Irish Bat Monitoring Schemes

BATLAS Republic of Ireland
Report for 2008-2009

Carden, R., Aughney, T., Kelleher, C. and Roche, N. (2010)

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

An Chomhairle Oidhreachta
The Heritage Council

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1.0 EXECUTIVE SUMMARY

The BATLAS 2010 national survey of the Republic of Ireland was conducted during two field survey years (2008 and 2009) to ascertain the distribution of four targeted bat species. The targeted species were; common and soprano pipistrelle, Daubenton's and Leisler's bats. These species were found in 591 of the 647 surveyed 10km squares in the Republic of Ireland; representing 71.6% of the total number of 10km squares in the Republic. Both pipistrelle species were widely distributed in the survey and although the common pipistrelle occurred in many of the same sites surveyed as the soprano pipistrelle, the soprano pipistrelle was detected in more of the surveyed 10km squares in the northern and western regions of the country. Daubenton's bat has a wide distribution within the Republic of Ireland and it was detected in every county, however, it was noticeably absent along coastal edges. Leisler's bat was also widely distributed across the country but was not found 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. During the survey of targeted species, additional, '*ad hoc*' observations, of other bat species were also noted and recorded and these are included within the report's appendices.

The BATLAS 2010 project was a field-based study that used a standardised survey protocol developed by Bat Conservation Ireland. This protocol was used by all 62 participating volunteer surveyors. These volunteer surveyors had either had previous specialised experience in bat surveying, participated in training workshop weekends (organised by Bat Conservation Ireland) and/or were provided with additional training by the BATLAS 2010 Project Co-ordinator. These volunteers facilitated the near complete coverage of the Republic of Ireland (647 of the 904 10km squares) and the compilation of 1,693 individual records during the two field survey years.

The resulting distribution map of each of the targeted species provides a fundamental baseline to which further records can be added over time and a repeat of the BATLAS 2010 national survey is recommended in 2020 and thereafter at ten-year intervals with specific surveys of selected targeted areas of special interest being conducted every five years, if necessary. Finally, recommendations are presented for future bat atlases of Ireland.

2.0 ACKNOWLEDGEMENTS

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3.0 INTRODUCTION

The Order Chiroptera is the second most diverse order of mammals (Wilson & Reeder 2005); exhibiting large taxonomic and ecological diversity (Stevens & Willig 2002; Simmons & Conway 2003). Ireland's species of bats fill an important ecological niche as nocturnal insect predators, as well as being an integral component of all major ecosystems. As European bats are specialist (in terms of prey items) and opportunistic feeders, preying almost wholly upon insect and spider populations, and have certain habitat requirements they have potential to act as broad landscape bio-indicators of environmental health (Fenton 1997; Walsh *et al.* 2001; Jones *et al*. 2009).

Within Ireland, there are nine confirmed resident breeding species of bats with the potential of one additional species. This animal group constitutes almost a third of the Irish terrestrial mammalian fauna. The nine species of Irish bats belong to two Families; Vespertilionidae (eight species) and Rhinolophidae (one species). The eight confirmed resident Vesper bats in Ireland are:

(a) common pipistrelle (*Pipistrellus pipistrellus*)
(b) soprano pipistrelle (*Pipistrellus pygmaeus*)
(c) Daubenton's bat (*Myotis daubentonii*)
(d) Leisler's bat (*Nyctalus leisleri*)
(e) whiskered bat (*Myotis mystacinus*)
(f) brown long-eared bat (*Plecotus auritus*)
(g) Natterer's bat (*Myotis nattereri*)
(h) Nathusius' pipistrelle (*Pipistrellus nathusii*)

One adult female Brandt's bat (*Myotis brandtii*, Vespertilionidae) was found in County Wicklow in 2003 (Mullen 2006) and after subsequently dying from injuries was genetically confirmed using molecular methods by Harris (2006). Further reports of Brandt's bat, keyed out to species using morphological characters, have been made by various bat field workers from Counties Tipperary, Cavan, Clare and Kerry (see Kelleher 2006); however these are yet to be confirmed genetically.

The lesser horseshoe bat (*Rhinolophus hipposideros*) is the only representative of the Family Rhinolophidae or horseshoe bats in Ireland. This species is confined to counties on the western seaboard namely Mayo, Galway, Clare, Limerick, Kerry and Cork. The smallest species that occurs in Ireland is the soprano pipistrelle and the largest is the Leisler's bat.

All Irish bat species are protected under domestic and EU legislation. Under the Republic's Wildlife Act (1976) and Wildlife (Amendment) Act (2000) it is an offence to intentionally harm a bat or disturb its resting place. The status of all Irish bat species in the 2009 Mammal Red List for Ireland is listed as '*Least Concern*' with the exception of Brandt's bat ('*Data Deficient*'; listed as resident species in Marnell *et al.* 2009) and Leisler's bat ('*Near Threatened*').

The EU Habitats Directive (92/43/EEC) lists all Irish bat species in Annex IV and one Irish species, the lesser horseshoe bat, is also listed in Annex II. Annex II includes animal species of community interest whose conservation requires the designation of Special Areas of Conservation (SACs) because they are, for example, endangered, rare, vulnerable or endemic. Annex IV lists various species that require strict protection. Article 11 of the Habitats Directive requires member states to monitor all species listed in the Habitats Directive and Article 17 requires States to report to the EU on the findings of monitoring schemes (Roche *et al.* 2009; Marnell *et al.* 2009). Ireland is obliged to maintain the favourable conservation status of its bat species.

Ireland is also a signatory to a number of conservation agreements pertaining to bats such as the Bern and Bonn Conventions. The Agreement on the Conservation of Populations of European Bats (EUROBATS) is an agreement under the Bonn Convention and Ireland is one of the 32 signatories. The Agreement has an Action Plan with priorities for implementation (Roche *et al.* 2009; Marnell *et al.* 2009).

3.1 Distribution of bat species

Due to their nocturnal behaviour, large home ranges and problems associated with identifying some species in flight, assessment of the distribution of bat species presents a challenge and thus accurate surveys are difficult (Walsh and Harris 1996; Flaquer *et al.* 2007). Bats can be unevenly distributed within any given localised region, given habitat heterogeneity, seasonal effects, environmental variables (localised conditions even on small scales) and insect abundance (de Jong & Ahlén 1991). Furthermore, local abundances of insects can vary widely both in terms of time and space and such abundances will directly affect the distribution of bat species within the landscape.

Data on distribution patterns and trends of animals can help us to acquire knowledge about species' requirements, thus potentially aiding the conservation decision-making process. The lesser horseshoe bat's peripheral distribution range on the island, for example, may have important implications for its biology and conservation as this species has undergone drastic population declines in Europe along with a severe distribution range constriction (Schober & Grimmberger 1997). The distribution of species that are now considered relatively common may change in the future. Thus current data on distributions can provide baselines from which to monitor changes in ranges over long time scales. Ongoing monitoring programmes that assess species' populations, combined with distribution data, therefore provide a comprehensive picture on species' requirements and changes.

Many authors have correlated animal diversity with structural diversity of the environment (see review by Karr & Roth 1971). The mosaic structure of the Irish landscape and vegetation provides productive habitats for bats, in particular woodlands and riparian habitats; the latter acting both as feeding grounds and drinking sites for bat species (Racey 1998; Russ & Montgomery 2002; Buckley *et al*. 2007). Ongoing habitat monitoring and recording in association with animal species are essential in any monitoring programme due to the indirect and direct effects between these two factors as well as correlated interactions between species' and their environments. Not only are such data vitally important in relation to creation and implementation of conservation policies but they also provide a foundation for further surveys and monitoring programmes.

3.2 Bat recording in Ireland since the 1990's

The results of the first large scale bat distribution mapping exercise carried out in the Republic of Ireland were published by O'Sullivan (1994). This publication succinctly showed the results of the National Bat Survey carried out by the NPWS between 1985 and 1988. Records were gathered by conducting roost surveys. Coverage of the country was quite poor due to the limited number of NPWS staff but a general picture of bat distribution in Ireland was developed (see Figure 1 for each of the Irish species' distribution maps within the Republic of Ireland and Northern Ireland, after O'Sullivan (1994)). The four most common species identified by O'Sullivan's (1994) survey in Ireland were the pipistrelle spp. (the soprano and common pipistrelle had not been separated into distinct species at the time), brown long-eared bat, Leisler's bat and Daubenton's bat (O'Sullivan 1994). O'Sullivan's (1994) publication was mirrored by a similar report for Northern Ireland in 2000 (Allen *et al.* 2000).

Since 1994, many small and large scale localised surveys and research projects, along with nationwide and island-wide monitoring schemes have been carried out or are ongoing (e.g. Tangney & Fairley 1994; McGuire 1998; Roche 1998; Shiel & Fairley 1998; Keeley 1999; Russ 1999; Shiel 1999; Roche 2001; Russ & Montgomery 2002; Keeley 2003; Russ *et al*. 2003; Kelleher 2004; Buckley *et al.* 2007; Aughney & Roche 2008; Aughney *et al.* 2009; Roche *et al*. 2009; Aughney *et al.* 2010; Lundy & Montgomery 2010). The results of most of these surveys or monitoring programmes have been compiled in an online bat database administered by Bat Conservation Ireland (BCIreland) which acts as a central repository for bat records in the Republic of Ireland. From these data it has become evident that there still exist many gaps in distribution ranges for many of our bat species including four of the species (common pipistrelle, soprano pipistrelle, Daubenton's bat and Leisler's bat) most easily recognised using a tuneable bat detector.

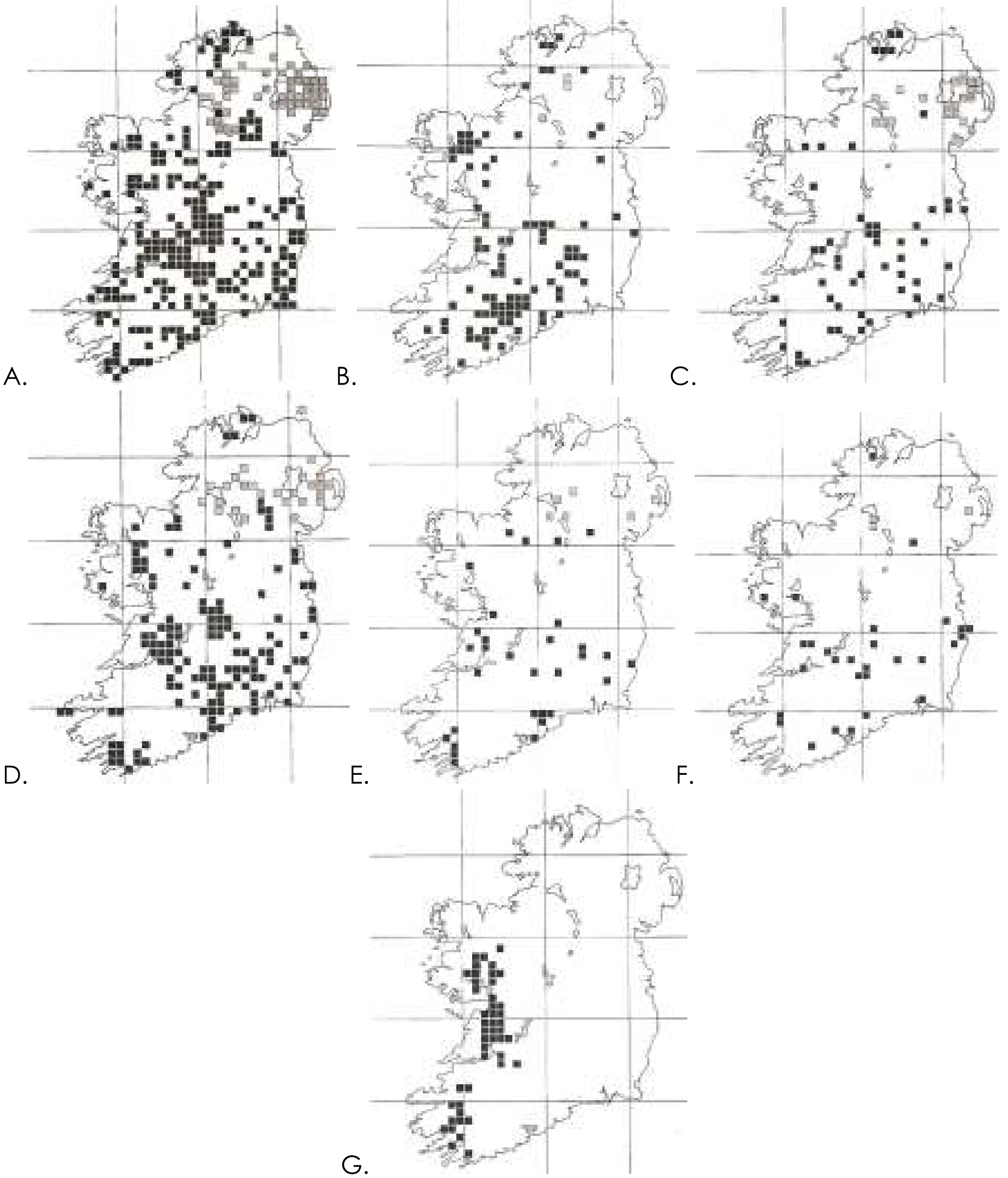

Figure 1. The distribution of bat roosts (A: pipistrelle spp., B: Daubenton's bat, C: Leisler's bat, D: brown long-eared bat, E: Natterer's bat, F: whiskered bat and G: Lesser horseshoe bat) in Ireland within 10 km surveyed squares during the 1985 to 1988 NPWS National Bat Survey. Solid squares indicate records from the 1985-1988 survey whereas the hatched squares were records from the Northern Ireland Bat Group (after O'Sullivan 1994).

3.3 Development of the BATLAS

Despite progress in bat identification and survey work in Ireland, during the process for reviewing the status of bats in Ireland, which included meetings between Irish bat specialists and NPWS staff in 2006, it became apparent that many gaps in coverage still existed (N. Roche pers. comm.). By 2007, apart from the lesser horseshoe bat, there was still a considerable paucity of data in terms of presence of bat species per 10km square in Ireland: 26% of these squares held records for soprano and common pipistrelle, 24% for Daubenton's bat, 20% for Leisler's bat and 11% for brown long-eared bat (NPWS 2009). The north western, north midlands and western regions were particularly lacking in records. Distribution patterns of bats in Ireland remained patchy mainly due to the limited number of qualified bat specialists. Gaps in coverage on the database often reflect the absence of trained bat workers in that location rather than the absence of bats. Therefore, it is extremely difficult to compile any type of review, comprehensive or otherwise, on the current status and distribution ranges/extents of resident Irish bat species. The review of the status of bats in Ireland carried out from 2006 was instrumental, therefore, in initiating a proposal for a Bat Atlas project that was submitted to NPWS and accepted for funding. The Bat Atlas project (BATLAS 2010) was implemented in the 2008 and 2009 field seasons. This project was managed by BCIreland with two year funding from NPWS and supplemented by funding from the Heritage Council (Wildlife Grant 2009 No. 17060).

3.4 Aims and objectives of BATLAS 2010

The primary objective of this project was to systematically survey a minimum of 600 10km squares using a standardised survey method in the Republic of Ireland (hereafter referred to as Ireland) to ascertain the current distribution of:

- common pipistrelle
- soprano pipistrelle
- Daubenton's bat and
- Leisler's bat

In 2009, a similar project was implemented in Northern Ireland funded by the Northern Ireland Environmental Agency (NIEA) for the same four target species.

