Memorandum

28 July 2022

To: Chris Buscall
        Snowy Hydro Limited
        chris.buscall@snowyhydro.com.au
From: Emma Matthews
Subject: Snowy 2.0 Main Works Fauna Strike Mitigation - Annual Mortality Monitoring Report 2021-2022

Dear Chris,

1 Background

Impacts to fauna as a result of vehicle strike was identified in the biodiversity assessment undertaken for the Snowy 2.0 Main Works project (EMM 2020) as an indirect or prescribed impact that could arise from the construction of the project. Mitigation measures were recommended, including reduced speed limits or underpasses and fencing.

In response to the potential for fauna strike to occur EMM Consulting Pty Ltd (EMM), in consultation with Snowy Hydro Ltd (Snowy Hydro) and Future Generation Joint Venture (FGJV), developed the Snowy 2.0 Main Works Fauna Strike Mitigation Strategy ('the Strategy') (FGJV 2020) which forms Appendix G of the Biodiversity Management Plan. The Strategy outlines an adaptive management approach to fauna strike, including:

• initial fauna strike management, primarily through speed management and driver training;

• installation of underpasses at six (6) locations along Ravine Road;

• a risk assessment framework, including:

  - a population viability assessment (PVA) to explore the level of fauna strike at which relative risk of extinction of the Smoky Mouse might be deemed unacceptable; and

  - mortality monitoring using detection dogs to provide reliable estimates of fauna strike across project roads, with data used to update the PVA.

This approach was designed to allow an informed, risk-based and adaptive management strategy to be implemented, ensuring that if mitigation is required it is targeted and effective.

Three listed species have been identified as having key habitat along access roads in the project area: Smoky Mouse (*Pseudomys fumeus*), Broad-toothed Rat (*Mastacomys fuscus*) and Eastern Pygmy Possum (*Cercartetus nanus*). The critically endangered Smoky Mouse is of particular concern, as this species is critically endangered in NSW, is nocturnal and occupies habitats that fringe two of the main access roads to the project.

This memo provides Snowy Hydro with a summary on the mortality monitoring, including the initial results of scavenger trials conducted in November 2020 and ongoing monthly monitoring to December 2021.

2 Method

2.1 Scavenger trials

Monitoring commenced in November 2020. During initial surveys, EMM and Snowy Hydro undertook the initial trial of the mortality monitoring using detection dogs and included scavenger and efficacy trials. The scavenger trials were undertaken to address a key concern from the NSW Biodiversity Conservation Division (BCD) and NSW National Parks and Wildlife Service (NPWS) around scavenging rates, particularly that high scavenging rates could render the monitoring ineffective. Efficacy trials were undertaken to test the effectiveness of the dogs at detecting small rodent carcasses in real-world project conditions.

During the trials, 60 Rat carcasses were laid out along Ravine Road at random intervals. Carcasses were laid out on or within 5 metres of the road surface, with some run-over by a light vehicle and others dragged to the road edge to replicate an animal being hit and seeking refuge. Carcasses were left visible on the road surface, on the side of the road in table drains covered with dust, hidden under rocks and boulders and hidden in vegetation to replicate real world conditions. The dogs and dog handlers were not present during placement of carcasses and trials were conducted blind.

Daily checks for the carcasses were undertaken over three days by an observer. If a carcass could not be located a detection dog was used to try and locate the carcass. This was done as monitoring indicated observers were extremely poor at relocating carcasses even when they had not been scavenged and were present.

2.2 Ongoing monitoring: January to December

Ongoing mortality monitoring consists of detection dog surveys conducted once per month with two rounds of survey per month:

- an initial survey to determine any mortality over the previous month and to essentially 'clear the road'; and

- a repeat survey conducted 3-5 days later to determine mortality over a shorter period.

The follow up survey is undertaken to provide a shorter, more finite period over which factors which can impact detection (such as scavenging) can be more reliably estimated.

During the surveys two dogs are used along with two dog handlers, with one dog per side of the road. Surveys are undertaken along the first 7 km of Ravine Road.

Small mammal fauna strike that could not be identified to species level was sent to the Centre for Conservation Ecology and Genomics (University of Canberra) for DNA testing and/or Scats About for hair identification.

2.3 Traffic Volume Data

Traffic counters were installed along Ravine Road and were in operation from 8 June 2021 to December 2021. Traffic data is collected to provide an indication of construction traffic volumes relative to fauna strike numbers, particularly night-time movements.

2.4 Population Viability Analysis

A Smoky Mouse population viability analysis (PVA) was prepared by The Analytical Edge Pty Ltd (The Analytical Edge 2022) and is provided in full in Appendix A.

The PVA was conducted using Vortex10 to determine Smoky Mouse population extinction risk due to increased night-time traffic. Extinction was defined as when only one sex remains. A sensitivity analysis was conducted to vary uncertain population parameters (mortality and population size) to look at the level of Smoky Mouse fauna strike that could occur before the extinction risk would become unacceptable. Two scenarios were tested, including a small population size (initial population size = 200, carry capacity = 500) and large population size (initial population size = 1000, carrying capacity = 1250).

