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 9 to the Operative Hamilton City District Plan.

Evidence of Dr Kerry Maree Borkin ([bat ecology in relation to SNAs]) on behalf of the Director-General of Conservation Tumuaki Ahurei
Submitter Number: 425

Dated 28 April 2023

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1. INTRODUCTION

1.1. My full name is Dr Kerry Maree Borkin.

1.2. I have been asked by the Director-General of Conservation ("DGC) to provide ecological technical evidence on *the potential effects on long-tailed bats of the proposed policies and rules surrounding SNAs.*

2. QUALIFICATIONS AND EXPERIENCE

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

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**.** 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).

2.3. 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.

2.4. 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**.**

2.5. 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.

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

2.7. 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; and on behalf of the Director General of Conservation regarding bat-related matters for the Amberfield subdivision and the Peacocke Structure Plan change (PC5).

2.8. 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

[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.

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

2.9. 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.

2.10. 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 recently co-supervised a MSc student at the University of Auckland who investigated the effect of noise on bats and birds and a BSc (Honours) student at the University of Otago into roost emergence behaviour by long-tailed bats. I currently supervise students investigating mātauranga Māori and bats, and drivers of bat use of habitat.

2.11. 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

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

Migratory Shorebirds - DAWE. I have since peer-reviewed an Appendix focusing on guidelines for managing impacts of lighting on bats.

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

2.13. In 2022 and 2023, I was actively involved in several United Nations CMS Technical Workshops on light pollution. In these workshops, I reviewed and provided input into 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 in October 2023, the fourteenth meeting of Conference of the Parties (COP) to the Convention on the Conservation of Migratory Species of Wild Animals.

2.14. 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.

2.15. 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
- 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.

2.16. I am experienced radio-tracking long-tailed bats in fragmented habitats similar to those covered by Plan Change 9 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. 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[3].

2.17. I am a technical expert for the Department of Conservation 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 Appendix B to this evidence.

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

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

3. CODE OF CONDUCT

3.1. I confirm that I have read the code of conduct for expert witnesses as contained in clause 9 of the Environment Court's Practice Note 2023 (the Code). I have complied with the Code when preparing my written statement of evidence.

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 to follow. This includes, where relevant:

a. why other alternative interpretations of data are not supported;

b. any qualification if my evidence may be incomplete or inaccurate without such qualification;

c. any knowledge gaps and the potential implication of the knowledge gap;

d. if my opinion is not firm or concluded because of insufficient research or date or for any other reason;

e. an assessment of the level of confidence and the likelihood of any outcomes specified in my conclusion.

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 OF EVIDENCE

4.1. I have been asked to provide evidence in relation to the notified Plan Change 9 to the Operative Hamilton District Plan and the Director General of Conservation’s (DGC) submission dated 2 September 2022 and further submission dated 18 November 2022.

4.2. My evidence addresses the following issues: long-tailed bat ecology and their needs in relation to:

a. Noise;

b. Light;

c. Tree felling/removal/trimming; and

d. Other proposed rules affecting long-tailed bats and the functionality of SNAs

5. MATERIAL CONSIDERED

5.1. The key material that I have relied on in forming my opinions and as referred to in my evidence, include:

a. National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds – DCCEEW (Accessed 30 August 2022.

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

c. 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

5.2. In preparing my evidence I have read the evidence of other witnesses. I have considered the evidence of:

a. Hannah Mueller, dated 14 April 2023[4]

[4] Mueller, H. 2023. STATEMENT OF EVIDENCE OF DR HANNAH MUELLER (Ecology - Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan. CP158 Director-General of Conservation, BORKIN Evidence, on SNA and bat ecology, Proposed PC9 [docCM-7322063]

b. John Mckensey, dated 14 April 2023[5]

c. Hamish Dean, dated 14 April 2023 including the 4Sight Technical Ecology Report[6]

d. Ashiley Sycamore, dated 28 April 2023[7]

5.3. I have read the following:

a. Sharman C, Soe YM, Buckingham E, Mauala V. 2023. Plan Change 9 – Historic Heritage and Natural Environment Planning Report and Recommendations Hearing Session 1: Historic Heritage Areas; Significant Natural Areas; and Notable Trees[8]

b. 'PC9 Technical Ecology Report for Hamilton City Council', prepared by 4Sight Consulting – Part of SLR, March 2023

5.4. I was involved in expert caucusing and am a signatory to the Ecology and Planning joint witness statement (dated 14 March 2023)[9].

