Norwich Western Link

Environmental Statement Chapter 11: Bats Appendix 1: 2019 Radio Tracking Survey Report Part 1 of 4

Author: WSP

Document Reference: 3.11.01

Version Number: 00

Date: March 2024

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1 Introduction

1.1.1 This interim report details the survey methods and results of bat trapping and radio-tracking surveys completed in 2019. These surveys were part of a suite of bat surveys conducted with the aim of understanding bat roosting and activity in the local area, and therefore this report should be read in conjunction with the 2019 Interim Bat Survey Report, which provides a detailed background to the scheme (WSP UK Ltd, 2020). This is an interim report and further surveys will be undertaken in 2020 to ensure a comprehensive and robust baseline to inform the Scheme.

1.1.2 We have included a summary of key information shown in this document in an accessible format. However, some users may not be able to access all technical details. If you require this document in a more accessible format please contact norwichwesternlink@norfolk.gov.uk.

Norfolk County Council

APPENDIX F – BAT SURVEY REPORT – 2019

Bat Trapping and Radio-Tracking

[Appendix F of the 2019 Interim Bat Survey Report]

70061370-09-01-F
APRIL 2020

Norfolk County Council

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Bat Trapping and Radio-Tracking

TYPE OF DOCUMENT (VERSION) CONFIDENTIAL

PROJECT NO. 70061370

OUR REF. NO. 70061370-09-01-F

DATE: APRIL 2020

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QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2
Remarks	-		
Date	28/02/2020		
Prepared by	IDW		
Checked by	UKHXB019		
Authorised by	UKARH003		
Project number	70061370		
Report number	70061370-09-01		

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1. INTRODUCTION

1.1. ECOLOGICAL BACKGROUND

1.1.1. The Norwich Western Link (NWL) is a highway scheme linking the A1270 Broadland Northway from its junction with the A1067 Fakenham Road to the A47 trunk road near Honingham. This will hereafter be referred to as 'the Scheme'.

1.1.2. The local area supports habitats considered to be of high suitability for bats (Collins, 2016). These comprised of continuous high-quality habitat that is well connected to the wider landscape by features such as the River Wensum, areas of semi-natural woodland, plantation woodland, floodplain, grazing marsh and extensive mature hedgerows and veteran trees. The rare woodland bat species barbastelle *Barbastella barbastellus* are known to be present in the local area, as highlighted by ecological surveying and reports produced in relation to the Norwich Northern Distributor Road (NDR), now known as the A1270 Broadland Northway.

1.1.3. This interim report details the survey methods and results of bat trapping and radio-tracking surveys completed in 2019. These surveys were part of a suite of bat surveys conducted with the aim of understanding bat roosting and activity in the local area, and therefore this report should be read in conjunction with the 2019 Interim Bat Survey Report, which provides a detailed background to the scheme (WSP UK Ltd, 2020). This is an interim report and further surveys will be undertaken in 2020 to ensure a comprehensive and robust baseline to inform the Scheme.

1.2. BRIEF AND OBJECTIVES

SURVEY OBJECTIVES

1.2.1. Davidson-Watts Ecology Ltd were commissioned in 2019 to complete advanced bat surveys (trapping and radio-tracking) to achieve the following objectives:

- Complete a desk-study for existing knowledge of barbastelle roosts and presence within the local area;
- Investigate the current local presence of barbastelle and other tree-roosting bats (e.g. *Myotis* species and possibly *Nyctalus* species), with an emphasis on woodland habitat and tree-lines during the early maternity period[1] (May 2019[2]);
- Identify any barbastelle maternity colonies within the survey area, and determine the activity patterns of this species and core habitat use. This survey objective was also extended to secondary target species (e.g. *Myotis* and *Nyctalus* spp.)
- Radio-track key individuals using the survey area to locate breeding colonies of barbastelle and as a secondary objective, other tree-roosting bats and to determine activity patterns and habitat use;

[1] Maternity roosts are defined by Natural England as where female bats give birth and raise their young to independence. Movement between roost by tree roosting species is often frequent, and the same tree roost can be used on a number of occasions throughout the breeding season (May-August) and therefore all roost sites containing pregnant females during this survey were considered potential maternity roosts.

[2] Due to a range of land access related issues and licensing conflicts with another project, this report only presents data from May 2019.

- Determine the Core Sustenance Zones (CSZs) and home ranges of radio-tracked bats.

1.2.2. The methods and results of these surveys are included within this report, along with details of further work to be completed.

SURVEY AREAS

1.2.3. The bat-trapping and radio-tracking surveys reported here focussed on habitats with the potential to be impacted by the Scheme (at the time of survey, route options B east, B west, C, D east and D west were still under consideration, as detailed in the main bat survey report (WSP UK Ltd, 2020)), as well as known barbastelle roosts present within 2km of these five route options (known from previous surveys). Radio-tracking surveys tracked bats within approximately 2km of the five route options, an area hereafter referred to as the 'Survey Area'.[3]

[3] The preferred route announcement in July 2019 confirmed that the Scheme would follow Route C. The exact alignment of this preferred route underwent a number of revisions and the current preferred route was confirmed in December 2019, and detailed in the main bat report (WSP UK Ltd, 2020).

2. METHODS

2.1. OVERVIEW

2.1.1. Investigating the habitat use and roost locations of barbastelle and tree-roosting bats is considered highly challenging, due to their frequent roost movements, flight behaviour and in the case of barbastelle bats specifically, large home ranges (Zeale, et al., 2012). Therefore, the approach of trapping bats and attaching radio-transmitting tags (radio-tags) from which individual bats could be tracked using receivers (radio-tracking), was the primary approach to achieving the survey objectives.

