BEFORE HEARING COMMISSIONERS
APPOINTED BY THE HAMILTON CITY COUNCIL

IN THE MATTER of the Resource Management Act 1991 (**RMA**)
AND

IN THE MATTER of Plan Change 5 – Peacocke to the Operative Hamilton City District Plan

Local Authority

Supplementary statement by Andrea Graves
6 October 2022

Dear Commissioners,

Here I supplement information I presented during the PC5 hearing regarding vehicle headlights.

1. As I said during my presentation, Hamilton City Council's decision not to include any requirement to screen significant bat habitat area seems to be based on the evidence of its lighting expert, John Mckensey. He wrote in his evidence:

> *37. In addition, during the Amberfield Environment Court hearing the applicant's ecologists, under the direction of Dr Stuart Parsons, undertook an analysis of historical LTB behaviour near road lighting and concluded that "Bats persist in the presence of vehicle headlights".*
>
> *38. Hence, in my opinion, it is neither practical nor necessary to regulate or screen vehicle headlight effects in relation to the LTB.*

To clarify, and as I said during my presentation, the Parsons analysis was never presented to the Environment Court. Weston Lea planned to present it in order to avoid any requirement to screen for headlights, but before that happened the parties negotiated an agreement to screen, and the Court agreed to it.

2. The agreement was to shield all 'bat priority areas' from headlights. The screen is to be 1.4 metres high, and that height increases to 1.8 metres where a road curves around and headlights therefore sweep through a bat priority area. The conditions of the Amberfield resource consent therefore require this. For your convenience I attach the relevant conditions plus a map from the conditions set that shows where the screening must be located (see Appendix A).

3. I told you that automatic bat monitors (ABMs) can detect bat passes 30–50 metres away from the ABM itself, and therefore the bat passes said to be recorded in the presence of headlights may in fact be from bats flying up to 50 m away from the road and screened from it by the established vegetation the ABM was placed next to. Today I intended to identify in the Parsons analysis which brand and model of acoustic bat monitor (ABM) was used so that I could confirm to you the distance at which that particular ABM can detect bat passes. Unfortunately, Professor Parsons did not specify this information. (Neither, as I mentioned during my presentation to you, did he or any of the Adare ecologists even mention vehicle headlights during their written evidence or evidence in reply to this hearing; it was also virtually absent from the HCC ecologists' evidence. I mentioned how unexpected this is given the primacy of this issue during the Environment Court hearing.)

4. Therefore we must guess which monitor was used. The most commonly used ABM in New Zealand is designed and manufactured by the Department of Conservation. It is the AR4 or, more formally, the Frequency Compression Automated Bat Monitoring unit. I sought evidence regarding the 30–50 m detection distance of these monitors, and the best available evidence on the second page of the paper in Appendix B (highlighted for your convenience). It refers to a personal communication from S. Cockburn, who designed these monitors and has today confirmed to me in an email that 30–50 m remains his best estimate of how far away an AR4 can detect bat passes.

5. The Appendix 2 paper reports different detection rates between models of ABM. Due to these differences, write the authors, "We agree with Parsons (1996) that the model and brand of detector used must be cited." I have also highlighted this sentence.

Yours sincerely,

Andrea Graves

Priority Areas adjoining the relevant subdivision stage and shall be selected to represent sites where, in the opinion of the technical lighting specialist, there is the greatest likelihood of illuminance being higher than the ASLL. There shall also be a visual audit supplemented by lighting measurement at any location where, in the opinion of the technical lighting specialist, the illuminance appears to be potentially higher than the ASLL.

134. The requirement to measure and report on road lighting shall apply to all subdivision stages with roads which adjoin the boundary of Bat Priority Areas. Road light levels shall be measured after all road lighting within each subdivision stage is established and operational and repeated as required following any adjustments to the road lighting regime until compliance with conditions 130 and 133 has been demonstrated. Section 224(c) shall not be issued for the relevant subdivision stage until this requirement is met.