Model simulations were summarised and the probability of extinction due to different levels of harvest (between 1 and 12 adult mice per year) was calculated. The population was assumed to be isolated, with simulations carried out over a 7-year period (max duration of the project) using a monthly timestep (to account for population trends).

3 Results

3.1 Initial surveys including scavenger trials

During the initial surveys, conducted one day after placement of carcasses, the detection dogs detected 59 out of 60 carcasses with an efficacy rate of 98.33%. One carcass, located approximately 40 m from the start of the surveys, was not detected. At this time both dogs showed high levels of excitement after being let out of the vehicle. In the follow up efficacy surveys, undertaken three days later, the detection dogs detected 54 out of the 54 remaining carcasses with an efficacy rate of 100%.

Scavenger trials, undertaken over three days, recorded six carcasses scavenged over the monitoring period with a scavenging rate of up to 10%.

The results of the scavenger and efficacy trials are provided in Table 3.1.

Table 3.1   Scavenging rates and detection dog efficacy

Site	Detection dog efficacy 28 Nov 2020	Scavenger surveys 29 November 2020	Scavenger surveys 30 November 2020	Detection dog surveys 1 December 2020
Scavenged	0 out of 60	2 out of 60	6 out of 60	6 out of 60
	0%	3%	10%	10%
Efficacy	59 out of 60	58 out of 58	54 out of 54	54 out of 54
	98.33%	100.00%	100.00%	100.00%

3.2 Ongoing monitoring: January 2021 to January 2022

Thirteen monthly surveys have been completed between November 2021 and January 2022 on Ravine Road.

Sixty-two animal mortalities have been recorded along Ravine Road during the monthly monitoring:

- Twenty-six reptiles, including:

    - three Copperhead Snakes;

    - two Highland Copperhead Snakes;

    - two unidentified Snakes;

- two *Lampropholis* sp. skinks;

- fourteen unidentified reptiles;

- two Common Blue-tongued skink; and

- one Eastern Three-lined Skink.

- Seven large mammals, including:

    - four Eastern Grey Kangaroos;

    - two unidentified macropod remnant; and

    - one unidentified large mammal remnant.

- Thirteen small mammals, including:

    - two unidentified rodents;

    - three unidentified animal remnant;

    - seven unidentified small mammals; and

    - one unidentified fur trace.

- Eleven frogs, including:

    - one Eastern Banjo Frog; and

    - ten unidentified Frogs.

- Five birds, including:

    - one Red-rumped Parrot;

    - one Nankeen Kestrel;

    - two Tawny Frogmouths; and

    - two unidentified Birds.

DNA samples of four unidentified small mammals, including the two unidentified rodent remains, the unidentified fur trace and one piece if animal trace, were submitted to the University of Canberra's Institute for Applied Ecology for analysis. No samples submitted for DNA analysis were a positive match for Smoky Mouse. Of the four samples submitted for DNA analysis, two samples could not be sequenced due to poor quality degraded DNA extracted from the sample. The remaining two samples shared less than 5% genotype call rate (SNP genetic similarity) to all Smoky Mouse samples in a reference data set. This means that either that DNA was poor quality which resulted in non-detectable relevant genetic information, or they were not from Smoky Mouse.

Three further pieces of hair and bone have been submitted for hair analysis. No samples submitted for DNA analysis were a positive match for Smoky Mouse.

There has been no reported or observed fauna strikes on threatened species. A summary of monitoring periods and results are provided in Table 3.2.

Table 3.2 Summary of monitoring events and recorded fauna strikes

Monitoring period	Survey dates	Recorded fauna strikes
November	Round 1 – 28/11/2020 Round 2 – 1/12/2020	• Nil
January	Round 1 – 18/01/2021 Round 2 – 21/01/2021	• 1 x unidentified Snake
February	Round 1 –15/02/2021 Round 2 – 18/02/2021	• 1 x Copperhead Snake • 1 x unidentified Snake • 1 x unidentified animal remnant
March	Round 1 –16/03/2021 Round 2 - 19/03/2021	• 1 x Red-rumped Parrot • 2 x *Lampropholis* sp. • 3 x unidentified Reptile
April	Round 1 – 19/04/2021 Round 2 – 22/04/2021	• 1 x Copperhead Snake
May	Round 1 – 18/05/2021 Round 2 – 21/05/2021	• 1 x Copperhead Snake • 1 x Eastern Grey Kangaroo • 1 x unidentified fur trace (hair in Red Fox scat) • 3 x unidentified Reptile
June*	Round 1 – 01/07/2021 Round 2 – 05/07/2021	• 2 x unidentified small mammals^
July	Round 1 – 27/07/2021 Round 2 – 30/07/2021	• 1 x Eastern Banjo Frog • 1 x Eastern Grey Kangaroo
August*	Round 1 – 31/08/2021 Round 2 – 03/09/2021	• 1 x unidentified animal remnant^ • 2 x unidentified rodents^ • 2 x Eastern Grey Kangaroos • 1 x Nankeen Kestrel
September	Round 1 – 26/09/2021 Round 2 – 29/09/2021	• 1 x Tawny Frogmouth • 2 x unidentified Reptiles • 1 x unidentified animal remnant
October	Round 1 – 26/10/2021 Round 2 – 29/10/2021	• 1 x Common Blue-tongued Skink • 2 x Highland Copperhead Snakes • 1 x Eastern Three-lined Skink • 1 x unidentified macropod remnant
November	Round 1 – 25/11/2021 Round 2 – 28/11/2021	• 1 x unidentified frog • 2 x unidentified reptiles • 1 x unidentified small mammal bone Ï • 2 x unidentified small mammals Ï • 1 x unidentified bird bone • 1 x *Macropus* sp. remnant • 1 x unidentified large mammal bones

