Date: September 2025

New Zealand Bat Recovery Group Advice Note – The Use of Artificial Bat Roosts

Context

Artificial roosts (also known as bat boxes) have increasingly been used in New Zealand with the aim of providing bats with alternative roosting options in response to tree felling and vegetation removal.

There is no evidence to date that artificial roost boxes are an effective mitigation tool for mitigating the loss of natural bat roosts.

Even when research has taken place overseas, these studies stated that "bat boxes are not a silver bullet conservation tool" and that "bat boxes are unlikely to compensate adequately for the broad-scale loss of tree hollows caused by various forms of human disturbance" (Griffiths, Bender, et al. 2017).

This is because overseas bat boxes have typically catered to common, abundant bat species of minimal conservation concern (Mering and Chambers 2014; Griffiths et al. 2017). This reduces their effectiveness for conservation purposes (Rueegger, 2016; Rueegger et al. 2019). Bat box programmes rarely consider species-specific roost preferences, which should be understood and targeted before installation (Robinson et al. 2023).

The purpose of this advice note is to provide the current view of New Zealand's Department of Conservation's Bat Recovery Group on the use of artificial roosts for bats. It is based on knowledge of New Zealand long-tailed bat ecology, the limited research conducted to date in New Zealand, and research on artificial bat roosts in Australia and elsewhere on different species.

Focus on retaining vegetation and old trees first because natural roosts take a long time to grow; we don't know how to replicate these well with artificial roost boxes, and there are consequences for bats:

- The use of artificial roosts should be a last resort rather than a first port of call. Focus should instead be on retaining vegetation, particularly old trees and natural roosts (Chambers et al. 2002), and predator control designed to increase bat survival.
- This is because bats use roosts that are chosen specifically for their thermal properties (Sedgeley Jane A 2001).
- Roosts are used over many years by generations of bats (O'Donnell and Sedgeley 1999).
- Reductions in the numbers of trees that are suitable as roosts may affect population viability (Sedgeley Jane A and O'Donnell 1999b).

- Populations in areas where roosts are few or rare are likely to be limited by roost numbers (O'Donnell and Sedgeley 1999; Sedgeley Jane A and O'Donnell 1999b).
- When bats use roosts that have poorer thermal qualities, populations are likely to have lower reproductive fitness (productivity i.e., fewer weaned young/female) and survival rates (Sedgeley J A and O'Donnell 2004).
- Most research into roosting ecology for New Zealand bats has taken place in summer months. This means that we know even less about what types of roosts bats require over winter.

Improvement is needed in artificial bat roost design; currently, they do not replicate natural roosts well

- We know very little about how to design artificial roosts to replicate the properties of natural roosts that best suit New Zealand bats, or where to place them that is (a) attractive to, or (b) suitable for bats.
- Microclimates provided by artificial roosts are likely to be different from those provided by natural roosts (Chambers et al. 2002). Without robust research into how to design artificial roosts so that they replicate conditions found in natural roosts, where bats have high reproductive fitness and survival, these will likely provide roosts that are inferior.
- If artificial bat roosts are used to replace natural high-quality roosts, then it is likely that populations using them will have reduced reproductive fitness and survival, especially if they are poorly designed. This is because poorly designed artificial roosts are likely to have inferior thermal qualities than natural roosts. Roosts with inferior thermal qualities are associated with lower survival and productivity (Sedgeley J A and O'Donnell 2004).
- Artificial roosts appear less likely to effectively replace natural roosts that bats choose when pregnant or raising their young. This is suspected because less than 3% of boxes installed in Hamilton city are used by breeding groups (maternity groups or colonies, (Robinson et al. 2024).
- Artificial roosts can be too hot or too cold for bats because of their design or placement. Research in Melbourne found that some artificial roosts were hotter than ambient temperatures on hot days, putting bats at risk of heat stress and even death (Griffiths 2021). Whilst this is concerning for adult bats, this is even riskier for young pups, which cannot readily thermoregulate, so are likely to be more susceptible to overheating (Crawford and O'Keefe 2021), and cannot fly, so pups cannot leave a roost independently if they get too hot. Climate change is likely to increase these risks even more (Flaquer et al. 2014).

