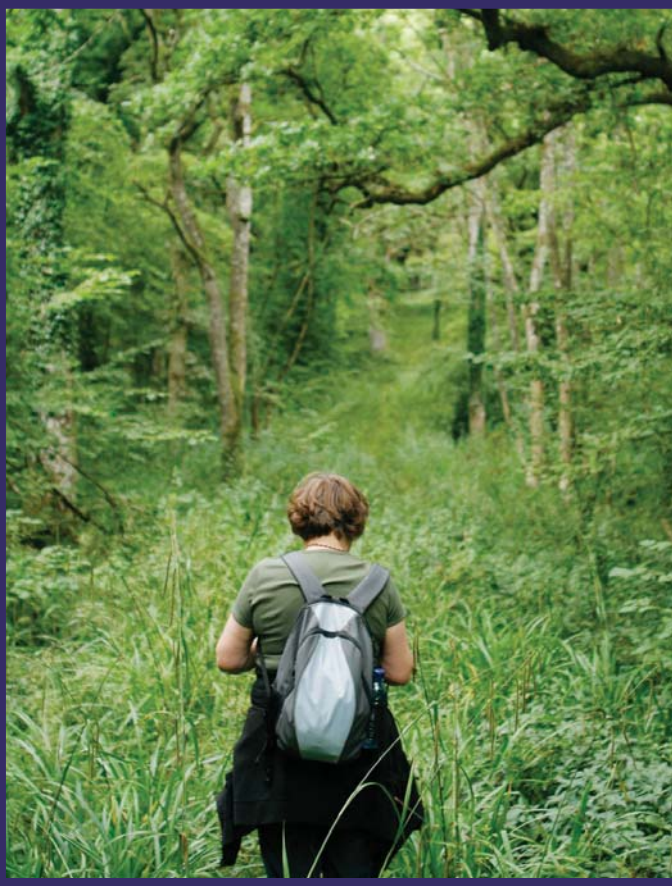
Bat Conservation Trust

Bechstein's Bat Survey

Final report
September 2007 – September 2011



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Project summary

The Bechstein's Bat Survey was a four year funded project which aimed to map the UK distribution of the elusive Bechstein's bat. Based on pilot work in south-east England (by Dr David Hill and Frank Greenaway), selected woodlands in southern England and south Wales were surveyed to gather more information about the species' range and habitat associations, and to identify conservation hotspots.

Ten local bat groups took part in the project; North Buckinghamshire, Cornwall, Devon, Dorset, Gloucestershire, Kent, Oxfordshire, Somerset, Surrey and Worcestershire. Between 2009 and 2011, 199 target woodlands were surveyed in which 838 bats of 12 species were caught, identified and released. This included 57 Bechstein's bats (29 female and 28 males) at 37 sites.

In addition 47 woodlands were surveyed by individuals from Carmarthenshire, Cornwall, Dyfed, Oxfordshire and Surrey Bat Groups in 2008. However, adverse weather conditions had a major effect on capture rates, and so the results of these surveys were not included in the final analysis.

New records of Bechstein's bats were obtained for sites in Buckinghamshire, Dorset, Gloucestershire, Kent, Somerset, Surrey and Worcestershire. When combined with the results of the pilot study, the data indicate hotspots in the distribution of breeding colonies of Bechstein's bat in Dorset/Somerset, southwest Hampshire/IOW and Sussex. Furthermore this work extends the known range of this species within the UK. The records collected in Buckinghamshire and Worcestershire are now the most northern UK records for breeding females of this species. Smaller populations on the edge of the species distribution such as Buckinghamshire and Worcestershire may differ in their habitat requirements and are likely to be more vulnerable to environmental change and management practices.

This work has demonstrated that the selection of woodlands for survey that most closely match the habitat characteristics of sites known to support maternity colonies, has been an effective method for extending our knowledge of the distribution of Bechstein's bat.

The results of the Bechstein's Bat Survey will feed directly into specific woodland management guidance that the Bat Conservation Trust is now producing for Bechstein's bat.

Further survey work is now underway to build on these results, with local projects undertaking more intensive survey work and radio-tracking to identify roosting sites and better understand Bechstein's bat use of newly identified woodland sites and the surrounding habitat.

Introduction

This is the final project report for the Bat Conservation Trust's (BCT) Bechstein's Bat Survey. The report is aimed at funders and bat group volunteers.

1.1 Bechstein's bat

As one of the UK's rarest mammals Bechstein's bat (*Myotis bechsteinii*) is listed on Annex II of the EC Habitats and Species Directive (JNCC, 2007) and is a Biodiversity Action Plan priority species. It is also listed as near threatened on the IUCN red list (IUCN, 2011).

In the UK Bechstein's bat is restricted to parts of southern England and south Wales, which comprise the northwestern edge of its European range. In Europe this species is found from England to Caucasus, and south to the Mediterranean (Harris *et al*., 2008).

Bechstein's bat is predominantly associated with ancient broadleaf woodlands (Greenaway & Hill, 2004); and previous studies have shown a strong association with oak and ash woodland (Hill & Greenaway, 2006). In the UK this species is thought to use woodlands all year round, favouring old woodpecker holes for both summer and winter roosting, although winter records for this species are rare. During the summer female Bechstein's bats form maternity colonies. These colonies use multiple roosts throughout the season, frequently splitting into subgroups (Kerth & Koenig, 1999) and switching roost sites regularly. Bechstein's bat is a gleaning bat with a preference for moths, with most foraging occurring in closed canopy (Harris & Yalden, 2008). Studies have shown that foraging occurs close to the roosting site, with bats rarely flying more than 1.5km between roost and feeding site (Schofield & Morris, 2000).

This species is notoriously difficult to survey for using standard monitoring techniques. It rarely leaves the cover of its roosting site until after dark, tending to forage high up in the canopy, where its low intensity echolocation calls make it difficult to detect using standard ultrasonic detectors (Hill & Greenaway, 2006). Any echolocation calls that are recorded are difficult to identify accurately to species, as call structure for many of the *Myotis* species overlaps (e.g. Parsons & Jones, 2000). Additionally Bechstein's bat avoids both harp traps and mist nets making capture for identification in the hand very challenging.

The great difficulty involved in detecting and surveying for Bechstein's bat using traditional methods resulted in a lack of basic knowledge of the species' distribution and population size.

Until the late 1990s there were very few records for this species, mostly of isolated individuals rather than confirmed roosting sites, providing very little information on the habitat requirements of Bechstein's bat, its conservation status or the threats it faced. In 1999 the first maternity colony at Ebernoe Common, in West Sussex was found (F. Greenway per comm., 2011). This is one of the earliest confirmed maternity colonies in the UK for Bechstein's bat and is now a well-studied site for this species. Following this discovery and additional roosts recorded in the surrounding area work began on a new technique to effectively survey for this species in UK woodlands.

Frank Greenaway developed and trialed the first synthesizer and was later joined by Dr David Hill and the University of Sussex who together developed an ultrasound synthesizer (the Sussex Autobat) that acts as an acoustic lure, greatly enhancing the ability to catch

Bechstein's bat in its woodland habitat (Hill & Greenaway, 2005). The Autobat is used to produce simulations of the ultrasonic communication calls of bats. When simulated social calls of Bechstein's bat are played they can elicit a rapid approach response which allows the bat to be caught in a harp trap. During the maternity season each breeding female will have its own discrete feeding area (e.g. Kerth *et al*., 2001) of about 1 ha (Hill & Greenaway, 2006) and the response to the Autobat seems to be particularly strong when calls are played in a female's feeding area. As feeding areas are always quite close to the maternity roost, capture of a breeding female can be taken as evidence that there is a breeding colony nearby.

Through the development and testing of the Autobat, Frank Greenaway and Dr David Hill were able to devise a systematic protocol for the survey of Bechstein's bat. Initial testing took place across parts of Hampshire, Sussex, Surrey and Kent and in the final stage of the work produced baseline distribution data for the species across East and West Sussex (see section 1.2 for further information about this technique). Following the completion of this work (in 2006) the Bat Conservation Trust (BCT) were approached to replicate this work on a national scale.

As lead partner for the Bechstein's bat, BCT is responsible for meeting the UK Biodiversity Action Plan targets (JNCC, 2007) for this species. These targets state the need to:

- Maintain the known range and populations,
- Increase the national population size by improving woodland age structure to enhance roosting and foraging opportunities.

It was therefore identified as a priority to address the lack of records of maternity roosts for this species outside of this study area and undertake a national survey for Bechstein's bat.

1.2 The Bechstein's Bat Survey

The BCT Bechstein's Bat Survey was a 4-year funded project that aimed to produce a more comprehensive distribution map for this species based on systematically collected survey data. The project is based and builds on the pilot surveys carried out in the south east of England in 2005 and 2006 (Hill & Greenaway, 2006), and was fortunate to have both Dr David Hill and Frank Greenaway acting as advisors throughout the duration of the project.

The survey method comprised an initial phase of site selection within the species' known range in which target woods were chosen that most closely match habitats where breeding colonies of the species have been recorded. The selected woodlands were then surveyed using the Sussex Autobat to attract the bats into harp traps in which they were caught. The successful capture of a female Bechstein's bat between May and September indicates that there is a maternity colony nearby. By completing surveys in selected woodlands across the likely range of the species using a standardized and repeatable method, we can gain a large-scale understanding of the distribution of the species and provide a baseline for future assessment of change.

A key feature and success of the project was the involvement and engagement of local bat groups who were given special training in the required techniques and provided with the necessary equipment. These groups then organised the surveys within their county, which allowed the survey of woodlands over a large area within the project time frame. A total of 12 bat groups took part over the four years of the project (see section 1.4). This approach also allowed us to share knowledge and develop skills across the bat group network.

1.3 Aims of the project

The overall aims of the project were to:

- Deliver systematically acquired baseline distribution data for Bechstein's bat across its entire range in England and Wales.

- Delineate the species' range and hotspots for conservation action.

- Understand the habitat associations of the species across its range in the UK.

- Provide a baseline against which ongoing presence of the species in 10km squares can be monitored for future Biodiversity Action Plan reporting and conservation status assessments. (Note that the survey was about mapping the distribution of core breeding maternity colonies, male only presence and inference of likely absence of a breeding maternity colony during the survey event - a much more detailed result than just a snapshot of presence/absence).

In addition, the project aim for wider woodland bat communities was to:

- Provide preliminary data on the distribution of other woodland bat species in relation to woodland quality by recording all other species caught during the surveys. This would provide a valuable foundation for a comprehensive study of the relationship between woodland quality and the structure and diversity of bat communities.

1.4 Engaging bat groups

A key element of the project was to involve local bat groups so that they could develop new skills and take on the responsibility for organising the surveys in their own areas. To this end, individuals from local bat groups were provided with the skills, knowledge and equipment necessary to survey their county following a standard method.

1.4.1 Survey area

The overall aim of the project was to survey the known range of the Bechstein's bat (based on what was currently known about female records) and the counties that neighbour this area, thereby giving the best opportunity to achieve an accurate picture of Bechstein's bat's UK distribution. Sussex had already been comprehensively surveyed during a pilot study (Hill & Greenaway, 2006), as had the Isle of Wight (Davidson-Watts, 2008). The original study area was therefore selected to be southern England and South Wales with the following counties specified as priorities; Dorset, Hampshire, Gloucestershire, Somerset and Wiltshire.

Each group was asked to commit to surveying one woodland in each 10km square in their county. Some of the groups initially approached (Hampshire and Wiltshire) were unable to take part due to time and resource limitations. This meant that there were some gaps in the survey effort in the core areas, but did allow the inclusion of some additional counties that were not initially a priority.

1.4.2 Bat groups

Three to four local bat groups were approached for each year of the project. Each group selected two individuals to act as co-ordinators for the duration of their involvement in the project. These co-ordinators attended relevant training and were responsible for organising the survey effort in the county.

Bat groups involved in 2008 surveys:

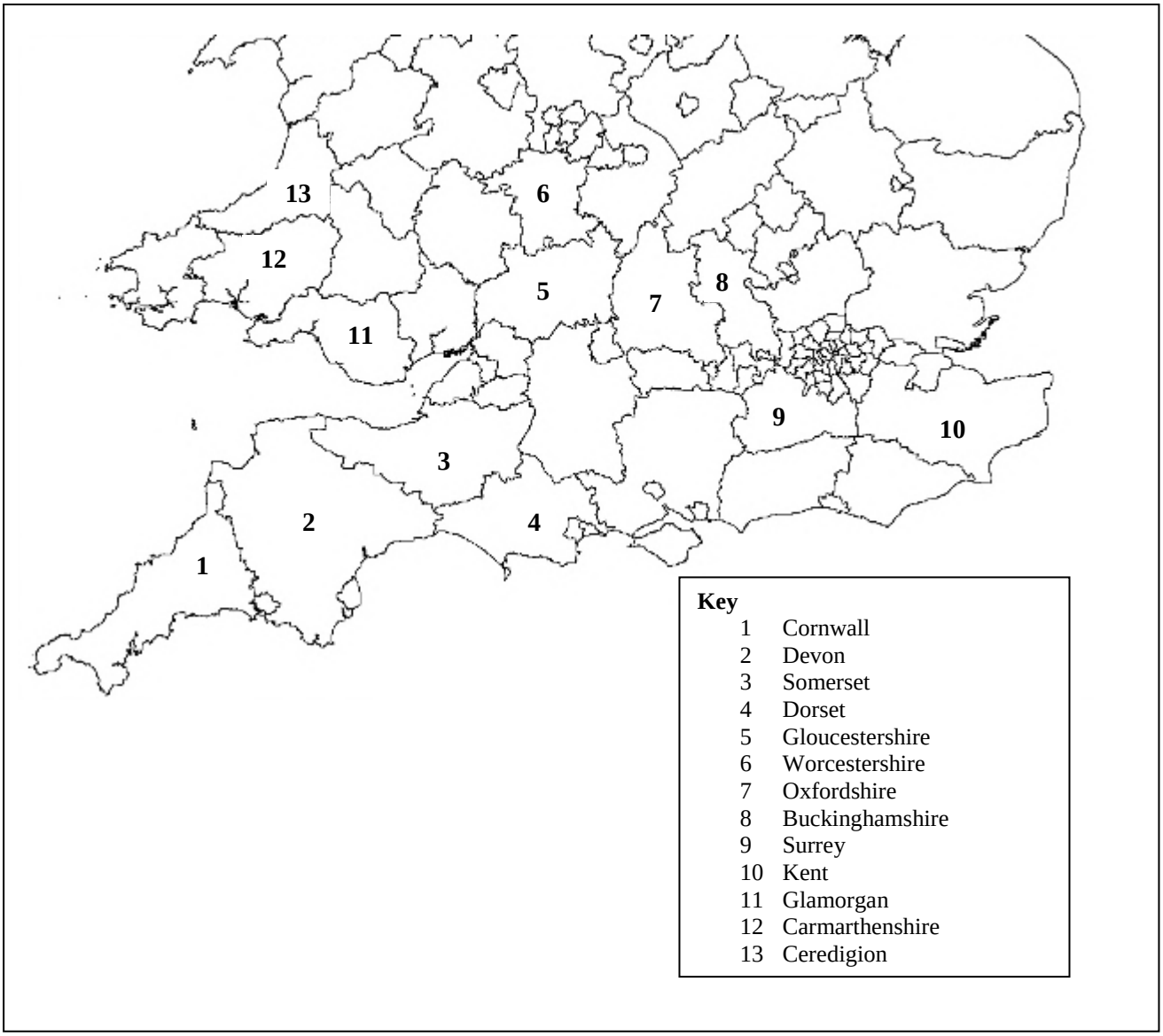
- Carmarthenshire/Dyfed (individuals from these two bat groups surveyed woodlands across Carmarthenshire, Ceredigion and Glamorgan)
- Cornwall
- Oxfordshire
- Surrey

In the first year of the project (September 2007 – September 2008) 47 target woodlands were surveyed, in which 139 bats of 11 species were captured. This included three Bechstein's bats, all of which (two males and one female) were recorded in Surrey.

Long-term monitoring of Bechstein's bat populations in the south-east of England suggested that there had been a reduction in the breeding success of this species over the summer of 2008 (F Greenaway, pers. comm., 2008). This was thought to be in response to the unfavourable weather conditions of the summers of 2007 and 2008. The Autobat acoustic lure appears to be most effective when played in the feeding areas of breeding females (see 2.3.2 below), thus the reduced breeding success also directly affected the data collected for the project in 2008 (Bat Conservation Trust, 2009). A decision was taken to re-survey three of the 2008 areas (Cornwall, Oxfordshire and Surrey), between May and September 2009, to ensure that data collected for the project would provide the best representation of Bechstein's bat distribution in these counties.

As a result, survey data collected during the 2008 survey period was not included in the main data analysis. 2008 results are given in Appendix 7.

Figure 1 – County map with groups that took part



Bat groups involved in 2009 surveys

- Cornwall (re-survey)
- Devon
- Dorset
- Kent
- Surrey (re-survey)
- Oxfordshire (re-survey)

Bat groups involved in 2010 surveys

- Buckinghamshire
- Devon (completing surveys)
- Dorset (completing surveys)
- Gloucestershire
- Kent (completing surveys)
- Somerset
- Worcestershire

Bat groups involved in 2011 surveys

- Buckinghamshire (completing surveys)
- Gloucestershire (completing surveys)
- Somerset (completing surveys)
- Worcestershire (completing surveys)

These counties are shown in Figure 1 to illustrate geographical location.

1.5 Training

The selected co-ordinators from each bat group were asked to attend a one-day woodland selection course and a four-day practical training session.

1.5.1 Woodland selection training course

The woodland selection training aimed to provide attendees with the skills they required to assess and select woodlands according to the habitat model used in this project (See section 2.1). These courses were held in the winter months as woodland selection is easier to complete when trees are not in leaf. It also gave groups time to do some of the necessary selection work prior to the summer survey season each year. The course was tutored by Frank Greenaway and consisted of a number of visits to woodlands in the Sussex area to highlight different characteristics of the woodland selection model. Following the course, attendees were able to use the specified criteria to select woodlands that exhibited the most potential for Bechstein's bats in their respective counties.

These courses took place on:

- 23 February 2008
- 13 December 2008
- 16 January 2009

1.5.2 Practical training course

A four day intensive training course was held at Juniper Hall Field Studies Centre in Surrey.

- 9-12 May 2008
- 1-4 May 2009
- 7-10 May 2010

The course was tutored by the project's expert advisors, Frank Greenaway and Dr David Hill, and covered all aspects of the project and the skills required by the co-ordinators to complete their surveys in a mixture of classroom sessions and practical evening site visits.

All of the co-ordinators who participated in the courses agreed that the training had been extremely worthwhile and had provided them with all of the skills that they required to undertake surveying on behalf of the project in their respective counties. Some examples of feedback are given in Box 1.

Box 1- Examples of feedback from the main training course for survey co-ordinators

Devon Bat Group attendee: "*A thousand thanks to you, Frank and David for such an enjoyable and fascinating few days*."

Dorset Bat Group attendee: "*Just a quick note to say thank you so very much for a fantastic weekend course, I learnt so much in the three days that I cannot believe it, it was simply great fun and very helpful*."

Kent Bat Group attendee: "*Many thanks for a superb weekend*."

Coordinators were also asked for their feedback on the training they received as part of a questionnaire. 100% of coordinators responded that the main training course was excellent or good. The main comments regarding potential improvements to the training related to the cold temperatures on some nights of the course which resulted in a small number of bats being caught and hence less opportunity for handling practice.

1.6 Approach to surveying

The Project Officer worked closely with each group taking part, to consider any relevant issues that could affect survey effort in their particular area. Where possible, options were suggested to give groups the best possible chance of fully completing their surveys without compromising the project's protocol and outputs. Following feedback from the groups that took part in the first field season some amendments were made to the protocol for subsequent years. The main issues related to the time and availability of volunteers who had to fit in their commitment to the project around busy lives, work and other commitments. Amendments were made to try to better balance the needs of the project and the volunteers involved who were generously dedicating their time to the project, and are set out below:

1.6.1 Extended survey period

To maximise the time available to bat groups to complete their surveys, new groups (unable to start surveying until they had completed training in mid-May) were given an additional two months (May and June the following year) in which to complete surveying. It was agreed that the 2008 re-survey groups, having already attended training, would not require this additional survey time in 2009 (see Box 2 for more detail on the project timetable).

1.6.2 Concentrated survey area

Devon and Cornwall are large counties comprising approximately 90 and 50 10km squares respectively. Surveying one woodland in each of these 10km squares was considered to be too much to achieve in the time period available. It was therefore decided to reduce the survey area for these groups and to concentrate on the southern half of Devon and the eastern part of Cornwall. These areas were selected to encourage full coverage of a more manageable area, provide survey connectivity across the south-west of England and still meet the project's overall aim to survey across the known distribution range.

1.6.3 Additional coordinators/equipment

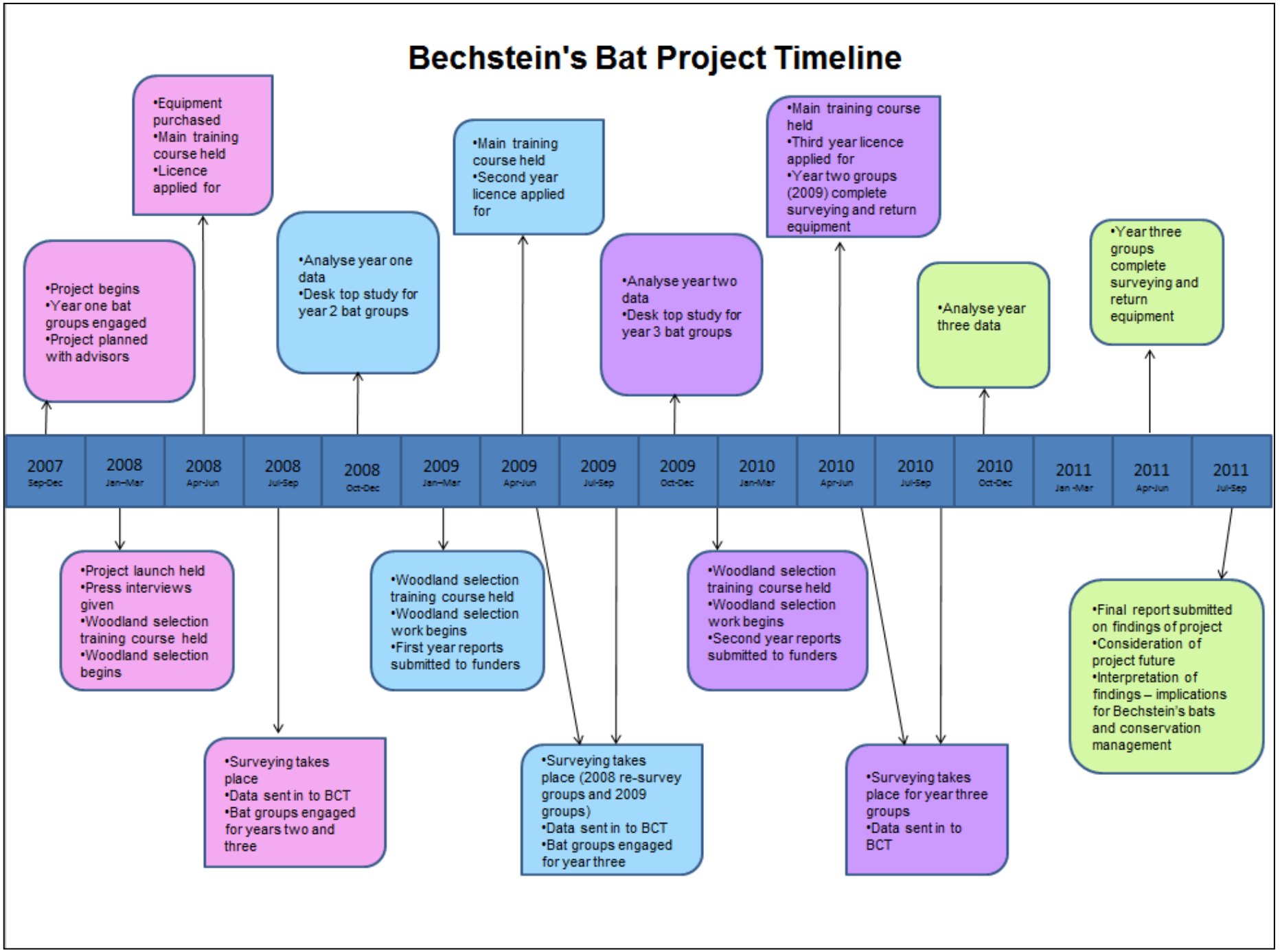
BCT agreed to allow the addition of a third coordinator for some groups (Kent and Worcestershire). This was to allow survey effort to be better shared between individuals. As the largest county involved, the Devon group were also given an additional coordinator, along with a further set of equipment, to aid their effort.

