Whakatipu Mahia possum eradication modelling

Prepared for: Hawke's Bay Regional Council

March 2019

Whakatipu Mahia possum eradication modelling

Contract Report: LC3455

Audrey Lustig, Andrew Gormley

Manaaki Whenua – Landcare Research

Reviewed by:	*Approved for release by:*
Grant Norbury Scientist – Wildlife Ecology and Management Manaaki Whenua – Landcare Research	Chris Jones Portfolio Leader – Managing Invasives Manaaki Whenua – Landcare Research

Contents

Summary

Project and client

- In Decemer In December 2018 the Hawke’s Bay Regional Council released an operational plan, launched as Whakatipu Mahia, for eradicating possums on Mahia Peninsula by the end of 2021. The objectives of the plan are to eradicate possums over the entire 14,616 ha peninsula and to maintain this eradication. The area has been divided into 10 control blocks, which will be tackled individually as a rolling front, starting at the bottom of the peninsula and working northwards. The regional council approached Manaaki Whenua to model the eradication plan and investigate the effectiveness of different control effort.

Objectives

- Map possum distribution and abundance across the eradication area.
- Assess the expected abundance of possums under different control regimes.
- Assess hotspots of possum activity after control to help inform targeted control.
- Forecast reinvasion from uncontrolled areas to controlled areas.

Methods

- We combined an agent-based mathematical modelling framework with spatial information on pest habitat distribution, population dynamics and levels of control to investigate the effectiveness of different spatial and temporal distributions of control effort.

Results

- The model located the highest levels of possum activity the eradication area, corresponding to areas of high-quality habitat. It is likely that eradication will be more difficult to achieve in these areas.
- Possum eradication could be achieved in the first 5,500 ha milestone. The proposed control strategy achieved eradication in more than 90% of simulations.
- Possum eradication is unlikely to be achieved in the second 11,000 ha milestone area under the proposed spatiotemporal control regimes due to dispersal from adjacent non-controlled areas. This was most problematic in control blocks 2A, 2B and 2C.

Conclusions and recommendations

- The results from the simulations suggest that possum eradication could be achieved in the first 5,500 ha milestone area under the proposed spatiotemporal control regimes, but is unlikely to be achieved in the second 11,000 ha milestone area.
- Maximising the use of barriers to dispersal between control blocks 2C and 2B, and between control blocks 2E and 2C, could potentially prolong eradication.
- It is important to note that the modelling exercise assumed a ‘closed population’; in other words, it does not include immigration from untreated areas outside the eradication area,

which, if present, would compromise the effectiveness of any eradication programme. These features would need to be accounted for in subsequent modelling.

1 Introduction

The Hawke's Bay Regional Council (HBRC) has been carrying out their Possum Control Area programme since 2000, with suppression of brushtail possums (*Trichosurus vulpecula*) implemented across 700,000 ha of the region. In 2011 a regional predator control programme was initiated in forest (Poutiri Ao ō Tāne), followed in 2015 by a programme based largely in farmland (Cape to City). The establishment of Predator Free 2050 has turned the focus towards attempting regional possum eradication.

In December 2018 HBRC released an operational plan for possum eradication on Mahia Peninsula, called Whakatipu Mahia (Hawke's Bay Regional Council 2019). The objectives of the plan are (i) to eradicate possums over the entire 14,616 ha, and (ii) to maintain them at zero density. Whakatipu Mahia is an important step towards the goal of releasing native species from the pressure of possums.

The eradication area takes advantage of the geography of Mahia Peninsula, with the surrounding ocean largely creating an effective barrier to pest reinvasion from uncontrolled areas. The eradication area has been divided into 10 blocks of approximately 1,500 ha (Figure 1). Each block will be tackled individually as a rolling front, starting in a 1,500 ha zone at the bottom of the peninsula and working northwards, with the aim of eradicating all possums from the entire peninsula by the end of 2021.

2 Objectives

We used an agent-based, spatially explicit simulation model (Lustig et al. in press) for predicting the distribution and abundance of possums across Mahia Peninsula, and for gauging the effects of various control regimes (e.g. length of deployment of control devices, trappability parameters). The model describes the behaviour of adult and juvenile possums located explicitly in a map of their habitat. Key events in an individual's lifetime are birth, death, and dispersal, and these are simulated as stochastic processes (i.e. there is uncertainty in the timing of each event). Such modelling provides detailed forecasts of possum abundance at regular time intervals into the future.

