BATLAS 2020 – A Bat Distribution Survey

Final Report 2016-2018

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1. Executive Summary

BATLAS 2020 is an Ireland-wide bat survey distribution survey primarily funded by the National Parks and Wildlife Service with additional grants from several local authorities and district councils in the Republic Of Ireland and Northern Ireland.

It follows on from the BATLAS 2010 project which was completed in 2008 and 2009 and was the first distribution survey of its kind for bats in Ireland. It focused on the population distribution of four target species: common pipistrelle, soprano pipistrelle, Daubenton's bat and Leisler's bat and used a team of skilled 'citizen science' volunteers who surveyed 2 to 3 suitable sites within each 10 x 10 km survey square, recording the presence or absence of the target bat species along with a suite of environmental variables.

Methods for BATLAS 2020 were broadly similar to its predecessor, with the most significant change being that BATLAS 2020 incorporated more intensive levels of surveying, where possible, at a finer scale of resolution.

Thirty-seven training courses for BATLAS 2020 were delivered throughout the island of Ireland. Two hundred and thirty seven people registered their interest in participating and 121 volunteers actively surveyed and submitted data. This represented a 95% increase in volunteer participation from BATLAS 2010. Coverage also increased for the BATLAS 2020 survey from 751 to 778 10km^2 squares (representing 77% of the island). A total of 3,373 survey sites were also surveyed for BATLAS 2020 which was almost double the number of sites surveyed for BATLAS 2010.

Detection rates across target species followed a similar order to those for the BATLAS 2010 study with soprano pipistrelle being the most commonly detected, followed by common pipistrelle, Leisler's bat and Daubenton's bat. However higher detection levels were recorded during BATLAS 2020 of all species at both the 10km square and the individual site level:- at site level soprano pipistrelle increased from 63.7% to 68.0%; common pipistrelle from 40.7% to 53.9%; Leisler's bat from 32.1% to 36.1% and Daubenton's bat from 29.8% to 30.74%.

Environmental data was collected across all 3,373 survey sites providing a large data set. This provides the basis for statistical analyses exploring the comparative influence of the geographic and environmental parameters on the presence of the target bat species.

This report summarises the progress of the project through the 3 years of the study from 2016-2018 and provides relevant summaries and descriptive statistics where appropriate.

Acknowledgements

Bat Conservation Ireland would like to sincerely thank all of the volunteers who participated in BATLAS 2020. Your level of commitment to the conservation of bats across the island of Ireland is phenomenal and greatly appreciated. The success of BATLAS 2020 is due to your involvement and survey effort.

We would also like to thank the numerous bat groups that took on their local counties and populated the BATLAS 2020 database. Thank you for all of your support in relation to training courses, weekend survey trips and advice. Bat groups are the backbone to bat conservation on the island of Ireland and we appreciate your involvement.

A big thank you to NPWS for funding BATLAS 2020, particular, Dr Ferdia Marnell for his continuous support for bat conservation.

Thank you to all of the county councils, both in Northern Ireland and the Republic of Ireland, for providing additional funding for training courses and surveying.

BCIreland would also like to thank Dr Simon Pickett, principal co-ordinator and Dr Emma Boston, NI co-ordinator (2016) for their level of commitment and hard work to the BATLAS 2020 project. A big thanks to the regional trainers and surveyors for stepping in to get as much coverage as possible during the busy field seasons.

2. Introduction

2.1 BATLAS 2010

2.1.1 Overview

BATLAS 2010 was Ireland's first systematic bat distribution recording scheme that followed a standardised methodology. It was devised by Bat Conservation Ireland in 2007 and was funded in the Republic of Ireland by the National Parks and Wildlife Service ('NPWS') with assistance from the Heritage Council and in Northern Ireland by the NIEA. It was conducted during two field seasons (2008 and 2009) in the Republic of Ireland (Carden, Aughney, Kelleher, & Roche, 2010) and in 2009 in Northern Ireland (Hopkirk, Aughney, & Roche, 2010) to ascertain the distribution of four common target species - common pipistrelle, soprano pipistrelle, Daubenton's bat and Leisler's bat.

In summary, the country was divided up into 10x10km (n=1014) squares and surveys were conducted at this 10km^2 level in order to ascertain the island wide distribution of the target species. The aim was to attempt to survey a minimum of 600 10km squares in the Republic of Ireland and 120 10 km squares in Northern Ireland. The surveys were conducted primarily by a team of skilled volunteers.

Surveying of the target species was conducted in each 10km square using bat detectors. Species identification was aided in the field by visual observations of flight characteristics and an identification card designed for the survey(Roche, 2008). The four target species of BATLAS 2010 are easily distinguished from each other and relatively simple to identify in the field using heterodyne bat detectors. An on-line registration system was also provided on the BCIreland website to facilitate volunteer participation in the programme. Each surveyor was supplied with the assigned specific 10km Ordnance Survey maps (1:50,000, OSi licence: NPWS), the bat identification leaflet; a data recording sheet and, if necessary, a bat detector.

Field work was carried out only in favourable weather conditions; dry nights above 8^{o}C, starting 20-40 minutes after sunset with individual surveys lasting 10-15 minutes at each of the three or four sites selected within the 10km square. At least one of these sites was required to be adjacent to a water body, the preferred habitat of Daubenton's bat. If the surveyor detected and recorded all four target species during the first (or subsequent sites) within the assigned 10km square, further surveys were not undertaken. Additional data was recorded including start time of survey, temperature, weather conditions (cloud cover, wind and rainfall), location of survey and GPS coordinates for the survey sites. During the survey of targeted species, additional 'ad hoc', observations of other bat species were noted and recorded. 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 data record sheet. Following field work, all recording sheets were returned to the project coordinator and these records were collated on the Bat Conservation Ireland online database.

2.1.2 Summary

An all-Ireland bat distribution dataset was produced as a result of BATLAS 2010. This helped to build on our knowledge of the factors dictating bat habitat preferences, which is crucial in

devising suitable conservation policies for bats. Analyses of these data resulted in the creation of the Bat Conservation Ireland Landscape Model (Lundy, Aughney, Montgomery, & Roche, 2011) which has been a very useful tool in predicting national bat distribution based on large scale habitat characteristics.

Secondly the resulting distribution maps revealed previously unknown patterns in bat distribution across the island. It became apparent that these data were useful not only at a local, regional and national level for reporting and developing planning and policies but also for national reporting in a European context (Article 17 Reporting 2007-2012 for the Republic Of Ireland). Ultimately, the survey was an encouraging learning tool and provided both a baseline for comparing changes in bat distribution and a methodological template to be improved and refined for future national surveys of this type.

As a result of volunteer feedback, it became clear that there is an appetite for this kind of bat survey and mapping work among citizen scientists in Ireland and an eagerness to become trained in bat identification. The scheme also provided an ideal platform for many of the *Daubenton's Bat Waterways Survey* participants to improve their bat identification skills.

2.1.3 BATLAS 2010 Results - Republic of Ireland

Sixty-two volunteer surveyors participated in BATLAS 2010 in the Republic of Ireland. The majority of volunteer surveyors had participated in previous bat surveys, particularly in bat monitoring schemes managed by Bat Conservation Ireland. Training weekends were organised by Bat Conservation Ireland and additional training was provided by the BATLAS 2010 co-ordinator for the Republic of Ireland.

A total of 647/904 10km squares and 1,693 points were surveyed in the Republic of Ireland representing 71.6% of the total number of 10km squares in the country (Carden et al., 2010). Squares that were not surveyed included some off-shore islands and parts of west Kerry, south-west Cork, east Dublin, west Mayo, north Sligo and north Donegal. There were also some survey gaps in the midlands and County Tipperary (example of BATLAS 2010 map is shown in Figure 1). Bats were present in 591 and absent from 56 of the 647 10km squares surveyed in the Republic of Ireland.

Some specific distribution patterns became evident through analysis of the BATLAS 2010 data for the Republic Of Ireland. Firstly, both pipistrelle species were common and widespread and often occurred together, but the soprano pipistrelle was more common in northern and western regions of the country than the common pipistrelle, which was often absent. Daubenton's bat was recorded widely within the Republic of Ireland and it was detected in every county. However, this species was noticeably absent in coastal and upland areas. Leisler's bat was also widely distributed but was not recorded in northern regions of County Donegal, some midland areas and along exposed coastal areas of counties Sligo, Mayo, Galway, Clare, Cork, Waterford, Wexford and Wicklow. Additional records were also collected for non-target bat species including brown long-eared bats, Natterer's bats, whiskered bats, Nathusius' pipistrelle and lesser horseshoe bats (Table 1).

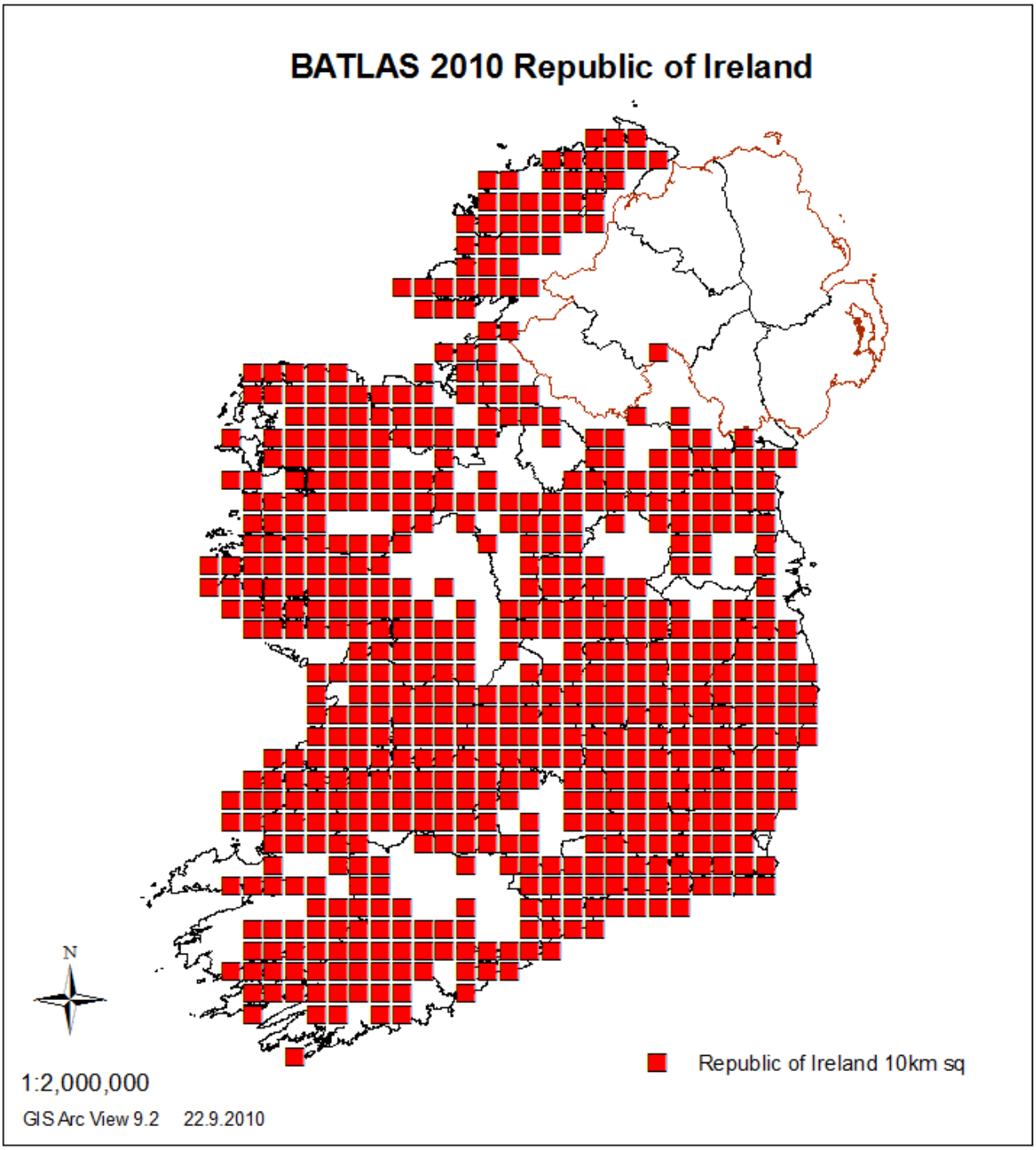

Figure 1: The distribution of the 10km squares surveyed in the Republic of Ireland for BATLAS 2010, areas without survey coverage are clearly visible where no squares are present.

Table 1: Survey results for BATLAS 2010 (Carden *et al.,* 2010). Target species are highlighted in bold.

Note: Unidentified *Pipistrellus* spp. refers to *Pipistrellus* bats echolocating between 48kHz and 52kHz which could not be definitively identified as either common or soprano pipistrelles.

Species	No. of 10km Squares Present	% of 10km Squares Present	No. of Survey Sites Present	% of Survey Sites Present
Soprano pipistrelle	551	85.1	1,079	63.7
Common pipistrelle	453	70	689	40.7
Leisler's bat	404	62.4	543	32.1
Daubenton's bat	397	61.4	505	29.8
Unidentified *Pipistrellus* spp.	81	12.5	95	5.6
Myotis spp.	212	32.7	290	17.1
Brown long-eared bat	132	20.4	148	8.7
Natterer's bat	62	9.6	68	4
Whiskered bat	20	3.1	20	1.2
Lesser horseshoe bat	15	2.3	18	1.1
Nathusius' pipistrelle	7	1.1	7	0.4
Unidentified spp	110	17	129	7.6

2.1.2 BATLAS 2010 Northern Ireland

Pre-existing records from other surveys across 131 10km squares were collated for the BATLAS Northern Ireland project, some which overlapped with squares located in the Republic of Ireland. A total of 125 10km squares had recordings of at least one target species representing 95.4% of the total number of surveys covered by the BATLAS Northern Ireland survey (Hopkirk et al., 2010). Forty-two 10km squares had all four target species recorded (32.1%) (See Figure 2). Soprano pipistrelle was recorded in the highest number of 10km squares (n=108, 82.4%) followed by common pipistrelles (n=106, 80.9%) while Leisler's bats were recorded in 76 10km squares (58%) and Daubenton's bats were recorded in 79 10km squares (60.3%) (See Table 2). Nathusius' pipistrelle was recorded from 13 locations within twelve 10km squares.

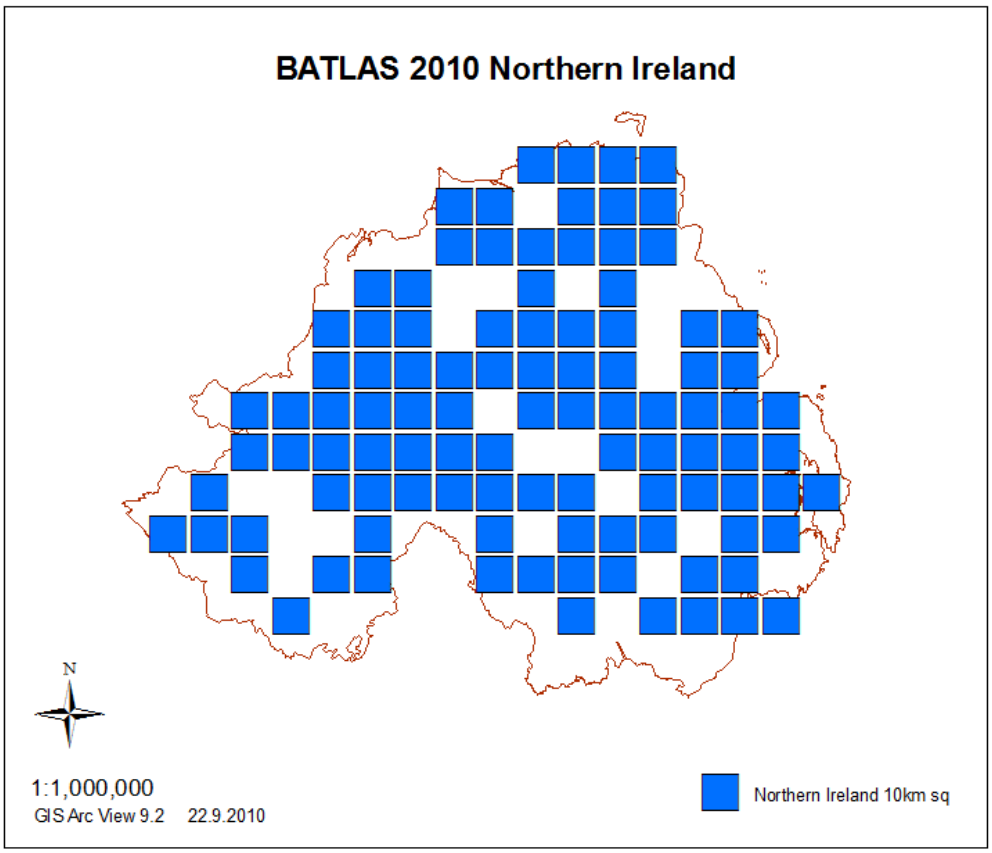

Figure 2: The distribution of the 10km squares surveyed in Northern Ireland for BATLAS 2010, areas without survey coverage are clearly visible where no squares are present.

Table 2: Records collated for the BATLAS Northern Ireland Project per 10km square (the four target species are highlighted in bold).

Note: Unidentified *Pipistrellus* spp. refers to *Pipistrellus* bats echolocating between 48kHz and 52kHz which could not be definitively identified as either common or soprano pipistrelles.

Species	No. of 10km Squares Present	% of 10km Squares Present
Soprano pipistrelle	108	82.4
Common pipistrelle	106	80.9
Daubenton's bat	79	60.3
Leisler's bat	76	58.0
Unidentified *Pipistrellus* spp.	17	13.0
Nathusius' pipistrelle	12	9.2
Brown long-eared bat	34	26.0
Myotis species	32	24.4
Natterer's bat	31	23.7
Whiskered bat	11	8.4

2.1.3 BATLAS 2010 All Ireland

A total of 751 10km squares were surveyed across the island of Ireland. Figure 3 details the distribution of all four target bat species from BATLAS 2010.

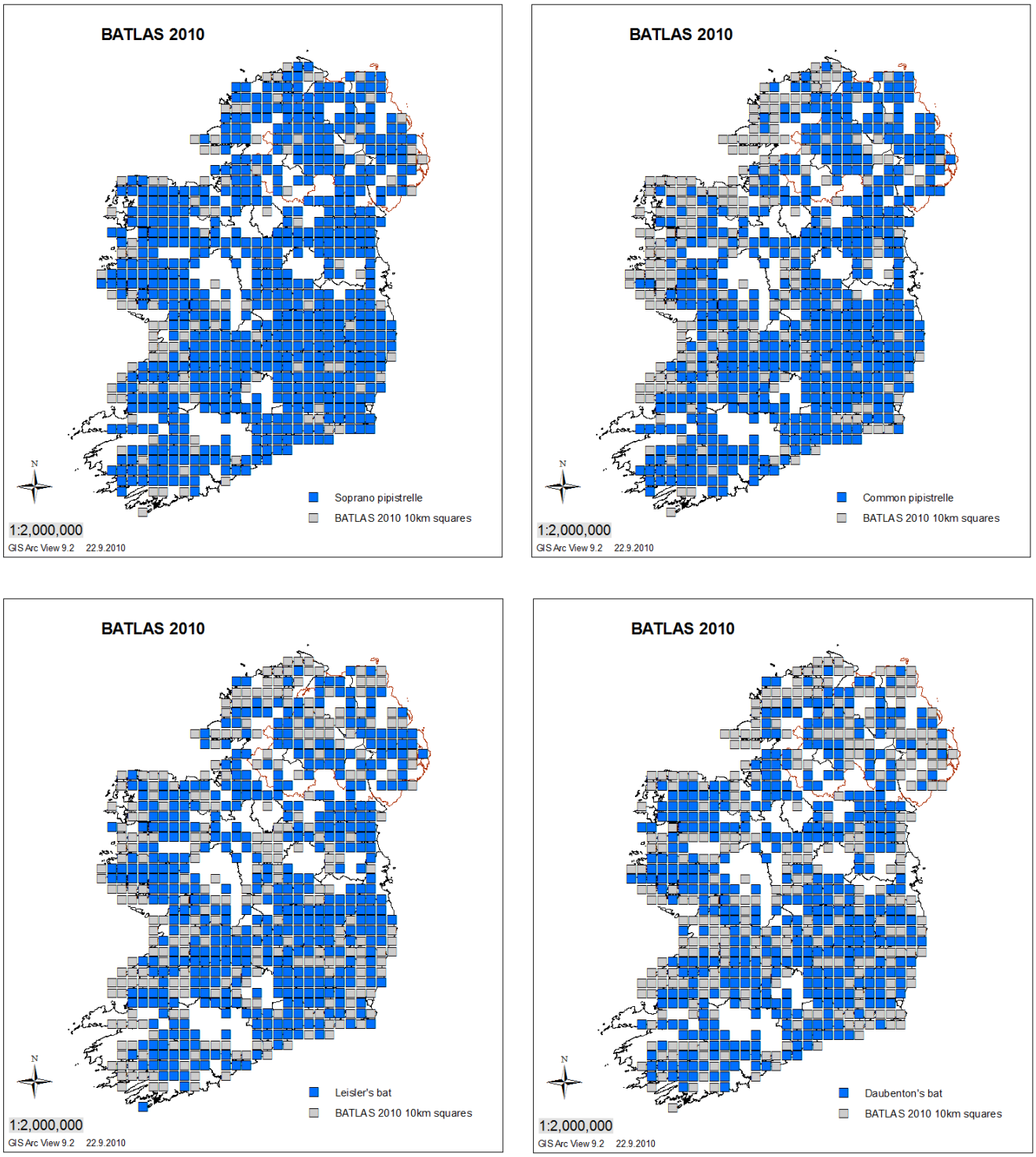

Figure 3: All Island bat distribution per 10km square of the four target bat species as reported by BATLAS 2010. Blue square indicates the presence of the target bat species and Grey square indicates the absence of the target bat species.