6. EXECUTIVE SUMMARY

6.1. Long-tailed bats (Pekapeka, *Chalinolobus tuberculatus*) are a highly mobile species that is ranked as "Threatened- Nationally Critical" – the highest threat ranking in the Department of Conservation's threat classification system. This is because each studied population where the predators of bats aren't controlled to low levels are declining. It is present throughout the Waikato Region and uses parts of Hamilton when roosting, feeding, breeding, and socialising. These bats are highly philopatric (loyal to specific locations) and are particularly at risk in the Hamilton area because they face the loss of roosts, where they

[5] Mckensey JK. 2023. STATEMENT OF EVIDENCE OF JOHN KINROSS MCKENSEY (Lighting – Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.
[6] Dean HA. 2023. STATEMENT OF EVIDENCE OF HAMISH ALSTON DEAN (Ecology - Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.
[7] Sycamore A. 2023. STATEMENT OF EVIDENCE OF ASHILEY SYCAMORE (Ecology - Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.
[8] Sharman C., Soe YM., Buckingham E., Mauala V. 2023. Plan Change 9 Historic Heritage and Natural Environment – Planning Report and Recommendations - Hearing Session 1: Historic Heritage Areas; Significant Natural Areas; and Notable Trees, 6 April 2023.
[9] Joint Witness Statement Ecology and Planning. 14th March 2023. IN THE MATTER of the Resource Management Act 1991(RMA) AND IN THE MATTER of Plan Change 9 to the Hamilton City District Plan. JOINT WITNESS STATEMENT (JWS) IN RELATION TO: ECOLOGY and PLANNING (1) 14th March 2023

shelter during the day and rest and socialise at night, and functional habitat regularly in this area.

6.2. Roosts and habitat can lose their functionality due to urbanisation including traffic and increases in housing density, and when exposed to noise, light, or tree loss due to felling/removal or trimming. Roosts can become unsuitable for bats to use, even when not felled or trimmed, if they are exposed to high levels of noise, light, or weather conditions because other surrounding trees have been removed/trimmed. This can mean that bats use roosts or areas less or may not be able to access areas they previously did. Lost roosts are difficult to replace because little is known about how to replicate the properties of natural roosts bats use, and newly planted trees can take up to 80 years to form the types of cavities bats might use. Artificial roost boxes are a short-term 'fix' that require high levels of maintenance to ensure that they are safe for bats to use.

6.3. There are currently no proposed restrictions on noise to protect the function of SNAs for bats.

6.4. Rules focussed on lighting do not follow all best practice principles. In my opinion, these should be followed including:

a. the use of 2700K rather than 3000K because of the associated reductions in the blue wavelength light that bats are sensitive to.

b. Lower lux levels in line with international best practice and/or wider setbacks to reduce the amount of light SNA are exposed to.

c. Shorter time periods for motion sensor lighting

6.5. Rules associated with tree felling/removal and trimming, in my opinion, allow relatively large areas of trees to be removed or trimmed each year, and raise the risk of high levels of cumulative loss to SNA. In my

opinion, the amount of tree felling/removal and trimming allowed in SNA should be reduced.

6.6. Providing rules that focus on protecting the functionality of SNA for bats will protect the integrity of SNA as a whole for a range of fauna.

7. TOPIC HEADING

7.1. My evidence covers the following topics:

i. Long-tailed bats are threatened with extinction, and,

ii. are highly philopatric (loyal to specific locations).

iii. Why this population is particularly at risk.

iv. What long-tailed bats need to persist:

a. Roosts,

b. Functional habitat

v. What stops habitat being functional: Noise, light, and tree felling/trimming or removal.

vi. How these might these risks to functionality be mitigated?

vii. Is the bat habitat within SNAs sufficiently protected by rules outlined in the draft PC9 policies? Noise, lighting, setbacks, tree felling/trimming and removal, city-wide rules.

8. LONG-TAILED BATS ARE THREATENED WITH EXTINCTION

8.1. 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%)."[10] The next step in the threat classification system is "extinction".

8.2. Long-tailed bats are present throughout much of the Waikato Region[11]. A lack of reporting of bats by the general public, with few records after the 1920s and 1930s[12,13], 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 Zealand populations that reside in and utilise cities. Dekrout (2009)[14] 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**.**

8.3. 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[15]; the population was estimated using the Minimum Number Alive method[16]. I took part in these counts.

8.4. Of the 28 roosts we found in that study, only three known roosts in artificial roost boxes are adequately protected from predators with

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[10] O'Donnell, C.F.J.; Borkin, K.M.; Christie, J.; Davidson-Watts, I.; Dennis, G.; Pryde, M.; Michel, P. 2023: Conservation status of bats in Aotearoa New Zealand, 2022. New Zealand Threat Classification Series 41. Department of Conservation, Wellington. 18 p

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

[12] 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.

[13] 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

[14] 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.

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

[16] 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.).

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 large areas of predator control (i.e., that protect all known roosts), bat population sizes are likely to be decreasing.[17, 18]

9. BATS ARE HIGHLY PHILOPATRIC/LOYAL TO SPECIFIC LOCATIONS

9.1. A home range is the area that an individual bat uses relatively regularly.[19,20] 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[21]. 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[22], and are faithful to their social group of bats[23]. If bats try to move to a new area, they may not be accepted by bats that are already resident.

