



Evaluation of proposed Kent Woods and Downs NNR

## *ASSESSMENT OF BAT ASSEMBLAGE*

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## GLOSSARY

ABEC: Adonis Blue Environmental Consultants

ANOVA: Analysis of variance

BAP: Biodiversity Action Plan

KBG: Kent Bat Group

KCC: Kent County Council

KMBRC: Kent and Medway Biological Records Centre

KWT: Kent Wildlife Trust

NNR: National Nature Reserve

PAM: Passive acoustic monitoring

UAV: Unmanned aerial vehicle (drone)

UKHAB: United Kingdom Habitat Classification

## EXECUTIVE SUMMARY

This report provides an evaluation of a proposed Kent Woods and Downs NNR from the perspective of the bat species assemblage. It is intended to be part of a series of taxonomic group evaluations and used in conjunction to prioritise conservation and other management practice.

A full suite of bat surveys was not undertaken due to the limited duration of the contracted work. The evaluation is therefore built upon a desk-based review of existing information, supplemented by a limited number of site visits, the latter being primarily driven by observed geographic gaps in bat observation records, and to align habitat mapping with on-the-ground observations. Given the general habits of bats (for example roosts and foraging localities often being some distance apart) we incorporated a 5 km radius beyond the farthest extent of the outer boundaries of the proposed NNR land parcels within which to focus our mapping of bat species and associated habitat.

Existing bat record data (1981–2023) for the proposed NNR area provided 1,575 observations. These data were augmented by a further 1,299 observations generated by a ground-truthing exercise comprising passive and active bioacoustic monitoring, giving a total 2,874 individual observations. Twelve bat species are recorded across 10 of the 15 land parcels earmarked for the NNR. Of these 12 species, 6—brown long-eared; Leisler's; Nathusius' pipistrelle; noctule; serotine; and soprano pipistrelle—are of conservation concern, being identified by one or more of: GB Red List, Natural Environment and Rural Communities Act (section 41) 2006, Biodiversity Action Plan Priority Species, Kent Biodiversity Strategy Indicator Species. We further include species groups within this consideration—*Myotis* spp., *Nyctalus* spp.—as they contain species identified to genus level only, and comprise species of conservation concern.

Differences in bat species-group assemblages were detected between and within land parcels/areas chosen for ground-truthing using passive acoustic monitoring. Although deployment site, sampling design, imperfect detection, and bioacoustic interference likely influenced results, our findings support the validity of long-held hypotheses regarding space- and habitat-use differentiation between bat species. Therefore, given the diversity of habitats across the proposed NNR, several avenues of opportunity to explore resource-use by multiple bat species are present, which can inform measures for medium- and long-term habitat management.

Despite our reported number of observations, the availability of records varies among the constituent land parcels of the proposed NNR, with more southerly areas having none, others having very few, and a general lack of information regarding roost locations. Any designation of areas within the proposed NNR as being more/less important to the bat species assemblage is therefore inadvisable. We recommend further surveys of both bat activity and an exploration of potential roosting resources across all 15 land parcels. However, there is remarkable consistency between records for 1981–2023 and our ground-truthing exercise for both species assemblage and general habitat types, indicating the historic and continued importance of the area of the proposed NNR and its environs for bats.

We provide an indicative series of suggested survey, monitoring, and management recommendations, encompassing cutting-edge bioacoustic data collection and analytical tools; site surveys for roosts and roost potential; trapping; tracking; statistical modelling; and multiple habitat creation and management activities. In addition, we advocate for the establishment of a collaborative stakeholder group to be responsible for driving a joined-up approach to managing and enhancing the proposed NNR for biodiversity more broadly, thereby ensuring cost effective interventions to deliver maximum ecological benefit across habitats and species groups while supporting current, ongoing, and future land-use by both landowners, and availability for the public good. Finally, we encourage collaborations with local, regional, and national groups, organisations, businesses, and institutions to foster business sponsorship, scientific research, and public engagement, and also for leveraging funds to support the development and long-term management of a brand new NNR: a biological area of enormous ecological interest, value, and research potential.



## INTRODUCTION

### BACKGROUND

Kent Wildlife Trust Consultancy Services (Adonis Blue Environmental) and Dr Jim Labisko were commissioned by the Kent Downs National Landscape team and White Horse Ecology to undertake an evaluation of the importance of the bat assemblage within a proposed Kent Woods and Downs NNR in the Cobham/Shorne area of north Kent. This evaluation is one of a series, undertaken by a range of relevant taxon specialists, coordinated by White Horse Ecology under contract to the ultimate client, Kent County Council.

### AIMS AND OBJECTIVES

The aim of this work is to better understand the presence, absence, and behaviour (for example habitat use) of bats within the proposed NNR (hereafter 'the NNR'). Our short-term activities will provide a snapshot baseline and are undertaken with a view to implementing medium-term adaptive management strategies and improving long-term, the favourable status of bats in Kent. To achieve our 'baseline for bats' in the NNR, we identified four core objectives:

- (1) Determine bat species historically and currently present/absent
- (2) Identify key locations—sites of suitable and unsuitable habitat—for bat species.
- (3) Establish priorities for future (next steps) survey and monitoring work.
- (4) Indicate priorities for future habitat creation and management.

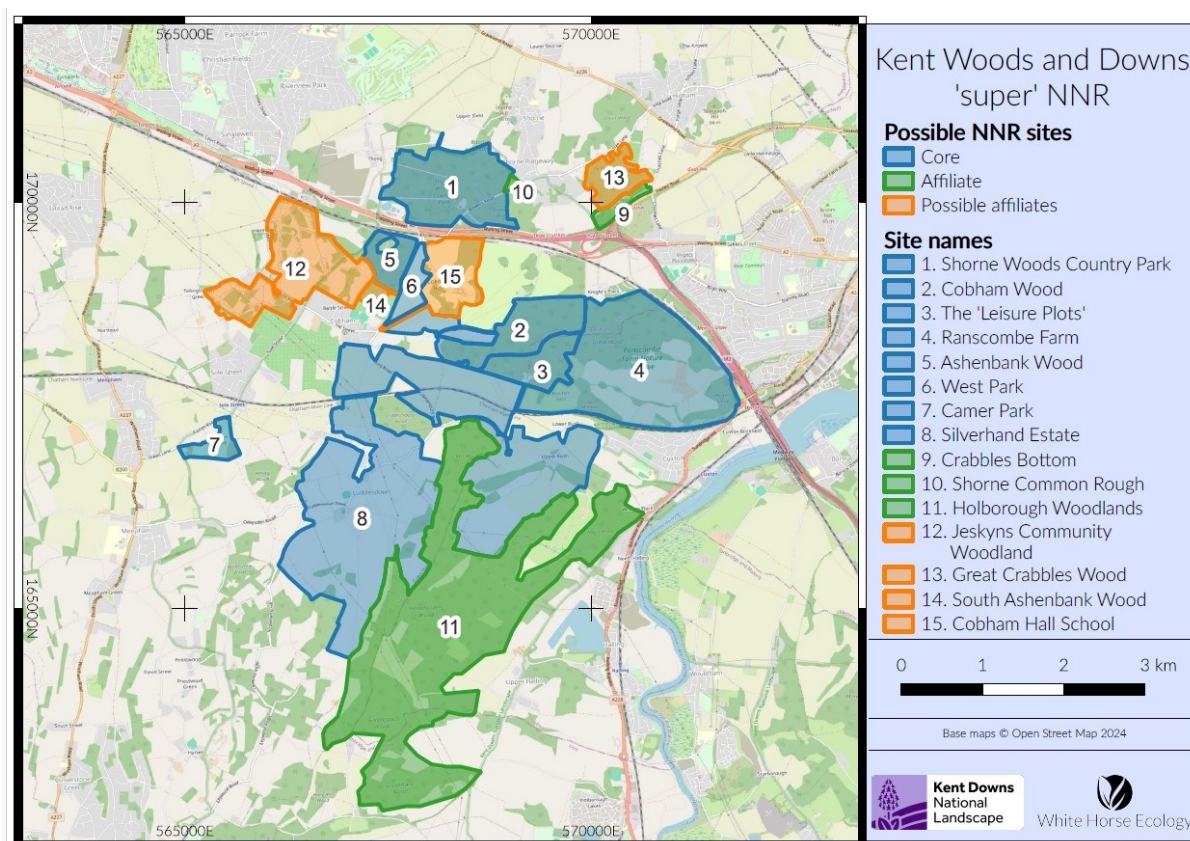
Our methods were partitioned into three successive work-packages: mapping, verification, and recommendations:

1. **Mapping.** Geographic representation of KMBRC/KBG/other data records of bat species presence/absence within the NNR to identify:
  - known localities of presence (up to 5 km radius beyond proposed extent)
  - known maternity and hibernation roost localities (up to 5 km radius beyond proposed extent)
  - areas of suitable habitat where bats have (i) not been recorded or (ii) are under-recorded
  - areas of suitable habitat important for the gamut of bat behaviours, for example habitat connectivity, foraging, roosting.
2. **Verification.** Review of mapping outputs to identify areas of opportunity, including ground-truthing survey work targeted toward:
  - verification and better understanding of important habitat for bats across the NNR and its environs
  - identifying where management interventions would bring both short- and long-term improvements for the bat species assemblage
  - key areas for the establishment of long-term survey and monitoring.
3. **Recommendations.** Combining outputs from 1 and 2, provide initial recommendations focussed on three main themes: Present Status, Improved Status and Future Proofing.

## METHODOLOGY

### SPATIAL COVERAGE

This evaluation covers a landscape proposed as a possible Kent Woods and Downs NNR. The area comprises a variety of woodland, downland and agricultural land uses, with an associated mix of habitat types and interfaces. It features a network of defined, connected land parcels that are of wildlife interest. These are currently categorised as 'core', 'affiliate', and 'possible affiliate' (Fig. 1).



**Figure 1.** Proposed Kent Woods and Downs NNR area and contingent land parcels.

## ANALYSIS AND MAPPING OF EXISTING RECORDS

Records from KMBRC/KBG for the ~10-year period spanning January 2013 to November 2023 were used to map species distribution across the NNR based on presence/absence records. A UKHAB base map was used to identify patterns between habitat type and current known species distribution, and to identify potential for bats to occur pending additional surveys of suitable habitats. General definitions of habitat for each of the 15 land parcels are described in Table 1. Given the propensity for bat roosts being distant from foraging sites, we also incorporated a 5 km radius beyond the farthest extent of the outer boundaries of the NNR land parcels within which to focus our mapping. Records of maternity and hibernation roosts within the NNR and its surrounding 5 km radius were determined to enable assessment of potential Core Sustenance Zones for maternity roosts.

On initial review of the ~10-year data package a lack of recent bat observations was evident (likely due to variation in recording activity over time) leading to the omission of multiple records of importance. Therefore, a review of all remaining records across the NNR (years 1981–2012) was undertaken. The combined results (1981–2023) are provided and discussed herein.

## VERIFICATION (GROUND-TRUTHING)

During July and August 2024, site visits were undertaken to ground-truth the initial mapping exercise. These targeted surveys would provide further insight into both the habitat and its potential for use and/or avoidance by bats. To determine areas/sites/habitats chosen for ground-truthing, we reviewed our preliminary analysis of bat record data and used this information, combined with a general interpretation of mapped habitat types and clusters of bat observations, to identify spatial gaps in bat records, and suitable/unsuitable bat habitat. We identified Cobham Wood, The Leisure Plots, Ranscombe Farm, Silverhand Estate, and Holborough Woodlands as appropriate locations for ground-truthing. Following initial site walkovers, further visits were undertaken to deploy AudioMoth

bioacoustic recorders (x 3) for passive acoustic monitoring (PAM) of bat vocalisations (Fig. 2–4). We also performed one transect survey using handheld detectors. Deployment period and recording schedule for PAM are detailed in Table 2.

Data analysis comprised of comparisons of group means of detected bat species groups: *Pipistrellus* spp., *Nyctalus* spp., *Myotis* spp. Serotine (*Eptesicus serotinus*) and brown long-eared (*Plecotus auritus*) were expected to be infrequently detected.