Vehicle Headlights

134A. The requirements in either (a) or (b) shall be met prior to s224(c) certification for any subdivision stage containing roads which immediately adjoin the Bat Priority Areas (Stages 1, 4, 5, 6, 6A, 13, 24, 25, 26, 27 and 28):

a) The Road Side Buffer Planting shown on Boffa Miskell Drawings A17134_054A Vegetation Strategy – Buffer Planting dated 18 June 2021 (Schedule A18) shall be established within the Bat Priority Areas adjoining the roads within the subdivision stage to achieve the following performance standards:
   i. 1.4m height and 80% canopy closure in the vertical plane for the 'Road Side Buffer Planting >1.4m High' and 'Road Side Buffer Planting 1.4m High (3.0m Wide)' and 'Road Side Buffer Planting 1.4m High (5.0m Wide)'; and
   ii. 1.8m height and 80% canopy closure in the vertical plane for the 'Road Side Buffer Planting >1.8m High' and 'Road Side Buffer Planting 1.8m High (3.0m Wide)'; and
   iii. Compliance with (i) and (ii) shall be demonstrated through a report (or reports) prepared by a suitably qualified and experienced ecologist being provided to the satisfaction of HCC's Planning Guidance Unit Manager (or nominee).

b) If the Road Side Buffer Planting has not achieved the performance standards in (a) at the time of s224(c) certification, temporary screen fencing shall be established as an alternative to achieve the applicable height standards in (a)(i) and (ii). The design of the temporary screen fencing shall be suitable to prevent light from passing through the fence and shall be in accordance with the certified Bat Protection Plan.

Advice Note:
For the avoidance of doubt, the Road Side Buffer Planting must also comply with the relevant requirements in conditions 84 to 94.

134AA. The Road Side Buffer Planting shall be designed in a way that minimises light spill into Bat Priority Areas in locations where access is required between public roads and Bat Priority Areas for pedestrian, cycling and maintenance purposes.

134B. Any temporary screen fencing established in accordance with condition 134A(b) shall be maintained by the consent holder in accordance with the certified Bat Protection Plan until the planting requirements in condition 134A(a) for the relevant subdivision stage have been met. The consent holder shall remove any temporary screen fencing for each subdivision stage as soon as practicable once the planting requirements have been confirmed to have been met.

134C. No public vehicular access shall be provided to roads adjoining the Bat Priority Areas within the relevant subdivision stage prior to s224(c) certification.

Reserve Lighting

135. The detailed design for the recreation, amenity, pedestrian and historical reserve Lots 1500, 1501, 1505, 1511, 1513 and 1515 and for the Lots within the Bat Priority Areas shall not incorporate installation of any lighting, with the exception of lighting within Lots 1100, 1101 and 1102 that may be required internally within the pump station cabinetry.

Residential Lot Lighting

136. For all the residential Lots 20-24, 62-80, 160-164 & 186 (Stage 1), Lot 131 (Stage 2), Lots 117 & 118 (Stage 3), Lots 41-61 (Stage 4), Lots 142-147,177, 187, 197-198, 235-242 (Stage 6), Lots 243-250 (Stage 6A), Lots 828-830 (Stage 7), Lots 796-802 (Stage 8) Lots 719, 730 & 752 (Stage 9), Lots 751 & 731 (Stage 12), Lots 540, 567, 746-750 (Stage 13), Lots 541-545 (Stage 24), Lots 303, 405, 407-409, 411-421 & 436 (Stage 25), Lots 304-311, 336-339, 397-404 (Stage 26), Lots 508-511, 514-522, 535-539 (Stage 27), Lots 437-455 (Stage 28), to minimise the spill of light into Bat Priority Areas, permanent outdoor lighting arrays, including but not limited to external feature lights, security lights, path lights and driveway lights associated with future buildings shall achieve the following requirements:

(a) No floodlights or lighting of outdoor sports (eg. tennis);
(b) Luminaires shall produce no direct upward light;
(c) Luminaires shall have a maximum nominal colour temperature of 3000K;
(d) All outdoor security lighting shall be motion sensor controlled.

Compliance with this condition shall be demonstrated at the building consent stage and shall be complied with on an ongoing basis.

