Bat Conservation Trust

Core Sustenance Zones: Determining zone size

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Introduction

A core sustenance zone (CSZ), as applied to bats, refers to 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. With reference to planning and development the core sustenance zone could be used to indicate:

- The area surrounding the roost within which development work can be assumed to impact the commuting and foraging habitat of bats using the roost, in the absence of information on local foraging behaviour. This will highlight the need for species-specific survey techniques where necessary.
- The area within which mitigation measures should ensure no net reduction in the quality and availability of foraging habitat for the colony, in addition to mitigation measures shown to be necessary following ecological survey work.

The approach used here to determine Core Sustenance Zone size does not take into account the use of satellite roosts or roost switching. It was felt that incorporating these behaviours would add an excessive level of complexity and uncertainty to the calculations; however this decision should be reassessed when this approach is revisited in future. Core sustenance zones have been developed with reference to communal bat roosts. Their relevance to solitary bat roosts (such as bachelor roosts) and flight records is under discussion. Additionally this approach does not consider local habitat or landscape configuration, or variation in foraging distances due to colony size, reproductive status or landscape quality, again because this would add excessive complexity.

Methods

Core Sustenance Zone sizes were determined via a meta-analysis of data describing foraging radii data. A literature review was undertaken to gather information on foraging behaviour. This review included all accessible literature that reported the results of radio-tracking studies where bats were tracked while foraging, from both the UK and Europe. Literature was identified using Web of Science, a Google search, an email request to relevant species experts and from consultancy reports submitted to Somerset County Council. It included peer-reviewed, grey literature and personal communications from researchers describing unpublished data.

The review identified three metrics of bat foraging radii that are commonly reported in the literature:

- **Maximum foraging radius** – this is the maximum straight-line distance from the roost occupied during the previous day to the furthest foraging area, or in some cases the furthest point travelled, by any bat during the study.
- **Mean-maximum foraging radius** – this is the average maximum foraging radius (see above) of all bats in the study. In most cases this is the maximum distance travelled by each bat across all nights of the study, averaged across all bats, however in a small number of cases the maximum distance travelled each night by each bat, averaged across all nights, is used.
- **Mean foraging radius** - the average straight line distance between the roost occupied during the previous day and each core foraging area used by the bats tracked during the study.

A workshop was held on 10/09/2013 to discuss approaches to determining CSZ size. At the workshop it was agreed that the absolute maximum distance travelled from the roost was too large and too susceptible to outliers to be of use for the majority of applications. It was also agreed that the mean foraging radius was too small to adequately safeguard the conservation status of a colony, as a large number of foraging sites are likely to fall outside this distance. Following the workshop it was decided to base CSZ size on mean-maximum foraging radius. To calculate CSZ size the mean-maximum foraging radius was averaged across all studies which reported this information, weighted by the number of bats tracked in each study. The weighted average was rounded to the nearest kilometre to reflect the level of precision attached to the figure.

For one species, *Plecotus auritus*, no information on mean-maximum foraging distances was available. For this species an alternative approach was used based on mean foraging distances. The mean foraging radius reported by each study was averaged across all studies, weighted by the number of bats tracked in each study. An additional 50% was added to the weighted average and it was rounded to the nearest kilometre to reflect the level of precision attached to the figure. The choice of 50% as a multiplier was made following discussions between BCT staff, with consideration to the practical application of CSZs.

If the study reported foraging radii separately by sex or age, only results for adult females were included in calculations, with the exception of *Pipistrellus nathusii* where data reported by Hargreaves (2011) for both sexes was combined due to a small sample size. Where separate foraging radii were not reported, results for mixed sex or age groups were used. Studies that tracked single individuals were only included in calculations if data from other studies were also available. If the number of bats tracked was not reported by the study that data was not included in the calculation of weighted averages. Data from *Myotis mystacinus*, *M. brandtii* and *M. alcathoe* were pooled to produce a single radius for this species group.

