAS 2010, and the remainder (76.3%) were new BATLAS 2020 sites. Fifty-four out of 68 10km squares were previously surveyed BATLAS 2010 10km squares and 14 were new 10km grid squares. 90.3% of the BATLAS 2010 sites in the re-surveyed BATLAS 10km squares were re-surveyed (130 BATLAS 2010 site re-surveys in total). Forty-one out of the 68 total 10km squares (60.3%) were surveyed fully in accordance with the BATLAS 2020 site selection protocol for 10km squares.

Soprano pipistrelle was the most widely detected species (62.0% of 548 sites and 82.3% out of 215 5km quadrants), followed by common pipistrelle (48.4% of 548 sites and 78.1% of 215 5km quadrants), Daubenton's bat (26.5%, 53.0%), and Leisler's bat was the least detected species (22.1%, 42.8%). At the 10km resolution, common pipistrelle was detected in more 10km squares than soprano pipistrelle (66 and 62 out of 68 surveyed 10km squares respectively).

The detection rate at the 10km square resolution of all target species was increased relative to BATLAS 2010 for the 54 10km squares that were re-surveyed, but this increase was statistically significant only for Daubenton's bat. The per-site detection rate of Leisler's bat was significantly lower than that of BATLAS 2010 for the 130 BATLAS 2010 survey sites that were re-surveyed during the Pilot Project, while the per-site detection rates of the other target species were similar between BATLAS 2010 and the 2015 BATLAS 2020 Pilot Project.

An exploration of the factors influencing the presence (or detection rate) of each of the target species using binomial generalised linear mixed models (GLMMs) indicated that the likelihood of detecting all species decreased with day number (date). GLMMs also indicated for example that artificial lighting influenced the detection of common pipistrelle and Leisler's bat, that Daubenton's bat and soprano pipistrelle had strong positive associations with watercourses and lakes/ponds, while soprano pipistrelle was negatively associated with coastal habitats. Common pipistrelle and Daubenton's bat were positively associated with woodland, but Daubenton's bat has a negative relationship with conifer plantation. None of the habitat types were significant factors for Leisler's bat, but it was more likely to be detected further east in the country. It is important not to read too much into the GLMM models produced from the relatively small Pilot Project dataset (548 survey sites with limited geographic coverage). However, the approach trialled during the Pilot is promising for producing useful insights from the much larger island-wide BATLAS 2020 dataset.

A high level of volunteer survey effort was involved in completing the proposed BATLAS 2020 surveys. Volunteers surveyed an average of 11.4 sites (median 12 survey sites), and spent an average of 3.2 survey evenings (median 3 evenings) in fully surveyed 10km squares. The methods stipulated that bat surveys at each site were to be carried out in suitable weather conditions preferably with temperatures above 8°C. Temperatures dropped fast in the evenings during the BATLAS 2020 Pilot Project and this contributed to the high number of evenings required to complete surveys according to the new BATLAS 2020 methodology. Difficulty in detecting Leisler's bat, relative to the other target species, in parts of the country (despite suitable weather conditions) increased the number of sites required to complete 10km squares. Both of these factors can be attributed to the late-season (post-September) timing of the Pilot Project.

The methodology trialled during the 2015 BATLAS 2020 Pilot Project appears broadly feasible for an island-wide roll out of BATLAS 2020. Key changes and recommendations include:

- An earlier deadline (late September) than BATLAS 2010 (November) for completion of bat surveys due to the reduced probability of detecting the target species later in the season.
- Reducing the maximum number of survey sites per 5km quadrant from three to two to substantially reduce volunteer survey effort while only slightly reducing species detection rates.
- Development of an online user-friendly data submission system before the roll out of BATLAS 2020.
- Clear guidance on selecting new BATLAS survey sites, as the sites chosen by volunteers during BATLAS 2020 will form the network of long-term monitoring points for future BATLAS surveys.
- Long-term repeatability of BATLAS 2020 surveys is a priority. Re-setting the baseline in some of the previous BATLAS 2010 10km squares is necessary where some sites are not suitable as part of the network of monitoring sites for some reason (e.g. sites which are not publicly accessible).
- Correction of location errors in the BATLAS 2010 dataset prior to BATLAS 2020 is necessary.
- Clear guidance on recording habitat types at survey sites.
- Additional waterway characterisation data to be recorded for each survey site.

Recruitment and training of new volunteers will be essential over the coming years for the successful completion of BATLAS 2020 as it is a more intensive survey than its predecessor. The enthusiasm of volunteers for Bat Conservation Ireland's BATLAS 2020 monitoring scheme is encouraging. The project offers an exciting opportunity not only to map island-wide bat distributions to a higher standard, but also to increase interest and knowledge about Irish bat species and bat field skills among enthusiastic 'citizen scientists' in the coming years.

2. Acknowledgements

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3. Background

3.1 The conservation status and legal protection of bats in Ireland

Bats are among the most highly protected mammals in Ireland. All bat species in Ireland and their breeding or resting places are legally protected under European (EU Habitats Directive) and national law (Irish Wildlife Acts 1976 - 2012). Under these laws, it is an offence to hunt or interfere with or destroy their breeding or resting places (roosts of all kinds), unless under statutory licence issued by the National Parks and Wildlife Service (NPWS).

There are nine confirmed resident bat species in Ireland; soprano pipistrelle *Pipistrellus pygmaeus*, common pipistrelle *Pipistrellus pipistrellus*, Nathusius' pipistrelle *Pipistrellus nathusii*, Leisler's bat *Nyctalus leisleri*, brown long-eared bat *Plecotus auritus*, lesser horseshoe bat *Rhinolophus hipposideros,* and three myotid species; Daubenton's bat *Myotis daubentonii*, Natterer's bat *Myotis nattereri*, and whiskered bat *Myotis mystacinus*. In addition, two bat species which may be vagrants from Britain or continental Europe have been found in Ireland. A Brandt's bat *Myotis brandtii* was discovered in County Wicklow in 2003, and a greater horseshoe bat *Rhinolophus ferrumequinum* was discovered in County Wexford in the winter of 2012-2013. No additional specimens of either species have been confirmed since.

All Irish bat species are listed in Annex IV of the EU Habitats Directive. Such species require strict legal protection, protecting both the animals and their habitats. One Irish bat species, the lesser horseshoe bat, is also listed on Annex II of the EU Habitats Directive. Annex II includes animal species of community interest whose conservation requires the designation of Special Areas of Conservation (SACs) because they are for example rare, vulnerable, endangered or endemic in Europe.

Article 11 of the European Habitats Directive requires member states to monitor all species listed in the Annexes of the Directive, and Article 17 obliges member states to report on the conservation status of those species on a six yearly cycle.

Assessing the national distribution of protected species is one of the key elements in evaluating and monitoring the conservation status of protected species, and this is a role filled by Bat Conservation Ireland's BATLAS project for some of our native bat species which are amenable to acoustic detection using bat detectors.

3.2 BATLAS 2010

In 2007, Bat Conservation Ireland devised BATLAS 2010, Ireland’s first systematic bat distribution recording scheme that followed a standardised methodology. The distributions of four target species

- common pipistrelle,
- soprano pipistrelle,
- Daubenton’s bat and
- Leisler’s bat

were mapped in 751 10km grid squares throughout the island, with 647 10km squares surveyed in the Republic of Ireland. The project was funded by the NPWS with assistance from the Heritage Council in 2008 and 2009 in the Republic of Ireland and in Northern Ireland in 2009 by the Northern Ireland Environment

Agency (NIEA). A report on the BATLAS 2010 project (Carden et al., 2010) is available on Bat Conservation Ireland's website at http://www.batconservationireland.org/wp-content/uploads/2013/09/BATLAS2010_FinalReport.pdf

The BATLAS 2010 project was an attempt to circumvent the inherent biases in opportunistic recording of bats that had been carried out by various mean of surveying up to 2007 (Carden et al., 2010). Furthermore, the common pipistrelle and soprano pipistrelle had not yet been recognised as separate species in Europe at the time of a national bat roost survey in the Republic of Ireland carried out in the 1980s by the NPWS (O'Sullivan, 1994). The soprano pipistrelle and the common pipistrelle occur sympatrically across much of Europe but are morphologically almost indistinguishable. Although differences in echolocation call characteristics had suggested separate species (Jones & van Parijs, 1993), it was not until the late 1990s that their status as separate species was definitively established through genetic testing (Barratt *et al.*, 1997).

The four target bat species for BATLAS were selected because they are easily detected and distinguished from each other acoustically and relatively simple to identify in the field using tuneable heterodyne bat detectors. Their echolocation calls are relatively loud and distinctive as heard on a bat detector. Other bat species such as the brown long-eared bat, for example, has echolocation calls which are usually very quiet and therefore quite difficult to detect acoustically. Indeed the brown long-eared bat sometimes flies and forages without producing echolocation calls at all due to its ability to listen for the slightest of rustling or fluttering sounds produced by its prey using its very large ears (Anderson & Racey, 1993).

The BATLAS 2010 survey showed that the soprano pipistrelle is the most widely distributed species on the island. The common pipistrelle may be equally or even more common but it was not detected from some parts of the extreme north and west. A lack of detector records for many species from coastal areas of the north and west of Ireland suggested a low occurrence rate or even absence from these areas. Leisler's bat and Daubenton's bat were also widespread species but had a more localised distribution (Carden et al., 2010).

The BATLAS 2010 project vastly increased the number of records on the Bat Conservation Ireland database for the target species. These data have been made publicly available through the online database of the National Biodiversity Data Centre. BATLAS 2010 acts as a baseline against which future distributional changes in these species can be measured.

3.3 Piloting BATLAS 2020

While BATLAS 2010 was a remarkable improvement in our knowledge of bat species distributions, some gaps in survey coverage remain, and Bat Conservation Ireland intends to not only re-map previously mapped 10km squares in more detail, but also to fill gaps in coverage in the present BATLAS survey.

In September 2015, BATLAS 2020 was kick-started with a Pilot Project where experienced surveyors trialled the proposed BATLAS 2020 methods. Surveys were similar to those of BATLAS 2010, except that each of the four 5km x 5km quadrants within 10km x 10km squares were surveyed systematically, and included re-surveys of all previous BATLAS 2010 sites. The higher resolution data will provide more detailed distribution maps and will be compatible with the 5km resolution of Bat Conservation Ireland's Bat Landscape Model (Lundy et al., 2011). The surveys will also help to eliminate gaps in survey coverage and give insight into potential changes in the distributions of the target bat species on the island.

A minimum of 50 10km squares in the Republic of Ireland to be surveyed for the four targeted species was set as the target for the 2015 BATLAS 2020 Pilot Project. Trialling of the new BATLAS 2020 survey methodology with volunteers, improving survey coverage, and exploring the field data collected by volunteers (e.g. habitat data) were the main objectives. Volunteers who were already confident in identifying the four target bat species using a bat detector were sought for participation in the BATLAS 2020 Pilot Project. Training of new volunteers to carry out BATLAS 2020 bat surveys will be part of the scheme in future years.

Additional site data on hedgerows and artificial lighting

A new addition to the proposed BATLAS 2020 survey method includes recording information on artificial lighting and hedgerow types as these may influence bat activity. Using the data collated by the All Ireland Daubenton's Bat Waterway Survey, Aughney et al. 2014 found that Daubenton's bats were 11.4% less likely to occur at waterway survey spots if street lights were present. Therefore such data collected by BATLAS 2020 surveyors can be tested to see if these factors are having a discernible effect on the detection on any of the target bat species.

4. Methods

4.1 Timing of the pilot project

The BATLAS 2020 Pilot Project commenced in September 2015. A target of surveys in 50 10km squares located anywhere in the Republic of Ireland was set for the Pilot, to be carried out by volunteers and the Pilot Project Co-ordinator. The deadline for completion of bat surveys was 22 October 2015.

4.2 Volunteer surveyors

Surveyors who were already confident in identifying the four target bat species (common pipistrelle, soprano pipistrelle, Daubenton's bat, and Leisler's bat) using bat detectors were sought for the BATLAS 2020 Pilot Project. The majority of the surveyors had their own acoustic bat detector equipment.