- We don't know which artificial roost box type is best at replicating the conditions New Zealand bats require, or even whether these are an effective way of mitigating roost loss. This is untested.
- This means, anyone considering using artificial roosts as a mitigation approach should undertake/support robust research into the thermal qualities of artificial roosts and their placement and compare these to those of the natural roosts in native forests that are preferred by bats and temperatures at which overheating may occur (Flaquer et al. 2014). This is crucial for ensuring better outcomes for bats when bat boxes are used as mitigation tools (Crawford and O'Keefe 2021). Designing artificial bat roosts based on thermodynamic properties of roosts found in native forests is likely to reflect true preferences; properties of roosts remaining in areas where levels of roost loss have already been high, such as in fragmented landscapes, are unlikely to be optimal.

Bats may take a long time to use artificial roosts, if they ever do.

- It may take some time for bats to begin using artificial roosts, if they ever do. A short-term DOC-led trial of artificial roost boxes in South Canterbury, found that long-tailed bats began to use some of the boxes within two years (2% of boxes (O'Donnell 2024). However, only 10% were used by bats after 12 years (O'Donnell 2024). Roost use was also dependent on where boxes were located, with only those in, or on the edge, of regenerating forest being used. If long-tailed bats use roost boxes, their use may likely take several to many years to be observed, as in overseas studies. The South Canterbury boxes were finally detected being used by maternity colonies after 22 years (C. O'Donnell, Mike Jones, pers. comm).

- Several artificial roosts were installed in Hamilton City's southern parks from 2011, five years after their installation long-tailed bats were first observed roosting in some of the artificial bat boxes. But it is unknown how soon after installation use began (K. Borkin, pers. obs. in Jones et al. (2019)) or the proportion of all boxes used by bats due to infrequent measurement.
- From 2019, a further 80 artificial roosts were installed throughout Hamilton City. Long-tailed bats were first observed roosting in a number of these bat boxes 1-2 years after installation (O'Sullivan 2021, Robinson 2022). Previous exposure to bat boxes has corresponded with quicker uptake elsewhere (Rueegger 2016). Therefore, it is likely that the previous use of artificial roosts in Hamilton City facilitated the relatively quick uptake of some boxes (Robinson et al. 2023).

Artificial roost boxes are a short-term tool that requires maintenance

- Artificial bat roosts should be considered a short-term tool, filling the time period or lag until planted vegetation forms potential roost features (Chambers et al. 2002).
- Annual maintenance should be expected.
- Focussing on retaining vegetation and planting to provide for roosts should be long-term goals (Chambers et al. 2002). Note that new plants will not have suitable roosting opportunities for many years (and only a small portion of new plants ever will). The youngest trees known to be used as roosts were 16 year old *Eucalyptus fastigata*, where they roosted under peeling bark (Borkin and Parsons 2011); these young roost trees probably have poor thermal properties. Native vegetation is likely to take much longer to mature and become suitable as bat roosts. Some botanists have suggested that it may take 80 years or more for natural roosts to form within native vegetation (Borkin and Martin 2018).
- If you intend to mitigate for potential roost loss by providing artificial roosts, then you should provide multiple artificial roosts for each potential roost that is lost. This is because:
  - of the lack of knowledge, as outlined throughout this advice note,
  - most artificial roosts that are deployed won't meet the criteria that bats are looking for, and,
  - the high likelihood that bats will not find or use the artificial roosts.

General Advice on installation, placement, and maintenance

- Placement, and other advice below, is based on a general understanding of bat ecology, generally learned through research that has taken place over summer. This is untested. We don't know a lot about roost selection for long-tailed bats in winter, so the advice provided below is focused on knowledge of summer roosting ecology.
- Female and male bats use different roosts because they have different metabolic requirements, so a variety of roosts are required to maintain a population (Borkin and Parsons 2011).
- To meet these different needs, boxes should be placed in locations and on trees so that they are exposed to variable amounts of sunlight, particularly on the north-eastern and south-western sides of trees.
- Female long-tailed bats: in summer, often choose roosts that warm in the morning (most exposed to the sun in the North-East) and stay warm all day (Borkin and Parsons 2011).
- Male long-tailed bats: in summer, often choose roosts that warm in the afternoon (most exposed to the sun in the South-West)(Borkin and Parsons 2011).
- Other placements/orientations are likely to be required to maintain a population, particularly given we know so little about roosts chosen by bats outside of summer.
- Research in Hamilton City indicates that bat boxes should be installed in the interior of tree stands rather than stand fringes or exposed ridge sites (Robinson et al. 2023). Sheltered artificial roosts likely have more stable microclimates compared to those on marginal features, which allows bats to conserve energy during winter and avoid overheating in summer (Hamilton and Barclay 1994; Borkin and Parsons 2011; Hoeh et al. 2018). Trees on the edge of a stand may also grow faster, requiring more frequent management/replacement of protective predator-proof bands.