3.5 BATLAS 2010 targeted species

The four targeted species of the BATLAS 2010 project are those that are the most distinct and easily identified in the field through acoustic methods using tuneable heterodyne bat detectors. The use of bat detectors is the most common and cheapest method to conduct nocturnal surveys of bat species. The advantage of using these detectors is that they are non-invasive and cause minimal disturbance to the bats, as they rely on the detection of species by acoustic means while the bat is in flight (Fenton 1997; Flaquer *et al.* 2007). The targeted species' group includes Leisler's bat which currently has a '*Near Threatened*' status in Ireland (see Marnell *et al.* 2009) and is considered to be of high *International Importance* (see species profile below). However, the lesser horseshoe bat, which has a restricted range both within Ireland and across Europe, and is considered '*Near Threatened*' within Europe, is omitted from the target species due to difficulties in detecting its very high frequency and highly directional echolocation calls using standard field equipment. The determination of the species within the targeted group was based not only on conservation concerns but also on the in-field practicalities of carrying out a large scale survey using volunteer surveyors. There have been ongoing specific monitoring schemes for the lesser horseshoe bat in Ireland and therefore the distribution of this species of bat is broadly well known (see McGuire 1998; Roche 2001; Kelleher 2004 and references cited therein).

However, records of other bat species (other than the four targeted species) recorded during the BATLAS surveys, when generated by a sufficiently experienced volunteer surveyor, were accepted.

3.6 Potential limitations to BATLAS 2010: Volunteer collected data

For the purposes of the BATLAS 2010 project it was assumed that species' identifications were correct and misidentifications were absent or, at most, infrequent. This potential problem is commonly encountered in many faunal surveying projects where field work is carried out by volunteers and relies on either independent verification by an expert in the field or a high degree of identification competency by volunteer surveyors (e.g. Carden *et al.* in review). It is difficult to standardise the ability of volunteer surveyors to discriminate between species (Walsh *et al*. 2001). Various researchers have found that volunteers can be relied-upon to carry out straightforward tasks such as learning to identify species and recording occurrence, and can yield accurate data comparable to those of professionals, particularly when the techniques can be taught to volunteers without lengthy or specialist training (Foster-Smith & Evans 2003; Newman *et al.* 2003). Estimating abundance and interpreting scales did, in one study, sometimes lead to volunteer errors (Foster-Smith & Evans 2003), although in the case of the BATLAS 2010, simple point recording of presence was all that was required. The BATLAS 2010 national survey required that the volunteer surveyor had certain minimum requirement(s) to participate these included: (i) attendance at a minimum of one bat detector weekend training workshop (coordinated by BCIreland), (ii) additional in-field training given by the Project Co-ordinator and/or a highly experienced bat field ecologist. In order to ensure the limits of volunteer capabilities would not be overstretched, just four bat species had been chosen as target species for the survey, and each of these are sufficiently distinct and identifiable so as to not pose a problem for a relatively inexperienced surveyor. To carry out the survey each surveyor was provided with supporting resources such as a purposely designed bat identification guide and offered telephone and internet-based support. Once these criteria were met, the volunteer surveyor was deemed competent to carry out fieldwork.

Furthermore, the acoustic frequencies and characteristics of the echolocation call emitted by each of the four targeted species is sufficiently distinct to allow the identification and discrimination of these species to a high level of accuracy. Most Irish and British bat species can be discriminated by their respective echolocation calls with the exception of some *Myotis* species (Walsh *et al*. 2001) which makes their identification fairly straightforward after minimum basic training. In instances when the volunteer surveyor was unsure of the identification of a bat species based on its echolocation call within a site, the 'unidentified bat' category was circled.

3.7 General ecology of the target species

3.7.1 Common and soprano pipistrelle – Pipistrellus pipistrellus and P. pygmaeus

Although the 'pygmy' or soprano pipistrelle was first identified in 1825 by Dr. Leach, the species was subsequently dismissed as being a separate species until Jones & van Parijs (1993) suggested a phonic separation in Britain between it and the common pipistrelle and suggested that it be split into two species - the soprano pipistrelle which emits echolocation calls with peak energy at 55 kHz and the common pipistrelle with peak energy at 45 kHz. The phonic separation was supported by skull morphology (Barlow *et al*. 1997), colouration and by subsequent genetic analysis and the common pipistrelle was reclassified as two species (Barratt *et al*. 1997). The 45 kHz phonic type, the common pipistrelle, is considered to be a wide-spread and abundant bat species in continental Europe and Britain, although it is rare in Scandinavia and the Netherlands (Jones & Racey 2008). Occurring in much the same geographic ranges as the common pipistrelle, the 55 kHz phonic type, the soprano pipistrelle, is also widespread throughout most of Europe and occurs more frequently at the outer margins of the overlapping ranges of the two (Barratt *et al.* 1997; Mayer & von Helversen 2001; Hulva *et al.* 2004; Jones & Racey 2008). Russ (1996) confirmed both phonic types of pipistrelles in Northern Ireland with sympatric ranges but one type occurring more frequently in some geographic areas than the other. The common pipistrelle may be more a generalist forager and is found in more habitats including deciduous woodland, while the soprano pipistrelle seems to be more a riparian foraging specialist, foraging preferentially in habitats associated with water (rivers, lakes, riparian woodland) and in broadleaf and mixed woodlands, parklands and cluttered habitats (Vaughan *et al*. 1997; Russ & Montgomery 2002; Davidson-Watts *et al.* 2006; Buckley *et al.* 2007; Jones & Racey 2008). Both species emerge from their roosting sites early after sunset, if not occasionally before sunset. The echolocation calls of both species are erratic with fast repetition rates and, on a heterodyne detector sound like 'slaps' and 'clicks'. The unique call structures of these species and the difference in peak frequency mean that both species are usually readily distinguishable in the field using a bat detector.

3.7.2 Leisler's bat – Nyctalus leisleri

The Leisler's bat is, in European terms, a relatively medium-sized bat species but it is the largest of the nine species resident in Ireland. It is a high-flying bat and is usually the first of the Irish species to emerge from its roosting site around sunset (Shiel & Fairley 1998). Although Ireland is considered its world stronghold (Mitchell-Jones *et al.* 1999), as it is common and widespread here (Shiel *et al.* 2008), it is scarce within its restricted geographic range in Europe (Stebbings & Griffith 1986; O'Sullivan 1994; Shiel *et al.* 2008). Leisler's bat preferentially forages over open areas (grasslands, parklands), lakes/rivers/canals, deciduous woodland edges. Artificial street lighting and floodlights are also important foraging sites (Russ & Montgomery 2002; Russ *et al.* 2003; Shiel *et al.* 2008). Its flight tends to be high, fast and straight with occasional dives (Shiel *et al.* 2008). Due to its body size, flight characteristics and early evening emergence around dusk it has often been mistaken for a swift (Aves: *Apus* sp.). The echolocation calls of Leisler's bat are characteristically loud, slow and bubbly ('chip-chop' pulses) having a peak in energy between 24 and 28 kHz (Shiel & Fairley 1998; Russ 1999; Shiel *et al.* 2008). These echolocation calls are distinctly different from all other Irish bat species and are clearly diagnostic of the species using bat detectors (Shiel & Fairley 1998).

3.7.3 Daubenton's bat – Myotis daubentonii

The foraging behaviour of Daubenton's bat is predominantly associated with still or slow moving freshwater habitats including rivers, canals, lakes, reservoir margins, riparian vegetation, drainage ditches in the open countryside and less frequently in urban areas (Swift & Racey 1983; Russ & Montgomery 2002; Richardson *et al.* 2008). Moreover, its preferred foraging habitat is significantly related to aquatic macro-invertebrate diversity. This species may act as a bio-indicator of water-pollution and associated insect diversities (Abbot *et al.* 2009) as population declines for Daubenton's bat may be linked with environments/habitats (Vaughan *et al.* 1997; Langton *et al.* 2010). This bat flies within a few centimetres of still water surfaces, foraging or trawling for insects (Norberg & Rayner 1987; Jones & Rayner 1988). It usually roosts in trees and man-made structures such as bridges, and in tunnels which are located near to water bodies (Boonman 2000; Richardson *et al.* 2008). The Daubenton's bat emits echolocation calls that are heard as regular, short, sharp, evenly-spaced clicks (similar to a 'machine gun rattle') and this distinctive sound has a peak energy at 45 kHz. However, the sound changes little as the frequency dial is turned on the bat detector from 35 to 70 kHz (Richardson *et al.* 2008) due to the fact that the echolocation call is comprised of Frequency Modulated sounds (Russ 1999). The use of a bat detector aided by short bursts from a handheld torch, therefore, make it relatively easy to identify Daubenton's bat based on its unique foraging style and echolocation calls.

3.8 Background – BATLAS 2010

Ireland consists of 869 10km squares, with a further 35 10km squares shared along the border region with Northern Ireland, within which there are numerous different habitats, as outlined in Fossitt (2000). A minimum of 600 10km squares to be surveyed for the four targeted species was set as the target for this project. Field surveying was initially prioritised wherever insufficient records existed within a given region.

From its inception, the BATLAS 2010 project was aimed at participation from volunteers in order to maximise coverage across the country. The use of volunteers in biological monitoring and survey work has been the subject of some debate among biologists in terms of the accuracy and precision of the recorded data (e.g. Newman *et al.* 2003; Foster-Smith & Evans 2003; Battersby 2005). Many Irish and British organisations that study national wildlife populations rely heavily upon volunteer participation (e.g. Irish Wildlife Trust, BCIreland, The Irish Whale and Dolphin Group, BirdWatch Ireland, The Mammal Society (UK), The British Deer Society, Bat

Conservation Trust). These organisations use certain field methods that are both useful for mammal monitoring and suitable for volunteers when a certain minimum level of training or upskilling has been provided by the organisation (Newman *et al.* 2003; Cohn 2008). The use of volunteer-based survey effort allows the collection of a much larger dataset than would be possible in more traditional scientific research. Additionally, these volunteer surveyors, once provided with adequate training, are invaluable assets to mammal monitoring studies and represent a cost-effective means of carrying out surveys. For the All-Ireland Daubenton's Waterways Survey volunteers have been found to accurately identify Daubenton's bat and to produce reliable data following a training course that takes just 2.5 to 3 hours (Aughney & Roche, in prep.). In order to ensure that the data collected by the BATLAS 2010 project would be reliable and robust, however, decisions were made at the start of the project on what records would be acceptable from volunteers of differing skill and experience levels. Volunteers with just experience of the All-Ireland Daubenton's Waterways monitoring scheme were asked to provide records for this species only or, if they wished to participate further, they were given additional training and allowed to provide records for all four species.

The BCIreland committee discussed the BATLAS 2010 methodology in detail and developed the standardised protocol used in the survey to minimise habitat and temporal biases. The standard method would also ensure repeatability not only between squares but in future national surveys.

4.0 METHODOLOGY

4.1 Volunteer surveyors

Initially surveyors were recruited to the BATLAS 2010 project via an online registration form devised specifically for the survey or during one of the many training courses held by BCIreland in 2008 and 2009. Depending on the volunteer's skills level, training by the BATLAS 2010 Project Co-ordinator was carried out. Training included a field visit and full survey of at least two 10km squares along with on-site clarification of species identification from echolocation calls using bat detectors. In addition, volunteers were provided, via e-mail, with sound recordings of each of the bat species as heard on a heterodyne bat detector (source: C. Kelleher). These resources were provided on an ongoing basis throughout the field seasons via electronic and telephone communications between the volunteer surveyors and the BATLAS 2010 Project Co-ordinator. Additional volunteers were recruited through public awareness of the national survey and these volunteers either had previous training and/or professional bat survey monitoring experience and were known to the BATLAS 2010 Project Co-ordinator. Following training or online/other registration by an experienced volunteer each surveyor was supplied with the assigned specific 10km Ordnance Survey maps (1:51,000, OSi licence: NPWS) (see Appendix I for an example), a bat identification leaflet ('Irish Bats in Flight: Identification Card', BCIreland; Appendix II), data record sheet (Appendix III) and, if necessary, a bat detector (e.g. Bat Box 3D). Standard Health and Safety advice on night time surveying was provided to all volunteers.

4.2 Fieldwork methodology

Acoustic surveying of the four species of bats was conducted in each 10km square using tuneable heterodyne bat detectors. Species identification was aided in the field by visual observations (flight characteristics and external morphological features) through the use of a handheld torch, which was used intermittently for brief durations. Fieldwork was carried out on nights that preferably had the following conditions: (i) still to relatively calm or light breezes/winds, (ii) dry to light rain and (iii) relatively warm temperatures of greater than 8° Celsius. A standardised methodology was developed: three to four random sites per 10km square were chosen by each surveyor. However, at least one of these sites was required to have a water body since this is the preferred habitat of Daubenton's bat. If the surveyor detected and recorded all four target species during the first (or subsequent) site(s) within the assigned 10km square, then they would move onto the next assigned 10km square without surveying the remaining two or three sites as this survey focused on the presence of the targeted species across the Republic of Ireland.

Fieldwork commenced between 20 and 40 minutes after sunset and where all-night surveys were conducted, surveying ended approximately 20 to 30 minutes prior to sunrise. All surveys were conducted between late April and early November (weather permitting). The duration of each site survey was 10 to 15 minutes and all species of bat detected were noted. Habitat classifications at each survey site were recorded at the intermediate level of detail as per Fossitt (2000) and these classifications were included on each record sheet. Additional data included time, temperature, weather conditions (cloud cover, precipitation and wind), location of survey and GPS coordinates for the survey sites. Following fieldwork, all record sheets were returned to the BATLAS 2010 Project Co-ordinator and these records were collated in the online BCIreland database.

Where there were gaps in surveyor coverage, the Project Co-ordinator specifically surveyed these areas. Survey effort by the Project Co-ordinator therefore, was predetermined by (a) volunteer surveyor participation and area coverage by same, and (b) 10km squares with no historical records.

4.3 Distribution maps

Distribution maps illustrating results of the 10km squares surveyed were plotted using GIS ArcView version 9.2 to the scale of 1:1,800,000.

5.0 RESULTS

5.1 Volunteer participation

A total of 62 volunteers participated in this national bat survey; the majority of these participated during both survey seasons (2008 and 2009) and were a combination of NPWS staff (n=16), BCIreland committee members (n=11) and volunteer surveyors (n=35). All had a minimum level of basic training; the majority had attended at least one training course for the All-Ireland Daubenton's Bat Waterways Monitoring Programme (see Aughney et al. 2007), attended a Bat Detector Workshop organised by BCIreland or had previous professional bat monitoring work experience. No surveyors who had just participated in Daubenton's survey training courses volunteered for the survey, all individuals had a greater level of experience and so records for all species were acceptable from all volunteers.

There was a lack of participation of surveyors located in the south and south west regions of the country (mainly in parts of Counties Waterford, Kilkenny, Tipperary and Kerry) and in the western regions (parts of Counties Galway, Mayo, Roscommon and Leitrim). These areas were therefore surveyed by the Project Co-ordinator.

5.2 Weather

Met Éireann provide monthly and annual summaries of the weather (rainfall, temperature and sunshine values) for 2008 and 2009 (http://www.met.ie/climate/monthly-summary.asp). During 2008 and 2009, the periods between June and August were extremely wet with November 2009 being the wettest month on record. Annual air temperatures for 2008 and 2009 were similar and the temperatures in May 2008 were the warmest on record at most stations.

5.2.1 Weather in 2008 season

After a relatively dry spring the weather was very wet between late May and mid-September. Annual rainfall totals were above normal everywhere (between 109% and 138% above the 30-year (1961-90) monthly normal records) so 2008 was the wettest year for six to 22 years. The months of June, July and August were exceptionally wet and daily rainfall led to flooding in many parts of the country. The annual number of wet days (days with 1mm or more rainfall) was above normal everywhere; generally between 10% and 20%.