Potential surveyors were contacted through Bat Conservation Ireland's current email list, and included volunteers who had previously participated in the Irish Bat Monitoring Programme such as BATLAS 2010 (Carden et al., 2011) and the All Ireland Daubenton's Bat Waterways Survey (Aughney et al., 2012). Volunteers were also reached through word of mouth and social media, including a new BATLAS 2020 Facebook webpage (www.facebook.com/batlas2020) and Bat Conservation Ireland's twitter account (twitter.com/BatConservIre). A new BATLAS 2020 email account was also set up as a point of contact with the Pilot Project Co-ordinator (batlas@batconservationireland.org).

4.3 Assigning 10km grid squares

Volunteers were assigned a 10km grid square which was convenient for them to survey, and which had not already been allocated to another surveyor. Survey squares could be either previously surveyed BATLAS 2010 10km squares or new BATLAS 2020 10km squares.

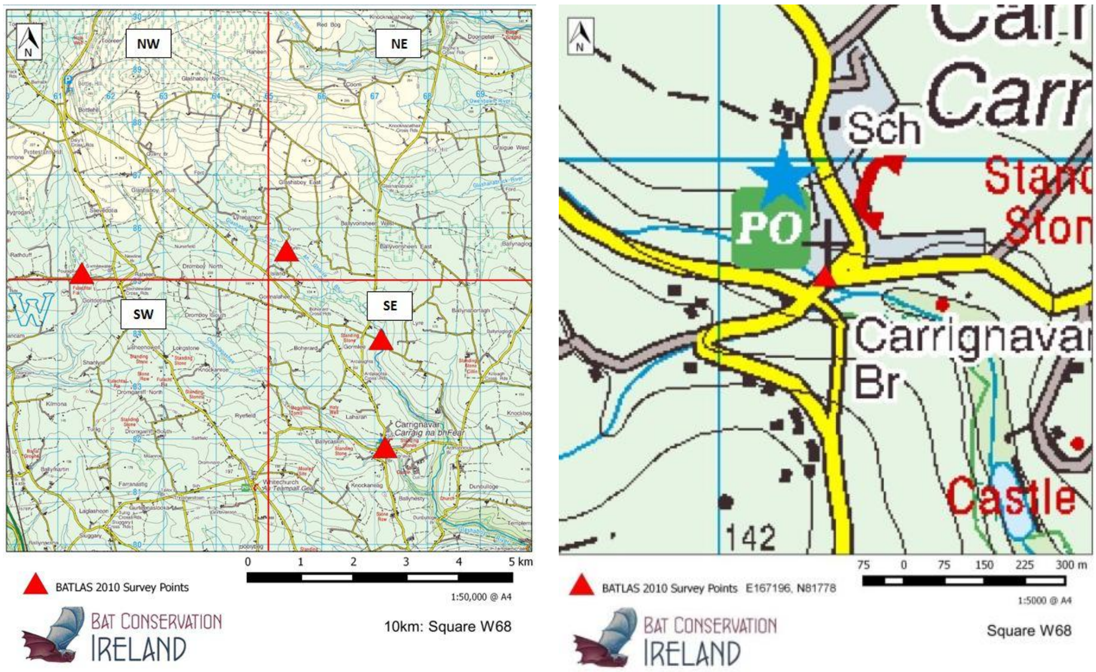

Fig. 1 Examples of an overview 10km map divided into four 5km quadrants (left) and a close up 1km map of a BATLAS 2010 site (right) provided in BATLAS 2020 Pilot Project volunteer packs

Each surveyor was emailed a volunteer pack with:

- an overview map of the assigned 10km grid square, divided into four 5km quadrants, and showing the locations of any BATLAS 2010 sites (Fig. 1 left)
- close up 1km maps of previous BATLAS 2010 sites within the 10km square (Fig. 1 right)
- a survey instruction manual including a worked example of a survey of a 10km square
- survey record sheets (Appendix I).

4.4 Fieldwork methodology

4.4.1 General methods overview

The proposed BATLAS 2020 methods which were trialled during the Pilot Project were similar to those of BATLAS 2010, except that they were applied to each of the four 5km x 5km quadrants within 10km grid squares, and included re-surveys of all previous BATLAS 2010 sites. The acoustic bat survey method at each survey site remained the same between BATLAS 2010 and the BATLAS 2020 Pilot Project.

Re-cap of BATLAS 2010 methods

As BATLAS 2020 is a follow-on survey building on BATLAS 2010, the methods for BATLAS 2010 are outlined below (text taken from the BATLAS 2010 report, Carden et al. 2010).

> "Acoustic surveying of the four species of bats was conducted in each 10km square using tuneable heterodyne bat detectors. Species identification was aided in the field by visual observations (flight characteristics and external morphological features) through the use of a handheld torch, which was used intermittently for brief durations. Fieldwork was carried out on nights that preferably had the following conditions: (i) still to relatively calm or light breezes/winds, (ii) dry to light rain and (iii) relatively warm temperatures of greater than 8° Celsius.
>
> A standardised methodology was developed: three to four random sites per 10km square were chosen by each surveyor. However, at least one of these sites was required to have a water body since this is the preferred habitat of Daubenton's bat. If the surveyor detected and recorded all four target species during the first (or subsequent) site(s) within the assigned 10km square, then they would move onto the next assigned 10km square without surveying the remaining two or three sites as this survey focused on the presence of the targeted species across the Republic of Ireland. Fieldwork commenced between 20 and 40 minutes after sunset and where all-night surveys were conducted, surveying ended approximately 20 to 30 minutes prior to sunrise. All surveys were conducted between late April and early November (weather permitting). The duration of each site survey was 10 to 15 minutes and all species of bat detected were noted. Habitat classifications at each survey site were recorded at the intermediate level of detail as per Fossitt (2000) and these classifications were included on each record sheet. Additional data included time, temperature, weather conditions (cloud cover, precipitation and wind), location of survey and GPS coordinates for the survey sites."

4.4.2 BATLAS 2020 site selection protocol

For the BATLAS 2020 Pilot Project, the aims of the survey for each 10km square were;

1. Re-survey all previous BATLAS 2010 sites in the 10km square
2. Expand surveys to record the four target bat species within each of the four 5km quadrants where they have not already been detected during BATLAS 2010 site re-surveys in a systematic way as outlined below.

The bat surveys which were required in order to complete a 10km square could be spread over a number of nights where necessary.

1. Re-surveys of BATLAS 2010 sites

All previous BATLAS 2010 sites required a re-survey (site survey method below). Surveys were carried out within each 5km quadrant, covering quadrants in any order. Up to a maximum of three sites per 5km quadrant were typically required, to include all BATLAS 2010 sites as the first priority. However, some 10km squares may have had more than three BATLAS 2010 sites in a single 5km quadrant, and all required a re-survey.

If there were three or more BATLAS 2010 sites in a 5km quadrant, then only BATLAS 2010 re-surveys were required in that 5km quadrant, regardless of whether all four target species were detected, and the surveyor moved onto the next 5km quadrant. There was no need to select new BATLAS 2020 sites where there were three or more BATLAS 2010 sites in a 5km quadrant.

2. Selecting new BATLAS 2020 sites

If the four target species were not already detected within each of the four 5km quadrants at the re-surveyed BATLAS 2010 sites (combined), surveyors then selected a number of New BATLAS 2020 sites up to a maximum of three per 5km quadrant (including BATLAS 2010 sites in this tally). At least one site in each 5km quadrant should include a water body since this is the preferred habitat of Daubenton's bat. BATLAS 2010 sites may not exist in some 5km quadrants. In this case, a maximum of three New BATLAS 2020 sites were selected in the quadrant (at least one to include a water body). It was not necessary to select three sites per quadrant if the four target species had already been detected at the first one or two sites combined.

Surveyors selected New BATLAS 2020 sites where they considered it likely that the remaining target species in each quadrant would be detected. New sites were selected with accessibility in mind, so that another surveyor could easily repeat the survey in the future.

4.4.3 Survey method at each site

Bats were surveyed at each site using acoustic bat detectors in almost the same way as BATLAS 2010, as detailed below.

Surveys could be conducted at any time of the night between approximately 40 minutes after sunset and 30 minutes before sunrise, and preferably on nights with favourable weather conditions as follows:

- Still to relatively calm or light breezes/winds
- Dry to light rain
- Relatively warm temperatures >8^{o}C.

Sites were surveyed for bats for up to 10 minutes or until all four target bat species were detected, whichever came sooner.

The start time of 40 minutes after sunset is different to the start time of 20 minutes to 40 minutes after sunset in BATLAS 2010. This change was introduced because Daubenton's bat is considered less likely to have arrived at its foraging sites before 40 minutes after sunset.

The site survey duration was also changed from 10-15 minutes in BATLAS 2010 to 10 minutes in the Pilot Project to offset the increased length of time it would take volunteers to complete the overall survey of each 10km square due to the extra sites being visited during the new proposed BATLAS 2020 method. For example, it would take two hours rather than three hours to survey twelve sites in a 10km square with ten-minute rather than fifteen-minute surveys (excluding the time taken to navigate between survey sites and record data).

Surveyors were asked to survey for bats for up to 10 minutes or until all four target bat species were detected, whichever came sooner. During BATLAS 2010, surveyors moved on as soon as the remaining of the target species for the 10km square were detected, without the requirement to wait up to the maximum of 10-15 minutes per site to detect all four target species at each site. The new method standardises the time spent at each site by waiting for all four target species for up to a maximum of ten minutes.

Data recorded at each survey site

Surveyors recorded information including site name (e.g. bridge or river name), site location in Irish Grid co-ordinates, bat detector model, start time, date, temperature, weather conditions (wind, precipitation, cloud), artificial lighting presence and type of lighting, hedgerow presence and type of hedgerows, habitat types, and bat species in the provided record sheets (Appendix I). Habitat classifications at each survey site were recorded at the intermediate level of detail as per Fossitt (2000) in the same way as BATLAS 2010, and 24 habitat classifications were included on each record sheet (Appendix I).

The 5km quadrants were labelled as NE (i.e. north-east), NW, SE or SW quadrants within each 10km grid square (see record sheet in Appendix I) and there was one record sheet per 5km quadrant. Surveyors also noted whether the site is a previous BATLAS 2010 site, and whether there was a waterway present. Surveyors recorded location in 10-digit Irish Grid reference form (e.g. O 00676 72750, Newgrange).

Additional site data for BATLAS 2020: (a) hedgerow categories

Where hedgerows/treelines occured in the direct vicinity of the bat survey site, the hedgerow type was recorded according to the categories described in more detail with photographs in Appendix II

- dense treeline (DT in record sheet)
- sparse treeline (ST)
- medium hedgerow (MH)
- small hedgerow (SH) or
- a combination of the above categories.

Where there were areas, or relatively wide strips of scrub or woodland, rather than obvious linear hedgerows or treelines, this was not counted as a hedgerow habitat, and was noted as scrub or woodland in the habitat classification section of the record sheet.

Additional site data for BATLAS 2020: (b) artificial lighting categories

Surveyors recorded whether there was artificial lighting e.g. street lighting within 100 m of survey sites, and also whether there was artificial lighting where bats were flying. Lighting type is categorised as

- white
- yellow
- orange

in a similar way to Bat Conservation Ireland's annual car-based monitoring scheme (Roche et al., 2012). Guidance on categorising lighting type is given in Appendix III.

4.5 Data returns

Survey results were returned to the Project Co-ordinator in the provided record sheets (Appendix I) either in paper format via postal delivery or scanned and emailed, or as an excel file via email. Data was inputted by the Project Co-ordinator into an excel file with each row holding all the variables for a single survey site.

4.6 Statistical analyses

Where comparisons were made between 20010 and 2015 using the same sites, McNemar's test (Armitage et al. 2001) was used (Genstat procedure MCNEMAR), calculating an exact binomial probability to avoid the need for a chi-squared approximation. Other comparisons between proportions used an ordinary chi-squared test (R version R.3.2.2 function prop.test).

In order to assess the significance of the relationship between bats and the habitat variables, whilst allowing for the spatial structure of the data, mixed logistic regression models (binomial GLMMs, Zuur et al. 2009) were fitted, with the response variable being the presence of the relevant bat species at each site. The 5km quadrants were fitted as random terms, nested within 10km grid squares. Variables for northing, easting, day and time after sunset were fitted first, dropping those that were not significant using a Wald test and checking for non-linearity using polynomial terms. A forwards stepwise approach was then used to select habitat and artificial light variables where these were significant at the nominal 5% level. Terms were dropped from the models if their significance levels fell below 10%. As always with a stepwise selection procedure, it should be noted that the final model is not necessarily the only plausible model, or even the best fitting one. Models were fitted using Genstat procedure GLMM.

