BATS IN NEW ZEALAND PLANTATIONS: FOREST MANAGEMENT GUIDANCE

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1. INTRODUCTION

These forest management guidelines have been developed so that forest owners, forestry companies, managers, and operators can consider, plan, and put in place forest management approaches to manage plantation forests so that New Zealand bat species may remain in them in perpetuity.

New Zealand bat species are unique, occurring nowhere else in the world. Bats are killed by rats, cats, stoats, and possums, and populations are declining in areas where these predators are not controlled. Research has shown that, in the absence of predator control, populations may become extinct within 50 years[1,2]. In the recent past New Zealand had three bat species: the long-tailed bat, the greater short-tailed bat, and the lesser short-tailed bat. The greater short-tailed bat is probably extinct because rats were accidentally introduced to their final island refuge.

Both bat species are small and similar in size to a mouse. They fly at night and rest during the day in roosts. Roosts can be found in a variety of places, including trees, tree ferns, rock crevices, caves, and even occasionally in buildings!

Bats echolocate to navigate at night and find their food, sending out sound waves from their mouths and noses which hit objects and bounce back/echo. Bats form a "map" of their surroundings using these echoes. They are not blind, despite the saying "as blind as a bat"!

Bats use 'torpor' - a short-term reduced metabolic state - to save energy when conditions are not ideal for searching for food. Hibernation is a long period of torpor.

In the past it was thought that bats needed large areas of indigenous forest to survive but surveys and research have shown that they live in and use exotic plantation forest year-round[3]. Exotic plantation forests have been shown to have higher rates of long-tailed bat activity than pasture environments and young regenerating indigenous reserves that were nearby[3]. Both the long-tailed bat and the lesser short-tailed bat have been found roosting in plantation forests, within production stands. Both long-tailed bats and lesser short-tailed bats also roost in adjacent indigenous forest remnants and may use adjacent pine forest for foraging habitat[4,5]. The use of plantation forest by bats means that bats are able to persist over far larger areas, and in greater numbers, than they would otherwise. Alongside the benefits to bats of using exotic plantation forest, however, come risks and responsibilities, as they are absolutely protected under the Wildlife Act (1953). Bats may be injured, killed, or displaced from their roosts during tree felling.

These guidelines have been developed to help forest managers and operators to improve and/or maintain the forests they own, manage, and work in, for New Zealand bats. To begin, the two bat species are briefly described, along with where they are most likely to be found within plantations. Options for management are then described. A combination of these options may be used to protect or support bats, subject to the size of your forest, the region it is in, surrounding habitat, and the species likely to be present.

2. NEW ZEALAND BAT SPECIES

Long-tailed bat (*Chalinolobus tuberculatus*)

- Under threat of extinction: ranked as Threatened-Nationally Critical by Department of Conservation in 2017[6].
- Long-tailed bats have been recorded in exotic plantation forests throughout their range: the North Island, Nelson-Marlborough, West Coast, Geraldine, Otago, Southland.
- 8-10 grams, which is smaller than a mouse.
- Roost by day in cavities, splits, and under peeling (exfoliating) bark of indigenous and exotic trees, large hollow tree stumps, within hollow tree ferns, and in caves or fractures and joints in rocky bluffs.
- Research in Kinleith Forest confirmed that long-tailed bats roost in radiata pine trees (*Pinus radiata*) as young as 23 years old, and in *Eucalyptus* species as young as 16 years old[7]. In the pine stands, bats in Kinleith were typically roosting under the bark of dead pine spars, in tree cavities, between the two trunks of double leaders, and on occasions in tree ferns in the understorey. Within *Eucalyptus* bats were found roosting under flaky or peeling bark.
- Often use forest roads or streams for feeding access, and also use skid sites[8].