**Table 1.** Fifteen land parcels constituting the NNR with name of locality and generalised habitat types present in each. See also Fig. 1.

| Parcel/area no. | Parcel/area name           | Dominant habitat types                                                                                                              |
|-----------------|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| 1               | Shorne Woods Country Park  | Ancient and semi-natural woodland, lowland deciduous woodland, veteran trees, smaller patches of wetland and parkland habitat       |
| 2               | Cobham Wood                | Lowland deciduous woodland and wood pasture and parkland                                                                            |
| 3               | The Leisure Plots          | Ancient and semi-natural woodland, orchard and man-made wildlife pond                                                               |
| 4               | Ranscombe Farm             | Ancient and semi-natural woodland and ancient replanted woodland, lowland deciduous woodland, lowland calcareous grassland, arable  |
| 5               | Ashenbank Wood             | Ancient and semi-natural woodland, lowland deciduous woodland                                                                       |
| 6               | West Park                  | Wood pasture and parkland                                                                                                           |
| 7               | Camer Park                 | Lowland deciduous woodland and wood pasture and parkland                                                                            |
| 8               | Silverhand Estate          | Arable (viticulture), lowland calcareous grassland, small fragments of ancient semi-natural woodland and lowland deciduous woodland |
| 9               | Crabbles Bottom            | Traditional orchard and lowland deciduous woodland                                                                                  |
| 10              | Shorne Common Rough        | Ancient and semi-natural woodland, lowland deciduous woodland                                                                       |
| 11              | Holborough Woodlands       | Ancient and semi-natural woodland, lowland deciduous woodland, lowland calcareous grassland                                         |
| 12              | Jeskyns Community Woodland | Semi-improved grassland, traditional orchard and lowland deciduous woodland                                                         |
| 13              | Great Crabbles Wood        | Ancient and semi-natural woodland, lowland deciduous woodland                                                                       |
| 14              | South Ashenbank Wood       | Ancient and semi-natural woodland                                                                                                   |
| 15              | Cobham Hall School         | Wood pasture and parkland with lowland deciduous woodland                                                                           |

**Table 2.** Location, dates, and recording parameters of passive acoustic monitoring of bats using AudioMoth static recorders (3 units per deployment) across the NNR. Parcels 2, 3 and 4 were combined and constitute a single area. \* = active acoustic monitoring: corresponding survey date in parentheses. See also Fig. 2–4.

| Parcel/area no. | Parcel/area name     | Survey Date(s)           | Recording parameters                                                                                                                                                          |
|-----------------|----------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2               | Cobham Wood*         | (03/07/24)<br>17–22/7/24 | Sample rate: 384 kHz; Gain: Medium; Recording duration (s): 60 'on' 240 'off'; Recording period: 20:47–04:00; Trigger type: Frequency (15.0 kHz, window length of 64 samples) |
| 3               | The Leisure Plots*   |                          |                                                                                                                                                                               |
| 4               | Ranscombe Farm*      |                          |                                                                                                                                                                               |
| 8               | Silverhand Estate    | 5–17/7/24                |                                                                                                                                                                               |
| 11              | Holborough Woodlands | 22–28/7/24               |                                                                                                                                                                               |



**Figure 2.** Extent of Area 8 and deployment locations of AudioMoth detectors 1.1, 2.1, and 3.1.



**Figure 3.** Extent of Area 2-3-4 and deployment locations of AudioMoth detectors 1.1, 2.1, and 3.1.



**Figure 4.** Extent of Area 11 and deployment locations of AudioMoth detectors 1.1, 2.1, and 3.1.

## RESULTS

### OBJECTIVE 1: BAT SPECIES PRESENT IN THE PROPOSED NNR

A total of 1,575 records were identified for the NNR and surrounding 5 km radius from KMBRC/KBG records for the period 1981–2023 (Table 3; Appendix I, Table S1). Records comprise 10 species—brown long-eared; common, Nathusius', and soprano pipistrelle; Daubenton's; Leisler's; Natterer's; noctule; serotine; whiskered—with further records for species groups where bats were identified to genus level only (two *Myotis* species groups: *Myotis* spp. and whiskered+Brandt's+Alcathoe for which identification in the hand is required to distinguish between taxa; and *Nyctalus* spp.) (see also Appendix I, Fig. S1–S9; Table S1). The data includes a single unverified record for barbastelle within Shorne Woods Country Park (land parcel/area 1).

### Maternity and hibernation roost records

Nine species and two species-group records for maternity and hibernation roost locations were determined within the NNR and surrounding 5 km radius (Table 4; Appendix I, Fig. S10). We also indicate the estimated Core Sustenance Zone (measured in km), being *“the area surrounding a communal bat roost within which habitat availability and quality will have a significant influence on the resilience and conservation status of the colony using the roost”* as defined by the BCT.

### Verification (ground-truthing)

The ground-truthing exercise totalled fourteen person-survey days. Bioacoustic monitoring with AudioMoth devices totalled 54 survey nights giving rise to 2,040 recordings (87.4 GB of data), and 139 recordings (0.43 MB of data) from one active survey. Records comprise nine species—brown long-eared; common, Kuhl's, Nathusius', and soprano pipistrelle; Leisler's; Natterer's; noctule;

serotine—with further records for four species groups where bats were identified to genus level only. For ease of reference all bioacoustic data are clustered by species groups (excluding serotine): *Myotis* spp.; *Nyctalus* spp.; *Pipistrellus* spp.; *Plecotus* spp. (Table 3–4; Appendix I, Table S1)

**Table 3.** Bat species present across the NNR, with conservation status (IUCN/GB Red List; Natural Environment and Rural Communities Act; Biodiversity Action Plan or Kent Biodiversity Strategy). DD = Data Deficient, LC = Least Concern, NT = Near Threatened, VU = Vulnerable. Numbers in underlined bold font indicate new records generated by ground-truthing July–August 2024. See also Appendix I, Fig. S1–S9; Table S1.

| Species/species group  | NNR Confirmed (parcel/area no.)                            | GB Red List | NERC Section 41 | UK BAP Priority or *KBS Indicator species |
|------------------------|------------------------------------------------------------|-------------|-----------------|-------------------------------------------|
| Barbastelle            | Unconfirmed                                                | VU          | Yes             | Yes                                       |
| Brown long-eared       | 1, <u><b>2, 3</b></u> , 5, 6, 8, 15                        | LC          | Yes             | Yes                                       |
| Common pipistrelle     | 1, <u><b>2, 3</b></u> , 5, <u><b>8, 11</b></u> , 15        | LC          | No              | No                                        |
| Daubenton's            | 1                                                          | LC          | No              | No                                        |
| Leisler's              | 1, <u><b>2, 3</b></u> , 5, <u><b>8, 11</b></u>             | NT          | No              | No                                        |
| Nathusius' pipistrelle | 1, <u><b>2, 3</b></u> , <u><b>8</b></u> , 11               | NT          | No              | No                                        |
| Natterer's             | 1, <u><b>2, 8, 11</b></u> , 15                             | LC          | No              | No                                        |
| Noctule                | 1, 2, <u><b>3, 4</b></u> , 5, <u><b>8, 11</b></u> , 15     | LC          | Yes             | Yes                                       |
| Serotine               | 1, 2, 5, <u><b>8</b></u> , 11                              | VU          | No              | *Yes                                      |
| Soprano pipistrelle    | 1, 2, <u><b>3, 4</b></u> , 5, <u><b>8, 11</b></u> , 12, 15 | LC          | Yes             | Yes                                       |
| Whiskered              | 8                                                          | DD          | No              | No                                        |
| <i>Myotis</i> spp.     | 1, 2, <u><b>3, 4</b></u> , 5, 8, 11, 15                    | –           | –               | –                                         |
| <i>Nyctalus</i> spp.   | 1, <u><b>3, 4</b></u> , 5                                  | –           | –               | –                                         |

**Table 4.** Currently identified maternity and hibernation roost records within the immediate environs of the NNR. CSZ (core sustenance zone) indicates the radius in km beyond a communal (maternity/hibernation) roost considered habitat-critical for the colony using a given roost. Note that roosts are often multi-species, therefore the total number of species roosts (66) may be higher than the actual number of roosts. See also Appendix I, Fig. S10.

| Species                     | Roost type  | No. of roosts | CSZ (km) | Within NNR | Within 0.1 km | Within 0.1–1 km | Within 1–5 km | Total roosts |
|-----------------------------|-------------|---------------|----------|------------|---------------|-----------------|---------------|--------------|
| Brown long-eared            | Hibernation | 12            | NA       | Y (2)      | N             | Y (3)           | Y (7)         | 14           |
|                             | Maternity   | 2             | 3        | N          | Y (1)         | Y (1)           | –             |              |
| Common pipistrelle          | Hibernation | 3             | NA       | N          | N             | N               | Y (3)         | 5            |
|                             | Maternity   | 2             | 2        | N          | Y (1)         | N               | Y (1)         |              |
| Daubenton's                 | Hibernation | 6             | NA       | Y (1)      | N             | Y (1)           | Y (4)         | 6            |
|                             | Maternity   | 0             | 2        | –          | –             | –               | –             |              |
| Leisler's                   | Hibernation | 2             | NA       | N          | N             | N               | Y (2)         | 11           |
|                             | Maternity   | 9             | 3        | N          | Y (7)         | Y (1)           | Y (1)         |              |
| Nathusius'                  | Hibernation | 1             | NA       | N          | N             | N               | Y (1)         | 1            |
|                             | Maternity   | 0             | 3        | –          | –             | –               | –             |              |
| Natterer's                  | Hibernation | 8             | NA       | Y (2)      | N             | Y (2)           | Y (4)         | 8            |
|                             | Maternity   | 0             | 4        | –          | –             | –               | –             |              |
| Noctule                     | Hibernation | 1             | NA       | N          | N             | Y (1)           | N             | 4            |
|                             | Maternity   | 3             | 4        | N          | Y (1)         | N               | Y (2)         |              |
| Serotine                    | Hibernation | 1             | NA       | N          | N             | N               | Y (1)         | 1            |
|                             | Maternity   | 0             | 4        | –          | –             | –               | –             |              |
| Soprano pipistrelle         | Hibernation | 1             | NA       | N          | N             | N               | Y (1)         | 8            |
|                             | Maternity   | 7             | 3        | N          | Y (1)         | N               | Y (6)         |              |
| Whiskered/Brandt's/Alcathoe | Hibernation | 4             | NA       | N          | N             | Y (1)           | Y (3)         | 4            |
|                             | Maternity   | 0             | 1        | –          | –             | –               | –             |              |
| <i>Myotis</i> spp.          | Hibernation | 3             | NA       | N          | N             | Y (1)           | Y (2)         | 4            |
|                             | Maternity   | 1             | 4        | N          | N             | N               | Y (1)         |              |

### Bioacoustic data: between area differences in bat species detections (ANOVA)

A further interrogation of the bioacoustic data revealed no difference in mean number of bat species detections between areas ( $F_{(2,12)} = 0.4229$ ,  $P > 0.05$ ). However, differences between area for species groups was detected in *Pipistrellus* spp. ( $F_{(2,933)} = 4.278$ ,  $P < 0.05$ ) (Area 8+Area 2-3-4; Area 11+Area 2-3-4, Tukey's HSD  $P < 0.05$ ) and *Nyctalus* spp. ( $F_{(2,273)} = 49.25$ ,  $P < 0.01$ ) (Area 8+Area 11; Area 8+Area 2-3-4, Tukey's HSD  $P < 0.01$ ). There was no detected difference between areas for *Myotis* spp. ( $F_{(2,71)} = 1.181$ ,  $P > 0.05$ ), or *Eptesicus serotinus* ( $F_{(1,61)} = 1.662$ ,  $P > 0.05$ ; Area 8 excluded as only one set of observations on 12/07/24). No tests were performed for *Plecotus* spp. due to small sample size.

### Bioacoustic data: within area differences in bat species detections (ANOVA)

#### Area 2-3-4 (Cobham Wood+The Leisure Plots+Ranscombe Farm)

We found within area differences in mean number of species detections between AudioMoth deployment sites for Area 2-3-4 ( $F_{(2,108)} = 5.556$ ,  $P < 0.01$ ) (AM1.1+AM2.1; AM2.1+AM3.1, Tukey's HSD  $P < 0.05$ ) (Fig. 2). While there was no difference in mean number of detections between AM deployment sites for *Pipistrellus* spp. ( $F_{(1,44)} = 2.995$ ,  $P > 0.05$ , no bats detected at AM3.1) or *Myotis* spp. ( $F_{(1,15)} = 0.01389$ ,  $P > 0.05$ ), a significant difference was observed for *Nyctalus* ( $F_{(2,43)} = 14.65$ ,  $P < 0.01$ ) (AM1.1+AM3.1; AM2.1+AM3.1, Tukey's HSD  $P < 0.01$ ).

#### Area 8 (Silverhand Estate)

We found within area differences in mean number of species detections between AudioMoth deployment sites for Area 8 ( $F_{(2,526)} = 153.3$ ,  $P < 0.01$ ) (AM3.1+AM2.1; AM3.1+AM1.1, Tukey's HSD  $P < 0.01$ ), and between all species groups: *Pipistrellus* spp. ( $F_{(2,331)} = 4.991$ ,  $P < 0.01$ ) (AM2.1+AM3.1, Tukey's HSD  $P < 0.01$ ); *Nyctalus* spp. ( $F_{(2,149)} = 40.51$ ,  $P < 0.01$ ) (AM1.1+AM3.1; AM1.1+AM2.1, Tukey's HSD  $P < 0.01$ ); *Myotis* spp. ( $F_{(2,38)} = 10.47$ ,  $P < 0.01$ ) (AM2.1+AM3.1, Tukey's HSD  $P < 0.01$ ) (Fig. 3).