Table 3: Records collated for the BATLAS 2010 project across all of Ireland (the four target species are highlighted in bold). Note: Unidentified *Pipistrellus* spp. refers to *Pipistrellus* bats echolocating between 48kHz and 52kHz which could not be definitively identified as either common or soprano pipistrelles.

Species	No. of 10km Squares Present	% of Surveyed 10km Squares Present	No. of Survey Sites Present	% of Survey Sites Present
Soprano pipistrelle	639	85.1	1,079	63.7
Common pipistrelle	538	71.6	689	40.7
Leisler's bat	466	62.1	543	32.1
Daubenton's bat	444	59	505	29.8
Unidentified *Pipistrellus* spp.	93	12.4	95	5.6
Myotis spp.	236	31.4	290	17.1
Brown long-eared bat	157	20.1	148	8.7
Natterer's bat	84	11.2	68	4
Whiskered bat	30	4	20	1.2
Lesser horseshoe bat	16	2.1	18	1.1
Nathusius' pipistrelle	17	2.3	7	0.4
Unidentified species	109	14.5	129	7.6

2.2 BATLAS 2020 Pilot 2015

2.2.1 Overview

In September 2015 Bat Conservation Ireland was grant-aided by NPWS to pilot a BATLAS 2020 methodology (Abbott, Aughney, Langton, & Roche, 2015). The proposed approach was similar to that of BATLAS 2010, however with increased surveying. In addition to re-surveying the previous BATLAS 2010 sites, it was proposed for BATLAS 2020 that additional survey sites should be chosen and surveyed in a systematic fashion; at least 2 sites in each of the four 5km x 5km quadrants within a 10km x 10km square would be surveyed (i.e. each 10km square would be surveyed at least 8 sites). The increased survey intensity would result in production of more detailed distribution maps and would be compatible with the 5km resolution of Bat Conservation Ireland's Bat Landscape Model. Another benefit of this approach was that it should eliminate gaps in previous BATLAS 2010 survey coverage and potentially give additional insight into the factors driving changes in the distributions of the target bat species. In addition to recording habitat types during BATLAS 2020, surveyors would also record information on artificial lighting and hedgerow types, factors which may also influence bat activity.

The aim for the 2015 BATLAS 2020 Pilot was to survey a minimum of 50 10km squares for the four target bat species while testing the new BATLAS 2020 protocol with volunteers. Those who were already confident in identifying the four target bat species using a bat detector were sought for participation in the Pilot Project.

2.2.2 Volunteer recruitment

The BATLAS 2020 Pilot Project commenced in September 2015 and was completed by 22 October 2015. A cohort of experienced volunteers who were familiar to Bat Conservation Ireland staff were approached to participate, the majority of whom owned their own acoustic bat detector equipment and were confident at identifying the four target bat species. These volunteers also already had survey experience with Bat Conservation Ireland, either through the BATLAS 2010 project(Carden, Aughney, Kelleher, & Roche, 2010) or the All Ireland Daubenton's Bat Waterways Survey (Aughney, Langton, & Roche, 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 Coordinator batlas@batconservationireland.org.

2.2.3 Surveying Summary

Volunteers were assigned a unique 10km grid square which was convenient for them to survey. Surveying could be spread over a number of nights where necessary. Survey squares were either previously surveyed BATLAS 2010 10km squares or new BATLAS 2020 10km squares. Each surveyor was emailed a volunteer pack with:

- An OS map of the assigned 10km grid square, divided into four 5km quadrants, showing the locations of any BATLAS 2010 sites
- Finer scale 1km maps of previous BATLAS 2010 sites within the 10km square

- An instruction manual for the survey including a worked example of a survey of a 10km square
- Survey record sheets.

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

- Re-survey all previous BATLAS 2010 sites in the 10km square
- Survey at least one survey site within each of the 5km quadrants within the 10km square
- Record environmental data including
  - The presence/absence of 18 habitat categories
  - The presence and type of artificial light were relevant
  - The presence and characteristics of hedgerows
  - The width of any waterbodies present
  - Weather data.

2.2.4 Results Summary

Forty-seven surveyors participated in the Pilot Project and conducted bat surveys at 548 survey sites in 68 10km squares throughout the island (Figure 4). A total of 130 sites (23.7%) 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. 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 (5km - 26.5%, sites - 53.0%), and Leisler's bat were the least likely to be detected (5km - 22.1%, sites - 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).

2.2.5 Analysis

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 (Table 4). 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.

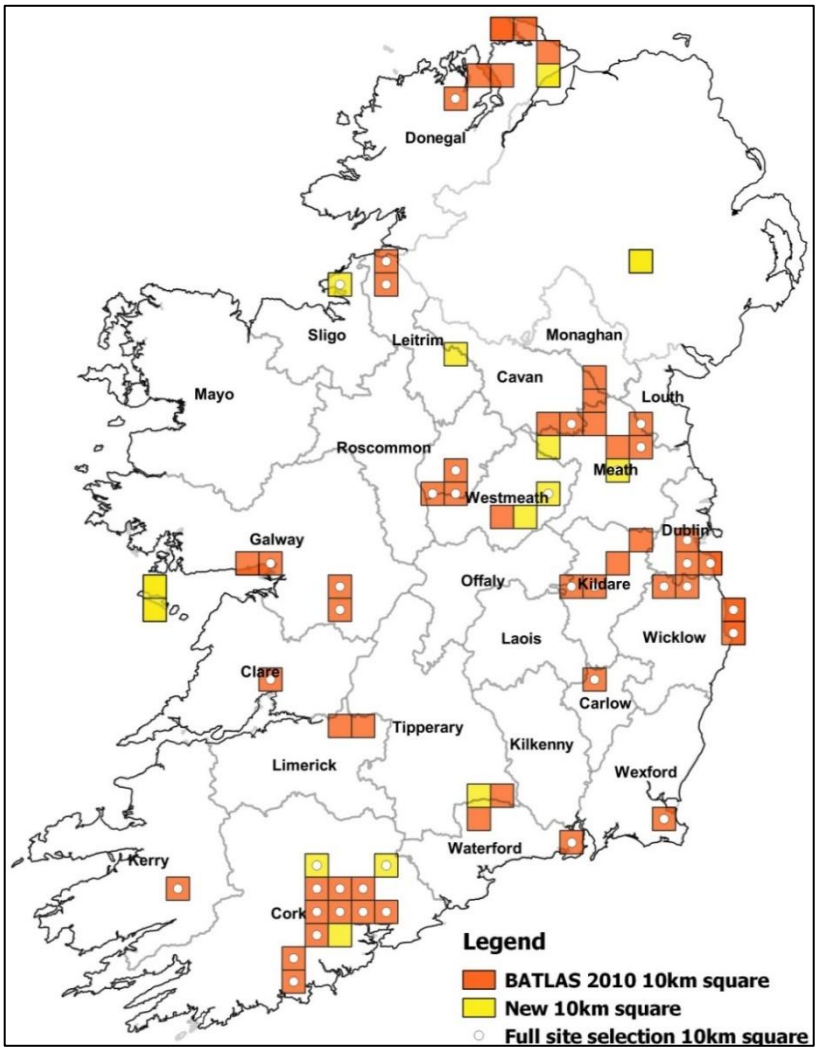

Figure 4: Overview map showing the 10km squares surveyed as part of the BATLAS 2020 Pilot Project indicating 10km squares previously surveyed during BATLAS 2010 in orange (n=54) and new 10km squares surveyed during the BATLAS 2020 Pilot Project in yellow (n=14). The central white dot inside squares denotes 10km squares which were surveyed in full accordance with the site selection protocol (n=41).

Table 4: 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 (Abbott *et al.,* 2015). ** Daubenton's bat was detected at 41.5% of 349 survey sites with a waterway.

Species	% of sites present	% of 5km quadrants present	*% of 'full' 5km quadrants	% of 10km squares	*% of 'full' 10km squares
Soprano pipistrelle	62	82.3	85.9	91.2	97.6
Common pipistrelle	48.4	78.1	80	97.1	100
Daubenton's bat**	26.5	53	58.4	77.9	87.8
Leisler's bat	22.1	42.8	43.2	63.2	56.1

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 as the survey season progressed. GLMMs also indicated for example that artificial lighting influenced the detection of common pipistrelle and Leisler's bat, with common pipistrelles less common at lights and Leisler's bats more abundant. 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.

Due to the small sample size of the pilot project caution must be applied in over-generalising these findings.

A high level of volunteer survey effort was involved in completing the pilot 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. Mean temperature decreased rapidly through the BATLAS 2020 Pilot Project period which stifled progress to an extent. 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 extended completion date for the Pilot Project.

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

- 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.
- The development of an online user-friendly data submission system before the roll out of BATLAS 2020
- Clearer guidance on how to select 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 was considered a priority. In many cases the BATLAS 2010 sites were deemed as non-optimal for future surveys, so new sites were selected for BATLAS 2020 in these cases, it was important that these new sites were optimal for future surveying
- Mapping errors of BATLAS 2010 sites were flagged as an issue, ensuring the accurate mapping of grid references for BATLAS 2020 was a priority
- Clearer guidance on how to record habitat data was flagged as a potential area for improvement
- Recording additional waterway habitat characteristics data in order to improve the level of detail of environmental information

It was determined that recruitment and training of new volunteers would be essential 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 was encouraging and it was considered that the project offered 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'.

3. BATLAS 2020 – Preparation, training and support

The scheme co-ordinator was recruited in June 2016. The main responsibilities of the Coordinator were to manage the team of volunteers and data produced from the survey as well as participate in BATLAS 2020 surveying.

3.1 Aims and Objectives

The BATLAS 2020 methodology closely follows the protocols trialed during the BATLAS 2020 Pilot Project, the key objectives were as follows:-

- Recruit a team of 'citizen science' volunteers
- Provide both in-person and remote training resources for volunteer teams
- Survey of at least 80% of the 1014 10km squares the country (i.e. > 811) under BATLAS 2020
- Survey a selection of off-shore islands
- Provide bat detectors, where required.

For each survey square, the primary goal was to:-

- Survey at least two sites within each of the four 5km^2 quadrants (i.e. North-West, North-East, South-West, South-East) recording the presence/absence of the four target species.
- Where possible, re-survey previous BATLAS 2010 sites taking into account factors such as accessibility, habitat suitability, potential mapping errors and suitability for future BATLAS surveys (new sites to be selected over 2010 sites if there were any more suitable options).

3.2 Recruitment and Enrolment

Volunteers were invited to select their own survey square(s). Upon registration, participants were sent a volunteer pack containing all the relevant information required to complete the survey which contained:

- A detailed BATLAS 2020 Manual. This was updated annually and included detailed survey instructions and information on how to submit results.
- A set of Ordnance Survey maps at various scales including:
  - An overview map of the assigned 10km grid square, divided into the four 5km quadrants, and showing the locations of any BATLAS 2010 sites.
  - Finer scale 1km maps of any BATLAS 2010 sites within the 10km square.
- Survey record sheets (see Appendix A).

3.3 Survey Methods

3.3.1 Survey Site Selection

Using the maps provided and online resources (such as google 'streetview') volunteers were instructed to choose suitable survey sites, selecting previous BATLAS 2010 sites only when they were suitable and the best option in terms of habitat suitability.

Sites were chosen on the basis that they were:-

- Accessible and safe, so that potential surveyors could easily find and access the site again in the future if required.
- Contained vegetation cover and/or aquatic habitat suitable for foraging bats. Given the strong association of Daubenton's bats with freshwater, volunteers were encouraged to try to select sites with good bat habitat near waterbodies to increase the likelihood of detecting this species.
- Since the aim was to maximise the likelihood of finding all four target species within each 5km^2 quadrant, volunteers were encouraged to choose secondary sites 'on the fly' where possible, after taking stock of the species were recorded at the first site. For example, if Daubenton's bat were not recorded on the first site, it would be recommended targeting any freshwater waterbodies within the 5km^2 quadrant to increase the likelihood of recording Daubenton's bats for that quadrant.

3.3.2 Surveying Instructions

Bats were surveyed at each site using bat detectors broadly following protocols set out with the BATLAS 2010 survey, but with some improvements to the survey structure.

Volunteers were recommended to:-

- Survey up to a maximum of two sites per 5km quadrant where possible, however if all four target species were detected in the first site, it was not required to visit a second site (i.e. the quadrant is finished).
- Choose a survey route in advance which minimised distance travelled in order to maximize efficiency of effort (sites could be surveyed in any order with respect to quadrants).
- Survey for a maximum of 10 minutes per site or until all four target species were detected, whichever comes sooner (i.e. if all four target species were recorded in less than 10 minutes, the volunteer was not required to stay longer).
- Complete the survey between 1st May and 15th September for each survey year inclusive, preferably on nights with the following conditions:
  - Still to relatively calm or light breezes/winds
  - Dry to light rain
  - Relatively warm temperatures >8°C.
- Survey at any time of the night between 40 minutes after sunset and 30 minutes before sunrise. The start time was increased from parameters set out in BATLAS 2010 instructions (20-40 mins after sunset). This change was introduced after feedback and analysis of the 2010 survey results, which suggested that Daubenton's bat typically may not appear at foraging sites until at least 40 minutes after sunset.

The instructions in the graphics below detail those provided to volunteers:

BATLAS 2010 Survey Sites

1. You will receive a map of your chosen 10km square, similar to the map shown to the right.
2. On this map, previously surveyed BATLAS 2010 survey sites will be marked in RED TRIANGLES. You will receive a separate 1km map representing each of these survey sites.
3. On your map, four 5km quadrants will be marked as shown in the example to the right. This will allow you to determine the survey effort required for your chosen 10km square.
4. It is important to note that you are surveying within **each 5km quadrant**, covering quadrants in any order you wish. Up to a maximum of **2 sites per quadrant** are typically required, to include BATLAS 2010 Sites as the first priority. A few 10km squares may have more than 3 BATLAS 2010 Sites in a single 5km quadrant, and the **two most suitable and accessible** will be re-surveyed.
5. Please go to each of the BATLAS 2010 Sites (RED TRIANGLE) with your bat detector and survey for a maximum of 10 minutes. If you detect all four target species earlier you do not need to stay for the full 10 minutes. Please note which species you record on your Record Sheet.
6. If there are **two or more** BATLAS 2010 Sites in a 5km quadrant, then that completes surveys in that quadrant regardless of whether all four target species have been detected, and you move to the next 5km quadrant in your 10km square(s). **There is no need to select New Sites where there are two or more BATLAS 2010 sites within a 5km quadrant.**

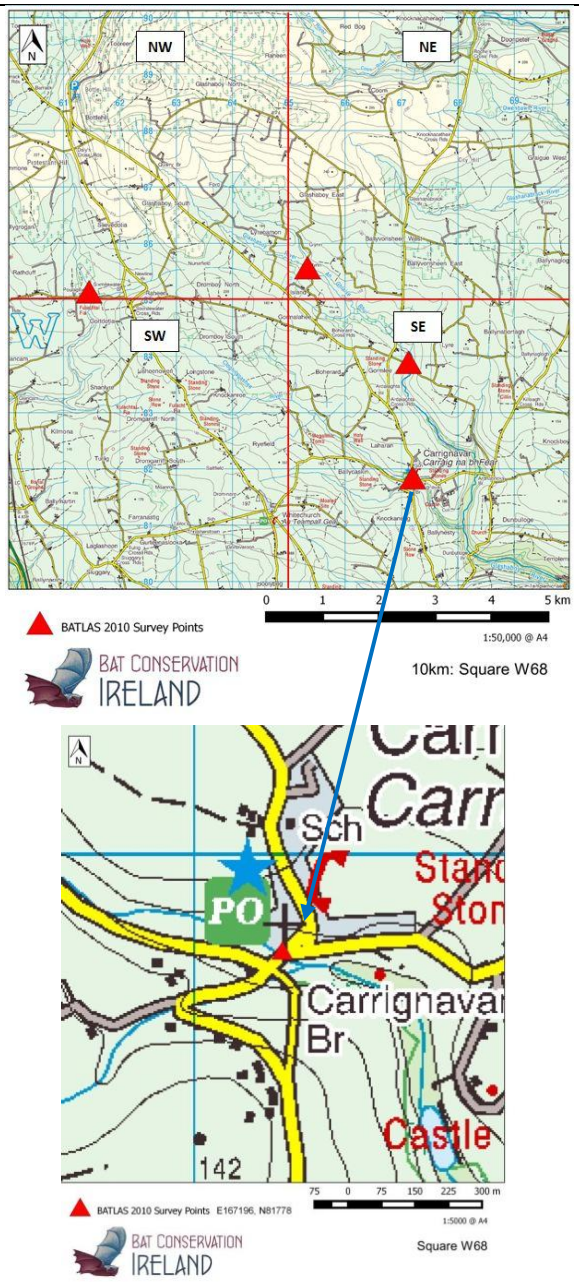

Figure 5a: Example of instructions provided for volunteer surveyors.

New BATLAS 2020 Survey Sites

1. If, within a 5km quadrant, you have not recorded all four target species from the existing BATLAS 2010 Sites (combined) AND where there are less than one BATLAS 2010 Sites, then you select New Sites up to the maximum of 2 sites per quadrant (to include BATLAS 2010 Sites).
2. Select sites where it is likely that you will detect the remaining species for the 5km quadrant e.g. watercourse for Daubenton's Bat.
3. Please choose New Sites with accessibility in mind, so that other surveyors could easily repeat your survey in the future.
4. Note the coordinates of your New BATLAS 2020 Site or mark on the map and find coordinates at home. E.g. on www.gridreference.ie
5. BATLAS 2010 Sites may not exist in some 5km quadrants. In this case, please select up to a maximum of 2 New Sites in the quadrant, at least one to include a water body since this is the preferred habitat of Daubenton's Bat.
6. If you detect all four target species during your first site survey, you move onto the next quadrant with no need to survey the remaining one or two sites

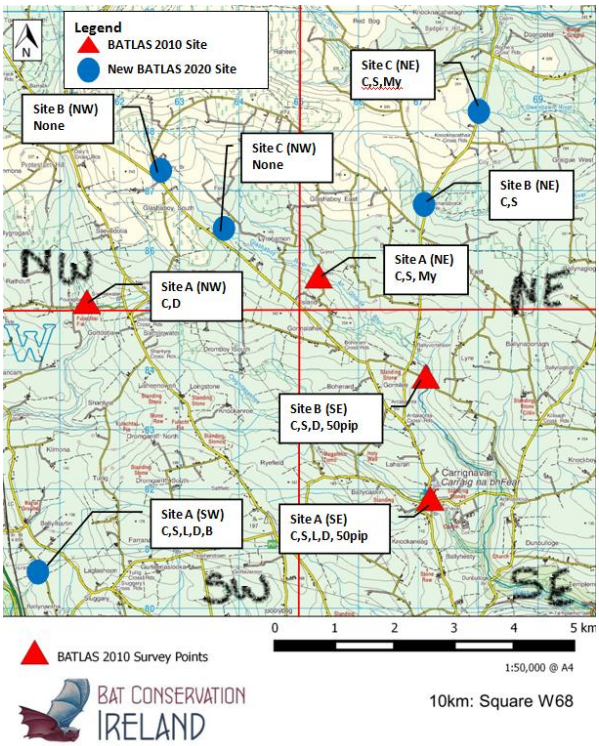

Figure 5b: Example of instructions provided for volunteer surveyors.