9.2. 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.

9.3. 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

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17 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.

18 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

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

20 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

21 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

22 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

23 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

across.[24] 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.[25] I was part 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.[26] 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. Consequently, SNAs based on what is currently known about long-tailed bat use of the Hamilton area will underestimate what is used, and needed, by long-tailed bats to persist and, particularly, to thrive.

9.4. Hamilton's bat population is found mainly in the southern part of the City and the adjoining peri-urban area; bats are detected less regularly in other parts of the city. The Waikato River, all of the southern Hamilton gully systems, and the Peacocke Structure Plan areas are considered particularly important habitat for long-tailed bats in the Southern Hamilton population and provide key linkages between roosting and foraging areas[27,28]. These areas are relied upon because

[24] 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

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

[26] 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.

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

[28] 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

they contain roosts, and connections between roosts and places bats feed, breed, and socialise.

10. WHY IS THIS POPULATION AT RISK?

10.1. 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[29]. Little bat activity appears to occur within parts of Hamilton which are highly urbanised i.e., have suburban housing[30], 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)[31] also found a significant negative correlation between long-tailed bat activity in Hamilton and housing and street light density – more houses, less bat activity. Bats in the Hamilton areas are also at risk because they are facing the loss of roosts and functional habitat regularly.

11. WHAT DO LONG-TAILED BATS NEED TO PERSIST? ROOSTS

11.1. 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, either native or introduced/exotic[32]; usually within cavities, broken

[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] 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.

[31] 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.

[32] 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.

trunks or branches, under peeling bark or in other deformities[33]. 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[34]. Long-tailed bats have been found to choose the best roosts in the landscape at reducing their energy costs.[35]

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

11.3. 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.

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

11.5. 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[36], and we know little about how 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 [37]. This means that populations will have fewer weaned young and adult bats surviving[38].

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.

34 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

35 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

36 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.

37 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

38 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

11.6. 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[39]

[39] 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

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

11.7. 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 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.

11.8. 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[40]. This is because these natural roosts will provide roosts with more stable thermal properties so resident bats will be more likely to survive[41] and it supports connectivity through the landscape.

11.9. 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.[42] 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. [43] Both solitary and communal roosts are crucial for populations to survive.

11.10. There are confirmed and potential roosts within Hamilton[44]. 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;

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40 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

41 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

42 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.

43 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.

44 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

c) the inability to use an area because there are no/few suitable roosts in 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[45].

11.11. Roosts outside of indigenous forest are considered to be relatively uncommon (i.e., rare) compared to numbers present within indigenous forests[46]. 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[47].

11.12. 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.[48] 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)[49]. This pattern of high rates of re-use of roosts both within the same summer and between years, is supported by other research

[45] 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

[46] 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.

[48] 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.

[49] 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.

outside of indigenous forest where roosts are also uncommon (for example, as I have shown in exotic plantation forest[50]).

11.13. Dekrout (2009)[51] 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[52].

11.14. 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 already occupied by other bats, or they may not be available because of their rarity.[53] The likelihood of being able to simply move to another equally suitable roost is particularly low in locations such as Hamilton and the surrounding area, where trees suitable as roosts are likely to be *particularly* rare.

11.15. 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.

12. WHAT DO LONG-TAILED BATS NEED TO PERSIST? FUNCTIONAL HABITAT

12.1. Bat "habitat" has been defined in the Waikato Bat Alliance high-level strategy document 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 B 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

[50] 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.

[51] 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.

[52] 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

[53] 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

Regional Council, Hamilton City Council, Waipā District Council, Waikato District Council, and Department of Conservation. These areas can comprise of either native or introduced/exotic vegetation, as well as nearby grassed areas/pasture.

12.2. 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. Functionality can be lost by allowing noise, and light to infiltrate these areas and by removal of trees or other vegetation.

12.3. 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.[54,55] 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.[56] 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 particularly important for bats for commuting, feeding, and roosting. This does not mean that other areas, with fewer trees, such as pasture, farms, orchards, or gardens are not important for bats to use when commuting, feeding, and roosting. All are used by bats and are bat habitat.

12.4. Long-tailed bats are considered an edge-adapted species[57] 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[58]. This means that these dark open

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[54] 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.

[55] 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.

[56] 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.

[57] 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.

[58] 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

spaces also need to be managed and maintained to reduce effects in these areas.

13. NOISE REDUCES CONNECTIVITY OF HABITAT FOR BATS. AND DO THE PROPOSED RULES ADEQUATELY PROTECT SNA FOR BATS?

13.1. Whilst there is international research that shows that feeding rates are reduced (both in terms of speed and success) for bats in noisier areas[59] and that bats change their flight paths to avoid the noisiest areas[60], 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 activity[61]. 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[62], so any differences could be obscured.

13.2. 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[63]. To help

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59 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.

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

61 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.

62 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.