5. Results

5.1 Volunteer participation and survey coverage

In total, 47 volunteers participated in the BATLAS 2020 Pilot Project (32 lead surveyors and 15 assistant surveyors). Nine of the pilot project participants (19.1%) had also carried out bat surveys during BATLAS 2010. Surveyors conducted bat surveys at 548 sites in total during the pilot project. Of these sites, 130 (23.7%) were previous BATLAS 2010 sites, while the remainder were new survey sites (76.3%) as shown on the map in Fig. 2.

Survey coverage was quite widespread throughout the Republic of Ireland with one 10km square in Northern Ireland also covered. Bat surveys were conducted in a total of 68 10km grid squares as shown in the map below (Fig. 2). Of these 68 10km squares, 54 (79.4%) were 10km squares previously surveyed during BATLAS 2010, and 14 (20.6%) were new BATLAS 2020 10km squares that had not been previously surveyed during BATLAS 2010. For the subset of 2010 10km squares that were covered during the pilot project (54), 90.3% of the BATLAS 2010 sites in those squares were re-surveyed.

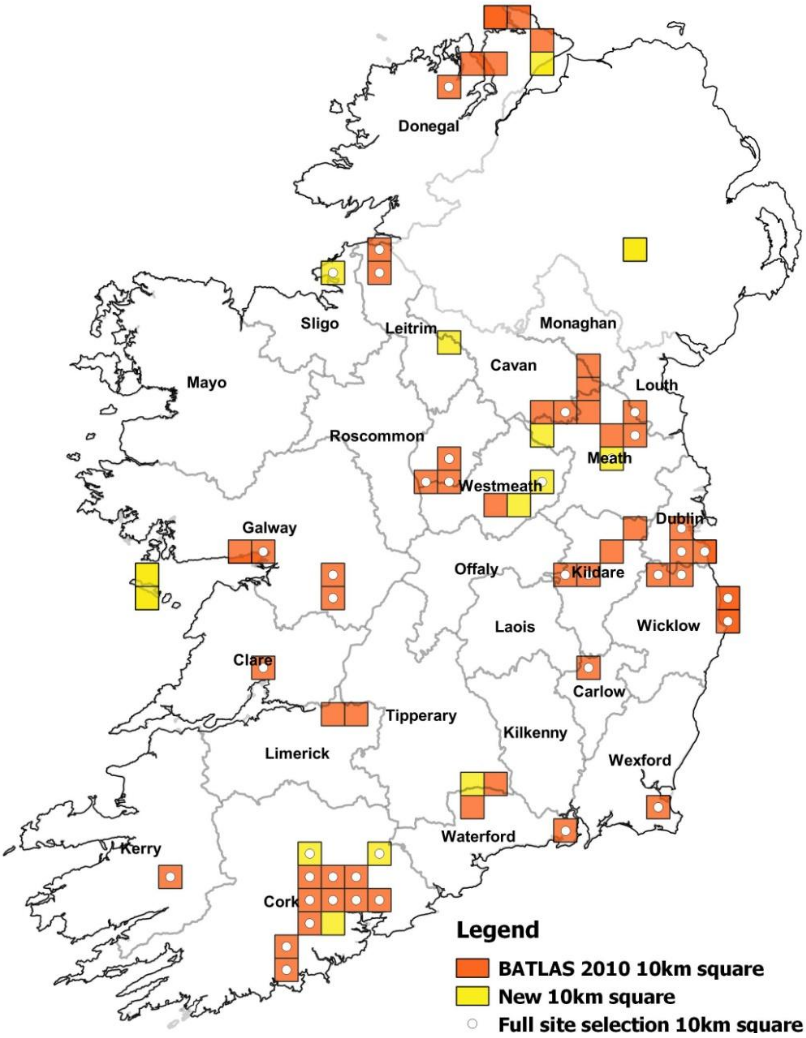

Fig. 2 Overview map showing 10km grid squares where bat surveys were conducted, indicating 10km squares previously surveyed during BATLAS 2010 in orange (54), and new 10km squares surveyed first during the BATLAS 2020 Pilot Project 2015 in yellow (14). The central white dot inside squares denotes 10km squares which were surveyed in full accordance with the site selection protocol (41).

The 68 squares in the map in Fig. 2 include squares where at least one site was surveyed. The average number of sites surveyed per 10km square was 8.1 and the median was 10 sites. A total of 41 out of the 68 squares (60.3%) were surveyed fully in accordance with the site selection protocol described in the methods (i.e. all four 5km quadrants surveyed, with the required number of sites per quadrant). The 10km squares with full site selection are indicated by a central white dot inside the 10km square on the map (Fig. 2).

At the 5km resolution, bat surveys were conducted in 215 5km quadrants. A total of 185 out of the 215 5km quadrants (86.0%) were surveyed fully in accordance with the site selection protocol (i.e. re-surveys of all BATLAS 2010 sites and new sites up to a maximum of three sites or until all four target species were detected). 63.7% of survey sites (349) had a waterway.

Survey coverage was expanded during the Pilot Project with 3.0 times the number of sites surveyed within BATLAS 2010 10km squares during the Pilot Project compared to BATLAS 2010. There were 3.6 times the number of sites surveyed for the subset of 10km squares surveyed with the full site selection protocol.

The majority of site surveys (96.2%) took place during September and October 2015. A minority of bat surveys (3.8%) from earlier during the 2015 season were also included as they were carried out according to the BATLAS site method for bat detector surveys.

5.2 Target bat species detection rates

All four target bat species were detected in 33 (48.5.8%) of the 68 10km squares surveyed. There were no 10km survey squares (0.0%) where there were no bat species detections during the 2015 BATLAS 2020 Pilot Project. In contrast, 56 out of 647 10km squares (8.6%) which were surveyed in the Republic of Ireland during BATLAS 2010 yielded no detection of any bat species.

The following summary data for bat species detection are given at three resolution levels (i) survey sites, (ii) 5km quadrants, and (iii) 10km grid squares.

On a per site basis, the soprano pipistrelle was the most widely detected bat species (62.0% of 548 sites), followed by common pipistrelle (48.4% of 548 sites), Daubenton's bat (26.5%) and lastly Leisler's bat (22.1%), which was the least widely detected of the target species. Daubenton's bat, which forages over waterways, was detected at 41.5% of the subset of 349 survey sites with a waterway. This information is summarised in the first column of Table 1 below.

While soprano pipistrelle was the most widely detected bat species on a per site basis (62.0% of sites) and per 5km quadrant (82.3% overall, 85.9% in full site selection 5km quadrants), common pipistrelle was detected in more 10km squares (97.1% overall, 100.0% in full site selection squares) than soprano pipistrelle (91.2%, 97.6%). Leisler's bat was the least widely detected of the four target species at all three levels of (i) site, (ii) 5km quadrant and (iii) 10km grid square (Table 1). Leisler's bat was not recorded in many 10km squares with intense survey effort. It was detected in just 23 out of the 41 (56.1%) 10km squares which were surveyed fully in accordance with the site selection protocol, and not detected in the remaining 18 (43.9%) (Table 1) despite 12 or more sites being surveyed in these 10km squares. Distribution maps for each of the target species at the 10km square resolution are shown in section 5.9, with squares with a central white dot denoting the 41 10km squares which were surveyed according to the full site selection protocol.

Table 1: Detection rates (%) of the target bat species at (i) site, (ii) 5km quadrant, and (iii) 10km grid square levels, *also showing results for the subset of 5km quadrants and 10km squares which were surveyed fully in accordance with the site selection protocol.

Bat species	% of sites (n = 548)	% of 5km quadrants (n = 215)	*% of 'full' 5km quadrants (n = 185)	% of 10km squares (n = 68)	*% of 'full' 10km squares (n = 41)
Soprano pipistrelle	62.0	82.3	85.9	91.2	97.6
Common pipistrelle	48.4	78.1	80.0	97.1	100.0
Daubenton's bat**	26.5	53.0	58.4	77.9	87.8
Leisler's bat	22.1	42.8	43.2	63.2	56.1

** Daubenton's bat was detected at 41.5% of 349 survey sites with a waterway

5.3 Comparison of target species detection rates with BATLAS 2010

5.3.1 Overall site detection rates

The overall per site detection rates of soprano pipistrelle and Daubenton's bat were comparable between the 2015 BATLAS 2020 Pilot Project and BATLAS 2010 (no significant differences, Table 2). Common pipistrelle and *Pipistrellus* sp. had a significantly higher percentage of detection-positive sites in the 2015 BATLAS 2020 Pilot Project compared to BATLAS 2010 (Table 2). In contrast, the detection rate for Leisler's bat was significantly lower during the pilot (22.1% of 548 sites) compared to BATLAS 2010 (32.1% of 1693 sites) (Table 2).

Table 2: Comparison of site bat detection rates between the 2015 Pilot Project and BATLAS 2010. Pearson chi-squared tests are approximate ignoring the spatial clustering of sites within 5km quadrants and 10km squares.

Bat species	2015 Pilot (total sites = 548)		BATLAS 2010 (total sites = 1693)		Chi-squared comparison statistic
	No. of sites	% of sites	No. of sites	% of sites	
Soprano pipistrelle	340	62.0%	1079	63.7%	No significant difference. Chi-squared = 0.44, 1 df, p > 0.05
Common pipistrelle	265	48.4%	689	40.7%	Significantly higher in 2015. Chi-squared = 9.63, 1 df, p < 0.05
Daubenton's bat	145	26.5%	505	29.8%	No significant difference. Chi-squared = 2.12, 1 df, p > 0.05
Leisler's bat	121	22.1%	543	32.1%	Significantly lower in 2015. Chi-squared= 19.35, 1 df, p < 0.05
Pipistrellus sp.*	71	13.0%	95	5.6%	Significantly higher in 2015. Chi-squared = 31.5, 1 df, p < 0.05

* Either soprano or common pipistrelles which could not be reliably assigned because of echolocation calls with a peak frequency of maximum energy at approximately 50kHz

5.3.2 Re-surveyed BATLAS 2010 sites

Out of a total of 548 sites surveyed during the 2015 BATLAS 2020 Pilot Project, 130 sites were re-surveyed BATLAS 2010 sites. The detection rate for common pipistrelle increased from 67 out of 130 BATLAS 2010 sites (51.5%) to 74 during the 2015 BATLAS 2020 Pilot Project (56.9%) (Fig. 3). The detection rate increased for Daubenton's bat from 27.2% during BATLAS 2010 to 35.4% during the Pilot Project, and was approximately the same for soprano pipistrelle at 71.5% during BATLAS 2010 and 69.2% during the Pilot Project (Fig. 3). The detection rate decreased for Leisler's bat from 43 out of 130 BATLAS 2010 sites (33.1%) to 28 of same re-surveyed 130 sites during the Pilot Project (21.5%) (Fig. 3). The decrease in the Leisler's bat detection rate was statistically significant (exact McNemar's test, p=0.028), while there were no significant differences for the other target species using this test (Table 3).