3.3.2 Recording information

One record sheet was used per 5km quadrant (Appendix A), quadrants were named and labelled according to location (e.g. 'NE' being the North-East quadrant) and all sites were mapped using the 10-digit Irish Grid reference accuracy (e.g. O 00676 72750). Surveyors recorded the presence/absence of all bat species per site, along with the following information:-

- The site name (e.g. bridge or river name)
- The survey square reference with 10km square and quadrant names (e.g. "C42NW")
- The site reference number (i.e. "1" or "2")
- The site location in Irish Grid coordinates
- The bat detector model used
- Survey start time
- Date
- Weather including temperature, cloud cover, precipitation and wind

- The presence and type of hedgerows present within 100m of the survey site (hedgerow types are detailed below)
- The presence and type of artificial lighting (lighting type categories are detailed below)
- The presence/absence of 24 broad habitat types as per Fossitt (2000)
- The width of any waterways present within 100m of the survey location.

Hedgerow Categories

Where hedgerows/treelines occurred in the direct vicinity of the bat survey site (within 100m), the hedgerow type was recorded according to the categories described in more detail below with example pictures (Please see Appendices for photograph examples):

- Dense tree line (DT)
- 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 tree lines, this was not counted as a hedgerow habitat, and was noted as scrub or woodland in the habitat classification section of the record sheet.

Artificial Lighting Categories

Surveyors recorded whether there was artificial lighting e.g. street lighting within 100m of survey sites, and if so noted if there were bats actively foraging around the lights. The presence/absence and type of all artificial street lighting within 100m of the survey site was recorded. Lighting type was categorised in a similar way to Bat Conservation Ireland's annual Car-based Monitoring Scheme(Roche et al., 2011), with the following categories used:

- White Light: Usually the brightest lights, security lights and floodlights are most often white for example. The modern LED (or "blue" light) should be included in this category
- Yellow Light: For example almost all motorway lights emit 'yellow'. Note that streetlights described as Yellow sometimes have a pinkish tinge
- Orange Light: Becoming less common, older streetlights often emit a bright/deep orange light

3.4 Island Surveys

Offshore island surveying was considered one of BATLAS 2020 goals. After trialling island surveying during the "Island BioBlitz" in 2016 on a number of islands (Cape Clear, Bere Island, Inismor and Clare Island), it was decided that a slightly different methodology from the standard BATLAS 2020 protocols was required to improve the efficacy of surveying on islands. Because of the lower densities of bats on islands and the difficulties of finding suitable survey sites, it was apparent that selecting only two points within each 5km square was not optimal. Instead it was considered that surveying along a walked transect was more appropriate, and only when bats were detected, the volunteer would stop and record bat activity and environmental information in accordance with standard protocols for the main survey.

A specific Island Survey Manual was drawn up for volunteers in preparation for the 2017 survey season onwards, the following methods were incorporated into the island survey manual:-

- During the daytime, walk or cycle the island looking for safe and potentially suitable survey sites within each 5km quadrant.
- Determine if there is a safely accessible survey transect of approximately 1km in length per each 5km quadrant. Transects may cross 5km quadrant boundaries, but please make an attempt to survey at least 1km within each quadrant.
- Start walking transects across the island 40 minutes after sunset. Where bat activity is found, stand for 5 minutes and record information as required by the standard BATLAS 2020 form (make sure to make a record of the grid reference and time etc).
- Continue until 1km transect is completed, following Step 3 every time bats are encountered along the 1km transect.
- Complete all 1km transects (to complete the island you should have surveyed inside all the accessible 5km quadrants).
- You have the option of surveying a second 1km transect within the same 5km quadrant if the first one does not yield any bat activity. This alternative transect can be prepared in case the first transect does not work out.

Volunteers were encouraged to survey on islands whenever possible, regional bat groups organised specific island survey trips (for example the Northern Ireland Bat Group completed survey trips to Rathlin island and Árainn Mhór in 2017 and 2018 respectively).

3.5 Statistical Methods

The relationship between the presence or absence of each species of bat and habitat variables was examined by fitting generalised linear mixed models (GLMM) with binomial errors. The response variable was a 1 if the species was present or 0 otherwise. Random terms were fitted for the 10km squares, quadrants within 10km squares, and years within quadrants, although only the 10km square term is large. Large-scale geographic trends were fitted using quadratic polynomial terms of northings, eastings and their interaction. Polynomial terms for day number in year were used to allow for temporal changes in presence/absence during each season, and between year differences were fitted as a fixed term. Similarly, polynomial terms for time after sunset were fitted to adjust for the time during the night when the survey was conducted. Terms were added to the model using a stepwise procedure with P=0.05 taken as the criterion for inclusion of a term. The starting point for each model was the model fitted when the data was previously analysed in 2015. The stepwise procedure was halted when no further terms could be added or removed.

4. BATLAS 2020 – Training & Support

4.1 Equipment

A combined pool of 26 heterodyne bat detectors were available for loan to BATLAS 2020 volunteers in 2016-2018 in the Republic of Ireland with an additional five detectors available in Northern Ireland through the Northern Ireland Bat Group (NIBG). A database was set up to manage bat detector loans to volunteers in April 2017. Thirty-four volunteers availed of bat detector loans throughout 2016-2018.

4.2 Training Courses

A pre-prepared BATLAS 2020 training talk (~60 minute Powerpoint presentation) was made available both for training courses and through the online training resources. This was refined prior to each survey season. A total of 37 BATLAS 2020 training nights were delivered across the island in 2016-2018 by the team of seven trainers (Table 5 and Figure 6), 26 of which were delivered in the Republic of Ireland. In addition, survey weekends were organised by the Northern Ireland Bat Group for Rathlin Island (Co Antrim) and Árainn Mhór Island (Co Donegal).

The training nights consisted of the verbal presentation followed by a practical demonstration of the survey techniques outside in a suitable location. The practical demonstration included training on locating bats using heterodyne detectors and identifying to species level using echolocation characteristics along with aspects of bat behavior, it also detailed how to record the required environmental data and submit results. The training courses attracted approximately 500 attendees in total across Ireland. Figure 6 maps the location of all the official training courses from 2016-2018.

Table 5: BATLAS 2020 training courses 2016-2018.

Location	Northing	Easting	Date	Trainer
Village Pub, Glasson, Co. Westmeath	209086	246845	08/07/2016	Tina Aughney
Creggan Country Park, Derry, Co. Derry	241792	417041	27/07/2016	Emma Boston
Cultra Manor, Cultra, Co. Down	342498	380116	28/07/2016	Emma Boston
Galway University, Galway, Co. Galway	129071	225960	10/08/2016	John Curtin
Ballyard, Tralee, Co. Kerry	83247	113435	25/04/2017	Tina Aughney
Library Seminar Room, Sligo IT, Co. Sligo	169285	336337	26/04/2017	Tina Aughney
GMIT Ecology Class, Castlebar, Co. Mayo	113606	289675	27/04/2017	Tina Aughney
Maghera, Co. Cavan	263981	285126	28/04/2017	Tina Aughney
Crom Estate, Co. Fermanagh	236628	324571	02/05/2017	Simon Pickett
An Creagan, Omagh, Co. Tyrone	262335	378920	03/05/2017	Simon Pickett
Glenveagh Visitors Centre, Co. Donegal	204059	423074	10/05/2017	Simon Pickett
Roe Valley Country Park, Limavady, Co. Derry	267947	420293	11/05/2017	Simon Pickett
Pullough School, Pullough, Co. Offally	219200	225203	17/05/2017	Tina Aughney
Kilkenny River Court Hotel, Co. Kilkenny	251026	155991	24/05/2017	Tina Aughney
Newbridge Library, Newbridge, Co. Kildare	280676	215316	25/05/2017	Tina Aughney
Malahide Castle, Dublin	322096	245438	25/05/2017	Kevin Delahunty
Antrim Castle Gardens, Co. Antrim	314481	387051	30/05/2017	Emma Boston
Clothworthy, Randalstown, Co. Antrim	308225	390192	30/05/2017	Emma Boston
Moira Demesne, Moira, Co. Down	314775	360680	01/06/2017	Emma Boston
Cabra Wetlands, Thurles, Co. Tipperary	213324	156250	05/06/2017	Tina Aughney
Focus Family Resource Centre, Killeshandra, Co. Cavan	231100	307118	08/06/2017	Ben Quinn
St Catherines Park, Lucan Demesne, Dublin	301679	236337	09/06/2017	Kevin Delahunty
Thomastown Community Centre, Thomastown, Co. Kilkenny	258458	141378	12/06/2017	Tina Aughney
Roscrea, Birr, Co. Offally	225984	185872	14/06/2017	Tina Aughney
Ballyconnell, Co. Cavan	227186	318510	17/06/2017	Ben Quinn
Leitrim County Library, Leitrim, Co. Leitrim	212761	311423	22/06/2017	Ben Quinn
Johnston Centre, Wexford County Hall, Wexford, Co. Wexford	302133	116640	22/06/2017	Tina Aughney
Galway University, Galway, Co. Galway	129071	225960	06/07/2017	John Curtin
NUI, Galway, Co. Galway	129081	225944	13/07/2017	John Curtin
Ennis School, Co. Clare	133342	177695	20/07/2017	John Curtin
Carnfunnock Country Park, Larne, Co. Antrim	338273	406729	04/08/2017	Simon Pickett
Kiltonga Church, Newtownards, Co. Down	347200	374480	11/08/2017	Emma Boston
Manor Hotel, Abbeylix, Co. Laois	243548	184083	14/08/2017	Tina Aughney
Wexford County Hall, Wexford, Co. Wexford	303142	122209	16/08/2017	Tina Aughney
Rathlin Island, Co. Antrim	314926	450552	19/08/2017	Simon Pickett
Limerick Library, Limerick, Co. Limerick	157979	157361	08/05/2018	Tanya Slattery
Arranmore Island, Co. Donegal	168142	415866	25/08/2018	Simon Pickett

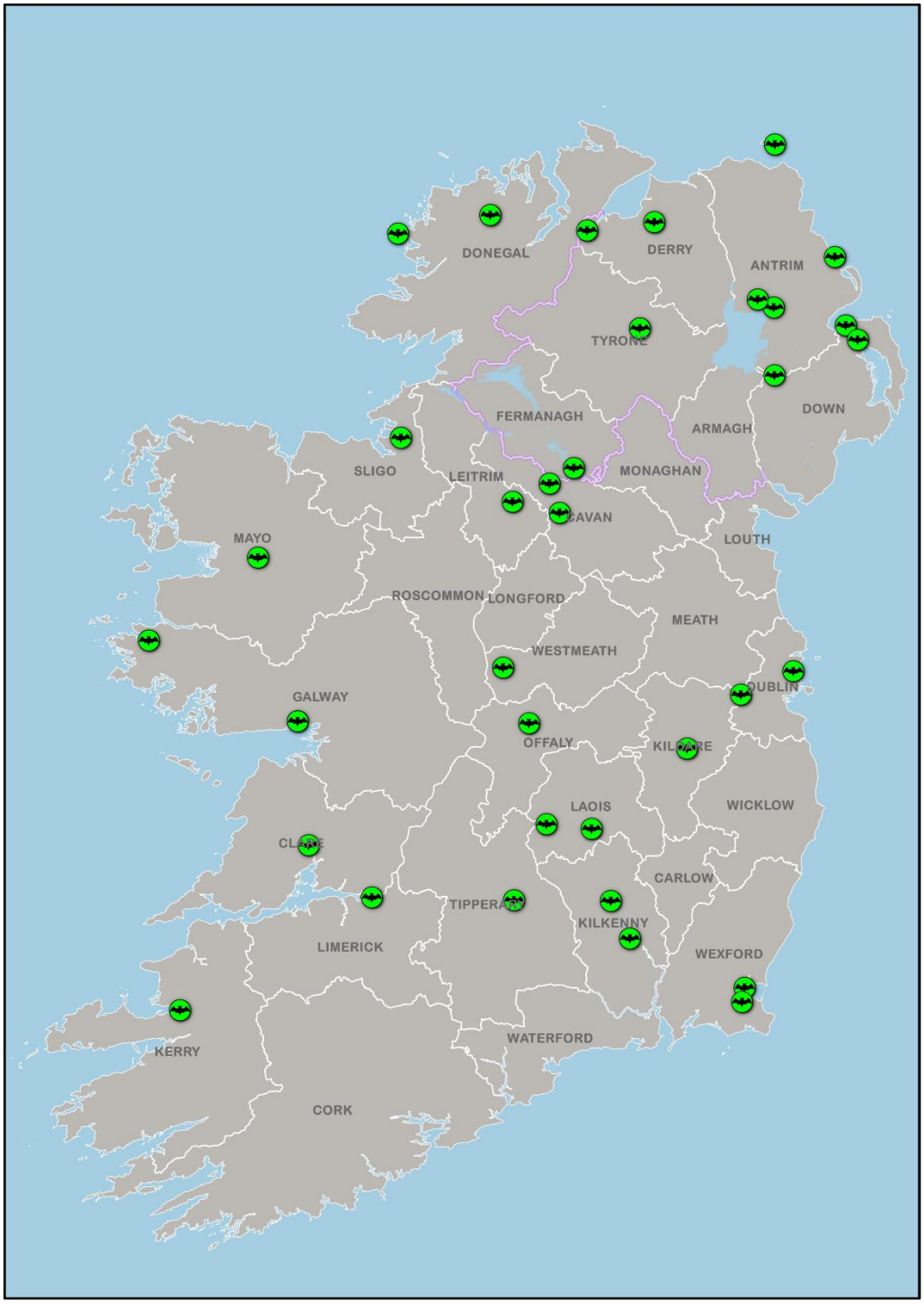

Figure 6: BATLAS 2020 training courses 2016-2018.

4.3 Remote resources

- Following volunteer feedback, an instructional video for BATLAS 2020 was produced in 2017 focusing on how to register and submit results online and uploaded to You Tube. This acts as a guide to volunteers to help them through the process and supported the survey manual.
- A library of bat calls was also uploaded to the BATLAS 2020 website to aid volunteers with bat identification.
- A Googlemap BATLAS 2020 map was developed by the Coordinator in 2017. This overlaid the BATLAS 2020 survey squares and survey sites onto an interactive Googlemaps map (Figure

7a). The survey squares were colour-coded according to their registration status and the map is automatically updated when volunteers either register for new squares or when new results are submitted (Figure 7b). The map allowed potential volunteers to easily view the available survey squares during the registration process, track the progress of BATLAS 2020 and choose suitable sites for their survey.

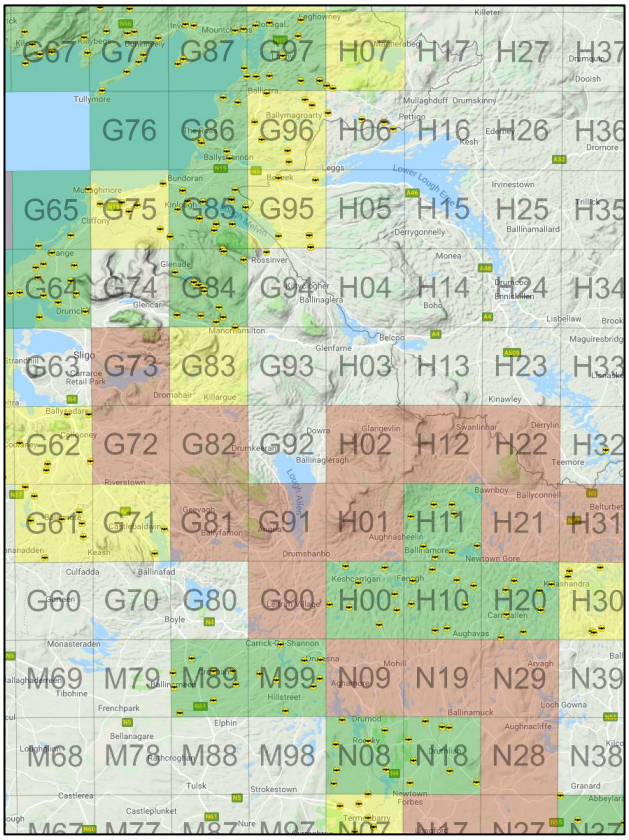

Figure 7a: BATLAS 2020 "Googlemaps"

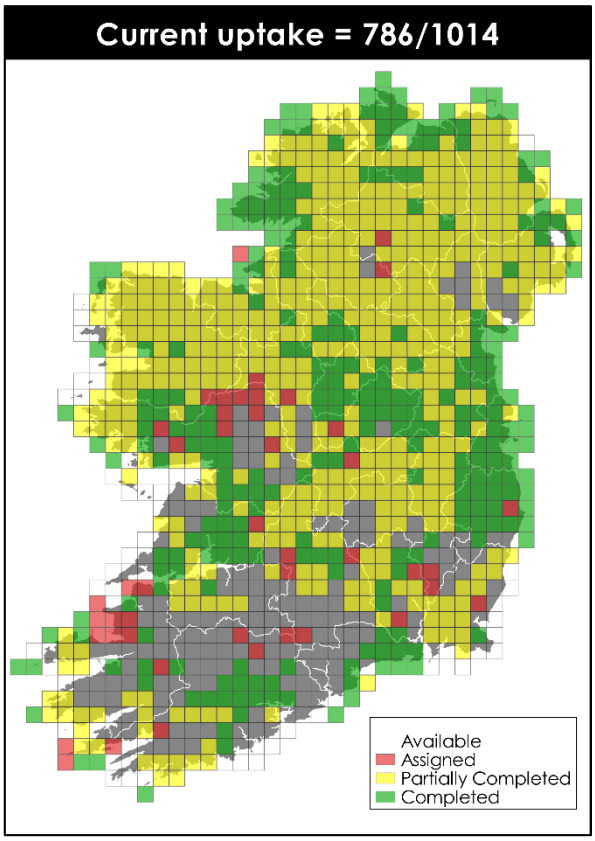

Figure 7b: BATLAS 2020 "Live uptake"

A mapping system (using Quantum GIS (Quantum GIS Development Team, 2016)) was created by the Coordinator which automatically generates live volunteer registration uptake maps (Figure 7b) and distribution maps for all bat species and uploads them to the website when either new squares are registered or when results are submitted. This allowed interested parties to view how the distribution maps are developing as the project continues and allows potential volunteers to easily view the available survey squares during the registration process, track the progress of BATLAS 2020 and choose suitable sites for their survey using the 'streetview' function.

4.4 Online registration and results submission

To deal with the large number of volunteers and volume of incoming results, an automated online system for volunteer registration and results submissions was set up in August 2016.

4.4.1 Registration

The online volunteer registration system successfully ran from 04/08/2016. This system provided volunteers an opportunity to view the current uptake, showing available survey squares. This system streamlined the ease with which volunteers could choose the areas they wish to survey.

When volunteers register, they received a standardised email welcoming them to the scheme; the Coordinator then sent them a personalised email with a volunteer pack containing a Survey Manual, a Risk Assessment form to complete and information where to find further support material.

4.4.2 Results Submissions

An online results submission form was also set up and has been running successfully since August 2016. This allows volunteers to submit their survey results online for each 10km square. The system contains a simple form for inputting data in a similar format to the Recording Sheet.

Following volunteer feedback, some changes and improvements were implemented to the online portal through winter 2016-2017 and winter 2017-2018.

Examples of changes include:-

- Capacity to record "NULL" results, i.e. where no bats were encountered during the survey.
- Options to report if 5km^2 quadrants were either 'inaccessible' or 'unsafe' for surveying and the reasons why.

4.4.3 Database system

A customised piece of software was written by the Coordinator to streamline the registration and results submission process (Figure 8). Its main functions were to:-

- Automatically compile all incoming results and new registrations to a GIS-based database on a local server.
- Update relevant maps on Bat Conservation Ireland website.

The system helps to reduce human error, improve the efficiency of the data management process and allow for quick and easy viewing and editing spatial data. The system required constant monitoring and was taken offline when crashes occurred in 2017 and 2018, the system was revived within days in both cases.

