EVIDENCE IN CHIEF OF BRIAN DONALD LLOYD - INDEX

Before the Board of Inquiry
Hauauru Ma Raki Wind Farm Proposal

Under	the Resource Management Act 1991
In the matter of	Resource consent applications by Contact Wind Limited relating to the Hauauru Ma Raki Wind Farm Proposal
And	
In the matter of	Notices of Requirement and a Resource Consent Application by Contact Energy Limited relating to the Hauauru Ma Raki Wind Farm Proposal

Statement of evidence in chief of Dr Brian Donald Lloyd

Dated:	27 March 2009
Date of hearing:	27 April 2009

Director-General of Conservation

18 – 32 Manners Street
P O Box 10-420
Wellington 6143

Tel +64 4 471 0726
Fax +64 4 471 3170

Solicitors acting: Shona Bradley/Jeremy Prebble/Alice Hunt

STATEMENT OF EVIDENCE IN CHIEF OF Dr. BRIAN DONALD LLOYD

INTRODUCTION

1 My full name is Brian Donald Lloyd.

2 I am an independent ecological consultant.

3 I have a Ph.D. in Ecology from Massey University (2002), a M.Sc. in Zoology from Victoria University (1988) and a B.Sc. (Hons.) in Biochemistry from Leeds University, UK (1972).

4 I have 33 years experience of ecological research in New Zealand. I initially worked as a science technician with the New Zealand Wildlife Service (1974-1977 and 1979-1987) and then as a research scientist with the Department of Conservation (1987-2008). Since September 2008, I have been working as an independent ecological consultant.

5 My research has encompassed a range of New Zealand species (South Island robin, little spotted kiwi, kakapo, kaka, short-tailed bats, long-tailed bats, seabirds and dolphins) and issues (species conservation, non-target impacts of vertebrate pesticides and the impact of aquaculture on marine wildlife).

6 Of immediate relevance to this proposal are my work on bats, my expertise in biostatistics and my experience in the design and execution of ecological surveys, monitoring programmes and experiments:

a. My PhD thesis was on "The Ecology and Molecular Ecology of the NZ Short-tailed Bat". This was based on ten years of field research on short-tailed bats (1992–2002), which included extensive surveys for bats throughout central North Island and Northland. More recently (Sep 2008-present), I have been leading surveys for long-tailed bats in the Nelson Marlborough area, working as an independent ecological consultant contracted to the Royal Forest and Bird Protection Society. I have published seven refereed scientific papers and thirteen management reports or articles on short-tailed bats. I authored the section on short-tailed bats in the most recent handbook of New Zealand Mammals. I assisted compilation of the Department of Conservations Bat Recovery Plan and was a founding member of the Bat Recovery Group (1995-2008). I designed and jointly led the short-tailed bat translocation to Kapiti Island (2004-2007).

b. I am proficient in mathematics and statistics. My M.Sc. thesis concerned the development of new statistical analytic methods for the analysis of remote radiotracking data. I was statistical advisor to Science and Research Unit, 1989–92. My statistical expertise encompasses: experimental design, classical univariate and multivariate statistics, multi-level hierarchical modelling, classification, tree building and phylogenetic analytic methods.

c. I have considerable experience in the design and execution of ecological surveys, monitoring programmes and experiments. These include:

- Surveys for bats in the Nelson, Marlborough area
- Surveys to determine short-tailed bat distribution
- Surveys of genetic variation in short-tailed bats
- Monitoring seasonal changes in bat activity using bat detectors
- Monitoring short-tailed bat roosting activity
- Monitoring short-tailed bat fatalities during aerial 1080 operations
- Monitoring 1080 levels in invertebrates after aerial 1080 operations
- Trials on the consumption of carrot baits by free-living kaka
- Trials on the attractiveness of lures and baits to captive short-tailed bats
- Field trials to evaluating the risks of rat baits to kakapo and bats
- Boat based distance-sampling surveys for seabirds & dolphins with synoptic sonar surveys for prey fish
- Photographic surveillance of seabird activity on mussel farms
- Video surveillance of dolphin behaviour
- Underwater acoustic monitoring of dolphin activity.

7 I am familiar with the proposal that is the subject of the resource consent applications and notices of requirement. I also confirm that I have visited the site.

8 I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise.

9 I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

10 My evidence will deal with the following:

- **The adequacy of bat survey work undertaken in the HMR project area**
- **The likelihood of bats being present within the HMR project area**
- **The significance of a resident bat population within the HMR project area**

- **Collision risk to bats posed by transmission lines and wind turbines**

- **Modelling collision risks for bats in wind farms**

- **Risk to bats from habitat clearance associated with the development**

- **Comments on the applicants proposals for:**
  - **Additional bat surveys**
  - **Avoidance, remediation, direct mitigation and offset mitigation**
  - **Post-construction collision monitoring**
  - **An Ecology Peer Review Panel**

- **Mitigation by curtailing wind generation during periods with high bat fatality levels**

- **Modifications to the applicants Suggested District Council Conditions**

- **Additional suggestions for District Council Conditions:**

  - **Staged bat risk-assessment programme:**

  - **Stage 1: Pre-construction Widespread Acoustic Bat Surveys**

  - **Stage 2: Pre-Construction Bat Population Monitoring Programme**

  - **Stage 3: Post-Construction Bat Population Monitoring Programme**

  - **Stage 4: Research to develop methods to avoid and mitigate bat fatalities at wind-turbines**

  - **Avoidance and mitigation of the adverse effects of roost tree removal**

  - **Offset mitigation for adverse effects on long-tailed bats**

SUMMARY OF EVIDENCE

11 In summary:

- To date, surveys for bats undertaken within the HMR project are inadequate and provide little reliable information on long-tailed bat presence within the area.

- Long-tailed bats have been observed in the HMR project area recently and I believe it is likely for this reason, and the others cited below, that they are resident there.

- A wind-turbine collision risk profile for long-tailed, compiled from the best available information on the species together with overseas information on bat fatalities at wind-turbines, indicates that long-tailed bats are likely to be at risk of wind-turbine strike.

- Overseas experience is that large numbers of bats are killed in wind farms as a result of turbine blade strike.

- Bats will also be at risk from the loss of roost trees through felling large trees within the project area.

- I endorse the proposals in the Suggested District Council Conditions to establish an Ecology Peer Review Panel and a Resident Bird Bat Collision Mortality Monitoring Programme.

- In the absence of information on long-tailed bat activity levels in the HMR project area and their behaviour around wind-turbines, it is impossible to reliably quantify the risk posed to bats by the HMR wind farm. Neither is it possible to determine whether adverse impacts can be avoided, remedied or mitigated To remedy this there should be a staged program of bat work in the project area:

  - Stage 1: Pre-construction Widespread Acoustic Surveys for bats throughout the entire project area prior to construction.