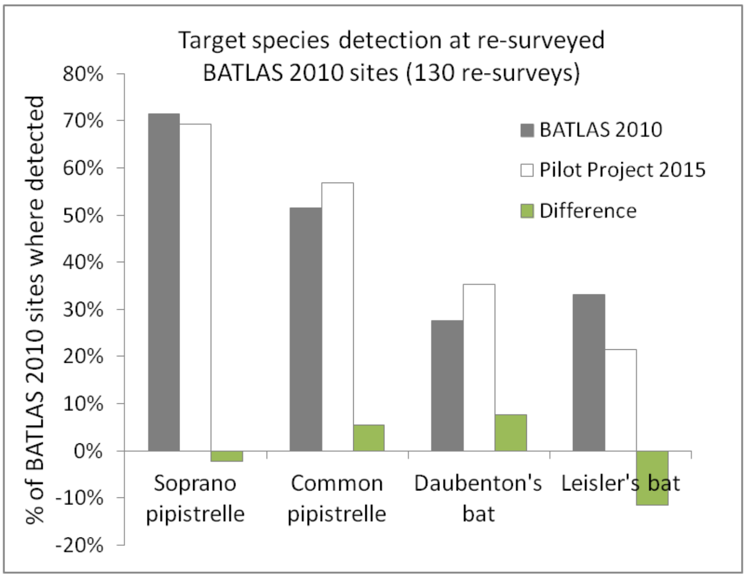

Fig. 3 The percentage of sites where target species were detected during BATLAS 2010 compared with the same sites surveyed for the 2015 Pilot Project (no. of sites = 130)

Table 3: Two-way tables of presence/absence for the target species for 130 sites surveyed during BATLAS 2010 and re-surveyed during the 2015 BATLAS 2020 Pilot Project for calculating McNemar's test statistic. Rows of the table represent BATLAS 2010 data, and columns represent 2015 data. P-values are exact probabilities (i.e. not using a chi-squared approximation).

a) Soprano pipistrelle (P=0.780)

		2015		
		Absent	Present	Count
2010	Absent	13	24	37
	Present	27	66	93(71.5%)
	Count	40	90 (69.2%)	130

b) Common pipistrelle (P=0.419)

		2015		
		Absent	Present	Count
2010	Absent	32	31	63
	Present	24	43	67(51.5%)
	Count	56	74(56.9%)	130

c) Daubenton's bat (P=0.121)

		2015		
		Absent	Present	Count
2010	Absent	72	22	94
	Present	12	24	36(27.7%)
	Count	84	46 (35.4%)	130

d) Leisler's bat (P=0.028)

		2015		
		Absent	Present	Count
2010	Absent	74	13	87
	Present	28	15	43(33.1%)
	Count	102	28 (21.5%)	130

The data presented in Table 3 are presented graphically in Fig. 4 below, showing the percentage of sites where the species detections were the same between surveys (i.e. either detected during both, or not detected during both surveys) and the percentage of discordant site pairs (i.e. detected in 2015 where not detected previously, or vice versa). For example, there were 20.8% of re-surveyed BATLAS 2010 sites where soprano pipistrelle was detected during BATLAS 2010 while it was not detected in a repeat survey during the pilot project (DOWN in Fig. 4), and 18.5% in the reverse direction (UP in Fig. 4).

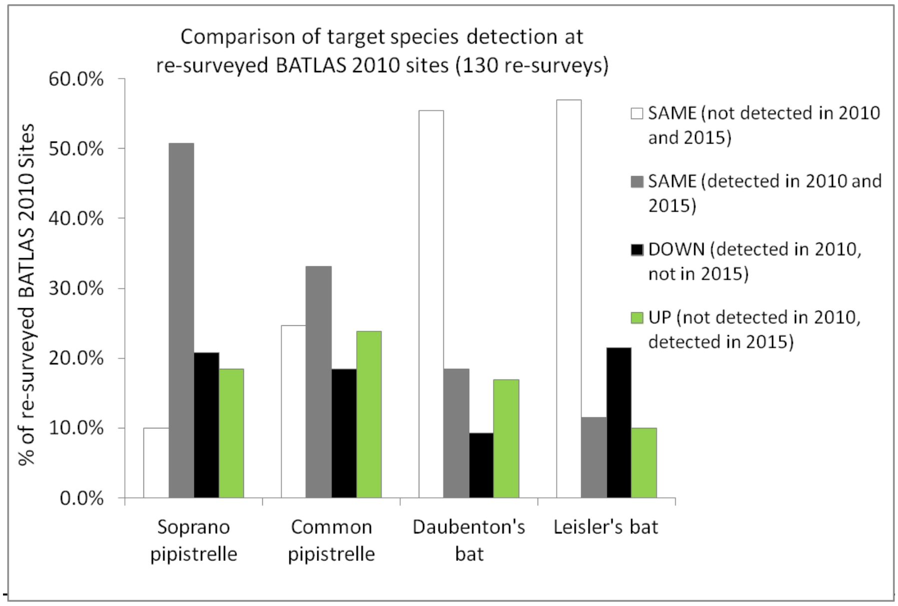

Fig. 4 Changes in target species detection on a per site basis for 130 BATLAS 2010 sites where a repeat survey was carried out during the BATLAS 2020 Pilot Project 2015

5.3.3 Re-surveyed BATLAS 2010 10km grid squares

A total of 54 out of 68 10km survey squares were previous BATLAS 2010 10 km grid squares. For these 54 squares, the number of 10km squares where the target species were detected was increased above the BATLAS 2010 tally for all four target bat species as shown in Fig. 5. This would be expected given the extra sites surveyed in each 10km square according to the new proposed BATLAS 2020 methods. Daubenton's bat had the highest increase in 'positive' 10km squares, increasing from 27 out of 54 squares during BATLAS 2010 to 44 out of the same 54 squares during the Pilot Project (31.5% more 10km squares), followed by common pipistrelle which increased from 43 to 51 10km squares (14.8%), soprano pipistrelle which increased from 47 to 51 10km squares (7.4%) and Leisler's bat which increased from 33 to 36 10km squares (5.6%). The increase in the Daubenton's bat detection rate was statistically significant (exact McNemar's test, p<0.001), while there were no significant differences for the other target species using this test (Table 4).

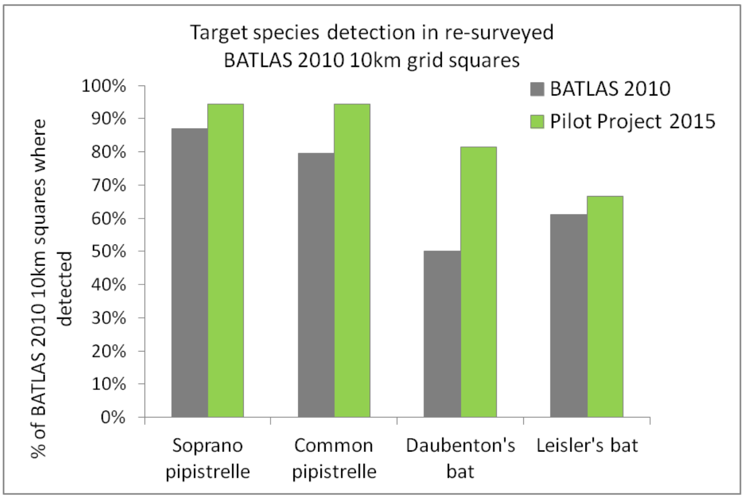

Fig. 5 Target species detection at the 10km scale for 54 BATLAS 2010 10km squares that were re-surveyed during the BATLAS 2020 Pilot Project 2015

Table 4: Two-way tables of presence/absence for the target species for 54 10km squares surveyed during BATLAS 2010 and re-surveyed during the 2015 BATLAS 2020 Pilot Project for calculating McNemar's test statistic. Rows of the table represent BATLAS 2010 data, and columns represent 2015 data. P-values are exact probabilities (i.e. not using a chi-squared approximation).

	a) Soprano pipistrelle (P=0.344)			
		2015		
		Absent	Present	Count
2010	Absent	0	7	7
	Present	3	44	47(87.0%)
	Count	3	51 (94.4%)	54

	b) Common pipistrelle (P=0.057)			
		2015		
		Absent	Present	Count
2010	Absent	0	11	11
	Present	3	40	43(79.6%)
	Count	3	51(94.4%)	54

	c) Daubenton's bat (P<0.001)			
		2015		
		Absent	Present	Count
2010	Absent	7	20	27
	Present	3	24	27(50.0%)
	Count	10	44 (81.5%)	54

	d) Leisler's bat (P=0.664)			
		2015		
		Absent	Present	Count
2010	Absent	9	12	21
	Present	8	40	33(61.1%)
	Count	18	36 (66.7%)	54

5.4 Survey effort per 10km grid square

For the 68 surveyed 10km squares the average number of sites surveyed per 10km square was 8.1 survey sites and the median was 10 survey sites. For the subset of 10km squares that were surveyed fully in accordance with the site selection protocol (i.e. all four quadrants, with the required number of sites per quadrant), volunteers surveyed 11.4 survey sites per 10km square on average (median 12, minimum 8, maximum 14). Surveyors spent 3.2 evenings on average surveying in these 10km squares (median 3, minimum 1, maximum 9). Some coastal squares were omitted from this latter calculation as the squares had a large proportion of area covered by sea rather than land, and thus would not represent a typical 10km square. Temperatures dropping fast in the evenings increased the number of evenings required to complete surveys in 10km squares, and this was an unusual circumstance of the late-season timing of the Pilot Project.

5.5 Effect of number of survey sites per 5km quadrant on target species detection

Table 5 shows the mean number of target species detected, per 10km grid square and per 5km quadrant, if just one site was chosen per quadrant (i.e. the A site), or if two (A and B) or three (A,B and C) were chosen. These analyses only include 5km quadrants which were surveyed fully in accordance with the site selection protocol (n = 185), so that three or more sites were surveyed per quadrant, except where all four of the target species were detected earlier, or where it was not possible to survey more sites due to the presence of a lake or sea for example.

Reducing from three to a maximum of two sites per 5km quadrant decreases the overall survey time/effort by 33% or more, but only decreases the average number of target species detected by 3.8% (10km squares) or 10.5% (5km quadrants) (Table 5).

Table 5: Mean numbers of target species that would have been detected if 1, 2 or 3 sites had been surveyed per quadrant (but stopping earlier if all target species detected).

			Mean number target species	
Sites per quadrant		Total sites	Per 10km square	Per 5km quadrant
1	A	185	3.00	1.89
2	AB	352	3.31	2.39
3	ABC	501	3.44	2.67

Fig. 6 shows the proportion of 10km squares and 5km quadrants with each species present under the three approaches i.e. if just one site was chosen per quadrant (i.e. the A site), or if two (A and B) or three (A,B and C) were chosen. It is clear that increasing the number of survey sites from two to three generally only slightly increases the chances of observing the target species.

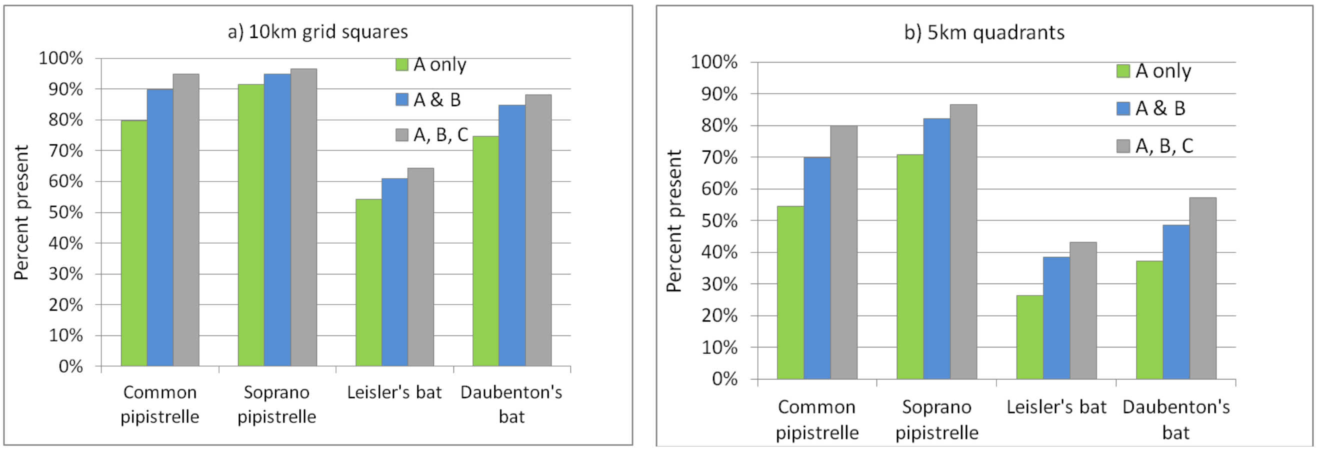

Fig. 6. Proportion of a) 10km grid squares and b) 5km quadrants with each species present with either 1, 2, or 3 sites surveyed per 5km quadrant

5.6 Additional site data and habitat types recorded

Hedgerows were reported in the direct vicinity of survey sites at 81.6% of the total survey sites, with the majority of these hedgerows being categorised as 'dense treelines' (see hedgerow descriptions in Appendix II). Artificial lighting was recorded at 146 out of the 548 sites surveyed during the 2015 BATLAS 2020 Pilot Project (26.6%). Bats were reported as flying in the direct vicinity of light for 12.3% of the survey sites where artificial lighting was recorded.