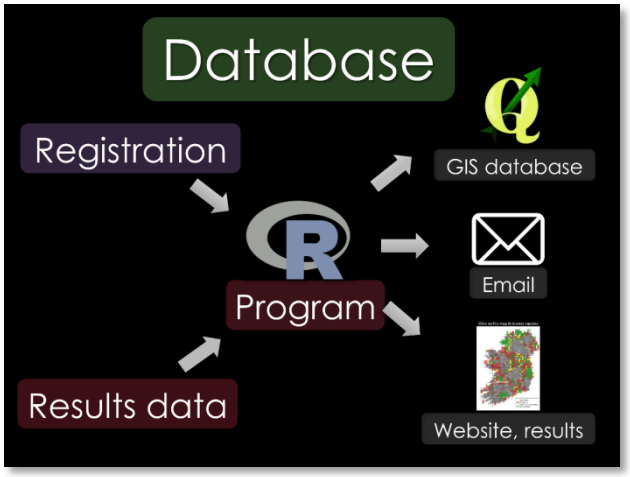

Figure 8: Functions of software created to streamline the processing of BATLAS 2020 registration and results submission data.

4.4.3 Volunteer feedback

Volunteers were invited by email to provide any feedback or suggestions for improvements to the BATLAS 2020 scheme in every year (between October and December). Suggestions and feedback were continuously implemented, for example the volunteer manual and online results submission portal were refined in both 2017 and 2018.

4.4.4 Audits

Data errors, unfinished survey squares and any other issues were identified through annual audit processes undertaken every year (between October and December). Reminders to submit results were sent to all volunteers by email individually (where required) before November in each survey year. The online system flagged potential grid reference errors, all these data were checked manually and volunteers were contacted during the audit process with their own relevant data to politely request them to check any potential errors.

Continuing volunteer engagement was a challenge throughout the BATLAS 2020 scheme, many volunteers (around half) did not follow through with the survey after registration or having attended the training events, so as part of the audit process volunteers who did not complete the submission of the results by October-November were asked if they wish to carry on with their assigned squares. Volunteers who did not reply after two attempts were dropped from the scheme so that their assigned squares could be deregistered and be made available to other potential volunteers. This was a time-consuming but crucial part of the process and ultimately was vital in maintaining the smooth running of the scheme.

4.5 Presentations

Outside the specific training events, the Coordinator gave presentations on the progress of the BATLAS 2020 project at the annual Northern Ireland Bat Group meeting on 01/07/2017, the 9th Irish Bat Conference in Dublin on 14/10/2017 and to the Bat Conservation Ireland Council on the 12/03/2017 and 03/02/2018.

4.6 Social Media

A targeted, funded advert campaign ran in April 2017 attempting to recruit new volunteers to BATLAS 2020 on Facebook, regular posts relating to BATLAS during the survey season. All training events were also added to Facebook as official 'Events'. The social media presence grew through 2017-2018, from ~200 followers to 715 at the time of writing, this significantly increased the profile of the project and temporarily boosted volunteer uptake to the scheme.

5. BATLAS 2020 - Progress

5.1 Volunteer recruitment & management

A total of 237 volunteers were either involved or expressed interest in BATLAS 2020 (including those involved in the 2015 pilot study). One hundred and twenty one (51%) volunteers submitted results by the end of the project, almost twice the number of people who participated in BATLAS 2010. Of the 121 active volunteers, 84 participated for one year only (69%), 26 individuals participated for two years (21%) and 11 (9%) contributed in all three years of the main survey. Figure 9 displays the number of volunteers participating in the survey (including the 2015 pilot).

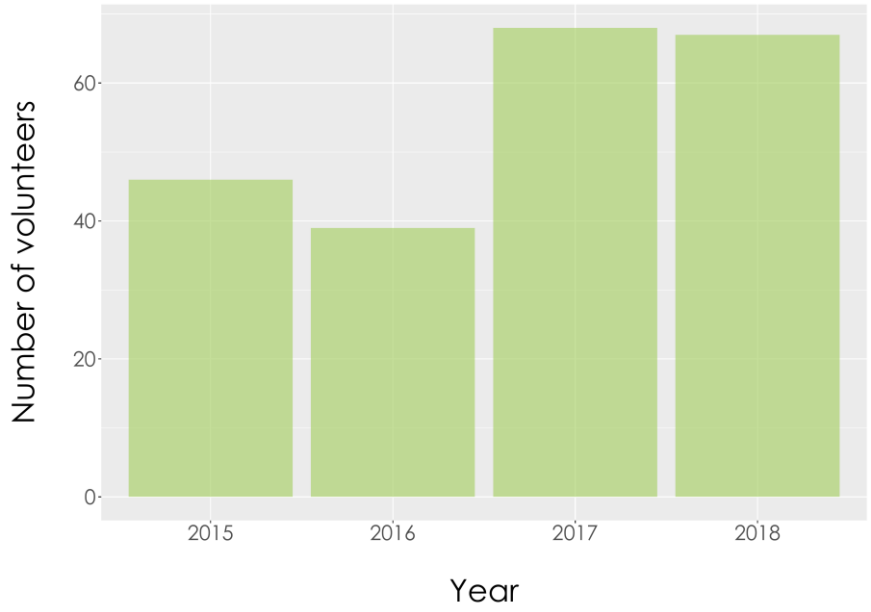

Figure 9: Number of volunteers participating in BATLAS 2020 for all years including the 2015 pilot scheme.

5.2 Uptake

5.2.1 2016-2018

Fifty-nine survey squares were surveyed to some extent in 2015 during the BATLAS 2015 pilot scheme, by the end of the 2016 season a total of 286 squares had been assigned, however only 83 of this subset (29%) had been finished according to the requirements, with 52 squares unfinished (18%) and 151 (54%) with no results.

In 2017 a further 138 squares were registered creating a total of 424 squares, however completion rates continued to be low with 167 squares (39% of the total submitted) containing no results and a further 81 squares (19%) unfinished.

By 2018 it was apparent that the original target of 80% coverage was unlikely to be met according to current completion rates, so the Bat Conservation Ireland Council agreed that seasonal surveyors should be deployed to specific areas in an attempt to finish as many squares as possible along with additional survey time allocated to the Coordinator to assist with surveying. It was also decided that to further increase coverage it was necessary to reduce the survey effort within each square for these specific surveyors. Surveying effort was reduced from

eight to two sites but these two were to be selected across different 5km quadrants wherever possible. This approach was rolled out for the 2018 survey season only. Figure 10 displays the survey effort (in terms of points surveyed) for surveyors and volunteers across the entire BATLAS 2020 survey.

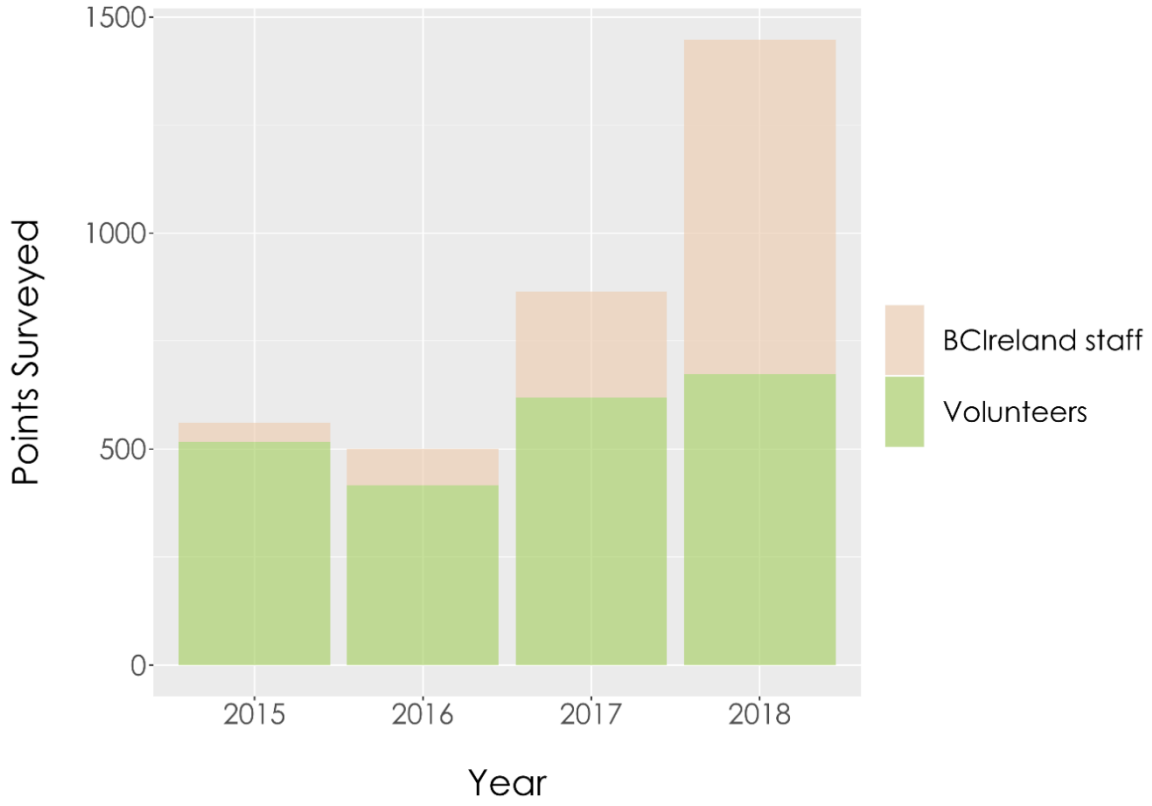

Figure 10: Survey contribution by staff and volunteers across all years of the BATLAS 2020 project.

5.3 Final coverage in 2018

By the end of the survey a total of 786/1014 (77%) 10km squares had been surveyed (i.e. 764 10km squares have at least one survey site while 22 were deemed 'inaccessible' or 'unsafe' for survey). However a further 54 squares are 'live' registered squares (i.e. assigned to volunteers who confirmed they were still actively surveying in 2018) but the results have not been submitted to-date.

A total of 3,373 unique survey sites were visited as part of BATLAS 2020. This is an almost twofold increase in the number of sites covered during BATLAS 2010 (BATLAS 2010 sites, n = 1,693). Forty-three percent (n=614) of the 1,693 sites surveyed for BATLAS 2010 were also surveyed for BATLAS 2020, the remaining 2,759 sites surveyed in BATLAS 2020 were selected by volunteers as new BATLAS 2020 sites.

At the 10km square level, a total of 506 survey squares were surveyed in both the BATLAS 2010 and BATLAS 2020 projects while the remaining 222 were new squares only surveyed for BATLAS 2020. One hundred and fifty squares surveyed for BATLAS 2010 were not surveyed by BATLAS 2020 and 136 squares remain un-surveyed through both projects, most of these are in relatively inaccessible areas (22 squares in total were classed as 'completely inaccessible' either by the volunteers during surveying or by the Coordinator upon analysis of the OS maps).

Table 6 lists the coverage by county and also summarised by country (counting all squares >1 survey point as 'surveyed'). Ninety-three percent coverage was achieved in Northern Ireland and 71% coverage was achieved in the Republic of Ireland. Figure 11 shows the proportion of surveyed versus un-surveyed squares at both the 10km^2 and 5km^2 level, Figure 12 displays the final survey square uptake map as of 31st December 2018.

While we do not have information on the amount of time spent on the survey by volunteers, we estimate based on our own staff input, that surveying these 3,373 sites represented *at least* 2,500 hours of work, not including the additional time spent inputting data to the online portal.

Table 6: The survey coverage of each county across the island by BATLAS 2020.

County/Country	Squares	Uptake	Surveyed	%
Cavan	20	20	20	100
Derry	22	22	22	100
Donegal	70	70	70	100
Dublin	18	18	18	100
Kildare	22	22	22	100
Leitrim	16	16	16	100
Louth	9	9	9	100
Meath	21	21	21	100
Monaghan	11	11	11	100
Antrim	33	32	32	97
Tyrone	31	31	30	97
Westmeath	22	22	21	95
Mayo	78	73	73	94
Longford	13	12	12	92
Sligo	13	13	12	92
Offaly	29	27	26	90
Down	33	29	29	88
Fermanagh	26	24	23	88
Roscommon	13	12	11	85
Armagh	19	15	15	79
Kilkenny	19	19	15	79
Laois	30	21	21	70
Galway	91	72	61	67
Wicklow	26	18	17	65
Clare	46	30	29	63
Tipperary	20	13	12	60
Waterford	38	19	19	50
Wexford	32	17	15	47
Cork	90	41	35	39
Kerry	81	42	31	38
Limerick	21	9	7	33
Carlow	1	0	0	0
Northern Ireland	**164**	**153**	**151**	**92**
Republic Of Ireland	**850**	**647**	**604**	**71**

Figure 11: Proportion of squares surveyed as a proportion (left = by 10km square, right = by 5km square). 'Access restricted' squares included those for which all of their 5km quadrants were listed as either 'inaccessible' (usually out at sea) or 'unsafe'.

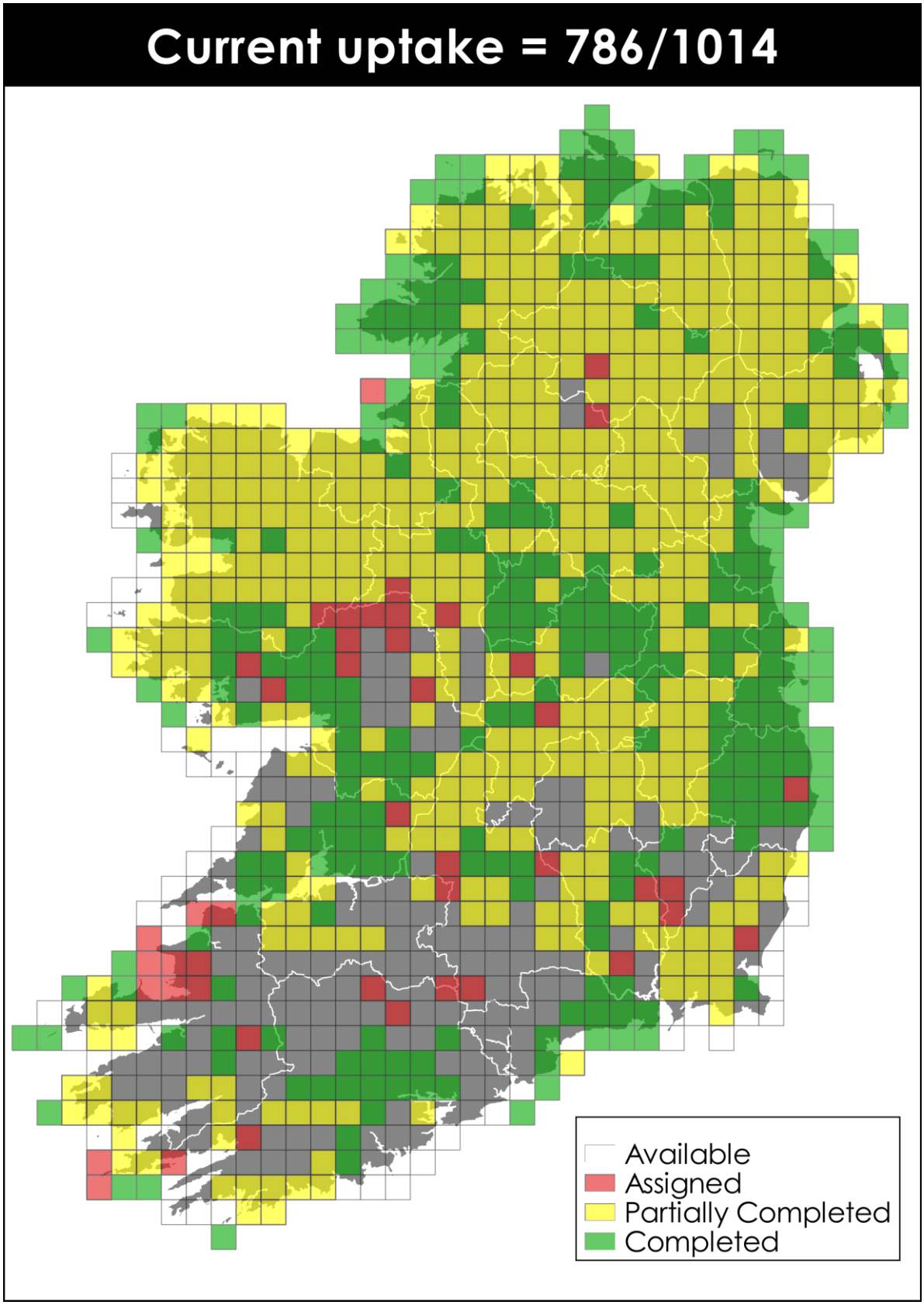

Figure 12: Final BATLAS 2020 coverage at the end of 2018 season. Colour codes relate to square completion status in accordance with original BATLAS 2020 targets, i.e. 'Completed' squares are those with all 4 quadrants completed (i.e. either 2 sites surveyed within each quadrant, all four target species recorded, or the quadrant was inaccessible/unsafe to survey). "Partially completed" applied to squares with at least one survey site but that was not completed, "Assigned" relates to registered squares with no results.

Figure 13 shows the relative frequency of the number of points surveyed per 10km square. The peaks for those with two sites surveyed primarily reflects the number of sites surveyed by staff in 2018, the peak at eight sites primarily reflects the target number of sites for volunteer surveyors.

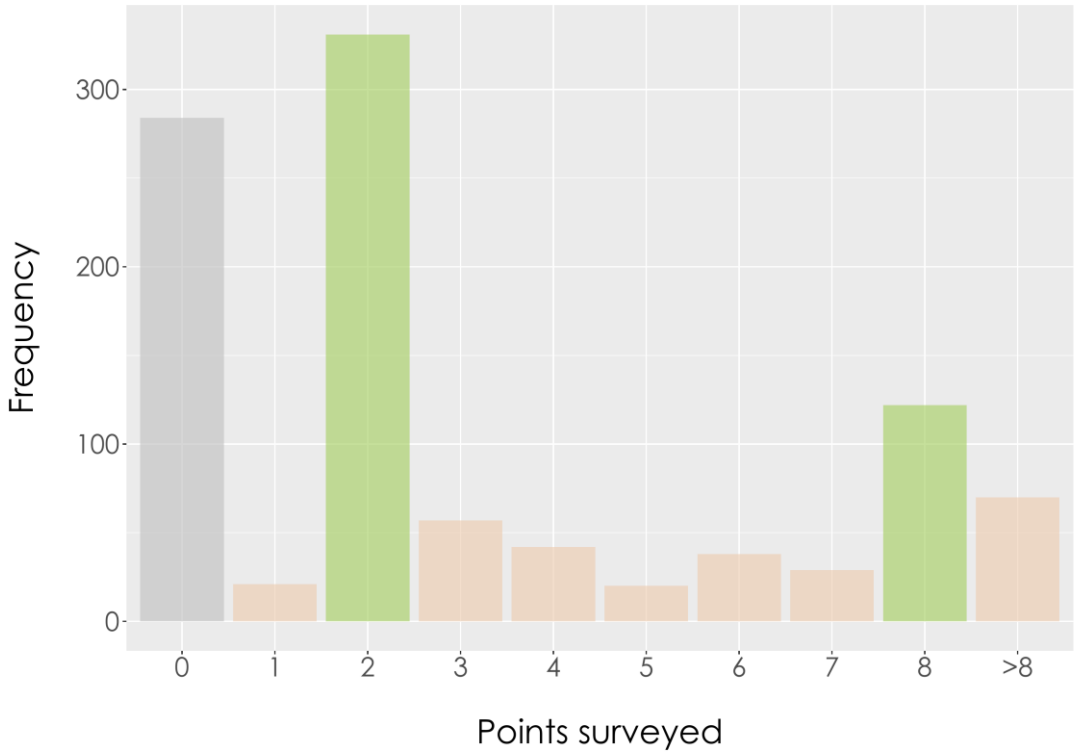

Figure 13: Histogram shows the number of points surveyed within each survey square. The green columns highlight the target number of sites (n=8 for volunteer full survey, n=2 for reduced staff surveys in 2018 survey season).

6. BATLAS 2020 Results

6.1 Species summaries

Results were collated for all nine resident bat species. Table 7 lists the detection rates of all bat species. Detection rates of target species followed the same order as the BATLAS 2010 study with soprano pipistrelle being the most commonly detected, followed by common pipistrelle, Leisler's bat and Daubenton's bat.