  - Stage 2: Pre-construction Bat Population Monitoring Programme undertaken to identify areas of high bat activity where turbines should not be sited to avoid bat fatalities by turbine strike and to establish baseline data.

  - Stage 3: Post-construction Bat Population Monitoring Programme to assess the effects of wind-farm construction and operation.

  - Stage 4: Research to develop effective methods to avoid and mitigate bat fatalities at operational wind-turbines.

- If long-tailed bats are resident in the project area all large trees should be considered potential roost sites their removal should be undertaken in a manner that doesn't endanger roosting bats. Their removal of potential roosts should be compensated for by placement of artificial bat roost boxes.

- Any offsite offset mitigation for adverse effects of wind-turbine on long-tailed bats should be a last resort and should be carefully targeted to ensure benefits to local long-tailed bat populations.

ADEQUACY OF BAT SURVEY WORK

12 The bat survey work undertaken in the Hauauru ma Raki (HMR) wind farm project area is described in Paragraphs 77 to 79 of Gerry Kessels' evidence. Further details are provided in (Kessels et al. 2008), a report assessing ecological effects of the proposal included among Contact's application documents. In summary, three bat surveys methods were employed: slow walks along line transects in the early evening with hand held bat detectors; overnight monitoring with recording bat detectors; and inspection of likely roost sites for evidence of bat occupancy by bats.

13 I do not consider that survey effort undertaken is adequate to draw any substantive conclusion about the status of long-tailed bats in the HMR project area. The most that can be said is that the bat survey sites were probably not within core activity areas of a sizeable population of long-tailed bats at the time of the surveys.

14 Inspection of likely bat roost sites for evidence of occupancy is not an effective method for locating long-tailed bats. Although accessible cave roost sites occupied by large numbers of bats may be identified by guano piles under areas occupied by bats, these roosts are rare as long-tailed bats primarily roost in trees (Sedgeley & O'Donnell 1999a) or inconspicuous limestone crevices (Griffiths 1996). There is usually little sign of long-tailed bats occupation at tree roosts. Roost entrances are usually high in the tree, most guano remains within the roost cavity, occupancy is normally for only a period of one or two days and roosts are seldom reused in the same season (O'Donnell 2005).

15 Over the four month period November 2007 to February 2008, a total of 13 two-hour long walking transects were undertaken each at a separate location. This comprises a total of *c.* 26 hours detection time spread along 13 transects. Recording bat detectors were deployed overnight for one night at six sites, giving a further *c.* 48 hours of detection time spread over 6 sites. Thus, the total bat survey effort undertaken using bat detectors to detect long-tailed bats within the 400 km^2 HMR project area was 74 hours of detection time spread between 19 sites.

16 This is a very small survey effort compared to the effort typically expended in bat surveys. For comparison, when surveying for bats, I typically deploy at least 10 recording bat detectors at *c.* 200 m spacing, for a period of three or more fine nights. Thus a single deployment provides >240 hours of detection time at >10 locations. The number of deployments is determined by the size of the area being surveyed and available resources. In an area the size of the HMR project area I would strive for deployments at several hundred of locations to give thousands of hours detection time. (See Paragraph 74 below for specific recommendations.)

17 I disagree with Kessels' (Paragraph 77) statement that the bat surveys covered a significant portion of all likely potential habitat areas for bats. All bat survey sites were within or along the edges of indigenous forest remnants or close to limestone formations. The

HMR project area is primarily a pastoral landscape, which includes: parklands (i.e. pasture areas with scattered large native and exotic trees), exotic shelter belts, plantation forestry, and numerous streams and wetlands. Long-tailed bats often forage over streams and wetlands and use streams for commuting. All of these habitats are used by long-tailed bats (Borkin 1999; Moore 2001; Griffiths 2007). Indeed (Moore 2001), working near Kinleith, reports that long-tailed bat activity was much greater in the pine plantation than native forest. (Griffiths 2007) noted extensive use of river and riparian habitats in a pastoral area of south Canterbury. (Borkin 1999), who surveyed for long-tailed bats in the Waikato, remarked that "*The majority were heard or seen on tracks and roads, and along rivers, streams, and bush edge. The greater part of these areas were relatively open with old trees present. Bats were often heard flying over pasture adjacent to areas with large trees, as well as in pine forest.* In the course of my own survey work in central North Island and the Nelson/Marlborough area, I have encountered long-tailed bats at indigenous forest/pasture boundaries, within pine plantations, along willow bordered rivers running through farmland and over hillsides covered with exotic brush weeds, as well as within and above indigenous forest. Dekrout & Reynolds (2008) report long-tailed bats active over open pasture in south Waikato.

18 Radio-tracking studies in the South Island (O'Donnell 2001; Griffiths 2007) show long-tailed bats range widely over the landscape, flying at speeds up to 60 km/hr. In beech forest, individual bats had median home range areas of 13–16 km^2 (maximum 56 km^2) and average range lengths between 3.3–10 km (maximum 19 km). Minimum nightly flight distances were 5–36 km. Home ranges were smaller in an agricultural environment, with individual home ranges of 3–6 km^2 and range lengths 2.8–4.4 km.

19 Even when reasonable numbers of long-tailed bats occur in an area, detection rates with bat detectors can be low. The maximum effective working range for detecting long-tailed bats with bat detectors is about 50 m. Thus, the volume of airspace being surveyed around a detector is tiny when compared to long-tailed bats ranging behaviour. In addition, long-tailed bats often fly too high for detection. Further problems arise because long-tailed bats aren't distributed randomly in the landscape: their activity is clustered both spatially and temporally in unpredictable patterns. When surveying for long-tailed bats, in order to compensate for the low detection rate and unpredictable temporal and spatial clustering, it is important to maximise both detection time, and the geographical spread and habitat diversity of sampling sites.

20 I concur with (Kessels et al. 2008): "*the detection of bats through ultrasound monitoring can be inefficient. Ultrasound recording cannot be considered a measure of presence and absence – it is a measure of presence and non-detection*". Nevertheless, ultrasound monitoring with recording bat detectors is the most efficient method for detecting long-tailed bats, which are by nature cryptic and elusive.

LIKELIHOOD OF BATS BEING PRESENT

21 In my opinion, there is no realistic possibility that short-tailed bats occur in the HMR project area. The species require extensive tracts of substantially unmodified old growth indigenous forest (Lloyd 2005) not found in, or near, the project area and there are no historical or contemporary records of the species in north-west Waikato (Daniel & Williams 1984; Lloyd 2005). The closest known populations of short-tailed bats are more than 80 km away at Pureora and Mamaku (Lloyd 2005) and short-tailed bats rarely fly outside of old-growth indigenous forest.

