# Putting woodland bats on the map

# Final report to Scottish Forestry Trust, October 2018



# Chloe Bellamy<sup>1</sup>, Katherine Boughey<sup>2</sup>, Sonia Reveley<sup>2</sup>, Charlotte Hawkins<sup>2</sup>, & Carol Williams<sup>2</sup>

<sup>1</sup> Forest Research; <sup>2</sup> Bat Conservation Trust





# Project summary for SFT website (150-300 word)

For actions aimed at halting biodiversity declines to be effective, significant evidence gaps must be filled. Information on woodland-specialist bat species is scarce because of the difficulties in surveying for bats in these structurally complex environments. This impedes conservation efforts and complicates the design and implementation of woodland management plans aimed at protecting bats and enhancing their habitats. More accurate and cost-effective methods are needed to provide reliable data on the activity levels and distributions of these rare and inconspicuous species.

Over two survey seasons, the Bat Conservation Trust and Forest Research-led project, <u>'Putting UK</u> <u>Woodland Bats on the Map'</u>, has worked with volunteers across four study areas to pilot methods and technologies for surveying woodlands for bats. The aim was to develop, for the first time, a citizen science approach that could be carried out at a large enough scale to provide species- and family-specific trend data on bats in woodlands. In addition to comparing the content and quality of the acoustic data recorded using different devices, practical issues such as equipment affordability and user-friendliness were considered. The findings are being fed into the development of the <u>British Bat Survey</u>, a new monitoring scheme under development by National Bat Monitoring Programme (NBMP).

As well as delivering a baseline for long-term monitoring, the species records collected from the survey are being incorporated into a modelling framework for predicting species distributions at national, regional and local scales. This robust, hierarchical approach is important for identifying the environmental factors influencing a species' habitat suitability and enables the impacts of potential environmental change to be assessed. Once validated, the spatially-explicit outputs can be used to inform targeted woodland- to landscape-scale decision-making and strategies in bat conservation.



# **Overview**

Over the first two years of the 'Putting UK Woodland Bats on the Map' project, significant headway has been made in developing and testing improved methods for gathering data on woodland-specialist bat species in Britain and gaining a better understanding of their ecology and distribution through statistical modelling.

A novel habitat suitability modelling (HSM) framework has been developed to predict species distributions and understand underlying species-environment associations (Bellamy *et al., In Prep*). Existing bat species data have been used to provide baseline model output for six species groups:

- Myotis nattereri
- Myotis bechsteinii
- Plecotus auritus
- Barbastella barbastellus
- Rhinolophus hipposideros
- Myotis brandtii/mystacinus/alcathoe (cryptic small Myotis species)

With the foundations in place thanks to the training and preparation carried out during 2017, the 2018 field survey season started smoothly and volunteers from each study area successfully collected the acoustic and trapping data required. A total of fifty five surveys (acoustic and trapping) across four survey areas (Figure 1) were carried out by volunteers from local bat groups. The data are currently being processed and analysed by staff at BCT and will be used to validate the baseline HSM.



# The project objectives

# Original aims & objectives (October 2016):

- 1. To improve our understanding of the ecological and human factors driving distributions of UK woodland bats at local to national scales.
- 2. To pilot the acoustic method for surveying bats in woodland as recommended by Scott & Altringham (2014) to allow a methodology that will be able to detect trends in woodland bats, to be rolled out over a greater area and with an ultimate aim to roll this out across Britain as part of the BCT National Bat Monitoring programme.
- 3. To utilise existing and upskill new volunteers recruited in woodland bat monitoring to ensure a legacy that will be applied beyond the project period and will ensure maximum gain and added value of the project.
- 4. To develop a transferrable, standardised approach for modelling woodland habitat suitability for a range of bat species.
- 5. To provide resulting national scale GIS data to everyone and regional scale layers to those with the appropriate Ordnance Survey data licence (this covers most public sector organisations), following Defra's Open Data Strategy.
- 6. To inform and update guidance to all those involved in woodland and forest management and creation, including those with a regulatory responsibility.
- 7. To make these findings robust enough to share via a peer reviewed paper to be published in an open access journal alongside the accompanying model code

# Progress towards our objectives (October 2018)

1. To improve our understanding of the ecological and human factors driving distributions of UK woodland bats at local to national scales.

This objective will be the last to be fully met as it requires all of the field work and modelling to be completed and that the findings of the field work are compared to the modelling outputs. At that stage it will be possible to review the modelled and actual distribution of bats, testing the accuracy and reliability of the models.

