BEFORE	the Independent Hearing Panel appointed by the Hamilton City Council
UNDER	the Resource Management Act 1991
And	
IN THE MATTER OF	Proposed Plan Change 5 – Peacocke Structure Plan
BY	Hamilton City Council

STATEMENT OF EVIDENCE OF DR KERRY MAREE BORKIN

On behalf of the

DIRECTOR-GENERAL OF CONSERVATION / TE TUMUAKI AHUREI

SUBMISSION 38 FS013

BAT ECOLOGY AND EFFECTS OF DEVELOPMENT

Dated: 16 September 2022

Counsel for Director-General of Conservation / Te Tumuakei Ahure
Michelle Hooper
Senior Solicitor/Rōia Matua
Department of Conservation/Te Papa Atawhai
Private Bay 3072
HAMILTON 3240

Telephone: 027 324 6314
Email: mhooper@doc.govt.nz

1. INTRODUCTION

2. QUALIFICATIONS AND EXPERIENCE

2.1. My full name is Kerry Maree Borkin.

2.2. My qualifications include a PhD in Biological Sciences from the University of Auckland (2010). This research focussed on the ecology of long-tailed bats in plantation forest. Over the period 2006-2010, my PhD research involved the capture and radio-tracking of long-tailed bats, as well as monitoring of their activity (comparison of activity between habitat types), observations at roosts and of roost emergence, and training of others in these skills.

2.3. I have a Postgraduate Diploma in Wildlife Management, with Distinction, from the University of Otago (1999). This included surveying the distribution of long-tailed bats throughout the Waikato Region for the Department of Conservation. My research dissertation for the Diploma focussed on feral cat diet and cat responses to prey abundance changes. I also have a BSc (Zoology and Ecology) from Massey University (1997).

2.4. I am certified as a "Trainer" (this was earlier Class E level) by the Department of Conservation's Bat Recovery Group, which means that I am considered highly competent at locating bat roosts, capturing and handling bats using a variety of techniques, and undertaking bat monitoring and surveys. I am certified to train others to do these tasks. This is the highest level of certification.

2.5. Since October 2019, I have been employed by the Department of Conservation as a Science Advisor focusing on research into threatened species. I am a member of the Department of Conservation's Bat Recovery Group (DOCBRG). I am a member of the panel of experts that reviewed the threat classifications of New Zealand bat species for the Department of Conservation in 2017, prior to joining the Department of Conservation, and again in August 2022.

2.6. Prior to October 2019, I was employed by Wildland Consultants Ltd as a Senior ecologist. I began my employment with Wildland Consultants Ltd as an ecologist in 2011. My role, during this time, involved in the design, oversight and interpretation of bat monitoring and surveys at various sites throughout New Zealand. I have also provided technical input and advice into the design of mitigation packages, and the development and implementation of management, mitigation, restoration, and monitoring plans that focus on bats.

2.7. From 1999 – 2006 I was employed as a research technician by Manaaki Whenua – Landcare Research focussing on predator/pest control impacts, ecology, and management.

2.8. I have previously appeared as an expert witness on behalf of the Waikato Regional Council regarding bat-related matters for the Hamilton Section of the Waikato Expressway; on behalf of the Director General of Conservation regarding bat-related matters for the Amberfield subdivision.

2.9. I have published 18 peer-reviewed scientific papers; thirteen focused on New Zealand bats. I co-authored the chapter focusing on long-tailed bats in the Handbook of New Zealand mammals[1]; this book summarises what is known about native or introduced mammal present in New Zealand. "*The Handbook of New Zealand Mammals* is the only definitive reference on all the land-breeding mammals recorded in the New Zealand region (including the New Zealand sector of Antarctica)."[2] It won a Certificate of Commendation in The Royal Zoological Society of NSW 2021 Whitley Awards: Zoology Handbook. I have written guidance documents that are focussed on managing effects of roading and other linear infrastructure projects on bats for Waka Kotahi; managing plantation forests with bats in mind for the New Zealand Forest Owners' Association; a Veterinary Care guidance document for the Wildlife Society of the Veterinary Association, Waka Kotahi (NZ Transport Agency), and the Department of Conservation; as well as Advice Notes for the DOCBRG on artificial bat roosts. I was involved in the recent review of the Roost Protection Protocol which superseded

---

1 O'Donnell CFJ, Borkin KM 2021. *Chalinolobus tuberculatus*. Chapter in King C, Forsyth D. The Handbook of New Zealand Mammals. 3rd Edn. Families Vespertilionidae and Mystacinidae, p 95-130. CSIRO Publishing, Melbourne.

2 https://www.amazon.com/Handbook-New-Zealand-Mammals-ebook/dp/B08W1RTMMK Accessed 9 August 2022.

the previous best practice of Vegetation Removal Protocols; all of which are considered industry standards.

2.10. I have acted as a peer reviewer for scientific papers regarding bats, their home range and roosts, welfare, and effects of linear infrastructure on them, for international and New Zealand-based journals. In 2017, I co-authored a report for the New Zealand Transport Agency that focussed on the effects of roads and linear transport infrastructure on New Zealand bat species.

2.11. In total, I have 24 years' experience in ecological management and research, including about 17 years focused specifically on New Zealand bats.

2.12. I currently co-supervise a PhD student, Titia Schamhart, at the University of Waikato who is researching the effect of light on long-tailed bats. I have taken part in the design and field work involved in this research and some related research. I currently co-supervise a MSc student, Alisha Hart, at the University of Auckland who is researching the effect of noise on bats and birds. I drove project concept development, and have taken part in the design and field work involved in this research and some closely related research. I regularly advise on research by a MSc student at the University of Waikato into the use of artificial roosts by long-tailed bats, and by a BSc (Honours) student at the University of Otago into roost emergence behaviour by long-tailed bats.

2.13. In 2020, I peer-reviewed for the Australian Government lighting guidelines that have since been endorsed by the United Nations Convention on Migratory Species (CMS): National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds - DAWE.[3]

2.14. In 2021, I attended the Leibniz IZW Akademie International Research online workshop focusing on Bat conservation and artificial light. This workshop focused on impacts of lighting on bats and used practical

[3] Commonwealth of Australia. 2020: *National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds*.

examples to illustrate how sustainable lighting concepts could be established from the perspective of bat conservation.

2.15. In 2022, I was actively involved in a United Nations CMS Technical Workshop on light pollution. The aim of the workshop was to review and provide input to a set of draft guidelines being developed under the aegis of CMS, aimed at providing generic advice on the reduction of light pollution and specific guidance regarding the impact of light pollution on migratory birds and bats. These guidelines are still in development and are expected to be adopted by COP14, the fourteenth meeting of Conference of the Parties (COP) to the Convention on the Conservation of Migratory Species of Wild Animals.

2.16. As part of my former role at Wildland Consultants, I gave advice to the Hamilton City Council, via AECOM (to whom we were sub-contracting), to use warm white lighting rather than cool white lighting for their streetlighting when retrofitting. I am aware of the developments in understanding since this time.

2.17. I was an author of three reports regarding long-tailed bat activity and monitoring in the southern Hamilton area:

- Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. Wildland Consultants Ltd Contract Report No. 4192d. Prepared for AECOM, New Zealand. 37 pp.

- Wildland Consultants 2018b: Thermal image monitoring of long-tailed bats for the Southern Links roading project in Hamilton: 2017 and 2018. Wildland Consultants Ltd Contract Report No. 4192c. Prepared for AECOM, New Zealand. 63 pp.

- Wildland Consultants 2017: Thermal imaging of long-tailed bats at Riverlea, Hamilton: March 2017. Wildland Consultants Ltd Contract Report No. 4285. Prepared for AECOM, New Zealand. 12 pp.

2.18. I was part of the Wildland Consultants team that developed the design of this monitoring in relation to long-tailed bats; this included light and noise monitoring. I led the field work, chose monitoring locations, undertook thermal imaging, analysed the bat detector and thermal imaging recordings, and was co-author of the reports that described the key findings. The majority of these sites were within the Peacocke Structure Plan area. As part of this work, I spent periods of time at sites within the Peacocke Structure Plan area watching bats flying via a thermal imaging camera, and later reviewing recorded footage. I am familiar with the area covered by the Peacocke Structure Plan as I have taken part in thermal imaging, acoustic monitoring, and radio-tracking projects for bats in this area.

2.19. I am experienced radio-tracking long-tailed bats in fragmented habitats similar to those covered by the Peacocke Structure Plan to understand both night-time fine-scale movements and use of habitat, and to locate roosts. I am experienced in teaching others to do the same. I have radio-tracked bats in fragmented landscapes in Central Hawkes Bay, the Central North Island, and South Canterbury. I have released bats and personally observed their movements in the presence of light and car headlights.

2.20. I also was part of the team that captured and radio-tracked long-tailed bats to determine roost locations, home ranges, and key linkages throughout southern Hamilton in January and March 2018[4].

2.21. I am a Department of Conservation representative on the Waikato Bat Alliance. The Waikato Bat Alliance is a partnership of Waikato-Tainui, Te Haa o te Whenua o Kirikiriroa (THaWK), Ngā Iwi Tōpū O Waipā (NITOW), Waikato Regional Council, Hamilton City Council, Waipā District Council, Waikato District Council, and Department of Conservation. The Strategy document developed by the Waikato Bat Alliance is included as an Appendix A to this evidence.

2.22. I am a member of the Australasian Bat Society, Birds New Zealand, and the New Zealand Ecological Society.

2.23. I am presenting this expert evidence for the Director-General of Conservation / Te Tumuaki Ahurei (Director-General) in relation to bats and the effects of development matters arising out of Hamilton City Council's proposed Plan Change 5 – Peacocke Structure Plan.

[4] Davidson-Watts I. 2018: Long-tailed bat trapping and radio tracking baseline report Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.

2.24. I took part in online facilitated conferencing related to this Plan Change on 24 August 2022.

3. CODE OF CONDUCT

3.1. I confirm I have read the code of conduct for expert witnesses as contained in the Environment Court's Practice Note 2014. I have complied with the practice note when preparing my written statement of evidence and will do so when I give oral evidence before the Hearing Panel.

3.2. The data, information, facts and assumptions I have considered in forming my opinions are set out in my evidence to follow. The reasons for the opinions expressed are also set out in the evidence.

3.3. Unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

4. SCOPE

4.1. I have been asked to provide expert ecological evidence in relation to long-tailed bats. My evidence will include evidence on:

a) the presence of long-tailed bats in the Peacocke Structure Plan Area (PSPA);

b) the vulnerability of this local population;

c) the ecological values required for habitat within the PSPA to be functional;

d) the importance of ecological connectivity to the gully systems, the Waikato River and the urban-rural transition zone; and

e) the effects of lighting, noise, roading, and predators.

4.2. In preparing this evidence, I have read and considered the following documents:

a) Proposed Plan Change 5 to the Operative Hamilton City District Plan (Peacocke Structure Plan);

b) Plan Change 5: Peacocke Structure Plan Section 32 Report Notification Version July 2021;

c) Submissions and further submissions;

d) Section 42A Hearing Report (dated 2 September 2022);

e) Statements of evidence (dated 2 September 2022) prepared for the Hamilton City Council by:

   i. Mr James (Jaimie) Grant Sirl (Planning);

   ii. Mr Nathanael Paul Savage (Wastewater and Water Supply);

   iii. Mr Alastair James Black (Transport);

   iv. Dr Hannah Mueller (Ecology – Bats, Wetlands, Freshwater Biodiversity);

   v. Dr Matthew James Baber (Ecology – Offsetting/Compensation);

   vi. Mr Gerardus (Gerry) Henricus Anthonius Kessels (Ecology);

   vii. Mr John Kinross Mckensey (Lighting); and

   viii. Mr Samuel Elliott Foster (Planning – Mdrs);

f) Joint Witness Statements:

   i. Planning & Bats 24 August 2022;

g) Waikato Regional Policy Statement: Te Tauākī Kaupapahere Te-Rohe O Waikato 2016 (RPS);

h) Davidson-Watts I 2019. Long-tailed Bat Trapping and Radio Tracking Baseline Report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM NZ Ltd;

i) Appendix L: Kessels G., Baber M. 2021. Peacocke Structure Plan Area: Ecological Significance Assessment. Report prepared by Tonkin and Taylor for Hamilton City Council. Report number: 1007479.0040.v4;

j) Appendix J: Mueller H, Davidson-Watts I, Kessels G. 2021. Peacocke Structure Area Plan Change Long-tailed bat report For Hamilton City Council. Document name:

4sight_Psp_Bat_Report_Final_June 2021. Appendix J of the "*Plan Change 5 – Peacocke Structure Plan - Assessment of Environmental Effects (2021)"*.

4.3. For ease of reference, I attach as Appendix F, a consolidated list of the reference material that I have relied upon in my evidence.

4.4. In preparing my statement of evidence, I have reviewed the statements of evidence of the following experts for the Director-General of Conservation:

a) Ms Moira Pryde (Bat ecology);

b) Susan Mander (Lighting);

c) Dr Ilse Corkery (Offsets and compensation); and

d) Jesse Gooding (Planning).

4.5. In my evidence I note any relevant assumptions and any certainties or insufficiency of information that underlies my expert opinion/evaluation.

5. EXECUTIVE SUMMARY

5.1. Long-tailed bats (*Chalinolobus tuberculatus*, Threatened-Nationally Critical) appear to be generally restricted to the southern parts of Hamilton with habitats of particular importance being those around wooded areas and the southern Hamilton gully system and along the Waikato River.

5.2. Long-tailed bats are present throughout the Peacocke Structure Plan area (PSPA), and are known to use the area for commuting, foraging, and roosting. All habitat types located within the PSPA are used by bats. There are known bat roosts – both communal and solitary – within the PSPA, both are rare and valuable.

5.3. Changes proposed within the PSPA are likely to result in reduced bat activity, use and functionality for bats because of the effects of development including increases in urbanisation, lighting, noise, predators including cats, rats, stoats, weasels, and possums, traffic, and roading network density. Loss of trees (and other vegetation) may result in a smaller bat population, with smaller home ranges, fewer roosts, and lower levels of functional connectivity through the area. A loss in functional connectivity within the PSPA is likely to reduce connectivity with areas within already urbanised parts of Hamilton, including the Mangakootukutuku gully, and in the Waipaa District and beyond.

5.4. Long-tailed bats have already been injured and killed in tree felling operations in the PSPA.

5.5. Careful planning and provisions will be required to manage effects of development across the entire area.

5.6. At present the proportion of the PSPA that is proposed to become 'Significant Bat Habitat Areas' is relatively small and may be insufficient to allow a stable bat population to persist in the PSPA.

6. LONG-TAILED BATS ARE PRESENT IN THE PEACOCKE STRUCTURE PLAN AREA (PSPA) AND ARE AT RISK

6.1. The New Zealand long-tailed bat (*Chalinolobus tuberculatus*) is an endemic bat, which means that it is found only in New Zealand. It is vulnerable to extinction and is ranked as "Threatened-Nationally Critical" which is the highest threat ranking in the Department of Conservation's threat classification system. It meets this threat ranking because it is undergoing a "very high ongoing or predicted decline (> 70%)."[5] The next step in the threat classification system is "extinction".

6.2. Long-tailed bats are present throughout much of the Waikato Region[6]. A lack of reporting of bats by the general public, with few records after the 1920s and 1930s[7,8], led to the incorrect belief that long-tailed bats had become extinct in urban habitats. The long-tailed bat population within the Hamilton area is now considered to be one of the few New

5 O'Donnell C.F.J., Borkin K.M., Christie J.E., Lloyd B., Parsons S., Hitchmough R.A. 2018: Conservation status of New Zealand bats, 2017. *New Zealand Threat Classification Series 21*. Department of Conservation, Wellington, New Zealand. 4 pp.

6 Department of Conservation's Bat Distribution (Database Version received 10 May 2018).

7 O'Donnell C.F.J. 2005: New Zealand long-tailed bat. Chapter In: C. M. King (Ed.): The Handbook of New Zealand Mammals, Second Edition. Pp 98-109. Oxford University Press, Melbourne.

8 Dekrout A.S., Clarkson B.D., and Parsons S. 2014: Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*). *New Zealand Journal of Zoology.* DOI: 10.1080/ 03014223.2014.953551

Zealand populations that reside in and utilise cities. Dekrout (2009)[9] confirmed the presence of long-tailed bats within Hamilton using systematic surveys of green spaces, and the capture and radio-tracking of individual bats to locate roosts and home ranges. This study confirmed their apparent reliance on gully systems in southern Hamilton and the peri-urban area, i.e., the landscape interface between town and country, the rural-urban transition zone**.**

6.3. Use of the PSPA by long-tailed bats for commuting and feeding (foraging)[10,11], and roosting[12] has been confirmed**.** I was part of the team which confirmed the use of the PSPA as bat feeding and commuting habitat. All habitat types present in this area are used by long-tailed bats (indigenous and exotic vegetation, and pasture)[13], so the entire PSPA is bat habitat.

6.4. I was part of the capture and radio-tracking team that confirmed the southern Hamilton long-tailed bat population includes at least 61 bats. This number is based on counts that took place at three active roosts on 16 January 2018[14]; the population was estimated using the Minimum Number Alive method[15]. I took part in these counts.

6.5. Of the 28 roosts we found in that study, only three known roosts in artificial roost boxes are adequately protected from predators with predator exclusion bands. As most roosts are not protected adequately from predators, it is likely that this population is declining, as others are throughout New Zealand. This is because in places without adequately

---

9 Dekrout A.S. 2009: Monitoring New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in urban habitats: ecology, physiology and genetics. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 168 pp.

10 Wildland Consultants 2018b: Thermal image monitoring of long-tailed bats for the Southern Links roading project in Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192c*. Prepared for AECOM, New Zealand. 63 pp.