22 In contrast, long-tailed bats do occur within the HMR project area and I believe there is a high probability that there is a resident long-tailed bat population in the project area. This belief is based on: reported bat sightings in the area, sparseness of survey effort, suitability of habitat, and proximity to known long-tailed bat populations:

- There are two recent reports of long-tailed bats seen within the area (Kessels et al. 2008). During my surveys for bats, I have found that the best predictor of bat populations in an area is reported sightings from the area within the last 40 years. I have encountered bat populations in almost every area I have surveyed where there have been reports of bats seen or heard within the last 40 years.
- Although no bats were recorded during bat surveys, the sparseness of survey effort means no conclusion can be drawn about the species status in the area except that the bat survey sites were probably not within core activity areas of a sizeable population at the time of the surveys.
- The project area provides ideal habitat for long-tailed bats, as it contains a mosaic of habitats that they are known to favour. These habitats included modified ones such as parkland, shelter belts, and plantation forestry (see Paragraph 17 above) as well as several large remnant areas of indigenous forest containing numerous large old trees, shrub-lands, limestone outcrops, streams and wetlands.
- The HMR project area is within easy dispersal range of other long-tailed bat populations. Radio-tracking studies in the South Island (O'Donnell 2001; Griffiths 2007) show long-tailed bats range widely over the landscape and are not confined to forest areas. Flying at speeds up to 60 km/h, individual bats had average range lengths between 3.3–10 km (maximum 19 km) and minimum nightly flight distances 5–36 km. Long-tailed bat populations are present in the south and east of the Waikato basin (Borkin 1999; O'Donnell 2002a; O'Donnell 2005; Guilbert et al. 2007), with the closest known population being only 35 km away in Hamilton City (Borkin 1999; Dekrout pers. comm.). There are reports of long-tailed bats at Mount Karioi, only 25 km away. The intervening landscape includes many forest remnants, farm shelter belts and forest plantations suitable for dispersing or resident long-tailed bats.

SIGNIFICANCE OF A RESIDENT BAT POPULATION IN THE HMR PROJECT AREA

23 Long-tailed bats are an endemic New Zealand species and are fully protected by the Wildlife Act 1953. The species is ranked as "Nationally endangered" in New Zealand's threat classification system list (2005), which means there is a high risk of extinction in the medium term if conservation management is not successful at reversing their declines (Hitchmough et al. 2007). However, ranking for the taxon is qualified as "Data Poor", which means that confidence in the listing is low due to there being only poor data available for assessment.

24 Once common throughout NZ, long-tailed bats numbers have declined markedly over the last 100 years and the species is now scarce in most areas (O'Donnell 2005). Although widespread throughout the north of the North Island, the species is not common. There is little reliable information on current population sizes or trends for long-tailed bats in the North Island. Results of a study of trends at Grand Canyon Cave, in south Waikato, were inconclusive (Pryde et al. 2006). However, it is reasonable to presume that North Island population are continuing to decline as a result of predation by introduced predators in much the same way that South Island populations are (O'Donnell 2002b; Pryde et al. 2005; Pryde et al. 2006).

25 Because significant numbers of long-tailed bats are present in the south and east of the Waikato basin (Borkin 1999; O'Donnell 2002a; O'Donnell 2005; Guilbert et al. 2007), a small resident population of long-tailed bats in, or close to, the HMR project area would have little regional or national significance, other than to bolster overall populations size for the taxon. Its primary significance would be to enhance local biodiversity values within the immediate area of north-west Waikato.

COLLISION RISK TO BATS POSED BY TRANSMISSION LINES AND WIND-TURBINES

26 I believe transmission lines pose a negligible collision risk to New Zealand bats. There are no reports of bats colliding with the many transmission lines traversing New Zealand (Daniel & Williams 1984). Although there are overseas reports of microbats[1] occasionally colliding with stationary structures during strong winds, collisions with transmission lines have not been reported as a significant source of mortality in microbats species overseas. More importantly long-tailed bats forage in areas with many stationary obstacles (among trees within forests, along the edge of forests and around buildings and lamp-posts) using their echolocation to avoid collisions.

[1] There are two types of bats: megabats and microbats. Megabats or fruit bats are generally larger and don't echolocate, whereas microbats are smaller bats that do echolocate.

27 In contrast, microbat fatalities caused by collisions with wind-turbine blades have been recorded at wind facilities from many regions of the world, including: Australia, Canada, USA and Europe (Kunz et al. 2007b; Arnett et al. 2008). Wind-turbine induced fatalities have been recorded for 11 of 45 bat species found in northern America. The issue of bat fatalities in wind farms first achieved prominence in 2003, when an estimated 1,400–4,000 bats were killed at the Mountaineer Wind Energy Center in West Virginia, USA (Kerns & Kerlinger 2004). Comprehensive information on the topic can be found on the Bats and Wind Energy Cooperative website (http://www.batsandwind.org/).

28 Bat fatalities at wind farms are caused either by the bats being struck by turning rotor blades (Horn et al. 2008), or barotrauma (i.e. internal haemorrhaging of the lungs) resulting from rapid decompression in vortices behind the moving blade tips (Baerwald et al. 2008).

29 There is insufficient evidence available to properly assess adverse impacts of wind-turbines on New Zealand bats. The only operational utility sized wind-farms in New Zealand located in an area that might harbor bats are near Palmerston North. However, the probability of bats being in the area is low and there has been no monitoring for bat fatalities at the farm. To assess the collision risk posed to New Zealand bats by wind-turbines one must resort to inference from overseas information on bat/wind-turbine interactions and the known behaviors of New Zealand bats. Mr. Kessels (Paragraph 143) rightly argues for caution in using such a strategy when undertaking risk assessment for New Zealand species.

30 Mr. Kessels (Paragraph 143) infers a low risk of wind-turbine strikes to New Zealand bats (Paragraph 147). I agree with Mr. Kessels' risk assessment for forest dwelling short-tailed bats, but not for long-tailed bats. If long-tailed bats are present in the HMR project area, there is a high probability of them suffering fatalities caused by wind-turbine strike.

31 While acknowledging the high levels of bat fatalities at overseas wind turbine sites, in his evidence Mr. Kessels predicts a low risk to long-tailed bats primarily because most bat fatalities at overseas wind-turbines are thought to result from collisions during migratory flights when the bats fail to detect and avoid the turbine because they are not echolocating. He argues that long-tailed bats are non-migratory, do not fly without echolocating and will be able to detect and avoid wind turbines.