Lesser short-tailed bat (*Mystacina tuberculata;* known as the short-tailed bat)

- Three sub-species: Northern, Central, and Southern.
- Risk of extinction varies regionally. In 2017, the Northern species is ranked as Threatened-Nationally Vulnerable; Central are At Risk-Declining; and Southern are At Risk-Recovering[6]. All populations rely on predator management to persist.
- Have been recorded using plantations in the central North Island, although they have been less well studied in plantations than long-tailed bats and therefore it is possible that they also utilise plantations elsewhere in their range. Short-tailed bats generally roost in mature indigenous forest but may travel through adjacent pine forest to reach food sources[9]. Where they have been recorded in pine forests this has generally been in locations where forests are adjacent to indigenous forest[4].
- 10-14 grams, which is slightly smaller than a mouse.
- Roost by day in cavities, splits, and under peeling (exfoliating) bark of trees, large hollow tree stumps, within hollow tree ferns, and in caves.
- Found roosting in old indigenous stumps in exotic plantation stands[4]. As they have been less studied than long-tailed bats in plantation forest, it is unknown how frequently short-tailed bats use roosts in plantation forests.
- Short-tailed bats are unusual as they can fold up their wings and use them like legs, to scramble around the forest floor and tree canopy.

Bat home ranges (the area that a bat uses each night) can be enormous relative to the size of the bat. For example, in plantation forest near Tokoroa, long-tailed bats use

areas as wide as 16 kilometres, and as large as 1,800 hectares, and use multiple roosts spread over smaller areas[3]. In plantation forest, they usually change roosts every 2.5 days, on average[3]. Roosts are generally in the oldest stands in plantation forest[3].

Both bat species feed at night on flying invertebrates (insects). The short-tailed bat also eats pollen, nectar, and ground-based invertebrates[10]. They are a pollinator of Te Pua o Te Reinga (wae wae atua; wood rose; *Dactylanthus taylorii*)[11], a parasitic flowering plant that is in serious decline and currently classified as Threatened-Nationally Vulnerable[12].

Bats can begin breeding at one year old[13]. The oldest known New Zealand bat is a female long-tailed bat from Fiordland that was at least 24 years old when last captured[14].

Threats to bats in plantation forests include:

- Felling of roosts.
- Predation by rats, cats, stoats, and possums.
- Habitat loss through land conversion.
- Some toxins[15].
- Collisions with vehicles[16].

3. BAT SURVEYS

Forest managers can either rely on casual sightings of bats within their forests to confirm their presence or use automated bat monitoring units (ABMs) to record echolocation calls. The most commonly used ABMs in New Zealand are made by the Department of Conservation and are available for purchase. Data created by ABMs can be reviewed by your staff or consultants using a computer package that is provided with the ABMs.

Surveys are more likely to detect bats in summer when temperatures are warmer, humidity is higher, and rainfall is low[17]. Surveys should take place over long periods, whenever possible. ABMs should be used for at least three fine nights[8], but preferably six or more fine nights[18].

Long-tailed bats and lesser short-tailed bats use habitats in different ways so slightly different strategies are required to maximise chances of detection. To maximise the chance of detecting long-tailed bats, place ABMs along edges such as tracks or roads through forest, stand edges, edges of skid sites, and stream edges[8,18]. For short-tailed bats, place ABMs, within older forest or indigenous remnants[18], on terraces, or saddles between catchments.

When undertaking surveys, the following should be recorded:

- Location (description and GPS coordinates), e.g. Johnstone Road, K Forest, Easting and Northing.
- Habitat type, e.g. *Pinus radiata* 25 years old.

- Surveyor, e.g. K. Borkin.
- Date and time survey started and finished, e.g. survey started 25 October 2017, finished morning of 30 October 2017. Recording started at 2100, finished at 0600 hrs.
- Weather conditions, including temperature range and rainfall.
- Species recorded.

Once you know that bats are using your forest you can select from a range of management options that are designed to support continued bat use. Not all of these options may be suitable for your forest.

You may consider entering a summary of your results in NatureWatch NZ http://naturewatch.org.nz which is a species distribution database into which members of the public can enter species' records. Adding to the database may help increase understanding of bat distribution in New Zealand. There is the option of ensuring that exact locations are not able to be obtained by other users, i.e. by obscuring locations.

4. WHAT WE KNOW ABOUT BATS IN PLANTATIONS

Most of the research into bats use of plantation forest has taken place in Kinleith Forest, a central North Island plantation, and has focussed on long-tailed bats. Some research into lesser short-tailed bats in the Pureora area found that they travelled through plantations to gain access to preferred food sources, such as *Dactylanthus* (the wood rose).