There are overheating risks with artificial roosts

- Bats are considered to be at risk of heat stress, dehydration, or death when temperatures inside bat boxes reach 40 ^{0}C or greater (Flaquer et al. 2014). Even in high altitude mountainous regions in Europe (990 m a.s.l.), bat box interiors reached these high temperatures on 60% of days in late summer (Flaquer et al. 2014). When ambient temperatures approach or exceed 30 ^{0}C, bat box interiors may approach 40 ^{0}C, putting bats at risk (Griffiths 2021).
- Providing boxes that are shaded may be one method to ensure boxes are cooler and reduce the risks of overheating (Crawford and O'Keefe 2021).
- Lighter colour boxes reduce the risk of overheating. Be aware that if dark-coloured boxes are put out, then these may get hot if not shaded. This is because temperatures can get very hot inside when boxes are dark colours; this puts bats (and other animals) at greater risk of heat stress during high temperatures (Griffiths, Rowland, et al. 2017). Because of this risk, a recent review suggested that a "dark, ventless bat house" was inappropriate for deployment in most temperate climates (Crawford and O'Keefe 2021).
- Consider/trial other ways to reduce overheating risks, such as those recommended by Crawford and O'Keefe (2021), Griffiths (2021), and Bakken and O'Keefe (2025):
    - provide multi-chambered boxes with transfer holes between chambers so that bats can move between chambers – altering the temperatures that they are exposed to – without exiting the box
    - vary the shading and the exposure of boxes to the sun
    - choose boxes that are light-coloured or have high surface reflectance to reduce radiation absorption
    - adding an external insulation layer **and** a heat storage layer
    - extending the length of the box
    - constructing boxes using thicker timber walls, and,
    - using materials with greater insulative capacity (e.g., wood-cement).
- However, note that there are trade-offs when manipulating designs to reduce maximum temperatures, as these may produce microclimates that are not conducive to pup development (Crawford and O'Keefe 2021).

Design considerations

- **This website gives a good summary of things to consider when choosing the type of box to install and gives some box designs that could be trialled:** Tips for making bat boxes safer for bats – Human-Wildlife Interactions
- Trialling a box with external insulation **and** a heat storage layer (made, for example, from a sealed water bladder) outside the bats' chambers is likely to result in more stable temperatures and combat heat extremes[1].
- Trialling longer boxes (≥ 90 cm) that allow bats to access a wider range of temperatures without leaving the box would also help bats manage extreme temperatures[2]
- Design choice should factor in ways to minimise the likelihood of use by non-target species (such as other mammals, birds, or insects), so that boxes are available for bats to use (Mering and Chambers 2014).
- Keep in mind in which Hemisphere information on roost placement and design was written. Directions/orientations bat boxes should be placed in, for example, will differ between the Southern and Northern Hemispheres.
- Understanding whether thermal conditions created by the artificial roosts you intend to put out are likely to be too hot for bats, is possible by using Code available at this link: Illinois Data Bank - Dataset. The code developers state that "The dataset available at the link provides instructions for procedures to use heat transfer analyses to estimate thermal conditions in artificial roosts for bats. The dataset contains scripts to employ in the program GNU Octave, example meteorology data, and example text files specifying roost dimensions and material properties. Using the code requires downloading GNU Octave or Matlab (free) and then following the instructions in the word document that is packaged with the code and files. The process of using the code and iteratively changing a design is described in Appendix C."

Common artificial roost designs

We know that long-tailed bats have used artificial roost boxes in two locations in New Zealand where natural roosts are likely to be rare: Hamilton and Geraldine (Jones et al. 2019). The artificial bat houses that long-tailed bats are using in Hamilton, are based on a Kent design.