Table 3.2   Summary of monitoring events and recorded fauna strikes

Monitoring period	Survey dates	Recorded fauna strikes
December*	Round 1 – 4/01/2022 Round 2 – 7/01/2022	• 1 x Common Blue-tongued Skink • 9 x unidentified frogs • 1 x Tawny Frogmouth • 1 x unidentified bird • 4 x unidentified reptiles • 2 x unidentified small mammals

Notes: *= monitoring period occurred outside the designated month due to resourcing constraints caused by the Covid 19 Pandemic and the Christmas shut down period, ^ = sample sent for DNA analysis, Ȋ = sample sent for hair analysis.

As outlined above, no Smoky Mouse were recorded during the fauna strike monitoring. To understand the possible mortality levels based on this data, an analysis was undertaken Using Evidence of Absence software (v2.0.7). Parameters included spatial coverage (set to 1, since the entire road was surveyed), temporal coverage (set to 1, the entire time period was surveyed) and the sampling days over the year. Mortality is then estimated from inputting total observed caresses during the period (X=0, here).

Given rates of detectability (very high) and scavenging (very low), we can be 95% confident that true mortality of Smoky Mouse due to fauna strike, across the year, was between 0-2 events.

4   Traffic Volume Data

Traffic counters were installed along Ravine Road and have been in operation from 8 June 2021. Plate 4.1 shows the total number of vehicle movements per day between 6pm and 6am between 8 June 2021 and 9 October 2021. Plate 4.2 shows the total number of vehicle movements by hour across the 124 days across the same period.