#### Area 11 (Holborough Woodlands)

For Area 11 we found no difference in mean number of bat detections between AM deployment sites ( $F_{(2,574)} = 0.816$ ,  $P > 0.05$ ) or between species groups: *Pipistrellus* spp. ( $F_{(2,487)} = 1.815$ ,  $P > 0.05$ ); *Nyctalus* spp.: ( $F_{(2,71)} = 1.819$ ,  $P > 0.05$ ); *Myotis* spp. ( $F_{(1,5)} = 0.6145$ ,  $P > 0.05$ ) (Fig. 4).

**Table 5.** Species-group detections from bioacoustic surveys of three areas comprising five land parcels across the NNR. Data for the single active survey are shown in parentheses. Survey dates as per Table 2/ Fig. 2–4.

| Species cluster            | Area 2-3-4<br>Cobham Wood; The Leisure Plots;<br>Ranscombe Farm | Area 8<br>Silverhand<br>Estate | Area 11<br>Holborough<br>Woodlands | Total        |
|----------------------------|-----------------------------------------------------------------|--------------------------------|------------------------------------|--------------|
| <i>Myotis</i> spp.         | 17 (8)                                                          | 41                             | 8                                  | 66           |
| <i>Nyctalus</i> spp.       | 46 (4)                                                          | 152                            | 74                                 | 272          |
| <i>Pipistrellus</i> spp.   | 46 (66)                                                         | 334                            | 490                                | 870          |
| <i>Plecotus</i> spp.       | 2                                                               | 1                              | 1                                  | 4            |
| <i>Eptesicus serotinus</i> | (4)                                                             | 1                              | 4                                  | 5            |
| <b>Total</b>               | <b>111 (82)</b>                                                 | <b>529</b>                     | <b>577</b>                         | <b>1,217</b> |

### OBJECTIVE 2: KEY SITES FOR BAT SPECIES IN THE PROPOSED NNR

Of the 15 land parcels, five—Camer park (7), Crabble Bottom (9), Shorne Common Rough (10), Great Crabbles Wood (13), South Ashenbank Wood (14)—had no record of bat species presence (Table 3). Of the remaining 10 land parcels, Shorne Woods Country Park (1) had 11 species/species-groups; Silverhand Estate (8) had 10 species/species-groups; Cobham Woods (2) had 9 species/species-groups; The Leisure Plots (3) and Ashenbank Woods (5) both had 8 species/species-groups;

Holborough Woodlands (11) had 7 species/species-groups; Cobham Hall School (15) had 6 species/species-groups; Ranscombe Farm (4) had 4 species/species-groups; with West Park (6) and Jeskyns Community Woodland (12) having single species records.

For GB Red List and/or BAP Priority/indicator bat species across the NNR, several species/species-groups were confirmed present (Table 6; Appendix I, Fig. S1–S9). Potential for species/species-group presence within each parcel was determined based on habitat type (see Table 1) and perceived connectivity based on expert judgement.

**Table 6.** Land parcels across the proposed NNR with confirmed records of threat-listed and/or priority/indicator species and the potential for these taxa in a given parcel.

| Parcel/area no. | Parcel/area name           | Species/species-group confirmed                                                                                                              | Species/species-group potential                                                                                 |
|-----------------|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| 1               | Shorne Woods Country Park  | Brown long-eared; Leisler's; Nathusius' pipistrelle; noctule; serotine; soprano pipistrelle                                                  | <i>Myotis</i> spp.                                                                                              |
| 2               | Cobham Woods               | Brown long-eared; Leisler's; Nathusius' pipistrelle; noctule; serotine; soprano pipistrelle                                                  | <i>Myotis</i> spp.                                                                                              |
| 3               | The Leisure Plots          | Brown long-eared; Leisler's; Nathusius' pipistrelle; noctule; soprano pipistrelle                                                            | <i>Myotis</i> spp.; serotine                                                                                    |
| 4               | Ranscombe Farm             | <i>Myotis</i> spp.; noctule; soprano pipistrelle                                                                                             | Brown long-eared; Leisler's; serotine                                                                           |
| 5               | Ashenbank Wood             | Brown long-eared; Leisler's; <i>Myotis</i> spp.; noctule; serotine; soprano pipistrelle                                                      |                                                                                                                 |
| 6               | West Park                  | Brown long-eared,                                                                                                                            | Leisler's; <i>Myotis</i> spp.; noctule; serotine                                                                |
| 7               | Camer Park                 | No records                                                                                                                                   | Leisler's; <i>Myotis</i> spp.; noctule; serotine                                                                |
| 8               | Silverhand Estate          | Brown long-eared; Leisler's; <i>Myotis</i> spp.; Nathusius' pipistrelle; noctule; serotine; soprano pipistrelle; whiskered/Brandt's/Alcathoe | –                                                                                                               |
| 9               | Crabbles Bottom            | No records                                                                                                                                   | Brown long-eared; Leisler's; <i>Myotis</i> spp.; Nathusius' pipistrelle; noctule; serotine; soprano pipistrelle |
| 10              | Shorne Common Rough        | No records                                                                                                                                   | Brown long-eared; Leisler's; <i>Myotis</i> spp.; Nathusius' pipistrelle; noctule; serotine; soprano pipistrelle |
| 11              | Holborough Woodlands       | Leisler's; <i>Myotis</i> spp.; Nathusius' pipistrelle; noctule; serotine; soprano pipistrelle                                                | Brown long-eared                                                                                                |
| 12              | Jeskyns Community Woodland | Soprano pipistrelle                                                                                                                          | Brown long-eared; Leisler's; <i>Myotis</i> spp.; noctule; serotine                                              |
| 13              | Great Crabbles Wood        | No records                                                                                                                                   | Brown long-eared; Leisler's; <i>Myotis</i> spp.; Nathusius' pipistrelle; noctule; serotine; soprano pipistrelle |
| 14              | South Ashenbank Wood       | No records                                                                                                                                   | Brown long-eared; Leisler's; <i>Myotis</i> spp.; noctule; serotine; soprano pipistrelle                         |
| 15              | Cobham Hall School         | Brown long-eared; noctule; soprano pipistrelle                                                                                               | Leisler's; <i>Myotis</i> spp.; serotine                                                                         |

## DISCUSSION

Our desk-based and ground-truthing activities delivered 2,874 individual observations, 1,299 of which are novel and recent records of bats within five land parcels (three sampled areas) of the NNR. We indicate the presence of 12 bat species (Alcathoe; brown long-eared; Daubenton's; Kuhl's, Nathusius', common, and soprano pipistrelle; Leislars; Natterer's; noctule; serotine; whiskered) comprising four species groups (*Myotis* spp., *Nyctalus* spp., *Pipistrellus* spp., *Plecotus* spp.), with these taxa distributed within and across at least 10 of the 15 land parcels currently earmarked as components of the NNR. We also determined the presence of multiple hibernation roosts within the NNR (brown long-eared; Daubenton's; Natterer's) and within a 5 km radius (brown long-eared; common, Nathusius', and soprano pipistrelle; Daubenton's; Leisler's; Natterer's; noctule; serotine; *Myotis* spp.). Either currently or historically, six bat species (brown long-eared; common, Nathusius', and soprano pipistrelle; Leisler's'; and noctule) are recorded to breed within and/or up to a 5 km radius of the NNR, as indicated by the presence of multiple maternity roosts.

Given the general lack of spatially representative observations from KMBRC/KBG records across the NNR (e.g. southern land parcels including 7, 8, 11, e.g. see Appendix I, Fig. S1–S9) we consider it likely that the current presence/absence status of bat species is highly underrepresented and as such in urgent need of further assessment. This lack of data also extends to knowledge of all types of communal roosts, as well as landscape-based resource-use by bats.

Using bioacoustic data collected across three sampled areas (comprising five land parcels) we observed between-area differences in bat species-group detections for *Pipistrellus* spp. between Area 8 (Silverhand Estate) and Area 2-3-4 (Cobham Wood+The Leisure Plots+Ranscombe Farm), and between Area 11 (Holborough Woodlands) and Area 2-3-4; and for *Nyctalus* spp. between Area 8 and Area 11, and Area 8 and Area 2-3-4. We also observed within-area differences for *Nyctalus* spp. at Area 2-3-4, and Area 8, and for both *Pipistrellus* spp., and *Myotis* spp. at Area 8. Of note was the low number of species-group detections for AudioMoth 3.1 in Area 2-3-4 which recorded just six detections (3 x *Myotis* spp., 3 x *Nyctalus* spp.) over five nights, compared to 21 for AM 1.1, and 84 for AM 2.1 over the same period. By contrast, Area 11 deployments recorded five species/species-groups, returning 421 identified detections over a five-day period.

Although the deployment site of AM3.1 in Area 2-3-4 was within a monoculture of densely planted, coppiced chestnut woodland (which would likely explain the significant difference between species detections here and the AM1.1 and AM2.1 deployment sites), overall, several factors likely contributed to the differences we observed in bat bioacoustic data between and within areas. As well as deployment site, these include sampling design, imperfect detection, and bioacoustic interference. However, despite such limitations, our results suggest the validity of long-held hypotheses regarding space- and habitat-use differentiation/partitioning between bat species, and that given habitat heterogeneity across the NNR (e.g. ancient and semi-natural woodland, wetland, parkland, pasture, orchards, vineyards, grassland, etc.), there are multiple avenues of opportunity to further explore resource-use by multiple bat species, with a view to informing measures for habitat management.

### OBJECTIVE 1: BAT SPECIES PRESENT IN THE PROPOSED NNR AREA

GB Red List threatened and BAP Priority/KBS Indicator Species present within the NNR are brown long-eared; Leisler's; Nathusius' and soprano pipistrelle; noctule; and serotine (Table 3; Appendix I, Fig. S1–S9). A summary of the ecology of these species and their conservation priorities is provided in Table 7.

The GB Red List status of several *Myotis* species, namely whiskered, Brandt's, and Alcathoe, is currently Data Deficient. Identification in the hand is generally required for these species and as such, their true UK-wide distribution is unknown. Similarly, using bioacoustic variables to identify these and other UK *Myotis* species can also be problematic. *Myotis* bats were consistently recorded within the NNR, and as this taxon includes GB Red List threatened and BAP Priority Species, *Myotis* spp. are

rightly considered within our survey and management recommendations.

**Table 7.** Ecology and conservation priorities of GB Red List threatened/BAP Priority Species/KBS Indicator Species recorded within the NNR.

| Species                | Habitat requirements                                                                                                                                                                                                                                            | Conservation Priorities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Brown long-eared       | <ul style="list-style-type: none"> <li>Roosts within both trees and buildings, as well as bat boxes</li> <li>Preferred foraging habitat is woodland, tree lines, and hedgerows (all unlit)</li> </ul>                                                           | <ul style="list-style-type: none"> <li>Trapping in woodland areas to provide more accurate information on the species distribution</li> <li>Less intensive woodland management to increase invertebrate abundance and diversity</li> <li>Retention of mature trees to provide increased roosting opportunities, particularly in areas away from the impacts of artificial lighting and cat predation</li> <li>Creation and retention of unlit, densely vegetated corridors linking woodland foraging habitat to urban roost locations</li> <li>Public education regarding importance of buildings for roosts, with dark connecting corridors to woodland</li> </ul> |
| Leisler's              | <ul style="list-style-type: none"> <li>Roosts within trees and buildings, also uses tree-mounted bat boxes</li> <li>Foraging habitat includes cattle grazed pasture, woodland and parkland.</li> <li>Light tolerant and forages around street lights</li> </ul> | <ul style="list-style-type: none"> <li>Less intensive woodland management to increase invertebrate abundance and diversity</li> <li>Retention of mature trees to provide increased roosting opportunities</li> <li>Effective management and protection of the farmed landscape in the vicinity of maternity roosts including permanent grazing pasture</li> <li>Public education regarding importance of buildings for roosts</li> </ul>                                                                                                                                                                                                                            |
| Nathusius' pipistrelle | <ul style="list-style-type: none"> <li>Roosts within buildings and trees</li> <li>Maternity roosts frequently shared with soprano pipistrelle</li> <li>Forages in riparian habitat, and close to large bodies of freshwater</li> </ul>                          | <ul style="list-style-type: none"> <li>Creation and management of wetland habitats with associated riparian vegetation</li> <li>Less intensive woodland management to increase invertebrate abundance and diversity</li> <li>Retention of mature trees to provide increased roosting opportunities</li> <li>Management to provide species-rich grassland and hedgerows</li> </ul>                                                                                                                                                                                                                                                                                   |
| Noctule                | <ul style="list-style-type: none"> <li>Roosts within trees and tree-mounted bat boxes</li> <li>Foraging habitat includes cattle grazed pasture, woodland and parkland</li> </ul>                                                                                | <ul style="list-style-type: none"> <li>Less intensive woodland management to increase invertebrate abundance and diversity</li> <li>Retention of mature trees to provide increased roosting opportunities</li> <li>Effective management and protection of the farmed landscape including permanent grazing pasture</li> </ul>                                                                                                                                                                                                                                                                                                                                       |
| Serotine               | <ul style="list-style-type: none"> <li>Roosts within buildings only, rarely found in bat boxes</li> <li>Preferred foraging habitats are cattle-grazed pasture, parkland and woodland edge</li> </ul>                                                            | <ul style="list-style-type: none"> <li>Effective management and protection of the farmed landscape in the vicinity of maternity roosts including permanent grazing pasture</li> <li>Chalk grassland restoration in east Kent has been proven to significantly benefit this species</li> <li>Public education regarding importance of buildings for roosts</li> </ul>                                                                                                                                                                                                                                                                                                |
| Soprano pipistrelle    | <ul style="list-style-type: none"> <li>Roosts within buildings, trees and bat boxes</li> <li>Most known maternity sites are close to rivers</li> <li>Forages within a broad range of habitats, including riparian habitat, gardens, hedgerows and</li> </ul>    | <ul style="list-style-type: none"> <li>Creation and management of wetland habitats with associated riparian vegetation</li> <li>Less intensive woodland management to increase invertebrate abundance and diversity.</li> <li>Retention of mature trees to provide increased roosting opportunities</li> </ul>                                                                                                                                                                                                                                                                                                                                                      |

| Species | Habitat requirements                    | Conservation Priorities                                                                                                                                                                                             |
|---------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         | both large and small woodland fragments | <ul style="list-style-type: none"> <li>• Management to provide species-rich grassland and hedgerows</li> <li>• Public education regarding roost protection and providing foraging habitat within gardens</li> </ul> |

## OBJECTIVE 2: KEY SITES FOR BAT SPECIES IN THE PROPOSED NNR

The availability of records varies among the constituent land parcels of the NNR, including a general lack of information regarding roost locations. As such, any indication of areas which are more/less important to the bat species assemblage based on existing records and recent survey information are inadvisable. Further surveys of both activity and potential roosting resources are recommended across all 15 land parcels to assist in identifying areas of importance ('hot spots') upon which to focus monitoring and/or management. Crucially however, there is remarkable consistency between records for 1981–2023 and the 2024 verification (ground-truthing) exercise reported herein, and this trend encompasses both species assemblage and general habitat types, indicating the historic and continued importance of the area for bats.