137. Pursuant to Section 221 of the Resource Management Act 1991, a consent notice shall be registered against the Record of Title for all the lots referred to in Condition 136 requiring that permanent outdoor lighting arrays, including but not limited to external feature lights, security lights, path lights and driveway lights associated with future buildings shall achieve the following requirements:

(a) No floodlights or lighting of outdoor sports (eg. tennis);

File Ref: A17134_054_A _Vegetation_Strategy.indd

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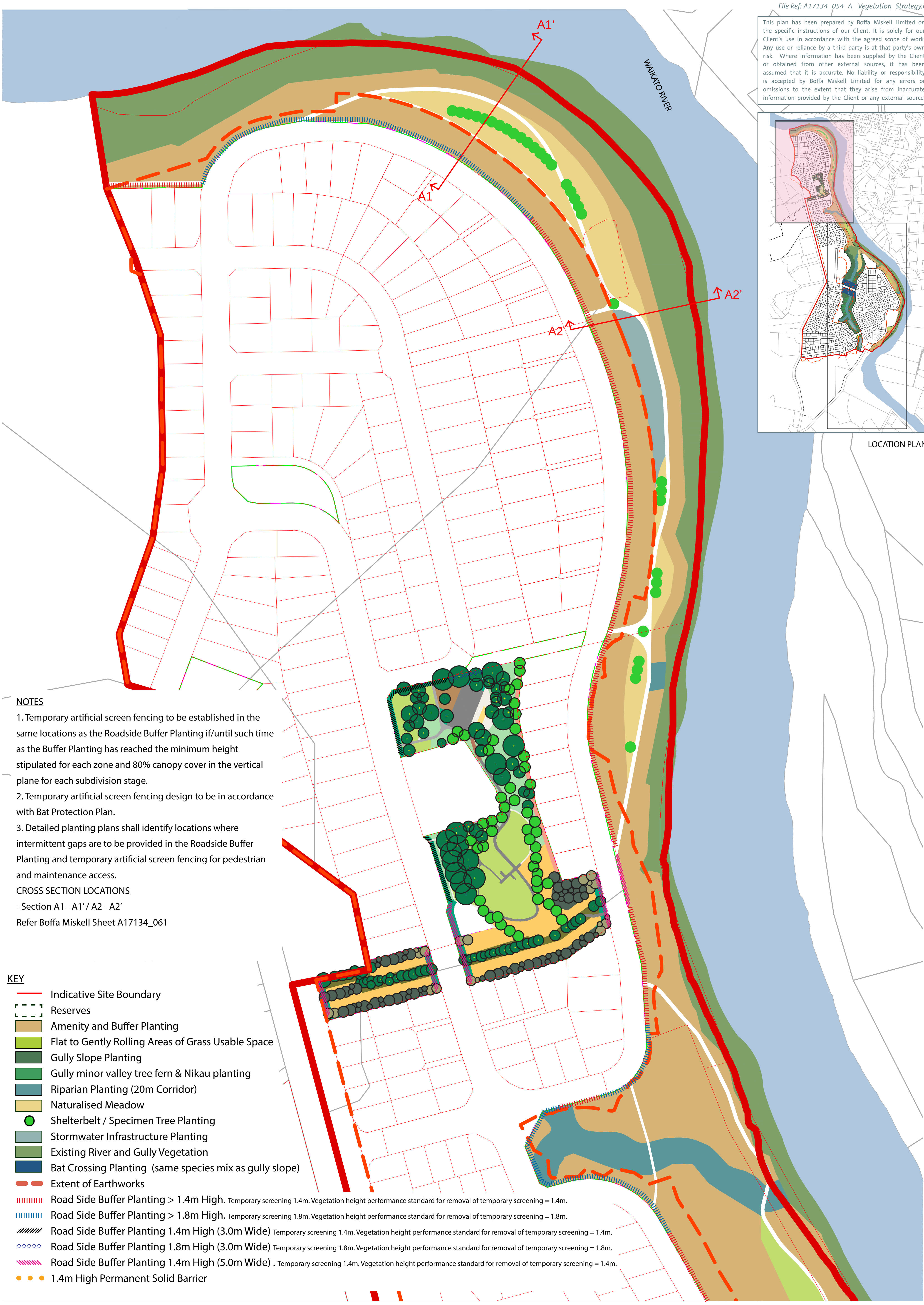

LOCATION PLAN

NOTES

1. Temporary artificial screen fencing to be established in the same locations as the Roadside Buffer Planting if/until such time as the Buffer Planting has reached the minimum height stipulated for each zone and 80% canopy cover in the vertical plane for each subdivision stage.
2. Temporary artificial screen fencing design to be in accordance with Bat Protection Plan.
3. Detailed planting plans shall identify locations where intermittent gaps are to be provided in the Roadside Buffer Planting and temporary artificial screen fencing for pedestrian and maintenance access.