Vehicle movements per night (6pm to 6am) have ranged from two vehicle movements (11 June) to 232 vehicle movements (8 October) with peaks and troughs occurring dependent on construction activities. Vehicle movements are greatest at the beginning and end of the night-time period with a drop in vehicle movements between 7 pm and 12 am. On average, the project saw 106 night-time vehicle movements per night.
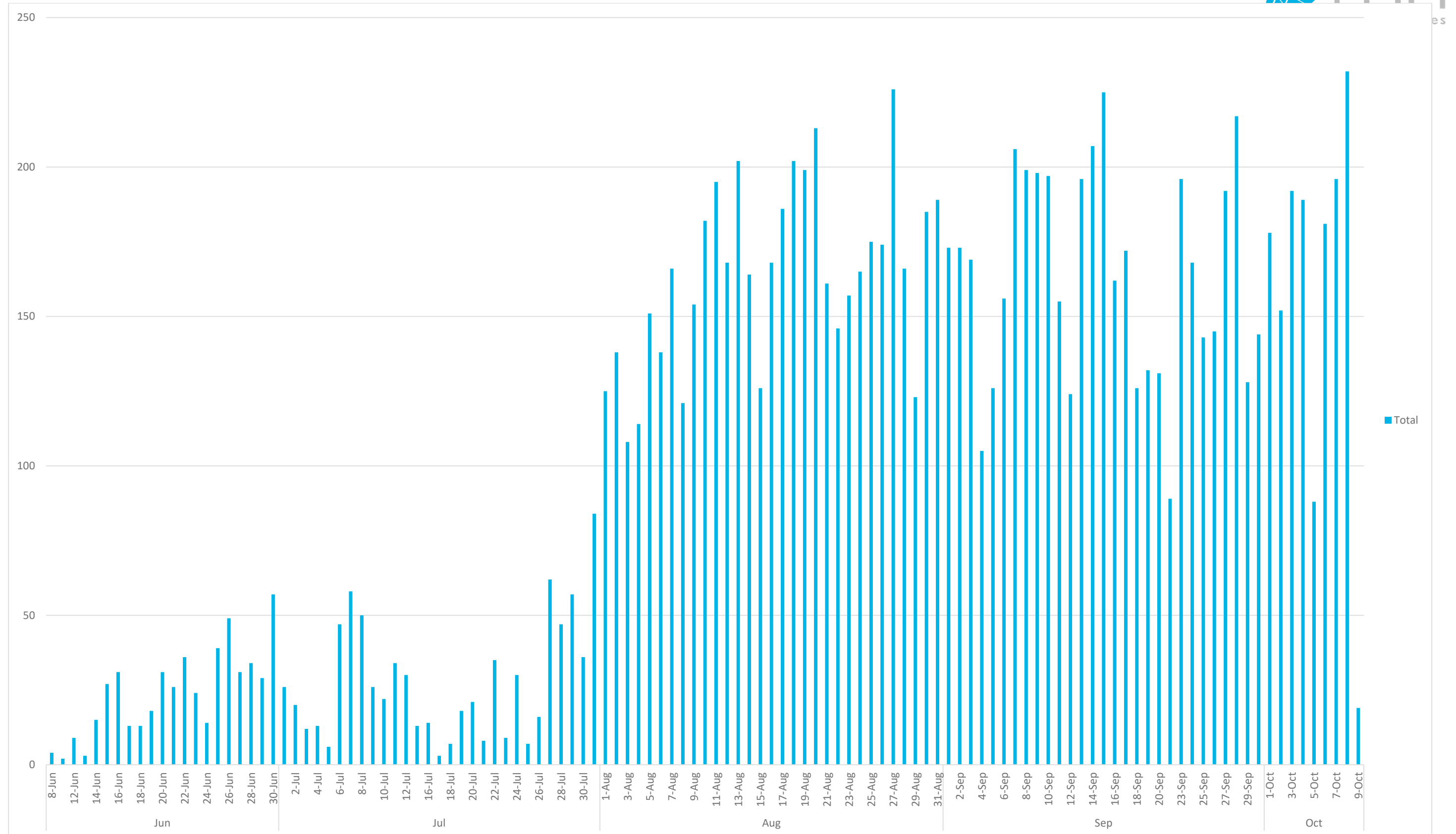
Plate 4.1   Total number of vehicle movements per day between 6pm - 6am, 8 June 2021 to 9 October 2021
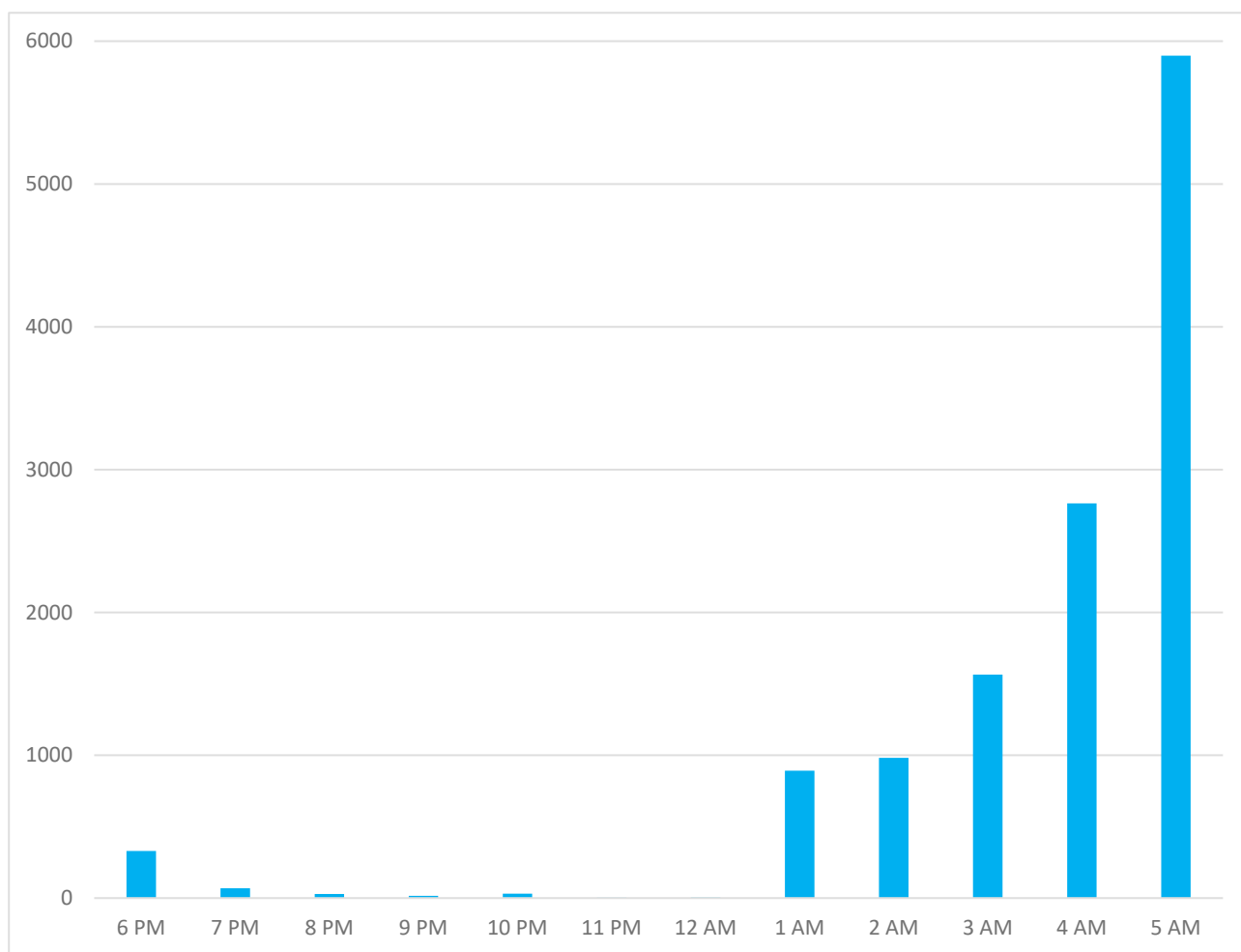
Plate 4.2   **Total number of vehicle movements by hour between 8 June 2021 and 9 October 2021 (124 days)**