32 The notion that bats collide with wind-turbines because they are not echolocating is no longer tenable. Recent study using thermal imaging cameras (Horn et al. 2008) showed bats foraging around and in the rotor-swept zone of the turbine. Bats were observed making repeated flight loops near moving blades. Avoidance behaviour was observed in 41 of 998 observations and actual strikes in 4 observations. Bats struck by turbine blades were not passing through the wind energy facility in straight-line flight typical of long-distance migrations. They were foraging, and it is

reasonable to assume that they were echolocating. Bats appeared to be attracted to wind turbines and actively investigated both moving and motionless turbine blades.

33 Although echolocating bats are usually capable of detecting and avoiding moving blades(Horn et al. 2008, when bats are foraging in close proximity to moving blades, the high speeds of blade-tips, even when rotors are turning slowly, and the limited range (<10 m) of frequency modulated (FM) echolocation means in some instances bats may not have time to avoid being struck by the blade-tips {Horn, 2008 #35). Alternatively, they may be caught in vortices trailing behind the blade-tip (Kunz et al. 2007a; Horn et al. 2008) and either be struck by the blade, or suffer barotrauma due to rapid decompression near the moving blade (Baerwald et al. 2008).

34 Thus, the commonly stated link between migratory bats, their non-echolocating migratory flights and high wind-turbine strike rates (Kunz et al. 2007b; Arnett et al. 2008) referred to by Mr. Kessels is almost certainly misleading. Bats are vulnerable to turbine-strike even during echolocating flight. There are studies documenting high incidences of wind-turbine strike in non-migratory species (Ahlén 2003) and resident bats during summer months (Piorkowski 2006). Because of the extreme continental climates migratory behaviour is common in tree roosting bats in northern America and Europe, where most studies on bat fatalities at wind-turbines have been undertaken.

35 Several behavioural characteristics have been suggested as contributing to high incidences of wind-turbine strike by some bat species: tree roosting, aerial hawking in open habitats, foraging along forest edge and linear corridors, and the use of Frequency Modulated (FM) echolocation calls (Kerns et al. 2005; Kunz et al. 2007a). All of these characteristic are exhibited by long-tailed bats.

36 In my opinion, there is currently insufficient evidence to undertake a reliable risk assessment on the impact of wind-turbines on long-tailed bats. However, a collision risk profile for the species based on the best available information indicates that there is a high probability that where wind farms are placed in areas inhabited by long-tailed there will be bat fatalities caused by wind-turbine strike. Long-tailed bats:

- forage by aerial hawking in open areas. This is a behavior observed in bat species with high incidences of wind-turbine strike fatalities.
- often forage >35 m above ground level. This places them within the rotor sweep zone of wind-turbines.
- forage around artificial structures such as buildings, lamp posts aviation warning lights and bridges.
- use frequency modulated (FM) echolocation calls, which have a limited range (<10m) and are used by bat species prone to turbine strike (Kerns et al. 2005)
- range widely over distances of up to 10 km when foraging. Thus, even when roosting considerable distances away from a wind farm they are likely to encounter it while foraging.

- are tree roosting. This is a common feature of bat species suffering high wind-turbine related fatalities and has led to the theory bats are investigating wind turbines as potential roosts sites (Kunz et al. 2007a)
- seek out areas with high insect concentrations for foraging . Overseas literature indicates flying insects congregate around wind turbines.
- forage along roads, forest edge, shelter belts and other linear features often associated with wind-farms (Kunz et al. 2007a).
- have been observed investigating large moving objects such as thrown stones.

MODELLING COLLISION RISKS FOR BATS

37 Sophisticated models have been developed to assess turbine collision risk for birds. There are no data available to develop even the most rudimentary model for bats in New Zealand, or more specifically for the HMR Project. Given the high level of uncertainties, it is impossible to say reliably what level of adverse effect will arise from wind-turbine related bat fatalities on any population. Some idea of the possible scale of impact on any bats present in the HMR wind project area can be gauged from overseas information.

38 Bat fatality rates obtained from carcass retrieval programmes have been estimated for wind farms throughout the United States as bat per megawatt of electricity generation capacity per year (i.e. bats/MW/year) (Kunz et al. 2007b; Arnett et al. 2008). Estimated bat fatality rates for wind-farms on forested ridge tops range from 15.3 bats/MW/year to 53.3 bats/MW/year. While fatality rates for wind-farms located in farmland range from 0.8 bats to 8.6 bats/MW/year. Using the most conservative fatality rate estimate of 0.8 bats/MW/year from wind farms in farmland together with the proposed HMR wind project nominal generation capacity of 540 MW (megawatts) provides an alarming estimate of 432 bat fatalities in one year. Because no data are provided on bat activity levels associated with bat fatality rates from America and there are no data on likely bat activity levels at turbine sites in the HMR project area this estimate is not a reliable prediction of fatalities in the HMR project area. However, it does provide a conservative (i.e. low) estimate of the magnitude of the bat strike problem likely at a wind farm with similar generation capacity in open farmland in America.

RISK TO BATS FROM HABITAT CLEARANCE

39 I believe the habitat clearance being proposed will have little impact on the areas available to long-tailed bats foraging in the project area.

40 Long-tailed bats are cavity roosting bats, depending on suitable cavities for protection from both predators and ambient conditions. Roost cavities may be in trees, in caves, on cliffs, in buildings and

under bridges. Most roost cavities are in large trees within indigenous forest. However, in modified landscapes without large areas of mature indigenous forest, long-tailed bats often roost in cavities of a range of exotic tree species: pine, macrocarpa, elm, wattle, poplar, eucalypt (Daniel 1981; Daniel & Williams 1984; Griffiths 1996; Moore 2001). Any standing dead or mature tree over 80 cm diameter may contain suitable roost cavities for long-tailed bats.

41 If there is a resident long-tailed bat population in the HMR project area, felling actual and potential roost trees will pose both direct and indirect threats to the population.

42 Felling occupied roost trees is a known cause of death for long-tailed bats (Daniel & Williams 1984). Fatalities are more likely during the winter hibernation period (May-September) when roosting bats are likely to be unresponsive because of extended periods of torpor. Torpor can best be described as a state of suspended animation used by the bats to save energy during adverse conditions. Their metabolic rates reduce to a few percent of normal and their body temperatures drop to close to ambient temperature. When in torpor bats are in an unresponsive coma-like state. It takes 20 to 30 minutes for bats to go from torpor to their normal active state.

43 Felling standing dead and mature trees greater than 80 cm diameter may have an indirect affect on bat populations, even when there are no bats present within the tree when it is felled. Long-tailed bats populations require large numbers of suitable daytime roost sites. During summer, bats change roosts almost daily and roosts are seldom reused in the same season (O'Donnell 2005). Suitable roost cavities have specific structures and internal microclimate (Sedgeley & O'Donnell 1999b, 1999a; Sedgeley 2001). The combination of specific cavity requirements, high roost turnover and low levels of roost reuse means that the availability of suitable roosts is almost certainly a limiting factor in modified landscapes (Sedgeley & O'Donnell 1999b, 1999a; Sedgeley 2001) such as the MHR project area. Thus, any reduction in the numbers of suitable roost trees in the MHR area could affect survival and productivity of a resident long-tailed bat population detrimentally.