The results of the simulations are then used to:

- map possum distribution and abundance across the eradication area
- assess the expected abundance of possums under different control regimes
- assess hotspots of possum activity after control, thereby informing areas to be targeted after 4 weeks of control in each control block
- forecast reinvasion from uncontrolled blocks to controlled blocks.

3 Methods

3.1 Operational rollout in Mahia Peninsula

Control stage

In each block, possum control will involve a network of about 1,500 bait stations set approximately 50 to 100 m apart (one station per hectare or less) (Stage 1). Bait stations will be active for a minimum of 4 weeks and a likely maximum of 8 weeks, with a requirement of 15 control nights with no bait take before being moved to the next control block. Within each control block, possum presence/absence will be assessed on a daily basis based on bait take from stations, as well as additional information including possum sign and interactions with motion-sensitive trail cameras. Additional bait stations and/or leg-hold traps will be placed in areas with possum sign (targeted control in high-risk areas) (Stage 2). At the end of Stages 1 and 2, a network of kill traps (1,500 Victor No. 1 leghold traps) will be deployed for 4 to 8 weeks at a density of one every 25 ha (Stage 3).

We focused on modelling Stage 1 and Stage 3: Stage 2 cannot be integrated in the model without further information from the actual control and surveillance operations in the field. As a result the model predictions of the effectiveness of control intervention on the possum population are likely to be conservative.

In the following simulations we set the density of bait stations to one station per hectare for 8 weeks (Stage 1), followed by 8 weeks of trapping at a density of one trap per 25 ha (Stage 3) (Table 1). We investigated the effect of different control durations by comparing control devices in place in each control block for 28 effective control nights[1] (i.e. 4 weeks), to 56 effective control nights (i.e. 8 weeks).

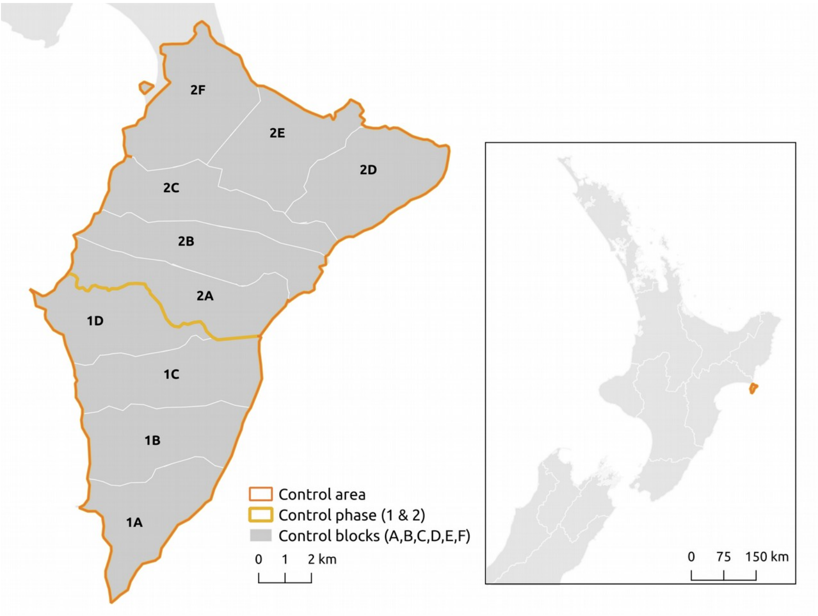

Figure 1. Whakatipu Mahia control phase rollout in the Mahia Peninsula eradication area in Hawke's Bay, New Zealand. The eradication area is delimited by the orange boundaries, the two control phases by the yellow boundary, and the control blocks by the white boundaries.

[1] In the model we did not account for trap saturation or bait shortage due to the high ratio of control devices to possums in the eradication area and the protocol for refilling baits and re-setting all traps every 21 days. In other words, for each control night we assumed that all bait stations and traps in the landscape were effective.