There are plans for these and similar designs, as well as other useful advice, at this link:

[1] Tips for making bat boxes safer for bats – Human-Wildlife Interactions
[2] Tips for making bat boxes safer for bats – Human-Wildlife Interactions

https://batboxes.wordpress.com/advice-about-bat-boxes/

The dominant species using the boxes in the Melbourne research project linked above are *Chalinolobus gouldii* – Gould's wattled bat (Griffiths, Bender, et al. 2017). These are closely related to long-tailed bats (the same genus), but we don't know if they have the same requirements when roosting.

Long-tailed bats have also used other artificial bat roost box types (Jones et al. 2019). These can be purchased from overseas. One example is the Schwegler bat boxes.

https://www.schwegler-natur.de/fledermaus/?lang=en

An example of a multi-chambered design is shown in Tuttle et al. (2013): https://merlintuttle.com/wp-content/uploads/2016/03/BHBuildersHdbk13_Online.pdf

Alternatives to artificial roost boxes

There is value in investigating methods other than artificial roost boxes for the provision of roosts for bats (Crawford and O'Keefe 2021).

Alternatives considered worthy of further investigation (Crawford and O'Keefe 2021; Griffiths 2021) include:

- the retention and creation of snags
- carving or using a chainsaw to cut hollows directly into live or standing dead trees.

Carved/Chainsawn hollows

Chainsawn hollows have been found to provide microclimates closer to those of natural roosts than those provided by artificial roost boxes (Griffiths et al. 2018).

Australian trials that created hollows by carving or chainsawing hollows into live, healthy, trees have found that trees will grow wound-wood that will/may eventually close over entrances (Dr S. Griffiths, La Trobe University, Melbourne, pers. comm., 22 September 2021). This research found that cavities that were carved with vertical fissure entrances were all closed by wound-wood within two years of cavity creation and required cutting back of the bark and cambium from the entrance slit for them to continue to be available as potential roosts (Dr S. Griffiths, La Trobe University, Melbourne, pers. comm., 22 September 2021). Trialling the cutting of cavities into dead standing trees may be worth investigating.

Details on the dimensions of roost cavities used by long-tailed bats are given in Appendix 1. These can be used to inform the design of carved/chainsawn hollows.

Placement of artificial roost boxes

- Predator proof! Place a predator-proof band around the tree above and below the box, distant enough so that predators cannot reach the box for a tasty bat snack, and so any maintenance required will cause less disturbance to any bats occupying the box.
- Do not place the box on a leaning tree so that predators can easily walk across the band, and make sure that the potential predator cannot reach the box via another tree. You might need to prune the host tree, or surrounding trees, to achieve this.
- Place the box, and associated predator-proof band, higher than a person can reach (for obvious reasons).
- Most roost cavities found in the Southern South Island beech forest in indigenous forest are 10 m or higher[3] (Sedgeley Jane A and O'Donnell 1999b); roosts in other habitat types may be closer to the ground.
- Placing them where there are likely to be few natural roosts is probably most useful (Mering and Chambers 2014). Putting them in mature indigenous forest may be wasting resources because there are probably already many natural roost sites available.
- Place where bats are detected regularly. This might make it more likely that bats encounter the artificial roosts, e.g., along a river where there are trees. In addition, installing artificial roosts near natural or already occupied artificial roosts may facilitate discovery (Robinson et al. 2023).
- Give bats space to leave – open air space is needed in front of the box.
- Some studies have suggested that placing boxes on snags or poles may be beneficial because this exposes boxes to more sunlight (Mering and Chambers 2014), and because boxes may be more obvious to bats when placed on snags/poles (compared to, for example, when attached to trees where they may be somewhat obscured). However, a review of artificial roost box placement found that when comparing what the boxes were attached to (e.g., to a pole/tree/building/snag), uptake of boxes appears to vary between studies and locations (Mering and Chambers 2014).

[3] Eighty-five percent of roost cavities found in the Eglinton Valley were over 10 m above the ground.