2. To pilot the acoustic method for surveying bats in woodland as recommended by Scott & Altringham (2014) to allow a methodology that will be able to detect trends in woodland bats, to be rolled out over a greater area and with an ultimate aim to roll this out across Britain as part of the BCT National Bat Monitoring programme.

In total, during the project, ten woodland sites across our four survey areas (Figure 1) were successfully surveyed from May to September. To complement the acoustic survey, advanced trapping techniques were also carried out by experienced volunteers working under a project licence, to confirm species recorded through the acoustic survey and to identify in the hand cryptic species that are hard to distinguish through acoustic monitoring.



Following the 2017 field season, overall progress and feedback from the volunteers was reviewed. Amendments were then made to the acoustic field survey methodology where needed, and a prototype external case for the Audiomoth was trialled for the second field season.



Analysis of the acoustic data is currently being carried out by BCT staff with the aid of autoidentification software. The data on bat species will be used to validate the habitat suitability models; to date, this has involved using the lesser horseshoe bat records from the field surveys to determine the protocol for validating and updating baseline models. Once analysed the data collected will be used to calculate the detection probabilities of all the different acoustic equipment used by the project and the effectiveness of the different methodology trialled will be compared. This will inform the way forward for the first widespread roll-out of a national woodland bat monitoring survey. In addition, the usability and recording quality of the Audiomoth sensor (including feedback from the volunteers regarding the deployment of the Audiomoths in the field) will be used by the National Bat Monitoring Programme (NBMP), as they work on their plans to roll out a new monitoring scheme, the British Bat Survey

(http://www.bats.org.uk/pages/british\_bat\_survey.html).

# Survey progress within the four study areas during 2018

At the end of the second field season, forty acoustic surveys and fifteen advance trapping surveys were completed.

- Eight acoustic surveys have been carried out in the Wales Study area four surveys in Hensol Woods and four surveys in Cwm George and Casehill Woods. In addition, six trapping surveys were carried out in both woodland sites during May, late July and late August.
- Thirteen acoustic surveys were carried out in the South of England study area five surveys in Rempstone, five surveys in Moreton (Affpuddle) and three surveys in Thorncombe. Four trapping surveys were carried out in Rempstone and Moreton (Affpuddle).
- In the East of England study area, volunteers collected acoustic data from nine surveys four surveys in Lownde Wood and five surveys in Warren Wood. Five trapping surveys in both woodland sites were also carried out during 2018.
- Ten acoustic surveys were carried out by the Loch Lomond Bat Group five surveys in Garadhban Forest and five surveys in Queen Elizabeth Forest Park, Aberfoyle.





Figure 1: Map showing survey study sites and the foraging-level habitat suitability model region

Through the project, the lead coordinators from each study area have mastered how to use Open Acoustic's low-cost AudioMoth sensor, Wildlife Acoustics SM2BAT+ and Pettersson's M500-384 Ultrasound Microphone plus Windows 10 tablet. A subset of lead coordinators attended an advanced training course in Surrey with ecological consultant Daniel Whitby to learn how to identify the cryptic small Myotis species. In addition, each lead coordinator recruited new volunteers and trained them using the instruction pack provided with support from BCT.

Lessons learnt through the project will be fed back into the British Bat Survey, a new NBMP monitoring scheme in development by the BCT. Beyond the project, we have had feedback that some volunteers are planning on applying the skills generated to continue using acoustic equipment to monitor nearby woodland sites. Other volunteers are continuing to further develop advanced survey skills by assisting their bat group with their monitoring.

# 4. To develop a transferrable, standardised approach for modelling woodland habitat suitability for a range of bat species.

Habitat Suitability Models (HSM) fill in the gaps around the typically patchy and biased species distribution data available with gridded predictive habitat suitability surfaces that estimate the probability of a species presence across the modelled study area. This quantitative, spatially explicit approach also provides information on the environmental correlates underlying the model. Multiscale HSM are designed to incorporate environmental correlates at the spatial scale at which they most influence a species behaviour or distribution and thus provide more accurate predictions and richer ecological insights compared to single-scale HSM. The outputs are useful for informing targeted conservation effort, land management and other decision-making at site- to landscape-scales.