CROSS SECTION LOCATIONS

- Section A1 - A1' / A2 - A2'

Refer Boffa Miskell Sheet A17134_061

KEY

- Indicative Site Boundary
- Reserves
- Amenity and Buffer Planting
- Flat to Gently Rolling Areas of Grass Usable Space
- Gully Slope Planting
- Gully minor valley tree fern & Nikau planting
- Riparian Planting (20m Corridor)
- Naturalised Meadow
- Shelterbelt / Specimen Tree Planting
- Stormwater Infrastructure Planting
- Existing River and Gully Vegetation
- Bat Crossing Planting (same species mix as gully slope)
- Extent of Earthworks
- Road Side Buffer Planting > 1.4m High. Temporary screening 1.4m. Vegetation height performance standard for removal of temporary screening = 1.4m.
- Road Side Buffer Planting > 1.8m High. Temporary screening 1.8m. Vegetation height performance standard for removal of temporary screening = 1.8m.
- Road Side Buffer Planting 1.4m High (3.0m Wide) Temporary screening 1.4m. Vegetation height performance standard for removal of temporary screening = 1.4m.
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- Road Side Buffer Planting 1.4m High (5.0m Wide) . Temporary screening 1.4m. Vegetation height performance standard for removal of temporary screening = 1.4m.
- 1.4m High Permanent Solid Barrier

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Data Sources:

Projection:

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AMBERFIELD, PEACOCKE STRUCTURE PLAN

Vegetation Strategy - Buffer Planting

DRAWING NUMBER A17134_054A

| Date: 29 June 2021 | Revision: B |

Plan prepared for Weston Lea Limited by Boffa Miskell Limited

Project Manager: Rachel.deLambert@boffamiskell.co.nz | *Drawn:* SWh | *Checked:* ABl

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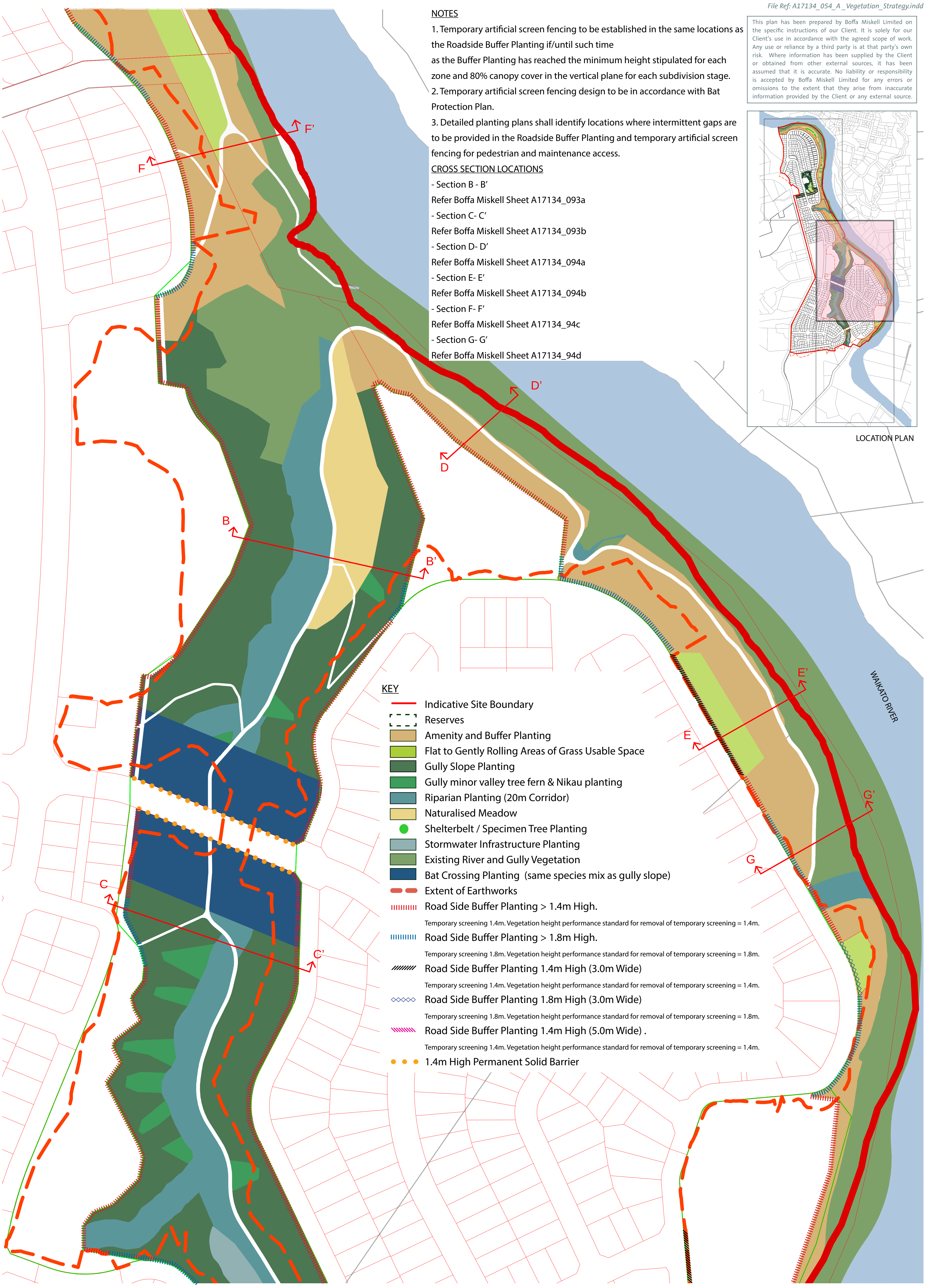
CROSS SECTION LOCATIONS