5   Population Viability Analysis

A total of 208 simulations were conducted for every combination of mortality values for the two different scenarios (small and large populations, total number of simulations = 416). On average, the small population was reasonably stable (Plate 5.1) and the large population showed signs of a decline (Plate 5.2).
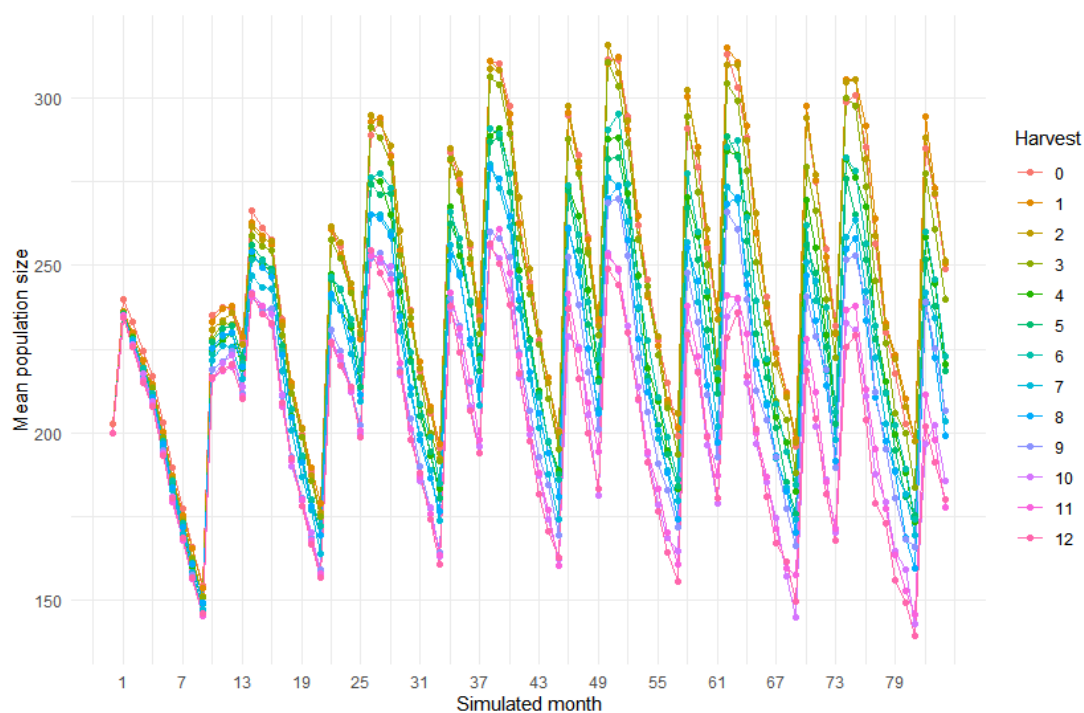
Plate 5.1 Mean simulated smoky mouse population size (initial population size = 200 mice; carrying capacity = 500) by harvest level (number of mice killed on the road each year) (The Analytical Edge 2022)

Plate 5.2 Mean simulated smoky mouse population size (initial population size = 1000 mice; carrying capacity = 1250) by harvest level (number of mice killed on the road each year) (The Analytical Edge 2022)