This is a fast-evolving area of research and we recognised a need for more transparent, flexible multiscale HSM frameworks that facilitate the use of current best practice approaches for modelling taxonomic groups with limited species records. Based on recent recommendations by McGarigal et al. (2016), during this project Forest Research developed a hierarchical, multiscale HSM approach that predicts species distributions at three nested geographic levels:

- 1) Population range (Great Britain extent, 5 km resolution)
- 2) Home range (study area extent, 1 km resolution)
- 3) Foraging areas (study area extent, 100 m resolution).

Following initial feedback from project partners and other stakeholders, the extent of the home range model outputs were increased to the scale of Great Britain from the original 'study area' extent to enable results to feed into national-scale initiatives.



Using existing species data from BCT's databases and the National Biodiversity Network Gateway (NBN Gateway; <u>http://www.nbn.org.uk/</u>), we used this opportunity to trial and fine-tune our hierarchical HSM framework to create baseline HSM for the six woodland-specialist bat species groups in Britain. Initial validation of the models indicates that these models are performing well, but further tests using the independent field data gathered via the pilot surveys are planned.

To enable other to utilise this approach, the methods have been written up in a journal paper that demonstrates the improvements this approach confers compared to more 'traditional' multiscale HSM methods, using the lesser horseshoe as a case study species (see update on objective 7; Figure 2; Bellamy *et al., In Prep*). The code has also been shared with University of Sussex researcher, Patrick Wright, for further testing and application to a bat landscape genetics study.



Figure 2: The steps involved in the hierarchical, multiscale HSM approach developed for this project (Bellamy *et al.,* In Prep).

Through discussions with the Woodland Trust, we received funding to showcase how the HSM framework can be used to forecast the potential impacts of climate or land use change on woodland bat species distributions. This scenario analysis is being carried out during October – December 2018.



5. To provide resulting national scale GIS data to everyone and regional scale layers to those with the appropriate Ordnance Survey data licence (this covers most public sector organisations), following Defra's Open Data Strategy.

Upon publication of the journal paper (Bellamy *et al.,* 2018), if resources allow the project partners plan to make the home range level model outputs (1 km resolution habitat suitability indices for Great Britain) available on a case-by-case basis upon requests via the project webpage. This is to allow project partners to:

- Gather information on how the results are being used
- Open a dialogue with end-users, so they can provide feedback and submit queries and we can provide updated outputs following the integration of field data
- Ensure that end-users are aware of the predictive nature of the outputs and therefore limitations regarding the use of HSM outputs in some decision-making contexts.

This will help the project partners to monitor data use and to better understand the barriers and opportunities to integrating HSM output into decision-making.

6. To inform and update guidance to all those involved in woodland and forest management and creation, including those with a regulatory responsibility.

This was planned to take place be in the final stage of delivery. However, much interest has already been shown by the Forestry Commission, in particular with regard the Public Forest Estate, and also the National Forest Inventory. The South England Forest District (SEFD) provided funding towards the project in recognition of the utility of the outputs (including a tailored report, delivered in March 2018) for their decision-making. Discussions with the SEFD led to a student project supervised by Professor Adrian Newton at Bournemouth University on the potential impact of historical heathland expansion on species-specific bat box use. These practical and applied approaches will inform the objective of updating guidance.

The Woodland Trust have been involved in the project throughout and are have provided support for the initial development of the HSM framework and its future application to scenario analysis.

More widely, we have endeavoured to communicate project plans and results to researchers, practitioners and policy makers when relevant opportunities arise, as well as hosting a project <u>webpage</u> on the Forest Research website.

- Presentation to Woodland Trust offices, 20<sup>th</sup> March 2018, Edinburgh
- Poster presented at the joint BES & UK Conservation Agencies Symposium: 'Securing Our Natural Environment for Future Generations', 23 -24 May 2018, Manchester
- Lunchtime seminar at the BCT offices, 31 May 2018, London
- Presentation at BCT's National Bat Conference, 7-9 September 2018, Nottingham
- Slide for rolling screen presented at BCT's 'Strategic Planning for Landscape-Scale Biodiversity Conservation Symposium', 11 October 2018, London
- Poster accepted for the Biodiversity Science Conference, 'Biodiversity Conservation Post 2020: New Challenges and New Approaches', 5-6 November 2018, Edinburgh (Figure 3).