- Section B - B'
Refer Boffa Miskell Sheet A17134_093a
- Section C- C'
Refer Boffa Miskell Sheet A17134_093b
- Section D- D'
Refer Boffa Miskell Sheet A17134_094a
- Section E- E'
Refer Boffa Miskell Sheet A17134_094b
- Section F- F'
Refer Boffa Miskell Sheet A17134_94c
- Section G- G'
Refer Boffa Miskell Sheet A17134_94d



KEY

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Data Sources:
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AMBERFIELD, PEACOCKE STRUCTURE PLAN
Vegetation Strategy - Buffer Planting
DRAWING NUMBER A17134_054A
| **Date: 29 June 2021** | **Revision: B** |
Plan prepared for Weston Lea Limited by Boffa Miskell Limited
Project Manager: **Rachel.deLambert@boffamiskell.co.nz** | *Drawn:* SWh | *Checked:* ABl

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BRIEF REPORT

A comparison of two bat detectors: which is most likely to detect New Zealand's *Chalinolobus tuberculatus*?

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ABSTRACT
The presence of bat species is commonly determined by placing acoustic bat detectors that record bat echolocation calls in the habitat they are likely to use. Detection rates are affected by variables including type of detection unit used. We compared detection rates of long-tailed bat (*Chalinolobus tuberculatus*) echolocation calls between two types of automated bat detectors: Wildlife Acoustics SMZC Zero Crossing Bat Recorders (ZC), and Frequency Compression Automated Bat Monitoring units (FC) produced by New Zealand's Department of Conservation. Units were placed in locations where bats were known to be present, but not all detected bats. The median number of bat passes recorded by FC units over 10 nights was 20 compared with a median of 3 bat passes for ZC units. ZC units also detected bats over significantly fewer nights than FC units. These results suggest FC units are more sensitive and therefore better to use where long-tailed bats are expected to be at low abundance or only present infrequently. Because of inconsistencies in detection rates, we recommend the use of only one model of the detector within a monitoring project. Our data also suggests that surveys should take place over long periods to maximise likelihood of detecting bats, if present.