2.1.2. One survey session of approximately three weeks duration was undertaken in late May/early June 2019. The survey session included the trapping of bats at pre-determined locations, predominantly in woodland/tree-dominated habitats within the survey areas.

2.1.3. Further survey sessions were originally planned for mid-summer 2019, however due to concerns of overlap with other local barbastelle bat tracking projects, the necessary licence was not issued by Natural England. These surveys are currently planned for July 2020.

2.1.4. In accordance with the conditions of Natural England licence 2019-39626-SCI-SCI and project objectives, target bat species were radio-tagged. The primary species of interest for tagging and radio-tracking was barbastelle, with secondary priority species including bats from the genus *Myotis* and *Nyctalus*. As stated in the licence, a maximum of 15 bats (of any species) would be radio-tagged.

2.1.5. Radio-tagged bats were simultaneously or subsequently followed by radio-tracking teams during the survey session to locate and identify roost sites and to examine nocturnal flying activity of the tagged bats, with a focus on collecting activity data for bats within the survey area and other key areas considered potentially important to barbastelle bat population(s).

2.1.6. Where access was possible to roost sites, emergence counts were undertaken at identified roosts to determine the status/function of the roost.

2.1.7. The following methods were undertaken with reference to Chapter 9 (Advanced licensed bat survey methods) of the Bat Conservation Trust Good Practice Guidelines (Collins, 2016).

2.2. DESK-STUDY

2.2.1. A review of bat radiotracking surveys completed in 2018 in the local area to inform the A1270 Broadland Northway (Wild Wings Ecology Ltd, 2019) was undertaken in order to inform the current survey.

2.3. TRAPPING AND RADIO-TAGGING METHODS

2.3.1. Bat trapping took place at nine locations (as detailed in Figure 1) between the dates 19th May – 30th May 2019. When choosing trapping locations, the following factors were considered in order to maximise barbastelle captures and to gather information relevant to the Scheme:

- **Suitability of the habitat feature for barbastelle** – woodland rides, woodland edges and tree-lines made up the majority of trapping locations;

- **Potential impact of the Scheme on the habitat feature** – most of the habitat features surveyed were due to be impacted by the Scheme, or were connected to habitats due to be impacted by the Scheme;
- **Proximity of the habitat feature to known barbastelle roosts** – trapping locations were concentrated around known barbastelle roosts (Wild Wings Ecology Ltd, 2019), to maximise barbastelle captures.

2.3.2. Bats were caught using six bat traps per trapping night (on some trapping nights two trapping locations were surveyed, and therefore the six traps were split between two locations), consisting of a combination of the following two types of bat traps:

- Harp-traps: 4m^2 harp traps or 6-12 m mist nets, placed in woodland/parkland habitats within the zone of influence of the Scheme. A harp trap consists of a bank of vertical fine nylon filaments tightly strung to a rectangular frame of aluminium pole further supported by aluminium pole legs. The trap safely catches bats in flight, and they safely fall into a large cotton bag affixed to the trap where they can be removed by hand.
- Mist-nets: two aluminium poles approximately 3-4 m in height, erected with 6 – 12 m lengths of fine netting between them. The nets safely catch bats in flight and entangles them until they are removed by hand.

2.3.3. Each trap was supplemented with a Sussex Autobat acoustic lure, implemented to improve the efficiency of the traps (Hill & Greenaway, 2005). These were placed next to / under the bat traps, and emitted synthesised bat social calls, including some which were based on barbastelle social calls, and social calls based on other European bat species (Hill, 2001-2018)

2.3.4. Any bats captured were removed by an ecologist with at least a Natural England Level 2 bat licence. Each trapping location was supervised by an ecologist with a Level 3 and 4 bat licence, working as a named ecologist under the Natural England project licence.

2.3.5. Once removed from the traps, each bat was transferred to an individual clean cloth bag. The bats were identified to species (where possible), and sex, age and breeding status were determined. Female bats were selected for radio-tracking in preference to male bats, as tracking females enables the identification of maternity roosts which are of higher conservation significance that other roost types. Bats which were heavily pregnant or not of sufficient condition were not selected for radio-tracking.

2.3.6. Captured bats of the target species were fitted with lightweight radio-tags[4] weighing no more than 5% of the weight of the bat. Tags were adhered to an area of shaved fur between the bats shoulder-blades using Torbot/Permabond contact adhesive. Bats were processed quickly, and non-target bats were released within 30 minutes, at the site of capture. Tagged bats were released at the site of capture once the glue attaching the transmitter had cured.

2.3.7. Trapping teams monitored trap sites with handheld bat detectors[5] during the trapping survey, in order to assess bat activity in the vicinity of the traps.

[4] BD – 2 x 0.39g or BD – 2 x 0.31 g tags, Holohil Systems, Ontario, Canada

[5] Pettersson 240x or Elekon Batlogger M

2.4. TRACKING METHODS

2.4.1. All radio-tagged bats were tracked using a Sika receiver[6] and a 3-element Yagi antenna[7]. Tracking teams tracked bats using a combination of vehicle-mounted antennae and on foot, depending on the movements of the bats.

2.4.2. Once fitted with a radio-tag, bats of all species were followed from dusk until dawn post-capture for a period of ten nights over two weeks. Positions of tagged bats were pinpointed at regular intervals throughout the night depending on whether the tracker was in contact with the bat. Tracking aimed to record positional fixes that enabled determination of home ranges and core areas of activity, and when in contact with a tagged bat, position fixes were recorded every ten minutes.