All four target species were detected at higher rates compared to the 2010 study at the 10km square level, although note that on average more sites were surveyed per 10km square for BATLAS 2020 (3.3) compared with BATLAS 2010 (1.4 sites). However, despite the higher number of sites per square, higher detectability also translated to the individual site level. Soprano pipistrelle occurrence per site increased from 63.7% to 68.0%; common pipistrelle from 40.7% to 53.9%; Leisler's bat from 32.1% to 36.1% and Daubenton's bat from 29.8% to 30.74%.

Detection rates for non-target species (confirmed identifications) were much lower, varying from 3.59% for brown long-eared bats to 0.39% for lesser horseshoe bats. While non-target species are more difficult to detect and/or identify we found that % presence per site was lower for all non-Daubenton's Myotis categories during BATLAS 2020 compared with 2010. Unidentified *Myotis* spp. were present in 17.1% of sites during BATLAS 2010 compared with 6% of sites during BATLAS 2020, while confirmed Natterer's declined from 4% to 2.2% and whiskered bats dropped from 1.2% to 0.9%.

A similar reduction was recorded for Brown long-eared between the two surveys which declined from 8.7% to 3.6%. Nathusius' pipistrelle on the other hand, increased from 0.4% to 1.6%.

Table 7: Detection rates of all bat species summarized across all BATLAS 2020 years at the 10km grid square (n =728) level and at the site level (n=3373), target species are highlighted in bold.

Species	No 10km squares Present	% 10km squares present	Number of sites present	% of sites present
Soprano pipistrelle	**677**	**92.99**	**2292**	**67.95**
Common pipistrelle	**624**	**85.71**	**1819**	**53.93**
Leisler's bat	**523**	**71.84**	**1218**	**36.11**
Daubenton's bat	**510**	**70.05**	**1037**	**30.74**
Unidentified *Myotis spp*	126	17.31	201	5.96
Unidentified *Pipistrellus spp*	**119**	**16.35**	**228**	**6.76**
Brown long-eared bat	98	13.46	121	3.59
Unidentified bat	80	10.99	150	4.45
Natterer's bat	68	9.34	75	2.22
Nathusius' pipistrelle	45	6.18	55	1.63
Whiskered bat	23	3.16	29	0.86
Lesser Horseshoe bat	11	1.51	13	0.39

Coverage maps are displayed below for all species (Figure 14-22), presence data is mapped as yellow dots along with the 10km square shaded in green where the bat species was recorded or grey if the bat species was not recorded.

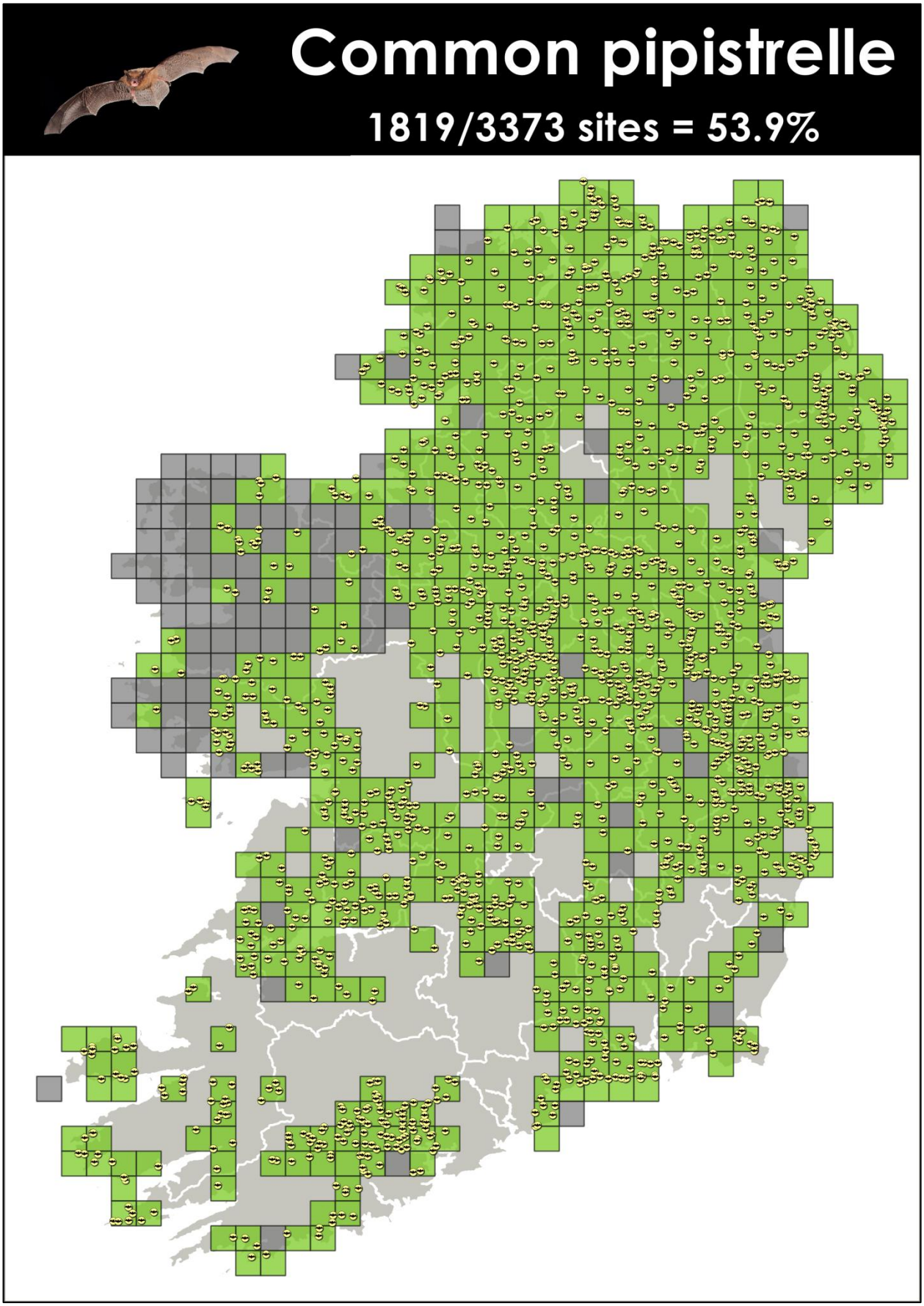

Figure 14: Common pipistrelle distribution across the island.

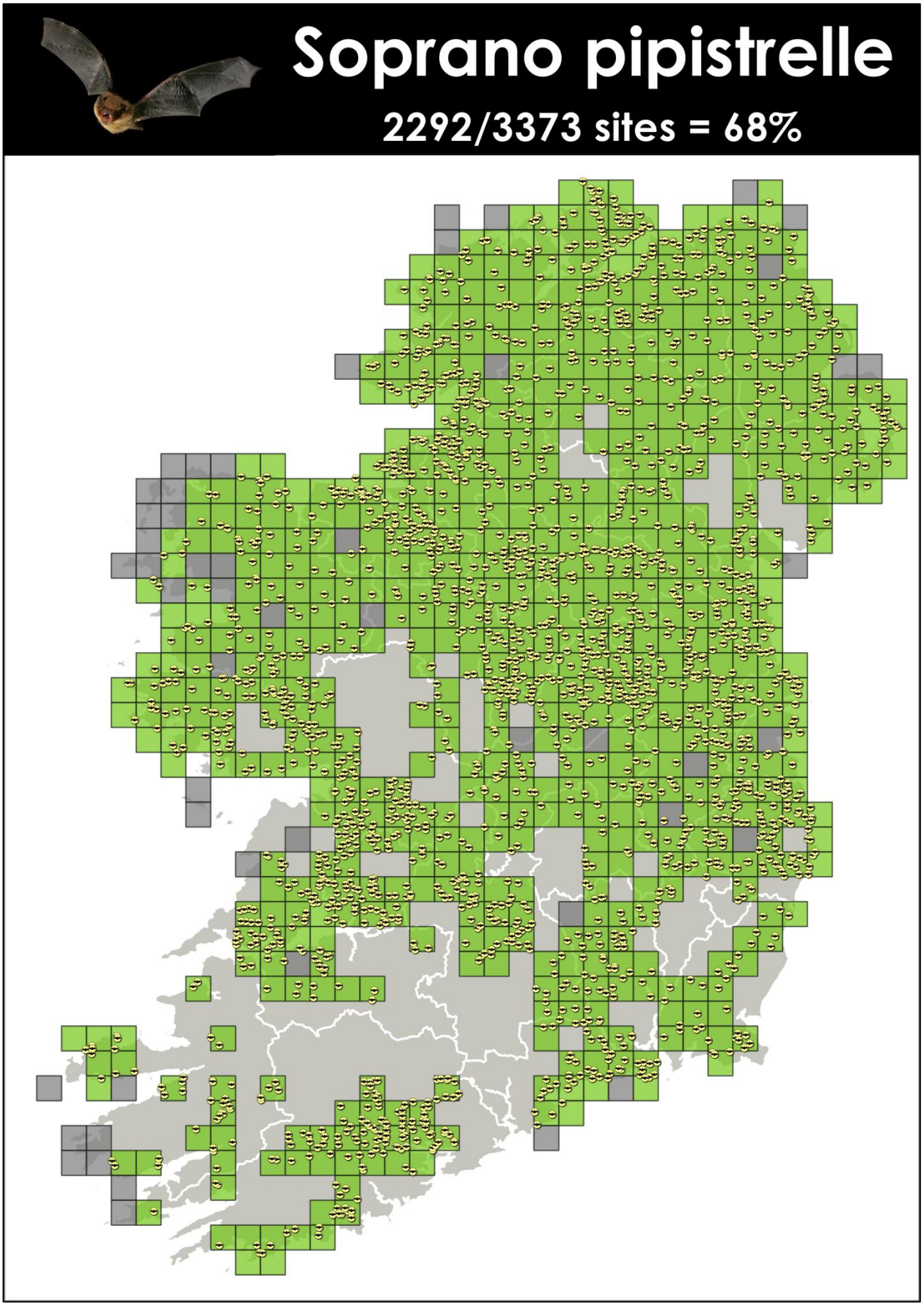

Figure 15: Soprano pipistrelle distribution across the island.

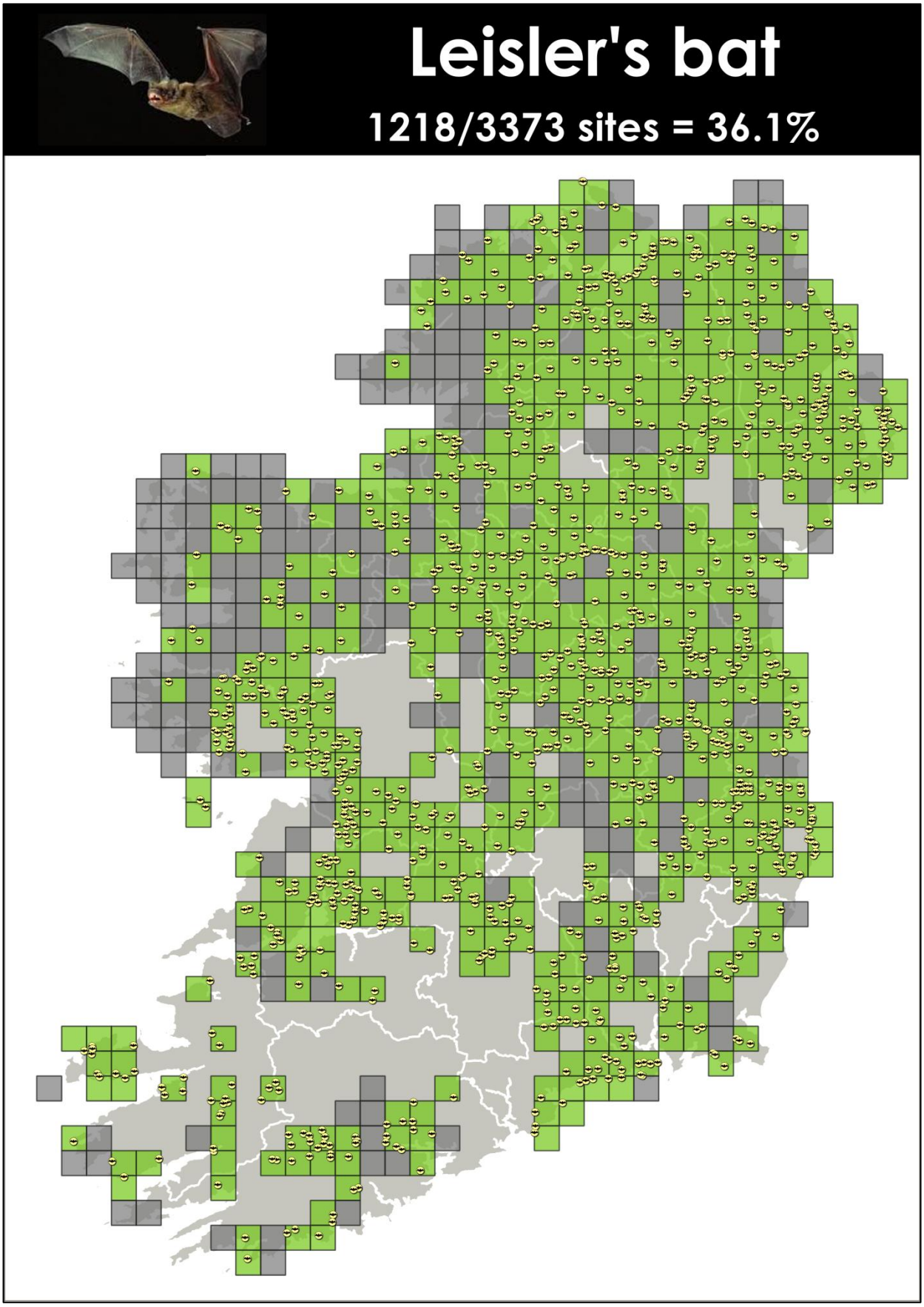

Figure 16: Leisler's bat distribution across the island.

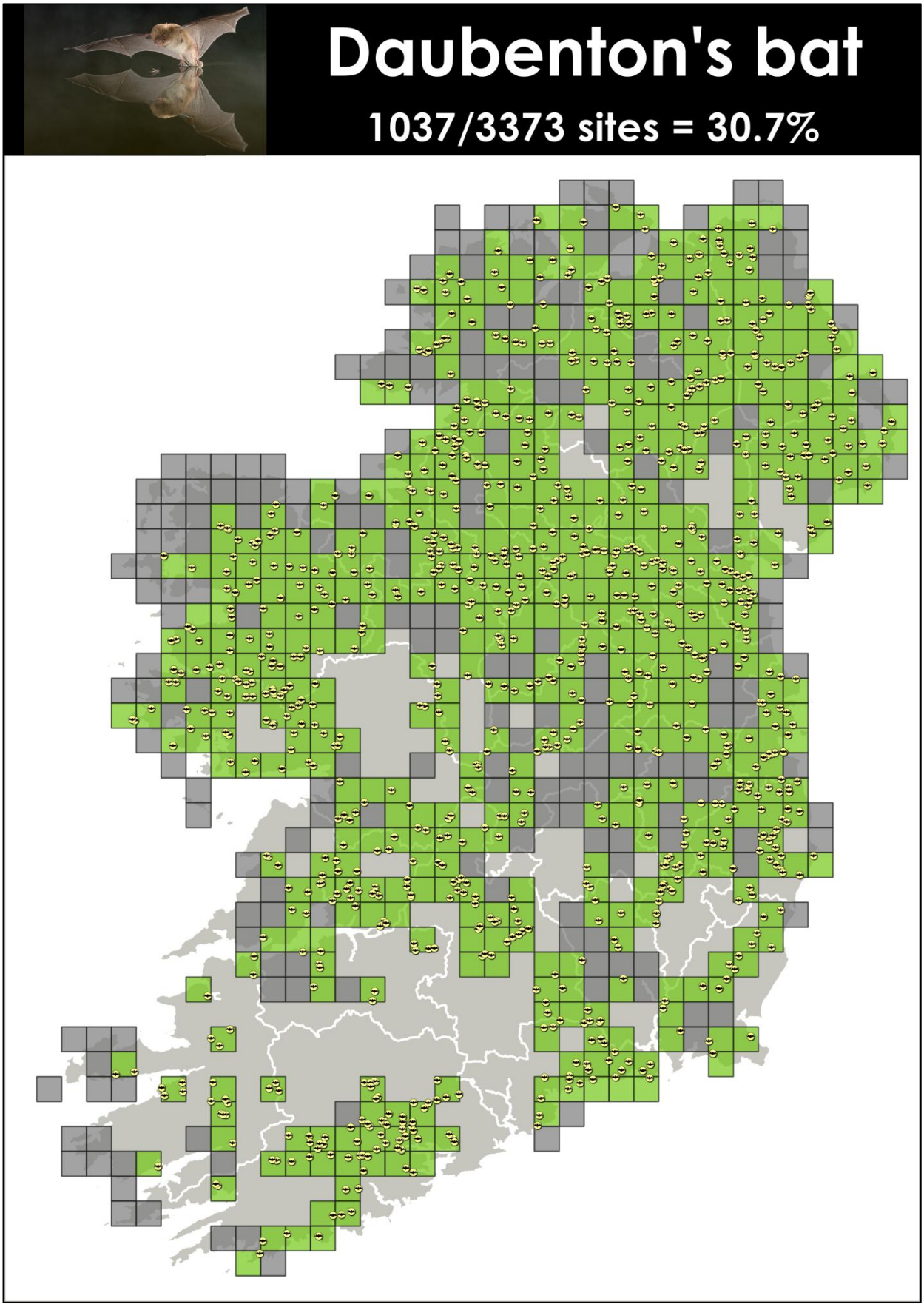

Figure 17: Daubenton's bat distribution across the island.

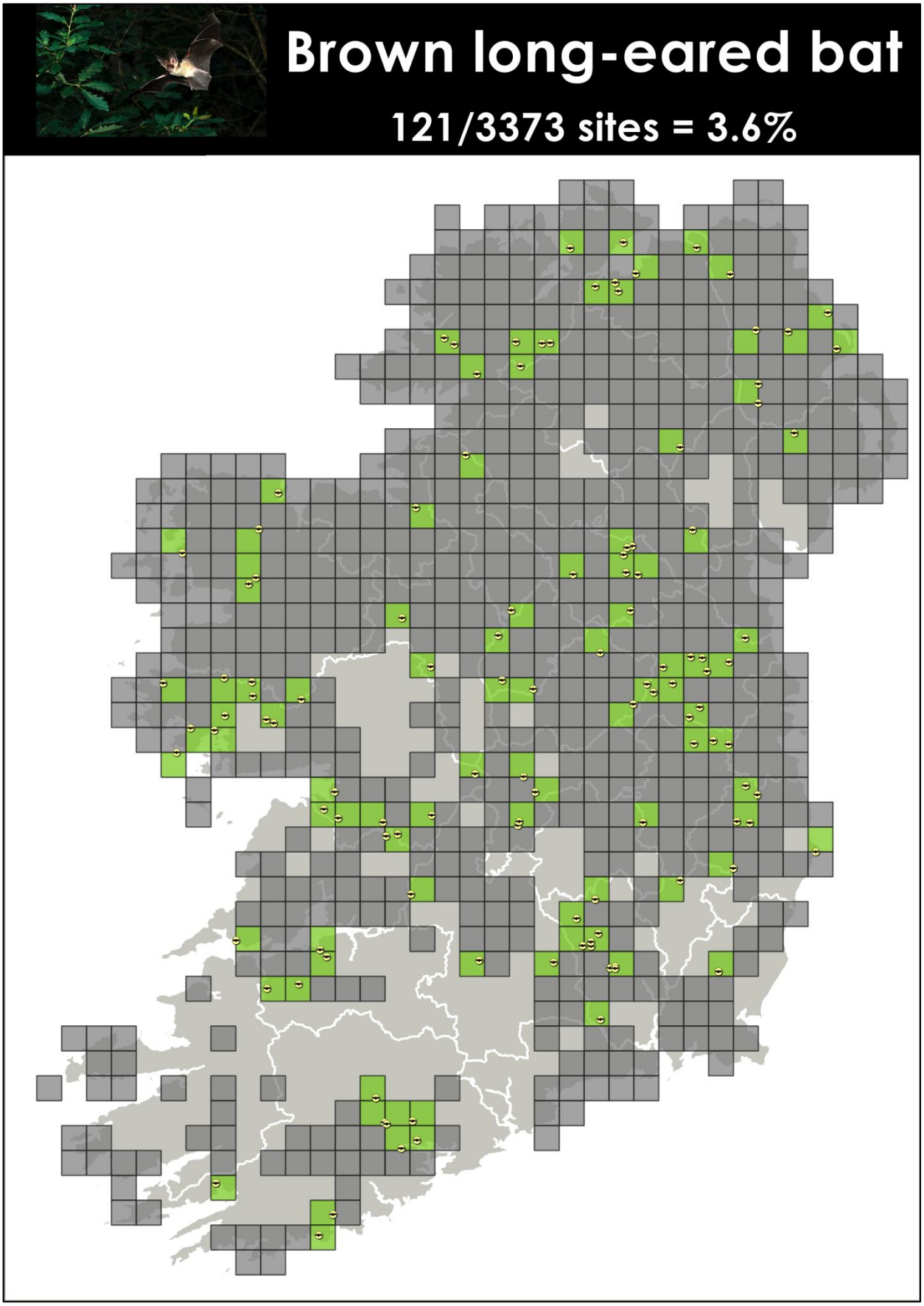

Figure 18: Brown long-eared bat distribution across the island.