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Acoustic monitoring; detection rates; *Chalinolobus tuberculatus*; long-tailed bat; detection devices

Introduction

The presence of bats at a location is often determined by using acoustic bat detectors to record bat echolocation calls (Smith et al. 2017). Bats may be present at a site but may not be detected because they, for example, have not echolocated in the vicinity of the detector, or, if echolocation did occur, the detector may not have recorded it. Detection rates can be affected by factors such as weather (Doty et al. 2019) and availability of invertebrate prey (O'Donnell 2000; Hałat et al. 2018), the period of the breeding cycle (O'Donnell 2002), social behaviour (Hałat et al. 2018), habitat (Suarez-Rubio et al. 2018), and the microsite (Gehrt and Chelsvig 2003) where the detector is placed, as well as the type of detector used (Adams et al. 2012). Detection rates may reflect changes in activity or detectability. For example, when temperature and prey availability increases, activity rates of bats may increase (O'Donnell 2000); when it rains, bats delay their emergence from roosts resulting in a shorter period over which they can be detected (Geipel et al. 2019).

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This article has been corrected with minor changes. These changes do not impact the academic content of the article.
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Detectability may reduce when, for example, echolocation calls are quiet (Parsons 1997); or be altered depending on the placement of detectors in relation to environmental clutter (Banner et al. 2018), and by the type of detector used (Fenton 2000).

Acoustic detectors are increasingly being used to determine the effects of development, and to investigate bat ecology (Kerbiriou et al. 2018). Using a mix of detector types and models that have different detection rates within one research or monitoring project could result in biased results (Waters and Walsh 1994) and therefore misleading conclusions. Systematic differences in detection rates between detector types can affect the comparability of quantitative surveys for bats (Waters and Walsh 1994). It is assumed that sensitivity of bat detectors is continually improving, so even the use of more recently developed models of the same brand of detector may bias results. This would be particularly concerning if it masked the decline of a threatened species or the effects of human activity.

The long-tailed bat (*Chalinolobus tuberculatus*) is one of the two extant bat species remaining in New Zealand. It is an edge-adapted species (Borkin and Parsons 2009; O'Donnell et al. 2006; O'Donnell 2000), and is considered vulnerable to extinction by the Department of Conservation (New Zealand government) and the International Union for Conservation of Nature (O'Donnell 2008). The threat classification for long-tailed bats is 'Nationally Critical', which is the highest threat status in the New Zealand threat classification system (O'Donnell et al. 2018). Consequently, understanding the reliability of different detectors for determining long-tailed bat presence is important for management.

The relative performance of the most frequently used detectors in New Zealand have not, recently, been compared. Previous research has taken place to compare detection rates of a continuous tone the same frequency as an echolocation call of a long-tailed bat. This found that detection distances differed between brands of detectors and by habitat type (Parsons 1996). Since that time, there have been many iterations of detector types and models, with potentially differing detection rates and likely increasing sensitivity, but this has not been formally tested. Long-tailed bats are usually monitored using omni-directional automated acoustic bat detectors based on Frequency Compression (FC) of ultrasound. These detectors have been estimated to detect bats over a distance of up to 30–50 m (S. Cockburn, Department of Conservation, Wellington, New Zealand, pers. comm., 29 October 2015; Frequency Compression Automated Bat Monitoring units produced by the New Zealand Department of Conservation). Frequency Compression uses a linear frequency transformation, eliminating artificial harmonics to create a more acoustically accurate result (S. Cockburn, Department of Conservation, Wellington, New Zealand, pers. comm., 29 October 2015). For each recorded call, the output from these units is a bitmap representation of a spectrogram of the bat pass for which phase information has been discarded (S. Cockburn, Department of Conservation, Wellington, New Zealand, pers. comm., 31 October 2019).

Other types of bat detectors are available on the market, and one that is commonly used outside New Zealand is the Wildlife Acoustics Song Meter Zero Crossing (SMZC; from here onwards ZC; Wildlife Acoustics Inc.). This bat detector has been estimated to detect bats, at 40 kHz, the peak amplitude of long-tailed bat calls, up to 38 m from units (Agranat 2014). The ZC uses Frequency Division to record bat echolocation calls. Frequency Division divides the frequency of the incoming signal by a predetermined ratio, lowering its frequency (Parsons et al. 2000). The zero-crossing analysis then counts the times the incoming waveform crosses a zero-voltage level and converts this signal into a sine or square wave, which may not reflect the amplitude of the original call (Parsons et al. 2000). Many zero-crossing systems attempt to minimise noise by imposing a threshold value for the division of the incoming signal (Parsons et al. 2000). This can decrease the overall sensitivity of this detector type, particularly for bats that have low amplitude calls, such as New Zealand's lesser short-tailed bat (*Mystacina tuberculata*, Parsons 1996).