2.4.3. Bats were tracked using two methods as outlined below:

- **The 'homing-in' / 'close approach' method** (White & Garrott, 1990). This required the radio-tracking team to follow an individual bat on foot or by vehicle while making observations of its behaviour and use of habitat when close contact with the bat is maintained. A bat's position was estimated by close approach wherever possible, however when access was not possible, the triangulation method was used.
- **The triangulation method** (Kenward, 2000). This required a minimum of two radio-tracking teams in different locations taking simultaneous bearings ('paired bearings') at regular intervals from the direction of the strongest signal of the bat. Notes were made of the compass bearing of the direction of the strongest signal in order to identify the location of each bat at a given time (termed as a fix). The point where the two separate teams' bearings cross determined the location of the fix.

2.4.4. The following information was recorded during each bat recording taken, and each observation made during the radio-tracking survey:

- Time;
- Compass bearing;
- GPS coordinates;
- Description of bat behaviour (where appropriate);
- Weather conditions.

2.4.5. After a position fix was established for a bat, the surveyors searched for another target bat or stayed in contact with the same bat they were following depending on the locations of other bats, repeating the same method in turn for all bats with active transmitters continually until dawn. This approach generally enabled fixes to be made every 10 – 45 minutes for each bat depending on the location of the bats in relation to each other i.e. the closer the bats were to each other the more regular the position fixes.

2.4.6. This method allowed for fixes to be independent of each other to avoid auto-correlation effects. However, in some cases, systematic and regular time intervals for recording the position of tagged bats was not achieved, for the following reasons:

[6] Biotrack Ltd., Wareham, United Kingdom

[7] Biotrack Ltd/Sirtrack

- There were often periods of time that a tagged bat's position remained unrecorded whilst the tracking team searched for the target bat. This was particularly the case where the tagged bats left the main survey area;
- Further, in some cases individual bats were prioritised for tracking where less tracking data had been obtained and their movements were within the survey area, or where transmitter batteries were expected to fail earlier.

2.4.7. The number of nights for which each bat was radio-tracked is shown in Table 3-3.

2.4.8. Where *Myotis / Nyctalus* species were tagged for roost location purposes, individual bats were released on the night of capture and daytime roost searches were undertaken the following day.

2.5. HOME-RANGE ANALYSIS

2.5.1. A home range is the area in which an animal lives and moves on a periodic basis and is the region that contains all the resources the animal requires to survive and reproduce. The identification of core areas is important as it shows where bats are spending most of their time.

2.5.2. Fixes of the locations of each bat, capture locations, roost locations and the night-time tracking surveys for each individual bat were plotted in the field on digital 1:25,000 scale were plotted in the field on digitised 1:25,000 scale OSGB Maps mobile[8]. All the fixes were pooled for each bat and subsequently transferred into Ranges 9 radio tracking software[9].

2.5.3. Accuracy of locations was considered to be +/-100 m. This was based on observer experience, knowledge of the area and the combined use of close approach and triangulation, rather than triangulation alone. Therefore, for analysis of home ranges in Ranges 9, a tracking resolution of 100 m was applied to take account of accuracy issues associated with triangulation at distance.

MINIMUM CONVEX POLYGONS

2.5.4. The digitised radio-tracking data was analysed in Ranges 9 to calculate home range areas, which are also known as 100% Minimum Convex Polygons (MCPs), and core activity areas using objective core analysis (Kenward, et al., 2001). MCP mapping creates a polygon based on the outside of all the fixes associated with a tagged bat. The MCP technique of determining home range was used as it is considered relatively unaffected by the effects of autocorrelation (Harris, et al., 1990). However, this method does overestimate home range and often includes large areas that the tagged bat flew through to get to possible foraging or roosting areas. This method does not provide information about how an animal uses its home range.

CORE AREAS

2.5.5. Cluster polygons (Kenward R., 2000) were considered the most appropriate minimum-linkage estimators to define the areas bats were spending most of the time (the core areas). This is because the barbastelle bats spent most of their time in relatively small areas compared to their full home range (the MCP), moving quickly between them. The fragmented cluster polygons show where bats were highly active (e.g. foraging/social activity) or night roosting/returning to roosts, rather than the area travelled through to get to such areas.

[8] MemoryMap, View Ranger Applications on smart phones or tablets

[9] Anatrack Ltd, Wareham, UK

OBJECTIVE CORE ANALYSIS

2.5.6. For the estimation of cluster polygons, also referred to as core areas, 'objective core analysis' was the chosen method. This approach is scientifically rigorous as it calculates core areas from the distribution of the bats' locations themselves rather than manual determination of what percentage of fixes should be excluded from the analysis, usually from assessment of utilisation distributions continuities (a manual method of excluding outlying locations). The objective core analysis method (Kenward, et al., 2014) uses the distribution of nearest-neighbour distances detecting and excluding outlying locations (Kenward, et al., 2001) resulting in an objective core.

2.5.7. Use of objective core analysis was especially relevant to this survey as it was considered that all estimated bat fixes should be used to determine overall activity patterns, and would provide a more conservative method, smoothing any accuracy issues with the collection of fixes. The limitation of objective coring is that the process sometimes estimates core areas larger than those from an equivalent number of locations compared to more manual methods.

2.1. ROOST EMERGENCE

2.1.1. When tagged bats were tracked to roost sites, subsequent roost exit counts were undertaken where access to the roost location was permitted. Every effort was made to pinpoint the exact location of roosts, however access to private land where roosts occurred was not always possible, which limited the level of information we could obtain on the overall population size. Emergence counts were prioritised for newly located roosts over known roosts, due to the transitionary nature of barbastelle roosts.