11 Davidson-Watts I. 2018: Long-tailed bat trapping and radio tracking baseline report Southern Links, Hamilton. Report prepared for AECOM NZ Ltd

12 AECOM 2019: Letter to Nathanael Savage Hamilton City Council: Bat roosts identified during radio tracking completed in January, March and December 2018 AECOM Reference: \\nzham1fp001.au.aecomnet.com\projects\601x\60164546\4. tech work area\4.25 nzta emmp\7.0 reports_final\bat roost data issued\ltr bat roosts sites identified during radio tracking.docx

13 Davidson-Watts I 2019. Long-tailed Bat Trapping and Radio Tracking Baseline Report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.

14 Davidson-Watts I. 2018: Long-tailed bat trapping and radio tracking baseline report Southern Links, Hamilton. Report prepared for AECOM NZ Ltd

15 The Minimum Number Alive population estimation method involves simply counting all bats seen alive at one point in time. This method has some flaws (or limitations), largely related to the likelihood of not being able to estimate the proportion of the population that is unseen at that time. It is therefore thought to probably underestimate population size (Smith D., Borkin K., Jones C., Lindberg S., Davies F., and Eccles G. 2017: Effects of land transport activities on New Zealand's endemic bat populations: reviews of ecological and regulatory literature. *NZ Transport Agency Research Report 623*. 249 pp.).

large areas of predator control (i.e., that protect all known roosts), bat population sizes are likely to be decreasing.[16, 17]

7. BATS ARE HIGHLY PHILOPATRIC

7.1. A home range is the area that an individual bat uses relatively regularly.[18,19] It includes all the breeding sites, feeding sites, and movement pathways for commuting that a bat uses. Long-tailed bats have strong fidelity to their home range; they are highly philopatric[20]. Even when large parts of an individual bat's home range have been lost due to tree felling, they are unlikely to move to an entirely new area because they are limited by their knowledge of suitable roosts and feeding (foraging) areas[21], and are faithful to their social group of bats[22]. If bats try to move to a new area, they may not be accepted by bats that are already resident.

7.2. The extent of an individual's home range is usually determined by capturing an individual and attaching a radio-transmitter. Individuals can then be followed and the extent of area that they use is estimated.

7.3. Long-tailed bat home ranges can be large. In and around Hamilton, Dekrout (2009) found that male long-tailed bats have home ranges from 25.9 hectares to 871.0 hectares, and 0.8 to 7.3 kilometres across.[23] More recently, Davidson-Watts (2018) found that female long-tailed bats in the southern Hamilton area used areas from 137.8 hectares to 1609.4 hectares in size, and 3.3 to 6.6 kilometres across.[24] I was part

---

16 Pryde M.A, O'Donnell C.F.J., and Barker R.J. 2005: Factors influencing survival and long-term population viability of New Zealand long-tailed bats (*Chalinolobus tuberculatus*): Implications for conservation. *Biological Conservation 126*: 175-185.

17 O'Donnell C.F.J., Pryde M.A., van Dam-Bates P., and Elliott G.P. 2017: Controlling invasive predators enhances the long-term survival of endangered New Zealand long-tailed bats (*Chalinolobus tuberculatus*): Implications for conservation of bats on oceanic islands. *Biological Conservation 214*: 156-167. http://dx.doi.org/10.1016/ j.biocon.2017.08.015

18 Burt W. H. 1943. Territoriality and home range concepts as applied to mammals. *Journal of Mammalogy 24*: 346–352.

19 Powell R. A., Mitchell M. S. 2012. What is a home range? Journal of Mammalogy, 93(4):948-958 http://dx.doi.org/10.1644/11-MAMM-S-177.1

20 Borkin K.M. and Parsons S. 2014: Effects of clear-fell harvest on bat home range. PLoS ONE 9(1): e86163 doi:10.1371/journal.pone.0086163

21 Law B.S. 1996. Residency and site fidelity of marked populations of the Common blossom bat Syconycteris australis in relation to the availability of Banksia inflorescences in New South Wales, Australia, Oikos 77(3): 447-458

22 Borkin K.M. and Parsons S. 2014: Effects of clear-fell harvest on bat home range. PLoS ONE 9(1): e86163 doi:10.1371/journal.pone.0086163

23 Dekrout A. S. 2009. Monitoring New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in urban habitats: ecology, physiology and genetics. *Unpublished PhD thesis*, University of Auckland, Auckland, New Zealand. Pp 168

24 Davidson-Watts I. 2018: Long-tailed Bat Trapping and Radio Tracking Baseline Report Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.

of the team that captured and radio-tracked bats for this project. Whilst these areas may appear large, it is likely that they do not include entire home ranges because of the relatively short timeframe over which radio-tracking usually takes place (normally 1-2 weeks). Radiotracking since 2010 has only taken place over four sessions of two-three weeks duration for roost finding, and far less than this for habitat use – usually only 1-2 full nights for each bat.[25] This means that the majority of the roosts will be unmapped for this population, and most of the ways individual bats use the landscape will be unknown, although they are likely to use similar habitat types as bats for which this is known.

7.4. Hamilton's bat population is found mainly in the southern part of the city and the adjoining peri-urban area, that includes the area encompassed by the PSPA.[26,27] Since 2010, the Waikato Museum has run tours highlighting the use of southern Hamilton by long-tailed bats, and particularly Hammond Park which lies immediately across the Waikato River from this area. Hammond Park is considered an important location for bats in Hamilton. Dekrout (2009) captured the majority of the bats in her study in this park, and located three of the 12 roosts found during her research in this green space.[28] Recent radio-tracking confirmed multiple roosts within the PSPA[29]. It should be noted, however, that radio-tracking only samples a small sub-set of roosts; transmitters are only attached to bats for a short period, and there will be more roosts within the area than what has been detected through radio-tracking[30].

---

25 Davidson-Watts I 2019. Long-tailed Bat Trapping and Radio Tracking Baseline Report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.

26 Dekrout A.S., Clarkson B.D., and Parsons S. 2014: Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*). *New Zealand Journal of Zoology.* DOI: 10.1080/ 03014223.2014.953551

27 Le Roux D.S., Le Roux N.S., and Waas J.R. 2013: Spatial and temporal variation in long-tailed bat echolocation activity in a New Zealand city. *New Zealand Journal of Zoology*. DOI:10.1080/03014223.2013.827125

28 Dekrout A. S. 2009. Monitoring New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in urban habitats: ecology, physiology and genetics. *Unpublished PhD thesis*, University of Auckland, Auckland, New Zealand. 168 pp.

29 Davidson-Watts I 2019. Long-tailed Bat Trapping and Radio Tracking Baseline Report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.

30 Note that the exact location of some roosts were not confirmed on some days of the radiotracking because access was too risky so these are also unmapped.

7.5. There have been numerous intensive surveys and monitoring studies of long-tailed bats in the PSPA[31,32,33,34,35,36]. The surveys, and the modelling of survey results, confirmed the importance of both the wider peri-urban area in southern Hamilton, and of the PSPA itself[37,38]. This is because very few records of bats were located outside of southern Hamilton.[39]

7.6. Indeed, Crewther and Parsons (Page 20)[40] noted that bats are most often detected: "on the periphery of urban Hamilton, predominantly in the south and southeast, and only extending north to the east of the city in areas of pasture containing linear features such as hedges, and where housing and street lighting density is very low".

7.7. The Waikato River, all of the southern Hamilton gully systems, and the PSPA are considered important habitat for long-tailed bats in the Southern Hamilton population and provide key linkages between

31 Le Roux D.S. and Le Roux N.S. 2012: Hamilton City Bat Survey 2011-2012. Report prepared by Kessels & Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). 22 pp. Document Ref: \\server files\Hamilton City Council\Bat survey city wide\city wide survey report_240512.

32 Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192d*. Prepared for AECOM, New Zealand. 37 pp.

33 Dekrout A.S., Clarkson B.D., and Parsons S. 2014: Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*). *New Zealand Journal of Zoology.* DOI: 10.1080/ 03014223.2014.953551

34 Wildland Consultants 2018b: Thermal image monitoring of long-tailed bats for the Southern Links roading project in Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192c*. Prepared for AECOM, New Zealand. 63 pp.

35 Dekrout A. S. 2009. Monitoring New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in urban habitats: ecology, physiology and genetics. *Unpublished PhD thesis*, University of Auckland, Auckland, New Zealand. Pp 168

36 Davidson-Watts I 2019. Long-tailed Bat Trapping and Radio Tracking Baseline Report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.

37 Dekrout A.S., Clarkson B.D., and Parsons S. 2014: Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*). *New Zealand Journal of Zoology.* DOI: 10.1080/ 03014223.2014.953551

38 Crewther K. and Parsons S. 2017: Predictive modelling of long-tailed bat distribution in the Hamilton area. *Walkingbats Consultancy report.* Prepared for Project Echo (a collaboration between Hamilton City Council, Department of Conservation, Waikato Regional Council, and Riverlea Environment Society Inc.).

39 Mueller H., Ulrich C., and Purcell A. 2017: Draft Hamilton City long-tailed bat survey 2016-2017. A report prepared by Kessels and Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). Pp 25.

40 Crewther K. and Parsons S. 2017: Predictive modelling of long-tailed bat distribution in the Hamilton area. Walkingbats Consultancy report prepared for Project Echo (a collaboration between Hamilton City Council, Department of Conservation, Waikato Regional Council, and Riverlea Environment Society Inc.).

roosting and foraging areas[41,42]. These areas are relied upon because they contain roosts, and connections between roosts and places bats feed, breed, and socialise.

8. WHY IS THIS POPULATION AT RISK?

8.1. When they can, long-tailed bats in the Hamilton area spend most of their time outside the city, even if they roost within the city limits[43]. Little bat activity appears to occur within parts of Hamilton which are highly urbanised i.e., have suburban housing[44], and activity decreases significantly with even small increases in housing density, street lighting, and roading Le Roux and Le Roux's (2012) survey of Hamilton found that when road and street light density was considered together with housing density, there was a significant negative effect on long-tailed bat activity. They also found that with a slight increase in housing density (from their lowest recorded score of less than one house per hectare to less than five) that bat activity declined by 42%. Earlier work by Dekrout (2009)[45] also found a significant negative correlation between long-tailed bat activity in Hamilton and housing and street light density – more houses, less bat activity.

8.2. Given that bat activity declined by 42% when housing density increased from less than one house per hectare to less than five houses per hectare, effects of urbanisation on long-tailed bats are therefore likely to be significant at lower levels of housing intensification than the housing densities proposed for the PSPA[46]. Chapter 3A DEV01-PSP:P9 aims to achieve a minimum of 30 – 45 dwellings per ha not including areas comprising reserves and roads. Effects of urbanisation

---

41 Davidson-Watts I. 2018: Long-tailed bat trapping and radio tracking baseline report Southern Links, Hamilton. Report prepared for AECOM NZ Ltd

42 Dekrout A.S., Clarkson B.D., and Parsons S. 2014: Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*). *New Zealand Journal of Zoology.* DOI: 10.1080/ 03014223.2014.953551

43 Davidson-Watts I 2019. Long-tailed Bat Trapping and Radio Tracking Baseline Report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.

44 Le Roux D.S. and Le Roux N.S. 2012: Hamilton City Bat Survey 2011-2012. Report prepared by Kessels & Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). 22 pp. Document Ref: \\server files\Hamilton City Council\Bat survey city wide\city wide survey report_240512.

45 Dekrout A.S. 2009: Monitoring New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in urban habitats: ecology, physiology and genetics. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 168 pp.

46 Le Roux D.S. and Le Roux N.S. 2012: Hamilton City Bat Survey 2011-2012. Report prepared by Kessels & Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). 22 pp. Document Ref: \\server files\Hamilton City Council\Bat survey city wide\city wide survey report_240512.

on long-tailed bats are likely to be significant at far lower levels than this.

9. WHAT DO LONG-TAILED BATS NEED? ROOSTS

9.1. For bats to remain in the landscape there must be roosts. Bats spend their days within roosts resting, socialising, and feeding their young. Most roosts known to be used by long-tailed bats are within trees[47]; usually within cavities, broken trunks or branches, under peeling bark or in other deformities[48]. Roosts are not simply a random subset of available trees. They are chosen to provide a stable micro-climate suitable for breeding and raising their young, and to minimise the unnecessary use of energy[49]. Long-tailed bats have been found to choose the best roosts in the landscape at reducing their energy costs.[50]

9.2. Roosts can become unsuitable by exposing them to light and noise, or felling surrounding trees, and making them exposed.

9.3. Roosts can become less accessible, and lose their functionality, when “barriers” are placed in the way of the bats. These barriers can be removal of vegetation/other trees or nearby open areas where bats can feed or drink, or the addition of light and noise, and traffic.

9.4. Roosts become less safe for bats when predators, light, and exposure to elements increase, and trees or other vegetation are removed.

9.5. When roosts are lost, they are difficult to replace. Attempting to replace roosts with artificial roost boxes is a short-term way to address roost loss, but these provide short-term homes with temperatures that vary widely i.e., become too hot and too cold[51], and we know little about how

---

47 O’Donnell C.F.J. 2005: New Zealand long-tailed bat. Chapter In: C. M. King (Ed.): The Handbook of New Zealand Mammals, Second Edition. Pp 98-109. Oxford University Press, Melbourne.
Chapter In: C. M. King (Ed.): The Handbook of New Zealand Mammals, Second Edition. Pp 98-109. Oxford University Press, Melbourne; Borkin K.M. and Parsons S. 2011: Sex-specific roost selection by bats in clearfell harvested plantation forest: improved knowledge advises management. *Acta Chiropterologica 13*(2): 373-383.

49 Sedgeley J.A. 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: 425–438

50 Sedgeley J.A. 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: 425–438

51 Chambers, C. L., V. Aim, M. S. Siders and M. J. Rabe (2002). "Use of artificial roosts by forest-dwelling bats in northern Arizona." Wildlife Society Bulletin 30(4): 1085-1091.

to design roosts that 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 [52]. This means that populations will have fewer weaned young and adult bats surviving[53].

9.6. Artificial roost boxes require regular (annual) maintenance to continue being available for use by bats. Without maintenance, they deteriorate, and eventually fall to the ground; this can happen within six years of installation. One local project, shown in the Figure 1, attempted to replace felled trees that were potential roosts with artificial bat roosts, but these were not maintained annually. Within six years 21 out of the thirty artificial roosts were no longer suitable/available for bats to use them.

Box 30, no bats, lots of ants

Representative photos of ropes left on trees where no box found

Figure 1. Image shows how artificial bat roosts deteriorate without maintenance for six years. Note the artificial bat roost on its side is not a suitable bat roost replacement[54]

9.7. On 10 September 2022, I visited Sandford Park, where bats were first confirmed to be using roost boxes in Hamilton and noted the large number of trees that had been felled since my previous visit in 2020. Felling trees around roosts is one way that roosts may become less

52 New Zealand Bat Recovery Group Advice Note – The Use of Artificial Bat Roosts: Department of Conservation Advice Note: https://ftp.doc.govt.nz/public/folder/J8y-HgKTuEmoYMZtafa6nA/bat-recovery/Bat%20recovery%20group%20advice%20notes/doc-artificial-bat-roost-advisory-note-2021.pdf

53 Sedgeley, J. A. and C. F. J. O'Donnell (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

54 Gollin J. 2019. Long-tailed Bat Annual Monitoring – 2019 Waikato Aggregates Prepared for Bloxam Burnett and Oliver Ltd 4 April 2019 by Ecology NZ. Report number: 1708145-002

suitable for bats, because this may change their exposure to weather. During my 10 September 2022 visit, I estimated that more than 40 mature trees had been felled or topped since I had last visited in 2020. The continued use of these artificial roost boxes highlights the rarity of natural roosts in the area.

Figure 2. One of the artificial bat roosts used by long-tailed bats with felled trees in background; Sandford Park, 10 September 2022.

9.8. Keeping already planted trees in perpetuity, alongside planting more trees, is a more suitable long-term method of providing roosts which are suitable for long-tailed bats[55]. This is because these natural roosts will provide roosts with more stable thermal properties so resident bats

55 New Zealand Bat Recovery Group Advice Note – The Use of Artificial Bat Roosts: Department of Conservation Advice Note: https://ftp.doc.govt.nz/public/folder/J8y-HgKTuEmoYMZtafa6nA/bat-recovery/Bat%20recovery%20group%20advice%20notes/doc-artificial-bat-roost-advisory-note-2021.pdf

will be more likely to survive[56] and it supports connectivity through the landscape.

9.9. My research has found that male and female long-tailed bats often choose different roosts, and this may be due to their differing energetic requirements.[57] Female bats are thought to form communal groups when their pups are young, and male bats largely roost alone elsewhere. However, this is not exclusively the case. I have captured male bats exiting roosts shared with females (*pers. obs.*), and in Fiordland, male and female bats frequently switch between communal and solitary roosts.[58] Both solitary and communal roosts are crucial for populations to survive.

9.10. There are confirmed and potential roosts within the PSPA[59]. There are several consequences of the removal of roosts. These include:

a) the risk of death or injury to bats during the tree felling and removal process;

b) the loss of a resource for bats that is already rare and vital for survival;

c) the inability to use an area because there are no/few suitable roosts to return to;

d) and associated likely reductions in bat survival and fitness (the ability of an individual to produce viable offspring). The reduction in survival and fitness is because bats will be forced to use less-preferred, poorer quality, roosts[60].

9.11. Roosts outside of indigenous forest are considered to be relatively uncommon (i.e., rare) compared to numbers present within indigenous

[56] Sedgeley, J. A. and C. F. J. O'Donnell (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

[57] Borkin K.M. and Parsons S. 2011: Sex-specific roost selection by bats in clearfell harvested plantation forest: improved knowledge advises management. *Acta Chiropterologica 13*(2): 373-383.