The objective of this research was to compare the effectiveness of ZC bat recorders and FC bat recorders at detecting long-tailed bats echolocation calls. In New Zealand the use of FC units is more common than the use of ZC units, but ZC units are used by some New Zealand bat ecologists to undertake survey and monitoring of long-tailed bats. Detection rates of FC and ZC detectors have not been compared to date. This research provides a comparison of the detection rates of two recently manufactured bat detector types. This represents the first-time bat detector performance has been formally tested using New Zealand long-tailed bat calls.

Materials and methods

Comparison of bat monitoring devices

We paired FC and ZC units at nine locations along road edges in exotic plantation forests where long-tailed bat populations were considered likely to be foraging along forest edges (Borkin and Parsons 2009). Locations were all in the Bay of Plenty region, in locations where long-tailed bats were thought to be the only bat species present. Paired FC and ZC units were placed 10 metres apart. Bat detectors were set to begin recording at sunset and to conclude recording at sunrise, from 30 December 2015–7 January 2016. All bat detectors were placed within two metres of the ground. The trial comparing FC and ZC bat detectors was undertaken during a period when overnight minimum temperatures ranged from 7.5 to 16.1°C, whilst temperatures at sunset ranged from 10.5 to 19.9°C. Overnight precipitation occurred on 1, 2, and 4 January: 4.2; 5.8; and 1.2 mm, respectively (CliFlo Station 41077: Rotorua EWS; http://cliflo.niwa.co.nz/ Accessed 16 May 2016).

A long-tailed bat pass was defined as a series of two or more calls each with a peak amplitude at or around 40 kHz, separated from other calls by a period of silence lasting at least one second (Thomas 1988). Short-tailed bat passes can be distinguished from long-tailed bat passes because they utilise two different parts of the spectrum: a fundamental frequency of 25–30 kHz and a harmonic frequency at 50–60 kHz, as well as a having shorter pulse duration and a higher pulse rate (Parsons 1997). Calls of New Zealand bats are readily distinguishable from other nocturnal sounds, including insects, birds, wind, and rain, which are also recorded on bat recorders.

For ZC units, bat calls were identified using the software Kaleidoscope Version 3.1.5 (Wildlife Acoustics, Inc. 2015). Recordings were processed and converted from ZC file format to an audible.wav file format. Identification of bat calls was undertaken manually by viewing a spectrogram and/or listening to the.wav file of each recording. Call shapes (or wave forms) were defined as pulses on the spectrogram, or clicks on the corresponding audible.wav file, each with a peak amplitude at or around 40 kHz.

For FC units, bat calls were identified using the software BatSearch 3.05 (Department of Conservation proprietary software, 2014). Identification of bat calls was undertaken manually by viewing a frequency compressed image of a spectrogram (i.e. the frequency axis is compressed but the time axis is not) of each recording and comparing these with images of known long-tailed bat calls (c.f. Cockburn 2014).

For each of the nine sites, the number of bat passes per night was tallied for each detector type, and the number of nights when bats were detected was calculated.

Data analyses

Because of large unequal variances and outliers in the data the total number of bat passes recorded by each type of detector were compared descriptively using box plots. However, a paired t-test was used to compare differences in the number of nights bats were detected at each site by the two detector types.

Results

Comparison of monitoring devices

The only bat species detected was long-tailed bats. The median number of detections per site for FC units was 20 (range = 1–228), while for ZC units it was three (range = 0–112). Both types of detectors have outlying values that made initial boxplots difficult to interpret, and these values have been removed in Figure 1 for visual purposes. FC bat detectors have a much greater variance in numbers of bat detections (variance = 52,612) than the ZC bat detectors (variance = 1309).

FC units had more nights where bats were detected (mean = 6.4) than ZC units (5.2 nights) and the paired t-test showed this difference to be statistically significant ($t = -4.4$, d.f. = 8, $p = .0023$).