2.1.2. The emergence surveys followed a standard methodology (Collins, 2016). The surveyors were in position adjacent to the tree where it was considered the tagged bat was roosting half an hour before sunset (positioned so that all possible roost features were visible) and remained in position until it was considered that all bats had emerged. Bats were counted as they emerged.

2.1.3. All roost emergence surveys were supported by infrared cameras (Canon XA10/XA25) with infrared illuminators to determine the numbers of bats emerging to assist with making roost characterisation assessment.

2.1.4. Roost attributes such as location, type of structure and other descriptors were recorded where trees were accessible.

2.1. LICENSING

2.1.1. All trapping, radio-tagging and radio-tracking activities were undertaken under a project licence from Natural England. The licence number was 2019-39626-SCI-SCI. The licence was obtained by an ecologist with 26 years bat survey experience, who also designed and coordinated the field surveys and undertook the analysis of the results and evaluation. Field surveys were led by experienced bat ecologists, all named persons on the project licence, and all with over 15 years bat survey experience and holding their own Class 3 or 4 licences. The radio-tracking was completed by a team of ecologists with radio-tracking experience.

2.2. ADJUSTMENTS AND LIMITATIONS

2.2.1. All bat species (but barbastelle in particular) are highly mobile and use a variety of roosts, commuting routes and foraging areas during their yearly life-cycle. This is influenced by a range of factors such as breeding status, climate, energetic requirements and the availability of prey (Zeale,

2011). The survey techniques described in this report involve a sampling effort that is considered appropriate for obtaining information on the location of roosts and core activity areas potentially affected by the Scheme during May 2019, while ensuring that local bat populations are not disturbed adversely by the survey method itself. The methods used here do not provide a full account of all bat activity in the area or activity at other times of the year outside of the survey periods (i.e. outside the early breeding period) which are focussed on identifying early-forming maternity populations. However, the results of the surveys reported here, in combination with the findings of past and future bat surveys conducted to inform the Scheme, will provide a robust understanding of the use of the survey area by bat species.

2.2.2. Weather conditions were appropriate throughout all survey sessions and as such the results of trapping and radio tracking were not constrained or affected by significant adverse weather. During rain events, tagged bats generally remained active during the surveys.

2.2.3. Usual scientific best practice avoids using data collected on the night of capture for analysis of ranging behaviour (Davidson-Watts, et al., 2006), due to the effects on behaviour of the disturbance from the capture/tagging procedure. In this survey, data collected during the first night of tracking was incorporated for analysis as some bats were trapped in locations where they were not recorded for the remainder of the survey. The exclusion of this information would not have reflected what was known of the home range of the tagged bats and whilst rigorous scientific approaches have been adopted to objectively record and asses/interpret the radio tracking data, the survey objective is to primarily understand the movement of radio-tracked bats (particularly barbastelle) within the survey area.

2.2.4. A limitation of radio-tracking studies relates to accuracy of positional fixes. Accuracy of fixes can be a common problem in studies of fast-moving bats, particularly those species that have relatively large home ranges (Holland & Wilelski, 2009). Whilst methods such as triangulation can provide relatively rapid and systematic location data for bats, studies have shown that due to variability of surveyor skill, especially at distance, positional fixes might only be accurate to >250m^2 (Bontadina, et al., 2002). In the case of this survey, it is considered that bat fixes were accurate to 100 m^2.

2.2.5. In order to reduce the above limitation, a combination of triangulation and close approach methods were adopted to increase accuracy. A number of factors such as the landform, access to private land and time bats spent in an area can affect the accuracy of fixes. To take account of this location error, the analysis of radio tracking data has been relatively conservative, especially when estimating core areas of activity. For instance, a tracking resolution of 100m has been applied to all location fixes and use of objective cores also aims to take account of these limitations.

2.2.6. The other major limitation influencing the ability to obtain data for this project were land access restrictions placed on the survey team for various reasons. Unfortunately, some of the previously recorded/studied barbastelle bat roosting areas were partially inaccessible, and this initially limited the effectiveness of trapping and tagging the planned number of barbastelle bats. Notwithstanding this limitation, the use of the acoustic lure assisted the trapping of further barbastelle bats within their foraging areas and previously unrecorded roost sites. At Weston Park and Hardingham Hills, an 2018 study (Wild Wings Ecology Ltd, 2019) undertook two repeated simultaneous roost counts in August which yielded a minimum maternity colony estimate of 46 individuals (very likely to consist of adult females and juveniles). Based on this minimum population estimate it is considered that the number of tagged bats eventually tracked in the present survey (*n*=7, 15% of the known minimum population) provides for a robust radio-tracking dataset for the early breeding period.

2.2.7. Due to licensing restrictions and coordination with other research projects also focussing on the same barbastelle population, the surveys in 2019 were limited to the second half of May and a second survey session in the post-parturition period was not possible. However, a second survey session is planned to be completed in July 2020 which will ensure a robust and comprehensive survey approach.

3. RESULTS

3.1. DESK STUDY

3.1.1. The A1270 Broadland Northway is a 22km road which runs from the A47 at Postwick, east of Norwich, to the A1067 Fakenham Road, north of Taverham. This was constructed between 2015 – 2018. The NWL will connect the A1270 Broadland Northway from the A1067 to the A47 at Honingham.

3.1.2. Extensive bat surveys have been completed in the local area in order to inform the A1270 Broadland Northway. Post- construction surveys were completed and reported by (Wild Wings Ecology Ltd, 2019).