Fig. 7 Lakeshore habitats in the NW 5km quadrant of 10km square V98, Killarney Co. Kerry. © Photograph by Mary Mahony

Out of the 24 habitat classifications listed in the record sheet (Appendix I) the ten most frequently recorded habitat types within 100m of survey sites are listed in order in Table 6, showing the percentage of sites where each habitat was recorded.

Table 6: Top ten habitat types recorded within 100m of survey sites.

Rank	Habitat type	% of sites (n = 548)
1	Hedge or treeline	84.7
2	Grasslands	75.7
3	Watercourse (not including lakes or ponds)	59.1
4	Built land	57.5
5	Woodland (not including conifer plantation)	30.1
6	Scrub	27.9
7	Cultivated land	15.7
8	Lakes or ponds	10.4
9	Conifer plantation	10.0
10	Disturbed ground	4.2

5.7 Binomial Generalised Linear Mixed Models (GLMMs)

5.7.1 GLMMs for the four target bat species

Table 7 shows the final models for each of the target bat species. Note that some terms have p-values slightly above P=0.05; this occurs where significance levels have changed slightly on adding other terms to the model. The estimates shown are on the logit scale, and the sign of the estimate gives the direction of the relationships. The numerical values of the estimates can be compared for the habitat variables, since these are all on the same 0/1 scale.

The results of adding each non-significant term separately to the GLMMs with the variables shown for each of the target bat species given in Table 7 are shown in Appendix IV. The GLMMs for each target species are described in more detail below.

Table 7: Test statistics from the binomial GLMMs for the four target bat species.

a) Common pipistrelle						
Term	χ^2	d.f.	P-value	Estimate	SE	Odds ratio
Minutes after sunset	3.52	1	0.06	-0.00376	0.002002	
Day number	12.39	1	<0.001	-0.03123	0.008872	
Scrub	10.52	1	0.001	0.7726	0.2383	2.17
Woodland	4.53	1	0.033	0.4867	0.2286	1.63
Yellow lighting	9.87	1	0.002	-1.349	0.4294	0.26
Lighting within 100m	7.33	1	0.007	0.8243	0.3045	2.28

b) Soprano pipistrelle						
Term	χ^2	d.f.	P-value	Estimate (lo	SE	Odds ratio
Minutes after sunset	6.33	1	0.012	-0.00535	0.002127	
Day linear	3.16	1	0.075	0.1765	0.09931	
Day quadratic	3.64	1	0.056	-0.00038	0.000198	
Watercourse	8.68	1	0.003	0.6901	0.2342	1.99
Coastal habitats	6.85	1	0.009	-1.436	0.5486	0.24
Lakes and ponds	4.75	1	0.029	0.9061	0.4158	2.47

c) Daubenton's bat						
Term	χ^2	d.f.	P-value	Estimate	SE	Odds ratio
Day number	4.63	1	0.031	-0.01574	0.00732	
Watercourse	48.37	1	<0.001	2.651	0.3812	14.27
Lakes and ponds	30.19	1	<0.001	2.436	0.4434	11.46
Woodland	6.25	1	0.012	0.624	0.2496	1.86
Conifer plantation	3.88	1	0.049	-1.003	0.5092	0.37

d) Leisler's bat						
Term	χ^2	d.f.	P-value	Estimate	SE	Odds ratio
Day number	22.02	1	<0.001	-0.04409	0.009395	
Eastings	8.18	1	0.004	0.009505	0.003322	
White lighting	6.62	1	0.01	1.253	0.4868	3.5
Scrub	6.8	1	0.009	0.7802	0.2993	2.18

5.7.2 Common pipistrelle GLMM

It can be seen from the GLMM presented in Table 7(a) for common pipistrelle that its presence (or detection) declined with day number (date) and with time after sunset. Common pipistrelle detection was positively associated with both scrub and woodland habitat types. The relationship with artificial lights was more complex, and is illustrated in more detail in Table 8. Orange and white lights were associated with a small increase in presence in the observed means, but the difference was much larger after adjusting for other variables in the model (woodland and scrub are less common at sites with orange and white lights than at sites with no lights, and so the model estimates are adjusted upwards to predict the presence had woodland and scrub been more common). In contrast, yellow lights showed lower levels of common pipistrelle detection, particularly after adjusting for the impact of the other variables in the model.

Table 8: Percentage of sites with common pipistrelles present by artificial lighting type. The model estimates are adjusted to the mean of the other variables in the model (i.e. time after sunset, day number, scrub and woodland).

			Model estimates			
Artificial lighting	n	Observed mean (%)	Estimate (%)	Lower 95%	Upper 95%	SE
No lights	400	49.0	54.9	45.5	63.9	4.6
Orange/white	86	54.7	73.5	59.7	83.8	6.0
Yellow	60	35.0	41.8	25.7	59.9	8.5

5.7.3 Soprano pipistrelle GLMM

Table 7(b) shows that soprano pipistrelle detection had a quadratic relationship with day number (date). Despite the positive coefficient for the linear date term, the probability of detection declined with increasing date, but the rate of decline accelerated rapidly towards the end of the survey period. There were strong effects of wetland habitats, with watercourses and lakes/ponds having strong positive associations, and coastal habitats showing a negative relationship. Artificial lighting had no significant effect on the detection of soprano pipistrelle, whilst, of the hedgerow variables, dense treelines were close to statistical significance (chi-squared = 3.61 with 1 d.f., P=0.058, Appendix IV) with a positive relationship.

5.7.4 Daubenton's bat GLMM

Daubenton's bat (Table 7c) detection decreased with day number (date), in an approximately linear pattern. The detection of Daubenton's bat had a strong positive association with the wetland habitat categories (watercourses and lakes and ponds), and a less strong positive association with woodland. Daubenton's bat detection showed a negative association with conifer plantations.

5.7.5 Leisler's bat GLMM

Leisler's bat detection also showed a negative relationship with date (Table 7d), and were more commonly detected to the east of Ireland. There was a strong positive association with white artificial light, but the effects of orange and yellow lights were not significant. None of the habitat type variables were significant for Leisler's bat, although woodland was close (chi-squared = 2.97 with 1 d.f., P=0.085, Appendix IV).

5.8 Additional 'non-target' bat data collected

In addition to the four target bat species, opportunistic bat detector records of the following species or species groups were also recorded during the 2015 BATLAS 2020 Pilot Project; brown long-eared bat, Natterer's bat, Nathusius' pipistrelle, whiskered/Brandt's bat, and lesser horseshoe bat. These additional species were detected infrequently, and this would be expected as acoustic detector surveys are not an optimal method for detecting most of these species. Table 9 shows the additional bat species or groups detected during surveys and the number and percentage of survey sites where detected.

Table 9: Additional bat records during the 2015 BATLAS 2020 Pilot Project

Bat species/group	Number of sites	% of sites (n = 548)
Unidentified bat	28	5.1%
Myotis sp.	33	6.0%
Natterer's bat	7	1.3%
Whiskered/Brandt's bat	3	0.5%
Brown long-eared bat	18	3.3%
Lesser horseshoe bat	1	0.2%

A roost of the brown long-eared bat was also found in a derelict building adjacent to one of the survey sites during the Pilot Project and the details have been added to Bat Conservation Ireland's roost database.

5.9 Distribution maps of target bat species

5.9.1 Soprano pipistrelle

The soprano pipistrelle was widely detected during the BATLAS 2020 Pilot Project 2015. As shown in the map below (Fig. 7), it was detected in 62 out of the 68 total surveyed 10km squares, and in 40 out of the 41 10km squares which were surveyed with the full site selection protocol.

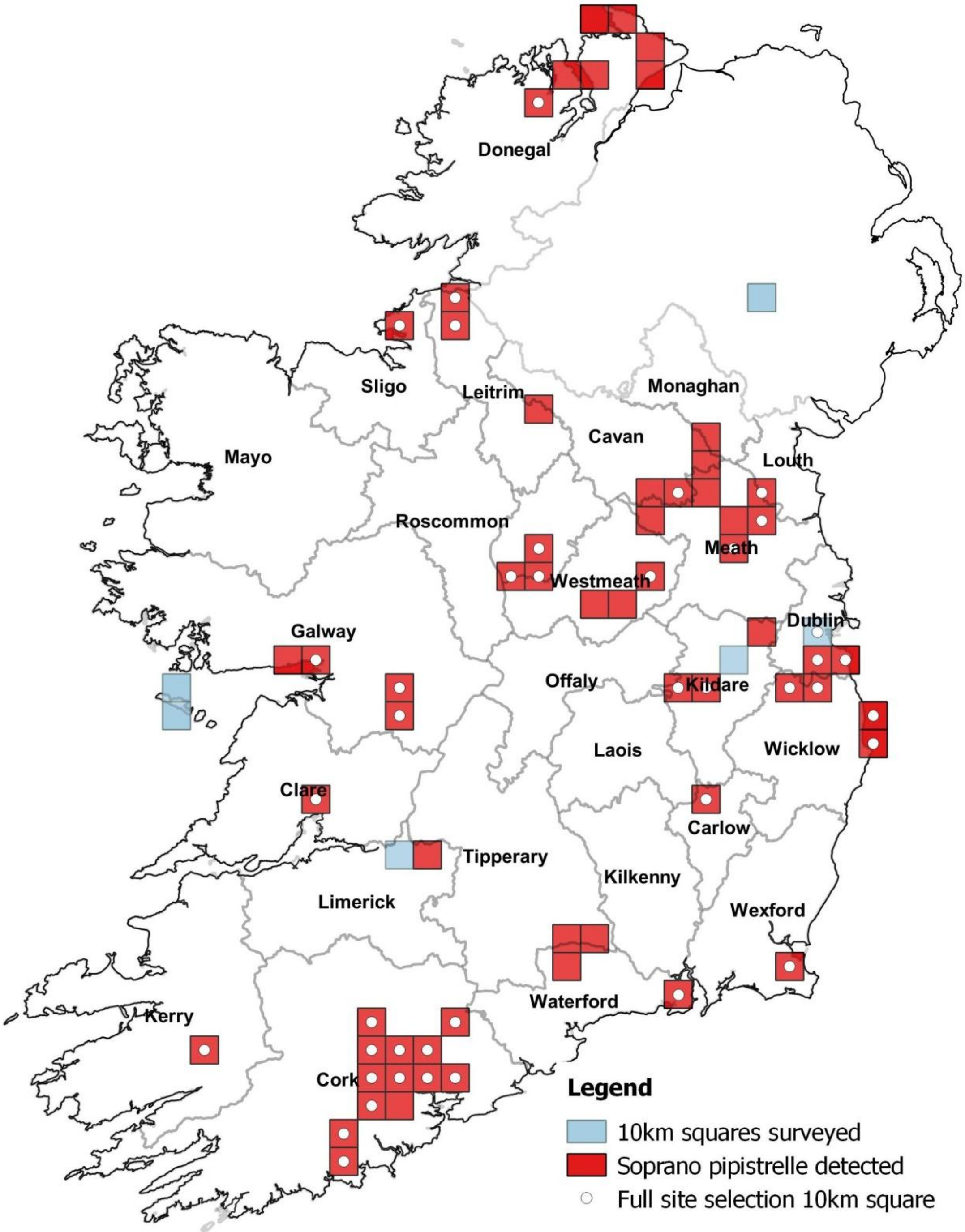

Fig. 8 The distribution of soprano pipistrelle (62 red 10km squares) within surveyed 10km grid squares during the BATLAS 2020 Pilot Project 2015 (68 in total). Blue squares denote 10km squares which were surveyed and where soprano pipistrelle was not detected. Squares with a central white dot denote the 41 10km squares which were surveyed according to the full site selection protocol.

5.9.2 Common pipistrelle

The common pipistrelle was also widely detected during the BATLAS 2020 Pilot Project 2015. As shown in the map below (Fig. 8), it was detected in 66 out of the 68 total surveyed 10km squares, and in 41 out of the 41 10km squares which were surveyed with the full site selection protocol.