Inspection and Maintenance

- Inspect and maintain boxes annually (Chambers et al. 2002).
- Maintenance should include:
    - removal of bird nesting material and other non-target species (including insects) that compete with bats for space,
    - ensuring boxes are still correctly secured to their tree (or pole etc), and,
    - ensuring predator-proof bands are still effective and maintaining them if they are not.
- At sites where maintenance did not occur for several years, we have evidence of bat roost boxes being unavailable/unsuitable for use by bats because they had fallen to the ground or turned upside down, predator-exclusion methods were no longer effective (e.g., bands had popped off), and boxes had rotted (A. Styche, Department of Conservation, pers. Comm., 6 September 2021). In one New Zealand-based study of artificial roost use, some roost boxes were filled with nesting material between checks, and were therefore unavailable for bats to use (Jones et al. 2019).
- Close inspections and repairs should take place when bats are not present.
- Plan maintenance inspections and repairs during May-October (when bats are not heavily pregnant, or lactating, or have non-volant young, that is young that are dependent and unable to fly).
- Checks to ensure bats are not present should also take place immediately before maintenance. Maintenance should only take place if no bats are present, so no disturbance is caused by the maintenance. If this is not possible, because bats are continuously present, then consider doing maintenance overnight once bats have left or seek a Wildlife Act Authority to cover this activity.

APPENDIX 1: POTENTIAL DIMENSIONS FOR CARVED/CHAINSAWN HOLLOWS FOR BATS

We recommend that when carved/chainsawn hollows are created, they follow dimensions identified as physical characteristics of natural tree roosts used by long-tailed bats as in Sedgeley Jane A and O'Donnell (1999a). We suggest that replicating these dimensions may be the best effort to mimic natural cavities, if the recommended research does not take place[4].

The following characteristics were obtained from research in southern beech forest by Sedgeley Jane A and O'Donnell (1999a). This four-year research project assessed 149 roost cavities found by capturing 73 individual long-tailed bats and radiotracking them to locate their roosts over four years.

[4] as noted above, research into how to mimic natural roost thermodynamics is critical if artificially-created roosts are to be used as a replacement for natural roosts: Crawford RD, O'Keefe JM. 2021. Avoiding a conservation pitfall: Considering the risks of unsuitably hot bat boxes. Conservation Science and Practice.e412.

An image illustrating specific orientations of dimensions is shown as Figure 1, which is copied from Sedgeley Jane A and O'Donnell (1999a).

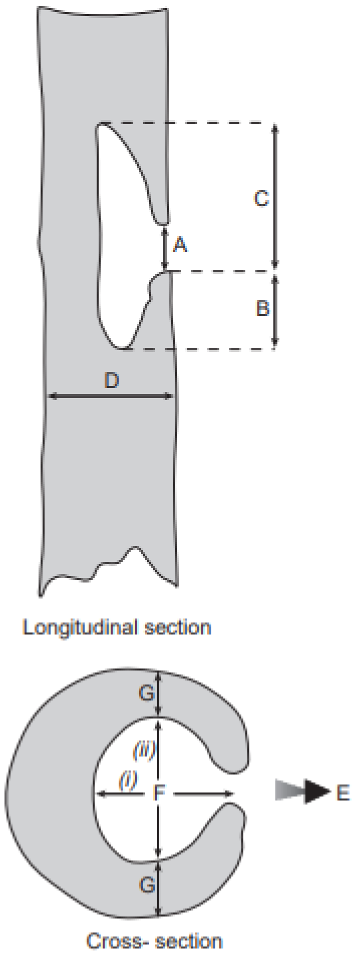

Fig. 1. Measurements taken from roost cavities and available cavities: A, the area of the entrance hole (height × width); B, cavity depth; C, cavity height; D, the tree diameter at cavity height (DCH); E, the direction the entrance faced; F, the cross-sectional area of the internal cavity (width *i* × width *ii*); and G, the cavity wall thickness (DCH − width *ii* ÷ 2).

On average, roost cavity entrances were 15 m above the ground with an entrance area of 100 cm^2. Internal dimensions follow from Sedgeley Jane A and O'Donnell (1999a); letter notation matches that in Figure 1:

Cavity characteristics: letter notation following Figure 1	**Mean**	**S.D.**
Distance to nearest vegetation	7 m	4.9
Entrance Height from ground	15 m	5.9
Entrance area (height x width): A	100 cm^2	85.0
Internal cavity depth: B	14 cm	18.2
Internal cavity height: C	43 cm	36.7
Diameter at cavity height (DCH): D	66 cm	26.8
Inside cross section: F	405 cm^2	318.6
Wall thickness: G	24 cm	11.8
Volume	26731 cm^3	32835

Roosts were in areas that had slightly less surrounding vegetation overall compared to random locations, with relatively clear air space above and below roost entrances (Sedgeley Jane A and O'Donnell 1999a).