1.7 Licensing

The survey techniques used in the Bechstein's Bat Survey (the Sussex Autobat and a harp trap) are potentially very intrusive as they involve luring and live-trapping and handling of bats in the field. It was essential therefore to ensure that all necessary measures were taken to ensure the responsible use of the equipment at all times and by all participants.

BCT applied to Natural England for a project licence to undertake the work. The licence was held by Frank Greenaway, with the trained coordinators from each survey group listed as accredited agents. The licence allowed each group to undertake surveying between May and September, and specified the county or area in which individuals would be licensed to survey. The project licence was renewed on an annual basis ensuring that appropriate groups for each survey year were included.

Box 2 - Timeline of the project



Methods

2.1 Winter woodland selection

Each county (or survey area) was divided into 10km squares following the OS grid system. Using the woodland model built as part of the pilot study and based on the characteristics of woodlands where Bechstein's bats have been recorded (Hill & Greenaway, 2006), a single woodland was selected in each 10km square in which the survey would take place. According to the woodland model, only woodlands that were at least 25ha in size were considered. This was either 25ha of continuous woodland, in a single block, or in two or three close stands of well-connected woods.

Woodlands that met the size criteria were then assessed and selected according to the following additional four key criteria:

Table 1 - Woodland selection criteria

1. Canopy cover	High canopy, with at least 75% cover. (Could be 50-74% cover **if** there is very well-developed understorey and species-rich herb layers).
2. Canopy composition	Predominantly native broadleaved woodland, preferably oak (or ash), or mixed including a high proportion of old oak.
3. Understorey cover	Well developed with at least 50% cover.
4. Understorey composition	Native species, especially hazel and hawthorn.

In squares where more than one wood was available that met the same number of criteria (using the table above) the following were also considered:

Positive considerations

- Presence of a small stream or pond within the woodland which retains water in summer.
- South-facing woods at lower elevations within the known range.
- Evidence of woodpecker holes.
- Stands of mixed ages including trees of >100 years.
- Occurrence of other suitable woodlands across the wider landscape (20km sq).

Negative considerations

- Evidence of recent management to clear understory, remove older trees, or reinstate coppicing.
- Higher altitudes or excessive exposure within the known range.

Where possible, woodland selection took place in winter/early spring during daylight hours. Landowner permission was obtained for all selected woodlands prior to the start of surveys.

Where no suitable woodland was present (i.e. where a woodland did not meet at least two criteria) a square was not considered to be a priority and only surveyed after higher priority squares were completed.

Where a previous record existed of a female Bechstein's bat in a 10km square (caught between May and September), a further survey was not necessary and these squares were excluded from this study.

2.2 Equipment

Each group taking part was provided with a set of equipment.

A set of equipment included:
- 2x Sussex Autobats (acoustic lure)*
- 2x harp traps (to catch the bats)*
- 2x 2-way radios (for communication and health and safety)*
- 1x county set of OS maps, scale 1:50 000 (for the selection of woodlands)

*Devon Bat Group was provided with an additional Autobat, harp trap and radio to assist with their surveys.

2.3 Summer surveying

2.3.1 Site selection

Following initial woodland selection, each target woodland was re-visited during daylight hours prior to the evening survey, to confirm selection of trapping sites, consider health and safety, and to ensure woods were still suitable for surveying. Site selection was based on the most likely location for Bechstein's bat foraging; traps were placed in dense canopy cover away from rides. Areas close to known roosts, flyways for other species, and the woodland edge were avoided.

On the night of the survey, project equipment was set up at the two selected sites in each wood. Sites were located at least 200m apart to maximise the chances of being in different foraging areas, if female Bechstein's bats were present. A recording station was also set up where the survey team was based for the evening – sited away from the traps, where captured bats could be identified and processed prior to release.

2.3.2 The Sussex Autobat

The Sussex Autobats used during the surveys were set to play a standardised series of ultrasonic bat social calls. These calls were predominantly simulated from Bechstein's bat social calls, but also included other species to increase the opportunity of catching multiple species. Call sequences were fixed to ensure standardisation of surveys between sites and between areas. Each Autobat was linked to a pair of speakers mounted to face each other, with a rotating metal vane between them that distributed the emitted sounds around the trap location. The mounted speakers were placed next to the harp trap, at the centre of the trap's frame

2.3.3 Evening survey

A survey team was made up of a maximum of eight individuals (usually divided into two groups manning a set of equipment each). A volunteer coordinator was present to oversee the survey at each site. Surveys began at least 1 hour after civil twilight. Each trapping site was surveyed for 1.5 hours. In some cases both sites within a wood were surveyed simultaneously by two teams, while in others they were surveyed one after the other by one team who moved the trap from the first site to the next. The benefit of the former being that survey nights were shorter with coordinators sharing responsibility and supporting each other. The advantage of the latter was the opportunity to survey two different woodlands on the same night, thereby maximising the number of surveys that could be undertaken.

The start and end survey temperatures, diurnal weather, cloud cover and rainfall were recorded for each survey. In addition the characteristics used to select the woodlands surveyed (according to the habitat model) were noted on the recording sheet – for the overall woodland and each site (at which equipment was set up) the percentage of canopy cover, percentage of understorey cover, dominant canopy species, dominant understory species, distance to water, nearest edge and woodland management were recorded. Groups were also asked to note the altitude and aspect of the woodland.

Throughout the 1.5 hour period, the harp traps were checked regularly and any bats found were transferred to holding bags (by appropriately licensed individuals) and taken to the recording station. This ensured that no bats remained in the trap and in close proximity to the Autobat for any length of time. If any problems arose, for example a bat caught within the strings of the trap, the Autobat was turned off.

Each bat caught was identified to species level, sexed, aged, and assessed for breeding condition (Hutson & Racey, 2004). Where a Bechstein's bat was caught, groups were asked to take a photograph and record forearm length.

At the end of the 1.5 hour period, the Autobat was turned off and the equipment packed away. Caught bats were released at this point, unless immediate releases after capture had been appropriate (e.g. a very stressed bat). Release calls were also recorded for some species on some surveys.

The method was repeated for each 10km square of the county/survey area, in which a suitable woodland had been selected. All surveys were completed between May and September.

All surveying was temporarily halted for a short period during the summer (between mid-June and early July) to avoid the highly sensitive time when females were giving birth. This was assessed locally to take into account regional variation. Local knowledge of young bats being born and observations in the field during trapping were used to identify this period.

2.4 Data processing and analysis

For each evening survey undertaken groups were asked to record the data onto an Excel spread sheet. Information was recorded about the overall woodland (in relation to the habitat model), each site at which a harp trap and Autobat were placed (in relation to the habitat model), environmental factors (such as cloud cover, rainfall and diurnal weather) and the individual bat captures. An example of the survey sheet used and the data collected is provided in Appendix 3.

Groups were asked to submit data sheets electronically to the project officer after each survey. Survey sheets were downloaded into a bespoke access database.

Some statistical analysis was carried out on the complete Bechstein's bat dataset. However, the analysis that can be done to investigate habitat associations in woodlands where capture was successful is limited due to the design of the project. Woodlands were selected for surveying based on a number of criteria to maximise the likelihood of capturing this species, and not on a random basis. The range of variation in woodlands in the study is therefore limited and hence any analysis on the results is also limited.

A Generalized Linear Mixed Model was used to investigate the effects of the main criteria of the woodland model on Bechstein's bat captures. In order to account for the uneven geographical distribution of captures of this species, an additional factor was added to the model dividing the entire survey region into 40km squares. In this way the model examines how differences in woodlands within each large-scale square influence the probability of catching Bechstein's bat.

Results

Between May 2009 and June 2011 199 selected woodlands were surveyed in a total of 199 10km squares over 200 nights. Surveys took place across Buckinghamshire, Cornwall, Devon, Dorset, Gloucestershire, Kent, Oxfordshire, Somerset, Surrey and Worcestershire. A summary of all data collected during the project is given in Table 2.

Table 2 – Summary data results

County	No. of 10km squares	No. of squares suitable for survey	No. of squares surveyed	No. Bechstein's bats caught (male and female)	No. species caught (including Bechstein's bat)	No. individuals caught (including Bechstein's bat)
Buckinghamshire	35	19	18	8(+1 out of time*)	8	71
Cornwall	63	33	9	0	6	27
Devon (south)	39	24	19	0	9	93
Dorset	39	32	21	16	9	88
Gloucestershire	43	36	16	2	6	33
Kent	51	38	36	2	9	148
Oxfordshire	39	20	12	0	7	32
Somerset	52	36	32	16	11	178
Surrey	30	19	19	1(+3 in 2008)	6	62
Worcestershire	28	23	17	7(+1 out of time)	8	96
Totals	414	277	199	52 (+5)	13	838

* 'Out of time' means that the bat was caught after the end of the survey period of 1.5hrs. These records are not included in the main analysis.

Table 3 – Squares with Bechstein's bats per county

County	Squares with female Bechstein's bats	Squares with only male Bechstein's bats	% squares with female Bechstein's bat	% squares with male Bechstein's bat
Buckinghamshire	2	1	11.1	5.5
Cornwall	0	0	0	0
Devon	0	0	0	0
Dorset	3	9	14.3	42.9
Gloucestershire	0	2	0	12.5
Kent	1	1	2.8	2.8
Oxfordshire	0	0	0	0
Somerset	8	3	25	9.4
Surrey	1	2	5.3	10.5
Worcestershire	3	1	17.6	5.9
Totals	18	19		

3.1 Bechstein's bat captures

A total of 57 Bechstein's bats (29 females and 28 males) were caught during the project at 37 sites. Full details of all captures are given in Appendix 2. Adult bats were caught at 33 sites, juvenile bats were caught at one site, and both adults and juveniles at four sites. This table includes the three Bechstein's bats caught in Surrey during the 2008 surveys.

With the exception of three squares, adult male and female Bechstein's bats were always caught in different squares. Where males and females were caught together this was either at the start of the survey season (in two of the squares), or where a juvenile male was caught alongside breeding females (in the third square).

Bechstein's bat captures in relation to the habitat model are provided in tables 4 and 5 and in section 3.5. The mean and range percentage of both canopy and understorey cover was slightly higher in woodlands where females were caught.

When plotted on a map female records in an area tended to be clustered together. A similar distribution pattern was also observed for male records.

Bechstein's bats were caught throughout the survey period (i.e. during May, June, July, August and September), as shown in Appendix 2.

Table 4: Canopy cover data for female and male Bechstein's bat woodlands

	Canopy cover					
	Mean % cover	**Range % cover**	**% oak dominant**	**% ash dominant**	**% oak & ash dominant**	**% other**
Female	79.2	70-90	44.4	5.6	27.8	22.2
Male	75.8	60-95	63.2	0	21.1	15.8

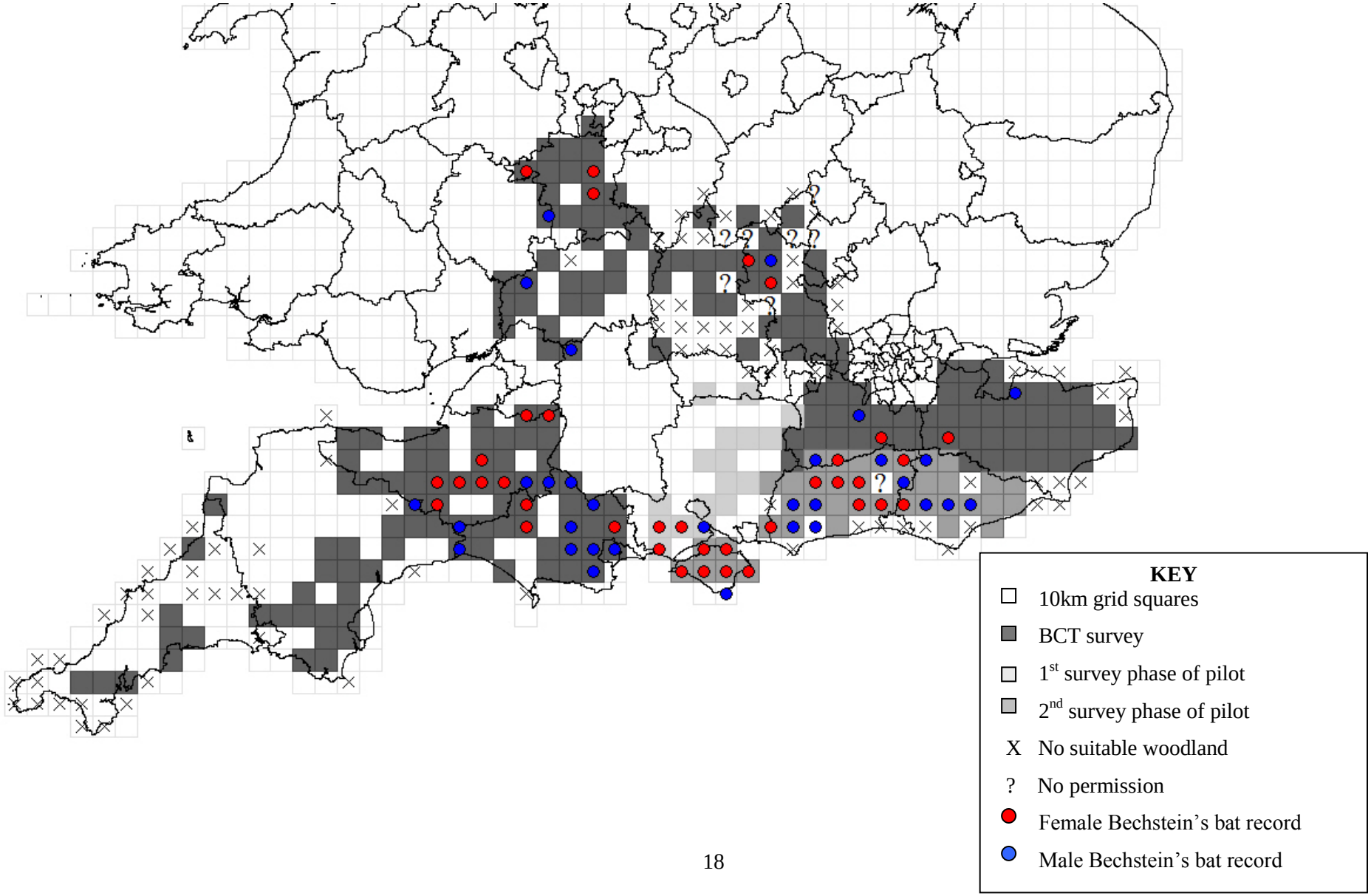
Table 5: Understorey cover data for female and male Bechstein's bat woodlands

	Understorey cover				
	Mean % cover	**Range % cover**	**% hazel dominant**	**% holly/hazel/hawthorn dominant**	**% other**
Female	69.2	40-90	78.8	16.7	5.6
Male	56.1	25-80	47.4	31.6	21.1

3.2 Distribution map

The Bechstein's bat records collected as part of the BCT project are displayed in Figure 2. Where both males and females were found in a square, just a red dot indicating female presence is displayed. Records collected during the pilot project (on which this work is based), in Sussex, Isle of Wight and parts of Hampshire are also included in this figure.

Figure 2. Bechstein's bat records from the BCT project and pilot



3.3 Other species recorded

Note: The following data only includes individuals caught within 1hour and 35minutes of the survey start time between 2009 and 2011 (this allows an additional 5 minutes after the finish time of 1hour and 30minutes, as occasionally bats were caught whilst equipment was being packed up).

In total, 838 bats of 12 species and one species group (those individuals recorded as pipistrelles spp.) were captured. Due to the difficulty in separating whiskered bat, Brandt's bat and Alcathoe bat, these species have been grouped together for the purposes of this analysis. A full breakdown of species caught by county is given in Appendix 1.

One or more bats were caught within the survey period in 190 of the 199 woodlands surveyed. Table 6 shows the species caught during the project, within the time period. Brown long-eared bat was the most frequently recorded species accounting for 42% of all individuals caught. The whiskered/Brandt's/Alcathoe group was the second most frequently encountered, accounting for 16.9%, although it must be noted that this is very likely to comprise individuals of up to three species. The third most frequently encountered species was Natterer's bat. The target species, Bechstein's bat accounted for 6.2% of all captures.

Table 6 – Total number and percentage of species caught over all surveys

Species	Individuals caught per spp.	% of all captured
Brown long-eared bat	352	42.0
Whiskered/Brandt's/alcathoe bat	142	16.9
Natterer's bat	119	14.2
Common pipistrelle	61	7.3
Soprano pipistrelle	56	6.7
Bechstein's bat	52	6.2
Daubenton's bat	24	2.9
Noctule	13	1.6
Barbastelle	7	0.8
Pipistrelle spp.	5	0.6
Serotine	4	0.5
Lesser horseshoe bat	2	0.2
Leisler's bat	1	0.1
Total	838	

Table 7 shows the number and percentage of target woodlands in which each species or species group was caught. The captures show a similar pattern with brown long-eared bat being caught in the most woodlands (70.7% of woodlands), followed by the whiskered/Brandt's/Alcathoe group (42.9% of woodlands), followed by Natterer's bat (40.9% of woodlands). The target species, Bechstein's bat was caught in 17.7% of woodlands surveyed.

Table 7 – Target woods in which species were found

Species	No. woods found in	% of target woods
Brown long-eared	140	70.7
Whiskered/Brandt's/alcathoe bat	85	42.9
Natterer's bat	81	40.9
Common pipistrelle	43	21.7
Soprano pipistrelle	41	20.7
Bechstein's bat	35	17.7
Daubenton's bat	19	9.6
Noctule	12	6.1
Barbastelle	7	3.5
Pipistrelle spp.	4	2.0
Serotine	4	2.0
Lesser horseshoe	2	1.0
Leisler's bat	1	0.5

Figure 3 – Number of bats by species across the survey season

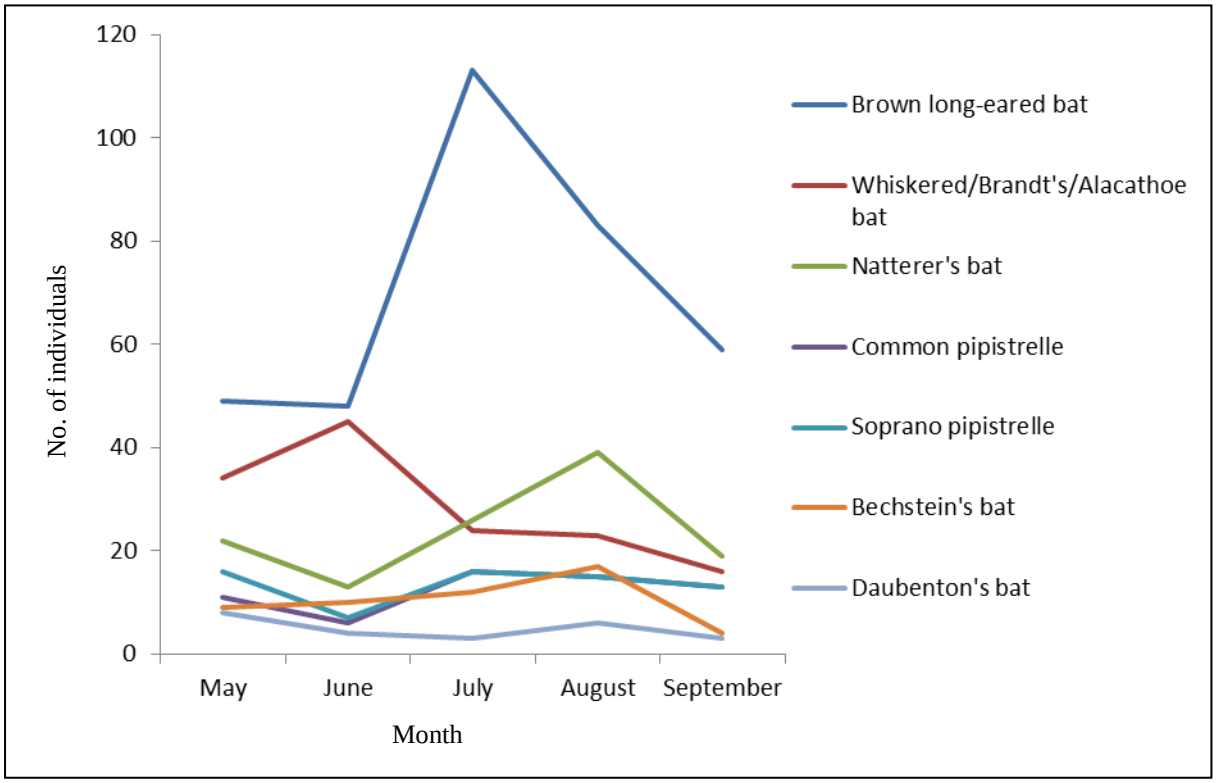


Figure 3 shows the number of bats of each species caught in each month for all years combined. The number of surveys completed in each month differed as it was affected by when groups started and ended their surveys. Also, surveys were halted in mid-June for a few weeks to avoid trapping during the peak time when bats were giving birth. Chi-squared tests, looking at the expected distribution based in survey nights in each month, show that there was no significant difference in the number of bats caught between months for Bechstein's bat (χ^2= 3.03, df=4, P=0.55), Natterer's bat (χ^2= 5.13, df=4, P=0.27), brown long-eared bat (χ^2= 8.96, df=4, P=0.062), common pipistrelle (χ^2= 3.98, df=4, P=0.41) and soprano pipistrelle (χ^2= 5.24, df=4, P=0.26). Monthly counts were too low to analyse data from Daubenton's

bats. There was significant variation between months for the whiskered group, however (χ^2= 42.2, df=4, P<0.001), and Figure 3 suggests relatively fewer bats were caught in the second part of the summer from July onwards than would be expected from the number of surveys carried out.