Chloe Bellamy<sup>1</sup>, Katherine Boughey<sup>2</sup>, Sonia Reveley<sup>2</sup>, Charlotte Hawkins<sup>2</sup>, & Carol Williams<sup>2</sup>

**Background:** For actions towards halting biodiversity declines to be effective, significant evidence gaps must be filled. Information on woodland-specialist bat species is scarce because of the difficulties in surveying for bats in these structurally complex environments. The **'putting woodland bats on the map'** project is piloting methods for surveying woodlands for bats (Box A) and modelling species distributions (Box B) in order to develop a better evidence base for woodland- to landscape-scale decisionmaking and bat conservation in Britain.

#### Box A. Trialling woodland survey methods

We have been piloting bat survey approaches and technologies with the aim of developing, for the first time, a method that could be carried out with volunteers at a large enough scale to provide trend data on these species in Britain: *Myotis nattereri, Myotis bechsteinii, Plecotus auritus, Barbastella barbastellus, Rhinolophus hipposideros, Myotis brandtii/mystacinus & Myotis alcathoe.* 

Woodlands within four pilot areas have been surveyed by volunteers during the summer months of 2017 & 2018 using a standardised protocol.



Acoustic surveys: transect routes are made up of six tenminute 'walks' separated by six 'stopping points'. Three different models of bat detector are being compared:

- Pettersson's M500-384 Ultrasound Microphone
- Wildlife Acoustic's SM2BAT+
- Open Acoustic's AudioMoth.

Chloe.bellamy@forestry.gsi.gov.uk

**Catching:** to confirm species presence, volunteers received training to catch and identify bats pre- and post-parturition under licence in the pilot sites.

As well as delivering a baseline for long-term monitoring, the data are being used to validate and update habitat suitability models (Box B).



# Box B. Predicting woodland bat species distributions

In tandem with piloting survey methods (Box A), we are developing a habitat suitability modelling framework to:

- Predict woodland bat species distributions
- Better understand underlying environmental correlates
- Undertake scenario analysis.

Multiscale models provide more accurate predictions and a better understanding of species-habitat associations at different scales. However, statistical issues such as multi-collinearity complicate analyses and interpretation. We developed an approach whereby models are hierarchically nested across three levels:

- Population range (Great Britain extent, 5 km resolution)
- Home range (Great Britain extent extent, 1 km resolution)
- Foraging areas (study area extent, 100 m resolution).

This modelling framework was found to perform better than traditional multiscale methods; it enables context dependency by allowing a species response to local features to vary according to regional suitability (Bellamy et al., *In Prep*). This flexible approach can be applied to any taxonomic group or area for which adequate data are available.

We are now working with the Woodland Trust to develop

scenarios for forecasting the impacts of potential land use or climate change on woodland bat species distributions.

We are grateful for the many volunteers carrying out surveys and providing data for this project. We would also like to acknowledge the organisations loaning equipment and providing funding support. Please scan QR code for more information.



Figure 3: Poster to be presented at the 'Biodiversity Conservation Post 2020: New Challenges and New Approaches' in November 2018









7. To make these findings robust enough to share via a peer reviewed paper to be published in an open access journal alongside the accompanying model code.

A journal paper that describes application of the hierarchical HSM framework to modelling the lesser horseshoe bat distribution has been drafted, with a planned submission date of December 2018 (Bellamy *et al.*, 2018). The methodological steps have been made transparent and example code will be provided in the paper's supplementary information to allow others to apply the framework to their own species data.



# Remaining tasks to be done before the close of the project (up until December 2018)

- Publication of the HSM methods journal paper.
- Continue with the analysis of the acoustic data collected from all the study areas, in order to provide data of bat species that will be used to validate the HSM.
- This analysis will allow us to review our understanding of the ecological and humans factors influencing bat distribution.
- Based on those findings to update guidance as appropriate.



# Funding information

Submitted to FLS, but removed from this version of the report.



# Summary of lessons learned and recommendations

# Field survey methodology

- **Recommendation:** Further work required on developing an external case for the Audiomoth detector that will protect the detector from the elements but will also allow for easy access to the detector.
- **Recommendations:** Together with the provision of the instruction pack, lead coordinators would benefit from additional in-house training at BCT at the beginning of the survey season, on the use of the acoustic equipment. This would have given the coordinators a better understanding of how the equipment works, enable them to deal with any technical issues that may arise and ensure the data download post survey procedure was adequately understood.
- Lesson learnt: To allow for a slow start to the deployment of new equipment and the use of new methods. However, good we think the training and instructions are there will always be issues the first season these are rolled out in practice. We were fortunate in having two seasons which allowed the second on toe operate free of the glitches that hampered the first season.
- **Recommendation:** The project has gained a great deal of interest from those wishing to monitor the Public Forest Estate and wider woodland (National Forest Inventory) and this work should continue and be applied through these avenues as a proof of concept and beyond that as a standard method of monitoring.
- **Recommendation:** In addition to the proof of concept (or as part of it) there should be targeted survey effort in a smaller number of sites that will be on a long-term basis. Sites to be chosen on the basis of volunteer availability and potential for greatest gains in knowledge.