All cavities should be carved so that they remain dry. Dimensions, orientation, height, tree species, and location should all be recorded so results from different projects can be compared in the future.

REFERENCES:

Bakken GS, O'Keefe JM. 2025. Simple design modifications can tailor bat box thermal conditions to life history requirements in different habitats. Ecological Solutions and Evidence. 6(2):e70057.

Borkin KM, Martin T. 2018. Bats in New Zealand plantations: forest management guidance. Wellington, New Zealand: New Zealand Forest Owners' Association.

Borkin KM, Parsons S. 2011. Sex-specific roost selection by bats in clearfell harvested plantation forest: improved knowledge advises management. Acta Chiropterologica. 13(2):373–383.

Chambers CL, Aim V, Siders MS, Rabe MJ. 2002. Use of artificial roosts by forest-dwelling bats in northern Arizona. Wildlife Society Bulletin. 30(4):1085-1091.

Crawford RD, O'Keefe JM. 2021. Avoiding a conservation pitfall: Considering the risks of unsuitably hot bat boxes. Conservation Science and Practice.e412.

Flaquer C, Puig X, López-Baucells A, Torre I, Freixas L, Mas M, Porres X, Arrizabalaga A. 2014. Could overheating turn bat boxes into death traps? Barbastella. 7(1).

Griffiths SR. 2021. Overheating turns a bat box into a death trap. Pacific Conservation Biology.

Griffiths SR, Bender R, Godinho LN, Lentini PE, Lumsden LF, Robert KA. 2017. Bat boxes are not a silver bullet conservation tool. Mammal Review. 47(4).

Griffiths SR, Lentini PE, Semmens K, Watson SJ, Lumsden LF, Robert KA. 2018. Chainsaw-Carved Cavities Better Mimic the Thermal Properties of Natural Tree Hollows than Nest Boxes and Log Hollows. Forests. 9(235).

Griffiths SR, Rowland JA, Briscoe NJ, Lentini PE, Handasyde KA, Lumsden LF, Robert KA. 2017. Surface reflectance drives nest box temperature profiles and thermal suitability for target wildlife. PLoS ONE. 12(5):e0176951.

Jones C, Borkin KM, Smith DHV. 2019. Roads and wildlife: the need for evidence-based decisions; New Zealand bats as a case study. New Zealand Journal of Ecology. 43(2):3376.

Mering ED, Chambers CL. 2014. Thinking Outside the Box: A Review of Artificial Roosts for Bats. Wildlife Society Bulletin 38(4):741—751.

O'Donnell CFJ, Sedgeley JA. 1999. Use of roosts by the long-tailed bat, *Chalinolobus tuberculatus*, in temperate rainforest in New Zealand. Journal of Mammalogy. 80(3):913-923.

O’Donnell CFJ. 2024. The use of artificial roosting structures by long-tailed bats (Chalinolobus tuberculatus) and non-target wildlife. New Zealand Journal of Zoology.1-14.

Robinson H, Ling N, Tempero GW. 2024. Occupation of artificial roosts by long-tailed bats (Chalinolobus tuberculatus) in Hamilton City, New Zealand. New Zealand Journal of Zoology. 51(2):186-199.

Sedgeley JA. 2001. Quality of cavity microclimate as a factor influencing selection of maternity roosts by a tree-dwelling bat, *Chalinolobus tuberculatus,* in New Zealand. Journal of Applied Ecology. 38(2):425-438.

Sedgeley JA, O'Donnell CFJ. 1999a. Factors influencing the selection of roost cavities by a temperate rainforest bat (Vespertilionidae: *Chalinolobus tuberculatus*) in New Zealand. Journal of Zoology (London). 249(4):437-446.

Sedgeley JA, O'Donnell CFJ. 1999b. Roost selection by the long-tailed bat, *Chalinolobus tuberculatus,* in temperate New Zealand rainforest and its implications for the conservation of bats in managed forests. Biological Conservation. 88(2):261-276.

Sedgeley JA, O'Donnell CFJ. 2004. Roost use by long-tailed bats in South Canterbury: examining predictions of roost-site selection in a highly fragmented landscape. New Zealand Journal of Ecology. 24(1):1-18.

Tuttle MD, Kiser M, Kiser S. 2013. The Bat House Builder’s Hand-Book. Austin, Texas, United States of America: Bat Conservation International.