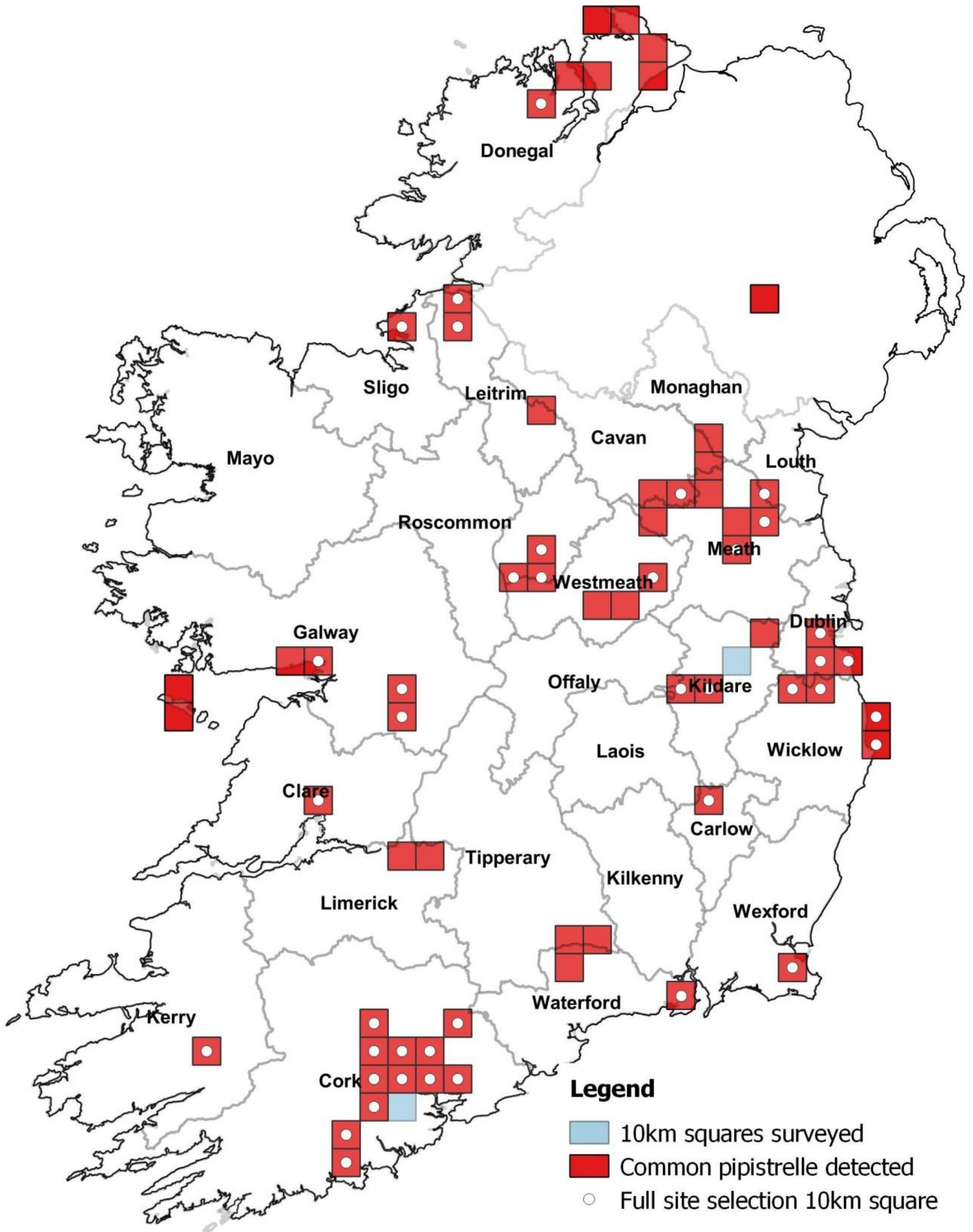

Fig. 9 The distribution of common pipistrelle (66 red 10km squares) within surveyed 10km grid squares during the BATLAS 2020 Pilot Project 2015 (68 in total). Blue squares denote 10km squares which were surveyed and where common pipistrelle was not detected. Squares with a central white dot denote the 41 10km squares which were surveyed according to the full site selection protocol.

5.9.3 Daubenton's bat

Daubenton's bat was widely detected during the BATLAS 2020 Pilot Project 2015, but not in as many squares as the soprano and common pipistrelles. As shown in the map below (Fig. 9), it was detected in 53 out of the 68 total surveyed 10km squares, and in 36 out of the 41 10km squares which were surveyed with the full site selection protocol. It was not detected in the most coastal of squares or the island squares.

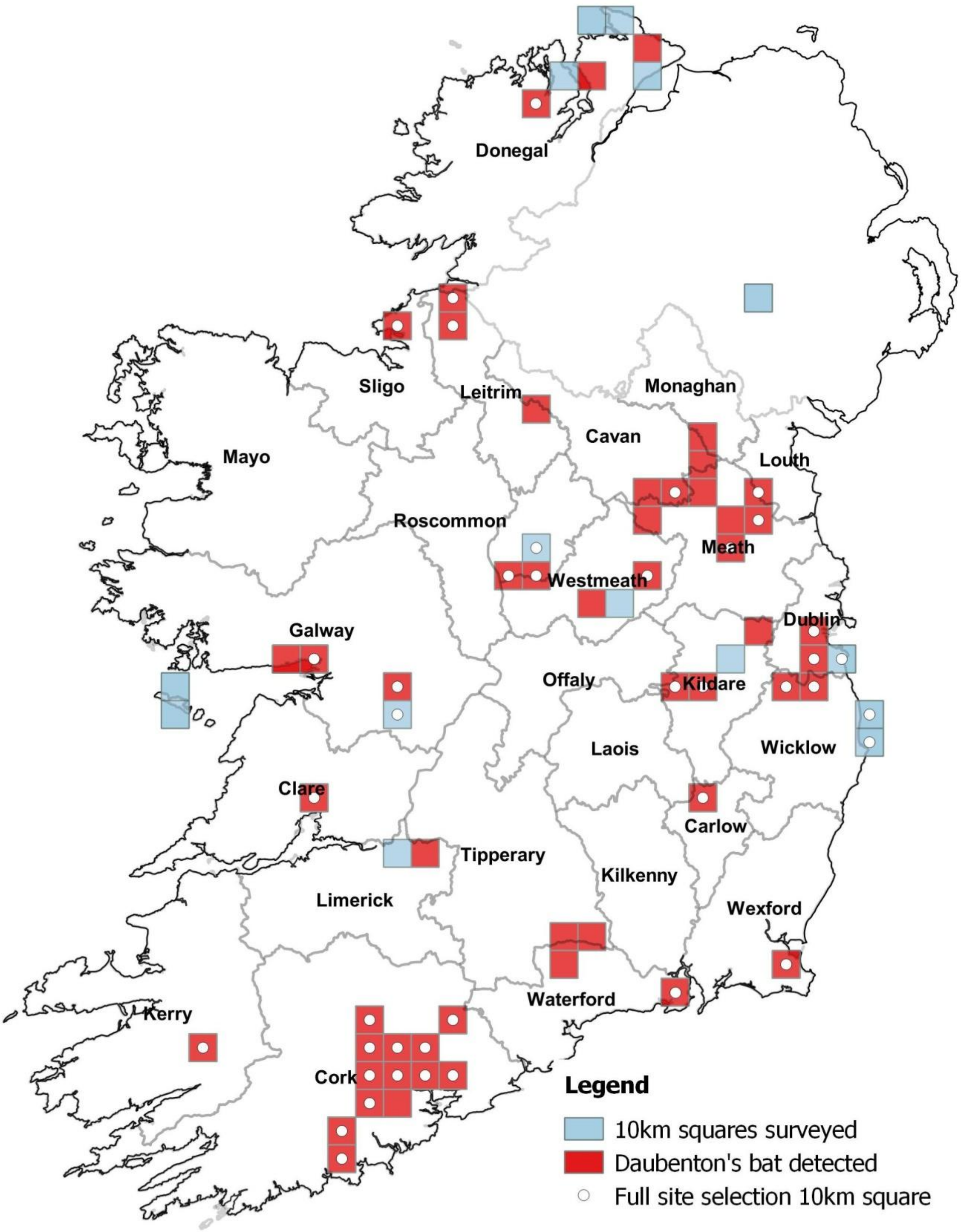

Fig. 10 The distribution of Daubenton's bat (53 red 10km squares) within surveyed 10km grid squares during the BATLAS 2020 Pilot Project 2015 (68 in total). Blue squares denote 10km squares which were surveyed and where Daubenton's bat was not detected. Squares with a central white dot denote the 41 10km squares which were surveyed according to the full site selection protocol.

5.9.4 Leisler's bat

Leisler's bat was the least widely detected of the four target bat species, detected in 43 out of the 68 total surveyed 10km squares, and in 23 out of the 41 10km squares which were surveyed with the full site selection protocol (Fig. 10). It was not detected for example in many pockets of 10km squares which received intense survey effort, and where it is known to occur earlier in the season. The GLMM for Leisler's bat (section 5.7) indicated an increased likelihood of detection towards the east, but little can be read into this result due to the limited geographic coverage of the Pilot Project surveys.

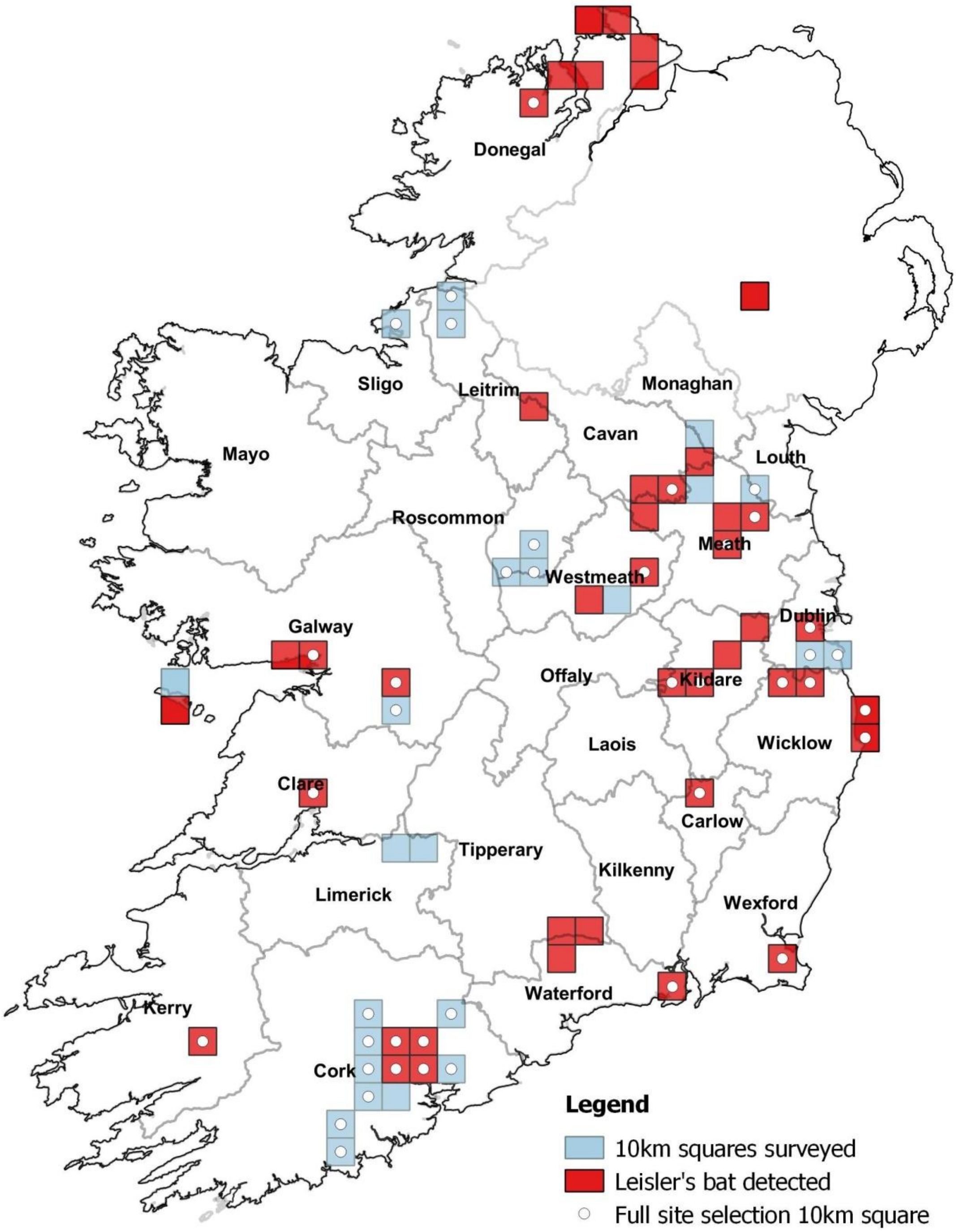

Fig. 11 The distribution of Leisler's bat (43 red 10km squares) within surveyed 10km grid squares during the BATLAS 2020 Pilot Project 2015 (68 in total). Blue squares denote 10km squares which were surveyed and where common pipistrelle was not detected. Squares with a central white dot denote the 41 10km squares which were surveyed according to the full site selection protocol.