3.4 Male to female ratio

For all bat captures, males were caught more frequently than females with a 1:3:1 (male:female:not recorded) ratio (in 14 individuals caught the sex was not recorded). This total includes all individuals caught across the 13 species/species groups (which include "pipistrelle species") between 2009 and 2011.

This was also true for the majority of species when analysed individually. Males equalled or outnumbered females caught in 12 of the 13 species categories, as outlined in Table 8. Only common pipistrelle and lesser horseshoe bat had equal numbers of captures of males and females. For the target species, Bechstein's bat, more females were caught than males but the difference here was just two bats.

Table 8 - Male to female ratio of species caught

Species	Male	Female	Unrecorded
Brown long-eared bat	189	157	6
Whiskered/Brandt's/alcathoe bat	82	59	1
Natterer's bat	70	46	3
Soprano pipistrelle	36	18	2
Common pipistrelle	30	30	1
Bechstein's bat	25	27	0
Daubenton's bat	16	8	0
Noctule	7	6	0
Barbastelle	5	2	0
Pipistrelle species	4	0	1
Serotine	2	2	0
Lesser horseshoe	1	1	0
Leisler's bat	1	0	0
	463	**351**	**14**

3.5 Woodland model criteria

3.5.1 Habitat model

All woodlands selected were the best fit woodland to the woodland model in each 10km square (assuming landowner permission was granted). Of the 199 woodlands surveyed, 69% matched either three or four of the woodland model criteria as shown in Figure 4. The breakdown of these woodlands by county is shown in Table 9. Of the 37 woodlands in which Bechstein's bats were caught, 19 of these matched all four criteria, 11 matched three criteria, five matched just two and two matched just one as shown in Table 10.

Figure 4 – Percentage of target woodlands matching criteria

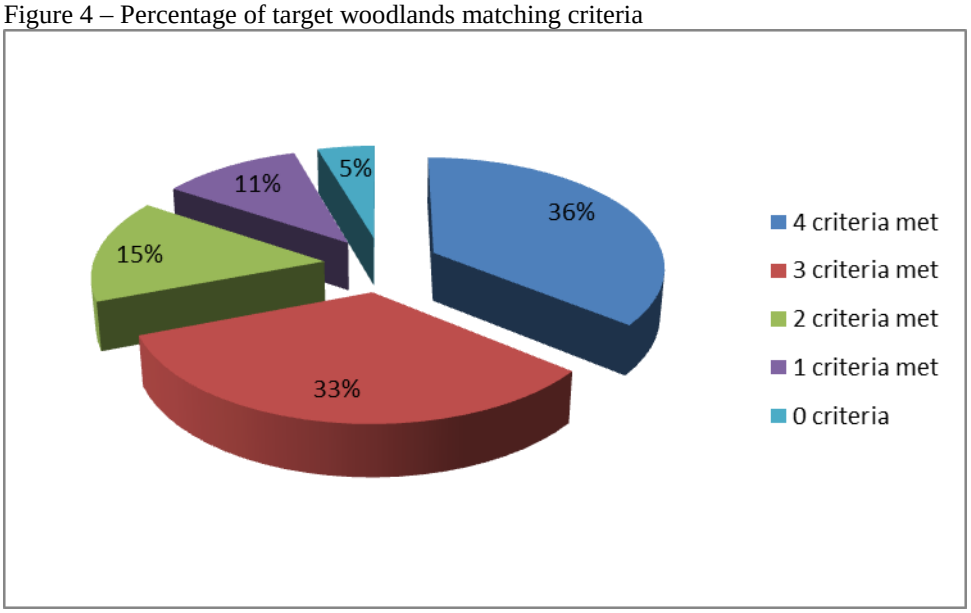


Table 9 – Number of woodland model criteria met by woodlands surveyed by county

County	4 criteria	3 criteria	2 criteria	1 criteria	0 criteria
Bucks	6	5	3	3	1
Cornwall	4	3	1	1	0
Devon	11	5	3	0	0
Dorset	12	7	2	0	0
Gloucestershire	6	8	2	0	0
Kent	7	12	4	8	5
Oxfordshire	0	4	4	3	1
Somerset	12	12	5	3	0
Surrey	7	4	5	2	1
Worcestershire	7	6	1	2	1

Table 10 – Number of woodland model criteria met by woodlands where Bechstein's bat were caught

Habitat criteria met	Female Bechstein's bat woodlands	Male Bechstein's bat woodlands
4	10	9
3	6	5
2	2	3
1	0	2
Total	**18**	**19**

3.6 Volunteer survey effort

It is estimated that each bat group spent between 250 and 500 hours on the project (dependent on the number of surveys undertaken, number of volunteers involved, size of survey area and ease of identifying woodlands and gaining landowner permissions). This figure also includes

attendance at the relevant training days. The number of volunteers that took part for each group is given in table 11.

Table 11 – Number of volunteers in each county/survey group

County	No. of volunteers
Buckinghamshire	33
Cornwall	25
Devon	24
Dorset	33
Gloucestershire	34
Kent	70
Oxfordshire	17
Somerset	56
Surrey	19
Worcestershire	32

3.7 Statistical analysis

In this section the results of the statistical analyses of the dataset are presented. The results should be interpreted with some caution due to the non-random design of the survey method. The pilot survey showed that the association between woods that matched the model and the presence of females was a highly significant one; the woods for the BCT survey were therefore chosen, as far as possible, using the model, meaning that the significance of any analysis should be viewed with care. However, the analysis can provide some useful information on which factors within the woodland model were found to be important in affecting Bechstein's bat captures during the BCT surveys.

3.7.1 Bechstein's bat captures

Table 12 shows the results of the logistic Generalized Linear Mixed Model to investigate the relationship between Bechstein's bat captures and woodland model characteristics used to select woodlands, taking into account regional variation with the inclusion of a 40km square area as a random effect. A full table of variables is given in Appendix 6.

Table 12 - Test statistics for the key criteria of the woodland model, before and after fitting 40km square as a random effect.

	Without fitting 40km square				After fitting 40km square			
Term	**F**	**df1**	**df2**	**P**	**F**	**df1**	**df2**	**P**
Canopy cover	0.81	1	161.3	0.371	0.44	1	61.8	0.509
Understory cover	7.74	1	185.9	**0.006**	4.98	1	85.4	**0.028**
Hazel in understory	1.59	1	226.1	0.208	0.69	1	91.5	0.409
Hawthorn in understory	3.31	1	175.2	0.071	2.16	1	69.2	0.146
Oak dominant in canopy	0.31	1	165.5	0.576	0.09	1	49.0	0.763
Ash dominant in canopy	1.07	1	162.3	0.303	2.36	1	65.0	0.129

The model shows that only understory cover has a significant effect (at the 5% level) on the Bechstein's bat captures both with and without the random effect of geographical variation. These results are surprising as we would expect all of these factors to be important in affecting Bechstein's bat captures. However, it is likely that because sites were selected for

these criteria, there is relatively little variation in these variables and few distinctly unsuitable sites in the dataset, making it less likely for significant results to be found.

The variance explained by each of the factors in the model (R^2) was also low (Table 13). The 40km square factor allowing for geographical location explained most of the variance (19.5%), with the other factors combined only explaining an additional 15.1% of the variation in captures of Bechstein's bat. Of the key criteria, understory cover is the only one that explains any significant amount of variation (2.7%).

Table 13 - Variance explained by key criteria of woodland model, with and without accounting for geographic variation using the 40km square factor.

	% variance explained (R^2)	
Term	**Before 40km square factor fitter**	**After 40km square factor fitted**
40 km square	19.5%	
canopy cover	0.0%	0.1%
understory cover	5.2%	2.7%
HAZEL in understory	1.7%	0.2%
HAWTHORN in understory	0.8%	0.5%
Oak in canopy	0.7%	0.0%
Ash in canopy	0.6%	0.8%

The inclusion of each of the possible explanatory variables into the model was then tried one at a time, with and without 40km square fitted. The full list of variables and test statistics for each is provided in Appendix 6. Despite the large number of variables, few had a significant effect on the presence of Bechstein's bat in woodlands. Only one variable remained significant after fitting the factor for geographical variation. The distance to nearest water is highly significant (F=8.99, df=1,309, P=0.003), and remains significant at the 5% level even after fitting 40km square factor (F=6.3, df=1,153, P=0.013). Table 14 illustrates that this is probably due to the fact that Bechstein's bat was never caught more than 1km from water.

Table 14- Relationship between presence of Bechstein's bat and distance to nearest water. Figures exclude Devon and Cornwall since no Bechstein's bats were found in this area.

Distance to water	**n sites**	**prop with Bechstein's**	**s.e.**
<100m	124	0.137	0.031
<500m	135	0.148	0.031
<1km	30	0.100	0.056
1km or more	24	0.000	0.000

3.7.2 Sex ratios: Bechstein's bat

For sites where Bechstein's bats were captured a logistic Generalised Linear Mixed Model was fitted to the proportion of males to see if it showed any relationship with any of the possible explanatory variables, to investigate the possibility that males are using suboptimal habitats. Values from the previous model were also fitted as a measure of how suitable the site is for the species and tried fitting this in the model for the sex ratio.

Unfortunately, whilst there is some indication of non-randomness in the distribution of the sexes (χ^2 = 66.47, df=41, P=0.007), the tests were not able to show that any of the variables are significantly associated with this variation. It is likely that differences in habitat used by males and females are too subtle to be shown by the data collected in this survey.

Discussion

4.1. Bechstein's bat records

The survey results are discussed against the project's main aims as set out in section 1.3.

- *Deliver systematically acquired baseline distribution data for Bechstein's bat*

During the four years of the project, surveys were completed across ten counties within southern England. From the 199 squares surveyed, 37 new woodland sites for Bechstein's bat were identified.

The surveys undertaken as part of the project (and the pilot work) comprise the first national survey for Bechstein's bat in the UK, producing baseline distribution data for this species.

- *Delineate the species range and hotspots*

As part of the project a request was sent to local bat groups to ask for any additional (non-project) Bechstein's bat records. This was essential to ensure that as comprehensive a map as possible could be produced of Bechstein's bat UK distribution.

These additional records, alongside the BCT and pilot work are displayed in Figure 5 to show the overall known summer distribution of Bechstein's bats in the UK. This shows that the female records in North Buckinghamshire and Worcestershire from the Bechstein's Bat Survey are the most northern records for breeding females in the UK, extending the known range of this species.

Figure 5 also illustrates "hotspot" areas in Dorset/Somerset, Hampshire/Isle of Wight and Sussex (and the borders of Surrey and Kent) where multiple squares containing breeding females were found. We consider that these hotspot areas, identified from the overall results of the Bechstein's Bat Survey are core areas for the population of this species which are likely to be significant in terms of the long-term viability of Bechstein's bat in the UK. It is worth noting that almost all records shown here have been collected using the Sussex Autobat, although not necessarily under the same protocol, confirming the success of this method as suitable for the identification of the presence of Bechstein's bat in woodlands in the UK.

It should be emphasised that where surveys undertaken have not shown the presence of Bechstein's bat, we cannot conclude absence of the species. Challenges encountered during the survey (e.g. environmental conditions and landowner permissions) may have reduced the likelihood of catching Bechstein's bat in some 10km squares. Additionally, some counties and 10km squares shown within the range of the species have not been systematically surveyed. For example, key areas such as Hampshire and Wiltshire were not surveyed as part of the Bechstein's Bat Survey, due to limited availability and resources in these bat groups. Some individuals have been kind enough to submit their records for Bechstein's bat in their areas (e.g. Hampshire bat group have been undertaking their own woodland project in part of the county), but the records provided here are not complete across the UK, particularly for example in Wiltshire, and the data shown may not accurately represent Bechstein's bat distribution in those counties.

The overall distribution map shown in Figure 5 should therefore not be used to illustrate absence; rather it should be used to give a better understanding of range and to highlight areas that appear to be important for the species on a wide scale to focus future conservation action.

- *Understand the habitat associations of the species across its range in the UK*

The woodland habitat model devised by Hill and Greenaway (2006) is based on studied sites in Sussex where Bechstein's bat maternity colonies have been recorded. As this was the best model available at the time of the start of the Bechstein's Bat Survey, it was used in this project. Co-ordinators from each bat group were therefore trained and instructed to find the best-fit woodlands according to this model within their counties for survey in each 10km square. 72 of the 199 squares surveyed fitted all four of the habitat model criteria. This task was found to be easier in some counties than others (as seen in Table 9). In some counties such as Oxfordshire there were few woodlands of sufficient size that matched all four of the key criteria. High altitude (e.g. Devon), lack of large woodland blocks (e.g. Dorset), and dominance by non-model species such as sweet chestnut (e.g. Kent) were the most common issues encountered by groups trying to select 'ideal' woodlands.

The majority of Bechstein's bats caught were found in woodlands that matched three or four of the habitat model criteria: 16 of 18 woodlands with female (or male and female) Bechstein's bats and 14 of the 19 woodlands with just males.

A summary of the habitat model characteristics of woodlands in which Bechstein's bat was caught are provided in Tables 4 and 5. There is a subtle difference between male and female woodlands, with those in which females were found having a slightly higher mean and range for both canopy and understorey cover. Previous work (F Greenaway pers. comm., 2008) has shown that females are found in optimal woodlands, so the project's findings although not significant do support this previous study. In addition, although not statistically significant, an observational comparison of understorey cover does suggest an association with hazel specifically for both male and female woodlands.

The presence of Bechstein's bat in some of the woodlands that did not match all four of the model criteria may be explained by looking at the breeding status of those individuals. Of the eight sites at which female Bechstein's bat were caught in woodlands that did not match all four model criteria, non-breeding females were caught at four of these sites (non-breeding females will not have the same resource demands and therefore may roost or forage away from the main roost site (Altringham, 2011)). Of the remaining four the breeding status was not recorded at two sites due to the timing of the survey (i.e. too early or late in the season to confirm). Therefore finding female Bechstein's bats in those woodlands that deviate from the 'ideal' model woodland does not necessarily refute our understanding that as a general rule core maternity colonies do require the four main criteria in a woodland site.

The statistical analysis of Bechstein's bat captures revealed that the only criteria from the model that was significant was understorey, both with and without inclusion of a factor for geographical variation. Given the way in which woodlands have been positively selected for particular criteria in this project, any analysis is likely to produce limited results as there is limited variation in the dataset. Therefore these results do not suggest that any of the criteria used are not significant for this species, but they do illustrate the particular importance of understorey cover. Within the dataset the greatest amount of variation (between woodlands surveyed) seems to be with regards to the percentage of understorey cover (as shown in tables 4 and 5), allowing us to highlight the importance of understorey through statistical testing. Hill and Greenaway (2008) have shown a clear association between a well-developed understorey and the number and diversity of woodland bat species (brown long-eared bat, Natterer's bat, whiskered bat, Bechstein's bat, and Brandt's bat). They suggest that understorey could be significant to protect from aerial predators, to provide key habitat for

prey species and to provide a more stable microclimate. The significance of understorey in our results therefore fits with previous findings for woodland bats.

Previous work has also suggested a difference in the woodland quality of male and female Bechstein's bat sites, with males often found in sub optimal habitats (Hill & Greenaway, 2006). The analysis of sex ratios of Bechstein's bats showed some non-randomness, but no significant relationship with any particular criteria from the woodland model. The survey was designed to find maternity colonies of Bechstein's bat with the best fit woodland selected in each square. Because of this, we cannot reliably test for differences between sites where male and female bats were captured. It is however clear that with a few exceptions (that normally occur at the very start or end of the breeding season); woodlands are typically used by either adult males or adult females but not both. Therefore subtle differences in sites, not recorded in this survey, appear to be playing a role in the suitability of sites. This is also likely to be true for those sites in which only non-breeding female Bechstein's bats were recorded (five sites).

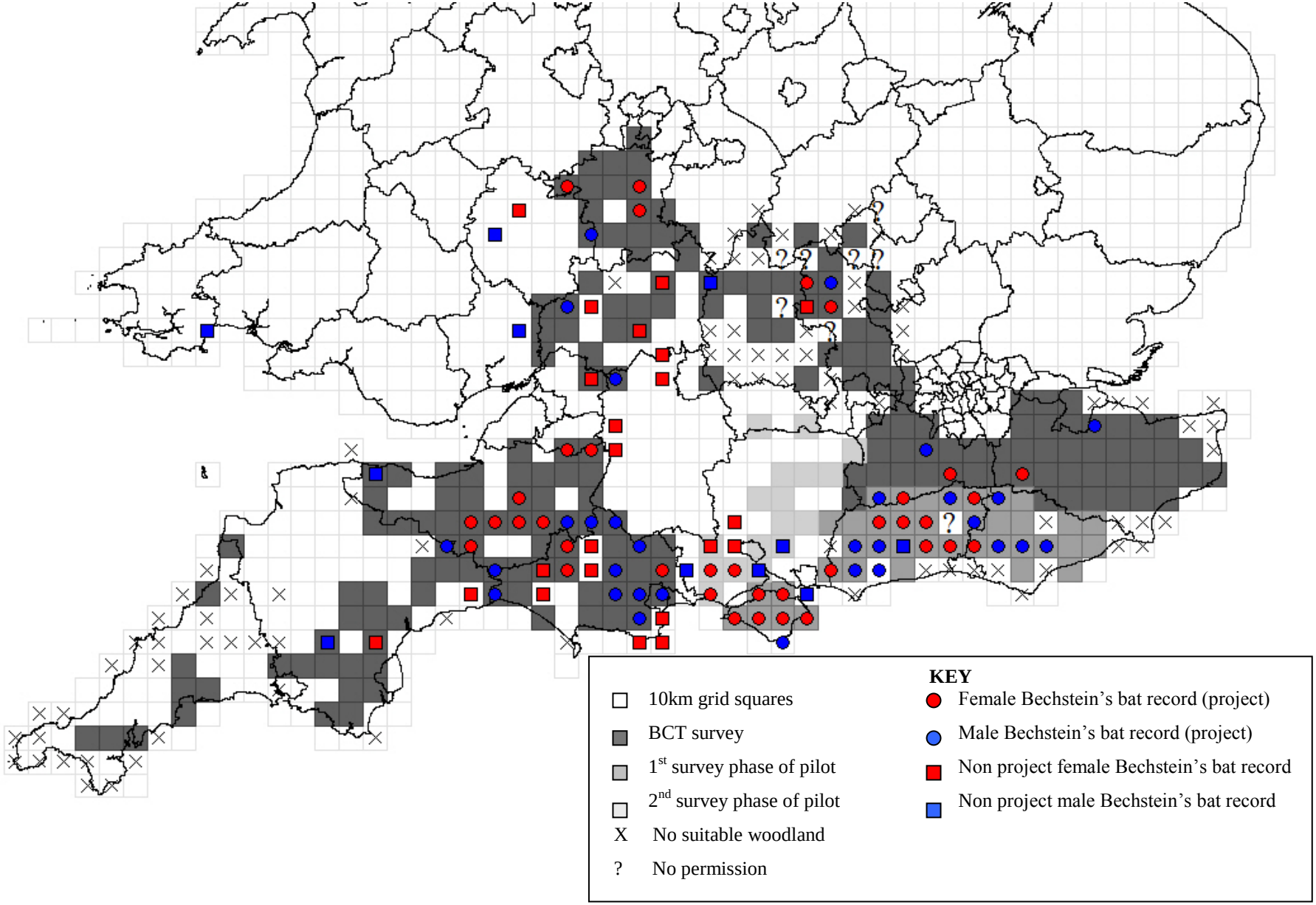
In addition to the main criteria, there were also observed differences in the woodlands used by Bechstein's bat across its range that are important to consider in terms of woodland management advice and the conservation of the core areas identified for the species. Sites in Dorset (and parts of Somerset) in which Bechstein's bat was found were much smaller blocks of woodland that on their own did not meet the 25ha size requirement, but were well connected to other small woodland blocks that together were of sufficient size (at least 25ha). This situation contrasts with the single larger woodland blocks found in areas such as Buckinghamshire, Surrey and Kent. It is therefore important to ensure that the surrounding area including connected woodlands are taken into account in any management decisions as well as the woodland block itself where bats are found. Groups of small woodland blocks are likely to be more vulnerable to change, and therefore in Dorset and Somerset any woodland management plans should consider all of the connected woodland blocks within an area used by Bechstein's bat.

In Worcestershire, which is on the edge of the range for this species, the type of woodland blocks used seemed to be variable, although this is only based on a very small sample of Bechstein's bat woodlands. Of the three woodlands in which females were found, one consisted of small woodlands blocks as described above, a second was a large (more than 25ha) single block and the third was smaller than the required size and appeared to be relatively isolated in its location. This woodland in particular is likely to be extremely vulnerable to any changes in management or disturbance and would benefit from additional survey work.

In the east of the survey area the catch rate of Bechstein's bat reflects the woodland types found in these counties. For example in Kent the single female record was located on the Surrey/Kent border in a small patch of woodland that provided the best fit to the woodland model for the county (all of the four main criteria were met here). Woodland in the rest of the county is largely sweet chestnut dominated with a history of coppicing, suggesting that the Bechstein's bat may be limited in its ability to expand its range (for maternity colonies) in this area due to a lack of availability of suitable habitat.

Finally in Buckinghamshire, available woodland that best fits the model appears to be in the northern part of the county where Bechstein's bat was captured. Further south and in parts of Oxfordshire, the woodlands did not fit the model as well; for example there were no woodlands in Oxfordshire where all four of the main criteria were met.

Figure 5. Bechstein's bat UK distribution map 2011



It is worth noting that where the project has recorded breeding female Bechstein's bats within a woodland, we cannot make any estimates on the size of the colony from these results. It is likely that some of the woodlands on the edge of the range, although able to support small numbers of females may not be suitable to support larger colonies, raising questions about their long-term sustainability. Only further survey work can confirm the extent of the populations in woodlands identified.

Additional woodland data collected
As outlined in section 2.1, in addition to the main habitat model groups were provided with positive and negative variables that should also be considered during the selection process. This included presence of water nearby, south facing aspects and low elevation, woodpecker holes evident and availability of suitable woodland within the surrounding landscape.

From statistical testing of these additional variables in relation to capture rate of Bechstein's bat, distance to nearest water appears to be highly significant for this species, with all individuals caught within 1km of water. This is likely to be a threshold effect rather than one which increases gradually with distance, and a maximum distance from water of 1km should therefore be considered when assessing the suitability of a woodland for this species. Other variables were not easily assessed during statistical analysis but will be important.