- **Long-tailed bat activity in exotic plantation stands is high relative to indigenous regenerating areas and pasture [3]**

- **Long-tailed bat activity levels increase with stand age [3]**

- **Bats roost within production stands [7]**

  Long-tailed bats roost mainly under peeling bark of long-dead *Pinus radiata* spars within 23-32 year old stands. Long-tailed bats also roost under the bark of production *Eucalyptus fastigata* and *E. regnans*, and within the hollow trunks of dead mamaku (*Cyathea medullaris*; black tree fern). Bats also use roosts within cavities, although these are much rarer. Short-tailed bats have been found roosting in long-dead indigenous spars within a plantation stand[5]. Roosts are probably in low numbers compared to roost numbers within indigenous forest[3].

- **Female and male long-tailed bats use roosts in slightly different locations**

  Female and male long-tailed bats use different roosts in different locations. Specifically, female bats use roosts that are closer to waterways and warm earlier during the day than do male bat roosts[7].

- **Roosts may be destroyed in clearfell harvest operations [19].**

- **Bats use roosts spread over large areas (median roost range span of lactating females 4.4 km [3]).**

- **Long-tailed bats fly along linear features such as edges of stands, skid sites, hillsides and stream edges [8,3].**

- **Long-tailed bat home ranges are smaller after harvest operations [20].**

5. 'BAT-FRIENDLY' FOREST MANAGEMENT

Long-tailed bats form female-dominated colonies, particularly whilst they are caring for young that are unable to fly[21]. Focusing management efforts on protecting, or providing for, these colonies will protect most bats and those that are most important for conservation of bat populations[22].

Long-tailed bats are most vulnerable to injury or death during the harvesting of their roosts when females are heavily pregnant, before juveniles can fly, or whilst juveniles are learning to fly[5], or when in torpor or inactive, which occurs more often in winter or on cold days.

Bats are least likely to escape if their roosts are felled between November and February when they are heavily pregnant, or when young are unable to fly, or during winter (when in torpor).

Female colonies during summer are usually within 150 metres of a waterway[3]. Harvesting of stands that contain waterways outside the "reproductively-vulnerable" period will protect most bats. This option for management is unlikely to be viable for most plantations due to conflicting requirements around harvest periods. It is suggested here as an option when removal of trees is necessary due to other reasons, such as health and safety risks, or when there is flexibility in the timing of harvest.

Management to protect bats could be focused within 150 metres of waterways, to maximise potential benefits to bats, if costs mean that management cannot be applied across entire plantations.

Based on what is known about the ecology of long-tailed bats within Kinleith Forest[3], and their biodiversity management requirements, management options fall within three main types:

- Increase roost numbers.
- Increase bat survival.
- Improve bat use of plantation landscapes.

These management options are addressed further below:

Increase Roost Numbers

In a well-managed plantation, it is likely that numbers of potential roost trees are rare because malformed or damaged trees are often removed during thinning operations.

- Protect potential roosts, when safe to do so, at harvest or when thinning, by retaining those with cavities or a broken crown, as well as tree ferns. Protection of potential roosts during harvest operations will help to safeguard individual bats from injury. It should be noted that the protection of potential roosts at harvest will increase both the costs of harvesting, because of increased duration of operations[23], and risks to workers because unstable dead spars are retained that may fall and injure them[24]. Consequently, this may only be an option in special circumstances.

- Create potential roosts by:

    i. Top trees[25] so that dead spars with peeling bark are available. This may not be practicable within production stands due to risks to staff but may be an option when management of "nuisance" trees in reserves or riparian area is necessary;

    ii. Poison, rather than fell, unwanted trees in reserves and riparian areas, e.g. wilding pines, large willows. Poisoning of trees will mean that the trees die and provide potential roost trees for bats.

    iii. Retain old wilding pines and other large exotic trees if their removal is not required for safety or ecological reasons on the basis they provide potential alternative roosting sites after harvest.

- Provide artificial roost boxes, especially within 150 metres of waterways or in areas that will not be harvested. Note that roost boxes may not be used frequently for some years[14] because bats need to find them. The design of roost boxes needs to be carefully considered and based on bats' needs.

- Extend streamside non-harvest areas. Riparian areas provide a good opportunity for promoting the regeneration of indigenous tree species, which may provide roosts long-term. Avoiding spraying of these areas may promote faster regeneration, depending on the species already present.