Buffer to re-invasion

In order to minimise reinvasion risk from untreated areas of the peninsula while eradication is underway in the first 5,500 ha milestone area (Phase 1), a bait-station network buffer will be deployed across blocks 2A and 2B. The buffer is likely to be active from June/July 2019. Similarly, while eradication is underway in the second 11,000 ha milestone area (Phase 2), a bait-station network buffer will be deployed across block 2F. We simulated a bait-station network at one station per hectare for 16 weeks in blocks 2A and 2B (July to October 2019), and one station per hectare for 48 weeks in block 2F (October 2019 to September 2020) (Table 1).

Immigration barrier

An immigration barrier will be constructed across the narrow neck of the peninsula to limit reinvasion risk from untreated areas outside. The barrier will match protocols developed by ZIP (Zero Invasive Predators), and is likely to consist of four or five parallel lines of leghold traps placed 100 m apart. The finalised design of the barrier will be completed by 31 March 2020 and construction will take place between April and June 2020. For this modelling exercise we assumed a closed system, meaning no immigration from outside the north edge of the eradication area (i.e. we assumed a perfect barrier). In the future, the barrier could be simulated once final density and placement of all traps has been decided.

Table 1. Timeline used to simulate the operational rollout in the Mahia Peninsula. The model describes possum reproduction and dispersal as stochastic events. While there are uncertainties in the timing of these events, reproduction and dispersal peaks are indicated in the last column.

Phase	Block	Ha	Stage 1 Bait station network at 1 station per hectare	Stage 3 Kill-trap network at 1 trap per 25 hectares	Buffer 1 station per hectare	Possum ecology
Phase 1	1A	1317.0	March / April 2019	May / June 2019		Reproduction
	1B	1419.4	May / June 2019	July / August 2019		Dispersal peak
	1C	1543.1	July / August 2019	August / September 2019	Block 2A / 2B	
	1D	1251.8	August / September 2019	October / November 2019	Block 2A / 2B	Reproduction
Phase 2	2A	1446.0	October / November 2019	December 2019 / January 2020	Block 2F / 2B	Dispersal peak
	2B	1463.2	December 2019 / January 2020	February / March 2020	Block 2F	
	2C	1407.8	February / March 2020	April / May 2020	Block 2F	Reproduction
	2D	1579.0	April / May 2020	June / July 2020	Block 2F	Dispersal peak
	2E	1450.2	June / July 2020	August / September 2020	Block 2F	
	2F	1673.6	August / September 2020	November / December 2020		

3.2 Mapping possum distribution and abundance across the eradication area

Based on possum carrying capacities in various classes of habitat (Warburton et al. 2009), we allocated a carrying capacity (K) to available georeferenced land-cover classes in New Zealand. We used the LRIS-LCDB-v41[2] database, along with the EcoSat indigenous forest layer, to provide finer differentiation of forest classes (lris.scinfo.org.nz). Land surfaces were partitioned into three types:

[2] The New Zealand Land Cover Database (LCDB) is a multi-temporal, thematic classification of New Zealand's land cover. It contains 33 mainland classes. The data is referenced to the New Zealand Transverse Mercator 2000 projection (NZTM2000).

habitats in which possums could establish home ranges (most of the land cover), habitats through which possums could disperse but not settle (e.g. rivers), and habitats that possums were assumed not to enter (e.g. estuarine open water) (Lustig et al. in press). The spatial layer was rasterised so that each grid cell was characterised in isolation by the local carrying capacity. The extent of the study was delineated by the eradication area. The resolution of the spatial layer was 500 m.

We first simulated the model without control to forecast hotspots of possum activity in the eradication area. Simulations were run with starting densities of 0.1 possums per hectare, equivalent to 1,500 possums across the entire Mahia Peninsula. Note that the current estimate of population trap catch is 0.8% residual trap-catch (RTC) (Hawke's Bay Regional Council 2019), which is broadly equivalent to less than two possums per hectare (National Pest Control Agencies 2005). Individuals were randomly located within the control area. The model was simulated using the life history and dispersal parameters for possums used in Lustig et al. in press and shown here in Table A1 (Appendix 1). We simulated the population for 10 years and recorded the total number of individuals present each month. An abundance map was obtained after 10 years of simulation, when the population reached a stable state (i.e. abundance >90% of the total carrying capacity). Results were averaged over 100 simulations to account for model stochasticity.