Negative considerations (which were tested in the earlier surveys and resulted in the current model) included recent management and high altitudes or excessive exposure. As explained above understorey was shown to be significant for Bechstein's bat captures, thus reinforcing the need for sensitive woodland management, especially understorey clearance at Bechstein's bat sites. Neither altitude nor exposure significantly affected Bechstein's bat capture rate in this study, but it is possible that this is a regional issue and one which may not be highlighted in this type of study where positive site selection was used. From the observed results, however, it appears likely to be a consideration in counties such as Devon, where high altitude in parts and the effect of large areas of open habitat such as Dartmoor probably limit the spread of Bechstein's bat across the county and further west into Cornwall. This hypothesis is explored further is section 5.

- *Provide a baseline against which ongoing presence of the species in 10km squares can be monitored for future Biodiversity Action Plan reporting and conservation status assessments.*

The project has provided a baseline dataset and distribution map that can be used for future monitoring of this species within the UK. Follow on and future work is discussed in section 5.

4.2 Other captures

- *Provide preliminary data on the distribution of other woodland bat species in relation to woodland quality by recording all other species caught during the surveys.*

The survey method for this project was designed to maximise female Bechstein's bat catches with both the trap placement and series of calls targeted towards catching this species. There were however additional calls added to the Autobat's call sequence to make the lure attractive to other bat species as well, thereby enhancing the catching opportunities during each survey to allow us to sample wider woodland bat species presence. The project was therefore a great opportunity for bat groups to understand the use of their woodlands by bats and to increase knowledge of woodland bat species within the UK.

Species from the *Myotis* genus are particularly difficult to distinguish from each other by using a bat detector (e.g. Russ, 1999), and some of the species that produce quiet echolocation calls, which often are found in woodland, can go undetected in bat detector surveys. In-hand confirmation of species presence in woodlands has therefore been an important aspect of this project, allowing bat groups to improve their knowledge about a local area, confirming previous suspected bat detector records for example. Local involvement from volunteers has also facilitated liaison with local landowners about species found.

In total 12 species and one species group were recorded during the project surveys, including some of the UK's rarer bat species (e.g. barbastelle), as well as those that are often under-recorded or hard to identify to species level. Project data distribution maps for each species are provided in Appendix 5. Alcathoe bat (*Myotis alcathoe*) was discovered as a resident UK species in 2010 (Jan et al, 2010). Due to this discovery and our subsequent decision to group all whiskered/Brandt's/Alcathoe bat captures together (due to the problems of identification without using genetic techniques which were not available to us in this project), we have not investigated differences in the distribution of these species.

For some species such as the brown long-eared bat, which was recorded in 70.2% of target woodlands, these data may allow us to expand upon what is already known about this species' local distribution. It is however worth being cautious when interpreting the data. Surveys are designed predominantly to collect information about Bechstein's bat, and our trap placement was focused on this species. The other species' data collected during surveys are unlikely to give a complete picture of the use of the woodland by non-target bats. Those species with a similar feeding strategy to Bechstein's bat are more likely to be attracted to the Autobat (Hill & Greenaway, 2008). Those species that have a different foraging strategy and tend to feed on woodland edges or rides for example (e.g. barbastelle) are less likely to be caught in similar numbers. To understand fully how a woodland is used by bats, additional surveys would be required such as detector surveys to support the trapping, more variation in trapping locations, or the use of a wider range of calls on the Autobat to increase the species likely to be attracted to it, which was outside the scope of the project.

4.2.1 Brown long-eared bats

The brown long-eared bat was the most frequently recorded species, both in terms of the number of individuals caught and the number of target woodlands it was found in. Brown long-eared bats are one of our more common UK species. Harris *et al.* (1995) estimated a population size of approximately 200,000 individuals in the UK, although this is likely to be an underestimate. The brown long-eared bat records collected are comparable with results from the pilot work (Hill & Greenaway, 2006). There are however, additional behavioural and ecological reasons for this species' frequency of capture. The brown long-eared bat is a woodland specialist with a preference for deciduous woodland. It is a gleaning bat, with a manoeuvrable flight pattern that allows it to feed in cluttered environments (Entwistle *et al*., 1996). It has also been shown that this species (particularly the females) favour foraging areas close to roosting sites: Entwistle *et al*. (1996) found that this species concentrated its foraging within 0.5km of the roosting site. Lastly this species also defends its territory in a similar way to Bechstein's bat. These characteristics are similar to those of the Bechstein's bat (Schofield & Morris, 2000). By placing traps in cluttered areas so that territorial, foraging Bechstein's bats will encounter the Autobat, the chances of trapping a brown long-eared bat are also likely to be increased.

4.2.2 Other species captures

Of the 12 species and one species group caught during surveys, capture frequency showed wide variation with some species such as the lesser horseshoe bat, Leisler's bat and serotine only being encountered on a handful of occasions, whereas other species, particularly *Myotis*

species and the pipistrelles were caught more frequently. These differences can be explained by a combination of factors. The species caught on a regular basis tended to be woodland specialists (*Myotis*) and the commonest species (pipistrelles). Those caught infrequently tended to be the bigger bats which do not usually forage in dense canopy cover where traps were situated (e.g. serotine, Catto *et al*., 1999).

4.3 Survey methodology

4.3.1 Assessing the effectiveness of the protocol – to catch Bechstein's bat

The success of the survey method, which involved the use of a harp trap and acoustic lure at two selected sites within each woodland, is illustrated by the rate of capture (across surveys) of Bechstein's bat and the subsequent distribution map that we have been able to produce (Figures 2 and 5).

Through this method we have been able to show the significance of Dorset and Somerset for this species, as is illustrated by Table 3 which looks at the proportion of woodlands with Bechstein's bat in each county. Bechstein's bat was found in 57.2% of Dorset squares surveyed (predominantly males) and 34.4% of Somerset squares (mainly females). In addition, the discovery of breeding females in Worcestershire, Buckinghamshire and Kent, three counties that had no previous records of this kind, demonstrates the success of the method used.

However, the performance of the Autobat (and survey protocol) in certain counties in which Bechstein's bat captures were expected but [rarely] found (specifically Gloucestershire) requires further consideration.

Why didn't the Gloucestershire surveys yield the expected results in terms of presence of Bechstein's bats in woodlands (and overall catch rates)? From other work (Palmer *et al*., 2007) we know that maternity colonies of Bechstein's bats do occur in Gloucestershire, however the Bechstein's Bat Survey results do not reflect this. Both Autobats used in Gloucestershire were tested to confirm they were working effectively, and were not found to have any faults. Towards the end of the group's involvement in the project, the survey period was extended by up to an hour for some surveys (although any additional captures are not included in the main data set), but this did not yield additional Bechstein's bat catches. It is possible that in large, heavily-wooded areas such as the sites surveyed in Gloucestershire, capture success increases in the later part of the evening/early morning (this occurred in previous work in the county, E Palmer, pers comm., 2008). This was also found in parts of Hampshire during the earlier stages of the pilot work. A suggested theory being that normally bats are reacting to the autobat as an intruder to their patch (when feeding and defending their individual area). Unless lactating, females will spend all of their time in their individual patch. It is suggested that in good woodlands or very good weather, individuals can feed more effectively, return to the roost site for longer periods and therefore have more time to socialise. The reaction to the autobat is then not aggressive but social, which normally occurs later in the night than the BCT survey period (F Greenaway, pers comm., 2011).

Other hypotheses that may explain the low numbers of Bechstein's bat caught in Gloucestershire include the possibility that in very large woodland areas it is more difficult to select a site and successfully lure a Bechstein's bat. The bats may be more spread out and therefore the chances of placing the trap within the bat's territory are lowered, or perhaps the colony are only using a small area during that particular season so identifying the right area in

the woodland to survey is difficult. In addition a larger wooded area available does not necessarily result in a larger number of individuals using that site. This is because there are other factors that will restrict the upper size limit of a colony, regardless of the foraging area available, e.g. available roosting sites, disease, competition, etc. Thus the chance of capturing a female when undertaking just one three hour survey in these large heavily wooded sites is reduced.

4.3.2 Assessing the effectiveness of the protocol – for non-Bechstein's bat captures

The secondary aim of the project was to provide data on other bat species using the woodland. The call sequence played by the Autobat consisted of both Bechstein's bat and non Bechstein's bat calls to try and attract other species to the trap. Previous experience suggests a three hour survey of this kind may yield a capture rate of approximately six individuals (F Greenaway pers comm., 2008); the average capture rate for each group is given in Appendix 1.

The number of individuals (of all species) caught per survey varied among woodlands (as would be expected) but also between counties, with some groups having a lower overall catch rate than others, for example both Worcestershire and Somerset had the highest catch rates with an average of 5.6 and 5.9 individuals per survey respectively. Groups such as Gloucestershire and Oxfordshire (2.7 and 2.7 respectively) had the lowest catch rates and also lacked the diversity of species caught. For individual woodland surveys, low catch rate and/or species diversity could be a result of the suitability of the woodland or environmental conditions on the night of the survey. Where catch rate was consistently low (e.g. across a number of surveys undertaken by a group) the success of trap placement should also be considered as well as weaknesses in the training provided and the nature of the management of the wider landscape (e.g. intensive forestry, farming, etc.).

Survey problems in Gloucestershire have been discussed in section 4.3.1 in relation to Bechstein's bat captures but issues encountered are likely to have affected the low catch rate observed here as well. Without further work, it is difficult to address this issue any further, but it is likely that the size of the woodland area surveyed is a factor. A more concentrated survey effort may be required in heavily-wooded areas such as those seen in this county.

Oxfordshire was not expected to generate many Bechstein's bat records due to its northerly location (although this thought was prior to the records found in neighbouring Buckinghamshire) but it is useful to address the low overall catch rate here as well. Oxfordshire was the only county to choose the option of surveying their two sites in each woodland consecutively rather than simultaneously. The consecutive survey method was used successfully in the pilot study and is not considered to yield differing results to surveying the two sites simultaneously as was done by all other bat groups (Hill & Greenaway, 2006).

Of the 39 10km squares within or partially within Oxfordshire, just 20 had suitable woodlands (and of the 12 squares that were surveyed, none supported woodlands that matched all four of the woodland model criteria). It could therefore be possible that this county does not have enough suitable woodland to support a Bechstein's bat population (as a result of the woodlands themselves and the management of the surrounding landscape). This may also limit the use of these woodlands by other woodland specialists.

Interestingly, the catch rate for Buckinghamshire (with the exception of the Bechstein's bats caught) was also quite low (3.1). The group have reported that suitable woodland (according to the habitat model) is mainly located in the northern part of the county. It may therefore be that the low average catch rate is as a result of the survey of woodlands in the southern part of the county, bringing the overall catch rate down.

4.3.3 Are there any changes we would make to the protocol?

The project had very clear objectives, one of these being to test the protocol devised during the pilot study across the UK range to see whether a systematic monitoring survey can be deployed by volunteers and be effective in providing baseline information on Bechstein's bat distribution. To ensure that data from each county or area were comparable, it was necessary to retain standardisation of the survey method across all areas and throughout the project. There was no capacity available to test deviations from the protocol or amendments to it, for example to trial different approaches in areas where we observed reduced success in capturing Bechstein's bat.

It is clear however, that the protocol was more effective in some areas than others (although we would suggest that this was predominantly a problem in just one county – Gloucestershire). If the protocol is to be used in future surveys small amendments to the survey method may be tested. For example, in heavily wooded counties such as Gloucestershire or Hampshire, a more intensive level of survey effort may be required to produce positive results. Additionally, starting later in the evening in these areas should be tested.

4.4. The volunteer system

Following on from the pilot study, Frank Greenaway and Dr David Hill approached BCT to deliver this project across the UK range because it required the involvement of bat group volunteers to be successful at such a large scale. Contracting one individual to undertake this work in each county of the Bechstein's bat range would be both prohibitively costly and time-consuming.

The volunteer element of this project has been key to its success both in terms of the project data generated (it allowed BCT to deliver this project across 10 counties within four years), and in the opportunity provided to BCT to support bat groups in developing their own skill and knowledge base. The progress of each survey group is discussed in appendix 3.

4.4.1. Lessons learnt – survey coverage

Surveying every relevant 10km square within a county is a substantial challenge, particularly for larger counties such as Devon and Cornwall. Attempts were made to reduce survey areas for the larger counties involved. However we had to acknowledge that the level of work required (which included a daytime ground survey of potential woodlands and evening surveys of the best fit woodlands, in addition to organising the involvement of other volunteers within the bat group) was too big an expectation for most groups. Asking volunteers who are donating their spare time and working around other commitments such as family and full-time jobs, to replicate the work of a paid contractor was extremely optimistic and in most cases not achievable.

We had to acknowledge at an early stage that it would not be possible to survey every square of the survey area. Rather it was imperative to provide support to groups, offer guidance in how to prioritise surveys and achieve as much as possible in a focused area.

4.4.2. Lessons learnt – standardisation

As this was a systematic survey it was important to ensure that as far as possible all groups taking part carried out the survey in a consistent manner. Co-ordinators were asked to attend

training sessions to be taught the methods to be used. In addition the Autobats were fixed to play a set sequence of calls, and the data was recorded onto a standard recording form.

It is however inevitable when using more than one individual or group to carry out field surveys, that there will be deviation from and different interpretation of the standard methods. For example recording the percentage of canopy cover in a woodland is subject to observer variation, and likely to yield different results depending on the individual assessing it. This has been taken into account when interpreting the suitability of woodlands surveyed.

There was also some deviation in how rigidly groups stuck to the standard timing of the surveys, which was set at 1.5hrs. Some groups surveyed for exactly 1.5 hours at each trap site following the method precisely. Others tended to run over slightly on each survey, and some actively chose to survey for longer than the required period. Records gained as part of these extended survey periods were considered useful at a local level but have had to be excluded from the main project data analysis to ensure that the results are comparable across the entire survey area.

4.4.3. Lessons learnt – volunteer expectations

One of the main appeals of being involved in the project for individuals was the new skills that the surveys required, and therefore the opportunity to develop new skills and gain experience using equipment such as harp traps and Autobats. We have however learnt that it is essential when planning a project such as this to consider the opportunities open to volunteers following the project. Equipment availability and licensing issues have limited the aspirations of some groups who would like to set up their own follow-on projects using the skills they have gained from the Bechstein's Bat Survey. BCT is now working to develop follow-up projects and support for the bat groups who have been involved in this project to help to overcome some of these issues.

Future development

5.1 Understanding habitat associations

Through the work of the Bechstein's Bat Survey we have been able to test whether a habitat model, devised and tested in Sussex, can be successful in identifying the presence of Bechstein's bat maternity colonies in woodlands across the species' UK range. We have shown that this model can be used as an overall selection tool to identify sites where Bechstein's bats are present. However, it is clear that there are differences in woodlands used by the species across its range and that the importance of particular variables (including higher level variables such as annual temperature and rainfall) may change across the range. There is therefore scope for further surveying and analysis to be undertaken in areas identified from this project to support populations of Bechstein's bats to look in more detail at the importance of particular variables in determining presence.

By combining the Bechstein's bat records from this project with other records that we have collated from bat groups and individuals, we can start to investigate relationships between species presence and some of the additional higher level factors such as annual temperature in a region, which were outside the scope of the project, but may also contribute to the overall distribution and range of this species within the UK. It is possible, from populations studied in Sussex, that Bechstein's bat fails to breed successfully in some summers (as was seen in 2008), which would support a link to temperature (F, Greenaway per comm., 2010).

We have completed some basic mapping work using Geographic Information System (GIS) MapInfo to look at patterns of Bechstein's bat presence and factors such as temperature and woodland cover. The aim of this mapping task is to identify potential questions that we would like to investigate in more detail, to focus the direction of future habitat modelling work, as outlined in section 5.3.

First, we overlaid the male and female Bechstein's bat records with annual growing days (a temperature data set available from the Met Office website: http://www.metoffice.gov.uk/) (Figure 6). This allows us to look at whether temperature might be correlated with Bechstein's bat distribution. At a visual level we can see that the hotspot areas identified (Dorset/Somerset, Hampshire and Isle of Wight, and Sussex) are mainly in relatively warm areas (as shown by the warmer orange and red colours on the map).In particular, the south-west part of Hampshire and Isle of Wight, where there is a concentration of records, is shown to be very warm. Additionally in the Dorset/Somerset hotspot, the majority of female records were found in Somerset which is where the slightly warmer temperatures appear to be from visual inspection of the map.

If annual temperature does play a factor in Bechstein's bat presence as suggested by this map, we may be able to begin to understand one of the barriers to range extension of core maternity colonies, for example into western Devon and Cornwall (where cooler annual temperatures are seen), or into parts of South Wales. However, the warmer areas do extend into parts of Gloucestershire where Bechstein's bats were not found where they were expected. If distribution is influenced by annual temperature, the warmer temperatures seen in Gloucestershire may provide support for the theory that the survey method was less successful in this area due to the large size of the woodlands, rather than any lack of suitability of these woodlands to support Bechstein's bats.

If broadleaf woodland patches of 25ha or larger are added to the map (Figure 7 – the red patches illustrate this), we can build on the picture of distribution in relation to temperature. It is possible to see that some woodland areas in Gloucestershire appear cooler in their annual temperature which may also affect the suitability of parts of this county for Bechstein's bat.

The map also highlights that the area of Worcestershire in which female records were collected is quite sparse in terms of woodland cover. This suggests that these populations could be quite vulnerable if not managed sensitively, and would benefit from additional survey work to better understand the area and its use by Bechstein's bat.

Lastly, by illustrating where colonies are present, we can start to suggest areas, originally outside the survey area in which suitable habitat may be present and therefore where further surveys could be undertaken.

5.2 Woodland management guidance

It is vital that work continues in areas where new Bechstein's bat records have been discovered as part of this project. For example, working with landowners and local bat groups to ensure that individuals responsible for the Bechstein's bat sites are aware of what has been found and what this means in terms of future woodland management and conservation needs.

It is also important to ensure that, where hotspots have been identified e.g. Dorset and Somerset that any work across the region takes into account the possible presence of Bechstein's bat and the significance of appropriate conservation and management at a regional scale to ensure the long term viability of the species here.

As part of the work of BCT's new Bats and Woodland Officer, we will be producing woodland management guidance specific to this species in 2012. The aim of the guidance will be to ensure that appropriate advice is given to ensure woodlands where Bechstein's bats are found are managed appropriately to provide the best habitat for this species, but also to allow landowners to understand when and how work can be undertaken. It will also provide information on funding and grant schemes which landowners may be able to access to promote the conservation of Bechstein's bat on their site.

The key information on Bechstein's bats and woodlands that has emerged from this project is summarised below:

- Breeding female Bechstein's bats are predominantly found in woodlands that meet three or four of the following criteria:
  - Broadleaf woodland particularly that dominated by oak and/or ash
  - At least 75% canopy cover
  - Native understorey present, particularly hazel and hawthorn
  - At least 50% understorey cover

- Core maternity areas need a woodland size of at least 25ha

- This woodland may be made up of one woodland block or may consist of two to three smaller, connected blocks. This is particularly true for woodland sites in Somerset and Dorset where maintaining woodland connectivity is vital.

- Understorey cover is particularly important and should be retained where possible

- Bechstein's bat maternity roosts are usually found within 1km of a water body

- Males, non-breeding females and smaller breeding colonies may be found in woodlands that do not meet the above criteria. These individuals are important to the long-term success of a colony and therefore woodlands where there presence has been identified should also be sensitively managed.

- Our current understanding of the UK range of the Bechstein's bat is that the species is present from Devon in the west of England to Kent in the east, extending north to Worcestershire and Buckinghamshire, with additional outlying male records in south Wales.

- Core areas for this species are Somerset, Dorset, Wiltshire, Hampshire, Isle of Wight and West Sussex. The long-term viability of this species in the UK requires significant conservation effort in these areas to safeguard populations and sensitively manage and maintain key woodland sites.

- Significant edge of range populations are also present in Worcestershire and Buckinghamshire. These populations are likely to be extremely vulnerable to any changes in woodland management practices or land use change for example resulting from large-scale development.

5.3 Future projects and research

The Bechstein's Bat Survey has met its original aims in terms of collecting baseline distribution data, identifying hotspots and defining the species range. There are however many further questions that this work has provoked and aspects that subsequent survey/research work could focus on.

5.3.1 Female Bechstein's bat records

Where female Bechstein's bats were caught, further survey work should be considered to locate maternity roost sites, develop an understanding of the size of the colony and how it uses the surrounding area. This information can identify key areas of woodlands used by the bats, and be used as a baseline for conservation management of that site. It will also add to our understanding of the importance of particular areas for the species.

In the final season of the project, some additional survey work was undertaken in Buckinghamshire, Dorset, Kent and Worcestershire as described below.

Buckinghamshire

The work carried out in this county has formed part of the Bernwood Forest Bechstein's Bat Project which began in 2011 (with additional work planned for 2012). This project involves those individuals who acted as co-ordinators for the BCT project and has been supported by BCT through the on-going loan of equipment.

In its first summer (2011) the work has involved surveying further woodlands within the area in which Bechstein's bat was recorded using the BCT Bechstein's Bat Survey protocol. Where females were caught the group have radio-tracked a proportion of these captures to identify roosting sites, estimate colony size and determine the foraging range of the bat colony. A summary report of this work has been produced which further emphasises the importance of the Bernwood area for the species (Damant et al, 2011). A count of over 60 individuals from one of the tree roosts identified confirms that this is a significant core

population. Further survey work will be carried out in the summer of 2012 with the support of BCT.

Dorset
Volunteers from the Dorset Bechstein's bat team surveyed a further 8 woodlands within squares 3611 and 3610 (in which females were found in 2009 surveys). These squares support a typical example of the small woodland block system that is present in much of Dorset. This further survey work has found an additional three sites used by female Bechstein's bats, two of which are connected/very close to the initial woodland identified. This is likely to mean that the same colony uses these new woodlands as an extension of their territory. However, the group have reported that the third new woodland identified is situated further away (from other female woodlands identified in the square) which could suggest that this woodland is used by a separate colony. This additional survey work illustrates how important it is, particularly in this county where the woodland is found in small, connected patches, to ensure that woodland management plans take into account the network of connected woodlands in any given area that could be used by Bechstein's bats, rather than focusing on individual blocks. Additional work at a more detailed level to identify roosting locations, colony size and foraging areas in this county would be beneficial to gain a better understanding of the populations using these woodlands.

Kent
Additional surveys carried out in Kent have centred on the area in which the single female Bechstein's bat was captured during the main surveys. Four additional woodlands were surveyed during the summer of 2011 (using the BCT protocol) but no further Bechstein's bats were captured. Although these woodlands matched some of the model criteria (particularly canopy cover and dominant species) they were lacking in the percentage of understorey cover, only one of the four woodlands met the percentage understorey cover criteria (at 50% cover). This is therefore likely to have affected suitability.