[58] O'Donnell C.F.J. and Sedgeley J.A. 1999: Use of roosts by the long-tailed bat, *Chalinolobus tuberculatus*, in temperate rainforest in New Zealand. *Journal of Mammalogy 80*(3): 913-923.

[59] AECOM 2019: Letter to Nathanael Savage Hamilton City Council: Bat roosts identified during radio tracking completed in January, March and December 2018 AECOM Reference: \\nzham1fp001.au.aecomnet.com\projects\601x\60164546\4. tech work area\4.25 nzta emmp\7.0 reports_final\bat roost data issued\ltr bat roosts sites identified during radio tracking.docx

[60] Chaverri G., Kunz T.H. 2011. Response of a Specialist Bat to the Loss of a Critical Resource. PLoS ONE 6(12): e28821. https://doi.org/10.1371/journal.pone.0028821

forests[61]. This is because trees in managed landscapes, e.g., towns, cities, and plantation forests, less frequently reach the age and senescence generally required to become potential bat roosts. This is because long-tailed bats are often found roosting in features such as within cavities or splits, or under decorticating (peeling or flaking) bark, and these features are usually not present within young vegetation. Most roosts found by Dekrout (2009) within Hamilton were under peeling bark[62].

9.12. Where there are lots of roosts, bats re-use them infrequently. For example, within Fiordland's indigenous forest, 10.1% of roosts were re-used in the same summer.[63] Where roosts are relatively uncommon, such as in Hamilton, roosts are re-used far more often. In the Hamilton area, Dekrout (2009) found that of the 11 bats she radio-tracked, all but two used only one roost throughout the entire radio-tracking period (5-19 days, and the remaining two used only two roosts)[64]. This pattern of high rates of re-use of roosts both within the same summer and between years, is supported by other research outside of indigenous forest where roosts are also uncommon (for example, as I have shown in exotic plantation forest[65]).

9.13. Dekrout (2009)[66] confirms that "*it is likely that each individual old tree is important* (Page 85)" to long-tailed bats because of the unexpectedly high fidelity (faithfulness) to individual trees as roosts. This finding is also supported by international research showing the importance of trees to urban bats[67].

9.14. When their roost trees are felled or removed, bats may not be able to easily move to another equally suitable roost because they may be

61 Sedgeley J.A. and O'Donnell C.F.J. 1999: 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*: 261-276.

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

64 Dekrout A.S. 2009: Monitoring New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in urban habitats: ecology, physiology and genetics. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 168 pp.

65 Borkin K.M. 2010: Ecology of New Zealand long-tailed bat (*Chalinolobus tuberculatus*) in exotic plantation forest. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 172 pp.

66 Dekrout A.S. 2009: Monitoring New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in urban habitats: ecology, physiology and genetics. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 168 pp.

67 Straka T.M., Wolf M., Gras P., Buchholz S., and Voigt C.C. 2019: Tree cover mediates the effect of artificial light on urban bats. Frontiers in Ecology and Evolution 7:91. doi: 10.3389/fevo.2019.00091

already occupied by other bats, or they may not be available because of their rarity.[68] The likelihood of being able to simply move to another equally suitable roost is particularly low in locations such as Southern Hamilton and the PSPA, where trees suitable as roosts are likely to be *particularly* rare.

9.15. Consequently, each known roost within the Hamilton area is likely to be of high value to the local bat population, and each roost, and the area surrounding these roosts, should therefore be protected.

10. WHAT DO LONG-TAILED BATS NEED? FUNCTIONAL HABITAT

10.1. Bat "habitat" has been defined in the Waikato Bat Alliance high-level strategy document[69] as "*collection of locations that provide the resources and conditions* needed *for bats to be present, and will include, but may not be limited to, areas that provide for breeding, roosting, foraging, and commuting*". This document is included as Appendix A of this evidence. As described earlier, the Waikato Bat Alliance is a partnership of Waikato-Tainui, Te Haa o te Whenua o Kirikiriroa (THaWK), Ngā Iwi Tōpū O Waipā (NITOW), Waikato Regional Council, Hamilton City Council, Waipā District Council, Waikato District Council, and Department of Conservation.

10.2. For bat habitat to be functional, it needs to contain sufficient areas for breeding, roosting, foraging, and commuting to occur, as well as functional links between these areas.

10.3. During field work in the PSPA between 2017 and 2019, I observed bats flying between roosts, breeding areas, and foraging areas both within the PSPA and to areas outside the PSPA[70]**.**

10.4. This movement between these areas, and between the Mangakootukutuku gully networks indicates that the areas is currently functional as an area for long-tailed bat foraging, commuting, socialising, and roosting. In my opinion, it is unlikely to remain as

---

[68] Chaverri G., Kunz T.H. 2011. Response of a Specialist Bat to the Loss of a Critical Resource. PLoS ONE 6(12): e28821. https://doi.org/10.1371/journal.pone.0028821

[69] Alternative Endings, 2021: *Framing a Bat Strategy for the Waikato Region: Themes, outcomes and engaging stakeholders - A discussion document for the Waikato Bat Alliance, 4 November 2021*.

[70] Wildland Consultants 2018b: Thermal image monitoring of long-tailed bats for the Southern Links roading project in Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192c*. Prepared for AECOM, New Zealand. 63 pp.

functional for long-tailed bats after it has experienced the effects of urbanisation. I will outline some of the reasons later in my evidence.

10.5. I was part of the team who undertook radio-tracking in southern Hamilton and found that core areas of bat home ranges – the areas where bats spent most of their time – were "focussed on woodland/tree dominated habitats such as treelines, small copses, gully systems or the wooded margins of the Waikato River", and that bats also flew, and potentially foraged, over "areas of pasture with scattered trees"[71]. This highlights the value of trees, including individual trees, to bats in this landscape.

10.6. Radiotracking of individual bats in the Southern Hamilton area, that I was part of, found that despite bats using roosts in or near to urbanised areas, such as the Mangakootukutuku gully system and in Sandford Park, they generally quickly leave areas close to their roosts and would spend most of their flying time foraging and socialising in the larger areas of Southern Hamilton less affected by the effects of development[72]. This highlights the avoidance of urban areas by long-tailed bats in Hamilton, and importance of connecting these urban areas to less developed areas.

10.7. Research, including my own, has found that long-tailed bats are most likely to be detected flying along edges of vegetation, such as bush-pasture margins or streams.[73,74] When recording bat activity along edges, I showed that young regenerating indigenous vegetation did not have as much bat activity as older, and taller, exotic forested areas.[75] Areas without any trees (for example pasture) had the least activity. Consequently, it is my opinion that older trees, and the surrounding areas, should be considered important for bats for commuting, feeding, and roosting.

---

[71] Davidson-Watts I. 2018: Long-tailed Bat Trapping and Radio Tracking Baseline Report Southern Links, Hamilton. Report prepared for AECOM NZ Ltd. Page 15

[72] Davidson-Watts I 2019. Long-tailed Bat Trapping and Radio Tracking Baseline Report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.

[73] Borkin K.M. and Parsons S. 2009: Long-tailed bats' use of a *Pinus radiata* stand in Kinleith Forest: recommendations for monitoring. *New Zealand Journal of Forestry 53*(4): 38-43.

[74] O'Donnell C.F.J., Christie J.E., and Simpson W. 2006: Habitat use and nocturnal activity of lesser short-tailed bats (*Mystacina tuberculata*) in comparison with long-tailed bats (*Chalinolobus tuberculatus*) in temperate rainforest. New Zealand. *Journal of Zoology 33*(2): 113-124.

[75] Borkin K.M. 2010: Ecology of New Zealand long-tailed bat (*Chalinolobus tuberculatus*) in exotic plantation forest. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 172 pp.

10.8. It should be noted that whilst detection rates of long-tailed bat echolocation calls are low in open pasture compared to other habitats, long-tailed bats do use pasture for feeding and commuting. I have observed long-tailed bats flying and feeding over pasture. I was involved in radio-tracking in southern Hamilton that found bats both feeding and commuting over open pasture[76]. Core areas of home ranges – the areas of a bats' home range that is used most often – included areas of pasture.[77] These core areas were used for feeding and night roosting. A similar pattern of long-tailed bats commuting and foraging through open pasture occurs in and around large areas of indigenous forest, despite the high value of the forest areas to bats[78].

10.9. Long-tailed bats are considered an edge-adapted species[79] that often fly along treelines taking advantage of the high abundance of invertebrates usually found at least several metres into dark open space from trees/forested areas[80]. Pasture has relatively high invertebrate abundance – even higher than native forest areas[81] - so is likely to be relatively valuable to bats, when considering foraging habitat value in this landscape. A review of impacts of urbanisation on invertebrate abundance found that in most cases, urbanisation resulted in lower invertebrate abundance[82], so in the case of the Peacocke Structure Plan area a permanent loss of pasture that comes with urbanisation is likely to result in poorer foraging opportunities for bats.

10.10. It is likely that if open pasture habitats are lost, as will happen with the urbanisation of the PSPA, then bat activity rates will decrease due to concomitant increases in effects related to urbanisation (see below for further discussion).

---

76 Davidson-Watts I. 2018: Long-tailed Bat Trapping and Radio Tracking Baseline Report Southern Links, Hamilton. Report prepared for AECOM NZ Ltd

77 Dekrout A.S. 2009: Monitoring New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in urban habitats: ecology, physiology and genetics. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 168 pp.

78 Bennett R.S. 2019. Understanding movement and habitat selection of the lesser short-tailed bat to infer potential encounters with anticoagulant bait. Unpublished MSc (Zoology) thesis, Massey University, Manawatū, New Zealand. 74 p.

79 O'Donnell C.F.J., Christie J.E., and Simpson W. 2006: Habitat use and nocturnal activity of lesser short-tailed bats (*Mystacina tuberculata*) in comparison with long-tailed bats (*Chalinolobus tuberculatus*) in temperate rainforest. New Zealand. *Journal of Zoology 33*(2): 113-124.

80 Pawson SM, Brockerhoff EG, Meenken ED, Didham RK. 2008. Non-native plantation forests as alternative habitat for native forest beetles in a heavily modified landscape. Biodiversity and Conservation 17: 1127-1148

81 Pawson SM, Brockerhoff EG, Meenken ED, Didham RK. 2008. Non-native plantation forests as alternative habitat for native forest beetles in a heavily modified landscape. Biodiversity and Conservation 17: 1127-1148

82 ones EL, Leather SR 2012. Invertebrates in urban areas: A review. European Journal of Entomology: 109:463-478.

10.11. The definitions of "low value", "moderate value", and "high value" value bat habitat as currently described in this Plan Change's Ecological Significance Assessment report[83] are likely to result in a misunderstanding. These are copied below for ease of reference[84]:

> On this basis, the Mueller *et al.*, (2021) report mapped and assigned a value to long-tailed bat habitats of 'high value', 'moderate value' or 'low value' (see Figure 4.3) as follows:
>
> - 'High value' habitats included the margins of the Waikato River, Mangakōtukutuku Gully and known roost sites;
> - 'Moderate value' habitats included areas containing:
>   - vegetation,
>   - edge pasture habitat near high value habitat which may be utilised by bats as commuting corridors,
>   - foraging habitats, or
>   - potential bat roost trees
> - 'Low value' habitats included areas of open pasture and scattered trees which may provide occasional foraging or commuting habitat for bats.
>
> Human-made structures, such as buildings and roads, are highly unlikely to provide habitat for bats.

10.12. The misunderstanding is likely to arise because all of these habitat types – "low", "moderate", and "high" – are currently used by bats, and all habitat types form part of bats' core habitat areas – the areas where bats spent most of their time.

10.13. The excerpt copied above also highlights that "*human-made structures, such as buildings or roads, are highly unlikely to provide habitat for* bats".

10.14. On average, long-tailed bats in Southern Hamilton have home ranges of 704 ha[85]. The entire PSPA comprises approximately 740 ha of rural land[86]. The entire area of bat habitat that will be permanently lost totals 537.84 ha[87]. This equates to a 78.7% of what remains available in the PSPA excluding the Southern Links area, according to Mr Kessels' evidence. However, this underestimates total loss as a result of urbanisation of the PSPA. When you include the Southern Links designation footprint – which is occurring due to the planned urbanisation of the PSPA and further afield, it is likely that more than

[83] Kessels G., Baber M. 2021. Peacocke Structure Plan Area: Ecological Significance Assessment. Report prepared by Tonkin and Taylor for Hamilton City Council. Report number: 1007479.0040.v4
[84] Kessels G., Baber M. 2021. Peacocke Structure Plan Area: Ecological Significance Assessment. Report prepared by Tonkin and Taylor for Hamilton City Council. Report number: 1007479.0040.v4
[85] Mean home range of 24 radio-tracked long-tailed bats from Southern Hamilton; Davidson-Watts I 2019. Long-tailed Bat Trapping and Radio Tracking Baseline Report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.
[86] Sirl JG. 2022. Statement of Evidence of James (Jamie) Grant Sirl (Planning) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.
[87] Kessels GHA 2022 Statement of Evidence of Gerardus Henricus Anthonius Kessels (Ecology) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.

80% of current bat habitat will be permanently lost. This leaves less than 200 ha that is not permanently lost to bats within the PSPA[88]. This does not include areas of bat habitat that, in the future, will be lost because they are bisected by roads additional to the Southern Links footprint. Clearly, the area remaining that is not to be developed will be significantly smaller than an individual bat home range. This will be insufficient to provide habitat for the 61 long-tailed bats resident in Southern Hamilton.

10.15. The risk of confining long-tailed bats, and the management of the effects of development on bats, to such small areas that are surrounded by houses as dense as 30-45 dwellings/ha[89] is that this will no longer provide sufficient, suitable, habitat for the area to be functional for a stable population to persist.

10.16. Given this considerable risk, it is my opinion that effects of development on long-tailed bats should be addressed over the entire PSPA, rather than the currently proposed approach.

10.17. Previous research in Southern Hamilton also confirmed this use of the PSPA, and found that gullies and corridors through urban areas may be useful *if* they link distant forest patches[90]. This highlights the need for, and importance of, corridors that effectively link forest patches, not for them to provide the entirety of habitat remaining.

10.18. Loss of functional corridors may also mean that access is lost to both to more central parts of the city and those areas outside the city boundary. Careful selection of corridors that are protected from the effects of development will be required in order for this area to have the chance to operate as a functional area for long-tailed bats.

11. HOW DOES URBANISATION AFFECT CONNECTIVITY? ROADING NETWORKS AND TRAFFIC

11.1. The proposed Plan Change will result in an increase in roads, and traffic during the night. This is likely to result in serious adverse effects

---

88 Note that both these figures from Council experts differ from what is quoted elsewhere so it is difficult to be exact with this lack of consistency.

89 Or more.

90 Dekrout AS, Clarkson BD, Parsons S 2014. Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*), New Zealand Journal of Zoology, 41:4, 285-295

on long-tailed bats. My research has found that the likelihood of detection of long-tailed bats decreases with increases in overnight traffic – more traffic, less bat activity[91]. A Hamilton-wide bat survey showed that bat activity decreased by 86% when road density increased slightly from their lowest recorded density[92]. I led research that found that there is a significant negative relationship between the presence of a road and bat activity in the southern Hamilton area. This shows there is an already existing effect of roads on bat activity at these sites[93].

11.2. This means that whilst there is the possibility that bats will continue to use areas that have increases in roading networks and traffic, it is likely that use would be reduced significantly.

11.3. Installation of tall plantings close to either side of roads may reduce the likelihood of collisions between bats and vehicles. This is only likely to be effective, however, if gaps in the vegetation above the road are small, lighting is minimised, and plantings align with previously identified bat flight paths.[94]

12. HOW DOES URBANISATION AFFECT CONNECTIVITY? LIGHTING

12.1. A growing body of New Zealand-based research suggests that the long-tailed bat may be considered sensitive to light. Research into the effect of light on the southern Hamilton long-tailed bat population found that as light increased, bat activity decreased[95]. I led research by Wildland Consultants (2018a) that found that at sites in peri-urban southern Hamilton where mean lux (light) were above 1.0, there was little or low bat activity, whilst as light levels decreased from 0.5 down

---

91 Borkin K.M, Smith D.H. V., Shaw W.B. McQueen J.C. 2019. More traffic, less bat activity: the relationship between overnight traffic volumes and *Chalinolobus tuberculatus* activity along New Zealand highways. Acta Chiropterologica, 21(2): 321–329.

92 Le Roux D.S. and Le Roux N.S. 2012: Hamilton City Bat Survey 2011-2012. Report prepared by Kessels & Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). 22 pp. Document Ref: \\server files\Hamilton City Council\Bat survey city wide\city wide survey report_240512.

93 Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192d*. Prepared for AECOM, New Zealand. 37 pp.

94 Smith D., Borkin K., Jones C., Lindberg S., Davies F., and Eccles G. 2017: Effects of land transport activities on New Zealand's endemic bat populations: reviews of ecological and regulatory literature. *NZ Transport Agency Research Report 623*. 249 pp.

95 Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192d*. Prepared for AECOM, New Zealand. 37 pp.

to 0 lux there was a tapered increase in bat activity. This is supported by a Hamilton-wide bat survey that found bat activity to be lower where street light density is higher; bat activity decreased by 72% when street light density increased slightly from their lowest recorded density[96]. Modelling by Crewther and Parsons (2017) also suggests that the probability of the presence of long-tailed bats in Hamilton increases with distance from streetlights (from 0-100 metres)[97].