With reference to critical habitat for breeding, specifically maternity roosts, multiple sites within the NNR are within the estimated Core Sustenance Zone (as per BCT Guidelines). We report maternity roosts for brown long-eared, Leisler's, noctule, serotine, and soprano pipistrelle (regional and national species of conservation concern, i.e. GB Red List, BAP Priority Species, Kent Biodiversity Strategy Indicator Species; Table 3) located within a 5 km radius of the NNR. Notably, 7 maternity roosts for Leisler's bats lie within 100 m of boundaries of northern land parcels of the NNR. Furthermore, multiple hibernation roosts for these species and Nathusius' pipistrelle are also present within the NNR and its surrounding 5 km radius, including several which are well-established and with evidence of historic and long-term use.

## OBJECTIVE 3: PRIORITIES AND RECOMMENDATIONS FOR FUTURE SURVEY AND MONITORING

We show that sites throughout the NNR support several bat species that are national conservation priorities. These include woodland specialists, and those which require a mosaic of habitats such as species-rich meadow, mixed or deciduous woodland, wetland habitats, and in some cases, built development. As such, both the range of habitats within the NNR and its geographic setting provide an excellent basis from which to develop a program of conservation management comprising surveys, research, habitat management, and public engagement to maintain and enhance a diverse bat species assemblage. Priorities for future survey work, including some initial estimations of the monetary cost of each Priority, are provided in Table 8. Given the current impracticality of determining the present status of multiple bat species across the NNR, the implementation of such recommendations is crucial for informing the next-steps toward improving their status (and likely also for bats across the county of Kent). In concert with an informed approach to habitat management (below) these actions should contribute to the formulation of a roadmap with the potential to achieve both improved conservation status, and a climate-resilient bat species assemblage.

## OBJECTIVE 4: PRIORITIES AND RECOMMENDATIONS FOR HABITAT MANAGEMENT

Recommendations for increasing habitat suitability for both current and potential bat species are listed in Table 9. These include measures within the NNR as well as strategic opportunities to enhance linkage to known offsite maternity and hibernation roost locations. The survey and monitoring information detailed will provide a baseline for further site-specific recommendations to be developed.

**Table 8.** Priority survey and monitoring recommendations for the NNR. Activities aim to fill data gaps, identify the relative importance of species-specific features, and inform approaches to habitat management. Priorities are listed in relative order, but one or more activities could be included or omitted within a given (e.g. yearly) timeframe, for example Priority 1 could be combined with Priority 7. + = multi year.

| Priority | Focus                                                                                                                                                                                                        | Period            | Summary of methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Resource requirements                                                                                                                                                                                                                                                                                                                    | Focus species and rationale                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | Establishment of a long-term bioacoustic monitoring programme for bats to determine species hotspots and habitat use to inform management and to monitor the effects of habitat management in the long term. | May–September.    | <p>High density placement of passive acoustic monitoring devices (for example AudioMoth detectors) within proposed NNR land parcels for four weeks, with minimum ten detectors rotated between areas through the bat survey season. Data processed and analysed using cutting-edge machine learning and AI identification tools (comprising randomly selected manual verification).</p> <p>Deployment of AudioMoth devices will also provide data for (i) bird monitoring, and (ii) soundscape analyses, which can be used as an indicator of ecosystem health.</p> | <p>Ten site visits per year (minimum) to install/collect detectors.</p> <p>10 x AudioMoth detector kits including waterproof case, batteries and microSD cards. Auto-identification software. Data analysis, data management and storage, data validation.</p> <p>Cost estimation: <b>Year 1: £7,500; year 2+: £5,000 (minimum).</b></p> | <p>Whole assemblage; targeting of species of conservation concern (see Table 3, 7). Determine presence/absence of nationally rare/under-recorded <i>Myotis</i> spp.</p> <p>Assess and evaluate baseline bat activity in relation to spatio-temporal differences between and among habitat types.</p> <p>Collect information on seasonal and/or annual land management practices across the NNR and develop hypotheses to determine their impacts on bat species assemblage. Identify areas of interest and formulate a strategy to monitor and evaluate changes in activity with a view to informing management activities to improve habitat.</p> <p>Identify roost locations as indicated by patterns in activity at emergence times.</p> |
| 2        | Mapping of known and potential roost resources.                                                                                                                                                              | Any time of year. | Site visits to assess the distribution and density of trees with suitable roost features. Map results to identify the current resource and areas on which to focus management to increase roost opportunities.                                                                                                                                                                                                                                                                                                                                                      | <p>Site visits to assess roost resources/potential within each of the 15 land parcels. Minimum of 15 days (30 person days: two surveyors) plus 2 days for mapping and reporting.</p> <p>Cost estimation: <b>Year 1 (only): £11,900</b></p>                                                                                               | <p>Tree-roosting species of conservation concern and nationally rare/under-recorded <i>Myotis</i> species.</p> <p>Obtain baseline data to inform management interventions to increase roosting resources.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

| Priority | Focus                                                                          | Period                                                   | Summary of methods                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Resource requirements                                                                                                                                                                                                                                                                                                                                                                                       | Focus species and rationale                                                                                                                                                                                                                                                                                                                                                             |
|----------|--------------------------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3        | Roost identification surveys.                                                  | May-August.                                              | Following (2): <i>Mapping of known and potential roost resources</i> , undertake eDNA sampling of potential tree roosts to assess usage; DNA sampling of faecal material where present. Laboratory analysis of samples.                                                                                                                                                                                                                                                                  | Long-term approach necessary due to large scale of task. Suggest 1–2 weeks of sampling per year. Two surveyors time and laboratory analysis required. Work at height (ladders, climbing) where required.<br><br>Cost estimation: <b>Year 1: £5,000 (minimum) for survey work only. Lab costs and further time TBA.</b>                                                                                      | Tree-roosting species of conservation concern and nationally rare/under-recorded <i>Myotis</i> species.<br><br>Species identification to determine (i) presence/absence, (ii) use of roost resources, and (iii) to inform habitat management interventions to increase roosting resources for species of conservation concern and nationally rare/under-recorded <i>Myotis</i> species. |
| 4        | Bat roost monitoring within purpose-built structures in Silverhand Estate.     | May-September.                                           | Acoustic and visual monitoring of six wildlife towers. Minimum three survey sessions per tower per year.                                                                                                                                                                                                                                                                                                                                                                                 | Detector and camera purchase, six site visits by one surveyor to deploy/collect equipment. Data analysis and verification.<br><br>Cost estimation: <b>Year 1+: £5,000 (minimum).</b>                                                                                                                                                                                                                        | Species of conservation concern that use built structures (see Table 3, 7).<br><br>Evaluate the use of wildlife towers as a conservation initiative for bats.                                                                                                                                                                                                                           |
| 5        | Trapping to verify/identify <i>Myotis</i> spp.                                 | Bat activity season excluding period of dependant young. | To commence year 2. Monitoring period likely to extend over 3–4 years (minimum) due to geographic extent of the survey area. Two overnight trapping sessions to be undertaken within selected land parcels using three harp traps per session. Survey areas to be informed by the outputs of (1): <i>Establishment of a long-term monitoring programme for bats to identify species hotspots to inform management and to monitor the effects of habitat management in the long term.</i> | Project Licence from Natural England and small team of four, including licensed personnel. Will require purchase of three harp traps in year one, acoustic lures, processing equipment. Laboratory analysis of DNA samples where taken (costs likely within those for 3. <i>Roost identification surveys</i> ).<br><br>Cost estimation: <b>Year 1: £25,000 (equipment purchase). Year 2+: up to £5,000.</b> | Species assemblage sampled through trapping with primary focus being to determine which <i>Myotis</i> species are present, but also likely to include nationally rare species such as Bechstein's and rare/under-recorded species such as Alcahoie.<br><br>Results will enable targeted habitat management recommendations and interventions.                                           |
| 6        | Radio-tagging and monitoring of individual bats of rarer <i>Myotis</i> species | Bat activity season excluding period of                  | In combination with (5): <i>Trapping to verify/identify Myotis spp.</i> Radio-tracking of individual bats to identify habitat use (roosting, foraging, habitat corridors).                                                                                                                                                                                                                                                                                                               | Project Licence and radio-tracking equipment. Licensed personnel. One week radio-tracking of one or more individual bats.                                                                                                                                                                                                                                                                                   | Research into habitat requirements of rare and lesser known <i>Myotis</i> spp.                                                                                                                                                                                                                                                                                                          |

| Priority | Focus                                                          | Period            | Summary of methods                                                                                                                                                                                                                                                                                                                                    | Resource requirements                                                                                                                                                                                                                                                                        | Focus species and rationale                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------|----------------------------------------------------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | following trapping under licence.                              | dependant young.  |                                                                                                                                                                                                                                                                                                                                                       | Cost estimation: <b>TBC (new tech continually coming on the market, and possible partnership with academic institution to design bespoke units possible).</b>                                                                                                                                | Results will enable targeted habitat management recommendations and interventions.                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>7</b> | Modelling habitat use and connectivity, species distributions. | Any time of year. | Mapping and predictive modelling to identify opportunities to (i) increase habitat connectivity across the proposed NNR and with the wider landscape of the county; (ii) identify sites and relative connectivity between and among known maternity/hibernation roost locations; (iii) identify prime locations for habitat management interventions. | GIS and modeling software, available bat habitat preference data and habitat maps of the proposed NNR sites, immediate surroundings, and the county to model the potential effects of habitat creation/enhancement measures.<br><br>Cost estimation: <b>Year 1 (only): £5,000 (minimum).</b> | Predict the bat species assemblage against different climate scenarios (e.g. 2030, 2050, 2100, and 1.5°C, 2.0°C, 2.5°C global average temperature increase) and identify optimum recommendations for habitat creation and management to enhance connectivity between high value resources (e.g. foraging habitats and known maternity and hibernation roost locations) and identify locations that will enhance cost-benefit of species-specific habitat management interventions under given climate scenarios. |

**Table 9.** Summary of habitat management recommendations currently considered most relevant to the NNR and species of conservation concern.