The group reported that all of these additional sites had an obvious lack of herb layer and a deer browse line. Given that the results of this project have highlighted the importance of a well-developed understorey, it is very likely that deer browsing could also affect the suitability of these sites for Bechstein's bat. The possible effects of deer browsing should be considered for all sites where Bechstein's bat is present.

Worcestershire
Surveys focused on adjoining squares 3826, 3925 and 3926 (female Bechstein's bats were caught in squares 3925 and 3926). Five new woodlands were surveyed in the latter part of the 2011 survey season using the BCT protocol. Two new Bechstein's bat sites were identified from this work (a male and female Bechstein's bat found at each of these new sites – squares 3925 and 3926). The bat group are now working with major landowners in the area to try to set up a radio-tracking project to gather more information on the use of this area by the Bechstein's bat population.

5.3.2 Habitat modelling work

In conjunction with Professor Gareth Jones from the Bat Ecology and Bioacoustic Lab at Bristol University, BCT will be using the Bechstein's bat data to look in more detail at distribution modelling. Maximum Entropy presence-only modelling (Maxent), which combines known locations of the species with environmental variables to give an overall predicted distribution, will be used to improve our understanding of the likely extent of where this species may occur. This work will identify where further survey work should be targeted to confirm the full extent of the species' range in the UK, and also consider the potential future effects of climate change on the distribution of the Bechstein's bat and available habitat.

Figure 6 - Bechstein's bat records against annual growing days temperature data set

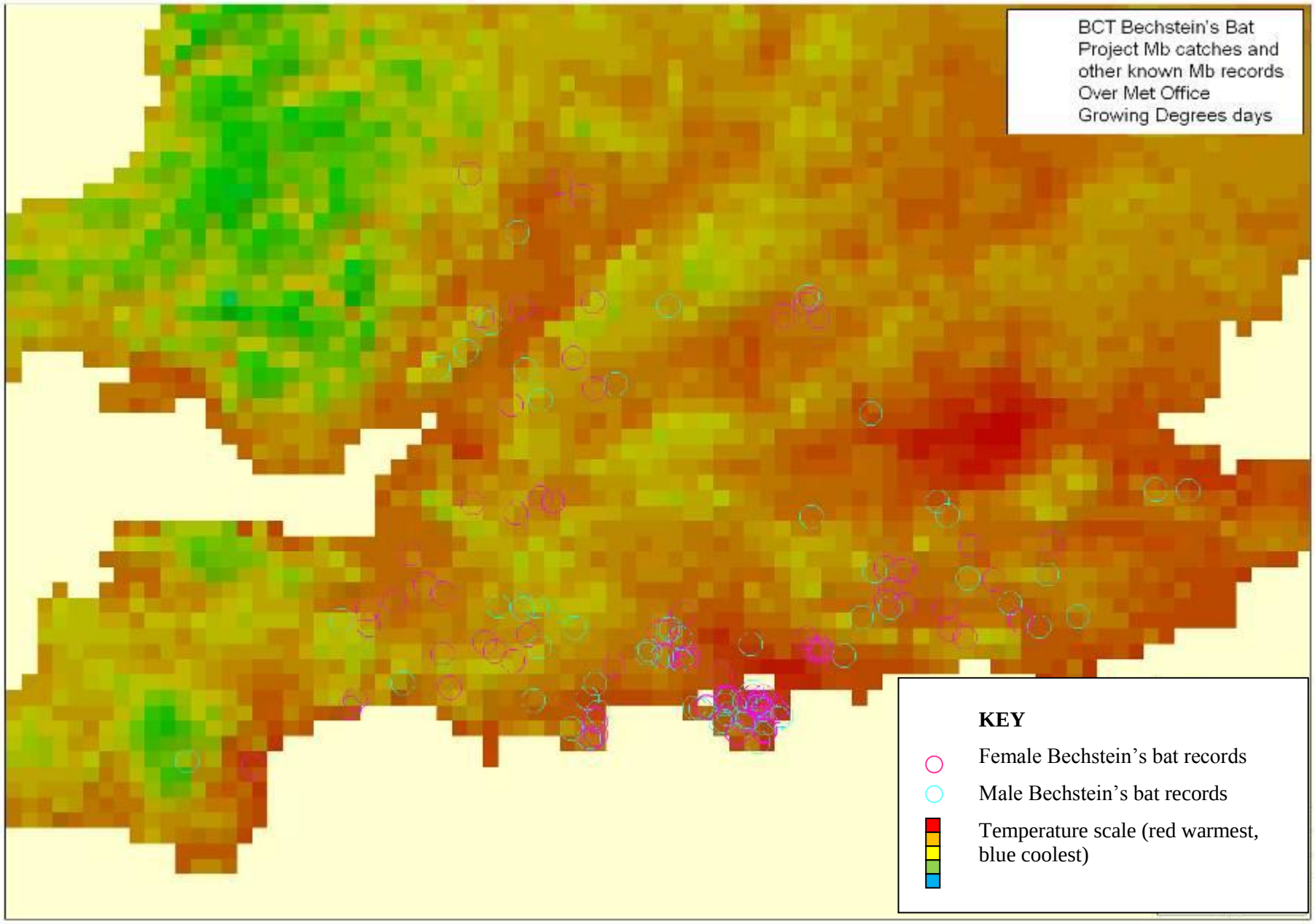
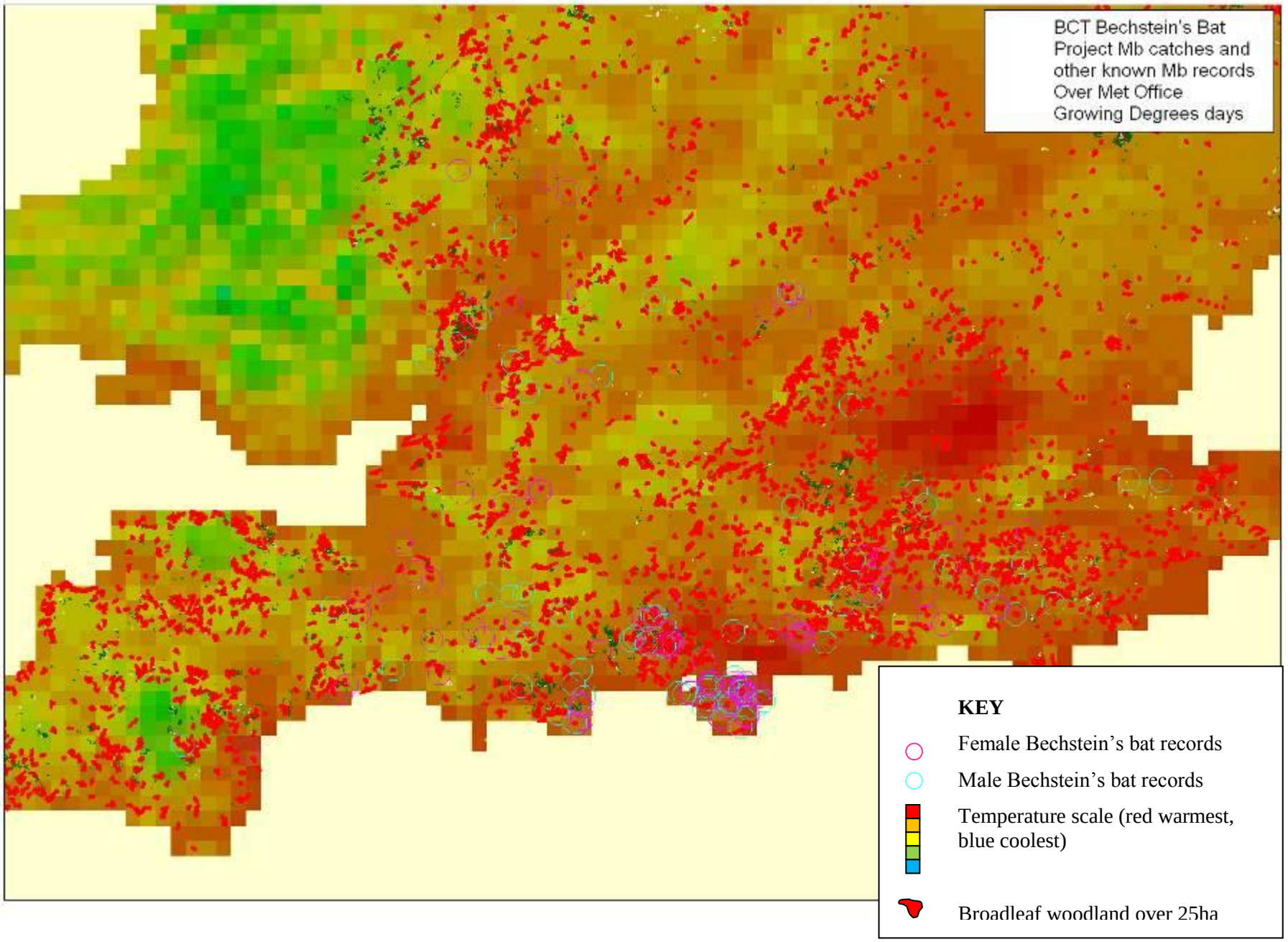


Figure 7: Bechstein's bat records against annual growing days and broadleaf woodland over 25ha



5.3.3 Future use of the data

The important new distribution data on Bechstein's bats in the UK delivered by this project can be used in the future in a number of ways:

- Future reporting under Article 17 of the Habitats Directive on the status of this species
- Informing the work of the Barbastelle and Bechstein's Technical Advisory Group (BBTAG) which was set up to facilitate collaboration, sharing of findings, development of new research techniques, and conservation management advice between experts working on these two species.
- Contributing towards BAP targets for the species
- Providing baseline information on which further project work on Bechstein's bats in the UK can be built, as already is happening in some counties
- Providing baseline distribution data which has been added to the National Biodiversity Network Gateway at an appropriate scale to help inform local conservation and communities of the bats in their area. The Bechstein's Bat Survey dataset can be accessed at http://data.nbn.org.uk/datasetInfo/taxonDataset.jsp?dsKey=GA000570
- Distribution modelling based on the improved information on distribution that is now available for this species
- Further analysis of the data on species other than Bechstein's bat

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- Forestry Commission GB
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- People's Trust for Endangered Species/Mammals
- Thames Valley Environmental Records Centre
- The Scottish Forestry Trust

Appendices

Appendix 1 – Species captures per bat group

Species	Total individuals	Buckinghamshire	Cornwall	Devon	Dorset	Gloucestershire	Kent	Oxon	Somerset	Surrey	Worcestershire
Lesser horseshoe bat	2								2		
Daubenton's bat	24	1		8	4		3		3		5
Whiskered/Brandt's/ alcathoe bat	142	2		20	9	11	25	1	42	5	27
Natterer's bat	119	15	4	12	12	3	20	11	24	6	12
Bechstein's bat	52	8			16	2	2		16	1	7
Noctule	13	1	1	2	1		3	1	2		2
Leisler's bat	1						1				
Common pipistrelle	61	2	3	12	1	3	6	1	13	10	10
Soprano pipistrelle	56	4	3	8	4		15	2	8	4	8
Pipistrelle spp.	5				1			1			3
Serotine	4			1				1	2		
Barbastelle	7		3	1	1	1			1		
Brown long-eared bat	352	38	13	29	39	13	73	14	75	36	22
Totals	**838**	**71**	**27**	**93**	**88**	**33**	**148**	**32**	**188**	**62**	**96**
No. squares surveyed		18	9	19	21	16	36	12	32	19	17
Average catch rate		3.9	3.0	4.9	4.2	2.1	4.1	2.7	5.9	3.3	5.6

Appendix 2 – Bechstein's bat captures

Female Bechstein's bat captures during the survey (female)

Date	County	Square no.	Sex	Age class	Breeding status	% Canopy cover	Canopy composition	% Understorey cover	Understorey composition	No. criteria met
06/06/2008	Surrey	5214	Female	Adult	Pregnant	YES	YES	YES	YES	4
10/05/2009	Dorset	3611	Female	Adult	Too early to confirm	NO	YES	YES	YES	3
26/07/2009	Kent	5514	Female	Adult	Lactating	YES	YES	YES	YES	4
21/08/2009	Dorset	3610	Female	Adult	Non-breeding	NO	YES	YES	YES	3
22/05/2010	Somerset	3212	Female	Adult	Non-breeding	YES	NO	YES	YES	3
08/06/2010	Somerset	3512	Female	Adult	Pregnant	YES	YES	YES	YES	4
08/06/2010	Somerset	3512	Female	Adult	Pregnant	YES	YES	YES	YES	4
08/06/2010	Somerset	3512	Female	Adult	Pregnant	YES	YES	YES	YES	4
10/06/2010	Worcestershire*	3926	Female	Adult	Pregnant	YES	YES	NO	YES	3
10/06/2010	Worcestershire	3926	Female	Adult	Pregnant	YES	YES	NO	YES	3
14/07/2010	Worcestershire	3626	Female	Adult	Lactating	YES	YES	YES	YES	4
14/07/2010	Worcestershire	3626	Female	Adult	Lactating	YES	YES	YES	YES	4
16/07/2010	Somerset	3312	Female	Adult	Lactating	YES	YES	YES	YES	4
16/07/2010	Somerset	3312	Female	Adult	Non-breeding	YES	YES	YES	YES	4
16/07/2010	Dorset	4010	Female	Adult	Lactating	YES	YES	YES	YES	4
16/07/2010	Dorset	4010	Female	Adult	Lactating	YES	YES	YES	YES	4

Date	County	Square no.	Sex	Age class	Breeding status	% Canopy cover	Canopy composition	% Understorey cover	Understorey composition	No. criteria met
02/08/2010	Worcestershire	3925	Female	Adult	Lactating	YES	YES	YES	YES	4
02/08/2010	Worcestershire	3925	Female	Adult	Non-breeding	YES	YES	YES	YES	4
04/08/2010	Buckinghamshire	4622	Female	Juvenile	-	YES	YES	YES	YES	4
04/08/2010	Buckinghamshire	4622	Female	Adult	Lactating	YES	YES	YES	YES	4
04/08/2010	Buckinghamshire	4622	Female	Adult	Lactating	YES	YES	YES	YES	4
04/08/2010	Buckinghamshire*	4622	Female	Adult	Lactating	YES	YES	YES	YES	4
04/08/2010	Buckinghamshire	4622	Female	Juvenile	-	YES	YES	YES	YES	4
14/08/2010	Somerset	3413	Female	Adult	Non-breeding	YES	YES	NO	YES	3
04/09/2010	Somerset	3211	Female	Juvenile	-	YES	YES	YES	YES	4
17/09/2010	Buckinghamshire	4721	Female	Adult	Not recorded	NO	YES	NO	YES	2
21/05/2011	Somerset	3715	Female	Adult	Non-breeding	YES	YES	YES	YES	4
31/05/2011	Somerset	3615	Female	Adult	Non-breeding	NO	YES	NO	YES	2
04/06/2011	Somerset	3412	Female	Adult	Pregnant	NO	YES	YES	YES	3

*Caught outside of main survey period

Male Bechstein's bats caught during the survey

Date	County	Square no.	Sex	Age class	Breeding status	% Canopy cover	Canopy composition	% Understorey cover	Understorey composition	No. criteria met
06/06/2008	Surrey	5214	Male	Adult	Adult male	YES	YES	YES	YES	4
01/08/2008	Surrey	4913	Male	Adult	Adult male	YES	YES	YES	YES	4
30/05/2009	Dorset	3809	Male	Adult	Adult male	YES	YES	YES	YES	4
30/05/2009	Dorset	3809	Male	Adult	Adult male	YES	YES	YES	YES	4
20/06/2009	Surrey	5115	Male	Adult	Adult male	NO	YES	YES	YES	3
28/07/2009	Dorset	3908	Male	Adult	Adult male	YES	YES	YES	YES	4
11/08/2009	Dorset	4009	Male	Juvenile	-	NO	YES	YES	YES	3
11/08/2009	Dorset	4009	Male	Adult	Adult male	NO	YES	YES	YES	3
18/08/2009	Dorset	3810	Male	Adult	Adult male	YES	YES	YES	YES	4
29/08/2009	Dorset	3712	Male	Adult	Alpha male	NO	YES	YES	NO	2
29/08/2009	Dorset	3712	Male	Adult	Adult male	NO	YES	YES	NO	2
31/08/2009	Dorset	3309	Male	Adult	**Alpha male	YES	YES	YES	YES	4
09/09/2009	Dorset	3812	Male	Adult	Adult male	NO	YES	YES	YES	3
30/05/2010	Worcestershire	3724	Male	Adult	Adult male	YES	YES	YES	YES	4
12/06/2010	Dorset	3909	Male	Adult	Adult male	NO	YES	YES	NO	2
07/07/2010	Kent	5816	Male	Adult	Adult male	YES	NO	NO	NO	1
12/07/2010	Dorset	3911	Male	Adult	Adult male	YES	YES	YES	YES	4
14/07/2010	Gloucestershire	3621	Male	Adult	Alpha male	YES	NO	YES	NO	2
31/07/2010	Somerset	3612	Male	Adult	Not recorded	YES	YES	YES	YES	4
02/08/2010	Worcestershire	3925	Male	Juvenile	-	YES	YES	YES	YES	4

Date	County	Square no.	Sex	Age class	Breeding status	% Canopy cover	Canopy composition	% Understorey cover	Understorey composition	No. criteria met
07/08/2010	Buckinghamshire	4722	Male	Juvenile	-	YES	YES	YES	YES	4
07/08/2010	Buckinghamshire	4722	Male	Juvenile	-	YES	YES	YES	YES	4
07/08/2010	Buckinghamshire	4722	Male	Adult	Alpha male	YES	YES	YES	YES	4
04/09/2010	Gloucestershire	3818	Male	Adult	Adult male	YES	YES	NO	YES	3
17/05/2011	Somerset	3111	Male	Adult	Adult male	NO	YES	YES	YES	3
21/05/2011	Somerset	3715	Male	Adult	Adult male	YES	YES	YES	YES	4
04/06/2011	Somerset	3412	Male	Adult	Adult male	NO	YES	YES	YES	3
07/06/2011	Somerset	3310	Male	Adult	Adult male	NO	NO	NO	YES	1

** Males: Adult male (testes developed) and Alpha adult male (testes enlarged)

Appendix 3 – Survey groups

In this section, the findings of the surveys from each county are discussed in more detail.

Buckinghamshire
The Buckinghamshire group surveyed 18 squares during 2010 and 2011 (this county had 19 squares with potential woodland out of 34 squares in total). Buckinghamshire was not part of the original survey area but due to the Hampshire and Wiltshire groups not being able to take part in the project, and the discovery of a male Bechstein's bat at a swarming site in Buckinghamshire in 2009 (C. Damant pers comm. 2009), the group were asked to take part.

Most of the potentially suitable woodland is situated in the northern part of the county known as the Bernwood forest area. In this part of the county there are broadleaf (predominantly oak) woodlands of 25 hectares or more with good canopy and understorey cover. The Bernwood forest area is also where all three Bechstein's bat sites were identified. This is the first time that breeding female Bechstein's bats have been recorded in Buckinghamshire. As information is currently very limited, there is uncertainty about the stability and size of the population present in this area. This is discussed further in section 5.

Aside from the Bechstein's bats found in Buckinghamshire, both the number of bats captured and the range of species caught is quite low compared to some other groups. This may be at least partly explained by the lower suitability of woodlands in the southern part of the county which supported a less diverse range of species.

Cornwall
This group identified 33 squares with woodlands that matched or partially matched the habitat model criteria. In the remaining 30 squares in the county (many of which were partially coastal) no suitable woodland was selected.

During 2008 volunteers surveyed 13 sites spread across the county. After consultation with the project officer it was decided that a focus on a smaller part of the county would be sensible so that full coverage of an area could be achieved.

In 2009, the Cornwall group focused on the eastern part of the county, surveying nine squares; three of which were woodlands also surveyed during 2008. Records from these surveys included three barbastelles caught at three sites where there was no previous record of this species. It is hoped that the local group can work with the landowners of these sites to ensure that this species (along with the other species caught) are considered in any future management of the site.

No Bechstein's bats were caught during the surveys in either 2008 or 2009 in Cornwall. Bechstein's bat has not been recorded here in recent history; the nearest records to Cornwall are located in east Devon. Coastal conditions may affect the suitability of woodlands here (e.g. wind and temperature); alternatively there may not be sufficient connectivity or there may be other barriers (e.g. high altitude in parts of Devon) that limit the expansion of this species into Cornwall.

Devon
Due to the large size of the county it was originally decided to focus surveys in southern Devon. It was also agreed that four co-ordinators (rather than two) would be trained and the group given two full sets of equipment (comprising four harp traps and four Autobats) to

efficiently cover the still large survey area. Unfortunately one of the coordinators had to step down, which left three co-ordinators (and three Autobats and harp traps) to complete the same area (with two co-ordinators ideally working together at any one time).

The Devon group were limited in their survey coverage by poor weather and low temperatures. In addition two of the three co-ordinators were also largely restricted to a single survey night each week (due to other commitments). The group completed 19 surveys with the number of bats and the variety of species caught here complementing what is already known about bat diversity in this county. As in Cornwall, no Bechstein's bats were caught during the surveys in Devon. Existing records are concentrated in the eastern part of this county, near to the Devon/Dorset border. Access issues in some of the woodlands in 10km squares adjacent to those with existing records meant that the area most likely to produce additional Bechstein's bat records was not able to be surveyed in this project. At the end of the survey, the group also noted that if given the opportunity to re-survey, following their experience and that of other neighbouring groups, they may have chosen to select smaller blocks of connected woodland (that still met the criteria) above some of the large woodlands that were surveyed over these because of their size.

Dorset

This group selected set dates on which to survey each week, so volunteers were given lots of opportunities to attend surveys. Bechstein's bats were caught in 52% of woodlands surveyed here, emphasising the importance of this county as a stronghold for the species, as discussed in section 4.1. A total of 21 squares were surveyed and records of other species included a male barbastelle at a site where that species had not been previously recorded.

This county has existing records for female Bechstein's bat in the north-west and south-east of the county. The females caught as part of the BCT project were identified in adjoining squares to these existing records.

Interestingly most of the male records identified in Dorset were found in squares that lie between these two hotspots. This would suggest that these woodlands are less suitable in some way than those in which females were identified. In terms of the habitat model, five male woodlands fitted all four criteria, two fitted three and one fitted just two criteria. In the three woodlands with females, two fitted all four criteria and one fitted three. So there doesn't appear to be a big difference here between male and female woodlands; however there is not enough data to discriminate fully at this scale. These results should also be viewed with caution; the group did report that access to first choice woodlands was refused in some of these squares in which males were caught. Additional work is planned to look in more details at the local population dynamics here.