Mean air temperatures for 2008 were approximately 0.5 of a degree above normal relative to the 30-year period at most weather stations. However, overall, 2008 was the coolest year for six to 14 years. The month of May was the warmest on record at most stations, with mean temperatures over three degrees above normal in western areas. Mean temperatures were normal for June and September but below avearge during the months of October and December. The highest temperatures of 2008 were recorded during the last week of July in most places. Annual sunshine totals were generally near to normal in all areas. The sunniest months were February, April, May, June, October and December with the dullest months being January, July and August.

Mean wind speeds were above normal everywhere during 2008 at seven to12 knots (13 and 22km/h) and these were the highest annual values for six to nine years.

5.2.2 Weather in 2009 season

During the early part of the season, much of the weather was unsettled. In May, rain or showers were recorded on many days. This rain was accompanied by unusually strong winds for May at times, particularly during the first week. There were also short spells of dry and sunny weather, especially at the end of the month, when temperatures rose well above normal. May rainfall totals were above normal at all stations except in parts of the east and southeast. Mean air temperatures for the month overall were above normal everywhere by close to one degree generally.

In June, there were warm and sunny conditions at times, but also spells of cool and unsettled weather, producing occasional heavy rain. Very warm weather was recorded at the beginning and end of the month and this brought mean monthly air temperatures above normal everywhere, especially in western and south-western areas. Mean monthly values were between one and two degrees above normal generally. It was the warmest June since 1970 at a number of stations. Although temperatures fell significantly during the second week after reaching *c.* 25°C at the start of the month. Mean windspeeds for June were below normal everywhere.

Later in the summer, in July and August, rainfall totals were above normal everywhere for the third successive summer, with around twice the average rainfall at some stations. In July, apart from a short spell of dry weather between the 7th and 9th, rain or showers were recorded on each day during the month, resulting in record high monthly totals at some stations. The weather pattern of the previous two summers was repeated, with Atlantic depressions tracking over or close to Ireland, producing substantial falls of rain at times, with frequent thunderstorms. The north and northwest of the country fared relatively well in July, however; in these areas the lowest rainfall totals were recorded and both mean temperatures and sunshine amounts were well above normal.

After the wettest July for over 50 years in places, August was another month of very unsettled weather with rainfall totals well above normal in western and south-western areas. There was very little variation in the weather pattern throughout August; areas of low pressure passing close to Ireland's north coast brought a succession of Atlantic frontal systems, giving some significant falls of rain and localised flooding at times. These conditions also gave a mild and cloudy month but with daytime temperatures only rarely rising above 20°C. While temperatures rose above 20°C on relatively few days during July and August, minimum temperatures were above normal throughout almost all of the summer.

The unsettled weather of July and August extended into the first week of September but high pressure led to settled conditions from the 9th onwards. Sunny conditions were recorded up to the middle of the month but afterwards the weather remained dull. Rainfall totals were below normal and temperatures were a little above normal generally.

Mean wind speeds for the summer season (June, July and August) of six to 12 knots (11 to 22km/h) were above normal everywhere and were the highest summer speeds for up to 35 years at Shannon Airport.

5.3 Adjacent habitats recorded during the BATLAS 2010 field surveys

Habitats, at the intermediate level of detail, as per Fossitt (2000) were recorded during the BATLAS 2010 field surveys (see Appendix III, survey record sheet).

5.4 Survey coverage

A total of 676 10km squares (from the total of 904 within Ireland), representing 1,693 surveyed points, were assigned to volunteer surveyors and the BATLAS 2010 Project Co-ordinator for acoustic surveying of the targeted bat species during 2008 and 2009 inclusive. Of this total, 647 were successfully surveyed (1,693 surveyed points). Therefore, 71.6% of the total 10km squares of Ireland were surveyed using the standardised BATLAS 2010 method for the four targeted species. Widespread coverage of the country was achieved with most extremities, many coastal areas and much of the midlands surveyed. Field surveys of 56 of these 10km squares yielded no detection of any bat species.

Just 29 of the assigned 10km squares were not surveyed (due mainly to adverse weather conditions, but also other reasons); these were in Counties Donegal, Galway, Mayo and Cork. Four of these squares, represented by the Aran Islands (County Galway), were impossible to survey due to unfavourable weather conditions over numerous dates during 2009. The only other off-shore island that was assigned but was surveyed (2008 field season) was Cape Clear, County Cork. The gaps in the survey, along with the remaining 230 squares that were not assigned nor surveyed, are evident in the distribution maps. Areas that were not surveyed as part of the BATLAS 2010 project were in parts of west Kerry, southwest Cork, east Dublin, west Mayo, north Sligo and north Donegal.

Distribution maps for the targeted species group are presented in Figures 2 to 7. Additional species of bats that were detected during the field survey were also recorded (see Appendix IV, Figures 8 to 13). Table 1 provides a summarised breakdown of the total numbers of 10km squares surveyed for each of the species recorded and the percentage represented of the total surveyed sites/squares.

Table 1. A breakdown of species results for BATLAS 2010, where total number of 10km squares surveyed was 647 and total number of Survey Sites surveyed was 1,693 (where between 1 and 4 points were surveyed in each square) during 2008 and 2009 field seasons.

Species	No. of 10km Squares Present	% of Surveyed 10km Squares Present	No. of Survey Sites Present	% of Survey Sites Present
BATLAS species				
Soprano pipistrelle	551	85.1	1,079	63.7
Common pipistrelle	453	70.0	689	40.7
Leisler's bat	404	62.4	543	32.1
Daubenton's bat	397	61.4	505	29.8
Pipistrelle sp.	81	12.5	95	5.6
Additional species				
***Myotis* sp.**	212	32.7	290	17.1
Brown long-eared bat	132	20.4	148	8.7
Natterer's bat	62	9.6	68	4.0
Brandt's/ 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 species	110	17.0	129	7.6

5.5 Soprano pipistrelle

The soprano pipistrelle was detected in 551 10km squares (representing 85.2% of the total surveyed area) and was found to be widely distributed across Ireland (Figure 2). Of the squares surveyed, this species was generally not found in coastal areas that were directly adjacent to the Irish Sea and the Atlantic Ocean in the northwest, west, southwest and parts of the east of Ireland. However, the soprano pipistrelle was detected along southern coastal regions (Counties Wexford, Waterford, Cork and parts of Kerry).

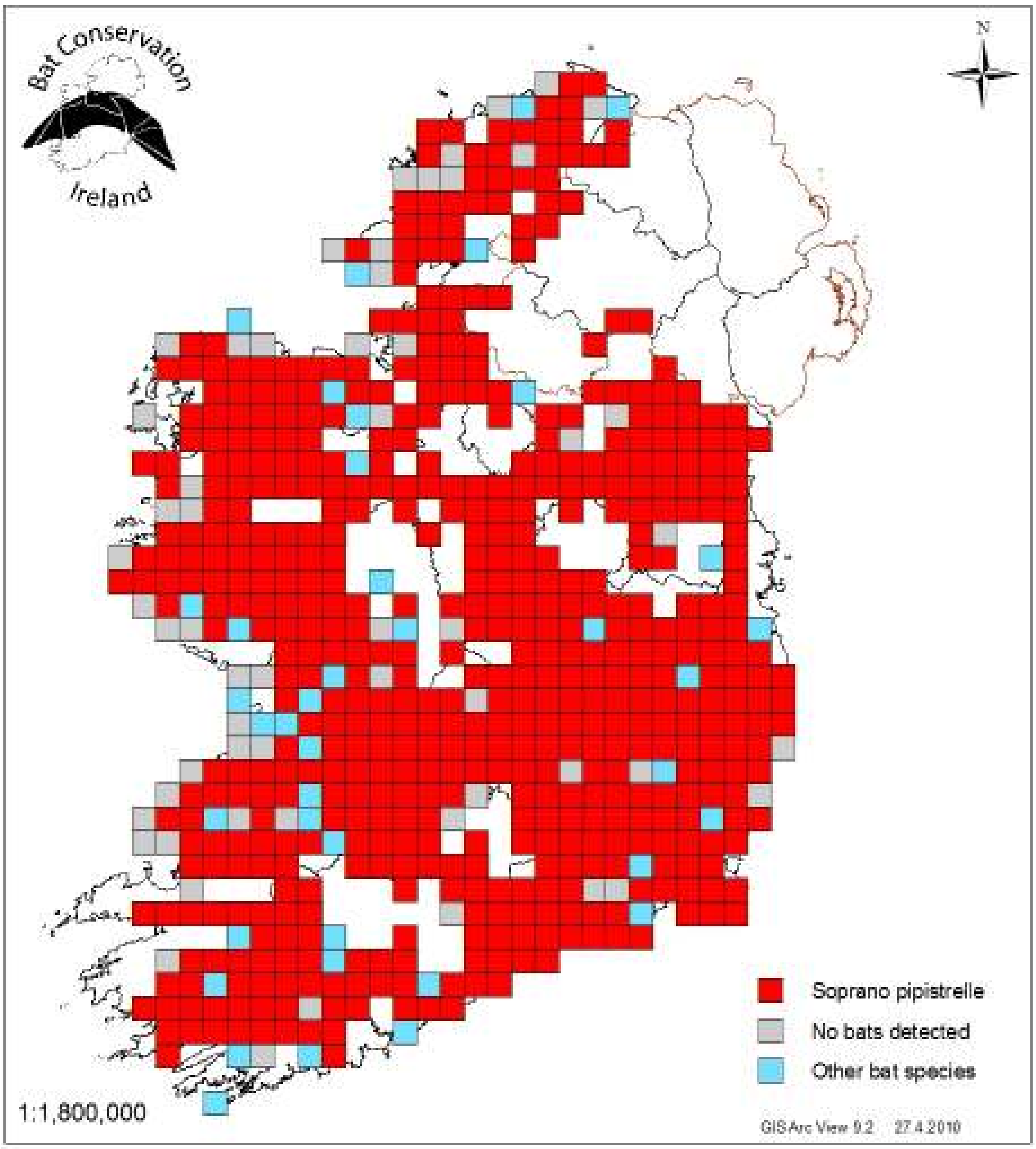

Figure 2. The distribution of the soprano pipistrelle (*Pipistrellus pygmaeus*) (denoted by red squares) in Ireland within surveyed 10km squares (n = 551/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 40/647).

5.6 Common pipistrelle

The common pipistrelle was detected in 453 10km surveyed squares, representing 70.0% of the surveyed areas. Although sympatric in much of its distribution range with the soprano pipistrelle it was not as widely distributed across Ireland (Figure 3). The common pipistrelle's distribution range was patchy in the most north-westerly and westerly regions of Ireland, specifically in Counties Donegal, Sligo, Mayo, Galway and Clare.

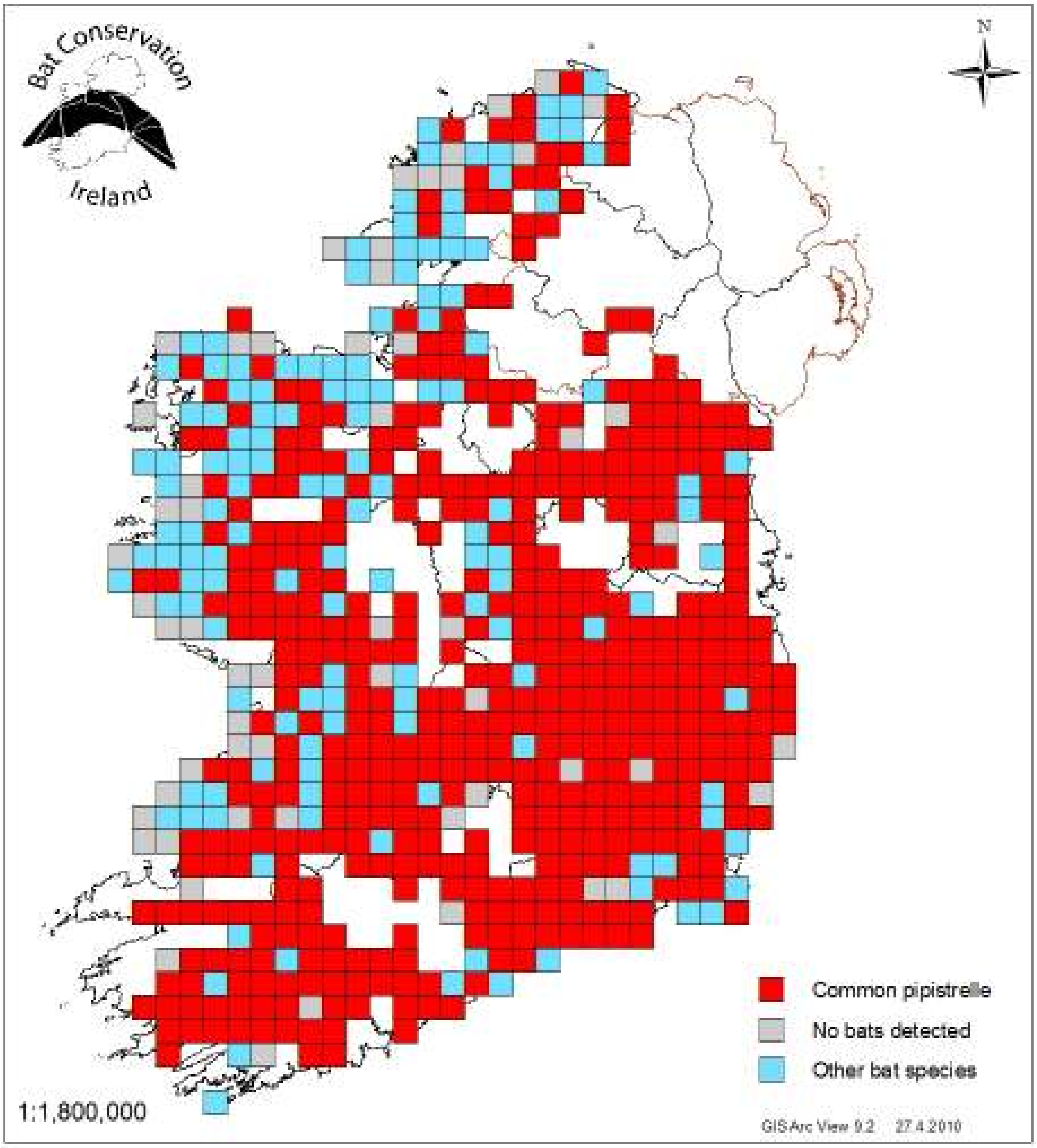

Figure 3. The distribution of the common pipistrelle (*Pipistrellus pipistrellus*) (denoted by red squares) in Ireland within surveyed 10km squares (n = 453/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 138/647).

5.7 Unidentified pipistrelle species

Unidentified pipistrelle species were recorded in 81 10km surveyed squares, representing 12.5% of the surveyed areas (Figure 4). Unidentified pipistrelle bats are individuals that are heard echolocating at a peak frequency between 48 kHz and 52 kHz. They could be either common pipistrelles or soprano pipistrelles but, due to a certain amount of overlap in the calls of these two species, it is not possible to state which.