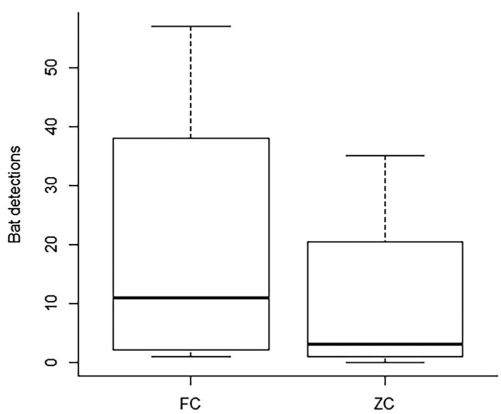

Figure 1. Boxplot comparing the number of bat detections between Zero Crossing (ZC) and Frequency Compression (FC) bat detectors with the two outliers removed.

Discussion and conclusions

FC units detected bats over more nights than ZC units indicating that FC units are more sensitive for detecting long-tailed bats. FC units also detected a greater number of bat passes than ZC units, with their upper range in bat detections being more than twice that of ZC units and their median rate of detections being 6.7 times that of ZC units.

However, this work confirms that ZC units do detect long-tailed bats, and consequently they can be used in surveys as long as deployed for a sufficient number of nights, although survey results will not be comparable to those undertaken with FC units. We recommend that FC bat detectors are used to survey and monitor long-tailed bats in New Zealand, particularly in situations where it is critically important to reliably determine presence/absence, because of their apparent higher sensitivity. FC bat detectors also had greater variance than the ZC bat detectors. This difference in variance will have implications when undertaking trend monitoring. Trends may be obscured when variance is high (Starcevich et al. 2018). Practical options to allow the observation of trends when variance is high, either between sites or years, may be to increase the number of sampling sessions i.e. the number of years (Urquhart and Kincard 1999); or to restrict the time period when sampling occurs to when activity does not vary significantly, for example to a specific seasonal window, to reduce noise in the data (Law et al. 2015).

These results should not be used as justification for changing the type of bat detector used within a monitoring programme. Best practice is to use one type, i.e. one model of detector throughout an entire monitoring programme in order to minimise any variation in likelihood of detection due to model sensitivity (Parsons and Szewczak 2009). Calibration of call rates between models of detector should occur if a change to a new detector is required.

This research focussed solely on the detection of long-tailed bats' echolocation calls. However, other types of calls, such as social calls, may also have research relevance. While FC bat detectors may detect long-tailed bats' social calls when these calls overlap the frequencies at which they record data, they may also miss some social calls that are outside their range of 28 and 40 kHz (Ian Davidson-Watts, Pers. Comm., 2 November 2016). Other detector types that record a broader range of frequencies, including ZC, may therefore be better for recording of social calls. This is because they record all frequencies simultaneously to provide real time output and high-quality recordings with complex call structure details preserved (Ian Davidson-Watts, Pers. Comm., 2 August 2019). Further investigation is required into the relative sensitivity of each type of detector to lesser short-tailed bat echolocation calls. We recommend following Parsons (1996, p. 41.) advice that bat workers choose the detector that meets their needs and 'stick with it' so that methods are standardised. We agree with Parsons (1996) that the model and brand of detector used must be cited. Parsons (1996) advice remains best practice.

Whilst this research did not focus on determining the optimal number of nights that surveys should take place over, it is clear from these data that long monitoring periods are required to improve the chance of detecting long-tailed bats if they are present. In each of the locations where we placed pairs of detector, long-tailed bats were known to be present, at least occasionally, yet they were not detected on all nights and in one case were not detected at all (Pair 8, ZC unit did not detect long-tailed bats whilst the FC unit did, Table 1). The reason for the low numbers of nights when bats were detected

Table 1. Number of nights when paired Frequency Compression (FC) and Zero Crossing (ZC) bat detectors did not detect bats.

	FC non-detections	ZC non-detections	Total nights
Pair 1	3	5	10
Pair 2	3	5	10
Pair 3	5	7	9
Pair 4	8	8	10
Pair 5	8	8	9
Pair 6	8	9	10
Pair 7	1	3	10
Pair 8	8	9	9
Pair 9	3	4	10

at some sites is unknown, but may be due to micro-site character or the lack of suitability of the wider habitat, weather or micro-climate, or proximity of detectors to resources such as roosts and foraging or commuting areas. If assessing whether bats are present is critical for management, then surveys should take place for as long as is practical.

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