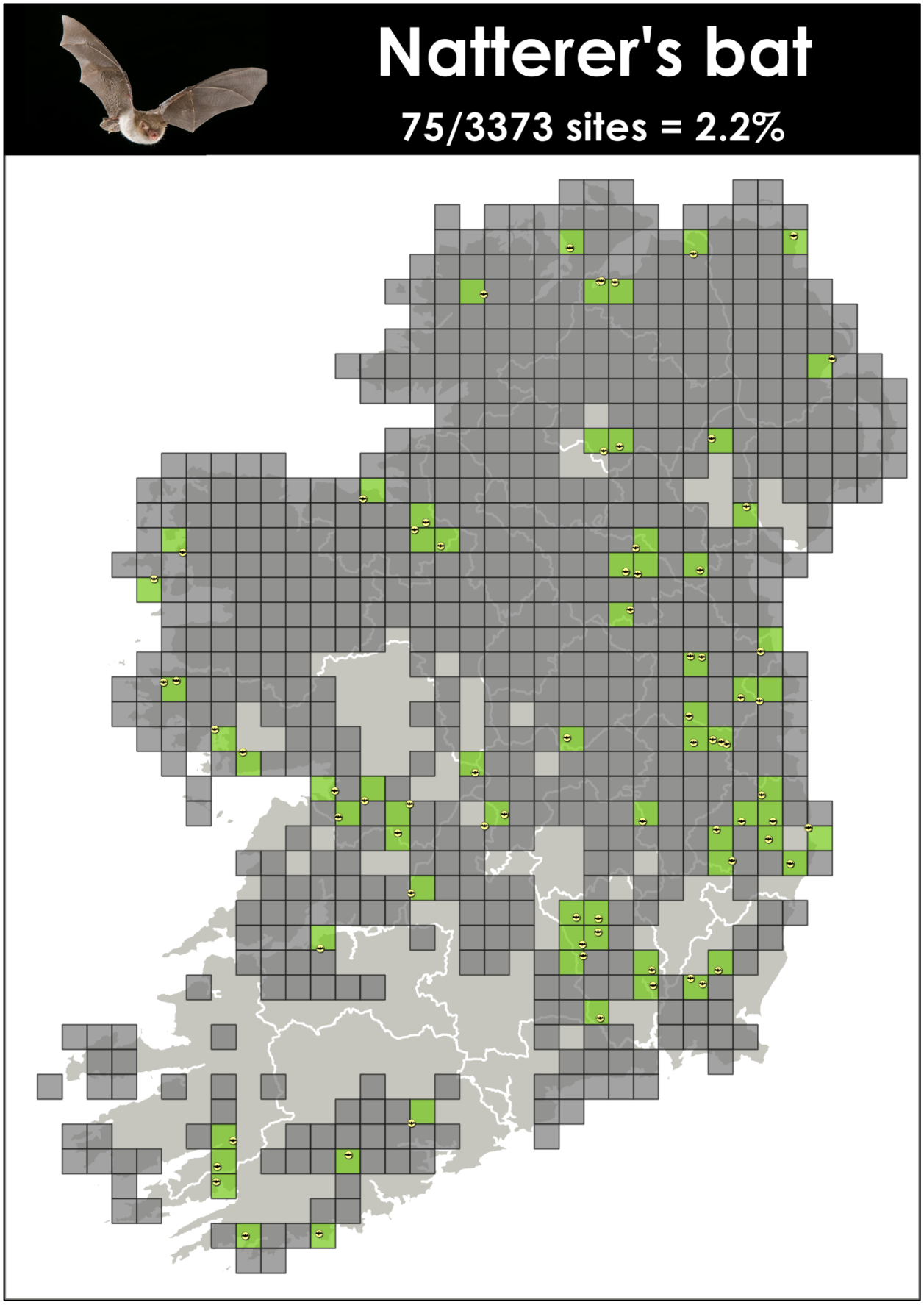

Figure 19: Natterer's bat distribution across the island.

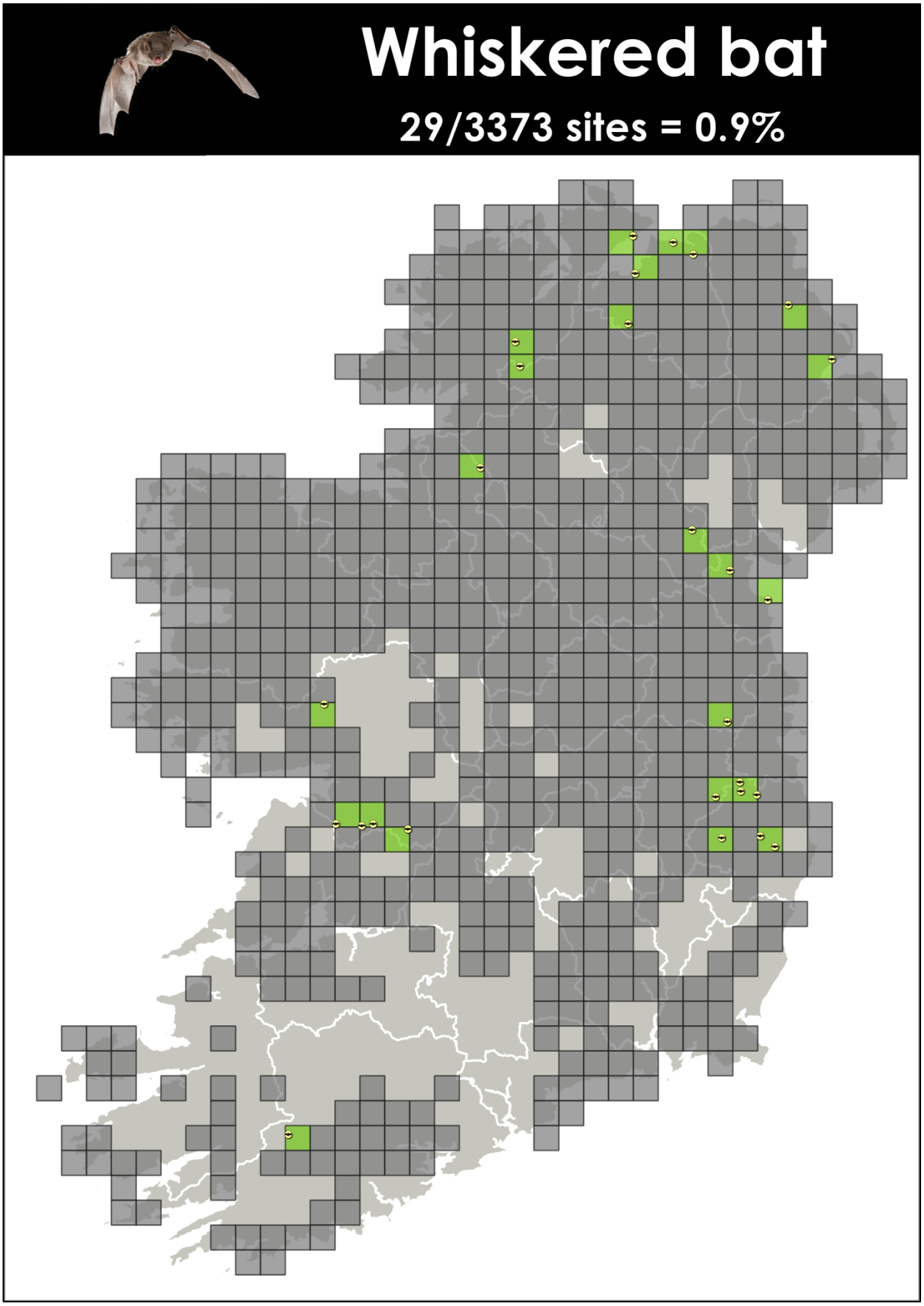

Figure 20: Whiskered bat distribution across the island.

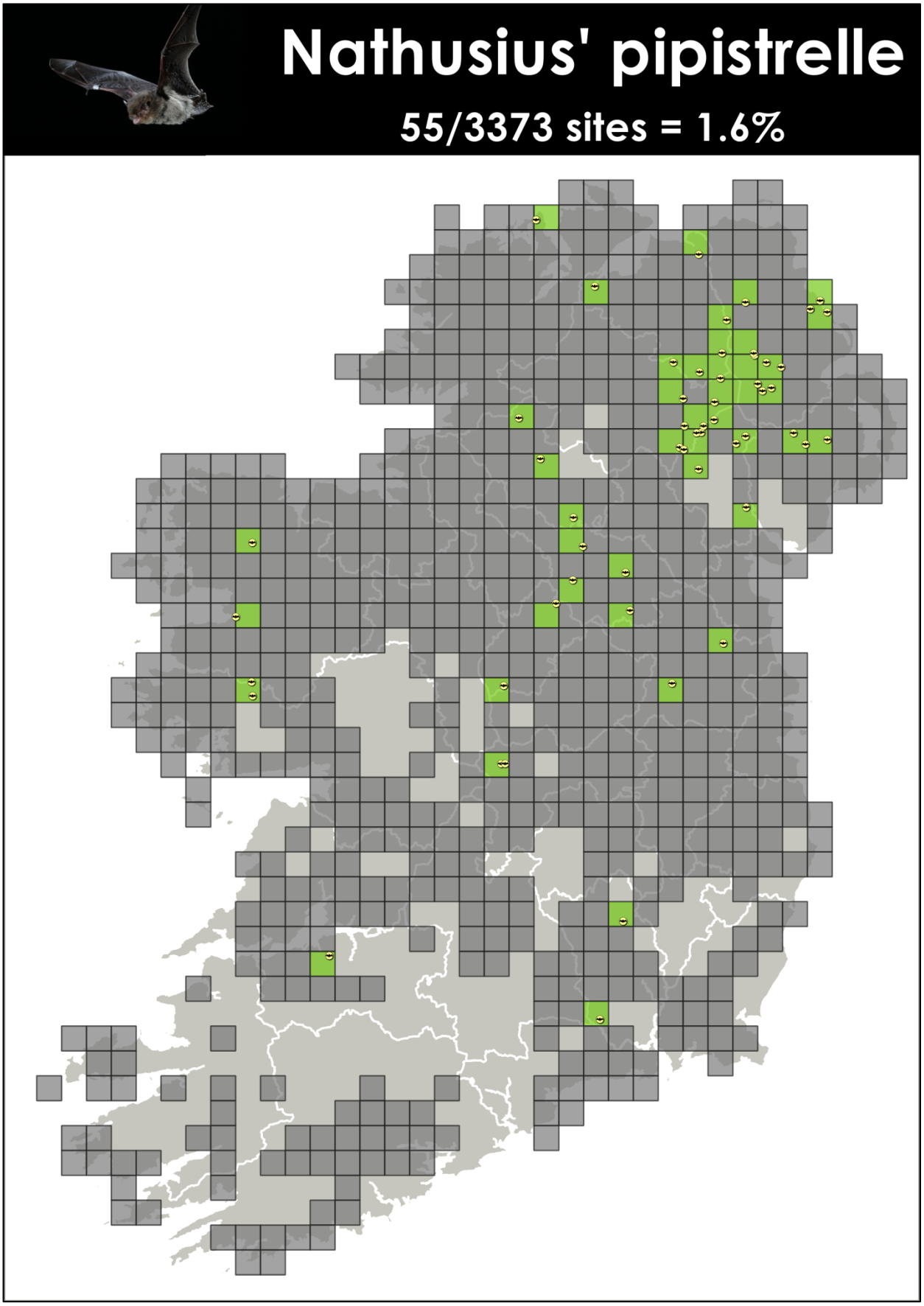

Figure 21: Nathusius' pipistrelle distribution across the island.

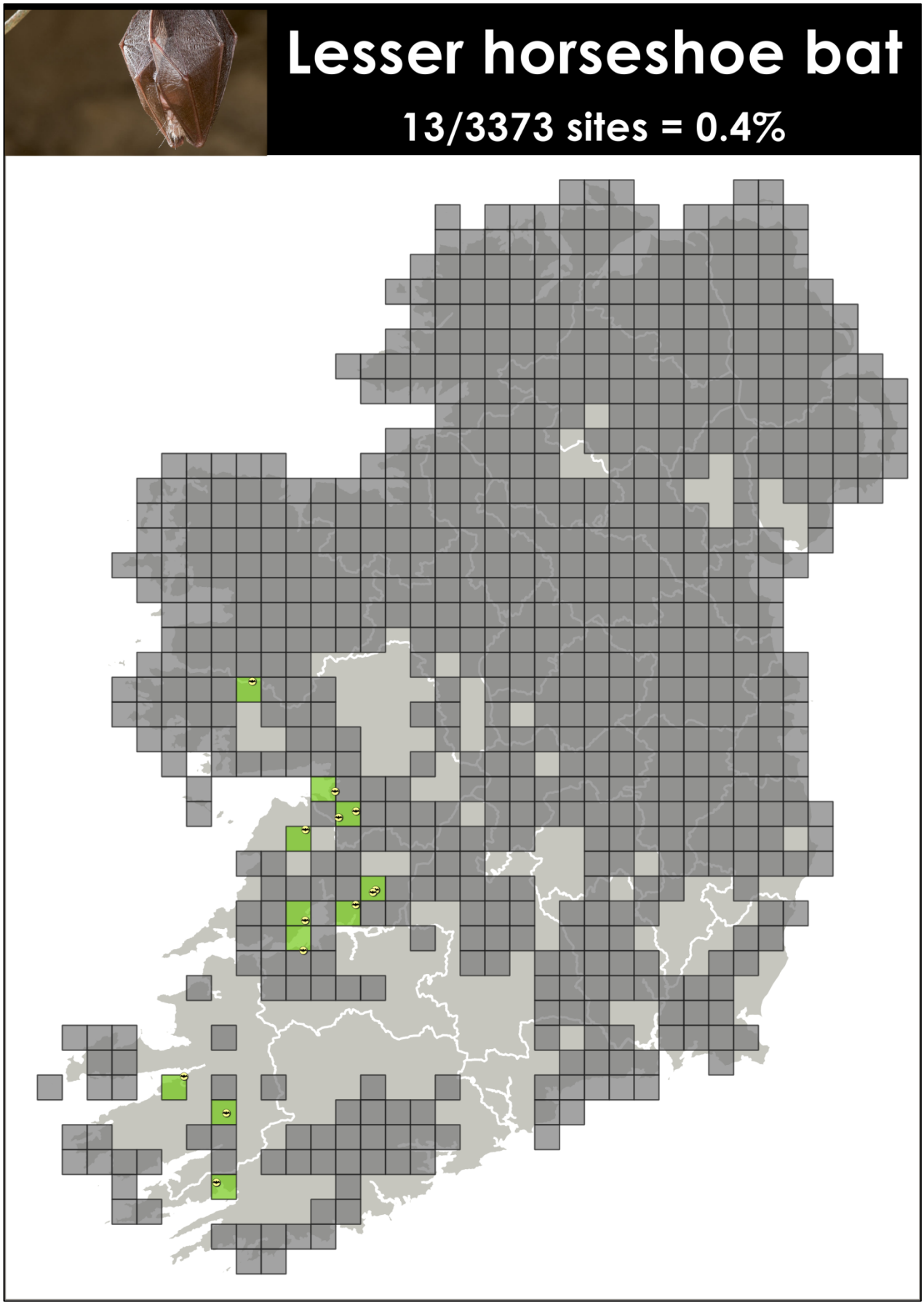

Figure 22: Lesser horseshoe bat distribution across the island.

6.2 Island Surveys

A total of eight offshore islands were surveyed as part of BATLAS 2020. Only Achill Island had been surveyed before for the BATLAS 2010 scheme, thus the additional seven islands represented new bat distribution data. Table 8 and Figure 23 detail the islands surveyed and the species detected.

Table 8: BATLAS 2020 island survey results. Species codes are CP = common pipistrelle, SP = soprano pipistrelle, LS = Leisler's bat, DB = Daubenton's bat, NTS = Natterer's bat, BLE = Brown long-eared bat, LHB = Lesser horseshoe bat, My = unidentified *Myotis* spp.

Name	Reference	Year	Squares	Species detected
Rathlin Island, Antrim	1	2017	D05,D14,D15	CP,SP
Tory Island, Donegal	2	2017	B84	None
Árainn Mhór, Donegal	3	2018	B61	CP,SP
Achill Island, Mayo	4	2017/2018	F50,F60,F70,L69,L79	SP,DB,NTS
Mweenish Island, Galway	5	2018	L72	SP,BLE
Inishmore, Galway	6	2015/2016	L80,L81	CP,LS
Great Blasket Island, Kerry	7	2017	V29	CP, SP, LS, LHB, My
Valencia Island, Kerry	8	2017	V37,V47	CP,LS

Figure 23: The location of the offshore island surveys completed as part of BATLAS 2020, numbers reference the islands as shown in Table 8.

6.3 Environmental Data

Environmental information was collected across all 3,373 sites by volunteers. Additionally, topographical data for each site was collated in December 2018 including elevation data (using 'googlmaps API') and distance to the coast using the 'rgeos' package in 'R' (R Core Team, 2018). This large dataset forms the basis for exploratory research into factors determining the presence of bats potentially at both a local and larger, geographical scale scales.

6.3.1 Lighting Data

Twenty-six percent of BATLAS 2020 survey points were within 100m of artificial lighting of some kind. Summarising by category, 'Orange' lights were the most common (12%), followed by 'White' (8%), then 'Yellow' lights (6%) and a combination of categories (>1%).

Instances of bats being present were relatively high at artificially lit sites for all categories (Orange = 93%; White/LED = 90%; Yellow = 89%). Instances of bats 'feeding around lights' at these sites was relatively low, with orange lights recording the highest proportion instances (Orange 32%; White/LED; 29%; Yellow = 25%). Figure 24 displays the total proportion of lighting types encountered during the survey, categorised by bat presence/absence status.