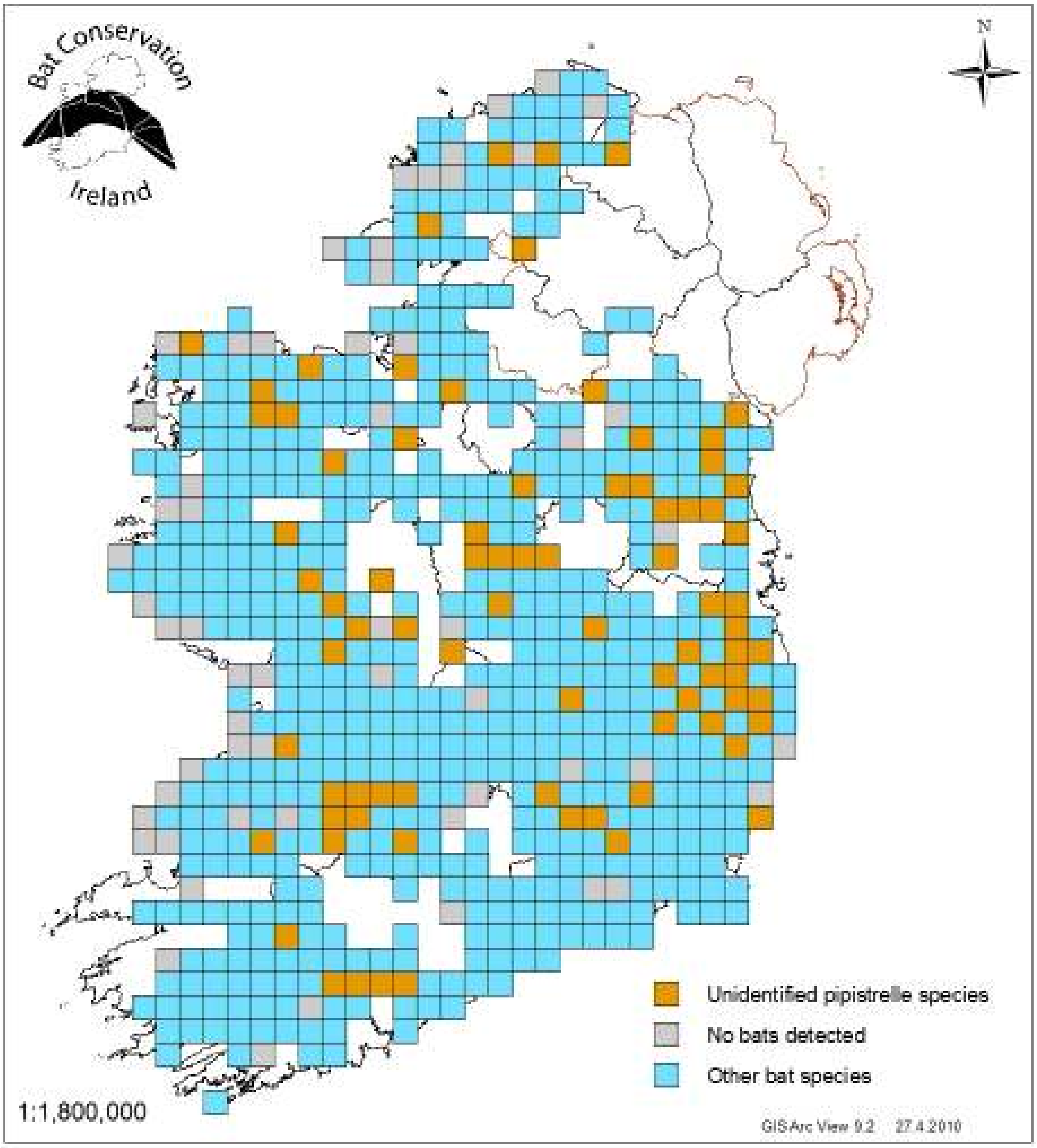

Figure 4. The distribution of unidentified pipistrelle species (denoted by yellow squares) in Ireland within surveyed 10km squares (n = 81/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 510/647).

5.8 Daubenton's bat

Daubenton's bat was detected in 397 10km surveyed squares, representing 61.4% of the surveyed areas. Although sympatric in much of its distribution range with both soprano and common pipistrelles, Daubenton's bat was somewhat more patchily distributed across Ireland (Figure 5). This patchy distribution may be an artefact of the survey site selection within each 10km square, where at least one of the three or four survey sites was on a waterway.

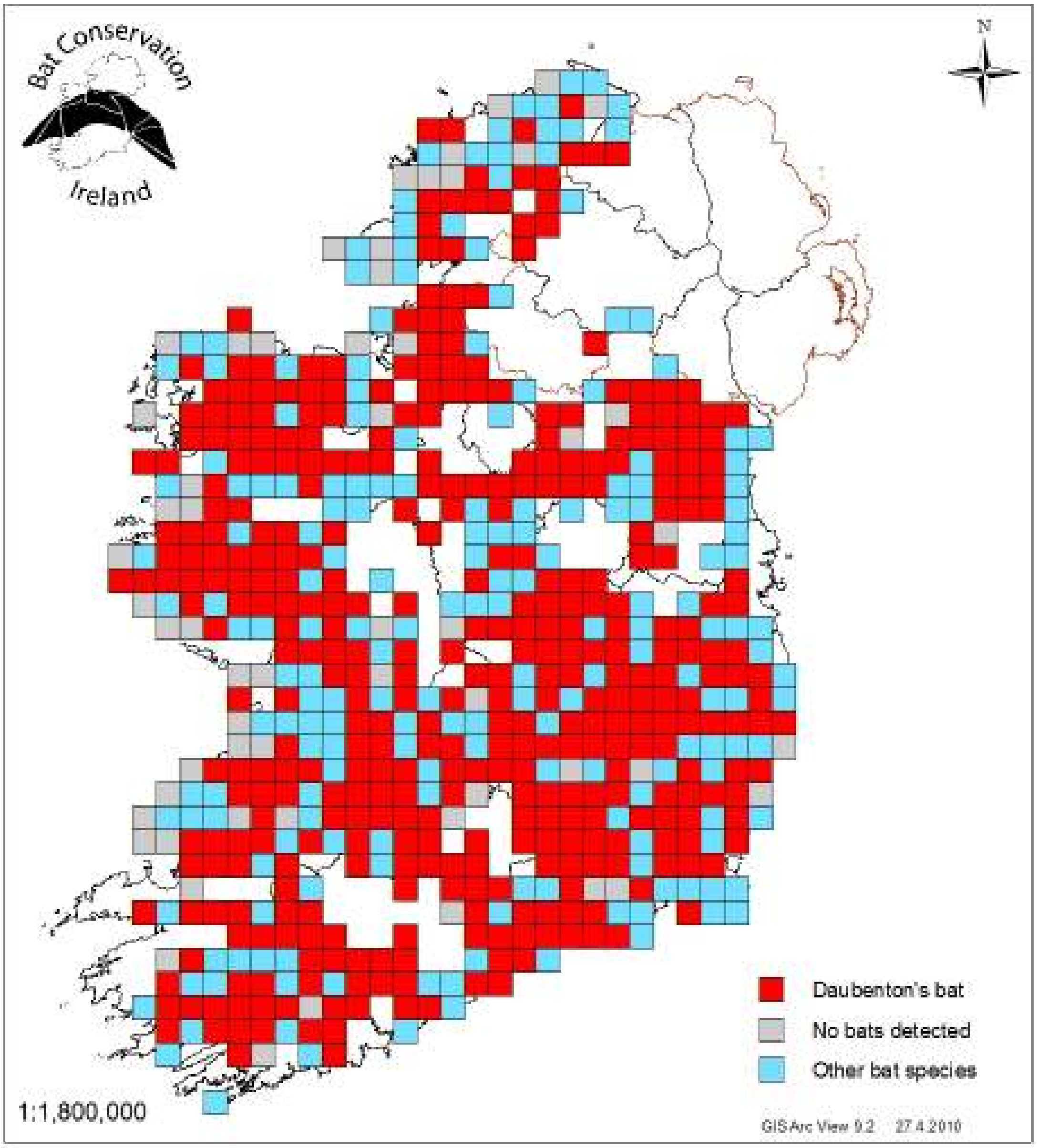

Figure 5. The distribution of Daubenton's bat (denoted by red squares) in Ireland within surveyed 10km squares (n = 397/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 194/647).

5.9 Leisler's bat

Leisler's bat was detected in 404 10km surveyed squares, representing 62.4% of the surveyed areas. A somewhat patchy distribution pattern, similar to that of Daubenton's bat, was observed in the Leisler's bat (Figure 6). The records suggest a limitation of the Leisler's bat range in north County Donegal and parts of the western areas of Counties Mayo, Galway, Clare, Kerry and Cork.

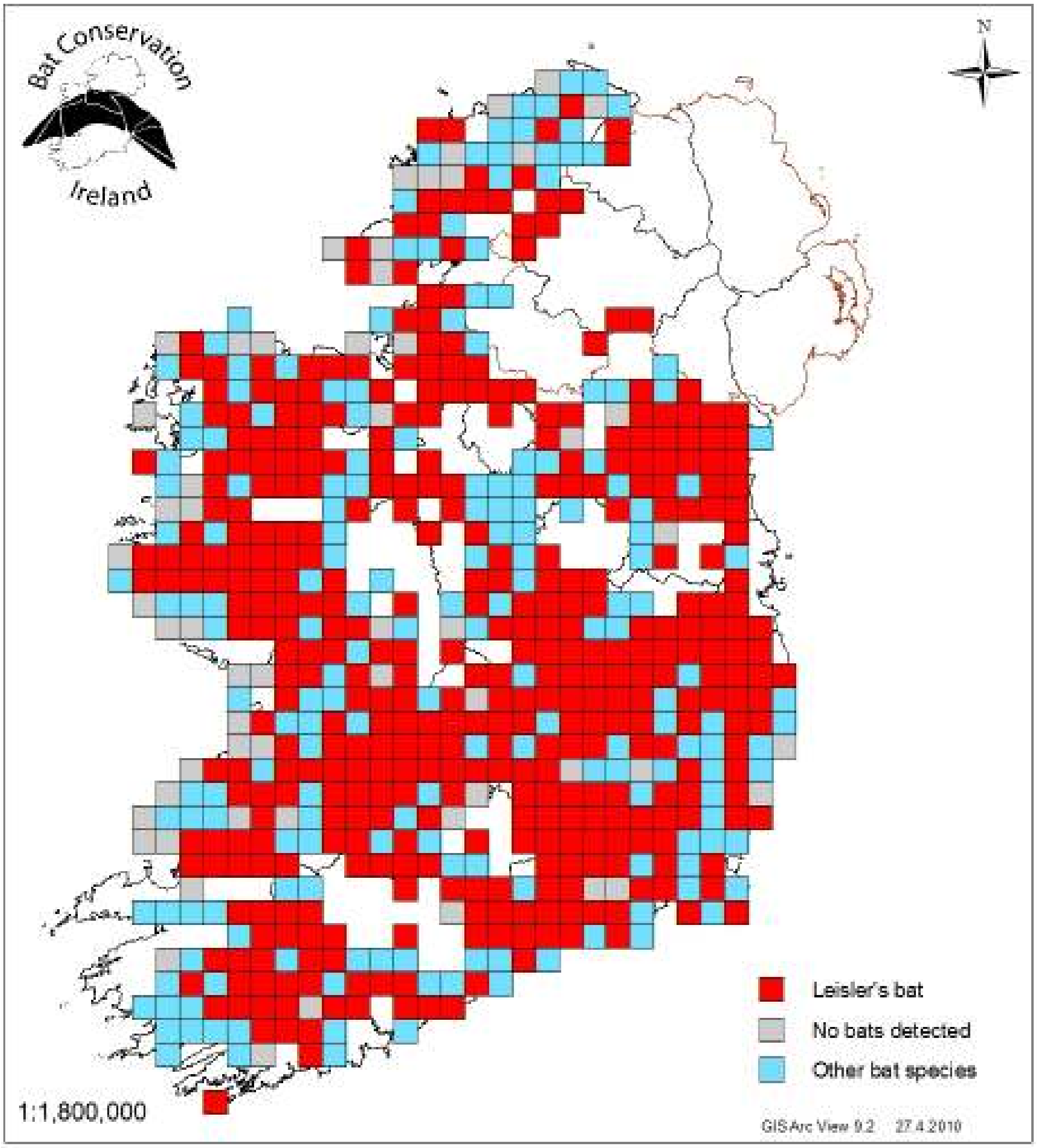

Figure 6. The distribution of Leisler's bat (denoted by red squares) in Ireland within surveyed 10km squares (n = 404/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 187/647).

5.10 Unidentified bat species

Unidentified bat species were detected in 110 10km surveyed squares, representing 17.0% of the surveyed areas (Figure 7).

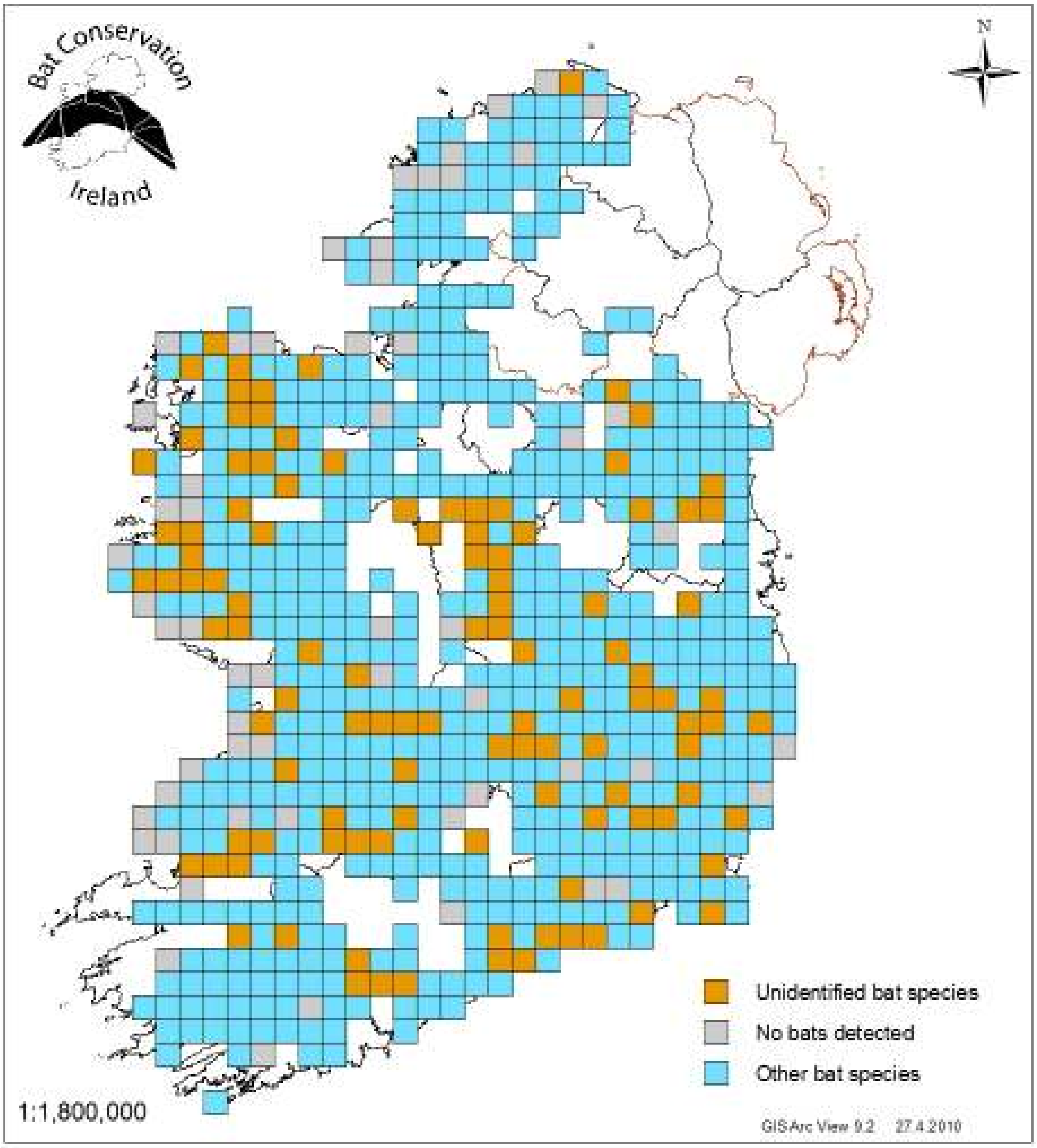

Figure 7. The distribution of unidentified bat species' records (denoted by yellow squares) in Ireland within surveyed 10km squares (n = 110/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 481/647).