63 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

understand whether there were effects of noise on bats and birds, the Department of Conservation Te Mana o Te Taiao research programme and the DOCBRG funded a MSc student, Alisha Hart from the University of Auckland, who I co-supervised, 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[64]. 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[65]. Similar effects were also found for eight forest bird species that were monitored: fantail, kākā, kākāriki, kererū, NZ robin, tui/bellbird, and grey warbler, with fewer birds calling when noise was added to their environment.

13.3. A reduction in bat activity due to noise would reflect a loss in functional/effective habitat[66].

13.4. In Hamilton, this means that 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.

13.5. Researchers suggested potential mitigation strategies to address the effects of noise on bats. These included noise barriers, substrate alterations and speed limits on roads[67]. Other measures could include restrictions on events and their locations, particularly near areas known or suspected to have roosts or those areas identified as bat corridors or SNAs. This is because even individual events, such as

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

[65] Hart A., Borkin K., Cain K., Pattemore D. 2023. **Bat activity of two endemic New Zealand species is lower in the presence of traffic sound playback: a large-scale experiment. [abstract] In: National Bat Hui 2023, 2-4 May 2023, Hamilton, New Zealand.**

[66] 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

[67] 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

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[68].

13.6. 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 in SNA should be considered to support connectivity and persistence by long-tailed bats. There are no rules currently proposed to manage the effects of noise in SNA. This should be, in my opinion, rectified.

14. LIGHTING REDUCES CONNECTIVITY OF HABITAT

14.1. It is considered "essential to preserve dark corridors to mitigate the impacts of artificial light at night on bat activity and movements". Zeale *et al.* (2018; Page 1)[69]

14.2. 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[70]. 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 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[71].

[68] 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

[69] 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

[70] 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.

[71] 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,

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)[72].

14.3. Most recently, there has been research in the 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. 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[73].

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

14.5. Further research, again by the University of Waikato student I co-supervise, found that reducing the amount of blue wavelength light present reduces the effect of lighting on long-tailed bats[74]. At sites lit by luminaires which had filtered out blue wavelength light, bat activity was similar to sites which were unlit. When unfiltered white light was used (4000K), bat activity rates dropped significantly. This research supports the recommendation to use luminaires with low, no, or filtered UV and blue wavelength light i.e., with 2700K or warmer colour temperature.

15. SO HOW MIGHT LIGHT BE MITIGATED FOR LONG-TAILED BATS? AND DO THE PROPOSED RULES ADEQUATELY PROTECT SNA FOR BATS?

15.1. The above New Zealand-based research, in my opinion, indicates four key ways the effects of light on long-tailed bats may be reduced:

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.

[72] 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.).

[73] Schamhart T, Tempero G, Browne C, Borkin K, Ling N, Pattemore D. 2022. Artificial light at night: does it affect long-tailed bat activity? [abstract]. In: NZ Ecological Society; 28 November – 2 December 2022, Dunedin, New Zealand.

[74] Schamhart T, Tempero G, Browne C, Borkin K, Ling N, Pattemore D. 2022. Does white and blue wavelength filtered light influence the activity of rural long-tailed bats? [abstract]. In: NZ Ecological Society; 28 November – 2 December 2022, Dunedin, New Zealand.

a. Not introducing light to a site if not needed[75]

b. Using the least amount of light possible (lowest possible illuminance, intensity or lux)[76] . Light trespass over 0.1 lux should be avoided according to EUROBATS 8[77].

c. If light is required, then using lights with little, no or reduced blue, violet and UV wavelengths[78].

d. Increasing distances lights are setback from the areas bats use[79]. These areas bats use – bat habitat – include roosts, both communal and solitary, and places used for breeding, foraging, and commuting.

16. SETBACKS DISTANCES AND LOW LUX TO MANAGE LIGHT IMPACTS ON BATS

16.1. There has been no New Zealand-based research into the specific distance light must be from areas bats use to mitigate its effect in entirety (although modelling by Crewther and Parsons (2017) suggests that the probability of the presence of long-tailed bats in Hamilton increases with distance from streetlights (from 0-100 metres)[80]). So, in my opinion, the international guidance and literature must be relied upon to understand appropriate setbacks for light from areas bats use, including those classified as SNAs.

[75] Schamhart T, Tempero G, Browne C, Borkin K, Ling N, Pattemore D. 2022. Artificial light at night: does it affect long-tailed bat activity? [abstract]. In: NZ Ecological Society; 28 November – 2 December 2022, Dunedin, New Zealand.

[76] 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.

[77] 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

[78] Schamhart T, Tempero G, Browne C, Borkin K, Ling N, Pattemore D. 2022. Does white and blue wavelength filtered light influence the activity of rural long-tailed bats? [abstract]. In: NZ Ecological Society; 28 November – 2 December 2022, Dunedin, New Zealand.

[79] 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.).

[80] 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.).