6. Conclusions and Recommendations

Distribution maps

The production of distribution maps was not a key objective of the 2015 BATLAS 2020 Pilot Project, which had a limited survey timeframe and non-systematic coverage of a small proportion of the 10km grid squares across the island. Distribution maps will however be the main objective of island-wide surveys during BATLAS 2020. The proposed BATLAS 2020 method has been shown to have the capacity to produce high quality distribution maps for the four target species.

Soprano pipistrelle (Fig. 8) and common pipistrelle (Fig. 9) were widely detected during the survey, as expected. Common pipistrelle but not soprano pipistrelle was recorded during island surveys off the west coast. Seven of the most coastal and island 10km squares had zero detections of Daubenton's bat. During BATLAS 2010, there were also many of the more coastal squares lacking detections of this species. This could be due to a lack of suitable waterways in these squares. Survey coverage in offshore islands and coastal squares will be a priority in BATLAS 2020. Only one offshore island was surveyed during BATLAS 2010 so island surveys during BATLAS 2020 will provide new information on the distributions of the target species.

There were a high number of 10km squares with intense survey effort (12 or more sites per square) where Leisler's bat was not detected (Fig. 11). The GLMM for Leisler's bat indicated that it was more likely to be detected in the east of the country during the 2015 BATLAS 2020 Pilot Project surveys.

Leisler's bat and late season timing of the 2015 BATLAS 2020 Pilot Project

Despite increased survey effort by volunteers during the 2015 BATLAS 2020 Pilot Project (surveying at more than three times the number of sites in many 10km squares), Leisler's bat was not detected in many 10km squares. There was a significant decrease in the per-site detection rate for Leisler's bat between BATLAS 2010 and the BATLAS 2020 Pilot Project at re-surveyed BATLAS 2010 sites. This decreased detection rate was not observed for the other target bat species. It is also worth remembering that Leisler's bat has much more intense echolocation calls than the other target bat species and can be detected from greater distances using a bat detector.

The reduced detection rate for Leisler's bat relative to BATLAS 2010 and the other target bat species is not likely to be a result of a decline in its distribution, but more as a result of its seasonal behaviour. The Car-based Bat Monitoring Scheme recorded a significantly increasing trend for the species from 2003-2014 (Aughney et al., unpub). Surveyors reported having recorded Leisler's bat earlier in the 2015 season in many of the squares where it was not detected in September and October during the Pilot Project. Leisler's bat activity has consistently shown a significantly positive correlation with temperature during the Car-based Monitoring Scheme which takes place from mid-July to mid-August each year (e.g. Roche et al., 2012). This suggests that Leisler's bat may be particularly sensitive to low temperatures compared to other species. Leisler's bat is adapted by wing shape, body size and echolocation call design to flight and foraging for insects in more open airspace than the other Irish bat species (Norberg and Rayner, 1987). It is not well adapted to catching insects close to clutter of vegetation or close to the ground or water surfaces. Insects may be less available in more open airspace on cooler nights, and this may cause Leisler's bats to be inactive on cooler nights where the other species remain active due to the availability of insect prey closer to the shelter of vegetation or the surface of waterbodies. The likelihood of detecting all of the target bat species decreased later in the season as indicated by GLMMs, and particularly so for Leisler's bat.

Earlier BATLAS 2020 survey deadline

The deadline for completion of surveys was November in the 2008-2009 survey seasons for BATLAS 2010 (weather permitting with temperatures preferably >8^{o}C). An end of September deadline for completion of bat surveys is recommended for BATLAS 2020 and other future BATLAS surveys due to the reduced likelihood of detecting Leisler's bat as well as the other target species late in the season as suggested by the results of the 2015 BATLAS 2020 Pilot Project.

An earlier deadline for completion of surveys is also likely to reduce survey effort for some 10km squares. The short survey window of the late-season Pilot Project meant that some volunteers had difficulty completing surveys because of unsuitable weather conditions on the nights that they were available to survey. Temperatures dropped fast in the evenings during the Pilot Project and therefore increased the number of evenings required to complete surveys in 10km squares. The difficulty in detecting Leisler's bat, relative to the other target species, during September and October in parts of the country (despite suitable weather conditions) added to the number of sites required to complete 10km squares. Both of these factors were unusual circumstances of the late-season timing of the Pilot Project, and it is expected that the average number of sites and number of nights required to complete surveys according to the full site selection protocol for 10km squares would be reduced in future BATLAS surveys that are conducted earlier in the season.

Higher minimum temperature for surveys?

The significant positive correlation of Leisler's bat activity with temperature observed during the Car-based Monitoring Scheme, and in particular the low activity observed below 10^{o}C, suggests that increasing the minimum temperature for BATLAS 2020 surveys from 8 to 10^{o}C is likely to yield more detections of Leisler's bat. The trade-off is that the higher minimum temperature places a tighter restriction on the nights which are available to volunteers in which to carry out BATLAS surveys. This may not be such a consideration with the earlier season deadline for completion of bat surveys. The decision on minimum temperature can be made with further consideration before BATLAS 2020.

Reducing the maximum number of survey sites per 5km quadrant

The proposed site selection protocol for BATLAS 2020 surveys trialled during the 2015 Pilot Project stipulated re-surveys of all previous BATLAS 2010 sites and up to a maximum of three sites per 5km quadrant, or less if all four target species were detected earlier. There is a strong case to be made for changing the BATLAS 2020 methodology to require surveys at up to a maximum of two instead of three sites per 5km quadrant. The trade-off is between reducing volunteer survey effort and reducing bat detection rates per 10km grid square. However, surveying a maximum of two instead of three sites per 5km quadrant will reduce surveyor effort considerably, while the results of the Pilot Project suggest that there would only be a moderate reduction in the detection rates for the target bat species (section 5.5). The reduction in survey effort includes the reduced duration of overall surveys per 10km square, but also includes a substantial reduction in the time to navigate between survey sites and record data. It may make the BATLAS project more sustainable for volunteers in the long-term to reduce survey effort by reducing the number of sites per 5km quadrant. With less survey sites at which to detect the target species if possible, site selection becomes even more important.

Setting the scene for a new national network of survey sites in BATLAS 2020

Site selection is a vitally important part of BATLAS 2020 and critical to data quality and the long-term repeatability of BATLAS surveys. The new survey sites selected by volunteers as part of the upcoming BATLAS 2020 surveys will form a new baseline network of national survey sites. These sites will be re-surveyed every decade in the long-term and often by different surveyors. For this reason, an important element of BATLAS 2020 training and instruction will include clear guidance on selecting suitable bat survey sites, and recording the habitat types at each site. Sites will be chosen to be easy to find and access (even for surveyors who may not be familiar with the local terrain), and also because the sites provide potentially suitable habitat for the target species where possible in each 5km quadrant. For example, rivers or lakes which are easily accessible by road, wide enough for foraging Daubenton's bat, and where volunteers can get close enough to the bank to be able to detect them would be recommended sites. Such sites may not exist in some 5km quadrants. Clear guidance on recording habitat types at each site will also provided to volunteers, and the Fossitt Guide to Habitats in Ireland (available as an online pdf) is recommended to be included in each volunteer pack in future (Fossitt, 2000).

As well as selecting new BATLAS 2020 sites, surveyors were asked to re-survey all previous BATLAS 2010 sites in their assigned 10km square. There were some 10km squares where the previous BATLAS 2010 sites were not suitable as long-term monitoring sites for one reason or another e.g. sites not on publicly accessible land or requiring long night-time hikes to reach, or many nearby sites clustered in one 5km quadrant which would make re-surveys in that quadrant onerous for the assigned surveyor while not adding a lot of extra information on species distribution or changes therein. Such squares were not assigned during the Pilot Project. Location errors or inaccurate grid references for some BATLAS 2010 sites exist for some 10kms maps. Correction of map errors in the BATLAS 2010 dataset and removing unsuitable sites for re-surveys before BATLAS 2020 surveys is necessary for long-term repeatability of the BATLAS scheme over the decades.

User-friendly online data submission system

Development of a user-friendly online data submission system is highly recommended prior to the roll out of BATLAS 2020 surveys across the country. Such a system is an essential pre-requisite to gathering clean survey data in an efficient manner.

Such an online system will make selection and allocation of survey squares and submission and management of data easier. Selection and allocation of the volunteers' preferred survey squares would be facilitated by allowing people to view maps and aerial satellite imagery of 10km squares and 5km quadrants, and showing previously allocated squares as unavailable. Online data submission would also be facilitated by a submission form where people can either click survey points on a detailed map with satellite imagery, or enter pre-recorded coordinates online. The pre-recorded coordinates would pop up on a map so that the recorder could confirm that they are correct before submitting. Recording of the many site variables (see record sheet in Appendix I) would also be facilitated by an easily clickable submission form. There were many data returns with some missing items of information during the Pilot Project. Online submission forms can be designed to prompt the user for all data fields before the data submission is complete.

The online system could potentially be designed in conjunction with a smart phone app which would record data in the field and upload data to the online submission system and validated by the user before final submission.

The influence of habitat types and other site variables on target bat species detection

GLMMs were used to explore of the relationships between target species detection (or presence/absence) and variables such as date, time after sunset, habitat types, and lighting types (section 5.7) and yielded some interesting results. This exploration should be interpreted with the caveat that the Pilot Project dataset is relatively small, sourced from just 68 10km grid squares. The dataset that will be amassed from the upcoming BATLAS 2020 surveys overall is intended to have data from many more survey sites and originating from more than ten times as many 10km squares with as near to complete geographic coverage of the island as possible. Modelling of the data collected during the 2015 BATLAS 2020 Pilot Project suggests that it is a worthwhile endeavour to continue to collect such data during BATLAS 2020, and the potential to produce useful insights into the factors influencing the presence of the target bat species is promising.

Waterway classification and Daubenton's bat

Waterways at survey sites were marked as present or absent during the BATLAS 2020 Pilot Project. Many volunteers wrote notes about the waterways such as narrow stream, fast flowing uneven surface, clogged with vegetation etc. to highlight that the waterway was not actually suitable as a Daubenton's bat foraging site. It is recommended that a simple waterway classification is included in the recording system for BATLAS 2020, such as stream/river/pond/lake and an assessment of whether the waterway seems suitable for Daubenton's foraging. This would enrich the data on Daubenton's bat detections and possibly other target species.

As part of the All Ireland Daubenton’s Bat Waterway Survey width values, as estimated by surveyors, were categorised into five groups (from <2m to >20m) for analysis to determine its effect on the presence or absence of this species on surveyed waterway sites. This parameter was found to be highly significant with bats less likely to be present at survey spots in very narrow waterways (<10m). This variable has also been reported as significant for each previous year of the monitoring scheme at the broader scale of waterway site (Aughney et al., 2014).

As part of the online data submission recommended above, incorporating the Environmental Protection Agency's GIS layers with river classification could also help to enhance the data on waterway survey sites.

Volunteer recruitment and training

The new BATLAS 2020 scheme is more intensive than its predecessor and it requires a considerably increased amount of surveyor effort per 10km square. Therefore, a comprehensive training and recruitment programme will be required from 2016 onwards, to ensure active involvement of 'Citizen Scientists' and an adequate pool of trained surveyors to achieve coverage of the required number of 10km survey squares. There appears to be an appetite for such training and an enthusiasm for learning how to survey for bats, so BATLAS 2020 offers an opportunity to harness this enthusiasm.