Additional species that were detected and recorded during the BATLAS 2010 field surveys other than the four targeted species are presented in Appendix IV (Figures 8 to 13: *Myotis* species, brown long-eared bat, Natterer's bat, whiskered/Brandt's bat, lesser horseshoe bat and Nathusius' pipistrelle respectively). It should be noted that these maps display patchy and limited distribution ranges as these species were not part of the targeted BATLAS 2010 group and correct identification of these species may have been beyond the capabilities of some volunteer surveyors. However, these records still warrant presentation.

6.0 DISCUSSION

The aim of 600 10km squares to be surveyed was exceeded during the BATLAS 2010 national survey. In total, 647 10km squares were investigated for the targeted bat species during the two field seasons. The survey coverage achieved, in terms of total number of 10km squares in Ireland was 71.6%. Sixty-two volunteer surveyors participated over two field seasons (April - November 2008 and 2009). Despite the relatively poor, wet summers of the two survey years the survey has resulted in vastly updated distribution maps for the four target species; soprano and common pipistrelles, Daubenton's bat and Leisler's bat, compared with the last national bat survey conducted nearly 25 years ago (see O'Sullivan 1994). It should be borne in mind, however, that the National Bat Survey carried out in the 1980s focussed mainly on roost records while the present BATLAS 2010 project was a field-based survey. While too few data are available to state this definitively, it may not be hypothesised that the absence of bats from many areas in the country from the 1980's survey was simply due to an absence of recorders/records.

6.1 Potential limitations to the BATLAS 2010: Volunteer data

There may have been problems with data generated by volunteer surveyors but as numerous other studies have demonstrated, volunteer surveyors can participate and assist in biological recording and monitoring. Where all volunteer surveyors are appropriately trained (verbal and in-field demonstrations) and provided with good supporting materials (e.g. Toms *et al.* 1999; Newman *et al.* 2003), data generated are robust.

Other limitations include the possibility that bats may be present in some 10km squares but were not recorded during surveying due to factors that can directly affect bat activity and therefore detection in the field by a surveyor using a tuneable bat detector if surveys have been carried out at sub-optimal times of the year and/or night. These factors have been outlined in Roche et al. (2009) and include the following in particular reference to field surveying: (i) air temperature that affects insect availability, (ii) wind speed and direction, which affects insect swarms, and (iii) habitat availability, different habitat types may affect bat abundance within a particular 10km square.

Not all bat calls or bat call sequences are identifiable, even by professional bat workers. Potential sampling problems in using bat detectors is the non-precise identification among species groups that contain several species with similar characteristics; certainly differences are apparent between certain species groups, e.g. the pipistrelles and *Myotis* groups (Vaughan *et al.* 1997). Detector microphone sensitivity can affect bat detection in the first instance, and possibly accurate identification; lower sensitivity at certain frequencies, for example, can mean that the detection range for a particular species is decreased. In addition, bats can adapt their calls depending on the habitat they are flying in at the time. Pipistrelle bats when flying in woodland, for example, will reduce the Constant Frequency (CF) portion of their calls (a useful diagnostic feature when using a tuneable detector) and increase the Frequency Modulated (FM) component, thus sounding more like a *Myotis* bat. Other factors that lead to misidentification or unidentified bats could be the presence of many different individuals of different species in one area that can make determination of a single species difficult. High levels of feeding activity may also lead to unidentified bats being recorded because feeding buzzes produce similar sounds regardless of species (Walsh *et al*. 2001).

These distribution maps may not be a completely true representation of the occurrence of these species in Ireland given time constraints, associated budgetary costs and adverse weather/environmental factors. Mountain areas and areas with poor quality or no roads were not considered for surveying (even if randomly chosen) due to time limitations, safety and effort required therefore the survey findings have an inherent bias in terms of accessible areas reached via roads.

6.2 BATLAS 2010 National Survey

The BATLAS 2010 national survey detected bat species during their routine commuting and foraging activities during nocturnal hours. It must be noted that this survey only provides data on where the species occurs in the landscape (a recorded set of GPS coordinates) at a given time and date and so these records do not indicate density across the distribution (Schwartz *et al.* 2006). The most commonly detected species of bat within the surveyed squares throughout Ireland was the soprano pipistrelle (85%). The second most commonly detected species of bat was the common pipistrelle (70.0%), followed by a similar proportion of squares with Leisler's bat (62.4%) and Daubenton's bat (61.4%). Apart from Cape Clear, off County Cork, no other off-shore island was surveyed during BATLAS 2010.

6.2.1 Distribution of Common and Soprano Pipistrelles

Both pipistrelle species were widely distributed throughout Ireland and were, in general, the two most frequently detected species of bat during the BATLAS 2010 surveying period. However, there are differences in the extent of their distributions. Although, the common pipistrelle occurred in many of the same sites surveyed as the soprano pipistrelle, the soprano pipistrelle was detected in more of the surveyed 10 km squares in the northern and western regions of Ireland. The common pipistrelle is currently considered to be the most abundant bat species in central Europe (Jones & Racey 2008). Within Ireland, based on the findings of BCIreland's Car-based Bat Monitoring Programme, this species' has been found to be most abundant in the south and south-east of the island (see Roche *et al.* 2009). Lowest encounter rates of this species are typically found in northern and western 30km survey squares (Roche *et al.* 2009). Results from the BATLAS 2010 survey found a similar trend within surveyed 10km squares in the northern and western regions of Ireland. These records suggest that the common pipistrelle may be at its most north-westerly distribution range in this region of Ireland and/or may be affected by suitable habitat availability as well as its foraging strategy. This apparent trend was not evident in the earlier national bat survey (see O'Sullivan 1994) because no discrimination was made between the two pipistrelle species as they had not been distinguished as separate species at that time. Further ongoing small scale monitoring within the northern and western regions would be beneficial to ascertain the extent of the limitations in the distribution of the common pipistrelle bat in Ireland and to ascertain trends associated with potential climatic fluctuations. Although the proportion of detection of this species in sites in each 10km square was not generally high relative to the proportion of detection of the soprano pipistrelle in the same areas, this does not negate the possibility that the common pipistrelle is present in

10km squares in northern and western Irish regions where it was not recorded during the present survey, albeit perhaps in lower densities than elsewhere in the country. There may still be suitable habitat available in these squares that are as yet unexplored as not all of each 10km square was surveyed. Since common pipistrelles may prefer to forage in deciduous woodland this habitat type could be targeted for a more detailed survey (Racey & Swift 1985; de Jong & Ahlén 1991). In some of the westerly, north westerly and south westerly coastal squares, the common pipistrelle and the soprano pipistrelle appear to be absent, or at least not detected, whether this can be explained by the prevailing windy conditions and cooler temperatures is uncertain. Although cooler temperatures may have adverse effects on the distribution of the common pipistrelle relative to the soprano pipistrelle in northerly and westerly areas, further investigations are warranted.

6.2.2 Distribution of Leisler's bat

During the NPWS National Bat Survey (based on roost sites only) between 1985 and 1988, Leisler's bat was considered to be numerous and widely distributed in Ireland when it was found in 57 10km squares (O'Sullivan 1994). The BATLAS 2010 survey also found Leisler's bat to be widely distributed within Ireland (found in 62.4% of the total area surveyed) and the third most encountered species within this survey. There were areas where this species was not detected, however, in particular in much of the northern regions of County Donegal. There was some similarity between these records and the distribution pattern from this survey and the Car-based Bat Monitoring Programme where encounter rates of Leisler's bat were the lowest in the north-western 30km squares (see Roche *et al*. 2009). The Leisler's bat was also absent along exposed coastal areas of Counties Sligo, Mayo, Galway, Clare, Cork, Waterford, Wexford and Wicklow. Additionally, areas within the north midlands region (Meath/Westmeath) did not have many records for this species. It is presently difficult to say why these possible gaps may exist as there are further regions, particularly within the centre of Ireland that require surveying. If we examine the distribution map of roosts from O'Sullivan's (1994, Figure 3; reproduced in Figure 1 this report) survey, the locations of roost sites for Leisler's bat, were generally in the east, south and south west of Ireland. Maternity roosts can contain over 500 females (McAney & Fairley 1990), but we do not know that the roosts in O'Sullivan (1994) were all maternity roosts. Based on these results, we could conclude that Leisler's bat has a preference for the southern half of Ireland, or habitats therein, although the survey effort in O'Sullivan (1994) was biased (see introduction) and therefore we probably should not directly compare the results from these two surveys. The Car-based Bat Monitoring Programme shows some very high encounter rates in 30km squares in Northern Ireland (see Roche *et al.* 2009). The results from the BATLAS 2010 survey document the presence of Leisler's bat widely throughout the country in a variety of habitats. Within Ireland, one study showed that between one third and over a half of all prey of Leisler's bat is derived from pastoral invertebrates; the yellow dungfly (*Scatophaga stercoraria*), for example, accounted for 22% of diet, although locally, insects with aquatic larvae are also important (Shiel *et al.* 1998). These results from Shiel *et al.* (1998) differ from results for Britain and Germany where woodland and aquatic insects can be of greater importance to Leisler's bat. Although Russ *et al.* (2003) found no relationship between season and use of habitat by Leisler's bat, Russ (pers. obs. in Russ *et al*. 2003) reports that fine scale seasonality effects may not have been revealed in their study due to the temporal range of insect activity above the ground and habitat.

Leisler's bat has a long-range echolocation call and as a previous study has shown, this species may be highly adaptable to its environment and thus may elude a typical habitat association (Russ & Montgomery 2002; Russ *et al.* 2003). Leisler's bat has also been observed to select locations where there is street lighting (mercury vapour i.e. white light), such as that found in urban areas, e.g. small villages and towns, throughout Ireland. Such artificial lighting provides exceptional foraging sites as these lights attract a high concentration of nocturnal insects and bats exploit this resource (Rydell 1989; de Jong & Ahlén 1991; Blake *et al.* 1994; Rydell & Racey 1995; Fenton 1997; Shiel & Fairley 1998; Waters *et al.* 1999; Arlettaz *et al.* 2000; Carden *pers. obs.*). Therefore small villages and towns that have but a few artificial street lights, coupled with the other aquatic and woodland habitats available for Leisler's bat to forage may provide important suitable habitats for this species in these areas.

6.2.3 Distribution of Daubenton's bat

The distribution of Daubenton's bat from the results of this national survey is very similar to the distribution of Leisler's bat. Daubenton's bat was detected by the surveyors within 61.4% of the total surveyed area; 397 10km squares. Surveyors were instructed to choose at least one of the three or four sites within each 10km survey that had suitable habitat for this bat species (e.g. riparian habitat). This surveying bias was essential due to the preferred strategy of feeding over still and calm bodies of water exhibited by Daubenton's bat (Norberg & Rayner 1987; Jones & Rayner 1988). Reservoir edges, slow moving river sections, lakes, relatively small ponds and lagoons were but a few of the riparian sites where Daubenton's bat was detected actively foraging during this survey (R. Carden *pers. obs.*). Many bat species, including Daubenton's bat, regularly roost under bridges and higher activity of this bat species has been recorded where bridges are adjacent to suitable water bodies (Smiddy 1991; Rydell *et al.* 1994; Shiel 1999; Keeley 2007; Masterson *et al.* 2008).

Daubenton's bat has shown preference for karst limestone areas in other studies (see Kozlov 2001: reanalysis of data from Il'in & Simrnov 2000) but it is difficult to draw a similar conclusion from the results presented here. This bat species was detected in certain regions of karst landscape (e.g. near Knockroe and Doolin areas) but not in all of County Clare during the BATLAS 2010 survey. Three roost sites were identified in the last national survey (O'Sullivan 1994) and McGuire (1998) identified four roosts during a survey for lesser horseshoe bats in North Clare in 1995. Small scale landscape and habitat association studies may reveal the importance of this unique geological region and associated habitats to bat species such as Daubenton's.

The All-Ireland Daubenton's Bat Waterways Monitoring Programme has documented the presence of this bat species in 193 10km squares in both the Republic of Ireland and Northern Ireland, collated from records from 256 waterway sites survey from 2006 to 2008 (Aughney *et al.* 2009). O'Sullivan's (1994) national survey recorded 213 roost sites widely distributed across Ireland which were frequently found in bridges. The BATLAS 2010 results demonstrate that this species has a wide distribution within Ireland and it was detected in every county. There were some noticeable gaps along the coastal edges where Daubenton's bat was not detected, presumably due to unfavourable habitat.

6.2.4 Additional records of other bat species

Of the 647 10km squares surveyed, unidentified bat species were detected in 110 of these squares (representing 17% of the total survey). If the call frequency was at its highest energy between 49 and 51 kHz and had the characteristic calls of a pipistrelle species ('slaps', 'click', high but irregular repetition rate) then the 'unidentified pipistrelle spp.' category was circled. Unidentified pipistrelle species were recorded in 12.5% of the total surveyed squares.

The distribution records of other bat species collected during the surveying of each site within 10km squares were presented in Figures 8 to 13, Appendix IV. Within this category, *Myotis* species records (Figure 8) were the most frequently detected (32.5% of the surveyed 10km squares). These records were from throughout Ireland. Within the known Irish *Myotis* species group, such records may indicate the presence of any of the following bat species: Natterer's, Daubenton's, Brandt's or whiskered.

The brown long-eared bat (Figure 9) was the second most recorded species within the additional records category, being detected in 132 10km squares from across Ireland. Natterer's bat (Figure 10) was detected in 62 surveyed squares, although it was not as wide spread throughout Ireland as the other *Myotis* species or brown long-eared bat. Whiskered/Brandt's (Figure 11), lesser horseshoe (Figure 12) and Nathusius' pipistrelle (Figure 13) were detected to a much lesser degree, 3.1%, 2.3% and 1.1% respectively.

It is important to note that these additional records do not indicate the distribution of these species in Ireland, but are included as incidental observations that will be added to the growing national database of collated records on these species.

6.2.5 Surveyed areas that had no bats detected

Field surveys of 56 of the 647 10km surveyed squares yielded no detection of any species of bat. Absence of bats of any species is as significant as their presence; however absence of any animal species from an area, particularly bats, is impossible to prove due to numerous factors that include species' ecologies, mobility, environmental and habitat variables (Greenwood & Robinson 2006; Krebs 2006). Records of absence could indicate true absence but they could also be an artefact of insufficient investigation and survey coverage or result from the method employed to ascertain distribution. Absence may also arise if the site is surveyed at the incorrect season or time or during inappropriate environmental conditions.

The BATLAS 2010 national survey tried to negate some of these factors that were under human control, for example, by using a standardised survey protocol and record sheet and ensuring that between three to four sites were surveyed (although if all four targeted species were detected at the first survey site, the surveyor moved onto the next 10km square) and ensuring that survey work was carried out at appropriate times and seasons. It would be of interest to carry out further field work in areas of absence/not detected in order to determine more definitively if bats are truly absent from these 10km sites and, if not, to use these data for the benefit of honing the methodology of future bat atlas surveys to ensure bats will not be missed.

6.3 Future directions for bat distribution surveys and atlases

Irish bats are widely distributed within the various habitats in the Irish landscape; however the exact current ranges or distributions of all species are unknown. The BATLAS 2010 national survey conducted over two consecutive years (2008 and 2009) addresses, in part, and provides important distribution range information for four Irish bat species.