The results were summarised by harvest level (number of Smoky Mice killed per year) and mean cumulative probability of extinction (proportion of model iterations that went extinct at any point during the simulated 7-year period). None of the large population simulations resulted in extinction. The small population simulations showed that as the harvest level increased from 0 to 12 mice per year, the extinction probability of the small population increased from 0 to 0.14 (Plate 4.1).
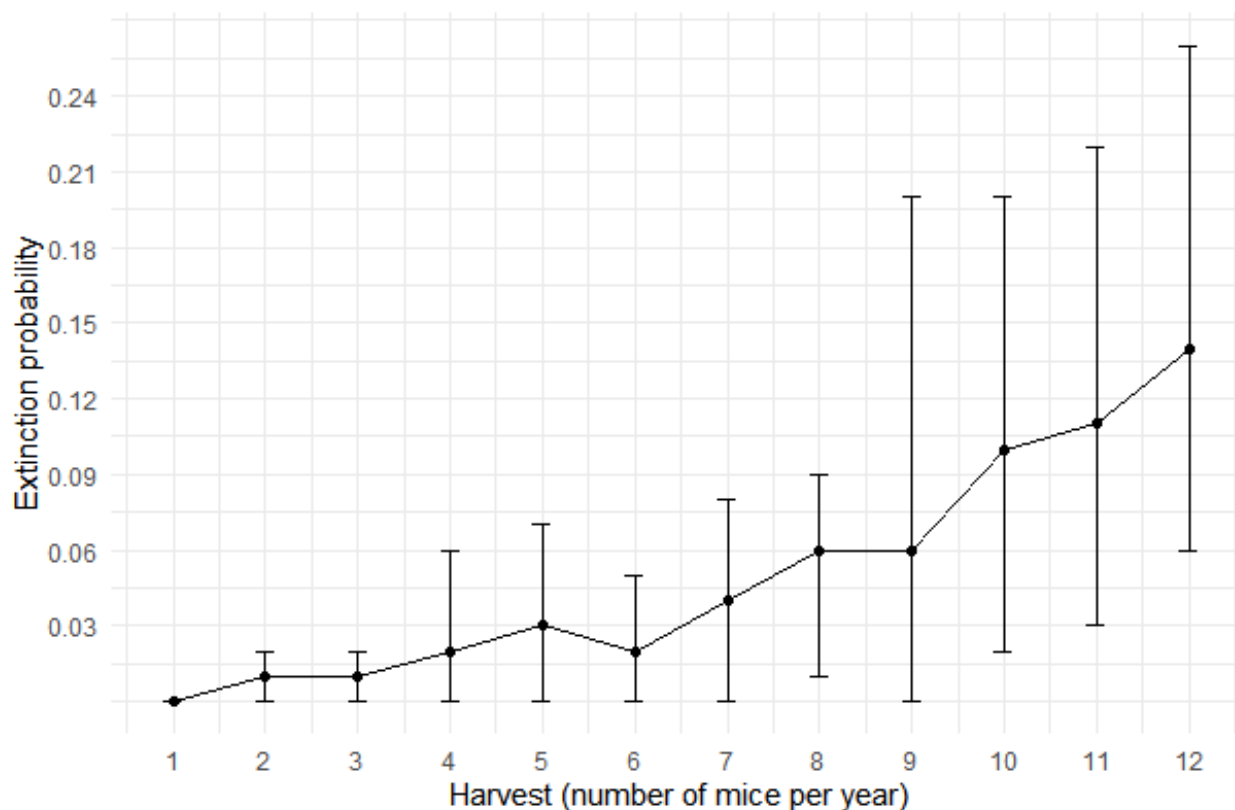

Plate 5.3   **Mean cumulative probability of extinction relative to harvest level (number of mice killed on the road each year) for the small population. Bootstrapped 95% confidence limits show by error bars (The Analytical Edge 2022)**

6   Conclusions and recommendations

The use of the detection dogs in the fauna strike monitoring has proven to be effective, with extremely high efficacy rates. The PVA concluded no probability of extinction for a large population with up to 12 Smoky Mice fauna strikes per year for 7 years. The mean cumulative probability of extinction for a small population increased from 0 to 14% as harvest level was increased from 0 to 12 mice per year.

To date, the mortality monitoring program has not recorded any fauna strike of threatened species, with overall recorded fauna strike numbers considered low given the number of vehicle movements each night. An analysis to understand real levels of mortality indicates we can be 95% confident that actual mortality is between 0-2 animals per year. At this level of mortality there is nil risk of extinction under the large population scenario and a negligible increased risk of extinction from 0 to 0.018 under the small population scenario.

Triggers for adaptive management are described in Table 3-1 of the Strategy (FGJV 2020). As no fauna strike of threatened species has been recorded management measures remain at Level 1. No adaptive management is required.

As 13 months of monitoring has resulted in no fauna strike of threatened species, monitoring has ceased along Ravine Road.

Yours sincerely,

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Appendix A

Population Viability Analysis

Smoky mouse population viability analysis

The Analytical Edge Pty. Ltd.

Approved for release:	Joanne Potts, A.Stat., PhD. Director, The Analytical Edge Ptd. Ltd. *J. Potts*
Release date:	14th June 2022
Notes:	Report has not changed since v3 was released on 19 January 2022

Table of Contents

1   Population viability analysis (method)

A population viability analysis was conducted using Vortex10 (Pacioni et al., 2017) based on best available information (see Table 1) to determine smoky mouse population extinction risk (defined as when only 1 sex remains) due to increased nighttime road traffic. A sensitivity analysis was conducted to vary uncertain population parameters (mortality and population size) and to address the harvesting issue i.e., how many mice can be harvested - killed on the road - before extinction risk becomes unacceptable (see Table 2). Additionally, two scenarios were tested: 1.) small population (initial population size = 200, carry capacity = 500), and 2.) large population (initial population size = 1000, carrying capacity = 1250). Model simulations were summarized and the probability of extinction due to different levels of harvest (varied between 1 and 12 adult mice per year) was calculated. The smoky mouse population was assumed to be isolated, and simulations were carried out over a 7-year period (max duration of project) using a monthly timestep (to account for seasonal population trends).

Table 1. Constant values used in population viability analysis. Values were derived from literature (given in source) and expert opinion.

Parameter	Value	Source
Age of first offspring	12 months	(Happold, 1976) (Cockburn, 1995)
Maximum lifespan	4 years	(Abicair, 2020)
Maximum number of broods per year	1	(Cockburn, 1981)
Maximum number of progeny per brood	4	(Cockburn, 1981)
Percentage of adult females breeding	93%	(Woods and Ford, 2000)
Sex ratio	50:50	(Woods and Ford, 2000)

Table 2. Parameters varied in population viability analysis.