Gloucestershire

Male Bechstein's bats were recorded in two woodlands in Gloucestershire, but no female records were found during the surveys. This county does have existing records of female Bechstein's bats and is heavily covered with potentially suitable woodland. It was therefore expected that surveys would confirm Gloucestershire as an important area for Bechstein's bat. As well as the lack of female Bechstein's bats caught, the number of individuals of other species and the number of species recorded was low (33 bats of 6 species were caught during 16 surveys). With disappointing results for both Bechstein's bat and general species catches, it is possible that the protocol has not been effective in this county, as discussed in the main report.

Although the lack of individuals caught was disappointing for the group, the project was successful in terms of the involvement and development of the local bat group. The

Gloucestershire co-ordinators have mentioned that the project was an excellent opportunity to involve the wider members of the group and encourage members to take on new projects to keep the group active.

Kent

The Kent survey group completed the highest number of surveys during their involvement in the project with 36 squares surveyed. (Kent has 51 10km squares of which 39 had at least one potential woodland). Because of this high sampling rate, the number of bats caught was high. Species diversity was also high. Overall, however, the average catch rate was lower than some of the other groups (such as Somerset and Worcestershire). Kent's woodlands have been heavily managed which has affected their suitability for a wide range of bat species. The group also reported difficulties in finding sites fitting the habitat model across the county. This is extremely useful information and provides an insight into available habitat in this county. It is also worth highlighting that one or more bats was trapped in 34 of the woodlands surveyed, illustrating the importance of a variety of woodland types for different bat species and the importance of considering bat species in all woodland types.

As was the case with all groups, brown long-eared bat was the most frequently caught species in Kent. It is interesting to note that the fourth most commonly encountered species in Kent (after brown long-eared bat, Natterer's bat and soprano pipistrelle) was the whiskered/Brandt's/Alcathoe bat group. Prior to Kent's involvement in this project, very few records of these species were held and they were thought to be some of the county's rarer bats. The results collected during these surveys have given the group a better understanding of the occurrence of these species.

Oxfordshire

The decision to involve Oxfordshire in the project followed the discovery of a male Bechstein's bat in a bat box on a woodland site in north-west Oxfordshire in 2005 (L. R Tipping pers comm., 2007). This record suggested potential for the species to be present in the Thames and Chiltern area, and identified the need for further investigation.

Oxfordshire had 39 squares to work with in the county, but the group reported that 19 of these squares had no suitable woodland, with the majority not fulfilling the size criteria of 25ha or above. Following the success of the survey approach used in 2008 in this county, this group divided the remaining squares between two teams (a north and a south Oxfordshire team). This had the advantage of increasing the number of sites able to be surveyed during the season; although it did result in longer survey nights. Dividing up the available equipment between the two sub-groups meant that only one harp trap and Autobat could be used per woodland and therefore the two sites within a woodland were surveyed consecutively on the same night rather than simultaneously.

Unfortunately, the surveys did not result in any new Bechstein's bat records for Oxfordshire. This does not mean that the species is not present in the county; rather that Oxfordshire is not likely to be a stronghold. It is possible that some of the woodlands here are used by a small number of male Bechstein's bats at certain times during the year.

Oxfordshire followed a similar pattern to other groups trapping predominantly brown long-eared bats and Natterer's bats. This group also trapped a male serotine at one of their southern sites. This was a rare species for the project and a new record for that woodland.

Somerset
The Somerset bat group surveyed woodlands in 32 squares of their county, and recorded the highest number of individuals (178) and species (11) for any of the groups taking part. In addition this group caught 16 Bechstein's bats (the same as Dorset bat group) at 11 sites, 8 of which were new female Bechstein's bat sites. These results confirm that this county's woodlands are rich in bat species diversity with the group also catching other rare species such as lesser horseshoe bat and serotine.

The majority of Bechstein's bat records were located in the southern half of the county near to the Dorset border. When combined with the records collected in Dorset these surveys provide an important picture of this area and its importance as a hotspot for Bechstein's bat.

Surrey
This group caught three males and one female Bechstein's bat during their 2008 and 2009 surveys. During the 2009 re-survey, 19 squares were surveyed (all squares with a possible woodland for survey in the county), and seven species were recorded in total. Common pipistrelle was the second most frequently encountered bat (after brown long-eared bats) with a higher number of common pipistrelles caught compared to soprano pipistrelles (2:1 ratio).

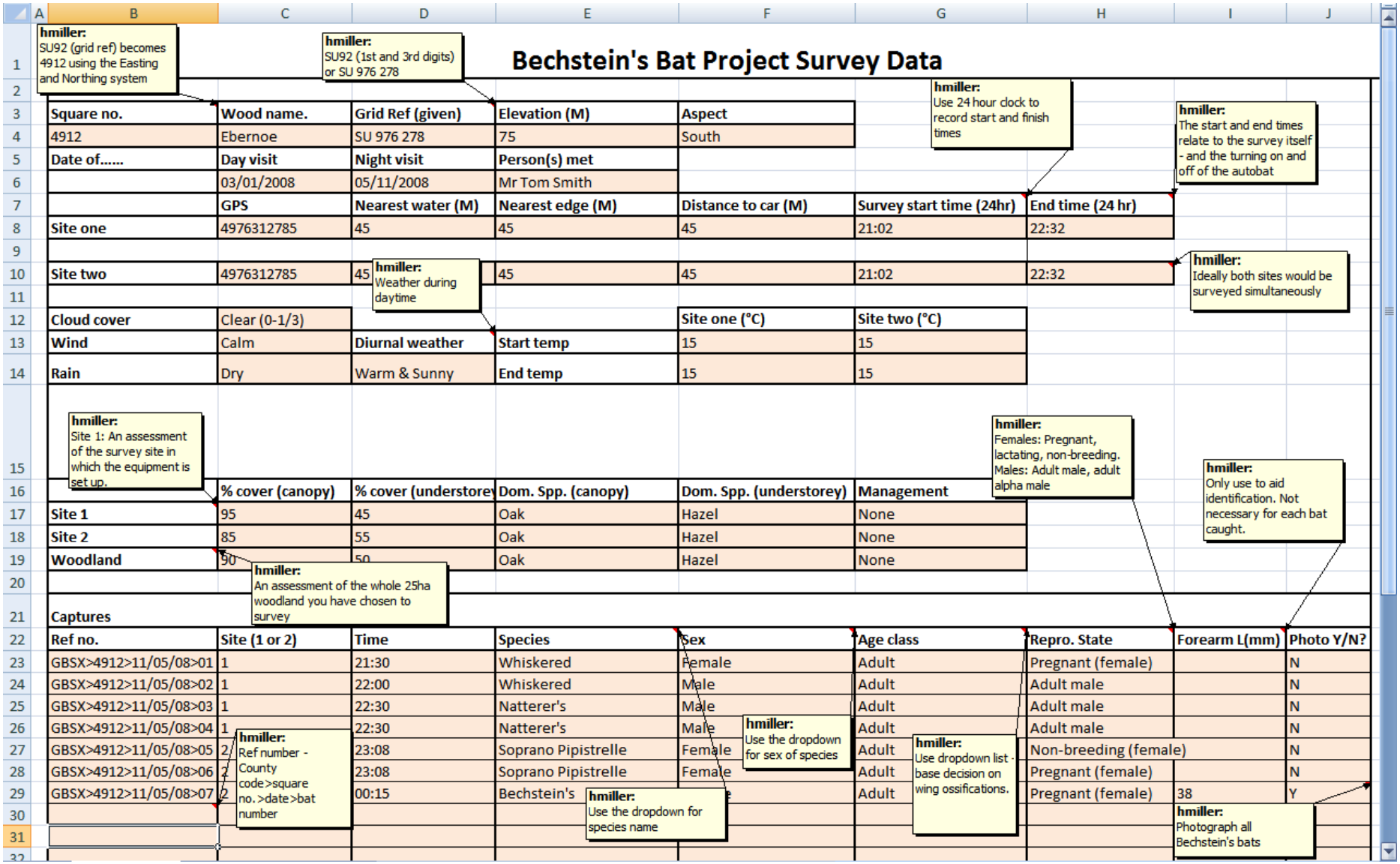
Records of female Bechstein's bats already existed in four of Surrey's squares (as shown in Figure 5). As Surrey is a relatively small county the group were confident that they could survey all the remaining squares and still have some time available. It was therefore agreed that the group could also undertake surveys of new woodlands within squares which already had female Bechstein's bat records. The woodlands selected were the next best fit woodland according to the model. The Bechstein's bats found as part of this survey are not therefore the first record of the species in these particular squares. They are however new records for the woodlands that they were discovered in. Hence these records provide important additional information about the local distribution of this species.

In terms of the organisation of surveys this group used a small selection of experienced members. Having the same individuals present on each survey provided consistency and ensured that the setup of equipment and the running of the survey were very efficient.

Worcestershire
Prior to the start of the Bechstein's Bat Survey, there were no records of breeding female Bechstein's bats in Worcestershire. The nearest records were located in Herefordshire where a colony is known to use a bat box scheme. It was originally suggested that surveys take place across Herefordshire and Worcestershire, but due to available time and volunteers it was decided to focus efforts in Worcestershire. Additionally this group had three co-ordinators, so that the workload could be shared.

The group surveyed 17 squares in which 96 bats of 8 species were recorded. The average catch rate for Worcestershire was 5.6 which is one of the highest catch rates seen across the groups that took part. Of the 96 bats caught, 8 Bechstein's bats were discovered at 4 sites, providing new information about the species in this area, which the group and landowners are now keen to follow up. In addition a further woodland was surveyed in square 3626 (not included in the main project analysis) in which a male and female barbastelle were caught.

Appendix 4 – Example data sheet



Bechstein's Bat Project Survey Data

hmiller: SU92 (grid ref) becomes 4912 using the Easting and Northing system

hmiller: SU92 (1st and 3rd digits) or SU 976 278

hmiller: Use 24 hour clock to record start and finish times

hmiller: The start and end times relate to the survey itself - and the turning on and off of the autobat

hmiller: Weather during daytime

hmiller: Ideally both sites would be surveyed simultaneously

hmiller: Site 1: An assessment of the survey site in which the equipment is set up.

hmiller: An assessment of the whole 25ha woodland you have chosen to survey

hmiller: Females: Pregnant, lactating, non-breeding. Males: Adult male, adult alpha male

hmiller: Only use to aid identification. Not necessary for each bat caught.

hmiller: Ref number - County code>square no.>date>bat number

hmiller: Use the dropdown for sex of species

hmiller: Use dropdown list - base decision on wing ossifications.

hmiller: Use the dropdown for species name

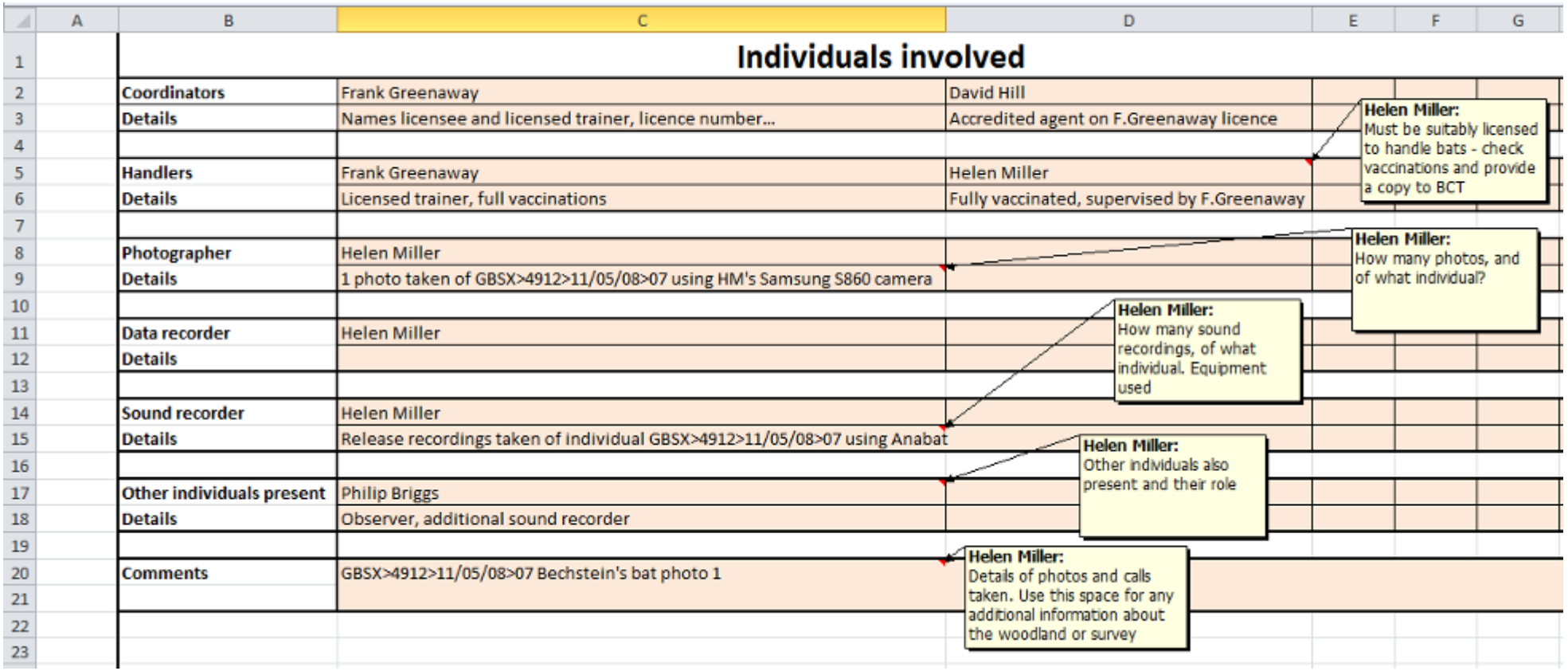
hmiller: Photograph all Bechstein's bats

Square no.	Wood name.	Grid Ref (given)	Elevation (M)	Aspect		
4912	Ebernoe	SU 976 278	75	South		
Date of.....	**Day visit**	**Night visit**	**Person(s) met**			
	03/01/2008	05/11/2008	Mr Tom Smith			
	GPS	**Nearest water (M)**	**Nearest edge (M)**	**Distance to car (M)**	**Survey start time (24hr)**	**End time (24 hr)**
Site one	4976312785	45	45	45	21:02	22:32
Site two	4976312785	45	45	45	21:02	22:32
Cloud cover	Clear (0-1/3)			**Site one (°C)**	**Site two (°C)**	
Wind	Calm	**Diurnal weather**	**Start temp**	15	15	
Rain	Dry	Warm & Sunny	**End temp**	15	15	

	% cover (canopy)	% cover (understorey	Dom. Spp. (canopy)	Dom. Spp. (understorey)	Management
Site 1	95	45	Oak	Hazel	None
Site 2	85	55	Oak	Hazel	None
Woodland	90	50	Oak	Hazel	None

Captures

Ref no.	Site (1 or 2)	Time	Species	Sex	Age class	Repro. State	Forearm L(mm)	Photo Y/N?
GBSX>4912>11/05/08>01	1	21:30	Whiskered	Female	Adult	Pregnant (female)		N
GBSX>4912>11/05/08>02	1	22:00	Whiskered	Male	Adult	Adult male		N
GBSX>4912>11/05/08>03	1	22:30	Natterer's	Male	Adult	Adult male		N
GBSX>4912>11/05/08>04	1	22:30	Natterer's	Male	Adult	Adult male		N
GBSX>4912>11/05/08>05	2	23:08	Soprano Pipistrelle	Female	Adult	Non-breeding (female)		N
GBSX>4912>11/05/08>06	2	23:08	Soprano Pipistrelle	Female	Adult	Pregnant (female)		N
GBSX>4912>11/05/08>07	2	00:15	Bechstein's		Adult	Pregnant (female)	38	Y



Individuals involved

Coordinators	Frank Greenaway	David Hill	
Details	Names licensee and licensed trainer, licence number...	Accredited agent on F.Greenaway licence	
Handlers	Frank Greenaway	Helen Miller	
Details	Licensed trainer, full vaccinations	Fully vaccinated, supervised by F.Greenaway	
Photographer	Helen Miller		
Details	1 photo taken of GBSX>4912>11/05/08>07 using HM's Samsung S860 camera		
Data recorder	Helen Miller		
Details			
Sound recorder	Helen Miller		
Details	Release recordings taken of individual GBSX>4912>11/05/08>07 using Anabat		
Other individuals present	Philip Briggs		
Details	Observer, additional sound recorder		
Comments	GBSX>4912>11/05/08>07 Bechstein's bat photo 1		

Helen Miller:
Must be suitably licensed to handle bats - check vaccinations and provide a copy to BCT

Helen Miller:
How many photos, and of what individual?

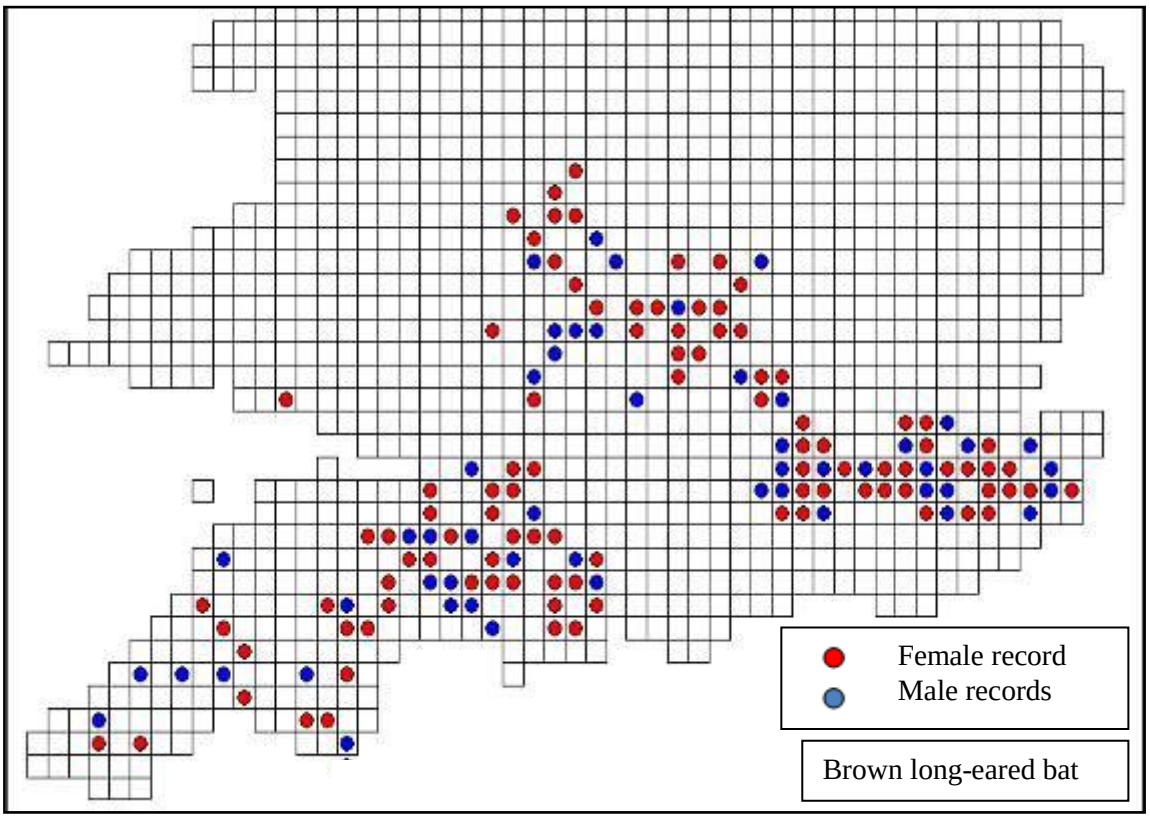
Helen Miller:
How many sound recordings, of what individual. Equipment used

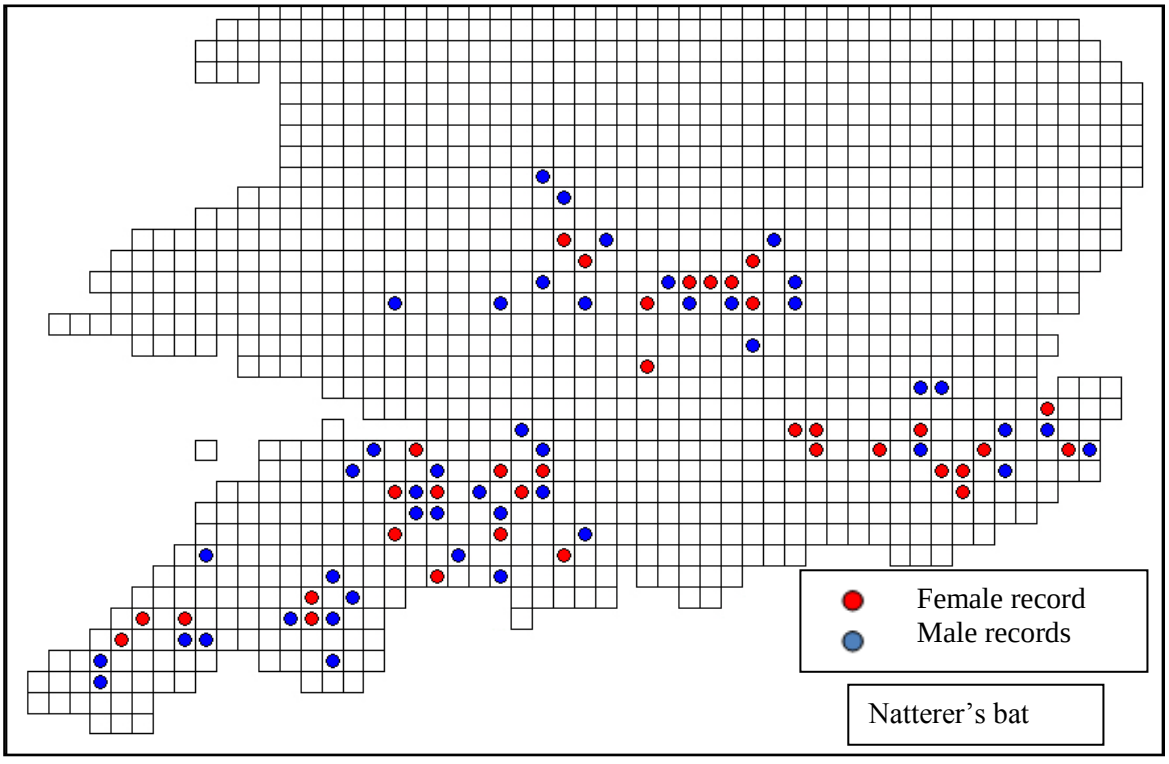
Helen Miller:
Other individuals also present and their role