For the species groups *Pipistrellus sp. Plecotus sp*., *Myotis sp*., and *Nyctalus sp*. the largest of the individual species zone sizes was used to represent the CSZ of that group. For *Chiroptera sp*. the average core sustenance zone across all species was used.

Results

Data availability was limited for most species. Core sustenance zone sizes are given in Table 1, together with an assessment of the confidence that can be attributed to the final calculation, given data availability and other caveats.

Table 1. Core Sustenance Zone sizes calculated for UK bat species and species groups, together with sample sizes and an estimate of the confidence that can be attributed to the zone size calculated, given data availability.

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Species	Weighted average (km)	CSZ radius (km)	No. bats	No. studies	Confidence in zone size
Rhinolophus ferrumequinum	3.34	3	39	4	**Moderate.** Calculation based on a reasonable sample size from multiple colonies and studies, however CSZ figure is rounded down from weighted average.
Rhinolophus hipposideros	2.02	2	83	4	**Good.** Calculation based on a reasonable sample size from multiple colonies and studies. CSZ radius close to weighted average.
Barbastella barbastellus	6.47	6	69	3	**Moderate.** Calculation based on a reasonable sample size from multiple studies, however CSZ figure is rounded down from weighted average, which lies just below the threshold where it would be rounded up to 7km.
Plecotus auritus	3.45*	3*	38	1	**Poor.** *No data on mean-maximum foraging distances available in the literature, therefore an alternative method of calculating CSZ radius was used, based on mean foraging distances. Data on mean foraging distances only available from a single pers com. Figure highly susceptible to change with the addition of further data.
Plecotus austriacus	3.06	3	20	1	**Moderate.** Data available from multiple colonies but only from a single study, therefore overall sample size is small. CZS figure is not excessively rounded down from weighted average.
Plecotus sp.		3			
Myotis daubentonii	1.78	2	7	2	**Poor.** Data available from two studies but for a limited number of individuals. Also the weighted average mean-maximum foraging distance (1.78km), calculated using data from two studies, is less than the weighted average mean foraging distance (2.3km) calculated using data from four studies. This disparity suggests that CSZ size is currently underestimated and additional data on mean-maximum foraging distances could increase the CSZ for this species.
Myotis nattereri	3.81	4	53	2	**Good.** Calculation based on a reasonable sample size from multiple colonies and

					studies. CSZ figure not rounded down.
Myotis mystacinus/brandtii/ alcathoe	0.80	1	24	1	**Poor.** No data on mean-maximum foraging distances available for *M. alcathoe*. Data available from multiple colonies but only for a single study for *M. mystacinus* and *M. brandtii*.
Myotis bechsteinii	0.82	3**	70	4	**Moderate**. Data available from multiple studies and for a large number of individuals. ** The weighted average mean-maximum foraging radius for *M. bechsteinii* rounds to 1km, however an increased CSZ size of 3km has been selected for this species due to its rarity and specialised habitat requirements.
Myotis sp.		4			
Pipistrellus pipistrellus	1.90	2	23	1	**Poor.** Data available from multiple colonies but only from a single study.
Pipistrellus pygmaeus	2.79	3	91	3	**Good.** Calculation based on a good sample size from multiple colonies and studies. CSZ figure not rounded down.
Pipistrellus nathusii	3.15	3	9	2	**Poor.** Calculation based on small sample size. CSZ figure is not excessively rounded down from weighted average.
Pipistrellus sp.		3			
Nyctalus noctula	4.26	4	20	1	**Poor**. Calculation based on a single study. CSZ figure rounded down from weighted average.
Nyctalus leisleri	2.85	3	20	2	**Moderate.** Calculation based on multiple colonies and studies, but overall sample size is small.
Nyctalus sp.		4			
Eptesicus serotinus	4.30	4	13	1	**Poor.** Calculation based on a single study and small sample size. CSZ figure is

					rounded down from weighted average.
Chiroptera sp.		3			Note this figure is an average of the CSZ sizes of all bat species and is therefore susceptible to change if the CSZ of individual species is altered.