Bat detectors enable bats to be studied in greater detail, are neither invasive nor stressful to the bats and are used by most bat researchers to monitor and survey bats in the landscape. Acoustic sampling methods can yield greater species richness than capture based methods (Murray *et al.* 1999; O'Farrell & Gannon 1999). Echolocation monitoring should be but one component of future bat surveys, as a combination of different techniques (roost site, *ad hoc* records and capture) are required for more comprehensive inventories.

Various factors may affect the distribution patterns of bats within a landscape, on either a localised level or over broad areas. Such factors include inter- and intra-specific competition, availability of suitable roosting and hibernation sites and insect abundance (de Jong & Ahlén 1999). The presence of predators must also be accounted for, although there are no specialised predators of bats in Europe (de Jong & Ahlén 1999). Potential predators within Ireland include owl species such as the barn owl (*Tyto alba*) and diurnal raptors such as kestrels (*Falco tinnunculus*) (Fenton *et al.* 1994) and Mustelids (Jenkins *et al.* 1998). However owls, diurnal raptors and others appear to prey upon bats at an opportunistic level, for example dietary analyses of barn owl pellets within the British Isles have revealed very few bat skeletal remains (Fairley & Deane 1967; Fairley & Clark 1972; Glue 1974; Forster & Fairley 1975; Smal 1997). Where routine monitoring of raptor species is ongoing, where possible, pellets from raptors should be examined for bat skeletal remains and identified to species level. These identifications of skeletal remains derived from raptor pellets may prove useful as a secondary means of detecting the presence of additional bat species present in Ireland, as was the case in the detection of Ireland's newest land mammal, the greater white-toothed shrew (*Crocidura russula*) (Tosh *et al*. 2008).

Due to common prey of insects (mainly moths and Diptera), interspecific competition exclusion hypothesis between different bat species may exist and affect observed distribution ranges. For example, there is a plausible theory that such competitive exclusion, because of predation upon common insect prey, may exist between the lesser horseshoe bat and the common pipistrelle (see Arlettaz *et al.* 2000) and which may be indirectly related to loss of suitable habitats. Pipistrelle species' foraging habits are associated with artificial (street) lighting in increasingly urbanised areas, thus potentially expanding the range of this species (Arlettaz *et al.* 2000). This may be affecting the overall decline of the lesser horseshoe bat in Europe and the expansion of the ranges of populations of the common pipistrelle in conjunction with increased urbanisation (see Arlettaz *et al.* 2000). This theory could be investigated in Ireland within a specific targeted study. The lesser horseshoe bat's range in Ireland is limited to the western region of Ireland (see McGuire 1998; Roche 2001; Kelleher 2004 and references cited therein; this report) and the range appears to be have diminished since historical times, as evident from identified cave skeletal remains in County Waterford (Carden RF & Monaghan NT, unpub. data).

Anthropogenic disturbances (for example, forestry related activities, increased urbanisation, agricultural development etc.) can either directly or indirectly affect habitats used by bats. This, combined with their slow reproductive rate makes them very vulnerable to declines in population not only locally, but also nationally. It is therefore essential to have current and ongoing monitoring programmes that track the distribution ranges of bat species within specified time periods so that the impacts of anthropogenic disturbances, diseases (e.g. White-nosed Syndrome) and climatic events on populations can be monitored.

As previously stated, the only off-shore island that was surveyed during this project was Cape Clear, County Cork as prolonged adverse weather conditions prevented survey of the Aran Islands (County Galway). To ascertain the presence and absence of bat species (including roost sites) on our offshore islands a targeted surveying project is warranted.

For future surveying of bat distributions it is recommended to use a combination of different methods to record and collate species' presence, absence and 'not detected' (as opposed to absent) records (Flaquer *et al.* 2007). Depending on the bat species, certain recording methods are more appropriate than others due to the different preferred habitat choices and ecologies of each species. Additionally, some methods are more invasive than others and may cause undue stress in the studied species. As recommended by Flaquer *et al.* (2007), ongoing monitoring programmes should therefore consider the following in bat surveying studies: (i) surveying of roost sites and emergence from houses and other natural and man-made structures (caves, mines, bridges etc.), (ii) surveying of woodlands may be greatly increased through the use of bat boxes, especially where natural suitable roosting sites may be limited or absent, (iii) use of tuneable heterodyne, Frequency Division and Time Expansion bat detectors for in-field surveying, (iv) the use of harp traps and mist nets where capture is necessary for the collection of biological and morphological data and (v) specific methods such as car-based transect and waterways survey methods. Additionally, GIS mapping of habitats, isotherms, altitude, land use and topographical data can be overlaid with distribution records and monitored and modelled for direct or indirect changes over time. Depending on targeted survey species, the use of numbers of trained volunteer surveyors and/or expert bat field workers may be desired. The use of trained volunteer surveyors means that there is an element of outreach to the public community and this can be harnessed to the advantage of the survey in question. Moreover, the BATLAS 2010 national survey demonstrated the effective use of a number of upskilled volunteers through participation in training workshop weekend courses. These volunteers went on to facilitate near complete coverage of the Republic of Ireland. The compilation of 1,693 individual records within 647 10km squares could not have been achieved during the two survey field seasons without these volunteer surveyors.

6.4 The Irish BATLAS: Into the future

It is considered that the coverage obtained and the field method used during the surveying period between 2008 and 2009 inclusive was sufficient in terms of investigation and geographic range to fulfil the requirements of the current project. Obviously there are further areas that require surveying; 230 10km squares of the total available area of Ireland (n=904) were neither assigned nor surveyed during this BATLAS 2010 survey. However, records of bat species do exist for majority of these areas from other bat monitoring programmes coordinated by BCIreland (e.g. Roost Surveys, Daubenton's Bat Waterways Monitoring Programme, Car-based Monitoring

Programme) as well as from other organisations such as the NPWS, Centre for Irish Bat Research (CIBR) and records contributed by individual bat workers.

BCIreland proposes to combine the records from this BATLAS 2010 survey with data inputted into the national online database to provide an even more complete record of bat presence/absence, roost sites and known distribution across the island for all Irish bat species for the period of 2000 to 2009 inclusive.

As a specific protocol was used in the BATLAS 2010 project, the distribution maps of each of the four species provide a fundamental basis to which further records (*ad hoc* and in accordance to specific similar methodologies) can be added over time. A repeat of the BATLAS 2010 national survey is recommended in 2020 and thereafter in ten-year intervals. Specific surveys of selected targeted areas of special interest (for example, SAC's or areas where there is substantial increased urbanisation occurring with subsequent loss of habitat for bat species) could be conducted every five years.

In conclusion, the usual biases associated with distribution atlases and methods used for collection of data have been given due consideration (see Walsh *et al*. 2001; earlier sections in this report) therefore the records and results presented within this report represent a robust record of the targeted four species' distribution ranges within the Republic of Ireland. Not only is it vitally important to know the current distribution of any animal species within a relatively short period of time but an understanding of distribution patterns or trends (within long-term monitoring programmes) of species of bats within Ireland is required if we are to address habitat needs for bat species in the future and to devise suitable conservation policies. Changes in ranges are usually associated with population changes and future maps may enable us to compare and contrast these. Ireland is located in the far north-western edge of Europe and overall distribution of these targeted four species can now be monitored within a European bat distribution context.

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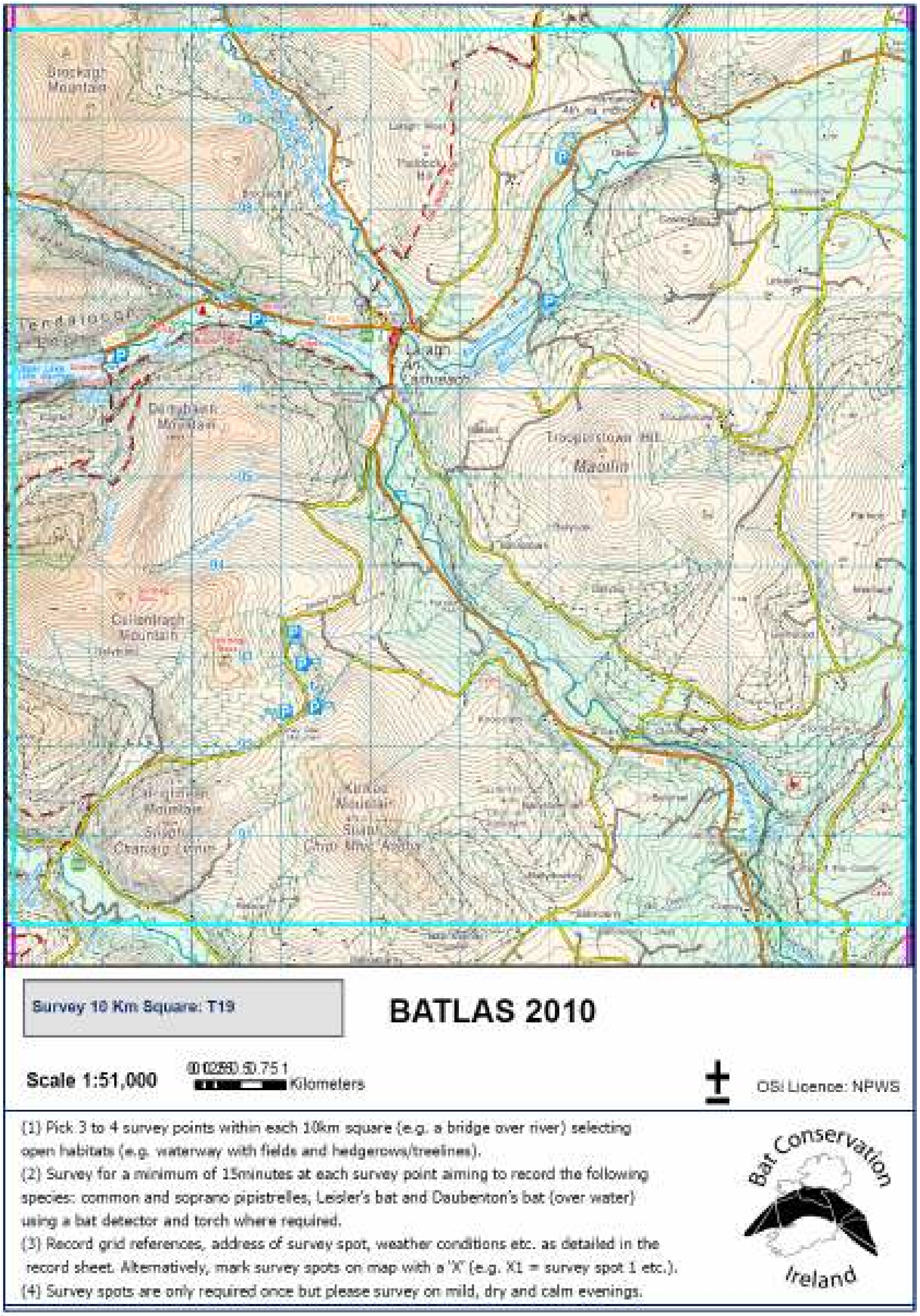
APPENDIX I

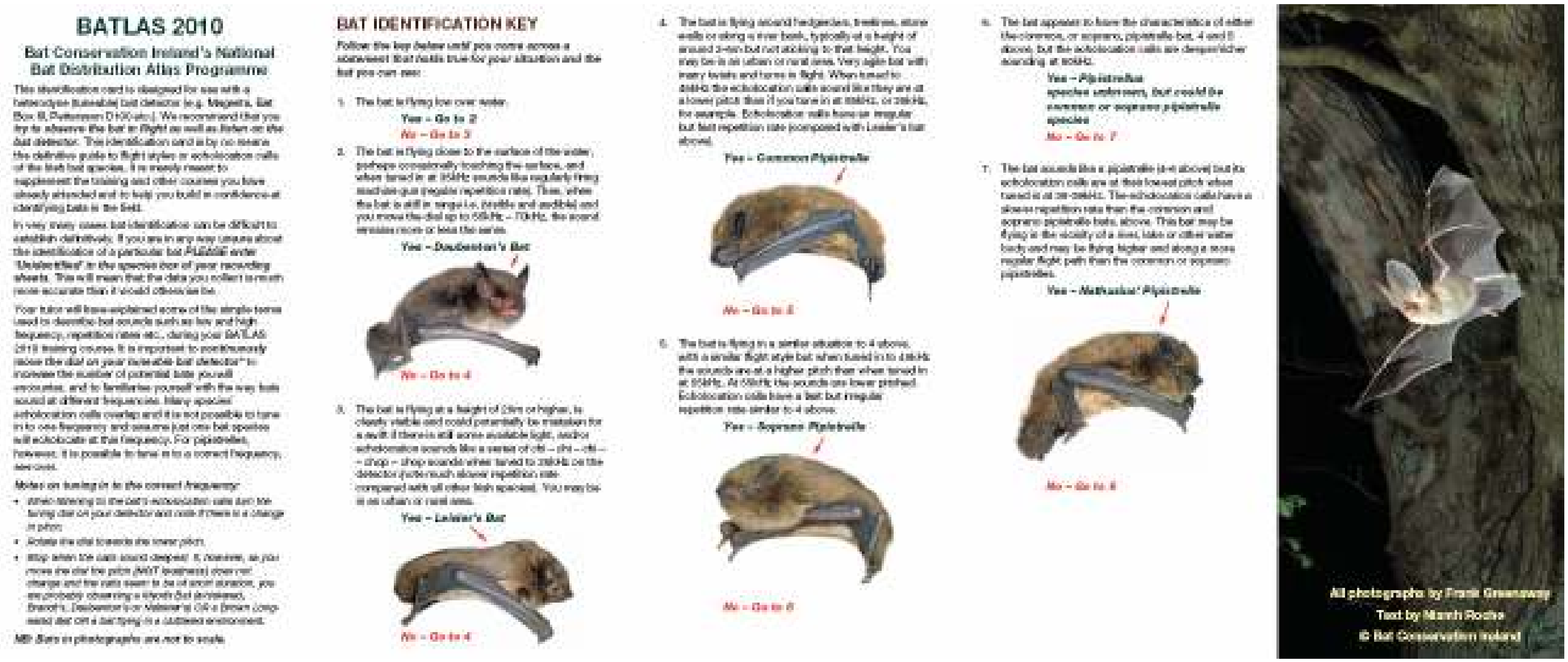
Example of a 10km Ordnance survey map (T19, County Wicklow) (1:51,000, OSi licence: NPWS) supplied to each volunteer surveyor.



APPENDIX II

'The Irish bats in Flight' identification card.

Page 1



‘The Irish bats in Flight’ identification card.
Page 2

8. The bat is flying very closely to a treeline, wall or hedgerow, or perhaps along a forest track but you do not hear anything on your bat detector unless you tune in around 110kHz and are very close to the bat. At 110kHz you hear a warbling sound. You are in County Cork, Kerry, Limerick, Clare, Galway or south Mayo and are unlikely to be in an urban area.

Yes – Lesser Horseshoe Bat

No – Go to 9

9. The bat has a similar flight style to 7 above or is hovering close to tree or shrub vegetation. When you tune to 35kHz you hear a very quiet, fast repeating echolocation call that sounds very similar to the sound you hear at 50 or 60kHz. The bat is so quiet that it needs to be within maybe 5m or you cannot hear it. If you have a very good view, or see it silhouetted against the sky you see its very long ears. You are in an area with good numbers of trees.