12.2. Most recently, there has been research in the Southern Hamilton area into the effects of light on long-tailed bats by a PhD student, Titia Schamhart from University of Waikato, that I co-supervise. I was involved in review, and advice through my co-supervisory role for this research. Through my co-supervisory role, I have reviewed the results of this research. It appears that the research has found that when lit, the research site had lower rates of bat activity and bats arrived at the site later than when it was unlit (T. Schamhart, publication in prep[98].). Understanding the effect of light on nocturnal species, like bats, by research like this was recommended as prioritised fundamental research crucial for understanding whether light impacts needed to be managed, by a recent research report for Waka Kotahi NZ Transport Agency[99].

12.3. Increasing light at a given site may therefore result in less use of that site by long-tailed bats.

13. HOW DOES URBANISATION AFFECT CONNECTIVITY? EFFECTS OF CAR HEADLIGHTS ON LONG-TAILED BATS

13.1. It is unclear whether the effect of car headlights on long-tailed bats will be addressed by the current proposed Provisions.

---

96 Le Roux D.S. and Le Roux N.S. 2012: Hamilton City Bat Survey 2011-2012. Report prepared by Kessels & Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). 22 pp. Document Ref: \\server files\Hamilton City Council\Bat survey city wide\city wide survey report_240512.

97 Crewther K. and Parsons S. 2017: Predictive modelling of long-tailed bat distribution in the Hamilton area. Walkingbats Consultancy report prepared for Project Echo (a collaboration between Hamilton City Council, Department of Conservation, Waikato Regional Council, and Riverlea Environment Society Inc.).

98 Schamhart T. in prep. The impact of artificial light on long-tailed bat behaviour and ecology.

99 Simcock, R., Innes, J., Samarasinghe, O., Lambie, S., Peterson, P., Glen, A., & Faville, N. (2022). Road edge-effects on ecosystems: A review of international and New Zealand literature, an assessment method for New Zealand roads, and recommended actions (Waka Kotahi NZ Transport Agency research report 692). 692 assessment of edge effects biodiversity ecosystems mitigation road edge effects (nzta.govt.nz) https://www.nzta.govt.nz/assets/resources/research/reports/692/692-road-edge-effects-on-ecosystems.pdf

13.2. I am aware that Professor Stuart Parsons recently compiled a report outlining the potential effect of car headlights on long-tailed bat activity[100] and that this has been referred to by other experts, including Mr Mckensey in his evidence[101]. In this report, Professor Parsons summarised results from several studies alongside roads and noted that long-tailed bat activity was still recorded at these sites. This is in line with my previous research that found at some sites alongside roads there are still long-tailed bats detected. However, in two separate studies, my research found that there is likely to be less activity alongside roads than at sites further away[102,103]. One of these studies took place in the Southern Hamilton area and found a negative effect of roads on long-tailed bat activity – alongside roads there was likely to be less bat activity[104].

13.3. To understand what would happen when long-tailed bats have car headlights shone on them or in their direction, as it likely to happen in the PSPA, you would need to shine car headlamps on bats and see whether they flew away or not. This did not happen in the course of the Parsons report.

13.4. From my experience radiotracking long-tailed bats in Kinleith plantation forest, I have some insight into what may happen when car headlights are shone on bats – they fly away[105]. This occurred repeatedly. In the case of the car headlights in the Parsons' report, headlights would rarely, if ever, shine directly on the locations where bats would be flying i.e., headlights rarely shone at right angles to the road. This is because the surveyed locations had no or few driveways, corners, or intersections nearby. There will be many driveways, corners, and intersections in the PSPA, so car headlights will frequently shine on areas bats fly in, even if these are set-back from the road. Without management to mitigate this, car headlights will frequently penetrate

---

100 Parson S. 2021. AMBERFIELD – PERSISTENCE OF BATS IN THE PRESENCE OF VEHICLE HEADLIGHTS Prepared for Weston Lea by Walking bats Specialist Environmental Consulting,

101 Mckensey JR 2022. Statement of Evidence of John Kinross Mckensey (Lighting) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.

102 Borkin K.M, Smith D.H. V., Shaw W.B. McQueen J.C. 2019. More traffic, less bat activity: the relationship between overnight traffic volumes and *Chalinolobus tuberculatus* activity along New Zealand highways. Acta Chiropterologica, 21(2): 321–329.

103 Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192d*. Prepared for AECOM, New Zealand. 37 pp.

104 Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192d*. Prepared for AECOM, New Zealand. 37 pp.

105 I quickly learned to stop my car as far distant as possible from the area that the bat was likely to be flying and to dip my lights well in advance to reduce the likelihood of the bat flying away.

the SBHA, SNAs and other areas bats fly and roost. It appears that there are currently no provisions to address this effect.

13.5. A recent report by Manaaki Whenua for Waka Kotahi - the New Zealand Transport recommended actions to mitigate the impact of car head lights on nocturnal fauna. It recommended using "*barriers to block headlight spread, especially at corners where light travels a long distance. Barriers can include plants (when dense and tall enough)*." and to ensure roads were not elevated in sensitive areas as two of many methods to manage effects of light[106] Other methods may include increasing the separation between roads and areas bats use.

14. SO HOW MIGHT EFFECTS OF LIGHTING ON LONG-TAILED BATS BE MANAGED?

14.1. Zeale *et al.* (2018; Page 1)[107] noted that it is "*essential to preserve dark corridors to mitigate the impacts of artificial light at night on bat activity and movements"*.

14.2. Azam *et al*. (2018; Page123)[108] investigated the effect of lighting on bat activity in France and recommended "separating streetlights from ecological corridors by at least 50 m and avoiding vertical light trespass beyond 0.1 lux to ensure their use by light-sensitive bats". Azam *et al*. (2018) recommended this distance because streetlight avoidance was noted for some French bat species at up to 50 m distant from lights. This distance is untested for long-tailed bats but is likely to be greater than 50 m. This is because modelling by Crewther and Parsons (2017) found that long-tailed bats were more likely to be detected at 100 m than at 50 m distant from streetlights[109].

106 Simcock, R., Innes, J., Samarasinghe, O., Lambie, S., Peterson, P., Glen, A., & Faville, N. (2022). Road edge-effects on ecosystems: A review of international and New Zealand literature, an assessment method for New Zealand roads, and recommended actions (Waka Kotahi NZ Transport Agency research report 692).

107 Zeale M.R.K., Stone E.L., Zeale E., Browne W.J., Harris S., and Jones G. 2018: Experimentally manipulating light spectra reveals the importance of dark corridors for commuting bats. Global Change Biology 1-10. DOI: 10.1111/gcb.14462

108 Azam C., Le Viol I., Basa Y., Zissis G., Vernet A., Julien J-F., Kerbiriou C. 2018: Evidence for distance and illuminance thresholds in the effects of artificial lighting on bat activity. Landscape and Urban Planning 175: 123-135

109 Crewther K. and Parsons S. 2017: Predictive modelling of long-tailed bat distribution in the Hamilton area. Walkingbats Consultancy report prepared for Project Echo (a collaboration between Hamilton City Council, Department of Conservation, Waikato Regional Council, and Riverlea Environment Society Inc.).

14.3. Consequently, one focus of a lighting regime that avoids in the first instance, then remedies, then mitigates effects of lighting on long-tailed bats should be to:

a) preserve dark corridors and avoid the use of lights where possible;

b) any proposed buffer for lighting should be conservative, and should provide a greater than 50 metre separation, although 100 m is likely to be more appropriate based on local research, between lighting and habitat likely to be used by long-tailed bats. This includes roosts, both communal and solitary. Any buffer created by planting is unlikely to be effective immediately, and a short-term approach, such as using non-reflective artificial buffers, should considered in tandem with a long-term planting approach**.**

14.4. Other methods of managing the effects of lighting should also be considered. Straka *et al.* (2019)[110] recommend the following:

a) Avoiding and minimising light in areas close to trees,

b) Avoiding light in areas of high habitat quality,

c) Adding dense vegetation to highly lit areas to buffer effects, and

d) Turning off lights when the area is not in use.

14.5. There are several key guidance documents available that have principles and recommendations suitable for designing lighting regimes that avoid, remedy, and mitigate the effects of lighting on bats. These documents give general principles which should be followed for bats and lighting[111,112,113] and are included in my evidence as Appendices B, C, and D.

---

110 Straka T.M., Wolf M., Gras P., Buchholz S., and Voigt C.C. 2019: Tree cover mediates the effect of artificial light on urban bats. *Frontiers in Ecology and Evolution 7:91. doi: 10.3389/fevo.2019.00091*

111 National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds - DCCEEW (accessed 30 August 2022.)

112 https://cdn.bats.org.uk/uploads/pdf/Resources/ilp-guidance-note-8-bats-and-artificial-lighting-compressed.pdf?v=1542109349 (Accessed 30 August 2022).

113 Voigt CC, Azam C, Dekker J, Ferguson J, Fritze M, Gazaryan S, Hölker F, Jones G, Leader N, Lewanzik D, Limpens HJGA, Mathews F, Rydell J, Schofield H, Spoelstra K, Zagmajster M. 2018. Guidelines for consideration of bats in lighting projects. EUROBATS Publication Series No. 8. UNEP/EUROBATS Secretariat, Bonn, Germany, 62 pp https://www.eurobats.org/sites/default/files/documents/publications/publication_series/WEB_EUROBATS_08_ENGL_NVK_19092018.pdf

14.6. There are obvious alignments between the three guidance documents for management of lighting effects. These include, but are not limited to:

a) Only light when and where necessary.

b) Keep illuminance levels as low as possible.

c) Minimise light spill.

d) Use lights with low, no, or filtered UV and blue wavelength light.

14.7. Two of the documents specifically note that if lighting is necessary then choosing lighting with a correlated colour temperature of 2700K or less, and minimal blue wavelength light, would be best for managing effects of lighting on bats[114,115].

14.8. Colour temperature of lights can be defined as Correlated Colour Temperature (CCT); measured by Kelvin (K). Somewhat counterintuitively, warmer colours correspond to lower CCT (lower Kelvin); cooler light generally includes more blue (and has higher Kelvin). So, for example *as a general rule of thumb*, 2700K lights are warmer and contain less blue wavelength light than 3000K or 4000K.

14.9. Because not all lights of a specific CCT (measured in Kelvin) have identical amounts of each wavelength of light, the interrogation of graphs, called Spectral Power Distributions (SPD), which shows the amount of each wavelength emitted by each light, will be important to ensure that lights chosen meet the common objective of the three guidance documents of using low, no, or filtered UV and blue wavelength light to minimise effects on bats.

14.10. The guidelines also focus on minimising the amount of time that bats are exposed to light by recommending only using lights when they are needed, and particularly recommend that any external security lighting

---

[114] https://cdn.bats.org.uk/uploads/pdf/Resources/ilp-guidance-note-8-bats-and-artificial-lighting-compressed.pdf?v=1542109349 (Accessed 30 August 2022).

[115] Voigt CC, Azam C, Dekker J, Ferguson J, Fritze M, Gazaryan S, Hölker F, Jones G, Leader N, Lewanzik D, Limpens HJGA, Mathews F, Rydell J, Schofield H, Spoelstra K, Zagmajster M. 2018. Guidelines for consideration of bats in lighting projects. EUROBATS Publication Series No. 8. UNEP/EUROBATS Secretariat, Bonn, Germany, 62 pp https://www.eurobats.org/sites/default/files/documents/publications/publication_series/WEB_EUROBATS_08_ENGL_NVK_19092018.pdf

should be set on motion-sensors and short (1min) timers[116]. Allowing lighting to remain on for longer periods will not minimise effects of lighting on long-tailed bats as much as is possible or practical.

14.11. In my opinion, it is important to follow these general principles of lighting design, discussed above, to minimise effects of lighting for bats over the entire PSPA. Not addressing lighting effects over the entire PSPA will reduce functionality of the area.

14.12. If lighting cannot be measured at an appropriately low level to allow for checks on compliance, or kept at suitably low levels, then additional measures should be required. These may include increasing set-back and buffer distances between lit areas and corridors, SNAs, or open spaces. Because lit areas are not planned to be separated from all areas likely to be used by bats by more than 50 m as recommended by Azam *et al*. (2018; Page123) [117], additional management, such as that recommended by Straka (*et a*l. 2019, above) is likely to be required in order to avoid and minimise effects of lighting on bats by increasing their physical separation from lit areas. In particular, planting buffers of tall, fast-growing, vegetation will provide additional physical separation of bats and lighting. In addition to reducing light spill into bat habitat, planting of dense buffers may also benefit bats by reducing noise and other disturbance.

15. HOW DOES URBANISATION AFFECT CONNECTIVITY? NOISE

15.1. Whilst there is international research that shows that feeding rates are reduced (both in terms of speed and success) for bats in noisier areas[118] and that bats change their flight paths to avoid the noisiest areas[119], there has been little research until very recently on the effect of noise on long-tailed bat activity. Some research in southern Hamilton for the Southern Links roading project found no clear relationship between long-tailed bat activity and noise, however, in this research there were also other differences in sites which would have affected

[116] https://cdn.bats.org.uk/uploads/pdf/Resources/ilp-guidance-note-8-bats-and-artificial-lighting-compressed.pdf?v=1542109349 (Accessed 30 August 2022).

[117] Azam C., Le Viol I., Basa Y., Zissis G., Vernet A., Julien J-F., Kerbiriou C. 2018: Evidence for distance and illuminance thresholds in the effects of artificial lighting on bat activity. Landscape and Urban Planning 175: 123-135

[118] Schaub A, Ostwald J, Siemers BM 2008. Foraging bats avoid noise. Journal of Experimental Biology 211: 3174−3180; Siemers BM, Schaub A 2011. Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators.
Proceedings of the Royal Society of London B: Biological Sciences 278: 1646–1652.

[119] Bennett VJ, Zurcher AA 2013. When corridors collide: road related disturbance in commuting bats. Journal of Wildlife Management 77: 93−101.

activity[120]. Other research into long-tailed bat activity at a site near Hamilton Airport found that, in comparison with pre-aircraft rates, echolocation rates were reduced when aircraft passed overhead and for a short time afterwards. However, these differences were not statistically significant. The authors did note that their sample sizes were very small[121], so any differences could be obscured.

15.2. One way to understand whether it is noise itself that causes an effect on bat activity is to isolate noise as the only variable that changes as part of a playback experiment. This method, using a 'ghost' or 'phantom' road to determine the effect of noise on fauna, was recommended as prioritised fundamental research crucial for understanding whether noise needed to be managed, by a recent research report for Waka Kotahi NZ Transport Agency[122]. To help understand whether there were effects of noise on bats and birds, the Department of Conservation's *"Te Mana o Te Taiao"* research programme and the DOCBRG funded a MSc student, Alisha Hart from the University of Auckland, who I co-supervise, to investigate the effect of noise (sound) on bats and birds using a playback experiment. I developed the project concept, applied for funding, and was involved in project design, site selection, field work and managing contracts and data processing for this research. Over six weeks, we set up a "phantom road", that is a series of speakers that played the ultrasound (ultrasonic) and audible (sonic) sound components of recorded noise[123]. Through my co-supervisory role, I have reviewed the results of this research. It appears that the research has found a negative effect of noise playback on long-tailed bat calls – when there was noise played back there was less bat activity (A. Hart, publication in prep.[124]).

[120] Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192d*. Prepared for AECOM, New Zealand. 37 pp.

[121] Le Roux D. S., Waas J. R. 2012. Do long-tailed bats alter their evening activity in response to aircraft noise? *Acta Chiropterologica 14*(1): 111–120.

[122] Simcock, R., Innes, J., Samarasinghe, O., Lambie, S., Peterson, P., Glen, A., & Faville, N. (2022). Road edge-effects on ecosystems: A review of international and New Zealand literature, an assessment method for New Zealand roads, and recommended actions (Waka Kotahi NZ Transport Agency research report 692). 692 assessment of edge effects biodiversity ecosystems mitigation road edge effects (nzta.govt.nz) https://www.nzta.govt.nz/assets/resources/research/reports/692/692-road-edge-effects-on-ecosystems.pdf

[123] Playback sound was traffic noise recorded at one site next to a busy 100km/h road.

[124] Hart A. in prep. Assessing the effects of anthropogenic (traffic) noise on native wildlife.

15.3. A reduction in bat activity due to noise would reflect a loss in functional/effective habitat[125].

15.4. In the PSPA situation, the addition of noise to a site might mean that corridors or significant natural areas (SNAs) or areas that are prioritised for bat habitat protection have reduced functionality.

15.5. Researchers suggested potential mitigation strategies to address the effects of noise on bats. These included noise barriers, substrate alterations and speed limits on roads[126]. Other measures could include restrictions on events and their locations, particularly near areas known or suspected to have roosts or identified as bat corridors. This is because individual events, such as music festivals, have resulted in delayed emergence of bats from their roosts; this means that the time available for feeding would be reduced and bats would be become more dehydrated with potential impacts on body condition and fitness if repeated[127].

15.6. Consequently, precaution would be prudent, and reducing or limiting the level of noise at a site is likely to be useful for ensuring the persistence of long-tailed bats, and maintaining functional connectivity**.** Provisions focused on noise reduction should be considered to support connectivity and persistence by long-tailed bats.