# Habitat suitability modelling

- **Recommendation:** That the previous recommendations have a feedback loop to the models produced as a result of this project to ensure they become ever more refined and accurate.
- **Recommendation:** That another output of the ongoing work is to detect changes in species distribution and population trends.
- **Recommendation:** That this ongoing work informs the suitability of woodland not studied. **Recommendation:** The improved accuracy and robustness of our hierarchical, multiscale HSM approach compared to more 'traditional' multiscale HSM methods indicate that modellers should implement similar approaches to modelling specie distributions.

# Need for further research

The ambitious targets set out at the beginning of this project to improve methods for (a), surveying woodlands for bats and (b), modelling species distribution using multiscale HSM, have been achieved. However, to maximise the impact of this project and to ensure the outputs and learning are distilled into practice, further work is required. The project partners are therefore looking for

further funding to continue the legacy of the 'putting woodland bats on the map' project. Future work would likely focus on these areas:

- There is a need to delve more deeply into the vast amount of data produced by the ground work and HSM outputs. Further thought is required on how the acquired field survey data (from this pilot and future surveys) can be fully integrated into the HSM framework, with the aim of eventually replacing current baseline models. Mechanisms and resources for periodically re-running the models using the latest species data would improve model robustness and predictive accuracy and could enable analysis of levels of bat activity, rather than focusing solely on bat presence. This would allow incorporation of the latest environmental data arising from improved technology e.g. spatial woodland structure metrics derived from LiDAR data.
- Whilst our initial journal paper provides a basis for applying the multiscale HSM approach we have developed and applied to modelling woodland bat species distributions in Britain, there is a great deal more scope to continue to interrogate and evaluate the data. Future publications could provide more detailed HSM outputs for all species modelled – including results from land use and climate change scenario analysis - with a focus on the conservation implications.
- We are currently unable to assess the impact of detailed woodland attributes on bat activity
  over large extents because of the paucity of data at very fine resolutions (< 100 m). The
  project partners are interested in discussing the potential to roll out acoustic bat surveys in
  areas coinciding with sites where detailed forest characteristics are measured e.g. National
  Forest Inventory sites. This would allow us to assess how features of the trees and their
  management impact on finescale bat activity.</li>
- By providing HSM outputs from this project on a case-by-case basis and monitoring data use, we can gather information on opportunities and constraints for integrating HSM data into conservation effort and decision-making. This information could be compiled, assessed and summarised for the research community to encourage the development of HSM outputs that better suit practitioner needs.
- BCT are working with researchers from University College London, Oxford University and the British Trust for Ornithology to develop a new survey for the NBMP, the British Bat Survey (BBS), where a range of habitats including woodlands can be surveyed using static acoustic sensors. The pilot field surveys from this project has allowed us to test the low cost full spectrum Audiomoths intended to be used by BBS and what we have learnt will improve our understanding of the usability of the sensor for the BBS. Further work however is still needed on developing other elements of the BBS pipeline, like the Audiomoth external cases and the upload tool to the central server for processing the data, before it is ready to be launched nationally.
- The predictive habitat suitability maps could be used to direct survey effort, highlighting areas where the habitat is predicted to be suitable, but records do not exist.



# **References**

- Bellamy, C., Boughey, K., Hawkins, C., Reveley, S., Spake, R., Williams, C., & Altringham, J. D. (In Prep) Improving multiscale habitat suitability modelling using a hierarchical framework. A case study of the lesser horseshoe bat.
- McGarigal, K., Wan, H. Y., Zeller, K. A., Timm, B. C., & Cushman, S. A. (2016). Multi-scale habitat selection modeling: a review and outlook. *Landscape Ecology*, 31(6), 1161-1175.
- Scott C. & Altringham, J.D. (2014) Developing effective methods for the systematic surveillance of bats in woodlands in the UK (including Barlow K. & Briggs P., Potential development of woodland monitoring based on the woodland bat survey and monitoring protocol). Report to Defra WC1015.