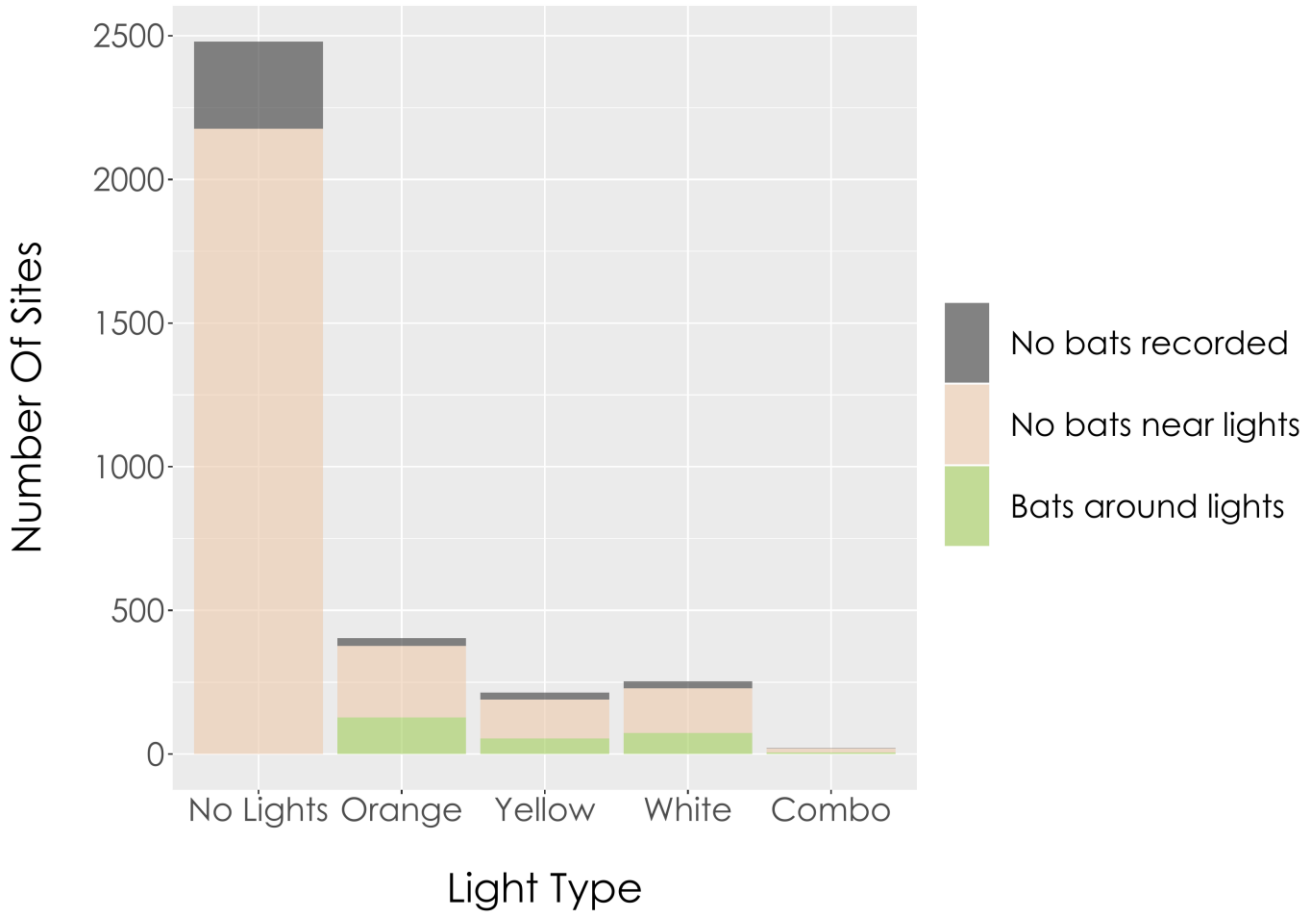

Figure 24: Proportion of sites with artificial lighting recorded during the BATLAS 2020 survey categorised by light type (no lights, orange lights, yellow lights, white lights or a combination of light types) and bat presence-absence status (no bats recorded at the site, bats recorded but not feeding around lights, bats feeding around lights).

6.3.2 Habitat Data

Eighty-two percent of BATLAS 2020 sites were recorded as being within 100m of a hedgerow, Figure 25 displays the relative proportions of the hedgerow categories recorded.

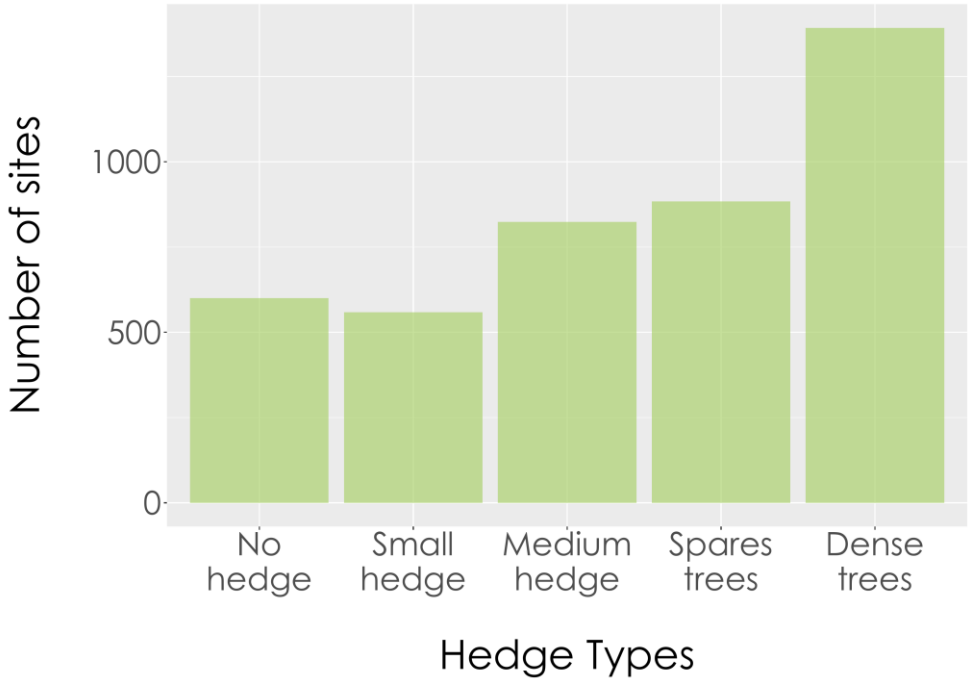

Figure 25: Number of BATLAS 2020 sites in each hedgerow category.

All 24 habitat types were recorded during the survey, the most common being "Tree-lined hedgerows". Figure 26 displays the number of instances each habitat category was recorded from most common to least common.

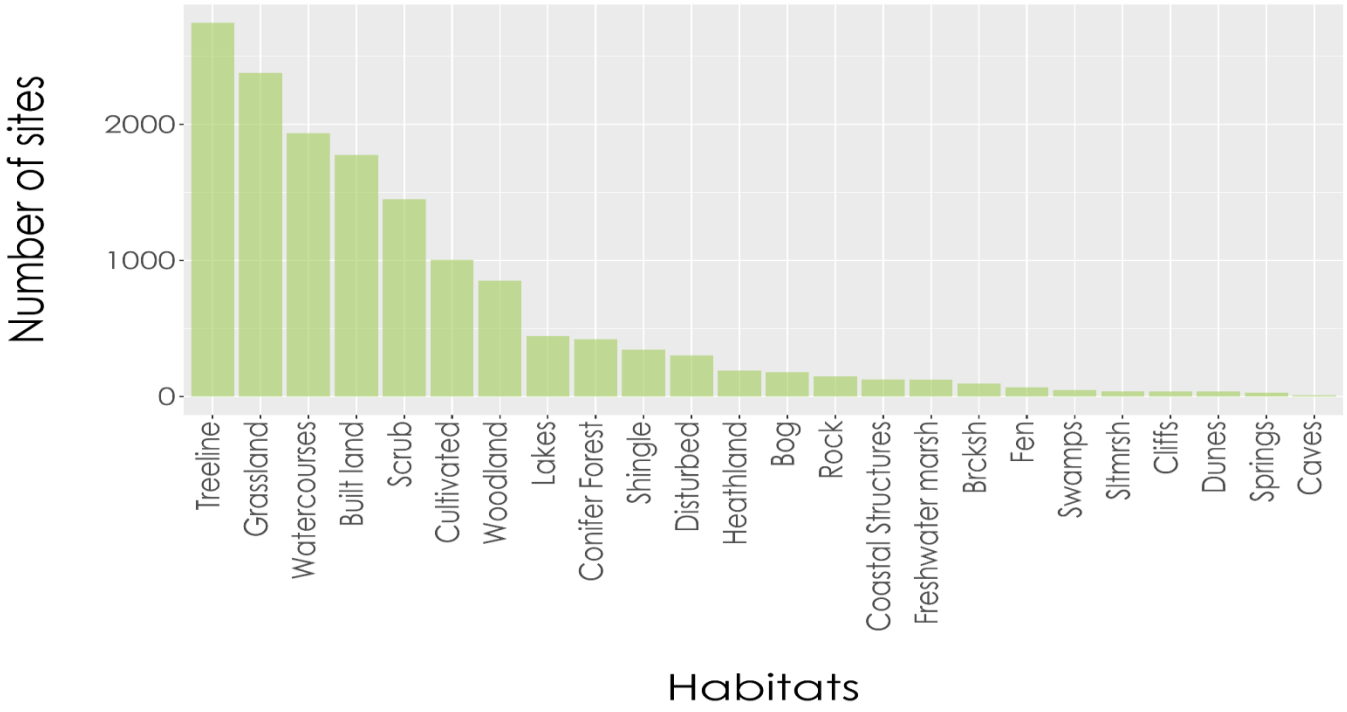

Figure 26: Number of BATLAS 2020 survey sites with named habitats recorded.

6.3.2 Statistical Analysis

The relationship between the presence or absence of each target bat species (i.e. common pipistrelle, soprano pipistrelle, Leisler's bat and Daubenton's bat) and habitat variables collected by surveyors was examined by fitting generalised linear mixed models (GLMM) with binomial errors.

Tables 9-12 show test statistics for the habitat variables included in the final models for each target bat species. Figures 27-30 present the heat maps for each of the target bat species depicting their modelled probability of occurrence based on combined significant habitat variables and spatial patterns across the island.

Common pipistrelle

Table 9 shows the significant non-spatial terms for common pipistrelle and the level of significance for each term in relation to its influence on the presence of common pipistrelles during BATLAS 2020 surveys. The proportion of surveys with common pipistrelles present declined with day number during the survey year and time after sunset (i.e. detection of common pipistrelles higher earlier in the night compared to later survey times). For day number, the probability is fairly constant up to August, then starts falling off with a rapid decline in September and October.

The presence of common pipistrelle was also lower when surveys were completed in breezy weather conditions.

There are positive associations with the presence of scrub, woodland and grasslands and where such habitats were recorded, common pipistrelles were also recorded. Common pipistrelles tended to be recorded where rivers greater than 10m wide were present at the BATLAS 2020 survey site.

Lighting also seems to have a positive effect, based on recording of street lighting by volunteers. Common pipistrelles were more likely to be recorded feeding around lights, when present.

As can be seen from Figure 27 there is a strong spatial pattern depicted with the greatest proportion of positive surveys for common pipistrelles in Northern Ireland, and the fewest positive surveys for common pipistrelles in Co. Mayo and Co. Galway.

Table 9: Test statistics from the Common pipistrelle binomial GLMMs.

Term	χ^2	D.f.	Pvalue	Estimate	Se
Day no. linear	28.35	1	<0.001	-0.007337	0.001378
Mins after sunset	4.93	1	0.026	-0.001322	0.0005957
Wind	4.73	2	0.009	n/a	n/a
Scrub	10.05	1	0.002	0.2751	0.08677
Woodland	14.41	1	<0.001	0.3620	0.09536
Grasslands	5.16	1	0.023	0.2203	0.09696
Bats feeding around lights	5.01	1	0.025	0.3348	0.1495
River Width>10m	8.27	1	0.004	0.3414	0.1187

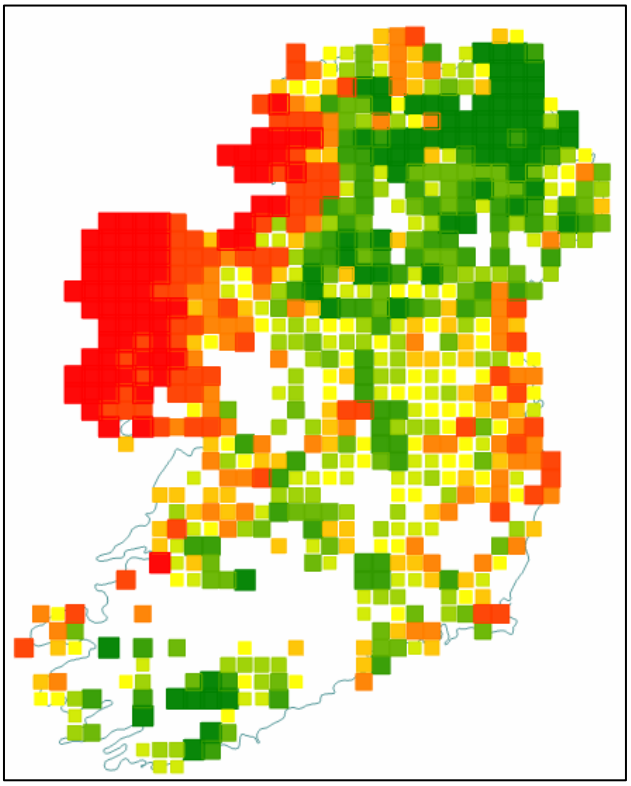

Figure 27: Average fitted values from the model for each sampled 10km square in relation to Common pipistrelles. The values essentially map a likelihood of presence based on spatial terms for northings and eastings combined with the impact of habitat variables from GLMM models. Shading shows ten equal groups from lowest (red) to highest (green).

Soprano pipistrelle

Table 10 shows the significant non-spatial terms influencing the presence or absence of soprano pipistrelles at BATLAS 2020 survey sites, according to the GLMM model. All of these significant terms are related to water or trees and hedges. There are strong positive relationships with watercourses, lakes and rivers over 10m in width with their presence having a positive influence on soprano pipistrelle occurrence. However, an equally strong negative relationship with coastal habitats (including habitats categorised as coast, cliffs, dunes, saltmarsh and brackish) reduced occurrence of soprano pipistrelle at the BATLAS 2020 survey sites.

There are positive relationships with both the overall habitat variable for hedges and tree lines, and for the individual categories sparse treeline and dense treeline hedgerow categories. The variables for woodland and scrub are also significant, again with positive coefficients.

Whilst the spatial pattern (Figure 28) is statistically significant, the impact of the quadratic terms for eastings and northings is relatively small and largely reinforces the pattern resulting from the habitat variables (e.g. negative effect of coastal habitats).

Table 10: Test statistics from the Soprano pipistrelle binomial GLMMs.

Term	χ^2	D.f.	Pvalue	Estimate	Se
Day no linear	8.70	1	0.003	0.04097	0.01389
Day no quadratic	9.43	1	0.002	-0.000104	0.000034
Watercourse	37.65	1	<0.001	0.5874	0.09574
Coastal habitat	9.75	1	0.002	-0.5526	0.1769
Lakes/ponds	37.49	1	<0.001	0.8975	0.1466
Hedge/tree lines	16.04	1	<0.001	0.4956	0.1237
Woodland	16.67	1	<0.001	0.4382	0.1073
Scrub	6.68	1	0.010	0.2437	0.09431
Hedgerow - Sparse treeline	6.93	1	0.008	0.2961	0.1125
Hedgerow - Dense treeline	12.31	1	<0.001	0.3606	0.1028
River Width>10m	28.76	1	<0.001	0.8122	0.1514

Figure 28: Average fitted values from the model for each sampled 10km square in relation to Soprano pipistrelles. The values essentially map a likelihood of presence based on spatial terms for northings and eastings combined with the impact of habitat variables from GLMM models. Shading shows ten equal groups from lowest (red) to highest (green).

Leisler's bat

This species shows significant relationships with a variety of different variables (Table 11). There are quadratic trends with day number within the survey period and time after sunset. In general, for time after sunset, the probability of detecting Leisler's falls to around two hours after sunset and then levels off for the rest of the night. There is no sign of any increase at sunrise, but this may be partly because there is less surveying completed later in the night and therefore less data towards sunrise times, and partly because of the varying length of nights at different times of year. For day number, the probability is fairly constant up to August, then starts falling off with a rapid decline in encounter rate in September and October.

Leisler's bats were more likely to be present when there was no breeze during BATLAS 2020 surveys.

There is a highly significant positive relationship with woodland, and a more borderline one with hedgerows categorised as medium hedgerows.

Volunteers were asked to record if any lighting was present adjacent to the BATLAS 2020 survey site and to also record if there were bats feeding around such street lighting. These two light variables had a significant positive influence on the present of Leisler's bats with a higher incidence of Leisler's bats recorded where street lights were present.

The spatial pattern is significant (Figure 29) with the eastings and northings terms leading to higher estimated probabilities of occurrence in the north east, but lower in the north west; a not dissimilar pattern to that for common pipistrelles.

Table 11: Test statistics from Leisler's bat binomial GLMMs.

Term	χ^2	D.f.	Pvalue	Estimate	Se
Day no linear	9.24	1	0.002	0.04000	0.01316
Day no quadratic	13.33	1	<0.001	-0.000119	0.000033
Mins after sunset linear	9.72	1	0.002	-0.005428	0.001741
Mins after sun quadratic	4.76	1	0.029	0.0000103	0.0000047
Wind	3.73	2	0.024	n/a	n/a
Woodland	13.33	1	<0.001	0.3517	0.09633
Medium hedge	4.49	1	0.034	0.2130	0.1005
Any light present	5.63	1	0.018	0.2577	0.1086
Bats feeding around lights	7.90	1	0.005	0.4727	0.1681
Lakes/ponds	9.46	1	0.002	0.3842	0.1250
Width>10m	17.59	1	<0.001	0.4924	0.1174

Figure 29: Average fitted values from the model for each sampled 10km square in relation to Leisler's bat. The values essentially map a likelihood of presence based on spatial terms for northings and eastings combined with the impact of habitat variables from GLMM models. Shading shows ten equal groups from lowest (red) to highest (green).

Daubenton's bat

The significant non-spatial terms that were shown to have an influence on the presence/absence of Daubenton's bats at BATLAS 2020 survey sites are shown in Table 12. There are quadratic trends with day number and time after sunset.

Water courses, lakes and rivers at least 10m wide all have a positive impact on the probability of detecting Daubenton's bats while this species are less likely to occur in coastal habitats.

Woodlands and hedge/tree lines have large and highly significant positive effects, whilst there is a negative relationship with coniferous woodland. There are smaller but positive effects for the presence of hedgerows (any of the four categories) and for scrub habitat.

Spatial terms for northings and eastings are statistically significant, but the pattern in Figure 30 is more strongly influenced by the habitat variables, similar to soprano pipistrelles.

Table 12: Test statistics from Daubenton's bat binomial GLMMs.

Term	χ^2	D.f.	Pvalue	Estimate	Se
Day no. linear	7.23	1	0.007	0.03755	0.01397
Day no. quadratic	9.17	1	0.002	-0.000105	0.0000347
Mins after sunset linear	3.51	1	0.061	0.004504	0.002403
Mins after quadratic	5.73	1	0.017	-0.0000171	0.00000716
Watercourse	181.41	1	<0.001	1.865	0.1385
Lakes/ponds	207.46	1	<0.001	2.255	0.1566
Width>10m	152.51	1	<0.001	1.584	0.1283
Coastal	10.46	1	0.001	-0.7595	0.2349
Woodland	20.47	1	<0.001	0.4864	0.1075
Conifer plantation	11.69	1	0.001	-0.5643	0.1651
Hedge/tree line	12.36	1	<0.001	0.6491	0.1846
Any hedge category	5.06	1	0.024	-0.4043	0.1798
Scrub	4.06	1	0.044	0.2008	0.09971

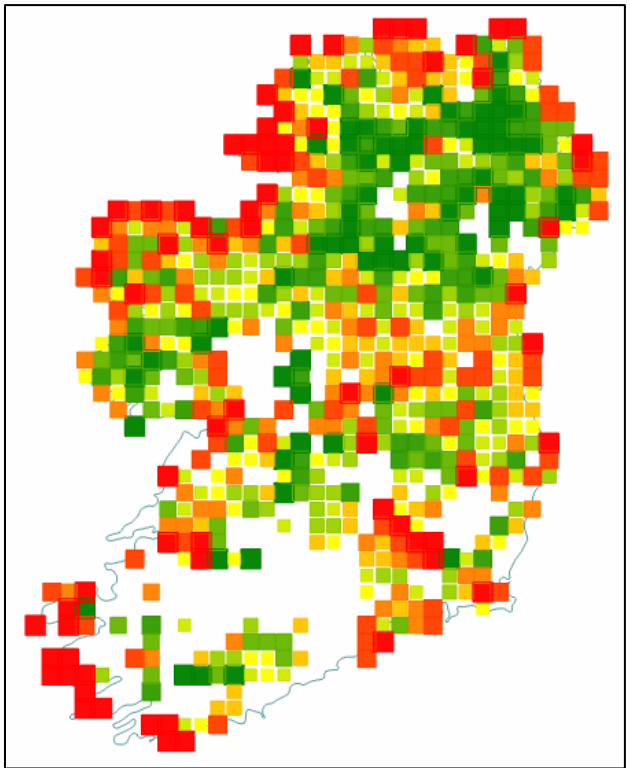

Figure 30: Average fitted values from the model for each sampled 10km square in relation to Daubenton's bat. The values essentially map a likelihood of presence based on spatial terms for northings and eastings combined with the impact of habitat variables from GLMM models. Shading shows ten equal groups from lowest (red) to highest (green).