Yes – Brown Long-eared Bat

No – Go to 10

10. The remaining three bat species can be very difficult to tell apart. Your bat has a very white underbelly, a hovering flight style, its echolocation calls have a very fast repetition rate and sound the same when tuned from 30kHz up to 100kHz. The Natterer’s bat sounds like the Daubentont’s bat, only quieter. You are in an area with trees and/or white water.

Yes – Natterer’s Bat

Although note that Natterer’s bat can be difficult to distinguish from the brown long-eared (9 above) when foraging. The Natterer’s bat is more likely to land on the ground to forage than the brown long-eared bat and is also sometimes associated with white water areas of fast flowing rivers. Natterer’s bat has slightly louder echolocation calls.

No – Go to 11

11. The echolocation calls have a fast repetition rate and sound very similar to the Daubenton’s. They are generally loudest around 35-40kHz. However, the bat is not flying low over water, often preferring forest tracks and woodland. This bat follows a very regular beat when flying. The echolocation calls usually fade out when you tune to 90kHz or thereabouts.

Yes – Whiskered/Brandt’s Bat

These two remaining species cannot be distinguished on the basis of echolocation calls or flight styles.

No

If none of the above points, 1-11, have described your bat please enter Unidentified in your recording form.

BAT MONITORING PROGRAMMES

Volunteers are welcome to participate in Bat Conservation Ireland’s monitoring programmes. Please register through our website www.batconservationireland.org.

BATLAS 2010

This programme involves random surveying of suitable habitats for bats within an assigned 10km square using a bat detector. Surveying is undertaken on mild, calm and warm evenings/nights when bats are actively foraging (April to October months are generally the most suitable periods). Volunteers are requested to visit suitable habitats (e.g. bridge over a waterway) and survey for the following bat species: common pipistrelle, soprano pipistrelle, Leisler’s bats and Daubenton’s bats (over waterbodies).

ALL IRELAND DAUBENTON’S BAT WATERWAY SURVEY

This programme is the most suitable programme for beginners to join in. Volunteer teams (minimum two people per team) are assigned a waterway site within 10km of their home address and are required to undertake two survey nights in the month of August. Volunteer teams survey 10 survey spots for 4 minutes per survey spot recording the Daubenton’s bat only using a bat detector and torch. The characteristic flight pattern of this species as it skims the water surface makes it very easy to identify this species in flight.

BROWN LONG-EARED ROOST MONITORING PROGRAMME

This programme involves emergence counts of known brown long-eared bats. Volunteer teams assist with counting the bats as they emerge from the roost.

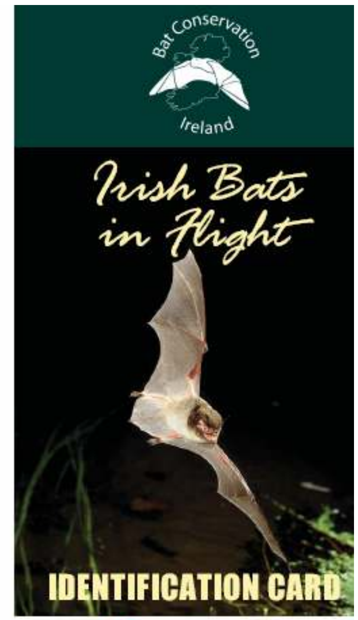
CAR-BASED BAT MONITORING PROGRAMME

This unique bat monitoring scheme is a method of monitoring bats while driving. For this scheme, time expansion detectors are used, which essentially make short recordings of a broad range of ultrasound and replay the sounds at a slower speed. The monitoring is carried out along mapped routes, at a specific time of year (one night in July and one night in August), while driving at a prescribed speed. Volunteers do not require any past experience with bat detectors. Volunteers are sought to drive mapped routes, read maps and to work equipment.

Descriptions of bat sounds as heard through a Heterodyne bat detector

Bat species	Description	Detection frequency	Flight pattern
Soprano pipistrelle	Pip Pop or slaps	52 - 56+ kHz	Rapid, agile swoops
Common pipistrelle	Pip Pop or slaps	42 - 48 kHz	Rapid, agile swoops
Nathusius’ pipistrelle	Slaps (slower beat)	38 - 41 kHz	Rapid, agile swoops
Whiskered/Brandt’s	Rapid dry clicks	35 - 65 kHz	Agile, straight-line flight at head height
Natterer’s bat	Rapid dry clicks	30 - 100 kHz	Agile and maneuverable swoops
Daubenton’s bat	Rapid dry clicks	35 - 70 kHz	Flies within 30 cm of water surface
Lesser horseshoe bat	Warbling call	110 - 113 kHz	Fast flight close to the ground
Leisler’s bat	Chip chop, very loud	22 - 28 kHz	Fast flying above tree tops
Brown long-eared bat	Quiet cracking noise	45 kHz	Slow fluttering flights

Forearm Length (cm)	28-35	28-35	32-36	33-40	36-43	30-38	36-40	39-47	34-42
Habitats	**SP**	**CP**	**NP**	**Daub**	**Natt**	**Wh/Br**	**LHB**	**Leis**	**BLE**
Open grassland	●	●						●	
Treelines / hedges	●	●	●		●	●	●	●	
Woodland rides/edge	●	●	●	●	●	●	●	●	●
Woodland	●	●			●	●	●		●
Waterways	●	●	●	●	●	●	●		



Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

APPENDIX III

The data record sheet supplied to each volunteer surveyor.

Bat Conservation Ireland BATLAS 2010 Records Sheet

Name		**Email**	
Address of survey (County)		**Tel no**	
		Bat detector model used (indicate if Time Expansion or Freq Division recordings were made)	
Date **Time**		**Grid Ref.** **Site Name**	
Temp (^{o}C)		**Wind** (circle one)	Calm Light Breezy
Cloud (circle one)	Clear (0–1/3) Patchy(1/3-2/3) Full (3/3)	**Rain** (circle one)	Dry Drizzle Light rain

Please tick bats species recorded and record number of individuals (where possible)

Unidentified bat		**Myotis spp.**	
Common pipistrelle		**Daubenton's bat**	
Soprano pipistrelle		**Natterer's bat**	
Pipistrelle (49-51 kHz)		**Whiskered/Brandt's bat**	
Nathusius pipistrelle		**Brown long-eared bat**	
Leisler's bat		**Lesser horseshoe bat**	

Comments

Please tick habitats recorded adjacent to survey area

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

Appendix IV

Myotis species

Myotis species of bats were detected in conjunction with other bat species during field surveying in 212 10km squares (or 32.8% of the total number of squares surveyed) (Figure 8).

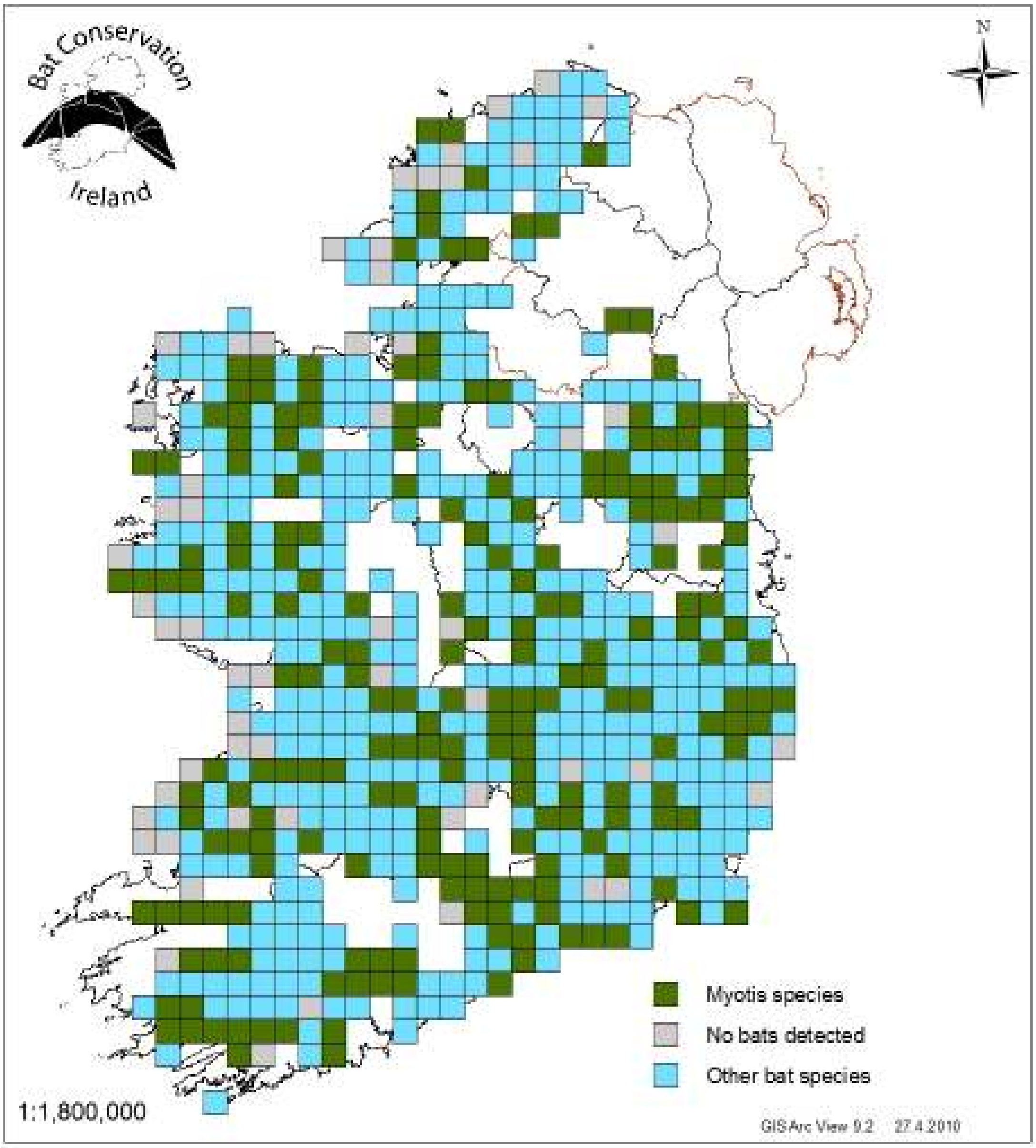


Figure 8. The distribution of *Myotis* species' records (denoted by green squares) in Ireland within surveyed 10km squares (n = 212/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 379/647).

Brown long-eared bat

The brown long-eared bat was detected in conjunction with other species of bats during field surveying in 132 10km squares (or 20.4% of the total number of surveyed squares) (Figure 9).

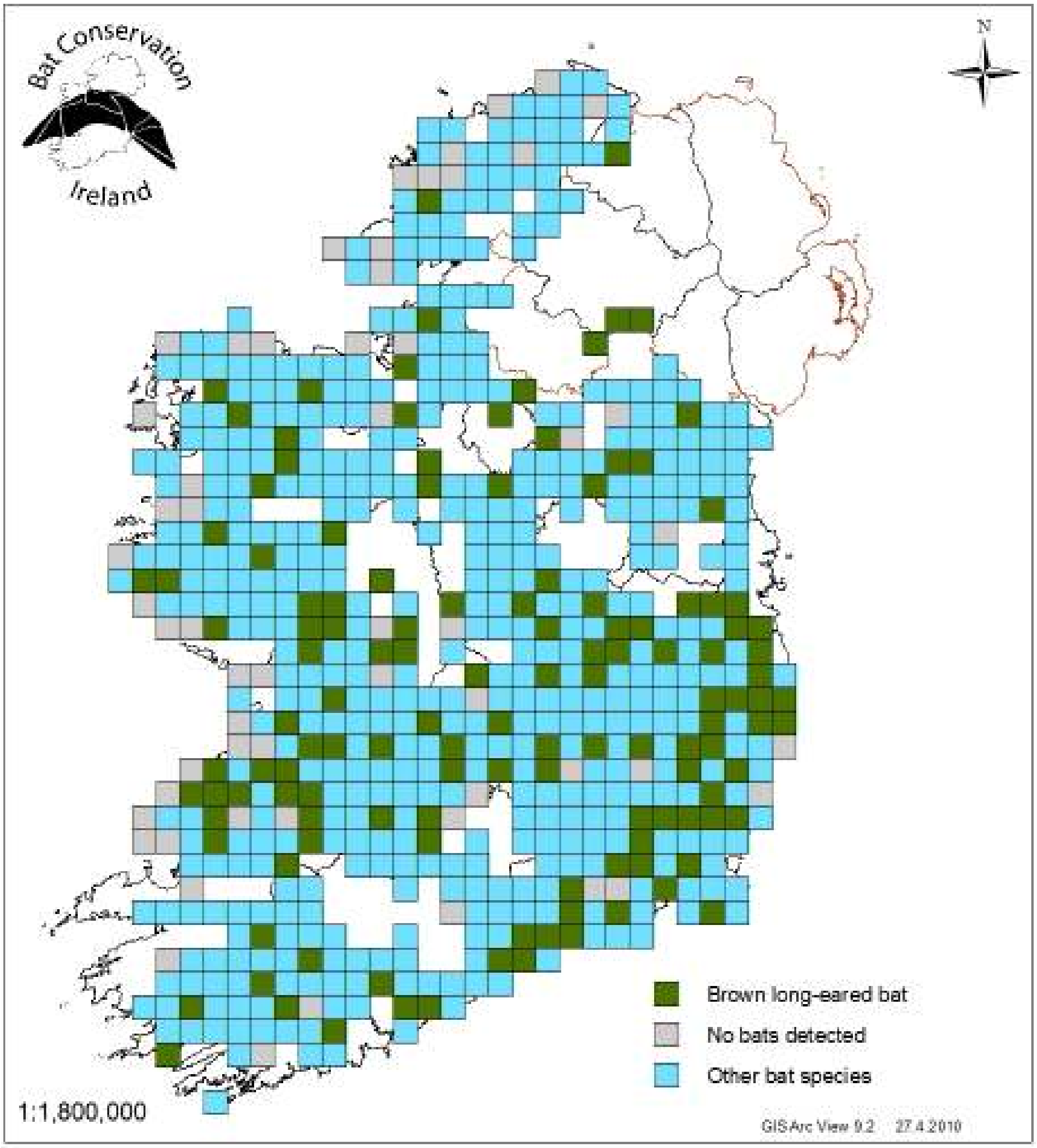


Figure 9. The distribution of brown long-eared bat records (denoted by green squares) in Ireland within surveyed 10km squares (n = 132/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 459/647).

Natterer's bat

Natterer's bat was detected in conjunction with other species of bat during field surveying in 62 10km squares (representing 9.6% of the total number of surveyed squares) (Figure 10).