44 Forest clearance for wind-turbines and access roads might also create the kind of landscape with linear edges and sheltered clearings that attract flying insects and bats, thereby increasing bats exposure to wind-turbine strike (Kunz et al. 2007a).

APPLICANTS PROPOSALS FOR ADDITIONAL BAT SURVEYS

45 I welcome Mr. Kessels' (Paragraph 196) recommendations for additional bat monitoring work. His recommendations include:

- local bat surveys prior to bush clearance to detect active bat roosts; and

- a programme of widespread bat surveys to establish whether bats are present within the HMR project area;

46 Local pre-clearance bat surveys are included in Daysh's Suggested Council Conditions. These pre-clearance surveys should not be restricted to indigenous bush clearance. As discussed above, all large trees whether indigenous or exotic are potential roost trees. Whenever a large (>80 cm diameter at breast height) standing dead or mature trees is to be felled, overnight bat activity at the tree should be monitored with a recording bat detector on the night before felling. During summer a single night's monitoring will be sufficient. However, during the winter hibernation period (May to September), when the bats remain inactive for periods of several days, even longer term (>10 nights) monitoring with recording bat detectors could fail to identify hibernation roost or hibernacula.

47 Although Mr Kessels has recommended further widespread bat surveys to establish whether bats are present in the project area the suggestion has not been incorporated into Mr. Daysh's Suggested Council Conditions. The only bat surveys provided for in the suggested conditions are limited surveys in areas where clearance of indigenous vegetation is to be undertaken. Because long-tailed bats range widely (up to 10 km) and use modified habitats freely, I consider that bat surveys limited to areas within and close to indigenous vegetation are pointless and inadequate except for finding active bat roosts within them.

APPLICANTS PROPOSALS FOR AVOIDANCE, REMEDIATION, DIRECT MITIGATION AND OFFSET MITIGATION

48 Relocation, or translocation, has been proposed as a direct mitigation method to reduce bat fatalities when areas of indigenous bush containing active roost trees are to be cleared and to relocate bats populations away from wind-turbine sites (Tonks, Paragraph 64; Daysh, condition 6.7; Kessels Paragraph 196). I consider that relocation is impracticable for either purpose, for two key reasons.

49 Firstly, residency periods for active long-tailed bat roosts are short, averaging about 2 days (range 1-8 days) in the summer. Thus, during summer, waiting for the bats to abandon the roost would incur only a few days delay and save the major effort and risk of capturing bats during roost departures. During the winter hibernation period residency periods are longer, and longer delays would be incurred. However, the alternative of removing hibernating bats from a roost for relocation would entail first felling the roost tree and ensuing fatalities.

50 Secondly, long-tailed bats are social animals that exhibit strong fidelity to both social group and site. Individuals have and well developed homing instincts (Guilbert et al. 2007). Adult bats relocated long distances will not establish new populations and if they can will quickly return to their home range. Translocation methods for bats have not been well developed. My own work

translocating short-tailed bats indicates that successful bat translocation requires translocation of captive-bred juveniles not imprinted with a home range. This is an expensive and time-consuming procedure, requiring establishment of captive facilities, captive breeding and soft release.

51 It has been suggested that the probability of bat strikes could be reduced by using red aviation warning lights shielded from the ground to avoid attracting insects instead of white lights (Kessels, Paragraph 149, and Daysh, Exhibits SGD1 & SGD2, Sections 6.7). New Zealand Civil Aviation Authority adheres to the internationally standard for aviation warning lights on wind-turbines. This stipulates a medium intensity red light flashing at a rate of 20 to 60 per sec. Although there are provisions to use white lights, they are reserved for exceptional circumstances and have never been used to mark wind turbines in New Zealand. A review of American studies of bat fatalities at wind-turbines (Arnett et al. 2008) found no differences between bat fatalities at wind-turbines equipped with red flashing aviation lights and turbines that were unlit. Thus, shielding red flashing lights will probably not change the probability of bat strike.

52 Increasing the echolocation reflectance of the turbine blades is another direct mitigation method proposed for reducing possible bat fatalities in the HMR wind project (Tonks, Appendix). Bats can, and do, detect the moving blades (see Paragraphs 32 and 33 above). Increasing the echolocation reflectance of the turbine blades is unlikely to lead to any reduction in bat strikes.

53 A review of studies of bat fatalities at American wind farms (Arnett et al. 2008) showed fatalities were evenly distributed among the farm turbines. Differences in wind-turbine positions did not affect bat fatality rates. Thus it seems unlikely that mitigation of bats fatalities can be achieved by modifying farm layout.

54 The procedure used to arrive at the offset mitigation package for long-tailed bats presented by Mr. Tonks and in (Kessels et al. 2008) Assessment of Environmental Effects report seem rather obscure. However, if there is a resident long-tailed bat population in the HMR project area, Mr Tonks' estimate of 0.4 bat fatalities per year is a very low estimate given the levels of bat fatalities reported from American wind-farms (see Paragraph 38 above).

55 I agree with Mr. Tonks' (Paragraph 63 and 64) comments that it is hard to justify offset mitigation if bats are not present in the area. However as set out above, I consider there is sufficient evidence in this case to conclude that it is likely that there is a long-tailed bat population present and I believe that the question of bats presence in the area could be easily resolved with adequate bat-survey effort, which has not yet been done. I also agree with Mr Tonks that direct mitigation of actual adverse effect is a more appropriate response if bats are present. However, I caution that direct mitigation may not be achievable.

56 In the case of bat fatalities at wind turbines I don't believe it is necessary to apply a pre-cautionary approach (i.e. provide offset

mitigation merely because of the possibility of an adverse affect) as Mr Tonks suggests. This approach is appropriate when it is difficult to identify adverse affects, but a bat population monitoring programme should provide reliable information on bats exposure to turbine strike and a properly constituted monitoring programme should identify even low levels of turbine strike in the HMR wind farm. Overseas study indicate that with trained carcass recovery dogs search efficiencies of around 80% can be achieved for dead bats at the base of turbines (Arnett et al. 2008). Therefore as long as an adequate monitoring programme for turbine strike is undertaken, I see no good reason for offset mitigation for long-tailed bats without proven adverse effects.

57 Although additional funding garnered for conservation by offset mitigation may be attractive, I believe offset-mitigation should only be resorted to if bat fatalities occur and avoidance, remediation and direct mitigation either fail or are prohibitively expensive.