3.1.3. The key finding of the A1270 Broadland Northway surveys was the presence of a maternity colony of barbastelle in Morton, which is situated approximately 1.5km to the north-west of the Scheme. All identified roosts within this colony were tree-roosts, and most occurred within the grounds of a Dinosaur Adventure Park. Other roosts associated with this colony occurred within Weston Golf Course, Hardingham Hills and Scotchwood Hills. Repeated minimum roost count surveys in August 2018 yielded a minimum maternity estimate of 46 individuals.

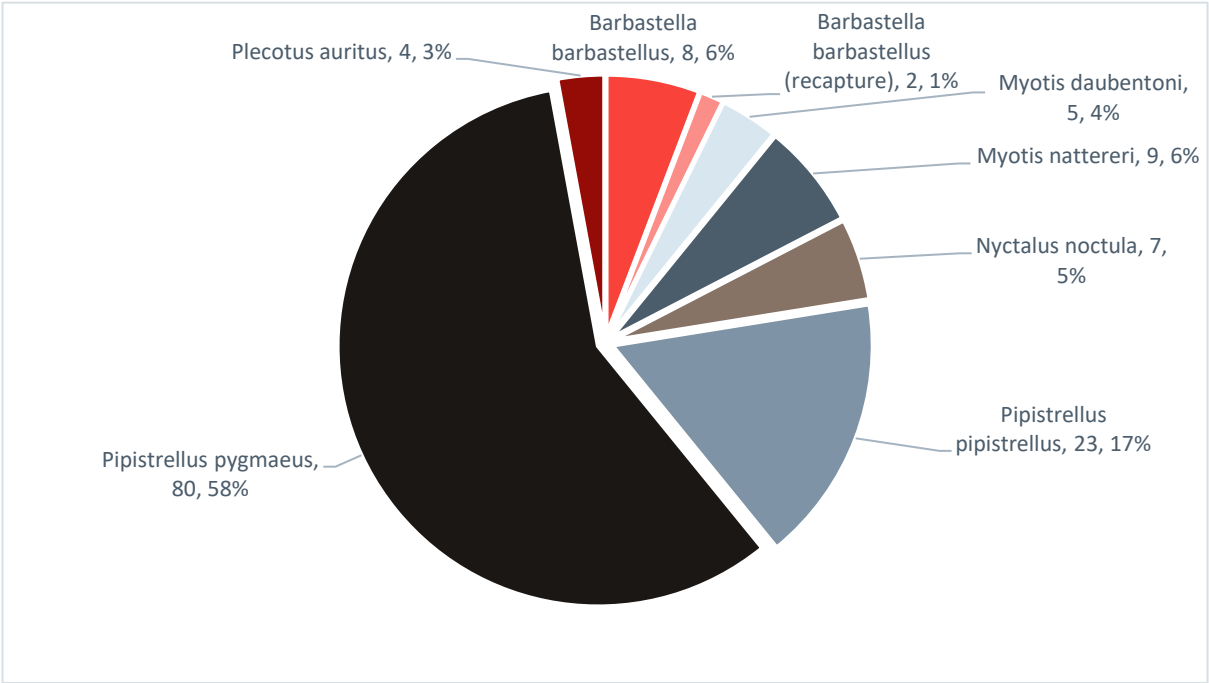
3.2. BAT TRAPPING

3.2.1. One bat trapping survey session was undertaken in May 2019. The locations of the trapping areas are detailed in Figure 1. A total of twelve trapping nights were undertaken using harp traps and mist nets (with a further ten trapping nights planned to be conducted in the August 2020 survey period – a total of 22 trapping nights). This survey effort is comparable with other studies, e.g. the NDR post-construction monitoring radio-tracking surveys included 14 trapping nights in total over both trapping sessions (Wild Wings Ecology Ltd, 2019). Each trapping night consisted of a team of two ecologists completing surveys using a minimum of three harp traps or mist-nets. On some nights, two teams of ecologists trapped at different locations which resulted in two trapping nights occuring simultaneously.

3.2.2. On one occasion a hand net was used to catch barbastelle bats whilst emerging from a known roost site to enable the capture of a suitable bat for tagging and subsequent radio tracking.

3.2.3. A total of 138 bats were captured during the nine trapping surveys. Detailed trapping data is presented in Appendix A. Plate 3-1 provides the species proportions of captures during the nine trapping surveys. The majority of captures were soprano pipistrelle *Pipistrellus pygmaeus* (58%) followed by common pipistrelle *Pipistrellus pipistrellus* (17%). Barbastelle made up 7% of the total captures (10 captures), although one barbastelle bat was captured three times.

Plate 3-1 - Species proportions of captured bats during May 2019.



3.2.4. Of the ten barbastelle captures (consisting of eight individual bats), seven were fitted with a radio-tag, as follows:

- Three were the same female bat which was radio-tagged and subsequently captured on two more occasions at the same location and on the same trapping night;
- One was a male bat captured at Broom Hills woodland south of Morton Hall. Due to its condition this bat was released without tagging.
- Six further female barbastelle bats were fitted with a radio-tag.

3.2.5. Other species captured included Natterer's *Myotis nattereri*, Daubenton's *Myotis daubentonii*, brown long-eared *Plecotus auritus*, soprano pipistrelle, common pipistrelle and noctule *Nyctalus noctula*. From these captures two female Natterer's and one male noctule were tagged for roost-finding purposes.

Table 3-1 – Summary of bat captures for each trapping site in May 2019. Bold text denotes breeding bats. Refer to Figure 1 for site locations and Appendix A for detailed trapping records.

Site (reference to Figure 1)	Trapping Night	Bats Trapped
Long Plantation (1)	19/05/2019	Nine bats (common pipistrelle, Natterer's and brown long-eared).
Marriot's Way east (2)	20/05/2019	Twenty-six bats (common pipistrelle, soprano pipistrelle, Daubenton's, and barbastelle).