Parameter description	Value set	Source/comment
Year 1 monthly mortality	2.6%, 3.6%, 4.6%, 5.6%	Based on a max total mortality of 50% by the end of the first year (i.e., 5.6% per month for the first year).
Year 2 monthly mortality	9.6%, 10.6%, 11.6%, 12.6%	Based on a max total mortality of 90% by the end of the second year (i.e., 12.6% per month for the second year).
Initial population size	200, 1000	Two scenarios: small (200) and large (1000) population size.
Carrying capacity	500, 1250	Two scenarios: small (500) and large (1250) population size.
Harvest (mice killed on road)	1 – 12 mice per year	Harvest expected to be low since no detections so far.

2   Population viability analysis (results)

Simulations were carried out for every combination of the mortality values (simulations = 208, see Table 2) for the two different scenarios (small and large population, total number of simulations = 416). On average, the small population was reasonably stable (see Figure 1), and the large population showed signs of a decline (Figure 2).

Figure 1. Mean simulated smoky mouse population size (initial population size = 200 mice; carrying capacity = 500) by harvest level (number of mice killed on the road each year).
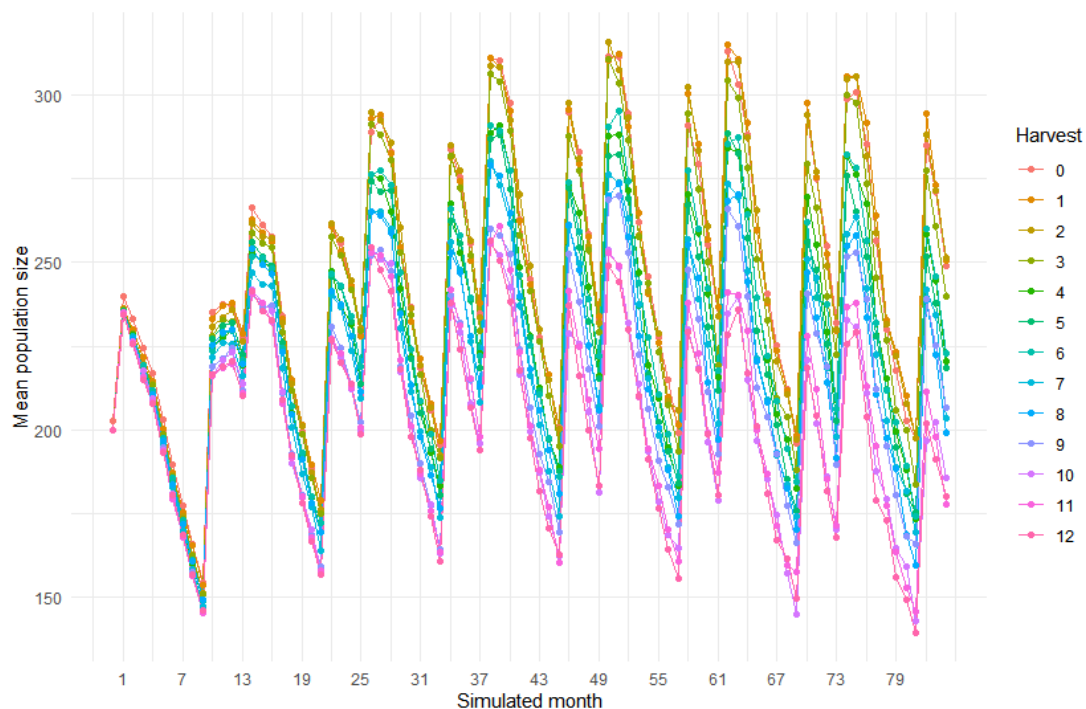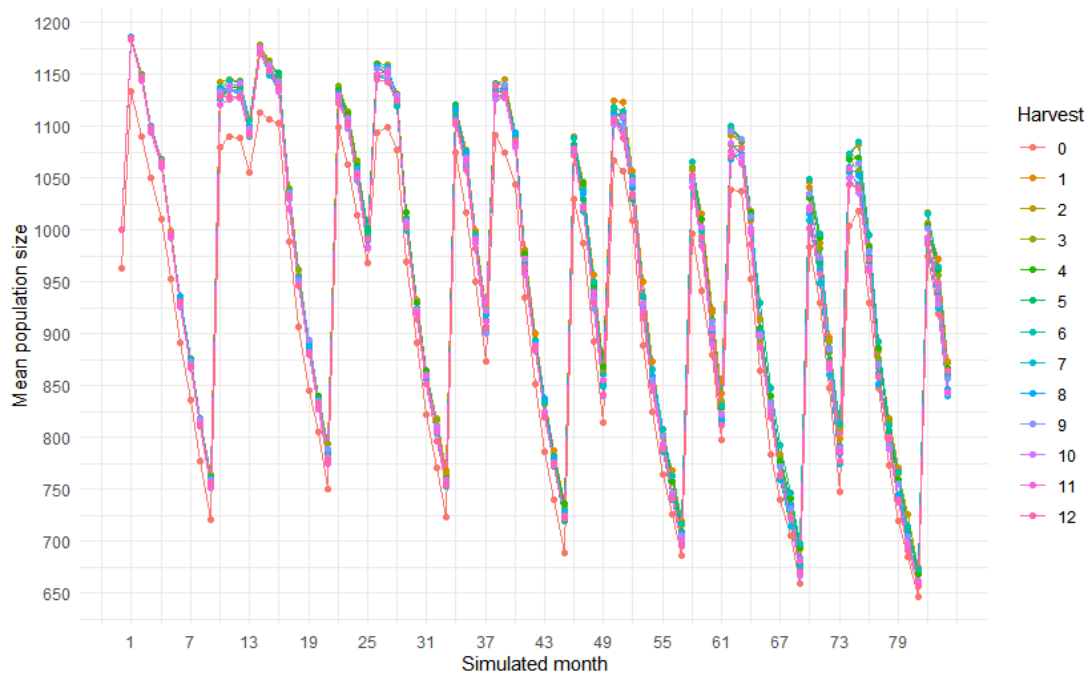