7. BATLAS 2020 Discussion

7.1 Volunteer Participation

Bat Conservation Ireland provided a wide array of training materials and volunteer support for the duration of the BATLAS 2020 project, including supports on the BCIreland website, training courses and training aids. The online registration system and logging of results was an important contribution to the smooth running of the project. The large volume of training courses completed in 2017 encouraged many new volunteers to bat conservation that were not previously participating in other BCIreland surveys. Citizen Science is a term used to describe the collaboration between scientists and members of the public in collecting essential information on a topic and it has increased in popularity over the last few decades (Silvertown, 2009). BATLAS 2020 primarily relied on participation by citizen scientists.

There are a number of benefits from members of the public participating in citizen science programmes including increasing scientific knowledge and involvement in local issues (Conrad & Hilchey, 2011). Nearly twice the number of volunteers participated in BATLAS 2020 compared with BATLAS 2010. This reflects an increased number of active bat groups on the island, as well as greater awareness and commitment by volunteers across the island. This level of dedication to BATLAS 2020 is a very positive force for bat conservation in Ireland. We estimate that the total time spent surveying for BATLAS 2020 to date has well exceeded 2,500hrs, a large proportion of which was by volunteers.

7.2 BATLAS 2020 Surveys & Species Occurrence

The number of sites surveyed for BATLAS 2020, 3,373, was very nearly double the number surveyed for BATLAS 2010. The BATLAS 2020 dataset therefore represents a significant increase in bat distribution bat records for the island.

One of the aims of BATLAS 2020 was to survey at least 80% of the 10km squares on the island. Seven hundred and seventy eight 10km squares were successfully surveyed, but this represents 77% of the island as a whole and 71% of the Republic of Ireland, which is somewhat lower than the 80% target. The shortfall of approximately 80 10 km squares for the Republic of Ireland are located primarily in the south-west and south-east of the country. BCIreland is committed to addressing the data gaps in 2019 with particular emphasis on 10km squares in the following counties: Kilkenny, Offaly, Laois, Wexford, Tipperary, Cork and Kerry.

Soprano pipistrelles were the most frequently recorded species during BATLAS 2020, occurring in almost 93% of squares and 68% of sites. Common pipistrelles were the second most frequently encountered found in almost 86% of squares and 54% of sites. However, common pipistrelles are the most frequently encountered species during BCIreland's car-based monitoring scheme (Aughney, Roche, & Langton, 2018). In 2018, as for most years of this systematic monitoring survey, bar 2006 and 2010, the soprano pipistrelle was the second most frequently encountered species (Aughney et al., 2018). The discrepancy between the car-based scheme and BATLAS may be because the two species have different core areas on the island. The estimated core area in Ireland for common pipistrelles is 56,485 km^2 and for soprano pipistrelles it is 62,020 km^2 (Lundy, Montgomery et al., 2011). So, while common pipistrelles may be Ireland's most common bat species, soprano pipistrelles have a greater range across the island and this is reflected in

the BATLAS 2020 results. Leisler's and Daubenton's bats were the third and fourth most frequently recorded bat species during BATLAS 2020, respectively, and this is also reflected in their differing estimated core areas: 52,820 km^2 and 41,285 km^2 (Lundy, Montgomery, et al., 2011).

All four target species were detected at higher rates during BATLAS 2020 compared to the 2010 study at the 10km square level and, while this square level increase may be attributed to the greater number of sites surveyed per square on average (i.e. greater total survey effort), we also found higher occurrence at an individual site level. The increase in occurrence differed between species with the biggest increase seen for common pipistrelles. This species occurred in 40.7% of sites during BATLAS 2010 and 53.9% of sites during BATLAS 2020. The species with the second largest increase from BATLAS 2010 to BATLAS 2020 was that of soprano pipistrelle which went from 63.7% to 68.0%. Leisler's bats increased by 4% from 32.1% to 36.1% while Daubenton's bat increased by less than 1% (from 29.8% to 30.74%). This suggests either a genuine increase in common pipistrelle, soprano pipistrelle and possibly Leisler's bat population densities/distributions over the 10 years between the two surveys, as has been suggested from data gathered by other systematic surveys (Aughney et al., 2018), or could have potentially arisen as a result of increased detection efficiency (for example choosing more optimal sites, surveying a different subset of squares, using more advanced equipment, volunteers being trained to a higher level etc).

As part of the Irish Bat Monitoring Programme, yearly trend analysis is carried out for common pipistrelles, soprano pipistrelles, Leisler's bats, Daubenton's bats and brown long-eared bats. The Car-based Bat Monitoring Scheme collates data on common pipistrelles, soprano pipistrelles and Leisler's bats while the All Ireland Daubenton's Bat Waterways Survey gathers data on Daubenton's bat. The car surveys have been running since 2003 while the waterways survey has been in operation since 2006. Common and soprano pipistrelles have both increased significantly since the start of the Car-based Bat Monitoring Scheme. Leisler's bat annual trend index rose significantly above the baseline in the first ten years of the car-based bat survey but, yearly estimates have dropped year on year since 2015 and so in 2018 the lower confidence interval dropped below the baseline. In relation to Daubenton's bats, the population trend derived from the All-Ireland Daubenton's Waterways Survey fluctuates from year to year but overall has been very slightly, though not significantly, increasing. Based on the results of these systematic monitoring schemes increased detection of common and soprano pipistrelles may have been anticipated in the ten years between BATLAS 2010 and BATLAS 2020, with some increases also possible for Leisler's bat. However, Daubenton's bat trend has not been significantly increasing, so the slightly increased detection rate for this species may be due to random fluctuation or other factors such as improved training courses or training resources available for BATLAS 2020.

Detection rates for non-target species (confirmed identifications) were much lower than for target species, as may be expected. While non-target species are more difficult to detect and/or identify we found that presence per site was lower for all non-Daubenton's *Myotis* categories during BATLAS 2020 compared with BATLAS 2010. Unidentified *Myotis* spp. were present in 17.1% of sites during BATLAS 2010 compared with 6% of sites during BATLAS 2020, while confirmed Natterer's reduced from 4% to 2.2% and whiskered bats dropped from 1.2% to 0.9%.

A similar reduction was recorded in brown long-eared bats between the two surveys; from 8.7% to 3.6% of sites. Nathusius' pipistrelle on the other hand, increased from 0.4% to 1.6%. These differences from one survey period to the other may be due at least partly, to the greater number of northern squares included in the 2020 survey compared with 2010. Most of these species, excepting Nathusius' pipistrelle, are more abundant to the south. Other differences such as increases in street lighting, new detector models, or even improved surveyor experience may all contribute to differences between the surveys. Nonetheless, a possible decline in *Myotis* spp. has been highlighted from limited data for these species gathered by the car-based bat monitoring scheme (Aughney, Roche, & Langton, 2019)

When the final suite of BATLAS 2020 surveying is complete in 2019, a more thorough analysis comparing the subset of sites that were surveyed during both schemes, should help elucidate some of the driving forces behind any changes. At the 10km square level, a total of 506 survey squares were surveyed in both the BATLAS 2010 and BATLAS 2020. However, due to the fact that there is a northern bias in the BATLAS 2020 survey sites compared to the southern bias in the BATLAS 2010 sites, it is important that further survey work is completed in 2019 to fill in the gaps in the southern 10km squares before this exercise is undertaken.

7.3 Spatial Distribution

There are strong spatial patterns depicted by the current dataset in relation to the target bat species. For common pipistrelles, there were fewer positive surveys for this species in Co. Mayo and Co. Galway. This pattern is also recorded by the car-based bat monitoring scheme where for most years of the survey no common pipistrelles have been recorded from square L64 (Connemara) (Aughney et al., 2018). Common pipistrelles are the species most frequently encountered by this monitoring scheme and overall the activity distribution of this species follows a south-east/north-west pattern with higher encounter rate car survey squares located in the southern half of the island.

The spatial distribution for soprano pipistrelles from BATLAS 2020 showed a more absence along coastal areas. The presence of the 'coastal habitats' variable , tended to have a negative impact on the presence of this species and may be the primary influence on the absence of this bat species along coastal 10km squares. The pattern of activity distribution for the soprano pipistrelle from the Car-based Bat Monitoring Scheme has never been as clear as for common pipistrelles although this species does show some western bias in some years of the monitoring surveys. By way of contrast, in 2018, lowest abundance car survey squares were in the extreme north and Connemara, the latter could be considered a coastal 30km square (Aughney, Roche, & Langton, 2019).

7.4 Survey Methodology

Both Leisler's bats and common pipistrelles were less likely to be encountered later in the survey night compared to the first couple of hours. Future surveys may be best restricted to the first half of the night. Encounter rates for Leisler's bats and common pipistrelles reduced as the survey season progressed. The probability of encountering bats is fairly constant up to August, then starts falling off with a rapid decline in September and October.This underlines the need for a survey cut-off by mid-September which was introduced by 2016 for the present BATLAS project.

Environmental variables such as weather may be a contributing factor to lower occurrence later in the survey season.

Surveyors were requested to carry out surveys during fine weather conditions. Where surveys were undertaken in breezy weather, significantly lower encounters of common pipistrelles and Leisler's bats occurred. This reconfirms that surveying should be undertaken in good weather conditions.

7.4 Environmental & Habitat Variables

Artificial lighting is a particular problem for nocturnal animals including bats. Mathews *et al.* (2015) reported that Leisler's bats were more frequently recorded along lit roadside transects while lighting was negatively associated with common pipistrelles distribution on a landscape scale, but that there may be some increases on a local scale in areas when street lighting was located in areas with good tree cover. We found similar results for the two species during BATLAS 2020 surveys, where both of these species were associated with street lighting although the effect of combined presence of lighting and shading from trees has not yet been examined in detail. This will be further investigated following the 2019 field season.

The presence or absence of lighting was of no significant influence in relation to soprano pipistrelles and Daubenton's bats during BATLAS surveys. However, analysis of the potential impact of lighting on Daubenton's bats by the Irish Bat Monitoring Programme confirmed that the presence of street lights has a significant negative impact on Daubenton's bat at specific points along surveyed rivers and canals in Ireland. This bat species is 9% less likely to occur at points along a waterway that are illuminated by street lights (Aughney, Langton, & Roche, 2012).

The Irish Landscape Model indicates that common pipistrelles select areas with broadleaf woodland, riparian habitat and low density urbanisation at a local level (Lundy, Montgomery, et al., 2011). In studies in Northern Ireland, the species has been reported as a generalist forager using a range of habitats including rivers, grassland and woodlands (Russ & Montgomery, 2002). This was confirmed by BATLAS 2020 surveys where the common pipistrelle was positively associated with the presence of scrub, woodland and grasslands. Common pipistrelles tended to be recorded where rivers greater than 10m wide were present at the BATLAS 2020 survey site.

The Irish Landscape Model reported that the soprano pipistrelle selects areas with broadleaf woodland, riparian habitats and low density of urbansiation (Lundy, Montgomery, et al., 2011) and Russ & Montgomery (2002) stated that it prefers riparian woodland and riparian habitats in Northern Ireland. Of all four target bats species for BATLAS 2020, this species showed the strongest association with habitats present at survey sites. There are strong positive relationships with watercourses, lakes and rivers over 10m in width and soprano pipistrelles were more likely to be present at the BATLAS 2020 survey site if linear wooded habitats were present, thus confirming the studies mentioned above. Boughey *et al* (2011) also reported that this species is more active along hedgerows with trees and hedgerows and which are located close to woodlands.

Lundy *et al.* (2011) reported that Leisler's bats selected woodland habitats at the local level and at a landscape level. BATLAS 2020 surveys show a highly significant positive relationship

between Leisler's occurrence and woodland, and a more borderline one with medium height hedgerows.

Habitat preferences for Daubenton's bats were reported by Lundy *et al.* (2011) to be broadleaf woodland, riparian habitat and low density urbanisaton at a local level. Water courses, lakes and rivers at least 10m wide were all reported by BATLAS 2020 as having a significant positive impact on the probability of detecting Daubenton's bats. Woodlands and hedge/tree lines also have large and highly significant positive effects.

8. References and Sources of Information

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Appendix

A - Record Sheet

Bat Conservation Ireland BATLAS 2020 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.

	Site A	Site B
Grid Ref: Site name (e.g. Bridge/river name):		
BATLAS 2010 site? (tick if yes):		
Date (reminder to change after midnight):		
Start Time:		
Temperature (^{o}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) *Please estimate width of linear waterways*	pond or lake (please circle) river or canal (please circle) (m)	pond or lake (please circle) river or canal (please circle) (m)

Bat species recorded

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

B – Photographic Aids

Small Hedgerow

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.

Medium Hedgerow

Hedgerows which are approximately 1.5 - 3 m in height.

Sparse Treeline Hedgerow

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.

Dense Treeline Hedgerow

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.

Car-based Monitoring Scheme(Roche et al., 2011), with the following categories used:

- White Light: Usually the brightest lights, security lights and floodlights are most often white for example. The modern LED (or "blue" light) should be included in this category
- Yellow Light: For example almost all motorway lights emit 'yellow'. Note that streetlights described as Yellow sometimes have a pinkish tinge
- Orange Light: Becoming less common, older streetlights often emit a bright/deep orange light

C- Typical example of how to complete a survey square

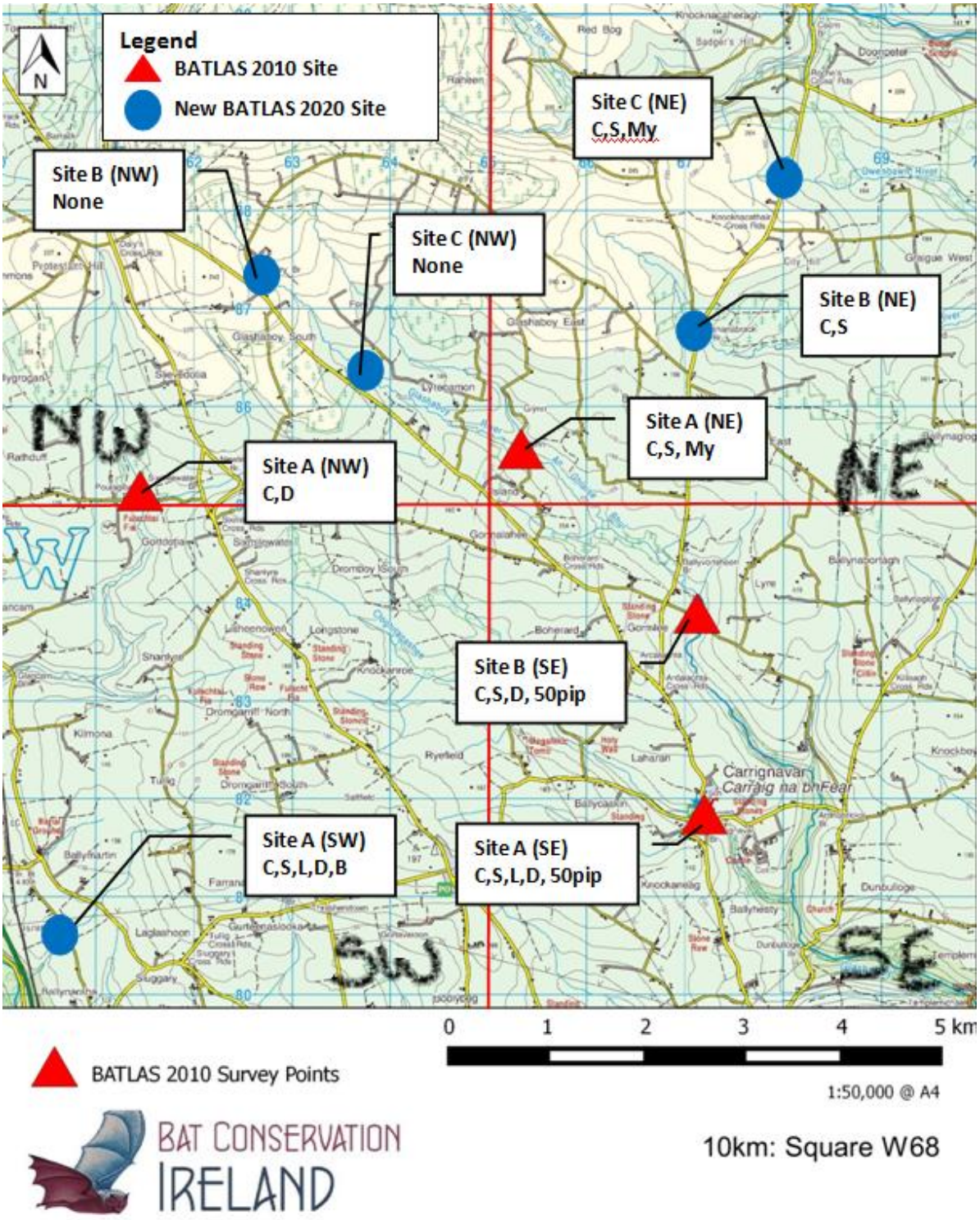
Please refer to the map, and example Record Sheets. One Record Sheet per 5km quadrant.

Quadrant 1
Started in the SE 5km quadrant (can survey the quadrants in any order).
Two BATLAS 2010 Sites to be done first.
Site A SE (label Sites in quadrant in the order visited). All four target species common pipistrelle, soprano pipistrelle, Leisler's bat, Daubenton's bat were recorded within 6 minutes at BATLAS 2010 Site A (SE), so didn't need to stay for the full 10 minutes.
If there had been no other BATLAS 2010 Sites in the quadrant, then that quadrant would have been finished, since all four target species were detected. There was one other BATLAS 2010 Site, and since all BATLAS 2010 Sites require a re-survey, went to that next.
Site B (SE). Detected common pipistrelle, soprano pipistrelle, pipistrelle (49 - 51 kHz), Daubentons' bat. Stayed for the max time of 10 minutes but Leisler' bat didn't show up.
Since all BATLAS 2010 Sites were surveyed, and since all four target species had been recorded within that 5km quadrant, moved onto the next one. Didn't need to pick a New Site here.

Quadrant 2
Moved to the NE 5km quadrant (can survey the quadrants in any order).
Site A. There was one BATLAS 2010 site, so did that first. Detected common pipistrelle, soprano pipistrelle, Myotis sp. in 10 minutes max. duration.
Site B. Picked a New Site to try to detect missing species Leisler's and Daubenton's - chose a watercourse for Daubenton's bat. Recorded common pipistrelle and soprano pipistrelle within 10 minutes max. duration. Still missing Leisler's and Daubenton's.
Moved onto the next quadrant, because two sites within a quadrant, including BATLAS 2010 Sites, is the maximum required.

Quadrant 3
Moved to the NW 5km quadrant.
Site A. One BATLAS 2010 Site, so did that first and detected common pipistrelle and Daubenton's Bat in 10 minutes maximum duration.
Site B. Picked a New Site to try to detect missing species. No bats detected in 10 minutes.
Moved onto the last quadrant, because two sites per quadrant is the maximum required.

Quadrant 4
SW 5km quadrant.
Site A. No BATLAS 2010 site, so picked an accessible site with good bat habitat. Recorded all four target species and brown long-eared bat within less than 10 minutes.
As all four target species were detected for that quadrant, and there were no BATLAS 2010 sites to cover, that was that quadrant finished. 10km grid square survey completed.



Bat species codes marked on map above for illustration: C: Common pipistrelle, S: Soprano pipistrelle, L: Leisler's bat, D: Daubenton's bat)

Bat Conservation Ireland BATLAS 2020 Pilot Project 2015 Record Sheet

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

Name: Isobel Abbott	Email: batlas@batconservationireland.org	
	Tel. No.: 086-1516391	
County: Cork	10 km Square: W68	5 km Quadrant (i.e. NW, NE, SE, SW): SE
Bat Detector Model: EM3+ and Batbox Duet		

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):	W67112 81796 Glashaboy R. Carrignavar	W67064 83888 Glashaboy R.	N/A
BATLAS 2010 site? (tick if yes):	✓	✓	
Date (reminder to change after midnight):	3/9/2015	3/9/2015	
Start Time:	21:00	21:20	
Temperature (°C):	12	11	
Wind (**1**. Calm, **2**. Light breeze, **3**. Breezy):	1	1	
Rain (**1**. Dry, **2**. Drizzle, **3**. Light rain)	1	1	
Cloud (**1**. Clear, **2**. Patchy, **3**. Full)	2	2	
Lighting within 100 m? (tick if yes)	✓		
Lighting where bats flying? (tick if yes)			
Lighting type (White, Yellow, Orange)	Orange		
Hedgerow present? (tick if yes?)	✓	✓	
Hedgerow type (SH, MH, ST, DT)	DT	DT	
Waterway present? (tick if yes)	✓	✓	

Bat species recorded

	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