Site (reference to Figure 1)	Trapping Night	Bats Trapped
Marriott's Way west (11)	20/05/2019	Twenty-seven bats (common pipistrelle, soprano pipistrelle, Natterer's)
Weston Golf Course (3)	21/05/2019	Twenty bats total (common pipistrelle, soprano pipistrelle, noctule, barbastelle, brown long-eared and Natterer's).
Middle Grove (4)	22/05/2019	Two bats total (soprano pipistrelle)
Common Meadow Carr (5)	22/05/2019	Nine bats total (common pipistrelle, soprano pipistrelle, Daubenton's and Natterer's).
Morton Hall - Broom Hills (6)	23/05/2019	Seventeen bats total (common pipistrelle, soprano pipistrelle, Natterer's and barbastelle).
Golf Course - Morton Plantation (7)	27/05/2019	Eight bats total (common pipistrelle, soprano pipistrelle, Daubenton's, barbastelle).
Golf Course - Morton Plantation (7)	28/05/2019	Five bats total (soprano pipistrelle and barbastelle).
The Broadway (8)	29/05/2019	Hand net of one barbastelle.
Poetsbreck Plantation (9)	30/05/2019	Fourteen bats total (common pipistrelle, soprano pipistrelle and noctule).
Scotchwood Hills (10)	19/05/2019	Six bats total (natterers and common pipistrelle).

Table 3-2 – Summary details of tagged bats (n=10) May 2019.

Bat ID	Capture site (refer to Figure 1)	Date captured	Species	Sex	Age Class	Breeding status
238326	Location 10	19/05/2019	Natterer's	Female	Adult	Pregnant
238325	Location 2	20/05/2019	Barbastelle	Female	Adult	Pregnant

Bat ID	Capture site (refer to Figure 1)	Date captured	Species	Sex	Age Class	Breeding status
238323	Location 7	21/05/2019	Barbastelle	Female	Adult	Pregnant
238321	Location 7	21/05/2019	Barbastelle	Female	Adult	Pregnant
238329	Location 6	23/05/2019	Natterer's	Female	Adult	Pregnant
238324	Location 7	27/05/2019	Barbastelle	Female	Adult	Pregnant
238316	Location 7	28/05/2019	Barbastelle	Female	Adult	Pregnant
238330	Location 7	28/05/2019	Barbastelle	Female	Adult	Pregnant
238322	Location 8	29/05/2019	Barbastelle	Female	Adult	Pregnant
238313	Location 9	30/05/2019	Noctule*	Male	Adult	N/A

*daytime radio-tracking only

3.3. RADIO TRACKING

BARBASTELLE BATS

3.3.1. A total of seven barbastelle (all female adults) were fitted with radio-tags during May 2019 and tracked throughout the night to obtain movement data. The overview core areas of all bat species are shown in Figure 3, and the core areas of barbastelle are shown in Figure 4. Individual barbastelle ranges are presented in Figures 5 - 11.

3.3.2. As a result of tag failure and/or an undetectable bat on the first or second night or tracking, a very small number of fixes were obtained for bats 238324 (n=7) and 238330 (n= 22). Although a small number of fixes were obtained for these bats, this is not enough to be able to rely on for any subsequent home range analysis, and it is not possible to depict a true account of their use of the Survey Area. The data obtained is shown in Figures 9 and 11 for illustrative purposes, however these two bats have been removed from further home range and core areas analysis as their inclusion disproportionally affected summary statistics.

3.3.3. The mean home range (MCPs) of the radio tracked barbastelle (excluding 239324 and 238330) was approximately 762ha, with mean a span of the MCPs of approximately 6.5km. The mean of the total core areas for these five barbastelle bats was approximately 177.3ha, with an average of three core areas per bat (range 1 – 7 core areas).

3.3.4. Key potential foraging and core areas for all bats included woodland/tree dominated habitats within the vicinity of the Weston Golf Club and the River Wensum to the north, and the woodland copses, plantations and woodland strips in the vicinity of Broadway, Telegraph Hill and Honnington Park to the South of the Survey Area.

3.3.5. Some bats travelled further to core areas. Barbastelle 238322 visited areas south of the survey area, including woodland areas to the south of the A47 south east of Honingham and also woodland and golf course areas to the south of Queen's Hills.

3.3.6. Barbastelle 238323 visited core areas to the north of the Weston Golf Course and Wensum Valley in the area of Alderford and Alderford Common.

3.3.7. Although bat 238324 had few fixes, it was established that this bat was flying up to 10km to the west of the Weston Golf course in an area to the north of the village of Swanton Morely. Less focus was placed on this bat due to its home range being westward of the main survey area, and regular monitoring of tag frequencies rarely confirmed the bat was present within 2km of the road options in the survey area.

OTHER BAT SPECIES

3.3.8. For roost finding purposes only, two female Natterer's and one male noctule were tagged and subsequently tracked the following day. Bat 238329, a female Natterer's, was initially subject to all-night tracking prior to catching greater numbers of barbastelle, and the home ranges for this bat are shown in Figures 1 and 2.

Table 3-3 – Summary of home range data for seven barbastelle bats radio-tracked within the Survey Area.