Figure 2. Mean simulated smoky mouse population size (initial population size = 1000 mice; carrying capacity = 1250) by harvest level (number of mice killed on the road each year).
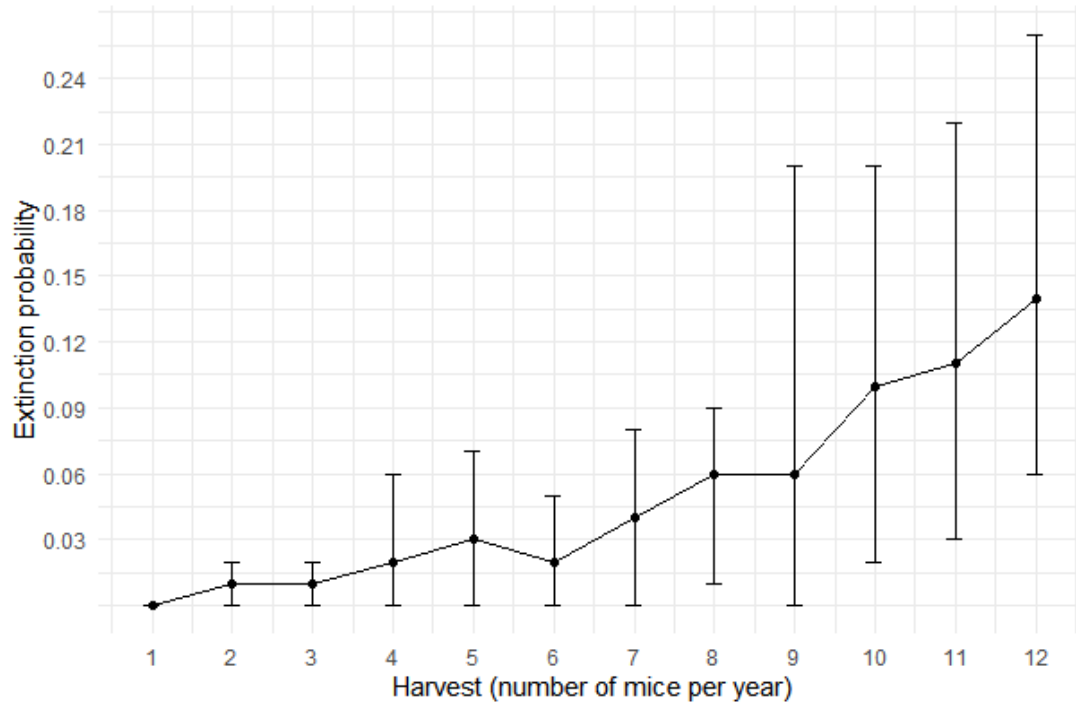
The results were summarized by harvest level and the mean cumulative probability of extinction (i.e., proportion of model iterations that went extinct at any point during the simulated 7-year period) was calculated. None of the large population simulations resulted in extinction. However, as the harvest level was increased from 0 to 12 mice per year, the extinction probability of the small population increased from 0 to 0.14 (see Table 3 and Figure 3).

Table 3. Mean cumulative probability of extinction by harvest level (number of mice killed on the road each year) for the small population. Bootstrapped 95% confidence intervals of mean values given in parenthesis.

Harvest (mice per year)	Mean cumulative probability of extinction
0	0 (0, 0)
1	0 (0, 0)
2	0.01 (0, 0.02)
3	0.01 (0, 0.02)
4	0.02 (0, 0.06)
5	0.03 (0, 0.07)
6	0.02 (0, 0.05)
7	0.04 (0, 0.08)
8	0.06 (0.01, 0.09)
9	0.06 (0, 0.2)
10	0.1 (0.02, 0.2)
11	0.11 (0.03, 0.22)
12	0.14 (0.06, 0.26)

Figure 3. Mean cumulative probability of extinction relative to harvest level (number of mice killed on the road each year) for the small population. Bootstrapped 95% confidence limits shown by error bars.

3 Conclusion

The probability of extinction of the small population during the 7-year period was predicted to increase from 0 to 14% as the harvest level was increased from 0 to 12 mice per year. The large population showed signs of decline, but never reached extinction in any of the simulations.

These results should be treated with caution since many of the population parameters were unknown and had to be estimated.

4 References

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