Note: There may be justification with Annex II and other rare species to increase the CSZ to reflect use of the landscape by all bats in a population. We would suggest increasing the CSZ of Bechstein's bat to at least 3km, reflecting its very specific habitat requirements.

Discussion

Comparison of the two methods used to calculate CSZ size

Only one species, *Plecotus auritus*, had insufficient data for mean-maximum foraging distances to be used to calculate CSZ size (there was also no data on foraging distances available for *M. alcathoe* but this species was included within the small *Myotis* species group in order to calculate a CSZ). The CSZ for this species was calculated using mean foraging radii and the addition of 50% (3km), which was identical to the CSZ size calculated for the closely related species *P. austriacus* using mean-maximum foraging radii. Data for both species is limited, but there is currently no evidence to suggest that these species differ with respect to the distance travelled to foraging sites. Based on the evidence currently available the use of the same CSZ size for both species is considered appropriate, however this may be revised following further research.

How could these CSZ radii change with increasing data availability?

These CSZ sizes have been calculated using all data available at the time, but for some species very little data is available and therefore the sample size is small (table 1). It is evident that there is a great deal of variation in foraging radii between colonies and also at different times of year. For example the mean-maximum foraging radii reported for *R. ferrumequinum* ranges from 2.1 - 7.5km (seven colonies), for *B. barbastellus* from 5.4 - 7.1km (three colonies) and for *M. nattereri* from 2.7 - 4.7km (nine colonies). Foraging radii differed depending on the colony studied and the time of year the bats were tracked. CSZs that have been calculated based on a single colony are therefore more likely to need revision as further information becomes available. This applies to *N. noctula.* There are several species for which data were available from multiple colonies, but only from a single study. Within a study colonies are more likely to share similar landscape characteristics and may not therefore represent the full variation in foraging radii exhibited across the UK. Data were only available from a single study for the following species: *P. austriacus, M. mystacinus, M. brandtii, P. pipistrelles, N. noctula and E. serotinus.* In addition there are no published studies that describe the mean-maximum foraging radii of *P. auritus* or *M. alcathoe,* and the calculations for *P. nathusii* and *N. leisleri* and *M. daubentonii* are based on relatively small sample sizes and could be improved by further data.

Other caveats and limitations

The foraging behaviour of bats differs depending on sex, age and breeding status. It can also be affected by colony size, habitat quality and landscape composition. As a result of this variation and the caveats described below, the core sustenance zone sizes presented here provide general guidance only, information on the foraging behaviour of local bat populations should always be prioritised where this information is available.

Mean-maximum foraging radii are calculated in different ways in different studies:

- In some studies the mean-maximum foraging radius is based on the distance from the roost to the furthest foraging area used, in others it is the distance from the roost to the furthest point travelled.
- The mean-maximum foraging radius is in some cases calculated by averaging the maximum foraging radius of each bat on each night, in other cases the maximum foraging radius per individual across all nights is used.

- Foraging areas are defined in different ways by different studies. Methods used to delimit foraging areas include cluster cores, kernel density estimation, harmonic means and personal judgement based on fluctuations in signal strength and movement.

As a result the figures reported by different studies are not absolutely comparable. However it is still necessary to summarise the results of different studies in an objective fashion. Variation between studies as a result of different analysis techniques is comparable to other sources of variation described here, and is likely to be less than variation in foraging behaviour between species. As such the approach used here is a valid way of determining CSZ size.

When calculating CSZ size, data have been weighted by the number of individual bats tracked in each study. We recognise that the behaviour of bats from the same roost is not necessarily independent and therefore the number of roosts sampled also has a bearing on effective sample size. However information on the number of roosts sampled was not always reported, so for simplicity averages are weighted by the number of individuals only.