| Priority | Habitat management                                     | Summary                                                                                                                                                                                                            | Target species/species-group(s)                                                               | Example land parcels |
|----------|--------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------|
| <b>1</b> | Increase the tree-roosting resource.                   | Short term: Provision of bat boxes, veteranisation where appropriate<br>Long term: Retention of more trees to maturity to enable the development of natural damage/decay features. Retention of standing deadwood. | Brown long-eared; Leisler's; <i>Myotis</i> spp.; Nathusius' and soprano pipistrelle; noctule. | 1, 4, 10, 11.        |
| <b>2</b> | Increase hibernation roost resource.                   | Adapt bunkers to provide additional hibernation roosts in Ashenbank Woods.                                                                                                                                         | Brown long-eared; <i>Myotis</i> spp.; <i>Pipistrellus</i> spp.                                | 5.                   |
| <b>3</b> | Promote dense understorey in existing and regenerating | Reduce and manage tree density to deliver improved understorey across all stages of woodland growth/succession and provide increased abundance and                                                                 | All species/species groups.                                                                   | 4, 11.               |

| Priority | Habitat management                                                                                                   | Summary                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Target species/species-group(s)                                                                                      | Example land parcels          |
|----------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-------------------------------|
|          | woodland.                                                                                                            | diversity of insect prey. Deer management or use of exclusion fencing is likely to be required.                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                      |                               |
| 4        | Create and enhance and/or expand availability of grazed and/or species-rich meadow grassland                         | Availability of larger insect prey is a critical requirement for Leisler's, noctule, and serotine. Essential resource close to (i) tree roosts for Leisler's and noctule, and (ii) building roosts for Leisler's and serotine.                                                                                                                                                                                                                                                                                                            | Leisler's; noctule; serotine.                                                                                        | 1, 4, 6, 8, 11, 12, 15.       |
| 5        | Pond management and creation, rewetting of woodland sites.                                                           | Vegetation and silt management to provide and/or enhance open wetland habitat and increase habitat heterogeneity and insect diversity. Enhancing dampness of woodland, through soft changes to water courses where feasible such as leaky woody dams, will enhance invertebrate food supplies and improve habitat quality. Construction of woodland ponds within densely planted coppiced sites.                                                                                                                                          | <i>Myotis</i> spp.; soprano pipistrelle; overall species richness.                                                   | 1, 2, 3, 4, 5, 6, 12, 14, 15. |
| 5        | Landscape scale approach to configuration of mixed woodland growth stages.                                           | Managed succession. Providing a mosaic of different growth stages across the landscape will result in increased habitat complexity and associated insect biodiversity.                                                                                                                                                                                                                                                                                                                                                                    | Overall species richness.                                                                                            | All sites with woodland.      |
| 6        | Softening edges between woodland and farmland parcels.                                                               | Establishment of scrub at interface between woodland and adjacent land will increase insect biodiversity providing additional foraging habitat.                                                                                                                                                                                                                                                                                                                                                                                           | Overall species richness.                                                                                            | All sites with woodland.      |
| 7        | Improve hedges and field margins in farmed areas.                                                                    | Provide substantial dark corridors to enhance linear connectivity between woodland blocks and between core roosting/foraging areas. Increase plant species-richness and subsequent insect diversity through management of hedges and edges.                                                                                                                                                                                                                                                                                               | Dark corridors: brown long-eared, <i>Myotis</i> spp.<br><br>Hedgerow and insect diversity: overall species richness. | All farmed sites.             |
| 8.       | Landscape scale approach to enhancement of hedgerows and woodland fragments to improve links to offsite roost areas. | Maternity and/or hibernation roosts for 11 species/species groups are located within the NNR and/or within a 5 km radius and include roosts of species of regional and/or national conservation concern (see Table 3–4). Favourable habitat interventions have the potential to increase the productivity and long-term survival of maternity roosts. Maintaining and enhancing habitat connectivity to maternity and hibernation roost locations through offsite habitat creation and management should be seen as a long-term priority. | Brown long eared; Leisler's; <i>Myotis</i> spp.; Nathusius' and soprano pipistrelle; noctule; serotine.              | All sites.                    |
| 9.       | Public engagement.                                                                                                   | Engagement program using (for example) peer-reviewed publications, grey literature (reports), press articles, opinion pieces, organised bat walks, all of which advertise the ongoing activities (and their results) to highlight bat-friendly practices and encourage retention of roosts within buildings within proximity to                                                                                                                                                                                                           | Brown long-eared; Leisler's; serotine; soprano pipistrelle.                                                          | All sites.                    |

| Priority | Habitat management | Summary                                                                                                                                                | Target species/species-group(s) | Example land parcels |
|----------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|----------------------|
|          |                    | the NNR. Explore opportunities to engage local champions for long-term bat monitoring in each land parcel under the National Bat Monitoring Programme. |                                 |                      |

## Opportunities for engagement and collaboration

The NNR offers opportunities to link with wider conservation efforts for bats including Natural England's Species Recovery Project, the Local Nature Recovery Strategy, and the Bat Conservation Trust's Connecting People and Landscapes Project, with potential for woodland trapping of bats alongside the National Barbastelle and Bechstein's Survey (NBBS). Future surveys may also contribute to the Bat Conservation Trust's National Bat Monitoring Program, the results of which are used to inform a broad range of conservation actions including Defra's UK Biodiversity Indicators program (<https://www.gov.uk/government/statistics/biodiversity-indicators-for-the-uk>).

Recommendations for woodland, grassland and wetland management for bats will be of significant benefit to a broad range of flora and fauna, including fungi, plants, invertebrates, amphibians, reptiles, birds, and mammals, many of which rely on a complex mosaic of habitat and resources at different times of year to support feeding, breeding, migration, and activity cycles. Ecological assessments have been undertaken across these plant and animal groups in the proposed NNR, and we strongly recommend the establishment of a steering-group comprising taxon-specialists, landowners, and other stakeholders. We propose that the goal of the steering-group should be to collate, review, monitor, and aid implementation of proposed habitat management interventions making these adaptive to current needs, responsive to future change, highly collaborative, and cost effective, such that maximum ecological benefit is reflected across habitats and species groups while supporting current, ongoing, and future land-use by both landowners and availability for the public good.

We encourage the pursuance of collaborations with local, regional, and national groups, organisations, businesses, and institutions beyond those focussed on bats. Such collaborations may take the form of business sponsorship, scientific research, and public engagement, and can be used to leverage funds to support the development and long-term management of a brand new NNR, itself a novel and infrequently presented opportunity with great biological investment and research potential.

## ACKNOWLEDGEMENTS

We thank Dr John Puckett (Chair, Kent Bat Group) for helpful discussions regarding existing records and the potential value of the NNR; Daisy Jowers for an initial review and preparation of bat record data for GIS work; Ben Birch of ABEC for subsequent GIS mapping of species records; and the landowners and staff of Cobham Wood, The Leisure Plots, Ranscombe Farm, Silverhand Estate, and Holborough Woodlands for supporting and/or facilitating our 2024 surveys.

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## SUPPORTING INFORMATION

### APPENDIX 1

#### Location records for bat species of conservation concern for the period 2013–2023

Mapped using the UK HABS classification system.

Fig. S1. Barbastelle

Fig. S2. Brown long-eared

Fig. S3. Leisler's

Fig. S4. Nathusius' pipistrelle

Fig. S5. Noctule

Fig. S6. Serotine

Fig. S7. Soprano pipistrelle

Fig. S8. *Myotis* spp.

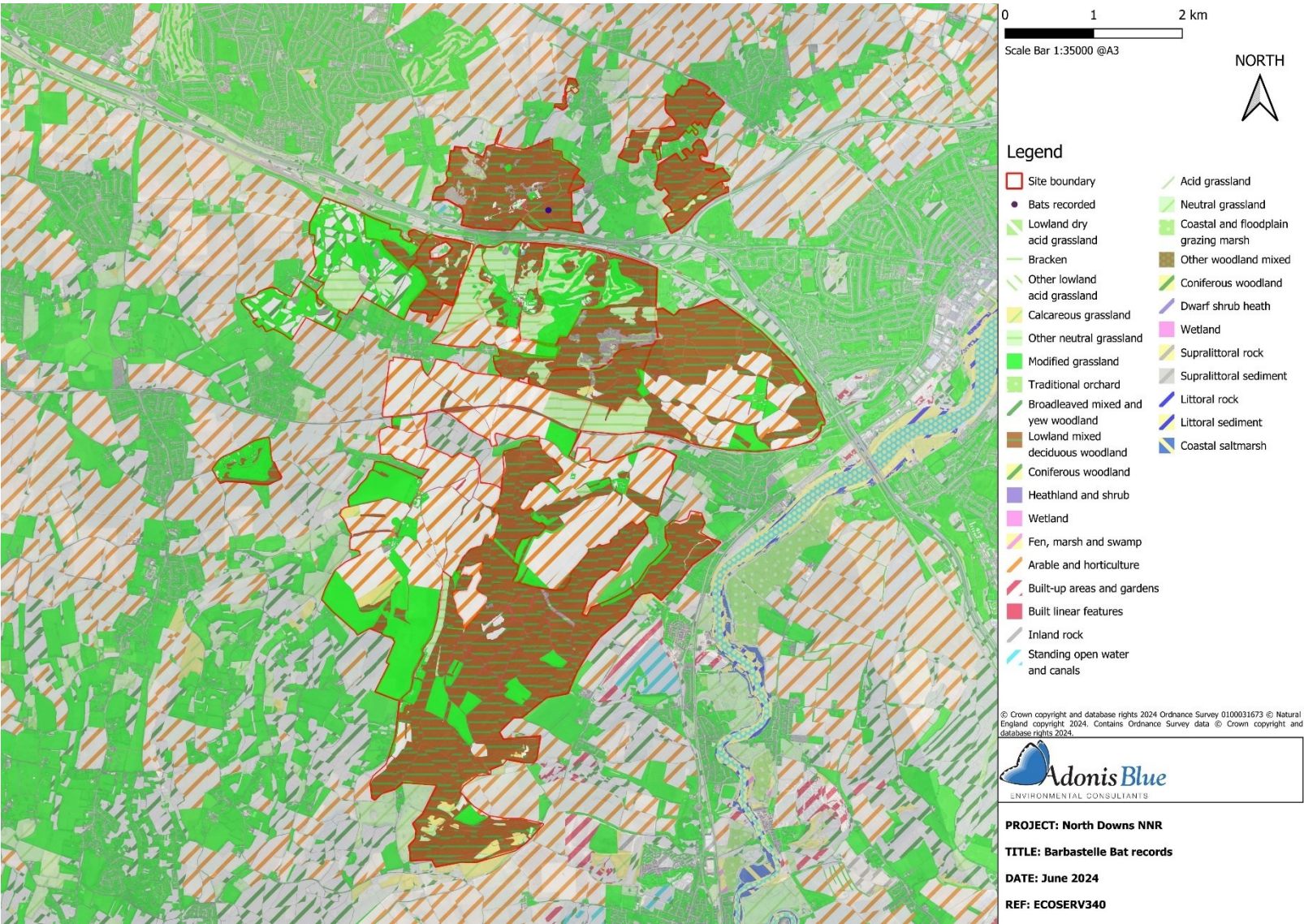
Fig. S9. *Nyctalus* spp.