16. HOW DOES URBANISATION AFFECT CONNECTIVITY? LOSS OF CONNECTIVITY

16.1. For bats to persist somewhere, they need sufficient resource patches that contain roosts as well as areas for foraging and socialising, and connectivity between these. Landscape connectivity is the "degree to which the landscape facilitates or impedes movement among resource patches".[128] Connectivity is risked when fragmentation of habitat occurs

[125] Bunkley JP, McClure CJW, Kleist NJ, Francis CD, Barber JR 2015. Anthropogenic noise alters bat activity levels and echolocation calls. Global Ecology and Conservation 3 (2015) 62–71

[126] Finch D, Schofield H, Mathews F. 2020. Traffic noise playback reduces the activity and feeding behaviour of free-living bats. Environmental Pollution 263(B): https://doi.org/10.1016/j.envpol.2020.114405

[127] Shirley MDF, Armitage VL, Barden TL, Gough M, Lurz PWW, Oatway DE, South AB, Rushton SP. 2001. Assessing the impact of a music festival on the emergence behaviour of a breeding colony of Daubenton's bats (*Myotis daubentonii*). Journal of Zoology 254(3):367-373 https://doi.org/10.1017/S0952836901000863

[128] Taylor P.D., Fahrig L., Henein K.,Merriam G. 1993. Connectivity Is a Vital Element of Landscape Structure. Oikos 68(3):571-573

through the removal of vegetation[129], the addition of lighting[130] and roading[131,132,133], and increases in urbanisation[134,135] because these result in bats flying less often in affected areas (all indicated by fewer bat detections).

16.2. For example, Carlier *et al* (2019) found that removing a 5 m section of woodland (treed) vegetation from the centre of a corridor (or known flight path) significantly reduced the functional connectivity within the immediate landscape. Adding woodland habitat to the corridor - e.g., by planting – significantly increased functional connectivity within the immediate landscape.

16.3. When connectivity is reduced because of increased fragmentation of habitat, populations are at greater risk of local extinction[136]. Areas of larger than 5 m will be removed from areas currently mapped as SNA or Open Space in the PSPA, and are currently being removed from other areas of Hamilton on which bats rely (See Figure 2's photo of felled trees for an example of loss of greater than 5 m reduction which may lead to reduced connectivity).

16.4. Currently there is functional connectivity across the PSPA and between the PSPA and elsewhere. I have watched bats flying across the area using a thermal imaging camera along treelines and across pasture, and followed their general paths both across the PSPA and to Hamilton

---

[129] Carlier J., Moran J., Aughney T., Roche N. 2019. Effects of greenway development on functional connectivity for bats. Global Ecology and Conservation Volume 18: e00613. Carlier et al (2019) found that when vegetation was removed functional connectivity was reduced, but when it was added functional connectivity increased.

[130] Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192d*. Prepared for AECOM, New Zealand. 37 pp.

[131] Le Roux D.S. and Le Roux N.S. 2012: Hamilton City Bat Survey 2011-2012. Report prepared by Kessels & Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). 22 pp. Document Ref: \\server files\Hamilton City Council\Bat survey city wide\city wide survey report_240512.

[132] Dekrout A.S., Clarkson B.D., and Parsons S. 2014: Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*). *New Zealand Journal of Zoology.* DOI: 10.1080/ 03014223.2014.953551

[133] Borkin K.M., Smith D.H.V., Shaw W.B., McQueen J.C. 2019. More traffic, less bat activity: the relationship between overnight traffic volumes and *Chalinolobus tuberculatus* activity along New Zealand highways. Acta Chiropterologica, 21(2): 321–329

[134] Dekrout A.S., Clarkson B.D., and Parsons S. 2014: Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*). *New Zealand Journal of Zoology.* DOI: 10.1080/ 03014223.2014.953551

[135] Le Roux D.S. and Le Roux N.S. 2012: Hamilton City Bat Survey 2011-2012. Report prepared by Kessels & Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). 22 pp. Document Ref: \\server files\Hamilton City Council\Bat survey city wide\city wide survey report_240512.

[136] Crooks K.R., Burdett C.L., Theobald D.M., King S.R.B., Di Marco M., Rondinini C., Boitani L. 2017: Quantification of habitat fragmentation reveals extinction risk in terrestrial mammals PNAS July 18, 2017 114 (29) 7635-7640; first published July 3, 2017 https://doi.org/10.1073/pnas.1705769114

City and further afield using radiotracking[137]. This current connectivity will be reduced by urbanisation of the area, felling of trees, and the removal of any vegetation for roads, cycleways, housing, or infrastructure.

16.5. Consequently, mitigation measures should focus on improving and enhancing functional connectivity by maintaining as large as possible, dark, treed areas, and by preserving tree lines – linear landscape features that I, and others, have found long-tailed bats are most often radio-tracked and detected flying along[138]. In order to support connectivity, habitat should be preserved as unaltered as possible, and where it is already altered, minimising disturbance is considered of primary importance[139].

16.6. Specifically, areas of corridors should not be considered to provide functional connectivity if they are severed by roads, or are affected by light spill, or noise, or if tree felling is allowed to take place. Additional areas should be included within protected corridors to mitigate this loss of functionality if avoidance of loss is not possible in the first instance.

17. HOW DOES URBANISATION AFFECT CONNECTIVITY? PREDATORS INCLUDING CATS

17.1. Rats, stoats, weasels, possums, and cats kill bats. This predation has contributed to significant declines in both New Zealand bat species.[140] Control of all these introduced mammalian species regularly occurs with the aim of improving bat survival and thereby increasing bat population size.

17.2. Predator control that focussed on reduction of rat and stoat populations has resulted in increases in long-tailed bat survival and population size.[141]

[137] Davidson-Watts I. 2018: Long-tailed Bat Trapping and Radio Tracking Baseline Report Southern Links, Hamilton. Report prepared for AECOM NZ Ltd. 57 p.

[138] Borkin K.M. and Parsons S. 2009: Long-tailed bats' use of a Pinus radiata stand in Kinleith Forest: recommendations for monitoring. New Zealand Journal of Forestry 53(4): 38 43; O'Donnell C.F.J., Christie J.E., and Simpson W. 2006: Habitat use and nocturnal activity of lesser short-tailed bats (Mystacina tuberculata) in comparison with long-tailed bats (Chalinolobus tuberculatus) in temperate rainforest. New Zealand. Journal of Zoology 33(2): 113-124; Borkin K.M. 2010: Ecology of New Zealand long-tailed bat (*Chalinolobus tuberculatus*) in exotic plantation forest. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 172 pp.

[139] Gili F., Newson S.E., Gillings S., Chamberlain D.E., Border J.A. 2020. Bats in urbanising landscapes: habitat selection and recommendations for a sustainable future. Biological Conservation 241:108343

[140] O'Donnell C.F.J., Christie J.E., Hitchmough R.A., Lloyd B., Parsons S. 2010. The conservation status of New Zealand bats, 2009. New Zealand Journal of Zoology 37: 297–311.

[141] O'Donnell C.F.J., Pryde M.A., van Dam-Bates P., and Elliott G.P. 2017: Controlling invasive predators enhances the long-term survival of endangered New Zealand long-tailed bats (*Chalinolobus*

17.3. Daniel and Williams[142] considered that domestic cats may be a significant cause of mortality, particularly near accessible roosts. Cats have been recently re-confirmed as predators of bats on residential properties and within public conservation land[143,144].

17.4. I recently published some research outlined the growing awareness of the impact that both feral and pet cats can have on New Zealand bats, which is included as Appendix E. In this, I outlined two examples: the first, when a feral cat was trapped and dissected, and a bat was found in its belly; the second, when a pet cat attacked, killed, and injured seven long-tailed bats over a period of two years[145]. A similar situation has recently taken place near Hamilton, when a pet cat attacked and brought home two long-tailed bats within a month[146]. Survival is highly unlikely when bats are attacked by cats, even if they escape, because of the high bacterial load in cats' mouths, and the likelihood of severe injury[147].

17.5. Attacks by cats can have severe impacts on an individual population of bats. Using the example of the pet cat above, one pet cat could theoretically drive a local population of 61 bats to extinction within seventeen years if they killed seven bats every two years.

17.6. Forty-one percent of New Zealand households have a pet cat; most of these have more than one[148]. This means that, without controls around cat numbers, increasing urbanisation will increase the number of pet cats present[149], and increase the risk of pet cats killing and injuring bats

---

tuberculatus): Implications for conservation of bats on oceanic islands. *Biological Conservation 214*: 156-167. http://dx.doi.org/10.1016/ j.biocon.2017.08.015

142 Daniel M.J., Williams G.R. 1984. A survey of the distribution, seasonal activity and roost sites of New Zealand bats. New Zealand Journal of Ecology 7: 9-25

143 Borkin KM, Easton L, Bridgman L. 2022. Bats attacked by companion and feral cats: evidence from indigenous forest and rural landscapes in New Zealand. New Zealand Journal of Zoology DOI: 10.1080/03014223.2022.2098782 https://www.tandfonline.com/doi/full/10.1080/03014223.2022.2098782

144 Scrimgeour J., Beath A., Swanney M. 2012. Cat predation of short-tailed bats (*Mystacina tuberculata rhyocobia*) in Rangataua Forest, Mount Ruapehu, Central North Island, New Zealand, New Zealand Journal of Zoology, DOI:10.1080/03014223.2011.649770

145 Borkin KM, Easton L, Bridgman L. 2022. Bats attacked by companion and feral cats: evidence from indigenous forest and rural landscapes in New Zealand. New Zealand Journal of Zoology DOI: 10.1080/03014223.2022.2098782 https://www.tandfonline.com/doi/full/10.1080/03014223.2022.2098782

146 https://www.stuff.co.nz/national/129547358/life-of-batman-in-the-balance-after-feral-cat-attack (accessed 26 August 2022).

147 Borkin KM, Easton L, Bridgman L. 2022. Bats attacked by companion and feral cats: evidence from indigenous forest and rural landscapes in New Zealand. New Zealand Journal of Zoology DOI: 10.1080/03014223.2022.2098782

148 Paul A. 2020. Companion animals in New Zealand 2016. Auckland, New Zealand

149 Borkin KM, Easton L, Bridgman L. 2022. Bats attacked by companion and feral cats: evidence from indigenous forest and rural landscapes in New Zealand. New Zealand Journal of Zoology DOI: 10.1080/03014223.2022.2098782

in the PSPA and nearby. Given that there are likely to be in excess of 8,000 households in the PSPA, if 41 percent of homes had only one pet cat, then this could mean an additional 3,280 pet cats enter the PSPA, and put bats at further risk of harm.

17.7. The Waikato Regional Council's Regional Pest Management Plan 2014-2024 has specific rules around feral cats, particularly focused on the release and/or support of any cats. In addition to this, management will be required to reduce the risk of pet, stray, and feral cats killing and injuring bats.

17.8. One recent study found that pet cats were regularly recorded at least 100m into a reserve at all times of the day and night, although they did not monitor cat activity at any greater distances[150]. Cats will travel long distances to visit 'green or open spaces' or reserve areas. Pet cats living in New Zealand urban fringe area were recorded travelling as far as 1.19 km in a straight line; cats in rural areas travelled further (2.29km)[151], so any bats within this distance are at risk of being attacked by cats. Researchers attempting to define recommendations for cat-exclusion zones in urban areas added 20% to these figures to estimate the minimum cat-exclusion zone required to protect fauna at specific locations[152]. In their example, they considered a 1.4km cat-exclusion zone around 'reserves and conservation areas created to protect populations of vulnerable or threatened species' to be appropriate in an urban-fringe area, although noted that cat home ranges varied by location[153].

17.9. The use of performance measures, or standards, to address the effectiveness of predator control is standard practice to ensure that targets, and therefore the purpose of control, are achieved. In this case, targets should be defined that ensure predators of bats are at sufficiently low levels to increase bat survival. These are: rat tracking indices ≤5%, possum residual trap catch <5%, cats and mustelids –

[150] Note that the trail cameras in this study were only placed as far as 100m into the reserve and cats would have been likely travelling further; Woolley CK, Hartley S. 2021. Activity of free-roaming domestic cats in an urban reserve and public perception of pet-related threats to wildlife in New Zealand. Urban Ecosystems 22:1123–1137

[151] Metsers EM, Seddon PJ, van Heezik YM. 2010 Cat-exclusion zones in rural and urban-fringe landscapes: how large would they have to be? Wildlife Research 37: 47–56

[152] To allow for an expected 20% error in tracking locations; Metsers EM, Seddon PJ, van Heezik YM. 2010 Cat-exclusion zones in rural and urban-fringe landscapes: how large would they have to be? Wildlife Research 37: 47–56

[153] Metsers EM, Seddon PJ, van Heezik YM. 2010 Cat-exclusion zones in rural and urban-fringe landscapes: how large would they have to be? Wildlife Research 37: 47–56

none detected. If performance measures are not met, then additional management should be triggered so that targets/performance measures are achieved.

17.10. Having pet cats present in the PSPA will limit the types of predator control tools that may be used in the PSPA and will limit the ability to kill-trap/poison other predators, including feral cats, mustelids, possums and rats. This will result in reduced effectiveness of predator control operations because the ability to switch between multiple options is generally required to maintain high effectiveness.

18. HOW DOES URBANISATION AFFECT BATS? POTENTIAL POPULATION LEVEL EFFECTS

18.1. Potential population-level effects of urbanisation may include a reduction in colony size due to tree felling and habitat loss. Felling of roosts may kill or injure bats and displace uninjured bats from thermally beneficial roosts. My research has found that colony sizes of long-tailed bats are smaller in areas where logging of exotic plantation forest has recently occurred, compared with areas where logging is less recent. [154] Long-tailed bats have been injured and killed during tree felling operations (pers. obs.) including within the PSPA. Appendix J of the Submission (4Sight report[155]) states on Page 13: "*Injury and death of bats has been observed in the PSPA when occupied bat roost trees have been felled (G. Kessels, pers. obs.)*".

18.2. Following tree felling in plantation forests, where I have studied these bats, bats also used fewer roosts[156] and had smaller home ranges[157] than those bats in areas that had not had trees felled recently.

18.3. The removal of known, and undiscovered or potential, roosts by felling of trees will have adverse effects on the local bat population. Functional loss of roosts – where roosts remain but are no longer used because

---

[154] Borkin K.M., O'Donnell C.F.J., and Parsons S. 2011: Bat colony size reduction coincides with clear-fell harvest operations and high rates of roost loss in plantation forest. *Biodiversity and Conservation 20*(14): 3537-3548.

[155] Mueller H, Davidson-Watts I, Kessels G. 2021. Peacocke Structure Area Plan Change Long-tailed bat report For Hamilton City Council. Document name: 4sight_Psp_Bat_Report_Final_June 2021. Appendix J of the submission.

[156] Borkin K.M., O'Donnell C.F.J., and Parsons S. 2011: Bat colony size reduction coincides with clear-fell harvest operations and high rates of roost loss in plantation forest. *Biodiversity and Conservation 20*(14): 3537-3548.

[157] Borkin K.M. and Parsons S. 2014: Effects of clear-fell harvest on bat home range. *PLoS ONE 9*(1): e86163 doi:10.1371/journal.pone.0086163

they are no longer suitable as roosts – may also occur because of habitat change from rural to urban with associated increases in lighting, roads, and housing. A reduction of roost numbers, which are already rare in the PSPA and are valuable to bats, will likely result in reduced bat survival and fitness (the ability of an individual to produce viable offspring). This is because bats will be forced to use less-preferred, poorer quality, roosts[158]. This would also result in adverse effects on the local bat population.

18.4. Despite this likely reduction in use by long-tailed bats, it is unlikely that bats will simply be able to fly somewhere else suitable when habitat within their home range is affected by adverse effects. Bats may not be able to simply fly or roost somewhere else because there may be no or little suitable habitat remaining[159]. There is limited suitable habitat available within Hamilton because Hamilton is highly urbanised and the areas where bats are most likely to be detected – gullies and publicly-owned open space[160] – form only 8% and 14% of the city area, respectively[161]. There is likely to be even less remnant natural vegetation and open green space that is unaffected by the presence of roads or other developments or infrastructure, and predators.

18.5. Bats also may not be able to simply fly or roost somewhere else because they may not know roosts and feeding locations in another area[162], or because that other area may already be occupied by another social group of bats.[163] This is because bats are strongly philopatric, that is they are highly faithful to their home range[164], to traditionally-

---

158 Chaverri G., Kunz T.H. 2011. Response of a Specialist Bat to the Loss of a Critical Resource. PLoS ONE 6(12): e28821. https://doi.org/10.1371/journal.pone.0028821

159 Chaverri G., Kunz T.H. 2011. Response of a Specialist Bat to the Loss of a Critical Resource. PLoS ONE 6(12): e28821. https://doi.org/10.1371/journal.pone.0028821

160 Crewther K. and Parsons S. 2017: Predictive modelling of long-tailed bat distribution in the Hamilton area. Walkingbats Consultancy report prepared for Project Echo (a collaboration between Hamilton City Council, Department of Conservation, Waikato Regional Council, and Riverlea Environment Society Inc.).; van der Zwan W., Mueller M. 2019. Hamilton City Long-tailed bat survey. Annual monitoring report, 2018-2019. Unpublished report for Project Echo, Hamilton, New Zealand. 35 p.

161 https://www.hamilton.govt.nz/our-city/parks/parksandgardens/Pages/Natural-Areas.aspx Downloaded 22 July 2020; Hamilton City Council 2013. Hamilton City Open Space Plan. https://www.hamilton.govt.nz/our-city/parks/Documents/HCC%20Open%20Space%20Plan%20September%202013.pdf Downloaded 22 July 2020. 18 p.

162 Law B.S. 1996. Residency and site fidelity of marked populations of the Common blossom bat *Syconycteris australis* in relation to the availability of Banksia inflorescences in New South Wales, Australia, Oikos 77(3): 447-458

163 O'Donnell C.F.J. 2000. Cryptic local populations in a temperate rainforest bat *Chalinolobus tuberculatus* in New Zealand. Animal Conservation 3: 287–297

164 Borkin K.M. and Parsons S. 2014: Effects of clear-fell harvest on bat home range. *PLoS ONE 9*(1): e86163 doi:10.1371/journal.pone.0086163

used legacy roosts[165], and to their strongly connected social groups[166]. Long-tailed bats rarely use the roosts of other social groups or change their roosting areas, even when roosts are destroyed.[167]

18.6. A male-skewed population has already developed in parts of Hamilton; researchers suspect that this is because female bats could be effectively excluded from relatively urbanised areas due to their needs for specific roost types when heavily pregnant and raising their pups – large, old trees, close to areas suitable for foraging with high invertebrate abundance and water sources[168]. These are rare in urban areas**.** Known effects of male-skewed populations include fewer offspring being produced and higher injury and mortality rates to females[169]. Increasing urbanisation may effectively exclude female bats from larger areas.