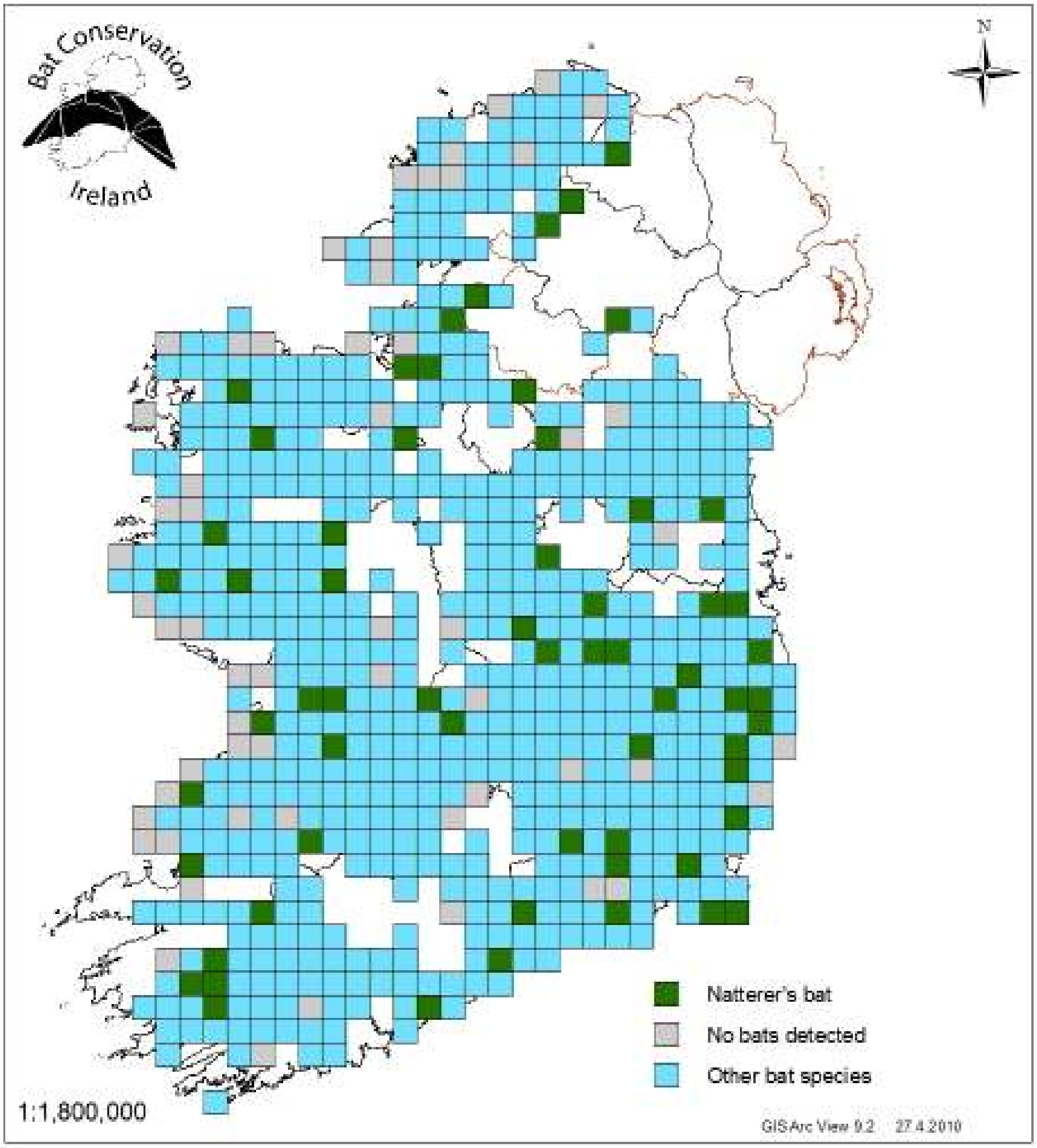


Figure 10. The distribution of Natterer's bat records (denoted by green squares) in Ireland within surveyed 10km squares (n = 62/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 529/647).

Whiskered/Brandt's bat

Whiskered/Brandt's bat was detected in 20 (or 3.1%) 10km squares in conjunction with other species of bat during field surveying (Figure 11).

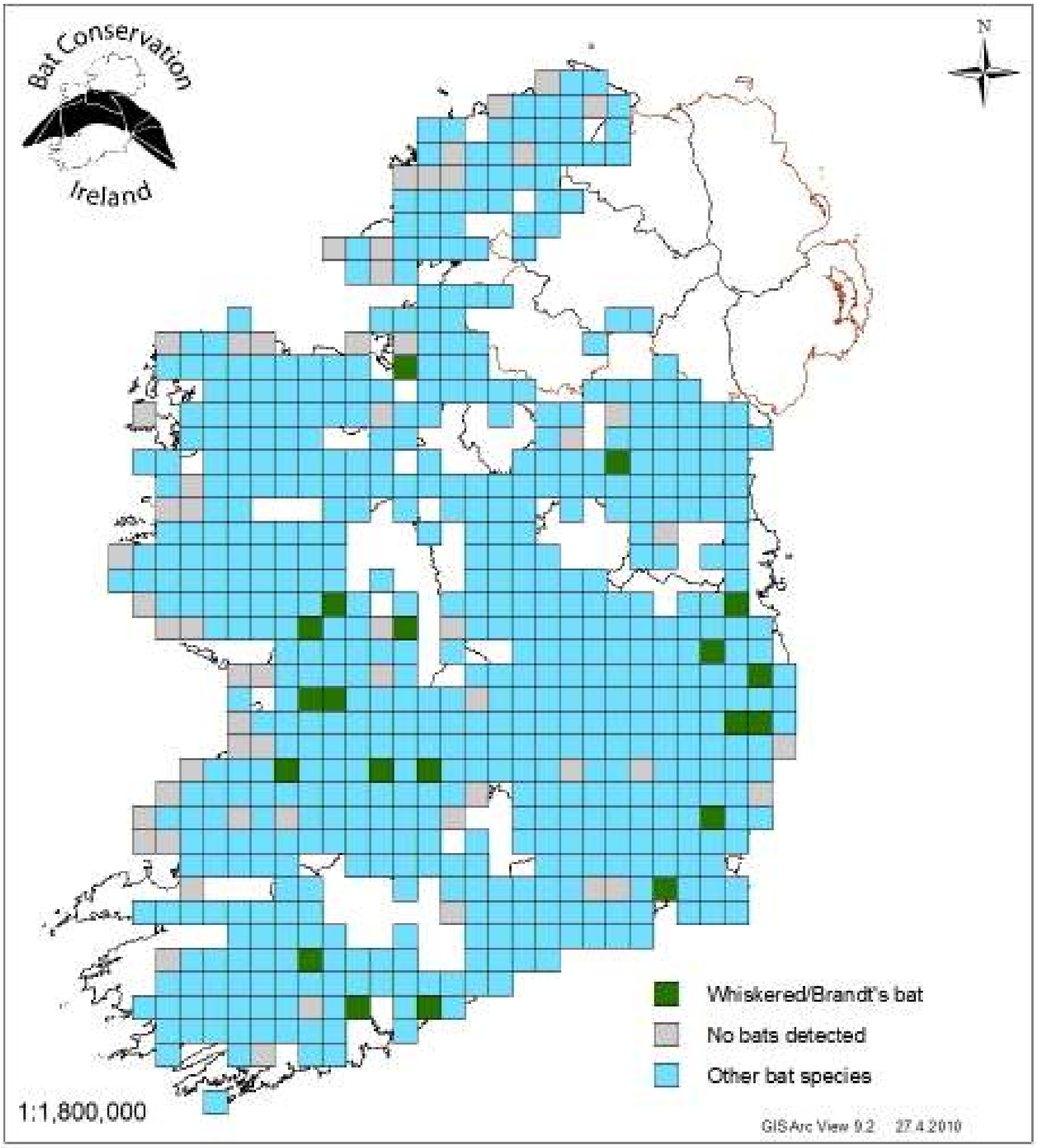


Figure 11. The distribution of whiskered/Brandt's bat records (denoted by green squares) in Ireland within surveyed 10km squares (n = 20/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 571/647).

Lesser horseshoe bat

The lesser horseshoe bat was detected in 15 or 2.3% of the total 10km surveyed squares, in conjunction with other species during field surveying (Figure 12). A new record of this species was recorded in County Sligo (near Tobercurry / Tubbercurry). The other records of lesser horseshoe bat were detected in Counties Galway, Clare, Kerry and Cork.

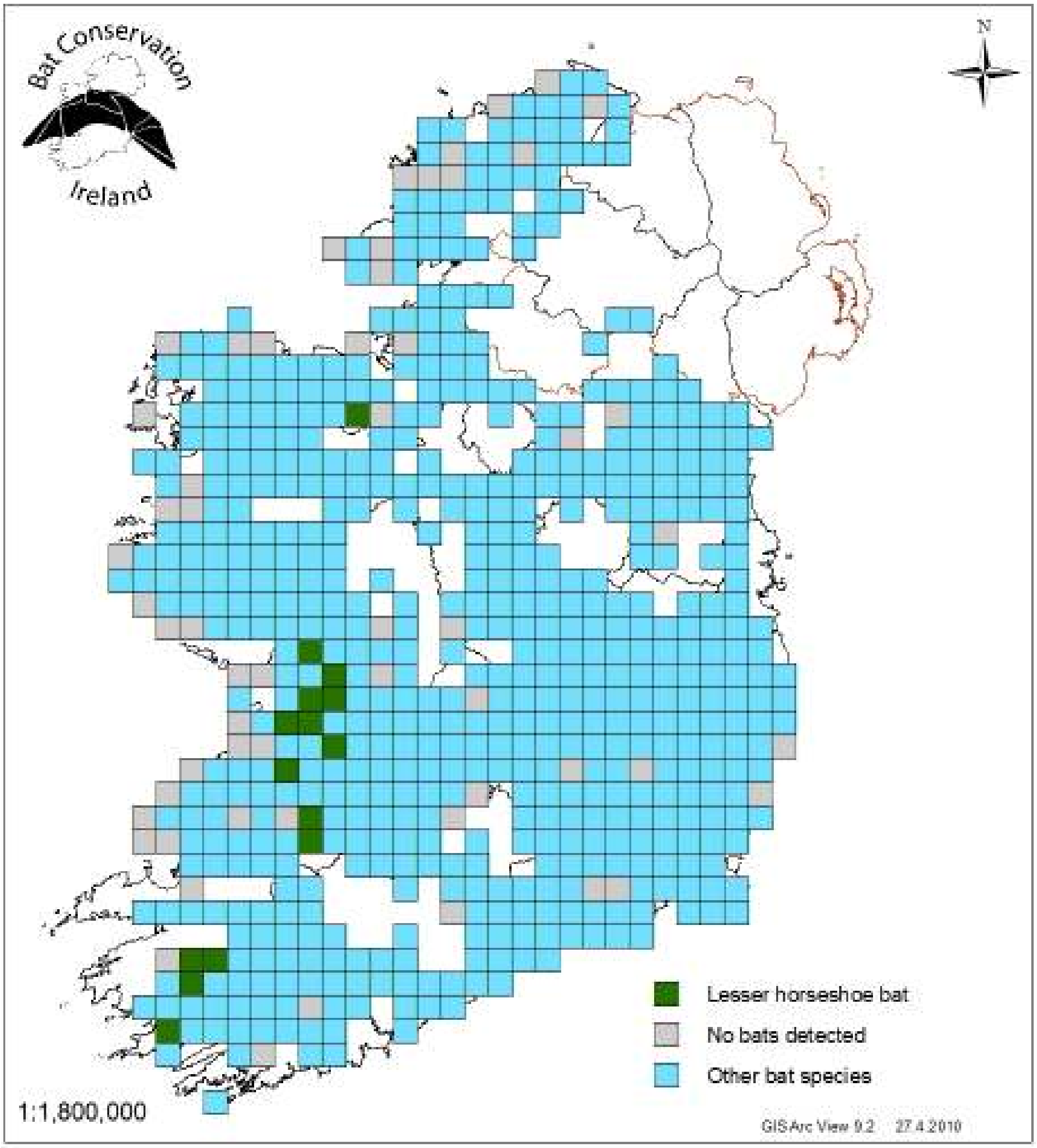


Figure 12. The distribution of lesser horseshoe bat records (denoted by green squares) in Ireland within surveyed 10km squares (n = 15/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 576/647).

Nathusius' pipistrelle

Nathusius' pipistrelle was detected alongside other species of bat in 1.1% or 7 of the surveyed 10km squares in Ireland (Figure 13) in Counties Wexford, Dublin/Kildare, Cavan/Meath, Leitrim and Kerry.

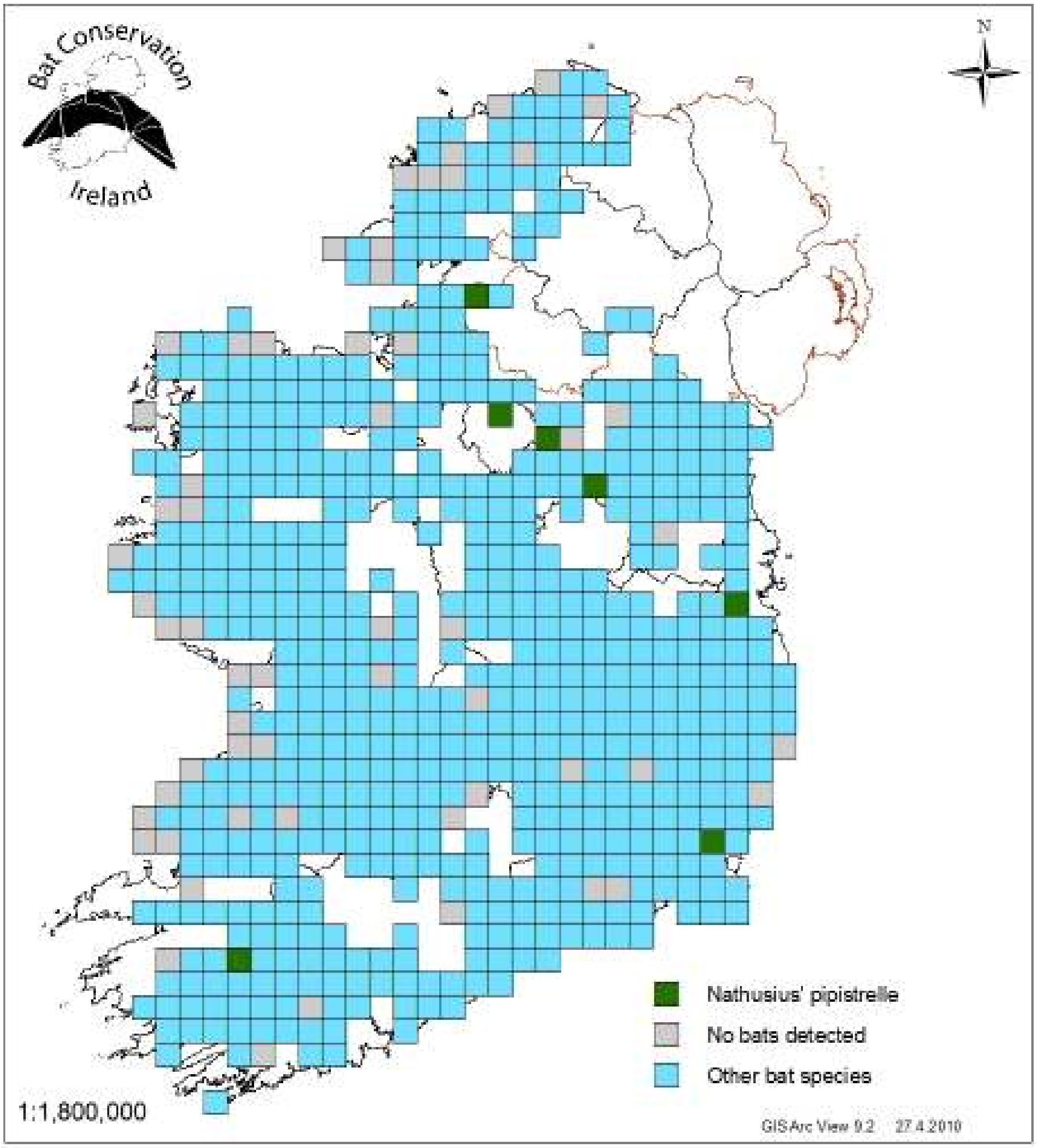


Figure 13. The distribution of Nathusius' pipistrelle records (denoted by green squares) in Ireland within surveyed 10km squares (n = 7/647) of the Irish Grid during the BATLAS 2010 survey. Grey squares denote squares where no bats were detected during the BATLAS 2010 survey. Blue squares denote where other bat species were detected (n = 584/647).