16.2. Azam *et al*. (2018; Page123)[81] 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[82]. This is a far greater distance that the setbacks recommended by John Mckensey in his evidence (5m or 10m dependent on the number of storeys the building has)[83]. If these larger setbacks cannot be achieved, then a lower level of lux could be applied.

16.3. Azam *et al* (2018)[84], and EUROBATS 8[85], recommend a lower light level – 0.1 lux – rather than the 0.3 lux noted in the evidence of Mckensey. In my opinion, the best approach to mitigating impacts or effects of light would be to follow the international guidance that focuses on bats, for PC9 this would require either a greater setback from SNAs or lower lux levels at the edge of SNAs than is currently in the draft rules for PC9.

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[81] 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

[82] 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.).

[83] Mckensey JK. 2023. STATEMENT OF EVIDENCE OF JOHN KINROSS MCKENSEY (Lighting – Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.

[84] 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

[85] 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

16.4. If lower lux or greater setbacks cannot achieve lower light levels in SNA, then other methods of managing the effects of lighting should also be considered. Straka *et al.* (2019)[86] 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.

If buffers are used to manage the amount of light reaching bat habitat, 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.

17. WHAT IS COLOUR TEMPERATURE OF LIGHTS AND WHAT COLOUR TEMPERATURES TEND TO MITIGATE IMPACTS OF LIGHT BEST?

17.1. 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 wavelength light (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.

17.2. 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 show 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.

[86] 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*

17.3. 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[87,88,89].

17.4. 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.

18. SHOULD 2700K OR 3000K LIGHTS BE USED WHEN ATTEMPTING TO MITIGATE THE IMPACT OF LIGHT ON BATS?

18.1. Two of these key guidance 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[90,91]. This

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

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

[89] 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

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

[91] 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

includes the document that is recommended as guidance for lighting in the rules set out for PC9 i.e., EUROBATS 8.

18.2. Whilst the rules proposed for PC9 recommend this guidance document (EUROBATS 8), the Ecology Technical Report (included as Appendix 2 of the evidence of Hamish Dean)[92], the report by Sharman et al (2023)[93], and some of the recommendations made by John Mckensey[94], in his evidence regarding lighting, diverge from recommendations made by international experts on lighting and bats.

18.3. They instead suggest the use of a different light type with a greater amount of blue wavelength light – they recommend using 3000K rather than 2700K – because it will be more convenient for residents. Sharman et al 2023[95] suggested, on Page 63, that allowing 3000K lights would be "*to reduce costs and difficulties for landowners*", whilst Mr Mckensey notes in Paragraph 26[96] that 2700K is "*uncommon in most retail lighting stores, and therefore more costly and difficult to source, while the setting of 3000K is the more reasonably priced*".

18.4. For further research on the topic of availability and costs of lights of either 2700K and 3000K, I undertook a search for products which included 2700K and 3000K bulbs in a New Zealand based online lighting store – Lighting Direct[97] – on 19 April 2023. I found 19 search results for products that included 2700K bulbs priced between $12.90 and $59.89, and 129 results for products which included 3000K bulbs priced $10.90 to $469.90. This search was not difficult for me.

[92] Dean HA. 2023. STATEMENT OF EVIDENCE OF HAMISH ALSTON DEAN (Ecology - Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.
[93] Sharman C., Soe YM., Buckingham E., Mauala V. 2023. Plan Change 9 Historic Heritage and Natural Environment – Planning Report and Recommendations - Hearing Session 1: Historic Heritage Areas; Significant Natural Areas; and Notable Trees, 6 April 2023.
[94] Mckensey JK. 2023. STATEMENT OF EVIDENCE OF JOHN KINROSS MCKENSEY (Lighting – Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.
[95] Sharman C., Soe YM., Buckingham E., Mauala V. 2023. Plan Change 9 Historic Heritage and Natural Environment – Planning Report and Recommendations - Hearing Session 1: Historic Heritage Areas; Significant Natural Areas; and Notable Trees, 6 April 2023.
[96] Mckensey JK. 2023. STATEMENT OF EVIDENCE OF JOHN KINROSS MCKENSEY (Lighting – Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.
[97] https://lightingdirect.co.nz/

18.5. In my opinion, this specific recommendation – the use of 3000K rather than 2700K – is not based on an approach that focuses on reducing effects on long-tailed bats and preserving functionality of SNAs for them. This is acknowledged in the Planning Report (i.e., Sharman et al 2023) as being based on convenience. My opinion is that reducing the amount of blue wavelength light is important, and that 2700K or warmer colour temperature will reduce effects on long-tailed bats more than the use of 3000K or cooler colour temperature lighting. This is based on international guidance specific to bats.

19. REDUCING THE AMOUNT OF TIME LIGHTS ARE ON TO MITIGATE IMPACTS OF LIGHT ON BATS

19.1. EUROBATS 8 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 should be set on motion-sensors and short (1min) timers[98]. 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. In my opinion, if external security lighting/outdoor lighting are allowed under rules proposed in PC9, then these should be set on motion-sensors that are set to levels that means that they will only be triggered by movement by people or larger i.e., not cats, birds or similar, and will remain on for only short – 1 min – periods.