18.7. Provisions will therefore need to address methods to avoid in the first instance, then remedy, and mitigate this loss of habitat, loss of roost trees, and potential loss of life of long-tailed bats with their associated effects at a population-level.

19. POTENTIAL RESIDUAL EFFECTS, AND HOW THESE MAY BE MANAGED

19.1. The confirmed negative effects of increases in urbanisation, lighting, and roading on this bat population along with the high level of uncertainty related to the effectiveness of mitigation methods means it is likely that post-mitigation efforts there will be residual adverse effects.

19.2. There are, however, measures that may increase the attractiveness of the site and surrounding areas to bats. I outline potential measures to address adverse effects in the following paragraphs.

---

165 Borkin K.M. 2010: Ecology of New Zealand long-tailed bat (*Chalinolobus tuberculatus*) in exotic plantation forest. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 172 pp.

166 O'Donnell C.F.J. 2000. Cryptic local populations in a temperate rainforest bat *Chalinolobus tuberculatus* in New Zealand. Animal Conservation 3: 287–297

167 O'Donnell C.F.J. 2000. Cryptic local populations in a temperate rainforest bat *Chalinolobus tuberculatus* in New Zealand. Animal Conservation 3: 287–297; O'Donnell C.F.J., Sedgeley J.A. 2006. Causes and consequences of tree-cavity roosting in a temperate bat, *Chalinolobus tuberculatus*, from New Zealand. In: Zubaid A, McCracken GF, Kunz TH (eds) Functional and evolutionary ecology of bats. Oxford University Press, New York, pp 308–328

168 Dekrout AS 2009. Monitoring New Zealand Long-tailed Bats (Chalinolobus tuberculatus) in Urban Habitats: Ecology, Physiology and Genetics. Unpublished PhD Thesis, University of Auckland, New Zealand.

169 Le Galliard, J.F., Fitze, P.S., Ferrière, R. & Clobert, J. (2005) Sex ratio bias, male aggression, and population collapse in lizards. Proceedings of the National Academy of Science USA, 102, 18231–18236.

20. PLANTINGS

20.1. Strategic planting of vegetation to mitigate for the loss of existing habitats with associated performance measures and/or prescribed planting plans may help address adverse effects on bats. When compared to a scenario where no planting takes place, planting may result in improved functional connectivity of resource patches[170], and provide of areas for feeding, navigating through the landscape, socialising, and potential creation of roosts in the long-term; although this is unproven. However, each of these reasons for planting – providing areas for feeding and navigation, and the potential creation of roosts – have different timeframes or time-lags before mitigation is likely to be effective. For example, planted trees are likely to take 80+ years to form cavities.[171]

20.2. The inclusion of performance measures and/or specific requirements for planting as this will help ensure these are specifically designed to address specific effects on bats by, for example, minimising the likely impact of light.

21. BRIDGE AND ROADING DESIGN AND PLANTING TO ADDRESS/REDUCE THE LIKELIHOOD OF BAT-VEHICLE COLLISIONS

21.1. Research has found that bat mortality rates due to bat-vehicle collisions are particularly high when vegetation canopy heights decline close to roads[172]. This is because bats are thought to fly lower (i.e., drop down) where vegetation is low or absent and are, therefore, more at risk of collisions with vehicles. Wider roads and wider gaps between tall vegetation means that bats are more likely to drop down and travel for longer through the danger zone where they are more likely to collide with vehicles and be injured or killed.

---

170 Carlier J., Moran J., Aughney T., Roche N. 2019. Effects of greenway development on functional connectivity for bats. Global Ecology and Conservation Volume 18: e00613. Carlier et al (2019) found that when vegetation was removed functional connectivity was reduced, but when it was added functional connectivity increased.

171 Borkin KM, Martin T. 2018. Bats in New Zealand Plantations: Forest Management Guidance. Prepared for NZ Forest Owners' Association. https://rarespecies.nzfoa.org.nz/site/assets/files/1088/bats_in_plantations_management_guidance_for_nzfoa_revised_23_may_2018.pdf

172 Russell A.L., Butchkoski C.M., Saidak L., McCracken G.F. 2009. Road-killed bats, highway design, and the commuting ecology of bats Endangered Species Research 8:49-60 DOI: https://doi.org/10.3354/esr00121

21.2. To reduce severance of connectivity, bridge and roading and surrounding footpath design should minimise total width of the paved area that does not have tall trees overhanging, and maintain tall vegetation either side of the open space. It is preferable that tree canopies are high and canopies on either side of the carriageway are as close to each other as possible above the road.

21.3. The team from Wildland Consultants Ltd, that I led, undertook thermal imaging that assessed bat flight paths in relation to current and proposed bridges and roads and vegetation, and made the following recommendations which are appropriate to take into account for bridge and road design and associated plantings in the PSPA[173]:

> *"Bridge design at new locations should consider the potential for long-tailed bats to be present. Design of the bridges and the surrounding environment should attempt to reduce the potential for direct impacts on bats as a result of vehicle collision. Potential effects on foraging and commuting bats through light spillage and loss of foraging habitat should also be addressed. The following suggested techniques draw on the findings of this investigation, the Southern Links acoustic monitoring investigation, and other research undertaken in New Zealand. In particular, designers should consider the following:*
>
> *a) Manage/limit vegetation removal where this may currently facilitate bats flying up and over the road.*
>
> *b) Undertake additional plantings to facilitate bat flight up and over the road.*
>
> *c) Plantings should be undertaken prior to construction.*
>
> d) *Design the bridge structure so that it prevents or minimises light spillage so that light does not alter bat behaviour [along the Waikato River]."*[174]

[173] Pp 33-34 from Wildland Consultants 2018b: Thermal image monitoring of long-tailed bats for the Southern Links roading project in Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192c*. Prepared for AECOM, New Zealand. 63 pp.

[174] Pages 33-34 from Wildland Consultants 2018b: Thermal image monitoring of long-tailed bats for the Southern Links roading project in Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192c*. Prepared for AECOM, New Zealand. 63 pp.

21.4. Therefore, I consider it important that planting either side of roads and bridges be designed with bat flight in mind and focus on their avoidance of the zone 0-5 metres[175] above the roads/bridges where vehicles are present.

22. USE OF MONITORING THAT ADDRESSES EFFECTS AND USES TRIGGERS TO SET OFF ADDITIONAL MANAGEMENT

22.1. I consider that well-designed monitoring of the bat population that includes both onsite and offsite monitoring is critical to understanding whether the effects of development within the PSPA and associated activities have been adequately addressed, whether mitigation measures have been effective, and whether there continue to be residual adverse effects that require additional mitigation. Without monitoring that is robustly designed with the focus of answering a specific question, there is no evidence that a management intervention or mitigation has been effective and whether adverse effects remain[176].

22.2. Provisions should outline monitoring that has the purpose of understanding the effectiveness of the proposed mitigation measures for bats, and triggering additional management or mitigation to address adverse effects on bats if the mitigation is not effective. The intent of this monitoring, and the associated triggers and additional management, is to make sure that best efforts are made to ensure that long-tailed bats continue to use the PSPA.

22.3. Acoustic monitoring is a widely used tool for detecting the presence of bats by recording their ultrasonic echolocation calls using acoustic recorders. The rate at which bats are detected is termed their "activity" or "activity rate". Bat activity is inherently variable[177]. That is, at one location on one night you may record one bat call and on the following night you may record 100 bat calls. Variation in bat activity is due to many factors including climatic conditions[178], reproductive activity[179],

175 The maximum allowable height of a heavy trailer and vehicle combination (including the load) is 4.3 metres https://www.nzta.govt.nz/vehicles/vehicle-types/vehicle-classes-and-standards/vehicle-dimensions-and-mass/heavy-trailers-and-vehicle-combinations/ Downloaded 17 July 2020. These are vehicles likely to be present.

176 Jones C., Borkin K., Smith D. 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

177 Law B.S., Gonsalves L., Tap P., Penman T., Chidel M. 2015. Optimizing ultrasonic sampling effort for monitoring forest bats. Austral Ecology 40: 886–897

178 Turbill C. 2008. Winter activity of Australian tree-roosting bats: influence of temperature and climatic patterns. Journal of Zoology 276: 285–290

179 Russ J.M., Briffa M., Montgomery W.I. 2003. Seasonal patterns in activity and habitat use by bats (*Pipistrellus* spp. and

the distance between roosts and feeding areas[180], and invertebrate activity[181]. The wide sample variance that results means that a large sample size – i.e., many nights and many sites – is required to gather precise estimates of activity.[182]

22.4. The variation in long-tailed bat activity (discussed above) means that, even with standardised methods, large sample sizes and/or long monitoring programmes are required to obtain sufficient power to detect changes in relative abundance if changes occur.[183] Power can be considered as a probability that a test of significance will pick up on an effect that is present.[184] Power analyses help calculate the sample size needed to determine an effect of a specified size, and takes into account variation in the data[185].

22.5. Provisions need to outline methods for robust design of monitoring and assessment. In terms of monitoring design, Jones *et al.*[186] recommend the use of power analyses to inform the sample size required (numbers of sites and numbers of nights over which monitoring should take place in order) to determine whether there is an effect if any, but caution that:

> *"Insufficient or highly variable data may not detect population trends that are actually occurring. Therefore, it is essential that a statistical power analysis [using data collected from the same population] be undertaken during the design phase of a monitoring programme. This [power] analysis should demonstrate that the monitoring programme is capable of producing sufficient data to answer questions pertinent to project goals."*

Nyctalus leisleri) in Northern Ireland, determined using a driven transect. Journal of Zoology 259: 289−299.

[180] Ciechanowski M., Zajac T., Biłas A., Dunajski R. 2007. Spatiotemporal variation in activity of bat species differing in hunting tactics: effects of weather, moonlight, food abundance, and structural clutter. Canadian Journal of Zoology 85: 1249−1263.

[181] O'Donnell C.F.J. 2000. Influence of season, habitat, temperature, and invertebrate availability on nocturnal activity on the New Zealand long-tailed bat (*Chalinolobus tuberculatus*).New Zealand Journal of Zoology 27: 207−221.

[182] Hayes J.P. 1997. Temporal variation in activity of bats and the design of echolocation-monitoring studies. Journal of Mammalogy 78: 514−524.

[183] O'Donnell C.F.J., Langton S. 2003. Power to detect trends in abundance of long-tailed bats (*Chalinolobus tuberculatus*) using counts on line transects. Science for Conservation 224. Wellington, NZ, Department of Conservation. 19 p.

[184] https://www.statisticsteacher.org/2017/09/15/what-is-power/ Downloaded 25 July 2020.

[185] Hunt A. 2015. A Researcher's Guide to Power Analysis. Unpublished report, Utah State University https://research.usu.edu//irb/wp-content/uploads/sites/12/2015/08/A_Researchers_Guide_to_Power_Analysis_USU.pdf Downloaded 25 July 2020. 11 p.

[186] Jones C., Borkin K., Smith D. 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

22.6. Project goals could include, for example, determining whether there are residual adverse effects related to the development and/or mitigation effectiveness. As recommended by Jones (*et al*.) data collected onsite should be used in power analyses to inform monitoring design.

22.7. When thoughtful monitoring that takes into account the life-history of bats is informed by power analyses that use relevant data, and is robustly designed and implemented following the recommendations gathered from power analyses, it may be possible to determine whether there are adverse effects or changes in behaviour or activity related to a specific project. In recent monitoring, effects of activities have been able to be attributed to a specific project or cause.

22.8. For example, in Southern Hamilton, there has been the identification of a currently occurring effect of built and operational roads on bat activity. In this case, a modelling approach to monitoring identified an effect of built and operational roads on bat activity[187]. Bats were less likely to be detected alongside operational roads than at distances greater than 200 m from roads.

22.9. This example shows that, with careful and robust design and interpretation, monitoring can determine effects and relate these to specific projects.

22.10. Monitoring of bats that has associated trigger levels, performance standards, or thresholds for additional management may be a further way to address residual adverse effects should these occur. This is because such monitoring would address the likely effectiveness of mitigation measures, around which there is uncertainty because they remain untested, and whether additional management is required to further reduce effects.

22.11. Details of the process involved with designing and assessing monitoring described above, about the type of monitoring device, the time of year, and the number of nights and sites, is necessary to ensure that data is comparable between monitoring sessions and sites.

[187] Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192d*. Prepared for AECOM, New Zealand. 37 pp.

22.12. My research has found that unless the model of bat detector used (for acoustic monitoring) is kept the same, data cannot be compared directly because detection rates and the number of nights that bats are detected vary between detector types.[188] There are similar issues with comparing data if the time of year during which monitoring takes place varies.[189] This is because bats have different activity rates at different times of year. For long-tailed bats, my research has found that activity rates are highest in October, November, and April, and that activity varies seasonally[190]. This research has led to most bat monitoring related to development taking place between November and April so that most of the peak activity period in Spring is encompassed (pers. Obs.). For these reasons, having very specific conditions that require monitoring at the same time of year, with the same models of detectors, at the same sites, and for the same number of nights are important so that data that is collected is comparable and fit for purpose. Provisions outlining bat monitoring should address these issues with variation.

22.13. As discussed earlier, increasing sample size (number of sites, nights, and years over which monitoring takes place) is considered a good way to reduce the influence of variation present in bat activity data[191]. Hayes[192] indicates that if sites are sampled inadequately, then there is greater probability of incorrect or ambiguous inferences being drawn. It, therefore, follows that increasing the sample size collected prior to the commencement of construction will reduce the influence of inherent variability on the data set, and ensure that there is a data set that is representative of the normal pattern of bat calls in the PSPA. Increasing the number of seasons (years) over which data is collected prior to construction is a good way to deal with the variation inherent in long-tailed bat data[193]. Collecting a larger data set will mean that it is more likely to allow statistically robust comparisons between activity

---

[188] Smith D.H.V., Borkin K.M., Shaw W.B. (2020): A comparison of two bat detectors: which is most likely to detect New Zealand's *Chalinolobus tuberculatus*? New Zealand Journal of Zoology https://doi.org/10.1080/03014223.2020.1754864

[189] Law B, Gonsalves L, Tap P, Penman T, Chidel M. 2015. Optimizing ultrasonic sampling effort for monitoring forest bats. Austral Ecology. 40(8):886–897. DOI:10.1111/aec.12269.

[190] Borkin K.M. 2010: Ecology of New Zealand long-tailed bat (Chalinolobus tuberculatus) in exotic plantation forest. Unpublished PhD thesis. University of Auckland, Auckland, New Zealand. 172 pp.

[191] Hayes J.P. 1997. Temporal variation in activity of bats and the design of echolocation-monitoring studies. Journal of Mammalogy 78: 514−524; O'Donnell C.F.J., Langton S. 2003. Power to detect trends in abundance of long-tailed bats (*Chalinolobus tuberculatus*) using counts on line transects. Science for Conservation 224. Wellington, NZ, Department of Conservation. 19 p.

[192] Hayes J.P. 1997. Temporal variation in activity of bats and the design of echolocation-monitoring studies. Journal of Mammalogy 78: 514−524.

[193] O'Donnell C.F.J., Langton S. 2003. Power to detect trends in abundance of long-tailed bats (*Chalinolobus tuberculatus*) using counts on line transects. Science for Conservation 224. Wellington, NZ, Department of Conservation. 19 p.

data collected before, during, and after construction and after occupancy of residential lots. This would help with understanding whether actions or inactions at specific locations are benefiting or hindering connectivity through the landscape for long-tailed bats.

22.14. The risk of supporting a centralised approach to monitoring, as does Dr Mueller in her evidence[194], is that it may not require individual properties or subdivisions to undertake monitoring so some effects may be missed. This means that it may be difficult to link specific effects to specific properties, and opportunities to address these may be missed.

23. LANDSCAPE WIDE APPROACH

23.1. Research by Gili (*et al*[195]) suggests that when addressing effects on bats, urban expansion should be accompanied by strategies such as creating bat-friendly habitat of an area at least equal to any new urban settlement in order to address negative effects of urbanisation. Clearly an area of this size, i.e., "at least equal to any new urban settlement", cannot take place within the PSPA given that this entire area is proposed for urbanisation. Nor could this scale take place solely "*across the known extent of the South Hamilton home range of long-tailed bats*" as is currently suggested by the proposed Hamilton City Council-operated *Long-tailed bat Population Protection and Enhancement Fund*, or within Hamilton city boundaries. There simply is not enough room.

23.2. Managing habitat for the persistence of bats is most effective when this takes place over a large or landscape scale[196]. Consequently, a strategic approach to managing the landscape to ensure that it is enhanced so that a stable population of long-tailed bats persist is appealing. This will be most effective when this can take place over an area larger than the home range of the Southern Hamilton bat population. This is because it will allow for a greater range of options to take place over a larger area. An area that encompasses the

---

194 Mueller H. 2022. Statement of Evidence of Dr Hannah Mueller (Ecology – Bats, wetlands, freshwater biodiversity) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan

195 Gili F., Newson S.E., Gillings S., Chamberlain D.E., Border J.A. 2020. Bats in urbanising landscapes: habitat selection and recommendations for a sustainable future. Biological Conservation 241:108343

196 Duchamp J.E., Arnett E., Larson M., Swihart R.K. 2007. Ecological considerations for landscape-level management of bats In Chapter: 9 Book: Bats in forests: conservation and management Publisher: Johns Hopkins University Press Editors: M. J. Lacki, J. P. Hayes, A. Kurta Pp 237-261

Southern Hamilton bat population and includes other known bat populations will provide more options for effective management at a landscape scale. A sufficiently large area for a strategic management approach that encompasses other known bat populations could be defined as between the Waihou River (to the east) and the west coast.