Off-shore island BATLAS 2020 surveys and the 'Island Bioblitz 2016'

Bat Conservation Ireland intends to survey off-shore islands for the first time during BATLAS 2020, providing new information on the distributions of the target bat species. The island bat surveys could be carried out in conjunction with the planned ‘Island BioBlitz’ being run by the National Biodiversity Data Centre in 2016, and this is an exciting opportunity for volunteers to participate in some sociable bat field work.

Questionnaire feedback from the Pilot Project participants

Volunteer participation was impressive during the 2015 BATLAS 2020 Pilot Project and the volunteers' experiences in the Pilot Project can provide further insights. Before beginning surveys in 2016, it is recommended that feedback from the 2015 Pilot Project participants is collected via a well-designed questionnaire so that improvements can be made to the volunteer experience and survey outcomes.

Storing the Pilot Project data in Bat Conservation Ireland's database

The data for the pilot is currently stored in an excel file, with each row storing the variables for each site survey. Design of a suitable storage system for BATLAS 2020 survey data is needed to incorporate data into Bat Conservation Ireland's database.

6.1 Summary of recommendations

The proposed BATLAS 2020 method that was trialled by experienced volunteers during the 2015 BATLAS 2020 Pilot Project has provided useful insights into the practicalities of conducting the proposed surveys, and the insights and distribution maps that will emerge from the survey data. The proposed methodology appears feasible for the roll-out of BATLAS 2020, with some key recommendations as summarised below:

- Earlier deadline for completion of bat surveys.
- Possible increase of the minimum start temperature from 8 to 10°C.
- Reduce maximum number of survey sites per 5km quadrant from three to two sites.
- Clear guidance to volunteers on both site selection and recording habitat types.
- User-friendly online data submission system (possibly in conjuction with a BATLAS smart phone app).
- Correction of location errors in the BATLAS 2010 dataset and removal of sites unsuitable for re-surveys.
- Enhanced classification of waterway characteristics relevant to bat activity.
- Volunteer recruitment and training programme for BATLAS 2020 will be key to the success of BATLAS 2020.

7. References

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8. Appendices

8.1 Appendix I. Survey record sheet for each of the four 5km quadrants in 10km squares

Bat Conservation Ireland BATLAS 2020 Pilot Project 2015 Record Sheet

Use one record sheet per 5 km quadrant within your 10 km square

Name:	Email:	
	Tel. No.:	
County:	10 km Square:	5 km Quadrant (.i.e. NW, NE, SE, SW):
Bat Detector Model:		

Site A is the first site visited within the 5 km quadrant, Site B is the second etc.

	Site A	Site B	Site C
Grid Ref: Site name (e.g. Bridge/river name):			
BATLAS 2010 site? (tick if yes):			
Date (reminder to change after midnight):			
Start Time:			
Temperature (°C):			
Wind (1. Calm, 2. Light breeze, 3. Breezy):			
Rain (1. Dry, 2. Drizzle, 3. Light rain)			
Cloud (1. Clear, 2. Patchy, 3. Full)			
Lighting within 100 m? (tick if yes)			
Lighting where bats flying? (tick if yes)			
Lighting type (White, Yellow, Orange)			
Hedgerow present? (tick if yes?)			
Hedgerow type (SH, MH, ST, DT)			
Waterway present? (tick if yes)			

Bat species recorded (tick if detected)

	Site A	Site B	Site C
Unidentified bat			
Common pipistrelle			
Soprano pipistrelle			
Pipistrelle (49-51 kHz)			
Nathusius' pipistrelle			
Leisler's bat			
Myotis sp.			
Daubenton's bat			
Natterer's bat			
Whiskered/Brandt's bat			
Brown Long-eared bat			
Lesser Horseshoe bat			
Comments:			

Habitat types within 100 m – circle Site letters A to C if habitat applies.

Cultivated land	A	B	C	Salt marshes	A	B	C	Exposed rock	A	B	C	Fens/flushes	A	B	C
Built land	A	B	C	Brackish waters	A	B	C	Caves	A	B	C	Grasslands	A	B	C
Coastal structures	A	B	C	Springs	A	B	C	Freshwater marsh	A	B	C	Scrub	A	B	C
Shingle/gravel	A	B	C	Swamps	A	B	C	Lakes/ponds	A	B	C	Hedges/treelines	A	B	C
Sea cliffs/islets	A	B	C	Disturbed ground	A	B	C	Heath	A	B	C	Conifer plantation	A	B	C
Sand dunes	A	B	C	Watercourse	A	B	C	Bog	A	B	C	Woodland	A	B	C

8.2 Appendix II. Recording hedgerow categories

Where hedgerows/treelines occur in the direct vicinity of the bat survey site, the hedgerow type is recorded according to the categories:

(i) small hedgerow (SH in record sheet)
(ii) medium hedgerow (MH)
(iii) sparse treeline (ST)
(iv) dense treeline (DT)
(v) a combination of the above categories.

Where there are areas, or relatively wide strips of scrub or woodland, rather than obvious linear hedgerows or treelines, this is not counted as a hedgerow habitat, and is noted as scrub or woodland in the habitat classification section of the record sheet.

(i) Small Hedgerow (SH in Record Sheet)
Cut hedgerows less than approximately 1.5 m high where there are no, or very few, protruding bushes or trees. These type of hedgerows would provide little shelter to bats.

(ii) Medium Hedgerow (MH in Record Sheet)
Hedgerows which are approximately 1.5 - 3 m in height.

(iii) Sparse Treeline Hedgerow (ST in Record Sheet)

Cut hedgerow with trees, the canopies of which, at least for the most part, do not touch. The hedgerow itself may be cut low or medium.

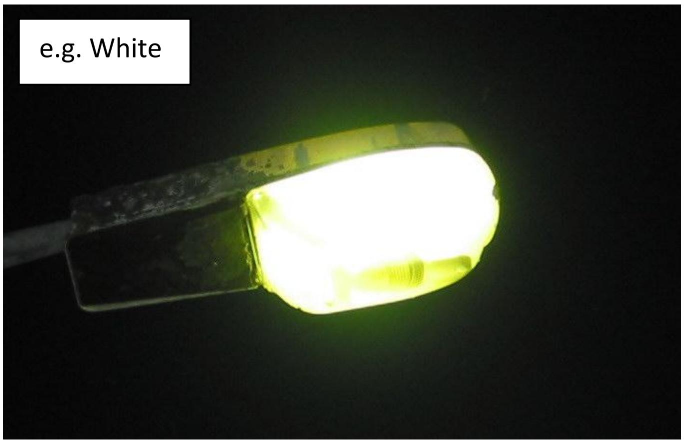
(iv) Dense Treeline Hedgerow (DT in Record Sheet)

Large uncut hedgerows or treelines, dominated by mainly large tree or very tall scrub species (e.g. tall hawthorn, blackthorn or hazel), where the canopies are mostly touching.

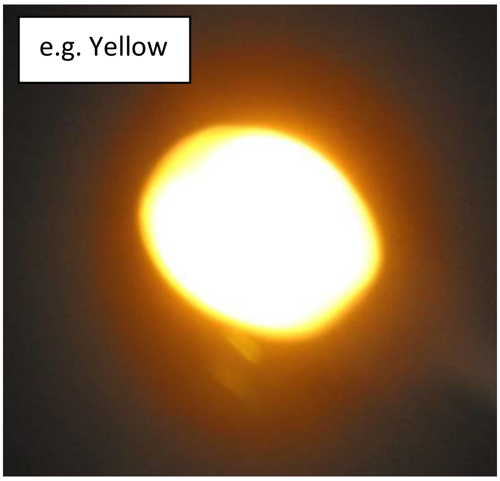
8.3 Appendix III. Recording artificial lighting categories

Artificial lighting types are categorised at survey sites according to the following guidance as

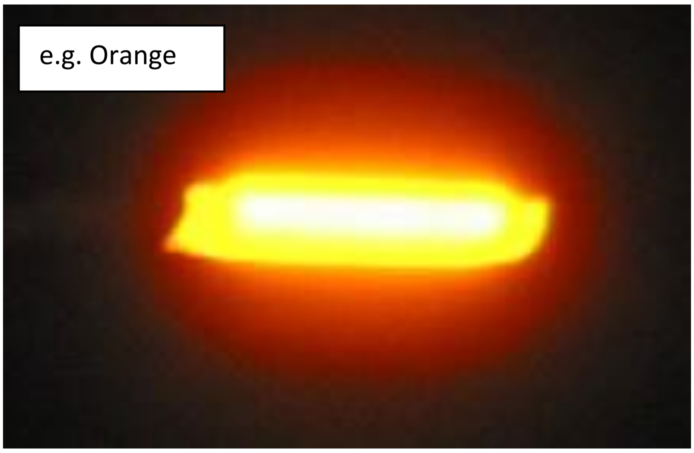
- white
- yellow
- orange



White Light: Floodlights are usually white for example.



Yellow Light: For example almost all motorway lights emit 'yellow'. Note that streetlights described as Yellow sometimes have a pinkish tinge.



Orange Light: Older streetlights often emit a bright/deep orange light

8.4 Appendix IV. Test statistics for non-significant terms in GLMMs

The results of adding each non-significant term separately to the GLMMs with the variables in the final models for each of the target bat species given in Table 7 are shown below. Missing values (-) indicate either that a term is already in the model given in Table 7, or that the model failed to converge.

Term	df	a) Common pipistrelle Chi-sq	P	b) Soprano pipistrelle Chi-sq	P	c) Daubenton's bat Chi-sq	P	d) Leisler's bat Chi-sq	P
Survey timing									
minsaftersunset		-	-	-	-	0.04	0.851	0.07	0.796
day1		-	-	-	-	-	-	-	-
Habitat types									
cultivatedland	1	0.85	0.357	0.08	0.781	0.81	0.368	0.03	0.861
builtland	1	0.7	0.403	0.74	0.391	0.37	0.541	1.85	0.174
watercourse		2.24	0.135	-	-	-	-	1.45	0.228
lakesponds		0.35	0.552	-	-	-	-	2.09	0.148
grasslands	1	0.4	0.527	3.78	0.052	2.5	0.114	0.06	0.806
scrub	1	-	-	0.81	0.369	0	0.957	-	-
hedgetreeline	1	0.03	0.872	1.62	0.203	0.04	0.846	0.53	0.467
coniferplantation	1	0	0.982	0.37	0.540	-	-	0.04	0.834
woodland	1	-	-	1.5	0.221	-	-	2.97	**0.085**
coastal		1.75	0.185	-	-	2.06	0.151	1.89	0.169
wetland	1	0.45	0.501	0.92	0.337	0.76	0.384	2.38	0.123
other	1	0.68	0.411	0.16	0.685	1.72	0.190	0	0.947
Hedgerow types									
sh	1	0.56	0.454	0.4	0.526	0.25	0.619	0.83	0.362
mh	1	0.02	0.887	0.41	0.519	0.17	0.681	1.83	0.176
st	1	1.58	0.209	2.39	0.122	0.41	0.523	1.74	0.187
dt	1	0.19	0.664	3.61	**0.058**	0.77	0.379	0.56	0.455
anyhedge	1	0.00	0.959	2.43	0.119	0.05	0.827	1.54	0.215
Weather									
wind	2	0.93	0.395	0.69	0.503	1.48	0.227	0.61	0.543
rain	2	0.12	0.891	0.29	0.748	2.57	0.077	0.22	0.803
cloud	2	0.03	0.974	0.05	0.949	0.04	0.964	2.05	0.129
Artificial light									
whitelight	1	0.25	0.617	0.11	0.744	0.86	0.355	-	-
yellowlight	1	-	-	0.5	0.479	0.16	0.689	0.35	0.553
orangelight	1	0.19	0.662	0.03	0.857	0.39	0.531	0.37	0.544
light100m	1	-	-	0.86	0.355	0.11	0.742	0.03	0.853
Geographic									
county	25	1.24	0.187	1.05	0.394	1.11	0.322	-	-
north	1	0.00	0.950	0.1	0.749	0.07	0.786	0.55	0.459
east	1	2.19	0.139	0.12	0.728	0	0.955	-	-