19.2. 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 city. Not addressing lighting effects over the entire SNA network will reduce functionality of the area.

19.3. 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 bat habitat – corridors,

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

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) [99], additional management, such as that recommended by Straka (et al. 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. These are not currently required by the draft rules set out for PC9.

20. TREE FELLING/TRIMMING/REMOVAL REDUCES FUNCTIONALITY OF HABITAT

20.1. 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".[100] Connectivity is risked when fragmentation of habitat occurs through the removal of vegetation[101], the addition of noise, lighting[102] and roading[103,104,105], and increases in urbanisation[106,107]

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[99] 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

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

[101] 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.

[102] 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.

[103] 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.

[104] 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

[105] 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

[106] 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

[107] 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.

because these result in bats flying less often in affected areas (all indicated by fewer bat detections).

20.2. For example, Carlier et al (2019)[108] 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.

20.3. When connectivity is reduced because of increased fragmentation of habitat, populations are at greater risk of local extinction[109]. Areas of larger than 5 m will be removed from areas currently mapped as SNA, 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).

20.4. To support connectivity and the function of cSNA, habitat should be preserved as unaltered as possible, and where it is already altered, minimising disturbance is considered of primary importance[110].

20.5. Specifically, areas of corridors or cSNA should not be considered to provide functional connectivity if they are allowed in the future to be severed by roads, or are affected by noise, light or light spill, 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.

20.6. Potential population-level effects of a loss of connectivity of cSNA and tree removal/felling or trimming may include a reduction in colony size due to habitat loss. Felling of roosts may kill or injure bats and displace

[108] 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.

[109] 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

[110] 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

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. [111] Long-tailed bats have been injured and killed during tree felling operations (pers. obs.) including within the Peacocke Structure Plan area. Appendix J of the Submission to the Peacocke Structure Plan Change (PC5, 4Sight report[112]) states on Page 13: "*Injury and death of bats has been observed in the PSPA [Peacocke Structure Plan area] when occupied bat roost trees have been felled (G. Kessels, pers. obs.)*".

20.7. Following tree felling in plantation forests, where I have studied these bats, bats also used fewer roosts[113] and had smaller home ranges[114] than those bats in areas that had not had trees felled recently.

20.8. 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 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 Hamilton 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[115]. This would also result in adverse effects on the local bat population.

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[111] 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.

[112] 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.

[113] 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.

[114] 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

[115] 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

20.9. 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[116]. 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[117] – form only 8% and 14% of the city area, respectively[118]. 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.

20.10. 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[119], or because that other area may already be occupied by another social group of bats.[120] This is because bats are strongly philopatric, that is they are highly faithful to their home range[121], to traditionally-used legacy roosts[122], and to their strongly connected social groups[123]. Long-tailed bats rarely use the roosts of other social groups or change their roosting areas, even when roosts are destroyed.[124]

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116 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

117 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.

118 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.

119 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

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

121 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

122 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.

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

124 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

20.11. 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[125]. 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[126]. Increasing urbanisation may effectively exclude female bats from larger areas.

20.12. Provisions/rules will therefore need to address methods to avoid in the first instance, then remedy, and mitigate this loss of habitat and loss of roost trees by either trimming, felling or removal, and potential loss of life of long-tailed bats with their associated effects at a population-level.

20.13. 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[127], 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.[128] Even after this time, because bats are highly

[125] 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.

[126] 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.

[127] 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.

[128] 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

philopatric, it is likely that planting in another area will not protect the bats of Hamilton. So, a priority should be to protect the trees that are already present, and to restrict the amount of felling/trimming or tree removal that is allowed in SNAs in order to protect their functionality. At present, 50m^2/year or 100m^2/year is allowed depending on whether the site is a property or asset. Tree felling at this level will reduce the functionality of SNA for bats. Tree felling/removal and trimming rules would need to be more restrictive in order to protect bats.

21. IS BAT HABITAT SUFFICIENTLY PROTECTED BY RULES OUTLINED IN PC9 FOR SNAS? A SUMMARY

21.1. There are currently no rules focussed on the management of noise in SNA. Effects of noise on the functionality of SNA for bats could be mitigated by, for example, including restrictions on noisy events/activities within or at a location where noise levels would increase substantially or for long periods in SNAs.