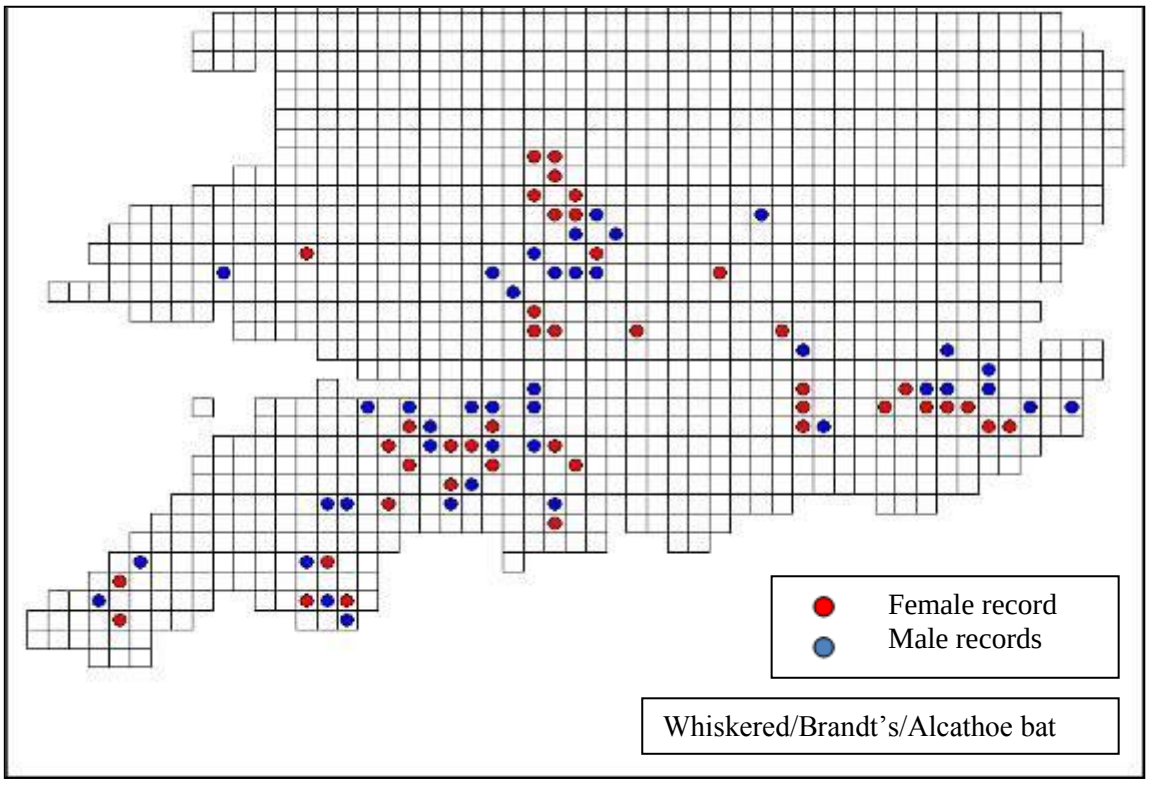
Helen Miller:
Details of photos and calls taken. Use this space for any additional information about the woodland or survey

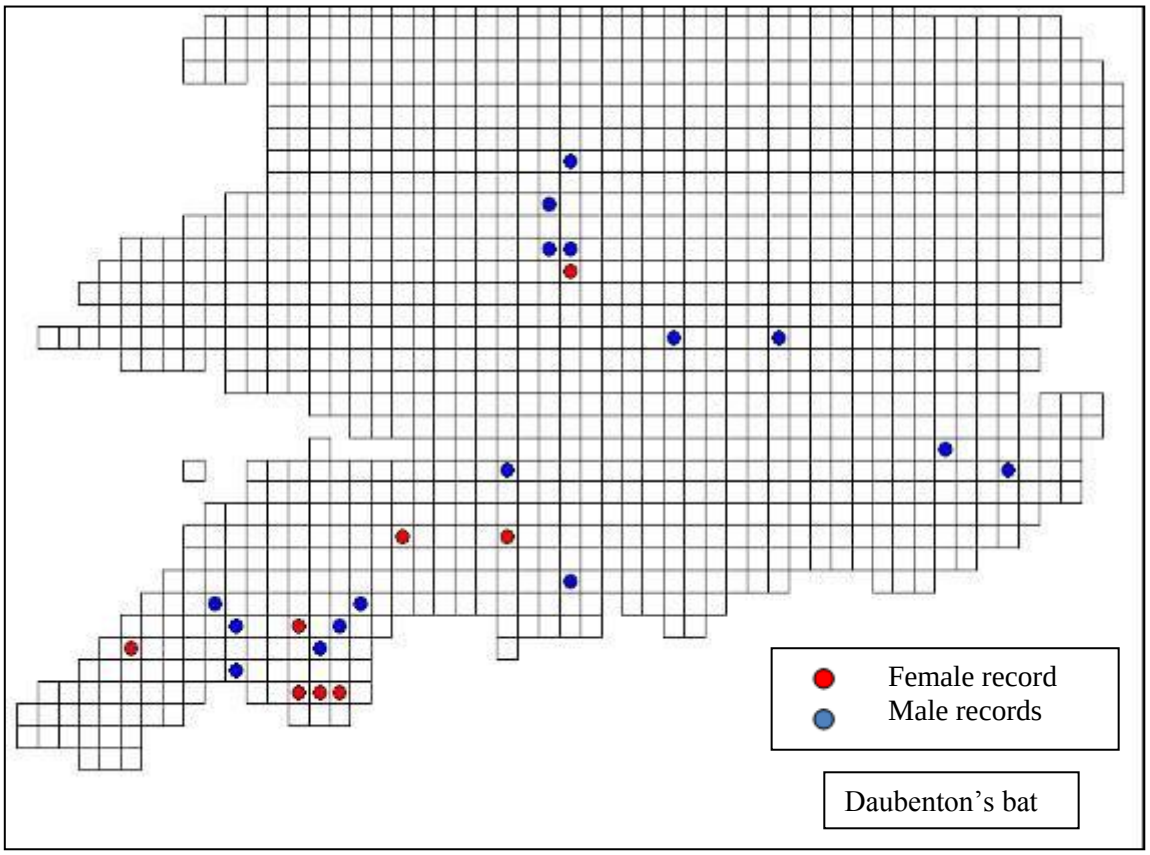
	A	B	C	D
1		**Woodland Details**		
2		**Woodland name**	Ebernoe Common	
3		**Landowner**	Sussex Wildlife Trust	
4		**Address details (of landowner)**	SWT	
5			Woods Mill	
6			Henfield	
7			West Sussex	
8			BN5 9SD	
9		**Happy with 10km resolution?**	Yes	
10		**Happy with 1km resolution?**	Yes	
11		**Previous species records for woodland**		
12		**Comments**		
13				
14				
15				
16				
17				
18				