- Plant long-lived tree species in non-harvest areas, thereby creating long-term roosts.

Increase Bat Survival

- Ideally, undertake simultaneous control of all introduced species that prey on bats, including brush-tailed possums (*Trichosurus vulpecula*), cats (*Felis catus*), rats (*Rattus* spp.), and stoats (*Mustela erminea*)[26,1]. If control is focused on only one species (e.g. possums), other predators, such as rats, can increase in numbers, with associated detrimental effects[27]. Plan pest control, if possible, so that predators are present in low numbers whilst the female-dominated bat colonies still contain dependent young. This will reduce predation when bats are least able to escape[5].

Long-tailed bats are considered to be at minimal risk of secondary poisoning from pest control poison operations, although this has not been tested[28]. This is because long-tailed bats mainly feed on flying invertebrates (insects) and therefore rarely come into contact with toxins. Short-tailed bats are considered to be at risk of poisoning in predator control operations, and have been found dead after cyanide operations[29] and ground-based Diphacinone operations[30]. Deaths may be due to direct consumption of bait, or secondary poisoning after consumption of prey[30]. In the case of cyanide, given that the single dead bat was found on a cyanide bait line[29], direct consumption was the most likely cause. Short-tailed bats are more likely to be at risk during poison operations than long-tailed bats because they feed on ground-dwelling invertebrates. It should be noted that research has shown that survival of short-tailed bats is high throughout Pindone operations[31] and aerial 1080 operations[32].

- Plan to harvest stands within 150 metres of waterways outside of the reproductively-vulnerable period for bats, i.e. not during the period November-February. As mentioned previously, this is probably not an option for most plantations, but may be an option when trees are to be felled for other reasons.

- Protect potential roosts at harvest time, when safe to do so.

- Maintain a mosaic of different age classes of trees, when possible. Bats generally roost within the oldest stands available in plantations[3].

- Take into account the home range extent of bats when planning harvest operations. Ensuring that alternate areas suitable for roosting are within the median range span of lactating female bats (4.4 kilometres in Kinleith Forest[3]) will aid their survival and reproductive success by reducing the energy costs associated with searching for new roosts when bats are caring for dependent young[33]. Alternative roosting areas can also include mature indigenous forest. Where the plantation forest occurs next to large tracts of mature indigenous forest it is likely they will have many alternative roost sites within the indigenous forest.

- Avoid felling areas of mature indigenous vegetation. Bats are likely to choose roosts in mature indigenous forest areas because trees in these areas are large, and could be well-insulated, making them valuable as potential roosts. If construction of forest roads and other infrastructure are necessary then consider felling production trees and constructing roads within stands in preference to within mature indigenous forest.

<u>Improve Bat Use of Plantation Forest Landscapes</u>

- Maintain a mosaic of different age classes of forest trees.

- Maintain linear landscape features, such as lines of trees across harvested or unplanted areas.

- Retain trees suitable as roosts.

- Maintain low predator abundance.

- Protect potential roosts at harvest, when safe to do so.

- Support research into bat ecology and management, so that future conservation efforts can continue to be focused and effective.

It should be remembered that the use of plantation forests by bats greatly extends the habitat available and the area over which bats are now present in New Zealand.

Other Relevant Research

Recent research by Wildlands has shown that long-tailed bat activity is lower alongside busy roads than roads with lower overnight traffic volumes[22], and activity is not affected in the same way away from roads. Why this happens is unknown, but could reflect behavioural differences, numbers of bats present, or other unknown reasons. Ensuring that large areas of plantation and other forests remain un-bisected by busy roads will help to support bat populations.

6. PLANTING OUTSIDE PRODUCTION STANDS

Planting could include indigenous or exotic species known to be used as roosts. Ideally, plantings will include a mix of species that are fast-growing (e.g. cabbage tree, kānuka, houhere), to provide habitat in the short-term (e.g. 10-100 years), and species that are slower growing (e.g. tōtara, rimu, kahikatea), that will provide roosts in the longer term (e.g. 80-800 years plus). All plantings should maximise establishment success by selecting species that occur naturally close to the planting site. Potentially suitable species are set out below:

- In the northern North Island (approximately north of a line from Kawhia to Thames, excluding the Hamilton Basin), these could include cabbage tree[*] (*Cordyline australis*), ribbonwood[*] (manatu; *Plagianthus regius*), kānuka[*] (*Kunzea* species[†]), kauri (*Agathis australis*), taraire (*Beilschmiedia tarairi*), tawa (*Beilschmiedia tawa*), tōtara (*Podocarpus totara*), miro (*Prumnopitys ferruginea*), matai (*Prumnopitys taxifolia*), kahikatea (*Dacrycarpus dacrydioides*), rimu (*Dacrycarpus cupressinum*), pukatea (*Laurelia novae-zelandiae*), and mamaku (*Cyathea medullaris*).