58 To provide probity, I believe that if there is resident bat population in the HMR project area and it is adversely affected any offset mitigation packages should target the HMR bat population. If this is not practicable (e.g. because the magnitude of the adverse impact by the wind-farm exceeds the achievable improvements from offset mitigation), then offset mitigation should target a nearby population of long-tailed bats.

59 The Offset Mitigation for Ecological Effects outlined in the Suggested District Council Conditions presented by Mr. Daysh (6.17 Exhibits SGD1 & SGD2) does not incorporate offset mitigation specifically for adverse impacts on long-tailed bats. I presume this is because applicant's experts believe that either there will be no adverse impact to bats (because bats aren't present or if present they won't collide with wind turbines), or that pest control and general habitat enhancement such as fencing, re-vegetation with native species, will compensate for any adverse effects on long-tailed bats.

60 I believe that there is sufficient information to presume a credible risk that long-tailed bat populations resident in the project area will suffer adverse effects as a result of both reductions in the number of available roosts sites and wind-turbine strike fatalities.

61 I also believe that long-tailed bat populations will derive few, if any benefits, from habitat enhancement and pest control (as proposed by Mr Kessels and Mr Tonks) unless it targets their roosting areas. Locating roosting areas in order to target habitat management would entail a major project to capture, radiotag and radiotrack a representative sample of bats (i.e. *c.*10 per month) over a period of at least 12 months.

APPLICANTS PROPOSAL FOR POST-CONSTRUCTION COLLISION MONITORING

62 I consider that the proposal for a Resident Bird Bat Collision Mortality Monitoring Programme in the Suggested District Council Conditions (Daysh, Exhibits SGD1 & SGD2, Section 6.17) is excellent. However the proposed monitoring targets birds and not bats and I suggest that the programme's effectiveness for monitoring bat fatalities would be improved by:

- scheduling carcass searches throughout the summer, early autumn period (December to March) when long-tailed bat activity is highest.[
- using trained dogs to increase carcass search efficiency. Because long-tailed bats are small (half the size of a mouse) and cryptically coloured visual searching for their carcasses may be ineffective. In searcher efficiency trials at American wind farms, trained carcass recovery dogs increased carcass discovery rates from 42% and 14% for human-only teams to 71% and 81% respectively (Arnett 2006).

APPLICANTS PROPOSAL FOR AN ECOLOGY PEER REVIEW PANEL

63 I endorse the proposed initiative to establish a panel of ecologists with the relevant expertise to provide the consenting authorities with independent assistance and advice on managing the wind project's ecological impacts. If long-tailed bats are present in the project area, it is important that expertise in bat ecology is included among the panel members.

MITIGATION BY CURTAILING WIND GENERATION DURING PERIODS WITH HIGH BAT FATALITY LEVELS

64 Studies of bat fatalities at American wind-farms show most fatalities occurred at low wind speeds < 6 m/sec (Arnett et al. 2008). Under these conditions rotor blades are moving, but little electricity is generated. It has been proposed that stopping turbine operation during these low-wind speed periods could reduce bat fatalities substantially without major reductions in electricity generation (Kunz et al. 2007b; Kunz et al. 2007a; Arnett et al. 2008). The same authors suggest further reductions in bat fatalities could be achieved by identifying periods when insect concentrations and hence bat concentrations at wind generators are highest and stopping wind generation during these periods. Studies indicate high concentrations of insects and bats can be predicted reliably from seasonal and weather patterns.

MODIFICATIONS TO THE APPLICANTS SUGGESTED DISTRICT COUNCIL CONDITIONS

65 On the basis of my knowledge of long-tailed bats, I recommend the following general modifications to the mitigation measures being suggested with respect to the Suggested District Council Conditions provided by Daysh in Exhibits SGD1 & SGD2:

a) Ecology Management Plans

66 I recommend the words "long-tailed bats" are deleted from section 6.7 e. It is neither desirable, nor practicable to relocate bats for the reasons given above.

67 The phrase "and bat strike" can be deleted from section 6.7 f. Evidence indicates red flashing lights do not influence bat strike risk, therefore shielding the lights will not have any influence.

b) Additional Pre-Construction Background Population Surveys

68 Section 6.8 b, on pre-construction background population surveys for long-tailed bats should be dropped from the conditions and replaced by widespread pre-construction bat surveys and avoidance and mitigation of the adverse effects of roost tree removal below.

c) Resident bird and bat collision mortality monitoring programme

69 The monitoring period included in sections 6.9 a) i, ii, and iii should reflect the bats seasonal activity pattern and the most likely period for turbine related bat fatalities (January to March inclusive). Thus monitoring should be undertaken in "the months of January, February, March, August and November" not just "January, August and November".

70 The concept of having a "collision carcass retrieval team" in sections 6.9 a) i and ii should include the use of trained carcass recovery dogs.

71 The Bird and Bat Collision Mortality Monitoring Plan should clearly include searches for bat carcasses. In particular, section 6.9 a) iv, the words "Bird carcasses" should be replace with "Bird and bat carcasses".

d) Offset Mitigation for Ecological Effects

72 Condition 6.17 deals with offset mitigation for ecological effects. At this stage, I consider it should be recognised that the plan should include any offset mitigation that is required to address the "Effects on any resident bat populations."

ADDITIONAL SUGGESTIONS FOR DISTRICT COUNCIL CONDITIONS

73 I suggest the following additional concepts that could form the basis upon which conditions are imposed.

A Staged bat risk-assessment programme

Stage 1: Pre-construction Widespread Acoustic Bat Surveys

74 Prior to construction there should be widespread surveys for bats throughout the entire project area. Surveys should:
- be undertaken by qualified personnel experienced with bat surveys;
- be undertaken using recording bat detectors;
- encompass all known bat habitats types; and
- be sufficient to provide reasonable certainty about the presence and distribution of bats in the study area.

75 The detailed explanation behind this suggestion is as follows:

a. To achieve adequate sample sizes and coverage, a survey programme to provide reliable information on long-tailed bats presence in the 400 km^2 HMR project area would require at least 20 recording bat detectors deployed for the entire 4 month summer and early autumn period (i.e. December to March inclusive).

b. The target for each bat detector deployment should be successful monitoring on 3 fine nights. Detectors should be relocated between each deployment to sample bat activity in a wide range of habitat types throughout the entire project area.

c. Habitat types sampled should include rivers, riparian vegetation (both indigenous and exotic), roads through and edges around indigenous forests and exotic plantation forests, limestone outcrops, caves, scrubland, permanent lights such as street lights and motel illumination, parkland with large trees, indigenous and exotic large trees and shelter belts. All of these habitat types are used by long-tailed bats.

d. Because long-tailed bats often fly >35 m above ground level a proportion of deployment should be placed high above the ground to monitor this layer (e.g. at the top of cliff and steep hill sides, in tall trees and on structures such as weather masts). The quality of distribution information would be increased by employing an adaptive sampling strategy in which more intensive sampling is undertaken in areas where any bat activity is recorded.

e. The recommended schedule would achieve approximately 6000 hours of monitoring at more than 240 sites within project area.