#### Location of selected roosts relative to the NNR

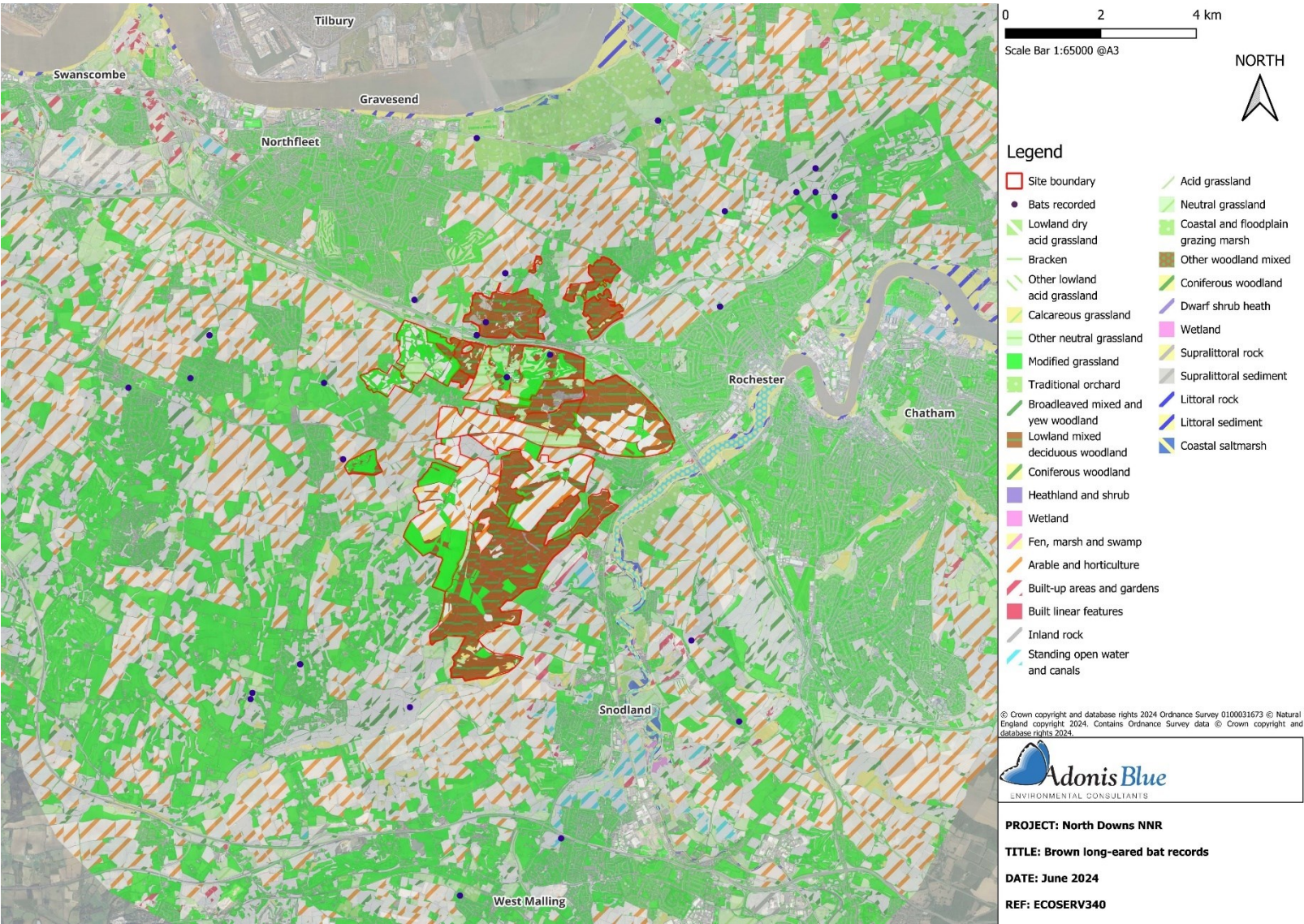
Fig. S10

#### Species records by land parcel/area

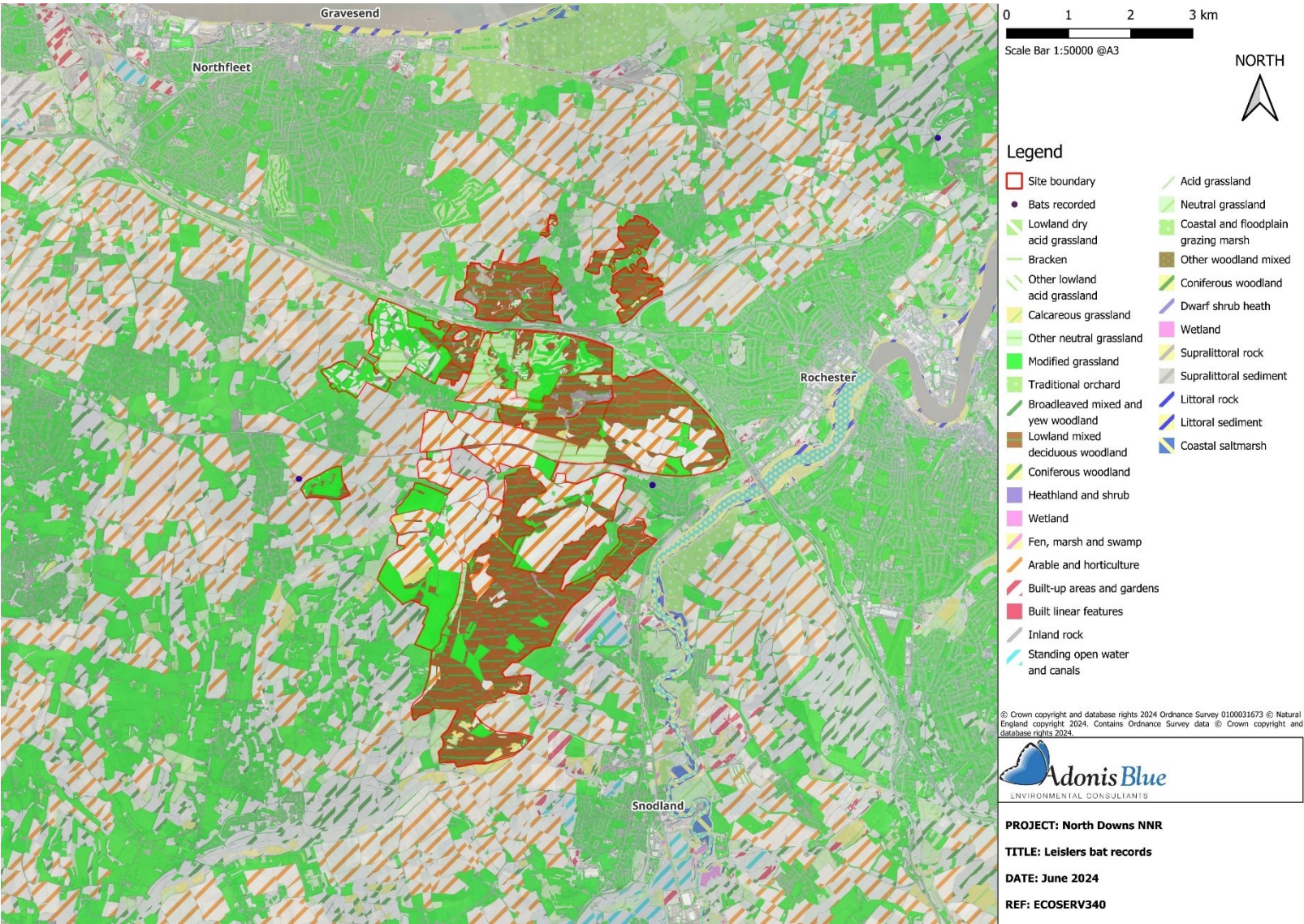
Table S1.



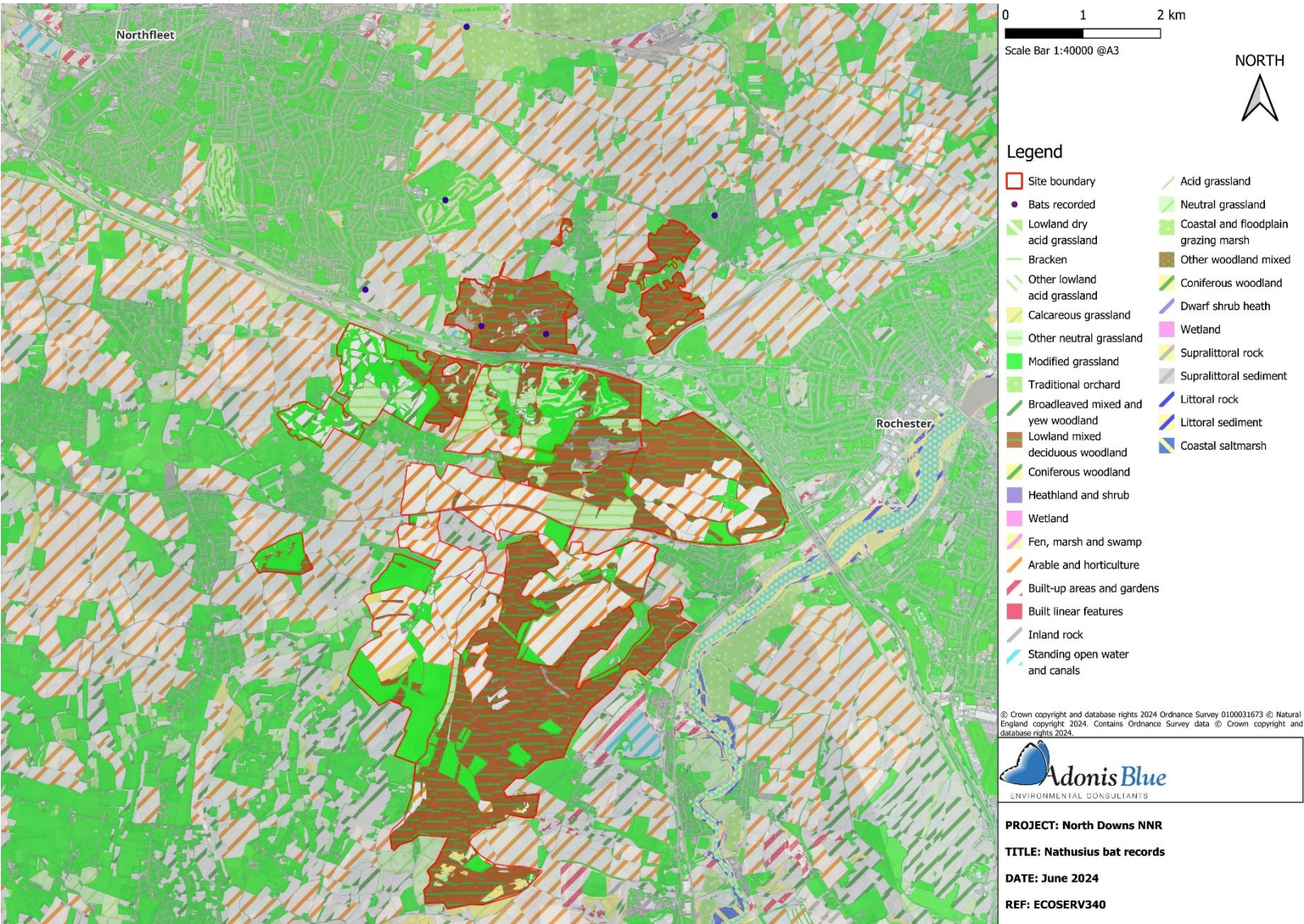
S1. Single (unverified) barbastelle record within the NNR.



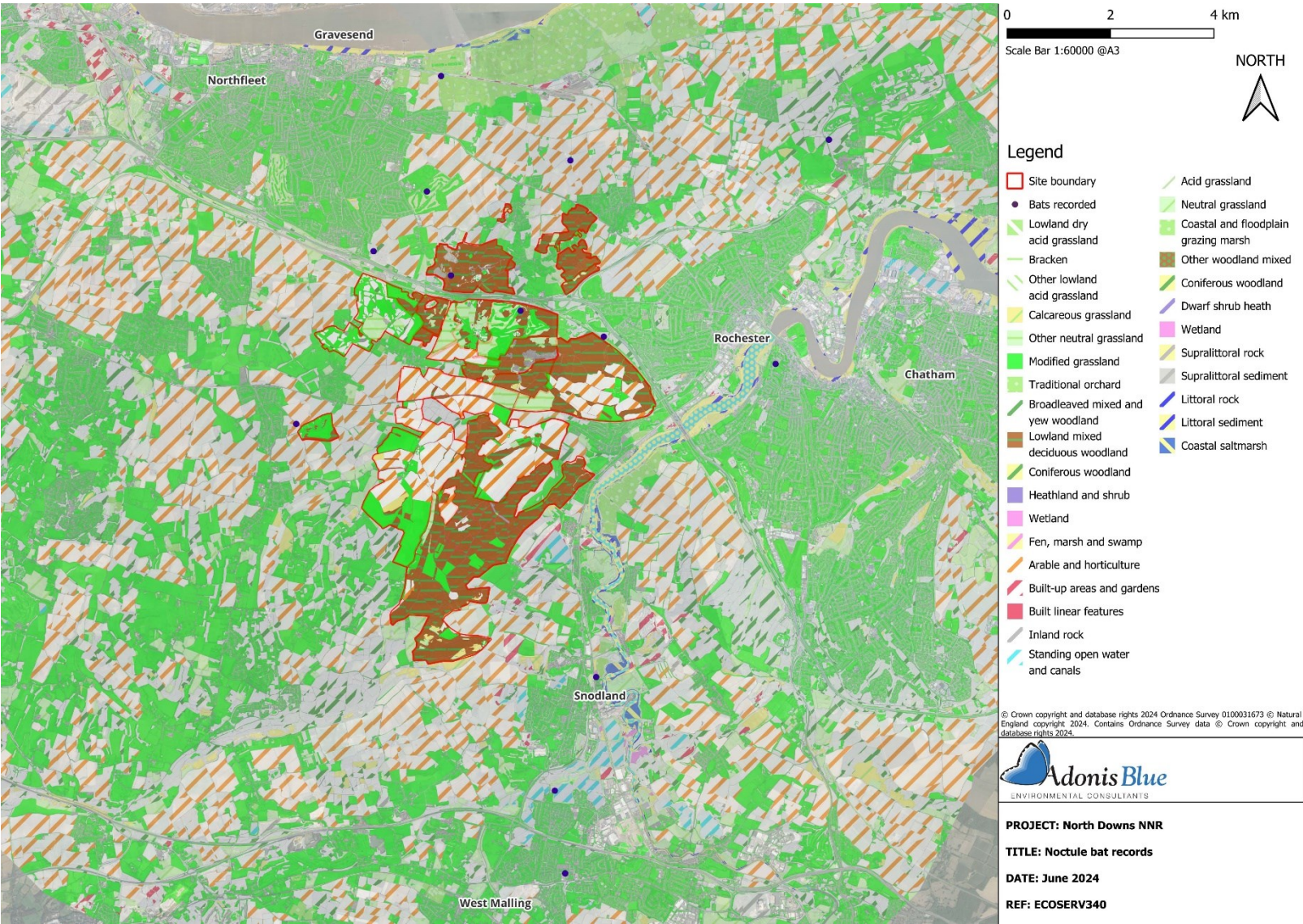
**S2.** Records of brown long-eared bat within the NNR and a 5 km radius. Locations may represent single or multiple observations.