23.3. However, it is unclear whether management over a larger area, outside the PSPA, would benefit long-tailed bats resident within the PSPA, because, as discussed above, bats cannot simply move to another area in response to a change in their home range – they are strongly philopatric, and bats resident in areas they try and move to may not accept them.

23.4. However, if a larger area, outside the PSPA, is used to manage or compensate for development activities that cannot be managed within the PSPA, will this benefit bats currently resident within the PSPA? This is unclear. This is because, as discussed above, bats cannot simply move to another area in response to a change in their home range – they are strongly philopatric, and bats resident in areas they try and move to may not accept them. This means that whilst compensatory work that takes place outside the area may benefit bats already outside that area, and support their persistence at least in the short term until they come under the same threats of development as the front of development moves out from Hamilton City; it is uncertain whether bats within the PSPA will benefit, simply because they may not use this area.

23.5. Options that could benefit bats at a landscape scale may include a strategic approach that focuses on the judicious enhancement of connectivity and provision of roosts through space and time[197]. Methods could include:

a) the purchase and/or protection of areas where roosts are known; and

b) the planting of areas to provide roosts and connectivity where this is low; and

[197] Duchamp J.E., Arnett E., Larson M., Swihart R.K. 2007. Ecological considerations for landscape-level management of bats In Chapter: 9 Book: Bats in forests: conservation and management Publisher: Johns Hopkins University Press Editors: M. J. Lacki, J. P. Hayes, A. Kurta Pp 237-261

c) predator and pest control to manage predators of bats and pests that inhibit the growth of potential roost trees; and

d) research into the needs of the bat population, identification of key resources, effectiveness of mitigation techniques, and how these could be best addressed may also be beneficial for their management; and

e) Actioning these research findings.

24. COMMENT ON SECTION 42A REPORT

24.1. There is a focus in the most recent set of draft Provisions on largely using corridors or areas currently defined as 'Significant Bat Habitat Areas' or 'Natural Open Space' to avoid, remedy, mitigate and off-set or compensate for the effects of development on 'identified Significant Bat Habitat areas and non-identified low to moderate habitat values within the Medium Density Residential Zone' (see Provisions SUB-PREC1-PSP:P20; 25.6.4.4, 1.3.3 m, 1.3.3 P5 q as examples).

24.2. This means that over the majority of the PSPA effects of development such as lighting, noise, traffic, or increase predators including cats, are not required to be avoided or mitigated. In addition, this relies upon the choice of corridors and their widths being sufficient to address such effects (see proposed provisions 1.3.3 P3j).

24.3. Currently, in my opinion, the recommended width of corridors is flawed in both the Appendix J (Mueller/4Sight report)[198] and the evidence of Mr Kessels[199] and Dr Mueller[200]. This is because, whilst both Appendix J and the evidence of Mr Kessels[201] support the design of corridors being a minimum width of 100 m without bespoke design, they both suggest that because in Sandford Park bats fly within 25-50 m of houses that this width of 50 m will be sufficient as both a corridor width and as a buffer to known roosts (they recommend buffers of 50 m

[198] Mueller et al 2021. Peacocke Structure Plan Assessment of Environmental Effects - Appendix J, Peacocke Structure Area Plan Change Long-tailed bat report, 4Sight 4 June 2021.
[199] Kessels GHA 2022 Statement of Evidence of Gerardus Henricus Anthonius Kessels (Ecology) in the matter of Proposed Plan Change 5 to the Operative Hamilton City district Plan.
[200] Mueller H. 2022. Statement of Evidence of Dr Hannah Mueller (Ecology – Bats, wetlands, freshwater biodiversity) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.
[201] Paragraphs 29 and 30. Kessels, G.

around communal roosts, and 25 m around solitary/non-communal roosts).

24.4. However, Sandford Park is on average substantially wider than 25-50m, and in some areas as wide as 270m. There are some narrow fingers of habitat which are 50m wide, but these are short in length, and supported by the wider areas. Where the gully system that feeds into Sandford Park is narrow it is generally steeper, and darker, and more densely vegetated, but these narrower areas are supported by substantially wider areas, greater than 100m in width, and at the Bader Street end as wide as 270m. Consequently, it is highly unlikely that 50 m wide corridors, and 25-50 m buffers around roosts, as Appendix J recommends, and Dr Mueller and Mr Kessels support in their evidence, will be sufficient to 'protect and maintain the ecological function of these corridors' as required by Provision 1.3.3e.

24.5. Mr Kessels goes on to state, in paragraph 31 of his evidence: *"While ecologists do not completely understand how long-tailed bats are able to persist in highly modified and largely exotic landscapes of southern Hamilton, my view is that we cannot miss facilitating opportunities to allow long-tailed bats to remain in this locality, as well as protect and restore other biodiversity values, as urbanisation expands into the PSPA"*. I agree, ecologists do not completely understand how long-tailed bats are able to persist in Southern Hamilton, and because of this mitigation measures, including corridor and buffer design, are relatively experimental.

24.6. Mr Kessels states in Attachment 1 to his evidence:

> However, ecological knowledge of the PSPA is incomplete. Planning mechanisms need to acknowledge and account for incomplete scientific knowledge and incorporation of new information which may alter the results of the ecological significance analysis presented in this report and the supporting technical ecology reports.

24.7. I consider that this suggests that because of this incomplete knowledge, a more cautious approach should be followed that allows for updates of scientific knowledge. This is in line with Attachment 1 to Mr Kessels' evidence which refers to the National Policy Statement on Indigenous Biodiversity exposure draft (NPS-IB, released in June

2022) and suggests that several policies from this draft exposure document are relevant to the PSPA, including Policy 3 (copied from Attachment 1): "*A precautionary approach is adopted when considering adverse effects on indigenous biodiversity*." With this in mind, in the case of corridors and buffers: it is my opinion, that minimum corridor widths should be expanded to greater than 100 m and buffers around known roosts be expanded to at least 100 m regardless of their communal or non-communal/solitary nature. Larger corridors greater than 100m width, with buffers, and similar width buffers to known roosts will be more likely to protect them from light, noise and other effects of development and use of the PSPA. Whether this is sufficient to allow for a stable bat population is uncertain – more area makes this more likely. Larger areas of land will be more in line with Mr Kessels' view, in Paragraph 28 of his evidence, that *"In terms of buffer and corridor habitat, for both enhancement of existing or recreation of new habitat areas, the most important general principle is that wide swathes of land are required to be set aside as bat habitat in order to retain a permeable and functioning landscape for long-tailed bats."* A similar comment has been deleted from the current draft of the Provisions (Appendix D).

24.8. It is clear that the ecological recommendations made to date are not based on full understanding of the area. This is acknowledged in Mr Kessels' evidence, where he states on Page 9 of Attachment 1: "*There is insufficient information to assess the full ecological value of wetlands within the PSPA as this will first require an assessment of presence and extent based on field investigations and application of the Wetland Delineation Protocol (MfE 2020)."*

24.9. Wetlands, both natural and constructed, are likely to be of high value to long-tailed bats because they are used for foraging and drinking, particularly if they include *"less*-turbulent *and deeper water"*[202] and it is likely that individual bats will visit drinking sites at least several times a night[203]. In my opinion, wetlands – both natural and constructed – and other water bodies in the Peacocke Structure Plan area should be considered important for bats because of their high likelihood of use,

[202] Rockell, G.; Littlemore, J.; Scrimgeour, J. 2017: Habitat preferences of *Chalinolobus tuberculatus* along riparian corridors of the forested Pikiariki Ecological Area, Pureora Forest Park. DOC Research and Development Series 349. Department of Conservation, Wellington. 11 p
[203] Rockell, G.; Littlemore, J.; Scrimgeour, J. 2017: Habitat preferences of *Chalinolobus tuberculatus* along riparian corridors of the forested Pikiariki Ecological Area, Pureora Forest Park. DOC Research and Development Series 349. Department of Conservation, Wellington. 11 p

and according to the current criteria could be considered Significant Natural Areas (SNA).

24.10. In ‘Appendix 2: Responses to transport-related submissions’ in the evidence of Alastair Black (Transport)[204] in its' Page 19 section 4.8 entitled ‘Open Space Edge Transport Corridor’, there is discussion of changes to Open Space Edge Transport Corridors. These corridors will have development only on one side of the road and border Open Space/Parks. There appears to have been no consideration of the effects of such changes on long-tailed bats in the suggestions Black makes to the draft Provisions on this matter. I suggest that mitigation measures, set-backs, and buffers that are required as part of avoiding, remedying, and mitigating effects of roads and development on long-tailed bats are considered in their design. This does not appear to be the case at present.

24.11. In ‘Appendix 2: Responses to transport-related submissions’ and elsewhere in the evidence of Mr Black there does not appear to be consideration of roading and transport network design that minimises bisecting areas currently defined as ‘Significant Natural Areas’, ‘Significant Bat Habitat Areas’, ‘Natural Open Space Zones’, or other areas used by bats, and does not address how these corridors will be managed to ensure connectivity around transport networks. This consideration is crucial to give the currently proposed corridors the best chance of being functional.

24.12. Currently, as a whole, the s42A report and associated documents focus the majority of their ‘protection’ of bats and effects’ management within relatively small areas – smaller than the home range of one individual bat. This may not be sufficient for a stable bat population to be maintained within the PSPA.

25. CONCLUSION

25.1. Long-tailed bats are an endemic species that is threatened with extinction in the short-term. It is classified as ‘Nationally Critical’ – the worst threat classification available in the New Zealand Threat Classification system.

[204] Black AJ. 2022. Statement of Evidence of Alastair James Black (Transport) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.

25.2. The development of the PSPA as an urban area, with increases in roading, overnight traffic, and lighting, and fewer roost trees, may result in a smaller long-tailed bat population that has access to fewer roosts and has smaller home ranges and lower connectivity.

25.3. Given that roads and buildings are unlikely to provide habitat for bats, according to Appendix J of the submission[205], there will be a substantial reduction in use of the area by bats. This expected reduction in use of areas, because they are urbanised, reflects a likely loss of connectivity and functional habitat.

25.4. Functional connectivity of the bat population is likely to be further reduced by the effects of urbanisation, including increases in light, roading, and overnight traffic and decreases in the vegetation that they fly along and use as roosts. I consider that this loss in functional connectivity may increase the risk of extinction[206] of the Southern Hamilton bat population.

25.5. There is substantial uncertainty in the effectiveness of mitigation measures for maintenance of bat populations. This is because the effectiveness of the majority of mitigation measures remain untested and are largely experimental[207]. This uncertainty means that there are a number of possible outcomes for long-tailed bats in the PSPA including:

a) increased use of the site (if proposed mitigation is effective); or,
b) reduction in use of the site;
c) abandonment of the site or parts of the site;
d) a male-skewed bat population may emerge. This has already happened in parts of Hamilton[208]; and
e) loss of functional corridors. The loss of functional corridors may also mean that access to more central parts of the city are lost without careful management.

---

205 Mueller H, Davidson-Watts I, Kessels G. 2021. Peacocke Structure Area Plan Change Long-tailed bat report For Hamilton City Council. Document name: 4sight_Psp_Bat_Report_Final_June 2021. Appendix J of the submission.

206 Reed D. H. 2004. Extinction risk in fragmented habitats. Animal Conservation 7(02):181 - 191

207 Jones C., Borkin K., Smith D. 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

208 Dekrout AS 2009. Monitoring New Zealand Long-tailed Bats (Chalinolobus tuberculatus) in Urban Habitats: Ecology, Physiology and Genetics. Unpublished PhD Thesis, University of Auckland, New Zealand.

25.6. Clearly, it is uncertain exactly what may happen with urbanisation of the PSPA, but what is clear is that large areas of bat habitat will be lost due to urbanisation.

25.7. These effects will mean careful planning is required to ensure that they are addressed across the entire area in a way that firstly avoids, then remedies, then mitigates effects including those on the long-tailed bats outside the PSPA.

25.8. The proportion of the area covered by the Peacocke Structure Plan that will have effects of development avoided and functionality maintained for long-tailed bats is small. Whether this is sufficient for a stable population of long-tailed bats to persist in the PSPA is uncertain.

Kerry Maree Borkin

Dated 16 September 2022

APPENDIX A: WAIKATO BAT ALLIANCE STRATEGY DOCUMENT

APPENDIX B: NATIONAL LIGHT POLLUTION GUIDELINES FOR WILDLIFE INCLUDING MARINE TURTLES, SEABIRDS AND MIGRATORY SHOREBIRDS

https://www.dcceew.gov.au/sites/default/files/documents/national-light-pollution-guidelines-wildlife.pdf

APPENDIX C: BAT CONSERVATION TRUST (BCT) AND THE INSTITUTE FOR LIGHTING PROFESSIONALS (ILP) GUIDANCE

https://cdn.bats.org.uk/uploads/pdf/Resources/ilp-guidance-note-8-bats-and-artificial-lighting-compressed.pdf?v=1542109349

APPENDIX D: EUROBATS 8[209] LIGHTING GUIDANCE DOCUMENT

https://www.eurobats.org/sites/default/files/documents/publications/publication_series/WEB_EUROBATS_08_ENGL_NVK_19092018.pdf

[209] Voigt CC, Azam C,, Dekker J, Ferguson J, Fritze M, Gazaryan S, Hölker F, Jones G, Leader N, Lewanzik D, Limpens HJGA, Mathews F, Rydell J, Schofield H, Spoelstra K, Zagmajster M. 2018. Guidelines for consideration of bats in lighting projects. EUROBATS Publication Series No. 8. UNEP/EUROBATS Secretariat, Bonn, Germany, 62 pp https://www.eurobats.org/sites/default/files/documents/publications/publication_series/WEB_EUROBATS_08_ENGL_NVK_19092018.pdf

APPENDIX E: PUBLICATION: BORKIN ET AL 2022. BATS ATTACKED BY COMPANION AND FERAL CATS: EVIDENCE FROM INDIGENOUS FOREST AND RURAL LANDSCAPES IN NEW ZEALAND

APPENDIX F: CONSOLIDATED LIST OF REFERENCES IN DR BORKIN'S EVIDENCE

AECOM 2019: Letter to Nathanael Savage Hamilton City Council: Bat roosts identified during radio tracking completed in January, March and December 2018 AECOM Reference: \\nzham1fp001.au.aecomnet.com\projects\601x\60164546\4. tech work area\4.25 nzta emmp\7.0 reports_final\bat roost data issued\ltr bat roosts sites identified during radio tracking.docx

Alternative Endings, 2021: *Framing a Bat Strategy for the Waikato Region: Themes, outcomes and engaging stakeholders - A discussion document for the Waikato Bat Alliance, 4 November 2021*.

Armitage V, Barden TL, Gough M, Lurz P, Oatway D, South A. 2001. Assessing the impact of a music festival on the emergence behaviour of a breeding colony of Daubenton's bats (*Myotis daubentonii*). Journal of Zoology 254(3):367-373

Azam C., Le Viol I., Basa Y., Zissis G., Vernet A., Julien J-F., Kerbiriou C. 2018: Evidence for distance and illuminance thresholds in the effects of artificial lighting on bat activity. Landscape and Urban Planning 175: 123-135

Bat Conservation Trust, United Kingdom: https://www.bats.org.uk/the-trust (accessed 30 August 2022).

Bat Conservation Trust, United Kingdom: https://www.bats.org.uk/our-work/buildings-planning-and-development/lighting accessed 30 August 2022.

Bat Conservation Trust, 2018 "Bats and artificial lighting in the UK: Guidance Note 08/18": https://cdn.bats.org.uk/uploads/pdf/Resources/ilp-guidance-note-8-bats-and-artificial-lighting-compressed.pdf?v=1542109349 (Accessed 30 August 2022).

Baber MJ 2022. Statement of Evidence of Matthew James Baber (Ecology – Offsetting/Compensation) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.

Bennett VJ, Zurcher AA 2013. When corridors collide: road related disturbance in commuting bats. Journal of Wildlife Management 77: 93−101.

Bennett R.S. 2019. Understanding movement and habitat selection of the lesser short-tailed bat to infer potential encounters with anticoagulant bait. Unpublished MSc (Zoology) thesis, Massey University, Manawatū, New Zealand. 74 p.

Black AJ. 2022. Statement of Evidence of Alastair James Black (Transport) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.

Borkin K.M. 2010: Ecology of New Zealand long-tailed bat (*Chalinolobus tuberculatus*) in exotic plantation forest. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 172 pp.

Borkin KM, Easton L, Bridgman L. 2022. Bats attacked by companion and feral cats: evidence from indigenous forest and rural landscapes in New Zealand. New Zealand Journal of Zoology DOI: 10.1080/03014223.2022.2098782 https://www.tandfonline.com/doi/full/10.1080/03014223.2022.2098782

Borkin K.M., O'Donnell C.F.J., and Parsons S. 2011: Bat colony size reduction coincides with clear-fell harvest operations and high rates of roost loss in plantation forest. *Biodiversity and Conservation 20*(14): 3537-3548.

Borkin K.M. and Parsons S. 2009: Long-tailed bats' use of a *Pinus radiata* stand in Kinleith Forest: recommendations for monitoring. *New Zealand Journal of Forestry 53*(4): 38-43.