76 It is my expert opinion that if the above provisions for further monitoring were adequately carried out, then this would be sufficient to provide robust and reliable information on the presence and distribution of bats in the project area.

Stage 2: Pre-Construction Bat Population Monitoring Programme

77 If the results from Stage 1 confirm that bats are resident within the project area, a population monitoring programme should be undertaken. The programme should be designed and undertaken by qualified and experienced bat researchers with the objectives of identifying commuting routes, foraging areas and roosting areas used by resident bat populations.

78 The programme would entail capture and radio-tagging monthly samples of bats throughout a full year and radio-tracking them to locate both daytime roosts and night time activity areas. Population sizes can be estimated by a combination of mark-recapture (using either passive insertable microchip tags or forearm bands) and video surveillance of roost departures.

79 Results from this Stage 2 Bat Population Monitoring Programme can be used to inform decisions about turbine location to avoid bat fatalities arising from turbine strike. They also provide baseline data for assessing effects of wind-farm construction on resident bat populations.

Stage 3: Post-Construction Bat Population Monitoring Programme

80 If the work undertaken for the Stage 2 pre-construction Bat Population Monitoring Programme is extended into the construction and post-construction period it should be possible to measure any effects of wind-farm construction and operation have on resident bat populations.

Stage 4: Research to develop methods to avoid and mitigate bat fatalities at wind-turbines

81 If bat fatalities levels detected at wind-turbines during post-construction monitoring are sufficiently high to support a reasonable expectation of significant adverse impacts on any resident bat populations, the Bat Collision Mortality Monitoring Programme should be extended into research project on bats behaviour around wind-turbines with the aim of developing effective methods to avoid or directly mitigate bat fatalities.

82 The detailed explanation behind this suggestion is as follows:

a. The proposed collision monitoring programme is essentially a carcass retrieval programme to monitor for bat and bird fatalities around the turbines. Although it might provide information on spatial and temporal patterns in the fatalities, it is unlikely to provide insights into why fatalities occur and how they could be avoided.

b. If significant bat fatality levels are observed, I believe carcass retrieval should be augmented by studies of bat behaviour around wind-turbines with the objective of developing strategies to avoid or mitigate bat fatalities. These studies can only be undertaken once operating wind turbines are in place as overseas research shows bats are attracted to wind turbines.

c. With this objective in mind, bat activity in and around the blade sweep zones of a representative sample of the wind turbines could be studied visually, using a combination of low-light video monitoring with supplementary infra-red light source, and acoustically, by ultrasound monitoring with bat detectors deployed at different levels above the ground including within the height of the blade sweep zone.

d. With correct placement and configuration, the marine radar units currently being used to investigate migratory shorebirds flight paths in the HMR project area (Kessels, Exhibit GK13) could also provide information on bats behaviour around wind turbines (Kunz et al. 2007b). Although it is generally not possible to distinguish birds from bats with marine radar alone (Kunz et al. 2007b) simultaneous use of the visual or acoustic monitoring methods suggested above would allow discrimination between bats and nocturnal birds. (Kunz et al. 2007b; Kunz et al. 2007a; Arnett et al. 2008) provide: guidance on the development of robust monitoring programme for bat fatalities at wind-turbine, commentaries on the technical details of method and suggestions for further investigation into causes of fatalities and mitigation methods.

Avoidance and mitigation of the adverse effects of roost tree removal

83 If there is a resident long-tailed bat population in the project area, any large tree (i.e. greater than 80 cm diameter at breast height) should be assumed to be a potential roost tree. This includes both exotic and indigenous tree species. Roost cavities cannot usually be identified by visual inspection. Therefore:

- To avoid deaths of hibernating bats large trees should not be removed during the bats hibernal period (May to September).
- When a large tree is to be removed, overnight bat activity levels around it should be monitored with recording bat detectors immediately before the planned removal. If activity levels indicate the trees is an occupied bat roost removal should be

postponed a few days until bat activity monitoring indicates the roost has been abandoned.

- Reduction in available roosts consequent on removal of large trees should be directly compensated for by provision of suitable artificial bat roosting boxes.

84 The detailed explanation behind this suggestion is as follows:

a. Although some bat roosts may be located during the Stage 2 Bat Population Monitoring Programme, this is likely to be only be a small proportion of roosts used by long-tailed bats. They use many roosts throughout a year, typically moving between day-time roosts every few days. Thus a bat population may use hundreds of roost cavities in a year and roosts availability may be a limiting factor in the HMR's modified landscapes.

b. During their hibernal period (May to September), long-tailed bats use extended periods of torpor lasting several days. It is difficult to identify roost trees containing hibernating bats as there can be many days, or weeks, without detectable bat activity around the tree. Torpid bats are vulnerable as it takes them 20 to 30 minutes to go from unresponsive torpor to an active state. Therefore, during the bat's hibernal period, large trees likely to be roost sites should not be felled.

c. During their non-hibernal period (October to April), bat fatalities associated with felling active roosts can be avoided by using overnight monitoring of large trees (>80 cm) with recording bat detectors to detect occupied roost trees before felling and then delaying felling them until they are abandoned. This would only incur a delay of a few days.

d. Reduction in available roosts due to felling of large trees can be directly compensated for by provision of roosting boxes. This is an established conservation management technique for tree roosting bats overseas. It has been used with some success for the long-tailed bat population in south Canterbury where roost boxes have been used to compensate for scarcity of suitable roost sites in a pastoral landscape with few large trees.

Offset mitigation for adverse effects on long-tailed bats

85 Offset mitigation for adverse effects of wind-turbine could then only be considered if long-tailed bat fatalities occur and avoidance, remediation and direct mitigation on site either all fail or are prohibitively expensive. Offset mitigation packages could entail habitat enhancement and pest control in the roost areas of a nearby population of long-tailed bats.

CONCLUSIONS

86 In conclusion, I note that:

- To date, surveys for bats undertaken within the HMR project are inadequate and provide little robust and reliable information on long-tailed bat presence within the area.

- Long-tailed bats have been observed in the project area recently and I believe it is likely for this reason, and the others cited above that they are resident there.

- Mr Kessels' evidence on risks to bats, the Assessment of Environmental Effects report (Kessels et al. 2008) and bat survey designs all appear to be based on the premise that any long-tailed bats in the project area would be restricted to indigenous habitat. This is incorrect: long-tailed bats forage over many of the modified habitat types found throughout the project area, and frequently roost in exotic trees.