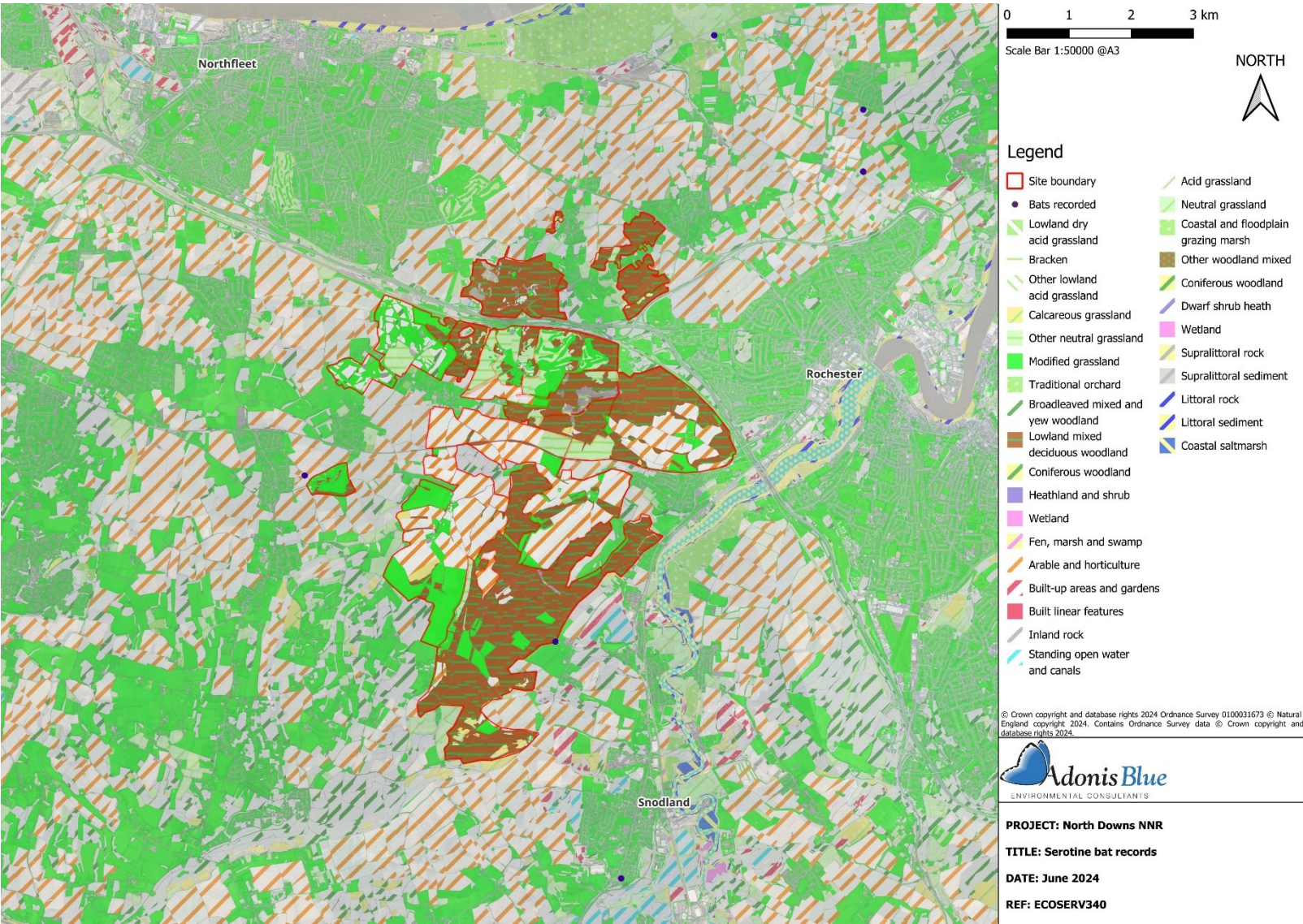
S3. Records of Leisler's bat within the NNR and a 5 km radius. Locations may represent single or multiple observations.



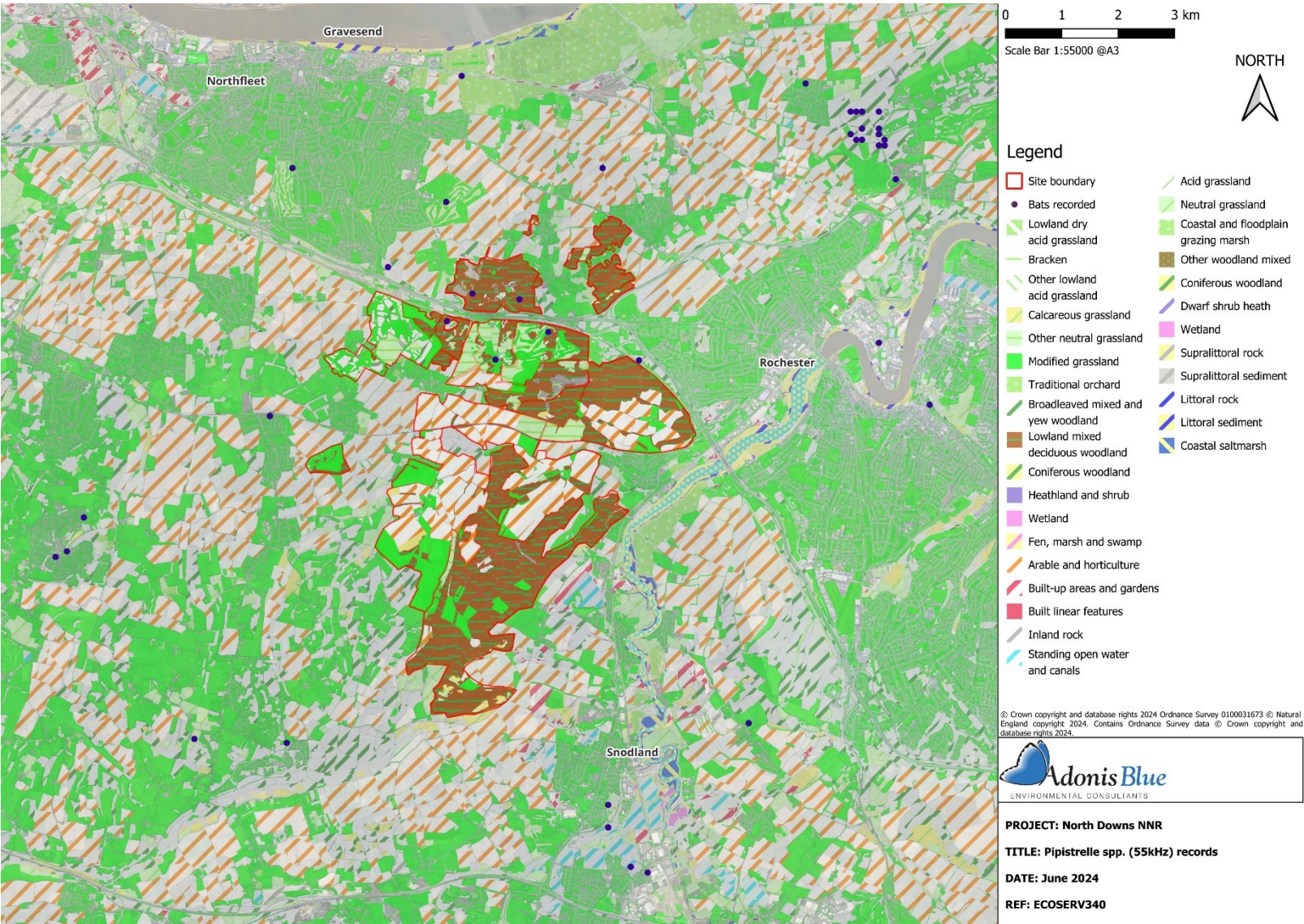
**S4.** Records of Nathusius' pipistrelle within the NNR and a 5 km radius. Locations may represent single or multiple observations.



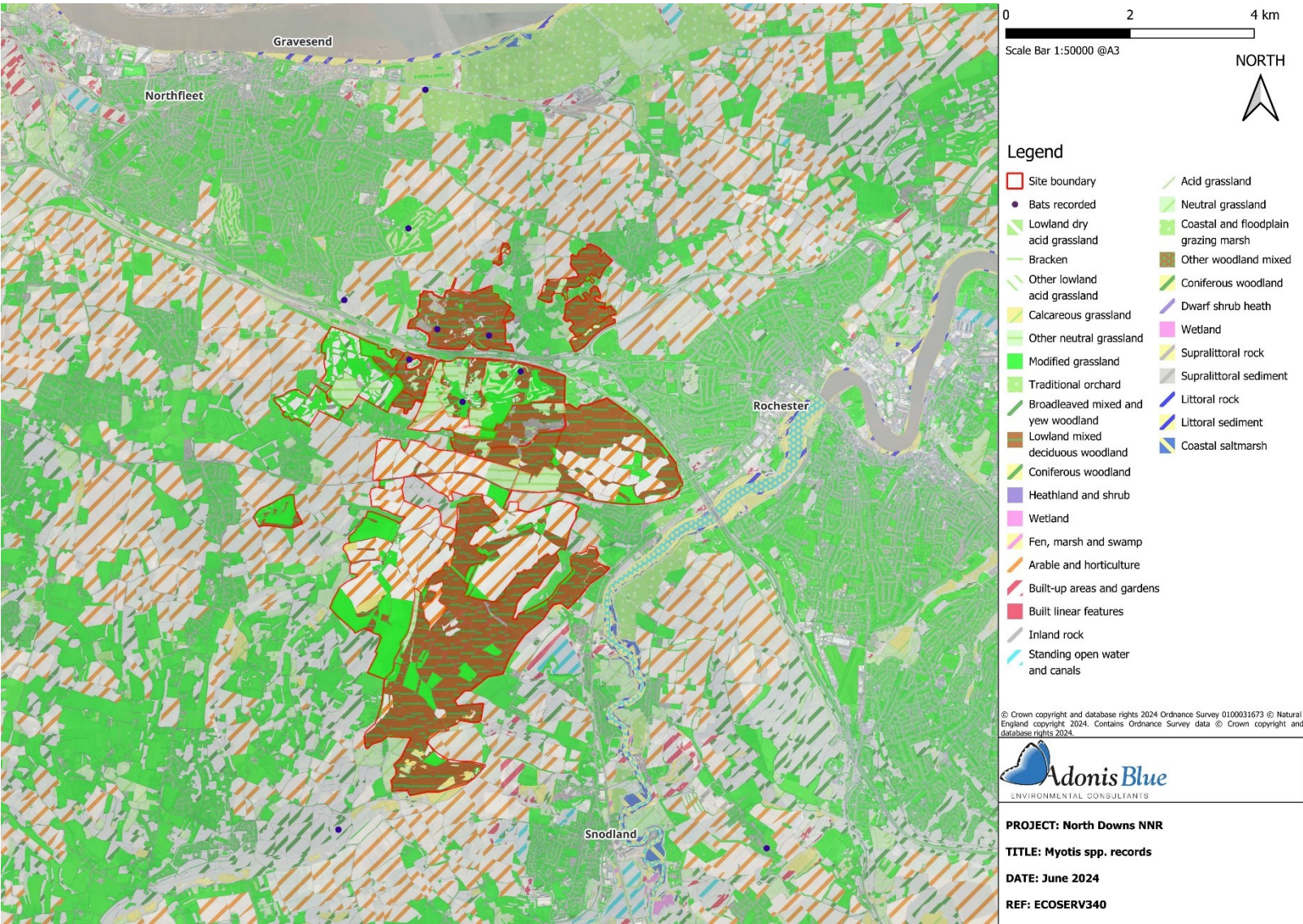
S5. Records of noctule bat within the NNR and a 5 km radius. Locations may represent single or multiple observations.