Bat ID	Sex	Number of Fixes/number of tracking nights	MCP area (ha)	Objective cores- % of locations used	Total core area(ha)	MCP Range Span (m)
238325	Female	58/9	708.7	87	206.0	5361.1
238323	Female	41/6	919.6	92	223.7	4873.5
238321	Female	112/4	869.1	96	148.5	5416.5
238324	Female	7*/2	179.5	93	41.2	2817.8
238316	Female	76/3	258.9	57	0.8	10198.7
238330	Female	22*/3	1093.9	72	216.6	5452.5
238322	Female	149/3	1054.8	97	307.3	6623.2

*Fixes for these bats are relatively low, therefore home ranges (MCPs) and core areas should be treated with caution. Low numbers of fixes were primarily due to bats being tagged later in the survey session, tag failure/misfunction or bats leaving the Survey Area away from the scheme (priority was given to tagged bats within the Survey Area). However, they have been included in the report for illustrative purposes.

3.4. ROOST USE

3.4.1. A total of 12 roosts were recorded for all bats tagged during May 2019. Natterer's 238329 used two presumed tree roosts that were triangulated to Primrose Grove woodland where no access was available to investigate the roosts. These Natterer's bat roosts are assumed on a precautionary basis to be maternity roosts, due to the individual bat being pregnant at the time of tagging.

3.4.2. Noctule 238313 was triangulated to a roost in Ave's Gap Wood. No access was possible to investigate the roost.

BARBASTELLE BAT ROOSTS

3.4.3. The remaining nine roosts were of barbastelle and all the bats tagged were female and pregnant. Therefore, where roosts could not be accessed for characterisation and emergence surveys, on a precautionary basis, these roosts have been assumed to be maternity roosts.

3.4.4. All nine barbastelle roosts were found in trees or woodland. The roosts were clustered in two broad locations, which included multiple roosts at the Weston Golf Club and adjoining Morton Plantation, and several copses and trees in the area of Broadway, Halls Hills and Telegraph Hill area, to the south of the survey area. One confirmed day roost of barbastelle (observed by torchlight as roosting during the day with no other bats visible in the same roost site under bark) was in Church Plantation immediately north of the A47.

3.4.5. Flaking bark and splits in oak trees were the main roost features used by barbastelle. The highest count of bats emerging from roosts was 27, and this number of bats occurred at both the Weston Golf Club and a roost in the area of the Broadway Road. Another roost in Hill Halls Plantation was discovered on the morning of 1st June (the last day of the survey) and approximately 25 bats were observed returning to this roost at dawn.

Table 3-4 – Roost use by radio-tagged bats. Emergence counts given are the highest number of bats recorded exiting the roost at dusk, see Figures 12 – 14 for roost locations.

Roost ID	Location OSGR	Date Found	Roost Type	Roost Feature	Peak Count	Bat (ID) recorded at roost
1	TG1142317387	21/05/2019	Oak tree within Oak Plantation woodland	Tear out	27	238325/238323
2	TG1324314627	21/05/2019	Tree within Primrose Grove	No access	N/A	238329 (Mn*)
3	TG1146713387	21/05/2019	Oak tree on field boundary south of the Broadway	No access	N/A	238321
4	TG1307414822	23/05/2019	Tree within Long Plantation/Primrose Grove	No access	N/A	238329 (Mn*)
5	TG1189913263	25/05/2019	Oak tree on The Broadway road	Hazard beam	No access	238321
6	TG1182113317	24/05/2019	Oak tree on The Broadway road	Not observed	1	238322
7	TG1184313325	27/05/2019	Oak tree on The Broadway road	Split limb	27	238321/238322
8	TG1201217316	27-31/05/2019	Various trees within Morton Plantation	No access	N/A	238325, 238316, 238324, 238330
9	TG1192217287	27/05/2019	Oak tree within Morton Plantation	Flaking bark	4	238325
10	TG1168311434	30/05/2019	Oak tree within Church Plantation	Flaking bark	1	238322

Roost ID	Location OSGR	Date Found	Roost Type	Roost Feature	Peak Count	Bat (ID) recorded at roost
11	TG11495 12741	1/06/2019	Oak tree in Hall Hills wood	Flaking bark	25	238322
12	TG 13489 12580	30/05/2019	Tree within Ave's Gap wood	No access	N/A	238313 (Nn*)

*Mn = Natterer's bat *Myotis nattereri*

*Nn = Noctule bat *Nyctalus noctula*

4. SUMMARY OF RESULTS AND RECOMMENDATIONS FOR FURTHER SURVEY

4.1. SUMMARY OF RESULTS

BARBASTELLE BATS

4.1.1. The results of the radio-tracking survey undertaken in May 2019 support data associated with the A1270 Broadland Northway bat studies, which state that an extant barbastelle maternity population(s) occurs within the Weston/Lenwade area, specifically the Weston Golf Course/Dinosaur Park, which was subject to investigation in 2018 (Wild Wings Ecology Ltd, 2019).

4.1.2. Access to the Weston Golf Course/Dinosaur Park enabled trapping, radio-tagging and roost finding activities in the areas known to support populations of barbastelle. Emergence surveys in the Weston Golf Course grounds and neighbouring Morton Plantation enabled two maternity roosts to be confirmed with emergence surveys. However, previously discussed access limitations meant that a number of roosts located in Morton Plantation could only be triangulated during the day from publicly accessible areas.

4.1.3. The present survey has also identified woodland habitats used by the same barbastelle population occurring further south on the Broadway. This area was not previously known to support barbastelle. This area was used by at least two of the radio-tracked barbastelle bats for a significant proportion of the present survey and six tree roosts were identified within on (or within proximity of) the Broadway (roosts 3, 5, 6, 7, 10 and 11 in Table 3-4), five of which were confirmed or likely to be maternity roosts. These Broadway roosts were located to the south-east of the Preferred Route, as shown in Figure 12, with the closest roost approximately 440m from the Preferred Route.