- In central and southern North Island (excluding the central Volcanic Plateau, which is described below), and northwest South Island, these could include cabbage tree[*], hinau (*Elaeocarpus dentatus*), kānuka[*] (mainly *Kunzea robusta*[†]), tawa, ribbonwood[*] (manatu; *Plagianthus regius*), tōtara, miro, matai, kahikatea, rimu (*Dacrycarpus cupressinum*), red beech (*Fucospora fusca*), hard beech (*Fucospora truncata*), black beech (*Fucospora solandri*), pukatea, mamaku, and houhere[*] (*Hoheria sextylosa* throughout, and *Hoheria angustifolia* in low rainfall areas of east coast).

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[*] Fast-growing, include at least one of these in each planting for bat habitat.

[†] Mainly *Kunzea robusta* (including on well-drained loams), *Kunzea amathicola* on mobile sands on the west coast of the lower North Island, south of about Levin, and ensure that planting stock is eco-sourced from naturally-occurring populations in the same habitat type in the ecological district/region where the planting is being undertaken (refer to de Lange 2014 for natural extent of each *Kunzea* species).

- On the central Volcanic Plateau, subject to altitude, these could include cabbage tree*, hinau, kānuka* (*Kunzea serotina*), tōtara, miro, matai, kahikatea, rimu, mountain beech, and silver beech (*Lophozonia menziesii*).

- In the South Island, west of the divide, these could include: cabbage tree*, ribbonwood* (manatu; *Plagianthus regius*), hinau, tōtara, miro, matai, kahikatea, rimu, red beech, silver beech, hard beech, and mamaku.

- In the South Island, east of the divide, these could include cabbage tree*, ribbonwood* (manatu; *Plagianthus regius*), hinau, kānuka* (mainly *Kunzea robusta* in coastal areas, and mainly *Kunzea serotina** in montane/inland areas†), tōtara, miro, matai, kahikatea, rimu, mountain beech, black beech (*Fucospora solandri*), and narrow-leaved houhere (*Hoheria angustifolia*).

- Exotic species that are known to provide opportunities for bat roosting include macrocarpa (*Cupressus macrocarpa*), poplar (*Populus alba*), oak (*Quercus* spp.), and willow spp.[34,35,36,37,38,39,40]. Poplars and oak can be planted throughout New Zealand, if the appropriate species or cultivar for local conditions is selected. Regional Council pest plant species lists should be consulted when developing a planting plan. Some willow cultivars, which long-tailed bats are known to use as roosts, are classified as pest plants by some regional councils. Species used by bats in Kinleith Forest include mamaku, *Pinus radiata*, *Acacia melanoxylon*, *Liriodendron tulipifera*, and *Eucalyptus* spp., and these could also be planted. Species that form hollows and cavities in trunks will be especially useful as long-term roosts.

7. ADVOCACY AND COMMUNICATION STRATEGY: POSTER

A poster has been published with the following information:

- Images of long-tailed bats and short-tailed bats.
- Brief information about New Zealand bats.
- Types of roosts bats are known to use in plantation forest.
- What to do when bats are found.

It is intended that this poster will be distributed amongst forestry crews, supervisors, and environmental team members, so that the presence of bats in plantations is widely known and there is some guidance about what to do if staff and contractors come into contact with bats. The poster is available for downloading on the NZFOA website http://rarespecies.nzfoa.org.nz/resources/guidelines/

* Fast-growing, include at least one of these in each planting for bat habitat.

† To ensure the appropriate species of kānuka is used, refer to de Lange 2014 for distribution records, and use stock that is eco-sourced from natural populations within the same ecological district/region in which the planting is being undertaken, and on the same habitat type.

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