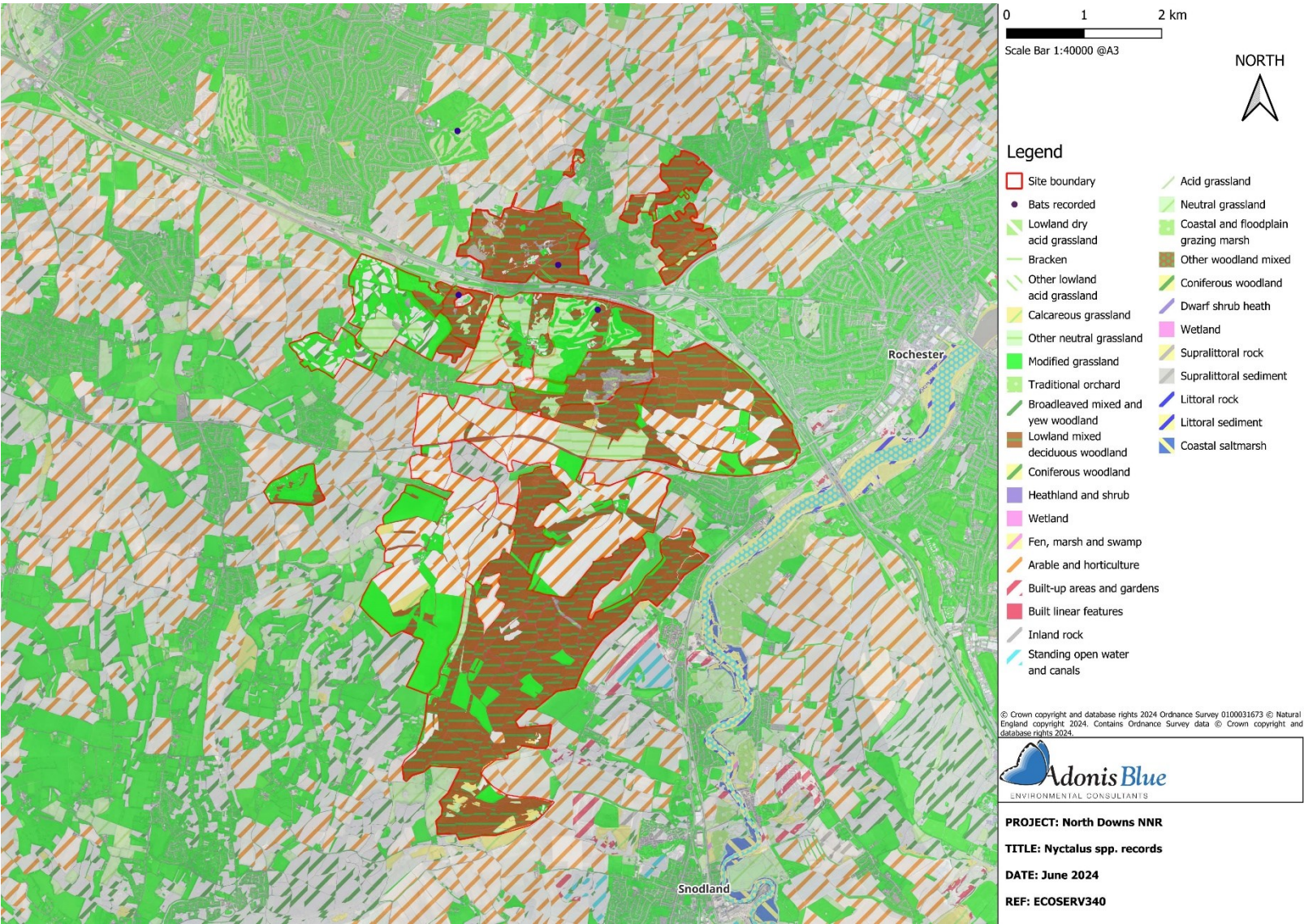
S6. Records of serotine bat within the NNR and a 5 km radius. Locations may represent single or multiple observations.



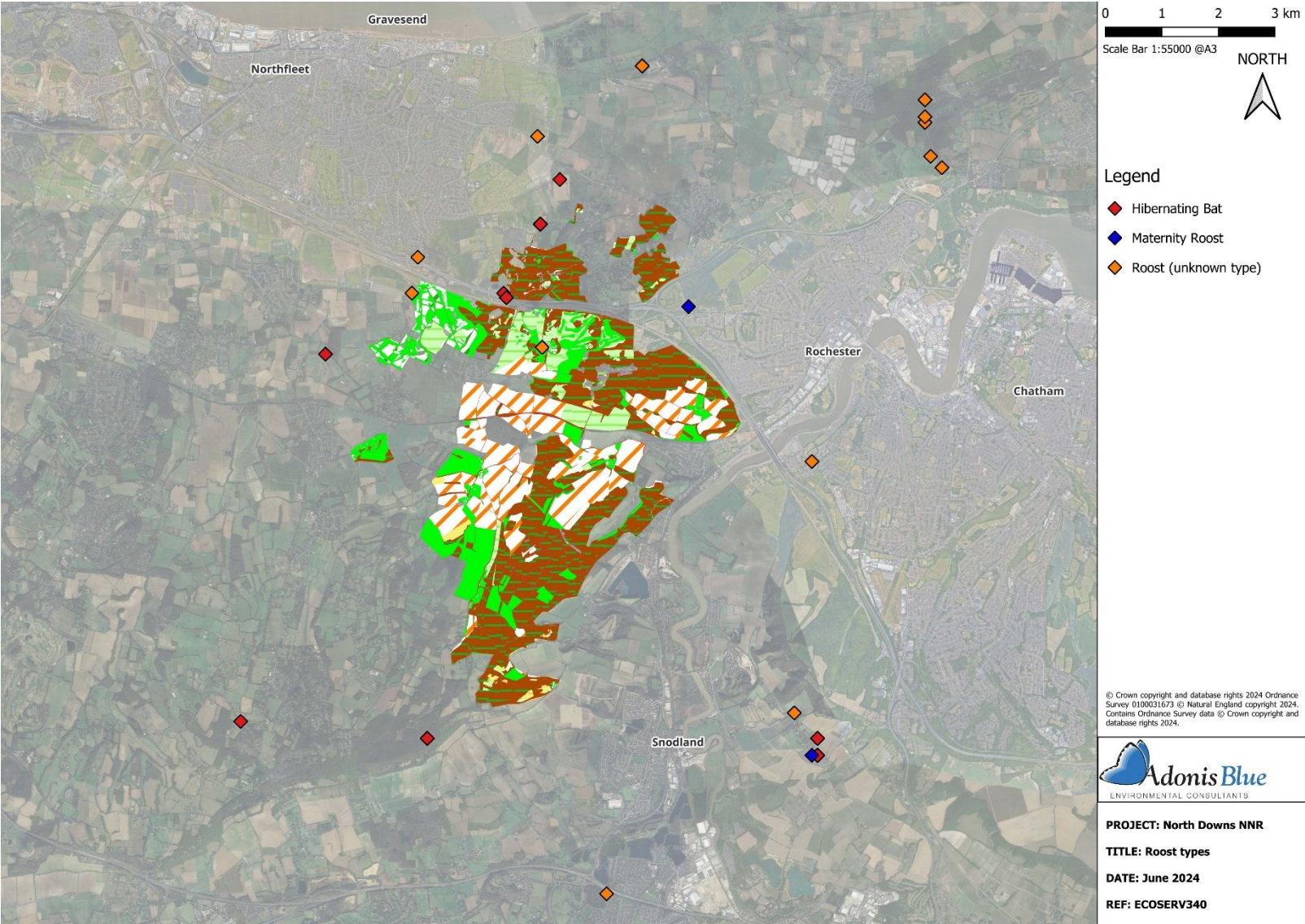
S7. Records of soprano pipistrelle within the NNR and a 5 km radius. Locations may represent single or multiple observations.



S8. Records of *Myotis* spp. within the NNR and a 5 km radius. Locations may represent single or multiple observations.



S9. Records of *Nyctalus* spp. within the NNR and a 5 km radius. Locations may represent single or multiple observations.



**S10.** Records of roosts within the NNR and a 5 km radius. Locations may represent single roosts for multiple species.

**Table S1.** Species records for the NNR by land parcel/area. Data based on (i) analysis and mapping of the KMBRC+KBG dataset, (ii) acoustic monitoring surveys in 2024 ('Records 2024' column). See also Fig. S1–S9; Fig. 1, Table 3 in main text.

| Parcel no. | Parcel name               | Species common name    | Records 1981–2012 | Records 2013–2023 | Records 2024 |
|------------|---------------------------|------------------------|-------------------|-------------------|--------------|
| 1          | Shorne Woods Country Park | Barbastelle            | –                 | UNVERIFIED        | –            |
|            |                           | Brown long-eared       | Y                 | Y                 | –            |
|            |                           | Common pipistrelle     | Y                 | Y                 | –            |
|            |                           | Daubenton's            | Y                 | –                 | –            |
|            |                           | Leisler's              | Y                 | –                 | –            |
|            |                           | <i>Myotis</i> spp.     | –                 | Y                 | –            |
|            |                           | Nathusius' pipistrelle | –                 | Y                 | –            |
|            |                           | Natterer's             | Y                 | Y                 | –            |
|            |                           | Noctule                | Y                 | Y                 | –            |
|            |                           | <i>Nyctalus</i> spp.   | –                 | Y                 | –            |
|            |                           | Serotine               | Y                 | –                 | –            |
|            |                           | Soprano pipistrelle    | Y                 | –                 | –            |
| 2          | Cobham Wood               | Brown long-eared       | –                 | –                 | Y            |
|            |                           | Common pipistrelle     | –                 | –                 | Y            |
|            |                           | Leisler's              | –                 | –                 | Y            |
|            |                           | <i>Myotis</i> spp.     | Y                 | –                 | Y            |
|            |                           | Nathusius pipistrelle  | –                 | –                 | Y            |
|            |                           | Natterers              | –                 | –                 | Y            |
|            |                           | Noctule                | Y                 | –                 | Y            |
|            |                           | Serotine               | Y                 | –                 | –            |
|            |                           | Soprano pipistrelle    | Y                 | –                 | Y            |
| 3          | The Leisure Plots         | Brown long-eared       | –                 | –                 | Y            |
|            |                           | Common pipistrelle     | –                 | –                 | Y            |
|            |                           | Leisler's              | –                 | –                 | Y            |
|            |                           | <i>Myotis</i> spp.     | –                 | –                 | Y            |
|            |                           | Nathusius pipistrelle  | –                 | –                 | Y            |
|            |                           | Noctule                | –                 | –                 | Y            |
|            |                           | <i>Nyctalus</i> spp.   | –                 | –                 | Y            |
|            |                           | Soprano pipistrelle    | –                 | –                 | Y            |
|            |                           | <i>Myotis</i> spp.     | –                 | –                 | Y            |
| 4          | Ranscombe Farm            | Kuhl's pipistrelle     | –                 | –                 | Y            |
|            |                           | Noctule                | –                 | –                 | Y            |

| Parcel no. | Parcel name                       | Species common name         | Records 1981–2012 | Records 2013–2023 | Records 2024 |
|------------|-----------------------------------|-----------------------------|-------------------|-------------------|--------------|
|            |                                   | <i>Nyctalus</i> spp.        | –                 | –                 | Y            |
|            |                                   | Soprano pipistrelle         | –                 | –                 | Y            |
| <b>5</b>   | <b>Ashenbank Wood</b>             | Brown long-eared            | Y                 | –                 | –            |
|            |                                   | Common pipistrelle          | Y                 | Y                 | –            |
|            |                                   | Leisler's                   | Y                 | –                 | –            |
|            |                                   | <i>Myotis</i> spp.          | –                 | Y                 | –            |
|            |                                   | Noctule                     | Y                 | –                 | –            |
|            |                                   | <i>Nyctalus</i> spp.        | –                 | Y                 | –            |
|            |                                   | Serotine                    | Y                 | –                 | –            |
|            |                                   | Soprano pipistrelle         | –                 | Y                 | –            |
| <b>6</b>   | <b>West Park</b>                  | Brown long-eared            | Y                 | –                 | –            |
| <b>7</b>   | <b>Camer Park</b>                 | NO DATA                     | –                 | –                 | –            |
| <b>8</b>   | <b>Silverhand Estate</b>          | Brown long-eared            | Y                 | –                 | Y            |
|            |                                   | Common pipistrelle          | –                 | –                 | Y            |
|            |                                   | Kuhl's pipistrelle          | –                 | –                 | Y            |
|            |                                   | Leisler's                   | –                 | –                 | Y            |
|            |                                   | <i>Myotis</i> spp.          | –                 | –                 | Y            |
|            |                                   | Nathusius' pipistrelle      | –                 | –                 | Y            |
|            |                                   | Natterer's                  | –                 | –                 | Y            |
|            |                                   | Noctule                     | –                 | –                 | Y            |
|            |                                   | Serotine                    | –                 | –                 | Y            |
|            |                                   | Soprano pipistrelle         | –                 | –                 | Y            |
|            |                                   | Whiskered/Brandt's/Alcathoe | Y                 | –                 | Y            |
| <b>9</b>   | <b>Crabbles Bottom</b>            | NO DATA                     | –                 | –                 | –            |
| <b>10</b>  | <b>Shorne Common Rough</b>        | NO DATA                     | –                 | –                 | –            |
| <b>11</b>  | <b>Holborough Woodlands</b>       | Common pipistrelle          | –                 | –                 | Y            |
|            |                                   | Kuhl's pipistrelle          | –                 | –                 | Y            |
|            |                                   | Leisler's                   | –                 | –                 | Y            |
|            |                                   | <i>Myotis</i> spp.          | –                 | –                 | Y            |
|            |                                   | Nathusius pipistrelle       | Y                 | Y                 | Y            |
|            |                                   | Natterer's                  | –                 | –                 | Y            |
|            |                                   | Noctule                     | –                 | –                 | Y            |
|            |                                   | Serotine                    | –                 | Y                 | Y            |
|            |                                   | Soprano pipistrelle         | –                 | –                 | Y            |
| <b>12</b>  | <b>Jeskyns Community Woodland</b> | NO DATA                     | –                 | –                 | –            |

| Parcel no. | Parcel name          | Species common name | Records 1981–2012 | Records 2013–2023 | Records 2024 |
|------------|----------------------|---------------------|-------------------|-------------------|--------------|
| 13         | Great Crabbles Wood  | NO DATA             | –                 | –                 | –            |
| 14         | South Ashenbank Wood | Common pipistrelle  | Y                 | Y                 | –            |
| 15         | Cobham Hall School   | <i>Myotis</i> spp.  | –                 | Y                 | –            |
|            |                      | Natterer's          | Y                 | –                 | –            |
|            |                      | Noctule             | Y                 | –                 | –            |
|            |                      | Soprano pipistrelle | –                 | Y                 | –            |