4.1.4. Although it was not possible to determine the relative population sizes of barbastelle from the present survey alone (given the time and access restrictions previously detailed) this is an interim report and further surveys are planned to be completed in 2020. The survey has shown that roost movement was frequent and tree roosts supported between one and 27 bats at both the Weston Golf Course and the Broadway Road area. The overall population is likely to be larger than these results suggest, as the majority of bats tagged at the golf grounds continued to use roosts in the same area throughout the survey period, suggesting the presence of two related populations. However, it is not known whether these two populations are likely to combine prior to parturition (usually late June/July) or remain separate sub populations. Such fission fusion behaviour has been observed elsewhere with both tree and building roosting bat species (Kerth, 2011).

4.1.5. Roost movements and switching are considered to be a response to a range of environmental influences affecting the efficient development of pregnancy and the rearing of young, especially during the lactation period, normally occurring in July (Davidson-Watts I. F., 2007). It can also be related to social relatedness (Kerth, 2011). It is also during this period that foraging behaviour can vary from other times during the bat active season, and lactating barbastelle have been previously observed making much shorter and more frequent foraging journeys, often less than 2km from the roost during July ((Davidson-Watts, 2015); (Davidson-Watts Ecology Ltd, 2016/2017); (Davidson-Watts Ecology Ltd, 2015). These foraging areas may therefore be of particular importance during the maternity period as part of the sustenance areas/zones of this barbastelle population(s) and require further investigation.

4.1.6. Therefore, understanding the relative importance and context of The Broadway area for the overall population of barbastelle west of Norwich is considered necessary to inform the impact assessment of the Scheme.

OTHER BAT SPECIES

4.1.7. In addition to the barbastelle, the other target species captured (Natterer's and noctule) were also predominantly captured in the east of the survey area. Noctule are typically high-flying bats that can fly long distances (Altringham, 2003) therefore roosts may be further away from their capture location. However, roosts for this species could occur in the survey area at other times of the year. The captures were mainly of male bats in the east and six males were captured in quick succession indicating some use of that area by multiple bats of this species.

4.1.8. Breeding female Natterer's were captured and found roosting in the Primrose Grove Woodland area and these woodlands are likely to support higher numbers of tree roosts for this likely maternity population.

4.2. RECOMMENDATIONS FOR FURTHER SURVEY

4.2.1. As previously stated, this is an interim report and further bat trapping and radio-tracking surveys are due to be completed in 2020 to investigate the roost locations and activity patterns of breeding barbastelle during the lactation period. This is often when essential habitats and sustenance zones can be identified prior to the dispersal and longer flying ranges associated with August, when the juveniles are flying, and females search for males (Zeale, et al., 2012). This will be an important investigation with the objective of informing potential impacts of the Scheme on barbastelle (and other bat species) and ensuring appropriate bat mitigation and habitat compensation and enhancement is implemented throughout the Scheme.

4.2.2. The 2020 surveys will be conducted using similar methods to those described in this report.

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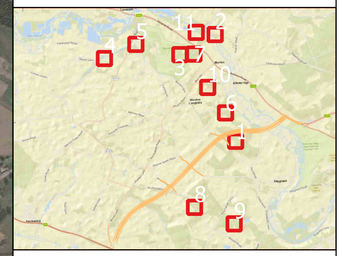
6. FIGURES

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED

Legend

- Preferred Route
- Trapping Locations



Revision Details	By / Check	Date	Suffix

Drawing Status: FINAL

Job Title: Norfolk County Council Norwich Western Link

Drawing Title: Appendix F - Figure 1 Trapping Locations 2019

Scale at A1: 1:12,000

Drawn		
UKMCW003		

Stage 1 Check	Stage 2 Check	Originated	Date
PL	MC	MW	31/03/2020

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Drawing Number: 70061370-09-01-0012

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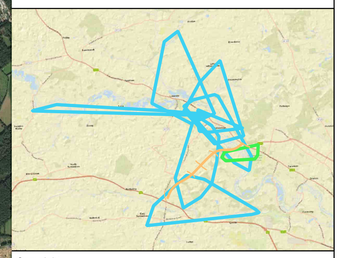
THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED

Legend

- Preferred Route
- Barbastelle Home Ranges n=7
- Natterer's Home Range n=1



Revision Details	By / Check	Date	Suffix

Drawing Status: FINAL

Job Title: Norfolk County Council Norwich Western Link

Drawing Title: Appendix F - Figure 2 Overview Home Ranges (MCPs) all bats (n=8)

Scale at A1: 1:25000

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UKRKR001		

Stage 1 Check	Stage 2 Check	Originated	Date
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Drawing Number: 70061370-09-01-0013

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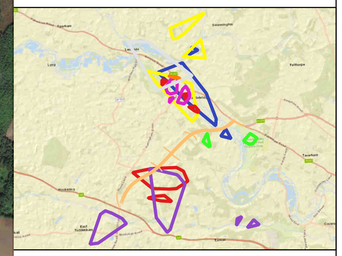
THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED

Legend

Preferred Route

Core Areas

- 238316 - Barbastelle
- 238321 - Barbastelle
- 238322 - Barbastelle
- 238323 - Barbastelle
- 238324 - Barbastelle
- 238325 - Barbastelle
- 238329 - Natterer's
- 238330 - Barbastelle



Revision Details	By / Check	Date	Suffix

Drawing Status: FINAL

Job Title: Norfolk County Council Norwich Western Link

Drawing Title: Appendix F - Figure 3 Overview Core Areas All Bats (n=8)

Scale at A1: 1:17500

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