22. LIGHTING INCLUDING SETBACKS, LUX LEVELS, AND 2700K

22.1. It appears that the setbacks recommended by Mckensey[129] in his evidence rely on residents having no doors, windows or other lighting apertures facing SNAs. His modelling, which suggests that lighting levels can be reduced to 0.3 lux within short distances appears to rely on people, even at 4m from an SNA, always pulling their curtains in the evening and having no outdoor lighting. 0.3 lux is considered insufficient by the international literature to mitigate the effects of lighting on bats. 0.1 lux is considered more appropriate as a (maximum) level to avoid light trespass/spill above by EUROBATS 8[130]. If this is not achievable, then wider setbacks should be sought in

[129] Mckensey JK. 2023. STATEMENT OF EVIDENCE OF JOHN KINROSS MCKENSEY (Lighting – Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.

[130] 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

my opinion to achievable light levels more likely to support functionality of the SNA for bats.

22.2. In my opinion, a wider set-back for all buildings than is currently proposed will be more likely to achieve lower levels of lighting in SNA and protect the purpose of SNA and connectivity. This would be more in line with the international guidance (EUROBATS 8) preferred by Mckensey[131] and in the proposed rules of: "Keep illuminance levels as low as possible". The currently proposed rules do not follow this guidance because setbacks are too narrow and rely on people designing buildings that do not take advantage of views.

22.3. In my opinion, adhering to the international guidance given by EUROBATS 8 for managing effects of lighting on bats will be the best way to reduce its effects. Both the Sharman et al (2023) report and John Mckensey in his evidence also support the use of the same international guidance[132]. This means, that in my opinion, all lights near SNAs should be 2700K or warmer colour temperature and that all other recommendations in the EUROBATS 8 document, which is recommended as the best guidance in both the rules and Mckensey's evidence, should be followed in their entirety.

23. TREE FELLING, REMOVAL, AND TRIMMING

23.1. I have shown in my evidence that losing even a small number of trees from an area bats use to commute through can mean they use it less. Carlier et al[133] showed than even when areas as narrow as a 5 m strip of trees were removed that bats used an area less. The proposed rules will allow areas larger than this, i.e., either 100m^2/asset/year or 50m^2/property/year, so these rules do not adequately protect the

[131] Mckensey JK. 2023. STATEMENT OF EVIDENCE OF JOHN KINROSS MCKENSEY (Lighting – Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.
[132] Mckensey JK. 2023. STATEMENT OF EVIDENCE OF JOHN KINROSS MCKENSEY (Lighting – Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan; Sharman C., Soe YM., Buckingham E., Mauala V. 2023. Plan Change 9 Historic Heritage and Natural Environment – Planning Report and Recommendations - Hearing Session 1: Historic Heritage Areas; Significant Natural Areas; and Notable Trees, 6 April 2023.
[133] 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

connectivity and function of the cSNA for bats. This level of vegetation clearance will, in my opinion, likely result in unacceptably high cumulative effects on the functionality of SNA for fauna, including bats. Hamish Dean also acknowledges in his evidence, on Page 12 Paragraph 51, "*that there is a risk that this level of clearance could result in unacceptable cumulative impacts on SNA*". In my opinion, tree felling/removal and trimming should be restricted further to support the function of these SNA, to protect bat roosts, and to reduce unacceptably high cumulative effects on SNA extent.

23.2. In my opinion, these rules should be based on best practice if the aim is also to protect bats from being killed or injured because they are in trees when they are felled. At present, they are not. Best practice guidance to protect bats from being killed or injured when trees are being felled is currently found at this link: https://ftp.doc.govt.nz/public/folder/J8y-HgKTuEmoYMZtafa6nA/bat-recovery/doc-bat-roost-protocol-v2-oct-2021.pdf

23.3. Allowing additional structures/infrastructure, including but not limited to roads, public walkways, cycleways, or park benches, to be constructed within SNA is likely to mean that there are pressures for lighting, noise, and tree maintenance (felling/removal or trimming) to take place within SNA. Allowing this to occur will reduce the functionality of SNA for bats. Therefore, in my opinion, additional structures/infrastructure should not be allowed in both fSNA and cSNA, rather than only 'carefully managed' in cSNA as suggested in the evidence of Hannah Mueller in her paragraph 35[134]. The rules proposed in PC9 do not currently protect SNA adequately from the insertion of additional structures/infrastructure and their associated effects of tree felling/removal/trimming, light, and noise.

[134] Mueller, H. 2023. STATEMENT OF EVIDENCE OF DR HANNAH MUELLER (Ecology - Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan. CP158 Director-General of Conservation, BORKIN Evidence, on SNA and bat ecology, Proposed PC9 [docCM-7322063]

24. DO THE PROPOSED 'CITY WIDE RULES' PROTECT BATS?

24.1. Research by Gili (et al[135]) 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 boundaries of the city of Hamilton given that this entire area is proposed for urbanisation. There simply is not enough room.

24.2. Managing habitat for the persistence of bats is most effective when this takes place over a large or landscape scale[136]. 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 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 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.

24.3. So, if a larger area, outside Hamilton or the areas of Hamilton where most bats are detected i.e., Southern Hamilton, is used to manage or compensate for development activities or losses of SNA that cannot be managed within Hamilton, will this benefit bats currently resident within Hamilton? 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

[135] 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

[136] 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

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 southern Hamilton will benefit, simply because they may not use this area. It may not be part of their home range.