- A wind-turbine collision risk profile for long-tailed, compiled from the best available information on the species together with overseas information on bat fatalities at wind-turbines, indicates that long-tailed bats are likely to be at risk of wind-turbine strike. Overseas experience is that large numbers of bats are killed in wind farms as a result of turbine blade strike. Bats will also be at risk from the loss of roost trees through felling large trees within the project area

- I endorse the proposals in the Suggested District Council Conditions to establish an Ecology Peer Review Panel and a Resident Bird Bat Collision Mortality Monitoring Programme (with some general modifications specified above).

- In the absence of information on long-tailed bat activity levels in the HMR project area and their behaviour around wind-turbines, it is impossible to reliably quantify the risk posed to bats by the HMR wind farm. Neither is it possible to determine whether adverse impacts can be avoided, remedied or mitigated To remedy this there should be a staged program of bat work in the project area:

  - Stage 1: Pre-construction Widespread Acoustic Surveys for bats throughout the entire project area prior to construction.

  - Stage 2: Pre-construction Bat Population Monitoring Programme undertaken to identify areas of high bat activity where turbines should not be sited to avoid bat fatalities by turbine strike and to establish baseline data.

  - Stage 3: Post-construction Bat Population Monitoring Programme to assess the effects of wind-farm construction and operation.

- Stage 4: Research to develop effective methods to avoid and mitigate bat fatalities at operational wind-turbines.

- If long-tailed bats are resident in the project area all large trees should be considered potential roost sites their removal should be undertaken in a manner that doesn't endanger roosting bats. The removal of potential roosts should be compensated for by placement of artificial bat roost boxes.

- Any offsite offset mitigation for adverse effects of wind-turbine on long-tailed bats should be a last resort and should be carefully targeted to ensure benefits to local long-tailed bat populations.

Dr. Brian Donald Lloyd
March 2009

List of References

Ahlén I 2003. Wind turbines and bats: a pilot study [in Swedish].

Arnett EB 2006. A preliminary evaluation of the use of dogs to recover bat fatalities at wind energy facilities. Wildlife Society Bulletin 34(5): 1440-1445.

Arnett EB, Brown WK, Erickson WP, Fiedler J, Hamilton BL, Henry TH, Jain A, Johnson GD, Kerns J, Koford RR and others 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72(1): 61-78.

Baerwald EF, D'Amours GH, Klug RJ, Barclay RMR 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18(16): R695-R696.

Borkin K 1999. Long-tailed bat distribution in the Waikato Conservancy. A report made in partial fulfilment of the Diploma of Wildlife Management and in association with the Waikato Conservancy of the Dept of Conservation. Unpublished thesis.

Daniel MJ 1981. First record of a colony of long-tailed bats in a *Pinus radiata* forest. New Zealand Journal of Forestry 26: 108-111.

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

Dekrout A, Reynolds 2008. Long-tailed Bat Survey Report for WEL Networks Ltd. Te Uku Wind Park.

Griffiths RW 1996. Aspects of the ecology of a long-tailed bat, *Chalinolobus tuberculatus* (Gray, 1843), population in a highly fragmented habitat. Unpublished thesis, Lincoln University, Lincoln, New Zealand.

Griffiths RW 2007. Activity patterns of long-tailed bats (*Chalinolobus tuberculatus*) in a rural landscape, South Canterbury, New Zealand. New Zealand Journal of Zoology 34(3): 247-258.

Guilbert JM, Walker MM, Greif S, Parsons S 2007. Evidence of homing following translocation of long-tailed bats (*Chalinolobus tuberculatus*) at Grand Canyon Cave, New Zealand. New Zealand Journal of Zoology 34(3): 239-246.

Hitchmough R, Bull L, Cromarty P 2007. New Zealand threat classification system lists 2005.

Horn J, Arnett EB, Kunz TH 2008. Interactions of bats with wind turbines based on thermal infrared imaging. Journal of Wildlife Management 72: 123-132.

Kerns J, Kerlinger P 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia.

Kerns J, Erickson WP, Arnett EB 2005. Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia. In: Arnett EB ed. Relationships between bats and wind turbines in Pennsylvania and West Virginia. Final Report, Bats and Wind Energy Cooperative. Pp. 24-95.

Kessels GHA, Deichmann B, Stirnemann R 2008. Hauauru ma raki - Waikato Wind Farm - Contact Wind Ltd - Assessment of ecological effects. 185p p.

Kunz TH, Arnett EB, Erickson WP, Hoar AR, Johnson GD, Larkin RP, Strickland MD, Thresher RW, Tuttle MD 2007a. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5: 315-324.

Kunz TH, Arnett EB, Cooper BM, Erickson WP, Larkin RP, Johnson GD, Mabee T, Morrison ML, Strickland MD, Szewczak JM 2007b. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. Journal of Wildlife Management 71(8): 2449-2486.

Lloyd B 2005. Bats: superfamily Noctilionoidea. In: King C ed. The handbook of New Zealand mammals. 2nd ed. South Melbourne, Oxford University Press. Pp. 110-130.

Moore GE 2001. Use of Kinleith Forest by Native New Zealand Bats and Effects of Forestry. Unpublished thesis, Massey University, Palmerston North.

O'Donnell CFJ 2001. Home range and use of space by *Chalinolobus tuberculatus*, a temperate rainforest bat from New Zealand. Journal of Zoology (London) 253(2): 253-264.

O'Donnell CFJ 2002a. Variability in numbers of long-tailed bats (*Chalinolobus tuberculatus*) roosting in Grand Canyon Cave, New Zealand: Implications for monitoring population trends. New Zealand Journal of Zoology 29(4): 273-284.

O'Donnell CFJ 2002b. Timing of breeding, productivity and survival of long-tailed bats *Chalinolobus tuberculatus* (Chiroptera: Vespertilionidae) in cold-temperate rainforest in New Zealand. Journal of Zoology (London) 257(3): 311-323.

O'Donnell C 2005. New Zealand long-tailed bat. In: King C ed. The handbook of New Zealand mammals. 2nd ed. South Melbourne, Oxford University Press. Pp. 95-109.

Piorkowski M 2006. Breeding bird habitat use and turbine collisions of birds and bats located at a wind farm in Oklahoma mixed-grass prairie. Unpublished thesis, Oklahoma State University, Stillwater, OK.

Pryde MA, O'Donnell CFJ, Barker RJ 2005. Factors influencing survival and long-term population viability of New Zealand long-tailed bats (*Chalinolobus tuberculatus*): Implications for conservation. Biological Conservation 126(2): 175-185.

Pryde MA, Lettink M, O'Donnell CFJ 2006. Survivorship in two populations of long-tailed bats (*Chalinolobus tuberculatus*) in New Zealand. New Zealand Journal of Zoology 33(2): 85-95.

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

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

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