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

Borkin K.M. and Parsons S. 2014: Effects of clear-fell harvest on bat home range. PLoS ONE 9(1): e86163 doi:10.1371/journal.pone.0086163

Borkin K.M, Smith D.H. V., Shaw W.B. McQueen J.C. 2019. More traffic, less bat activity: the relationship between overnight traffic volumes and *Chalinolobus tuberculatus* activity along New Zealand highways. Acta Chiropterologica, 21(2): 321–329.

Bunkley JP, McClure CJW, Kleist NJ, Francis CD, Barber JR 2015. Anthropogenic noise alters bat activity levels and echolocation calls. Global Ecology and Conservation 3 (2015) 62–71

Burt W. H. 1943. Territoriality and home range concepts as applied to mammals. *Journal of Mammalogy 24*: 346–352.

Carlier J., Moran J., Aughney T., Roche N. 2019. Effects of greenway development on functional connectivity for bats. Global Ecology and Conservation Volume 18: e00613.

Chaverri G., Kunz T.H. 2011. Response of a Specialist Bat to the Loss of a Critical Resource. PLoS ONE 6(12): e28821. https://doi.org/10.1371/journal.pone.0028821

Ciechanowski M., Zajac T., Biłas A., Dunajski R. 2007. Spatiotemporal variation in activity of bat species differing in hunting tactics: effects of weather, moonlight, food abundance, and structural clutter. Canadian Journal of Zoology 85: 1249−1263.

Commonwealth of Australia. 2020: *National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds*, National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds - DCCEEW (accessed 30 August 2022.)

Crewther K. and Parsons S. 2017: Predictive modelling of long-tailed bat distribution in the Hamilton area. *Walkingbats Consultancy report.* Prepared for Project Echo (a collaboration between Hamilton City Council, Department of Conservation, Waikato Regional Council, and Riverlea Environment Society Inc.).

Crooks K.R., Burdett C.L., Theobald D.M., King S.R.B., Di Marco M., Rondinini C., Boitani L. 2017: Quantification of habitat fragmentation reveals extinction risk in terrestrial mammals PNAS July 18, 2017 114 (29) 7635-7640; first published July 3, 2017 https://doi.org/10.1073/pnas.1705769114

Daniel M.J., Williams G.R. 1984. A survey of the distribution, seasonal activity and roost sites of New Zealand bats. New Zealand Journal of Ecology 7: 9-25

Davidson-Watts I. 2018: Long-tailed Bat Trapping and Radio Tracking Baseline Report Southern Links, Hamilton. Report prepared for AECOM NZ Ltd. 57 p

Davidson-Watts I 2019. Long-tailed Bat Trapping and Radio Tracking Baseline Report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM NZ Ltd.

Dekrout A.S. 2009: Monitoring New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in urban habitats: ecology, physiology and genetics. *Unpublished PhD thesis*. University of Auckland, Auckland, New Zealand. 168 pp.

Dekrout A.S., Clarkson B.D., and Parsons S. 2014: Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*). *New Zealand Journal of Zoology.* DOI: 10.1080/ 03014223.2014.953551

Dekrout AS, Clarkson BD, Parsons S 2014. Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (*Chalinolobus tuberculatus*), New Zealand Journal of Zoology, 41:4, 285-295

Department of Conservation's Bat Distribution (Database Version received 10 May 2018).

Duchamp J.E., Arnett E., Larson M., Swihart R.K. 2007. Ecological considerations for landscape-level management of bats In Chapter: 9 Book: Bats in forests: conservation and management Publisher: Johns Hopkins University Press Editors: M. J. Lacki, J. P. Hayes, A. Kurta Pp 237-261

Finch D, Schofield H, Mathews F. 2020. Traffic noise playback reduces the activity and feeding behaviour of free-living bats. Environmental Pollution 263 (2020) 114405

Gili F., Newson S.E., Gillings S., Chamberlain D.E., Border J.A. 2020. Bats in urbanising landscapes: habitat selection and recommendations for a sustainable future Biological Conservation 241:108343

Hamilton City Council, 2013, https://www.hamilton.govt.nz/our-city/parks/parksandgardens/Pages/Natural-Areas.aspx Downloaded 22 July 2020;.

Hamilton City Council, 2020, Hamilton City Open Space Plan. https://www.hamilton.govt.nz/our-city/parks/Documents/HCC%20Open%20Space%20Plan%20September%202013.pdf Downloaded 22 July 2020. 18 p.

Hart A. in prep. Assessing the effects of anthropogenic (traffic) noise on native wildlife.

Hayes J.P. 1997. Temporal variation in activity of bats and the design of echolocation-monitoring studies. Journal of Mammalogy 78: 514−524.

Hunt A. 2015. A Researcher's Guide to Power Analysis. Unpublished report, Utah State University https://research.usu.edu//irb/wp-content/uploads/sites/12/2015/08/A_Researchers_Guide_to_Power_Analysis_USU.pdf Downloaded 25 July 2020. 11 p.

Jones C., Borkin K., Smith D. 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

Kessels G.H.A., 2022, “Statement of Evidence of Gerardus Henricus Anthonius Kessels (Ecology) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.”

Kessels G., Baber M. 2021. Peacocke Structure Plan Area: Ecological Significance Assessment. Report prepared by Tonkin and Taylor for Hamilton City Council. Report number: 1007479.0040.v4

Law B.S. 1996. Residency and site fidelity of marked populations of the Common blossom bat Syconycteris australis in relation to the availability of Banksia inflorescences in New South Wales, Australia, Oikos 77(3): 447-458

Law B.S., Gonsalves L., Tap P., Penman T., Chidel M. 2015. Optimizing ultrasonic sampling effort for monitoring forest bats. Austral Ecology 40: 886–897. DOI:10.1111/aec.12269.

Le Roux D.S. and Le Roux N.S. 2012: Hamilton City Bat Survey 2011-2012. Report prepared by Kessels & Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). 22 pp. Document Ref: \\server files\Hamilton City Council\Bat survey city wide\city wide survey report_240512.

Le Roux D.S. and Le Roux N.S. 2012: Hamilton City Bat Survey 2011-2012. Report prepared by Kessels & Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). 22 pp. Document Ref: \\server files\Hamilton City Council\Bat survey city wide\city wide survey report_240512.

Le Roux D. S., Waas J. R. 2012. Do long-tailed bats alter their evening activity in response to aircraft noise? *Acta Chiropterologica 14*(1): 111–120.

Le Roux D.S., Le Roux N.S., and Waas J.R. 2013: Spatial and temporal variation in long-tailed bat echolocation activity in a New Zealand city. *New Zealand Journal of Zoology*. DOI:10.1080/03014223.2013.827125O’Donnell C.F.J. 2005: New Zealand long-tailed bat. Chapter In: C. M. King (Ed.): The Handbook of New Zealand Mammals, Second Edition. Pp 98-109. Oxford University Press, Melbourne.

Mander S, Chitty C. 2019. The measurement blues. IEEE Instrumentation and Measurement Magazine 22 (2): 17-20
Mckensey JR 2022. Statement of Evidence of John Kinross Mckensey (Lighting) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.

Metsers EM, Seddon PJ, van Heezik YM. 2010 Cat-exclusion zones in rural and urban-fringe landscapes: how large would they have to be? Wildlife Research 37: 47–56

Mueller H. 2022. Statement of Evidence of Dr Hannah Mueller (Ecology – Bats, wetlands, freshwater biodiversity) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.

Mueller H., Ulrich C., and Purcell A. 2017: Draft Hamilton City long-tailed bat survey 2016-2017. A report prepared by Kessels and Associates Ltd for Project Echo (project partners: Waikato Regional Council, The University of Waikato, Hamilton City Council, Department of Conservation, Waikato Tree Trust). Pp 25.

Mueller H, Davidson-Watts I, Kessels G. 2021. Peacocke Structure Area Plan Change Long-tailed bat report For Hamilton City Council. Document name: 4sight_Psp_Bat_Report_Final_June 2021. Appendix J of the submission.

O'Donnell C.F.J. 2000. Cryptic local populations in a temperate rainforest bat *Chalinolobus tuberculatus* in New Zealand. Animal Conservation 3: 287–297

O'Donnell C.F.J. 2000. Influence of season, habitat, temperature, and invertebrate availability on nocturnal activity on the New Zealand long-tailed bat (*Chalinolobus tuberculatus*). New Zealand Journal of Zoology 27: 207−221.

O'Donnell C.F.J. 2001. Home range and use of space by *Chalinolobus tuberculatus*, a temperate rainforest bat from New Zealand. Journal of Zoology (London) 253: 253-264

O'Donnell C.F.J. 2005: New Zealand long-tailed bat. Chapter In: C. M. King (Ed.): The Handbook of New Zealand Mammals, Second Edition. Pp 98-109. Oxford University Press, Melbourne.

O'Donnell C.F.J., Borkin K.M., Christie J.E., Lloyd B., Parsons S., Hitchmough R.A. 2018: Conservation status of New Zealand bats, 2017. *New Zealand Threat Classification Series 21*. Department of Conservation, Wellington, New Zealand. 4 pp.

O'Donnell CFJ, Borkin KM 2021. *Chalinolobus tuberculatus*. Chapter in King C, Forsyth D. The Handbook of New Zealand Mammals. 3rd Edn. Families Vespertilionidae and Mystacinidae, p 95-130. CSIRO Publishing, Melbourne.

https://www.amazon.com/Handbook-New-Zealand-Mammals-ebook/dp/B08W1RTMMK Accessed 9 August 2022.

O'Donnell C.F.J., Christie J.E., and Simpson W. 2006: Habitat use and nocturnal activity of lesser short-tailed bats (*Mystacina tuberculata*) in comparison with long-tailed bats (*Chalinolobus tuberculatus*) in temperate rainforest. New Zealand. *Journal of Zoology 33*(2): 113-124.

O'Donnell C.F.J., Christie J.E., Hitchmough R.A., Lloyd B., Parsons S. 2010. The conservation status of New Zealand bats, 2009. New Zealand Journal of Zoology 37: 297–311.

O'Donnell C.F.J., Langton S. 2003. Power to detect trends in abundance of long-tailed bats (*Chalinolobus tuberculatus*) using counts on line transects. Science for Conservation 224. Wellington, NZ, Department of Conservation. 19 p.

O'Donnell C.F.J., Pryde M.A., van Dam-Bates P., and Elliott G.P. 2017: Controlling invasive predators enhances the long-term survival of endangered New Zealand long-tailed bats (*Chalinolobus tuberculatus*): Implications for conservation of bats on oceanic islands. *Biological Conservation 214*: 156-167. http://dx.doi.org/10.1016/ j.biocon.2017.08.015

O'Donnell C.F.J. and Sedgeley J.A. 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 C.F.J., Sedgeley J.A. 2006. Causes and consequences of tree-cavity roosting in a temperate bat, *Chalinolobus tuberculatus*, from New Zealand. In: Zubaid A, McCracken GF, Kunz TH (eds) Functional and evolutionary ecology of bats. Oxford University Press, New York, pp 308–328

Parson S. 2021. AMBERFIELD – PERSISTENCE OF BATS IN THE PRESENCE OF VEHICLE HEADLIGHTS Prepared for Weston Lea by Walking bats Specialist Environmental Consulting, Powell R. A., Mitchell M. S. 2012. What is a home range? Journal of Mammalogy, 93(4):948-958 http://dx.doi.org/10.1644/11-MAMM-S-177.1

Paul A. 2020. Companion animals in New Zealand 2016. Auckland, New Zealand
Proceedings of the Royal Society of London B: Biological Sciences 278: 1646–1652.

Pryde M.A, O'Donnell C.F.J., and Barker R.J. 2005: Factors influencing survival and long-term population viability of New Zealand long-tailed bats (*Chalinolobus tuberculatus*): Implications for conservation. *Biological Conservation 126*: 175-185.

Reed D. H. 2004. Extinction risk in fragmented habitats. Animal Conservation 7(02):181 – 191

Rockell, G.; Littlemore, J.; Scrimgeour, J. 2017: Habitat preferences of *Chalinolobus tuberculatus* along riparian corridors of the forested Pikiariki Ecological Area, Pureora Forest Park. DOC Research and Development Series 349. Department of Conservation, Wellington. 11 p

Russ J.M., Briffa M., Montgomery W.I. 2003. Seasonal patterns in activity and habitat use by bats (*Pipistrellus* spp. And *Nyctalus leisleri*) in Northern Ireland, determined using a driven transect. Journal of Zoology 259: 289−299.

Russell A.L., Butchkoski C.M., Saidak L., McCracken G.F. 2009. Road-killed bats, highway design, and the commuting ecology of bats Endangered Species Research 8:49-60 DOI: https://doi.org/10.3354/esr00121

Schamhart T. in prep. The impact of artificial light on long-tailed bat behaviour and ecology.

Schaub A, Ostwald J, Siemers BM 2008. Foraging bats avoid noise. Journal of Experimental Biology 211: 3174−3180; Siemers BM, Schaub A 2011. Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators.

Scrimgeour J., Beath A., Swanney M. 2012. Cat predation of short-tailed bats (*Mystacina tuberculata rhyocobia*) in Rangataua Forest, Mount Ruapehu, Central North Island, New Zealand, New Zealand Journal of Zoology, DOI:10.1080/03014223.2011.649770

Sedgeley J.A. and O'Donnell C.F.J. 1999: 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*: 261-276.

Sedgeley J.A. 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: 425–438

Sharman C, Roberts M. 2022. PLAN CHANGE 5 – PEACOCKE STRUCTURE PLAN to THE HAMILTON CITY DISTRICT PLAN SECTION 42A HEARING REPORT 2 September 2022 Report on Plan Change 5 – Peacocke Structure Plan.

Sirl JG. 2022. Statement of Evidence of James (Jamie) Grant Sirl (Planning) in the matter of Proposed Plan Change 5 to the Operative Hamilton City District Plan.

Smith D., Borkin K., Jones C., Lindberg S., Davies F., and Eccles G. 2017: Effects of land transport activities on New Zealand's endemic bat populations: reviews of ecological and regulatory literature. *NZ Transport Agency Research Report 623*. 249 pp.

Smith D.H.V., Borkin K.M., Shaw W.B. 2020: A comparison of two bat detectors: which is most likely to detect New Zealand's *Chalinolobus tuberculatus*? New Zealand Journal of Zoology https://doi.org/10.1080/03014223.2020.1754864

Straka T.M., Wolf M., Gras P., Buchholz S., and Voigt C.C. 2019: Tree cover mediates the effect of artificial light on urban bats. Frontiers in Ecology and Evolution 7:91. doi: 10.3389/fevo.2019.00091

Taylor P.D., Fahrig L., Henein K.,Merriam G. 1993. Connectivity Is a Vital Element of Landscape Structure. Oikos 68(3):571-573

Turbill C. 2008. Winter activity of Australian tree-roosting bats: influence of temperature and climatic patterns. Journal of Zoology 276: 285–290

United Nations' Convention on the Conservation of Migratory Species of Wild Animals. 2020. https://www.cms.int/

van der Zwan W., Mueller M. 2019. Hamilton City Long-tailed bat survey. Annual monitoring report, 2018-2019. Unpublished report for Project Echo, Hamilton, New Zealand. 35 p.

Vidyadharan, A, 2022, Stuff Article dated 11 August 2022: "*Life of 'Batman' in the balance after feral cat attack*": https://www.stuff.co.nz/national/129547358/life-of-batman-in-the-balance-after-feral-cat-attack (accessed 26 August 2022).

Voigt CC, Azam C,, Dekker J, Ferguson J, Fritze M, Gazaryan S, Hölker F, Jones G, Leader N, Lewanzik D, Limpens HJGA, Mathews F, Rydell J, Schofield H, Spoelstra K, Zagmajster M. 2018. Guidelines for consideration of bats in lighting projects. EUROBATS Publication Series No. 8. UNEP/EUROBATS Secretariat, Bonn, Germany, 62 pp:

https://www.eurobats.org/sites/default/files/documents/publications/publication_series/WEB_EUROBATS_08_ENGL_NVK_19092018.pdf

Waikato Regional Council 2014: Waikato Regional Pest Management Plan 2014-2024. https://www.waikatoregion.govt.nz/assets/PageFiles/21542/3583%20-%20RPMP_2014-24.pdf 264 pp.

Waka Kotahi NZ Transport Agency, Ministry of Transport, 2016, "*Land Transport Rule: Vehicle Dimensions and Mass 2016 (Rule 41001/2016)":* https://www.nzta.govt.nz/vehicles/vehicle-types/vehicle-classes-and-standards/vehicle-dimensions-and-mass/heavy-trailers-and-vehicle-combinations/ Downloaded 17 July 2020.

Walmsley, A.L.E. and Brown, M.C., 2017, "*What is Power?*", Article on 'Statistics Teacher Website', September 15, 2017, Concordia University Wisconsin: https://www.statisticsteacher.org/2017/09/15/what-is-power/ Downloaded 25 July 2020.

Wildland Consultants 2018a: Baseline acoustic monitoring of long-tailed bats for the Southern Links roading project, Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192d*. Prepared for AECOM, New Zealand. 37 pp.

Wildland Consultants 2018b: Thermal image monitoring of long-tailed bats for the Southern Links roading project in Hamilton: 2017 and 2018. *Wildland Consultants Ltd Contract Report No. 4192c*. Prepared for AECOM, New Zealand. 63 pp.

Woolley CK, Hartley S. 2021. Activity of free-roaming domestic cats in an urban reserve and public perception of pet-related threats to wildlife in New Zealand. Urban Ecosystems 22:1123–1137

Zeale M.R.K., Stone E.L., Zeale E., Browne W.J., Harris S., and Jones G. 2018: Experimentally manipulating light spectra reveals the importance of dark corridors for commuting bats. Global Change Biology 1-10. DOI: 10.1111/gcb.14462