24.4. 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[137]. 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,

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.

24.5. There were additional draft policies and rules related to long-tailed bats introduced after the recently held conferencing on 14th March 2023. I refer to these as the 'City-wide rules'. I did not agree to these in principle during the Ecology and Planning conferencing session held

[137] 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

on 14th March 2023[138], despite what the Planning Report infers (Sharman et al 2023, on Page 50)[139]. These draft rules are found under the objective: 20.2.2 "Significant habitat for long-tailed bats is protected and enhanced." Bat habitat, as defined by the Waikato Bat Strategy (included as my Appendix B) includes areas used for breeding, roosting, foraging, and travelling (commuting) between these areas. Habitat includes native and exotic/introduced vegetation, gardens, orchards, farms, lifestyle blocks, pasture, and connecting corridors. Protecting only areas around known roost trees and areas with high bat activity will be insufficient to provide sufficient high quality feeding areas for bats to persist/thrive within Hamilton City boundaries or wider. All habitat used by bats is not protected through the proposed SNA mechanism – only some of the habitat used will receive some level of protection; and, in my opinion, for the reasons in paragraphs outlined above, these protections will be inadequate.

24.6. In addition to this, given that there will be little available area within the city boundaries to adequately restore or mitigate habitat, the city-wide approach is likely to fail to support bat population to thrive. A far wider landscape-scale approach is needed to manage habitat and bat populations and to mitigate effects, as discussed above, and as recommended in the international guidance document: EUROBATS 9[140].

24.7. EUROBATS 9 is recommended as a key guidance document to follow in the evidence of Hannah Mueller (Paragraph 39)[141]. I support, in principle, the use of this international guidance document.

[138] Joint Witness Statement Ecology and Planning. 14th March 2023. IN THE MATTER of the Resource Management Act 1991(RMA) AND IN THE MATTER of Plan Change 9 to the Hamilton City District Plan. JOINT WITNESS STATEMENT (JWS) IN RELATION TO: ECOLOGY and PLANNING (1) 14th March 2023

[139] Sharman C., Soe YM., Buckingham E., Mauala V. 2023. Plan Change 9 Historic Heritage and Natural Environment – Planning Report and Recommendations - Hearing Session 1: Historic Heritage Areas; Significant Natural Areas; and Notable Trees, 6 April 2023.

[140] Kyheröinen, E.M., S. Aulagnier, J. Dekker, M.-J. Dubourg-Savage, B. Ferrer, S. Gazaryan, P. Georgiakakis, D. Hamidovic, C. Harbusch, K. Haysom, H. Jahelková, T. Kervyn, M. Koch, M. Lundy, F. Marnell, A. Mitchell-Jones, J. Pir, D. Russo, H. Schofield, P.O. Syvertsen, A. Tsoar (2019): Guidance on the conservation and management of critical feeding areas and commuting routes for bats. EUROBATS Publication Series No. 9. UNEP/EUROBATS Secretariat, Bonn, Germany, 109 pp. https://www.eurobats.org/sites/default/files/documents/publications/publication_series/WEB_DIN_A4_EUROBATS_09_ENGL_NVK_01042019.pdf

[141] Mueller, H. 2023. STATEMENT OF EVIDENCE OF DR HANNAH MUELLER (Ecology - Significant Natural Areas) 14 April 2023, IN THE MATTER of Proposed Plan Change 9 to the Operative Hamilton City District Plan.

EUROBATS 9 highlights that “protecting roosts alone is not enough to ensure the conservation of bat populations” (Page 6), and that “mechanisms should be implemented to preserve a network of feeding areas and commuting routes outside protected areas” (Page 8).

24.8. EUROBATS 9 also recommends that any land use project likely to affect bats, their roosts, and feeding environment should include a bat survey and analysis of the projects’ potential effects on bats. Bat surveys and assessment of each projects’ potential effects on bats are not currently required in the draft PC9 rules.

25. CONCLUSIONS

25.1. EUROBATS 9 reinforces my opinion that only protecting areas within the proposed SNAs will not be sufficient to ensure bat populations persist within Hamilton. The protection of the proposed SNAs in their entirety along with a wider network will be necessary to ensure functioning bat populations remain in the area. In my opinion, the functionality of SNA for bats and other fauna would be better protected by stronger rules preventing the cumulative effects of tree and other vegetation removal/felling and trimming, and the use of best practice guidance to manage lighting and noise. Determining the effectiveness of the measures that are designed to protect SNAs will also be, in my opinion, crucial to supporting their functionality.

Dr Kerry Marie Borkin

DATED this 28th day of April 2023

Appendix A – Consolidated List of References in Dr Borkin's Evidence

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Appendix B – Waikato Bat Alliance Draft Bat Strategy