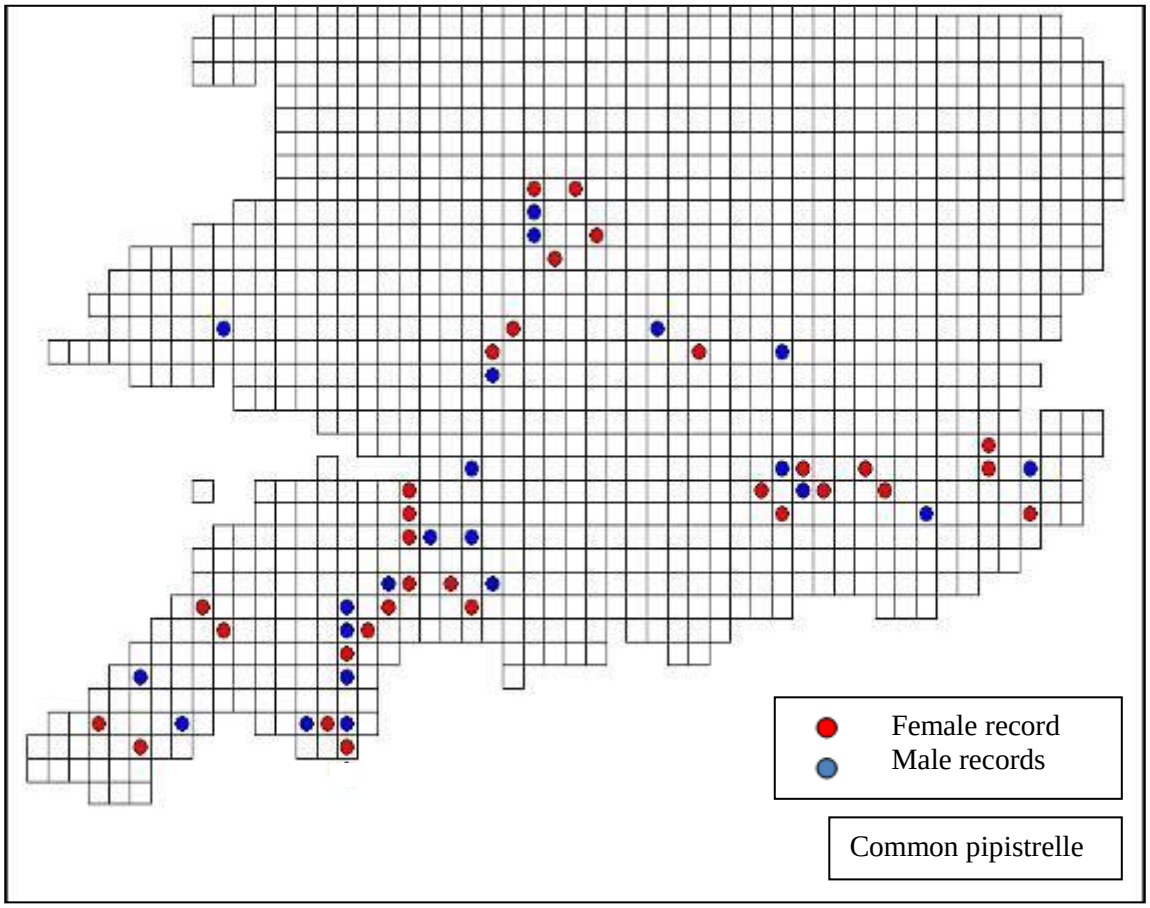
Appendix 5 – Species trapping locations

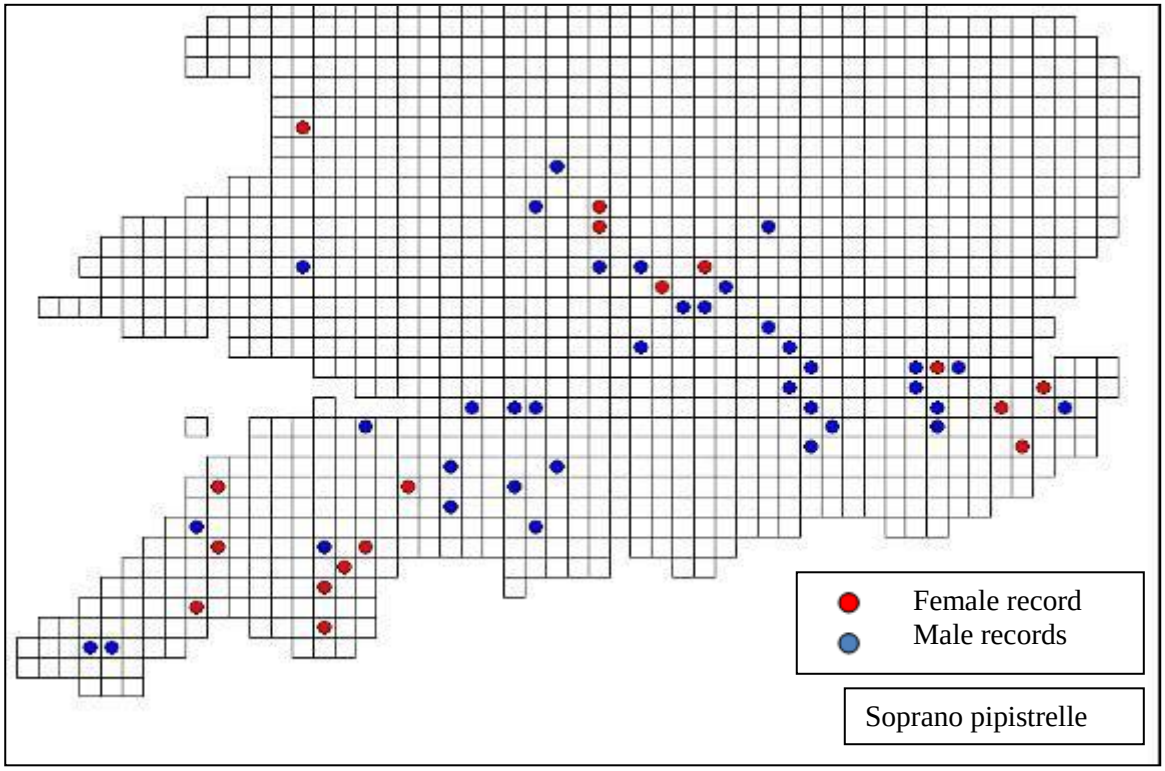


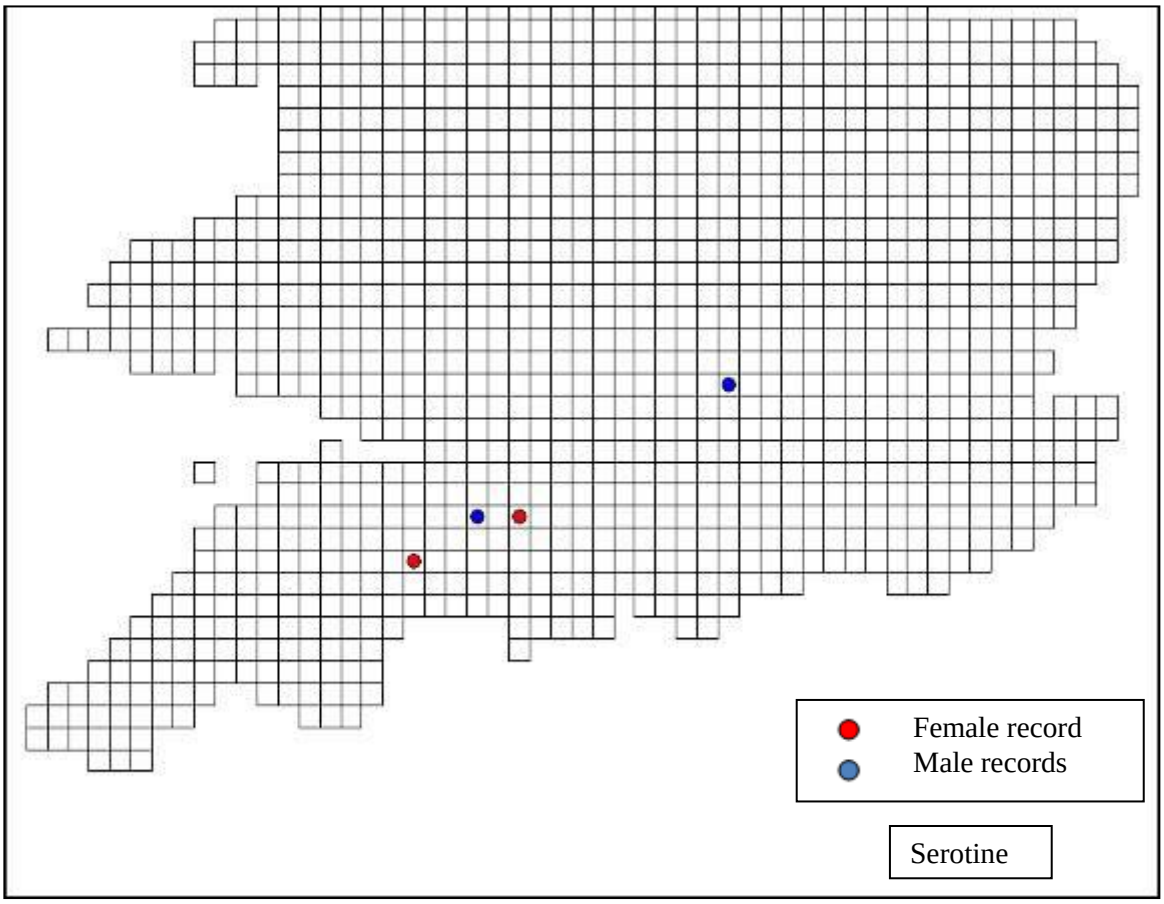


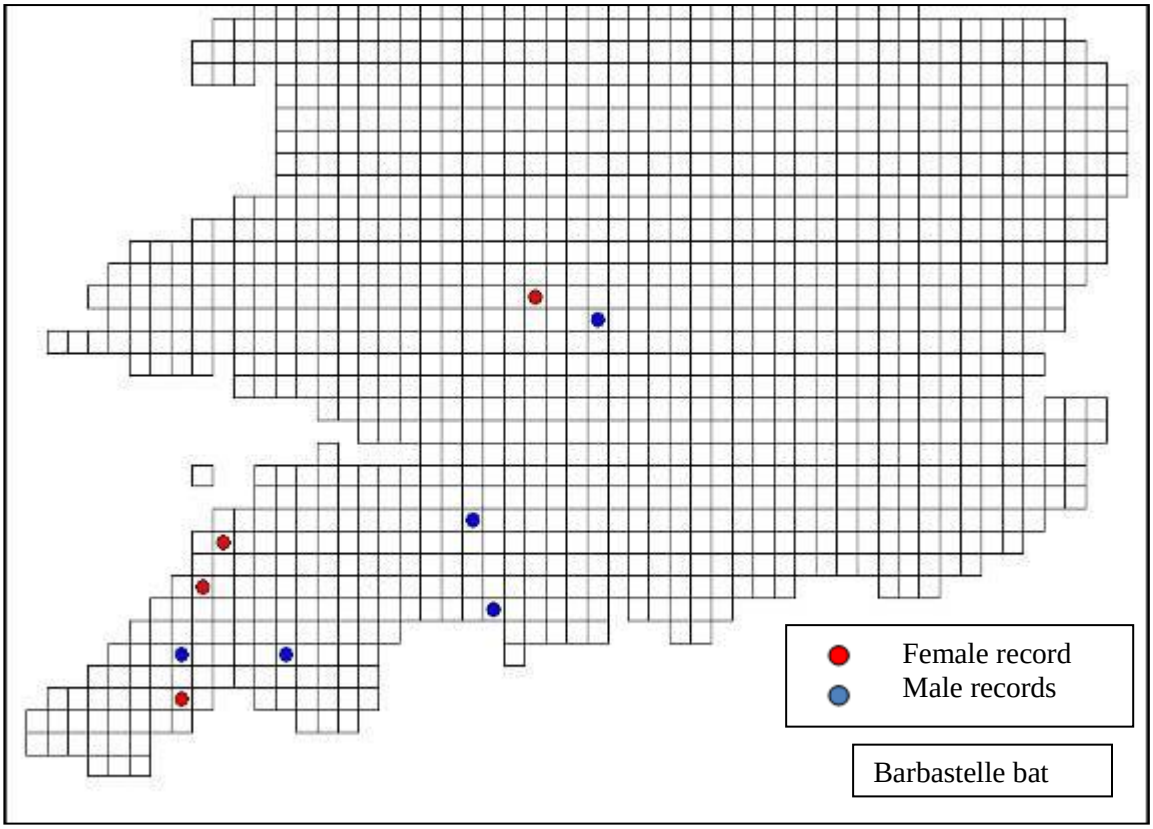

Female record
Male records
Whiskered/Brandt's/Alcathoe bat

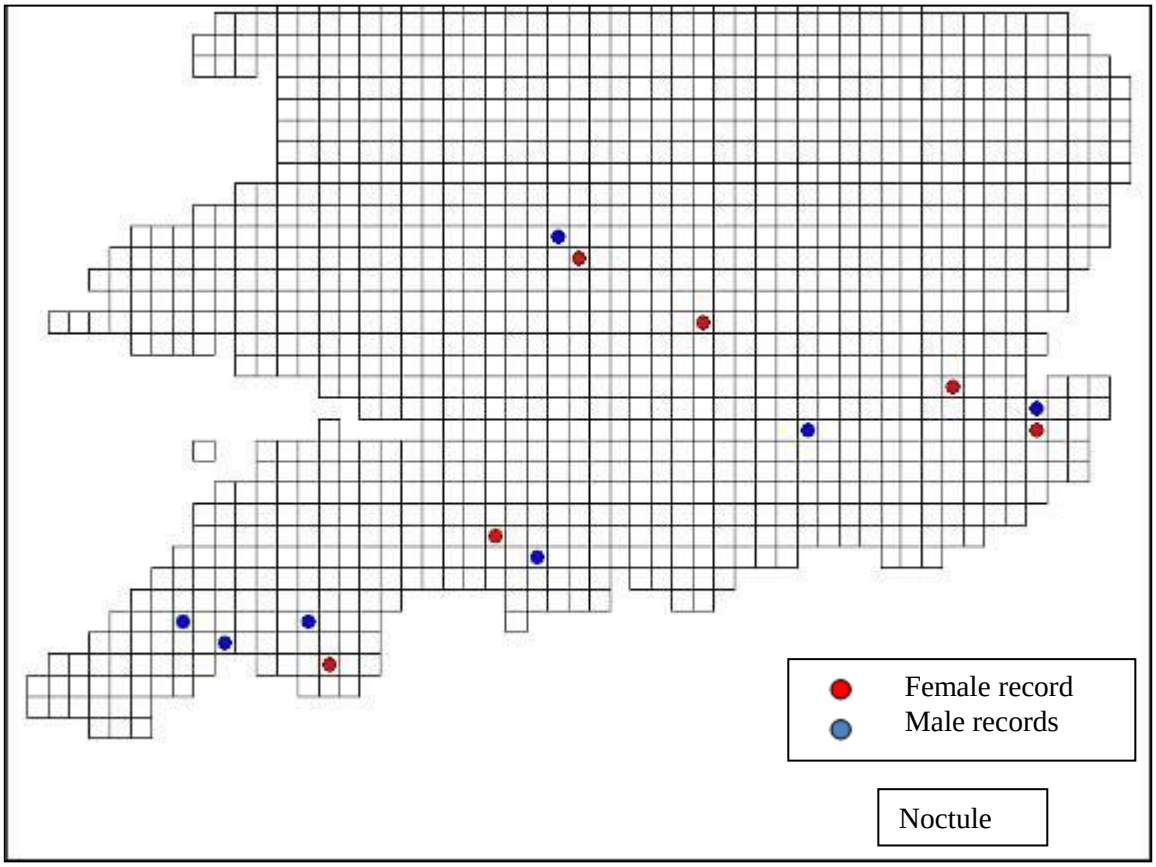

Female record
Male records
Daubenton's bat

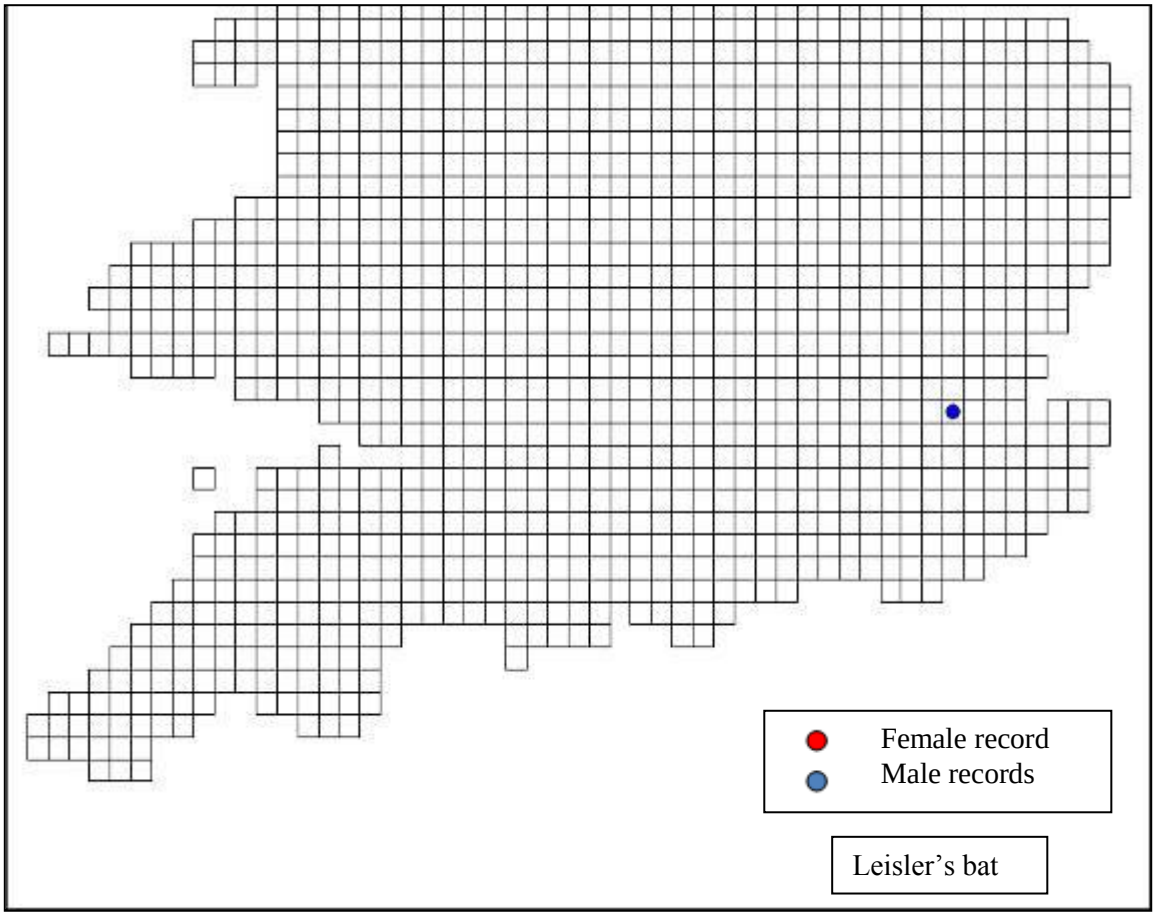

Female record
Male records
Common pipistrelle

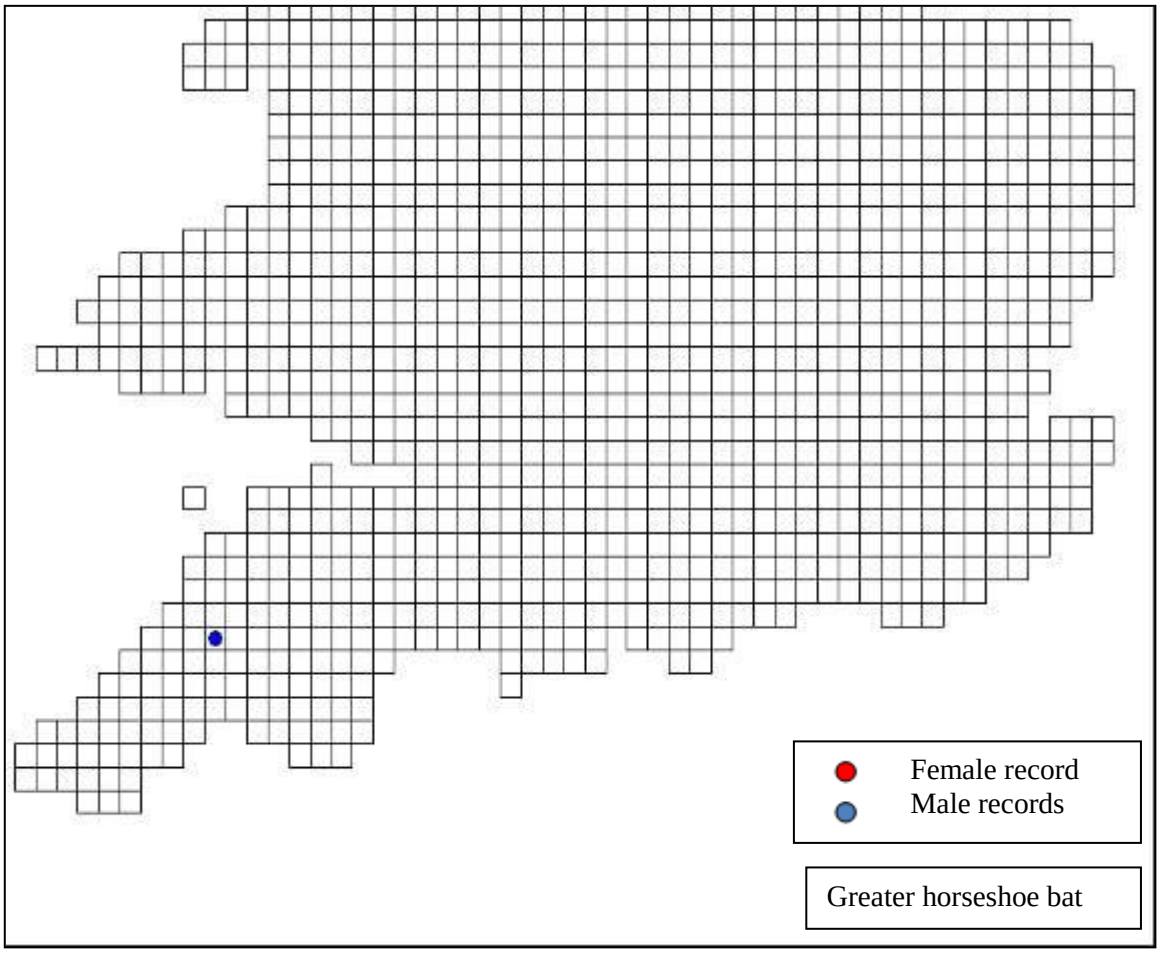

Female record
Male records
Soprano pipistrelle


Female record
Male records
Serotine

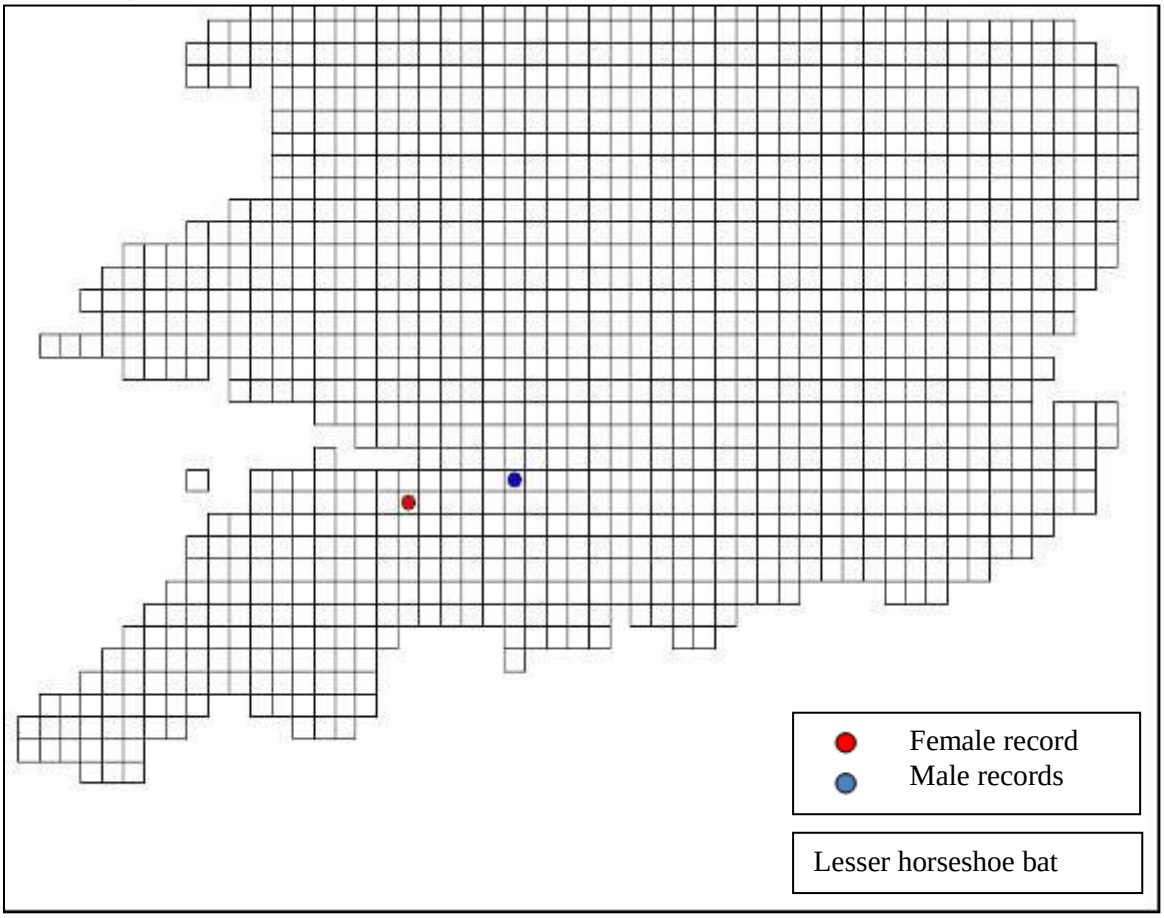

Female record
Male records
Barbastelle bat


Female record
Male records
Noctule


Female record
Male records
Leisler's bat



The greater horseshoe record was recorded during the 2008 surveys (not included in the main data set).



Appendix 6 – Statistical data

The significance of terms when added one at a time to the logistic GLMM

		Before fitting 40km square					After fitting 40km square			
Variable	**Variable explanation**	**F**	**df1**	**df2**	**P**		**F**	**df1**	**df2**	**P**
north	Northings	10.93	1	144	**0.001**		2.40	1	64	0.127
east	Eastings	10.32	1	204	**0.002**		0.92	1	70	0.341
dayno	Day number in the year	1.38	1	168	0.242		1.57	1	71	0.214
month	Month of survey	0.34	4	167	0.848		0.39	4	66	0.816
temp1	Start temperature	0.15	1	239	0.700		0.00	1	87	0.956
wind3	Wind	0.63	2	208	0.531		0.14	2	85	0.871
rain2	Rain	0.52	1	125	0.471		2.57	1	56	0.115
cloud	Cloud cover	1.71	2	161	0.184		0.74	2	66	0.483
distcar	Distance to the car	1.66	1	231	0.199		1.26	1	93	0.264
elevation	Elevation	2.30	1	193	0.131		1.69	1	87	0.197
ncanopy (n spp in canopy)	No. of species in the canopy	4.22	1	211	**0.041**		2.41	1	89	0.124
nunder (n spp in understorey)	No. of species in the understorey	5.67	1	339	**0.018**		1.44	1	95	0.233
nredge	Distance to nearest edge	4.30	1	299	**0.039**		0.40	1	133	0.528
nrwater	Distance to nearest water	8.99	1	309	**0.003**		6.30	1	153	**0.013**
logwater (log of nrwater)	Log-transformed distance to water	3.22	1	302	0.074		0.88	1	156	0.350
woodman	Woodland management	1.40	6	215	0.216		2.07	5	78	0.078
oak	Canopy species - oak	0.86	1	195	0.356		0.05	1	58	0.821
ash	Canopy species – ash	1.35	1	181	0.247		1.70	1	74	0.197
beech	Canopy species – beech	5.00	1	271	0.026		0.31	1	89	0.579
birch	Canopy species – birch	0.00	1	229	0.999		0.00	1	110	0.999
chestnut	Canopy species – chestnut	0.03	1	193	0.866		0.43	1	71	0.514
sweet	Canopy species – sweet	0.38	1	252	0.536		0.00	1	93	0.961
sycamore	Canopy species – sycamore	0.00	1	224	0.999		0.00	1	108	0.998
lime	Canopy species - lime	0.00	1	224	0.992		0.00	1	107	0.989
canpc[1] (from PCA of canopy spp)	pc1 for canopy spp	4.88	1	216	**0.028**		3.07	1	92	0.083
canpc[2]	pc2 for canopy spp	0.03	1	208	0.858		0.98	1	80	0.324
canpc[3]	pc3 for canopy spp	3.71	1	206	0.056		0.20	1	70	0.656
canpc[4]	pc4 for canopy spp	0.40	1	234	0.529		0.00	1	88	1.000
canpc[5]	pc5 for canopy spp	0.96	1	280	0.328		1.86	1	120	0.175
HAZEL	Understorey species - hazel	1.19	1	250	0.277		0.13	1	111	0.722

		Before fitting 40km square					After fitting 40km square			
Variable	**Variable explanation**	**F**	**df1**	**df2**	**P**		**F**	**df1**	**df2**	**P**
HOL	Understorey species - holly	0.80	1	206	0.371		0.83	1	79	0.365
HAWTHORN	Understorey species - hawthorn	4.05	1	191	**0.046**		1.68	1	74	0.198
SYC	Understorey species – sycamore	0.00	1	227	0.999		0.00	1	109	0.999
ASH	Understorey species – ash	0.30	1	246	0.585		0.36	1	96	0.548
BEECH	Understorey species – beech	0.00	1	225	0.999					
BIRCH	Understorey species – birch	0.00	1	226	0.999		0.00	1	108	0.999
BLACKTHORN	Understorey species – blackthorn	0.00	1	224	0.999		0.00	1	107	0.999
ELDER	Understorey species – elder	0.00	1	224	0.999		0.00	1	107	0.990
HORNBEAM	Understorey species – hornbeam	0.67	1	283	0.414		0.14	1	139	0.710
LAUREL	Understorey species – laurel	0.89	1	99	0.348		0.19	1	44	0.665
MAPLE	Understorey species – maple	0.00	1	225	0.999		0.00	1	108	0.999
ROWAN	Understorey species – rowan	0.00	1	224	0.999		0.00	1	107	0.997
SWEET	Understorey species – sweet chestnut	0.00	1	226	0.999		0.00	1	107	0.998
OAK	Understorey species - oak	3.92	1	77	0.051		0.00	1	108	0.999
undpc[1] (	pc1 for understorey spp	3.13	1	339	0.078		0.93	1	94	0.337
undpc[2]	pc2 for understorey spp	1.74	1	263	0.188		0.12	1	102	0.733
undpc[3]	pc3 for understorey spp	0.75	1	205	0.386		1.94	1	101	0.167
undpc[4]	pc4 for understorey spp	0.74	1	203	0.389		3.30	1	95	0.072
undpc[5]	pc5 for understorey spp	1.76	1	272	0.186		1.92	1	134	0.168
growday	Growing days from met data	3.72	1	176	0.055		1.10	1	79	0.298
dryday	Consecutive dry days from met data	16.00	1	129	<**0.001**		2.37	1	75	0.128
arable	% arable in 3x3km square	0.09	1	166	0.761		0.56	1	66	0.458
broadleaf	% broadleaf in 3x3km square	0.01	1	148	0.939		0.02	1	65	0.899
built	% built in 3x3km square	0.35	1	146	0.552		0.13	1	50	0.718
coastal	% coastal habitat in 3x3km square	1.06	1	117	0.306		0.08	1	57	0.772
conifer	% coniferous wood	0.06	1	307	0.813		0.00	1	94	0.969

		Before fitting 40km square					After fitting 40km square			
Variable	**Variable explanation**	**F**	**df1**	**df2**	**P**		**F**	**df1**	**df2**	**P**
	in 3x3km square									
impgrass	% improved grass in 3x3km square	0.01	1	151	0.911		0.41	1	52	0.524
openwater	% open water in 3x3km square	0.00	1	178	0.992		0.33	1	70	0.566
seaunclass	% sea or unclassified in 3x3km square	0.00	1	159	0.956		0.96	1	77	0.331
seminatural	% seminatural grass in 3x3km square	1.73	1	240	0.190		0.19	1	71	0.664
upland	% bog, heath and mountain in 3x3km square	0.61	1	186	0.438		0.27	1	66	0.606

Notes: arable-upland is the average proportion of the habitat in a 3km square block centred on the wood. Based on 1km resolution data from CS2000.
All models contain understory cover for the wood.

Appendix 7 – 2008 survey results

47 target woodlands were surveyed in 45 10km squares over 49 nights. All surveys took place between 30 May and 11 September 2008 in Carmarthenshire, Cornwall, Surrey, Swansea, and Oxfordshire.

Bechstein's bat captures

3 Bechstein's bats were found during the survey, all of which (2 males and 1 female) were recorded in Surrey. Bechstein's bats were recorded in 4% of target woodlands.

A male and a female Bechstein's bat were found during the first survey undertaken in Surrey, in early June (both were new records for that woodland). The third Bechstein's (male), caught during an August survey was a new record for that 10km square.

Species recorded

In total, 139 bats of 11 species were captured, with 1 or more bats being caught in 40 of the 47 woodlands surveyed. Table 1 shows the species caught during the project. Brown long-eared bat was the most frequently recorded species at 38.8% of all individuals caught. This was followed by soprano and common pipistrelles at 17.3% and 12.9% respectively. With a similar percentage to the common pipistrelle, Natterer's bat was the fourth commonest with a 12.2% share.

Table 1 – Number and percentage of species caught over duration of survey

Species	Individuals caught per spp.	% of all captured
Brown long-eared bat	54	38.8
Soprano pipistrelle	24	17.3
Common pipistrelle	18	12.9
Natterer's bat	17	12.2
Whiskered bat	9	6.5
Daubenton's bat	6	4.3
Brandt's bat	3	2.2
Bechstein's bat	3	2.2
Noctule	2	1.4
Whiskered/Brandt's bat	1	0.7
Greater horseshoe bat	1	0.7
Barbastelle	1	0.7
Total	**139**	

A similar result was observed when analysing the number of target woodlands in which each species was recorded (Table 2). As expected brown long-eared bats featured heavily – found in 57% of target woodlands. The top four species are consistent with that shown in Table 1.

Table 2 – Target woods in which species were found

Species	No. woods found in	% of target woods.
Brown long-eared bat	27	57
Common pipistrelle	14	30
Natterer's bat	13	28
Soprano pipistrelle	13	28
Whiskered bat	6	13
Daubenton's bat	5	11
Brandt's bat	3	6
Bechstein's bat	2	4
Noctule	2	4
Whiskered/Brandt's bat	1	2
Greater horseshoe bat	1	2
Barbastelle	1	2

Male to female ratio

Combining the data from all four survey groups, males were caught more frequently than females during the project with a 79:57 ratio (in 3 individuals caught the sex was not recorded).

When analysing the male to female ratio of each species, males were caught more frequently in 8 of the species recorded as shown in Table 3. Brown long-eared bat was the exception; this species showed a closer male to female ratio – 24 males to 28 females (sex was not recorded in 2 individuals). In the remaining 2 species (barbastelle and greater horseshoe) only 1 individual of each species was recorded.

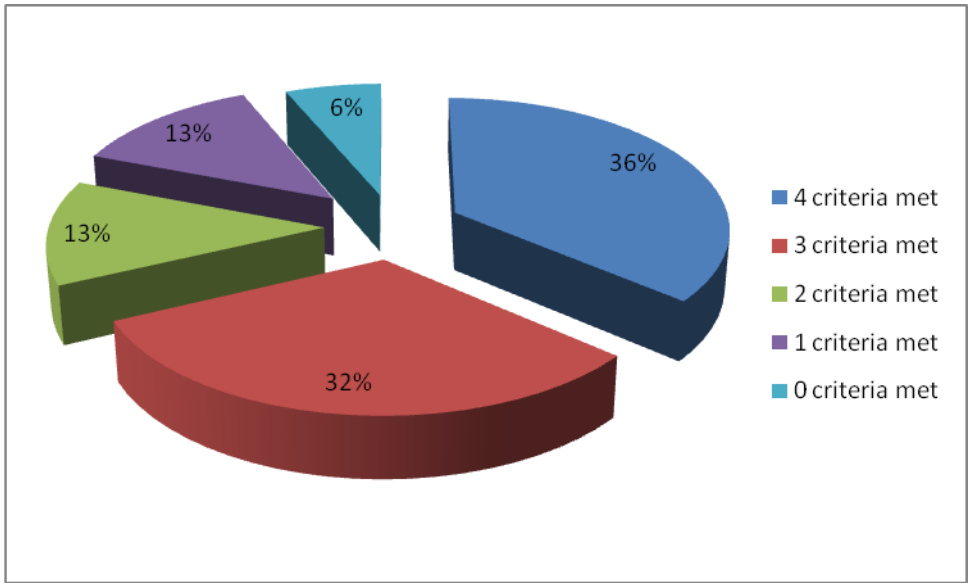
Table 3 Male to female ratio of species caught

Species	M:F
Brown long-eared bat	24:28 (2 not recorded)
Common pipistrelle	10:7 (1 not recorded)
Natterer's bat	10:7
Soprano pipistrelle	18:6
Whiskered bat	5:4
Daubenton's bat	5:1
Brandt's bat	2:1
Bechstein's bat	2:1
Noctule	2:0
Barbastelle	0:1
Greater horseshoe bat	1:0
Whiskered/Brandt's bat	0:1

Woodland selection

68% of woodlands surveyed matched either 3 or 4 of the criteria (as seen in figure 1). All woodlands selected were the "best fit" woodland in a 10km square (assuming landowner permission was granted). Data was also collected on other aspects of the woodlands such as the proximity to water, the level of management, and environmental conditions on the survey night, all of which may affect the results obtained to some degree.

Figure 1 – Percentage of target woodlands matching criteria



Volunteer survey effort

Table 4 provides an overview of the results obtained by each group.

Table 4 – Summary data results for 2008 groups

Area	No. squares surveyed	Squares with female Bechstein's	No. spp. caught	No. individuals caught
Cornwall	13	0	10	51
Oxfordshire	12	0	6	29
Surrey	14	1	7	49
S. Wales	6	0	5	10

BBC Wildlife Fund

Cyngor Cefn Gwlad Cymru
Countryside Council for Wales

Forestry Commission

Forestry Commission
England

Comisiwn Coedwigaeth Cymru
Forestry Commission Wales

people's trust for
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mammals

The Scottish Forestry Trust

WREN waste recycling environmental
Funding the future with Waste Recycling Group's Landfill Tax Credits

The Bat Conservation Trust

Bat Helpline: 0845 1300 228 www.bats.org.uk

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Bat Conservation Trust