3.3 Assessing the expected abundance of possums under different control regimes

We investigated the expected outcomes of the proposed control strategy in the Whakatipu Mahia eradication area under different control regimes (i.e. varying lengths of control device deployment and varying trappability parameters). Simulations were run with two starting densities of possums: 0.1 and 0.5 possums per hectare, equivalent to 1,500 and 7,500 possums, respectively. These starting densities encompass the current estimated population density of possums (0.2 per hectare, derived from an average 0.8% RTC). Individuals were randomly located within the peninsula. We used mean values of life history and dispersal parameters (Table A1, Appendix 1).

The two key animal parameters for the control sub-model are γ_0 (the nightly probability of capture of an individual by a control device placed at the centre of the animal's home range) and σ (the spatial decay parameter for a half-normal home-range kernel, to model the decline in detection probability with distance between the home-range centre and the control device). We carried out simulations at three levels of γ_0 and σ (Table A1, Appendix 1). These same values were used to parameterise a preliminary possum eradication model for the Whakatipu Mahia area (Howard & Gormley 2019) and correspond to the potential range of values from several field studies (Glen & Byrom 2014). There were no data available to assess the extent to which the γ_0 and σ parameters could vary with different control devices, so both variables were assumed to be the same for bait stations and kill traps. For each simulation described below, we chose a spatial resolution of R = 500 m. We carried out 500 simulations for each set of parameters to account for model stochasticity.

3.4 Assessing hotspots of possum activity after control, and forecasting reinvasion patterns from uncontrolled blocks to controlled blocks

We used the results of the agent-based model simulations described above to generate maps of:

1. relative possum abundance before control, at the end of Phase 1, at the end of Phase 2, and 3 years after control stopped (Figure 5)
2. likely numbers of captures expected (Figure 5).

Results were averaged over 500 simulations to account for model stochasticity.

4 Results

4.1 Possum distribution and abundance

The total carrying capacity for the Whakatipu Mahia eradication area is estimated at 21,015 possums (1.44 possums per hectare) (Figure 2). Individuals could spread rapidly across most of the study area due to the high level of connectivity among habitat patches. The model located the highest levels of possum activity in the control blocks 2B and 2C and control blocks 1B and 1C, corresponding to areas of high-quality habitat (Figure 2).

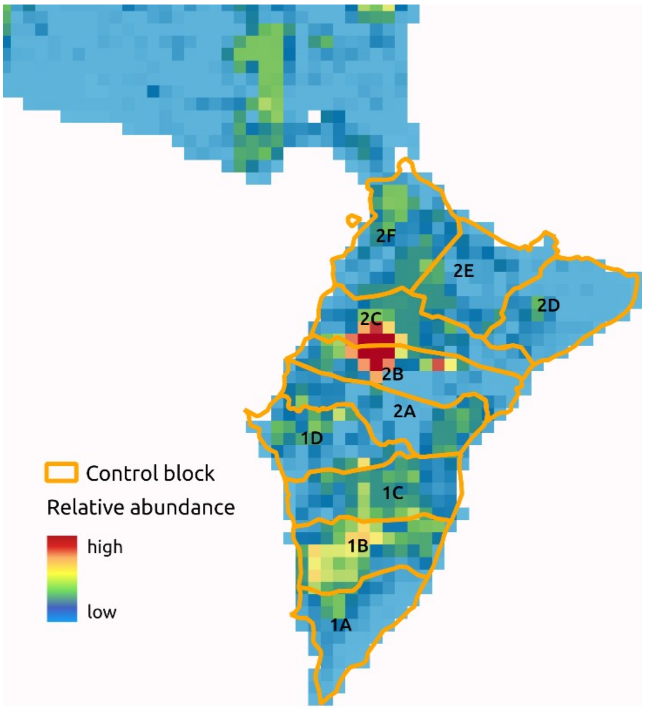

Figure 2. Possum abundance map averaged over 100 simulations. The gradient of colors (blue to red) indicates the estimated abundance of possums per grid cell. The eradication blocks are delimited by the orange boundaries.

4.2 Assessing the expected abundance of possums under different control regimes

The model predicted markedly lower possum abundance as a result of the proposed spatiotemporal control strategy (Figures 3 and 4). At the end of Phase 1 of control, eradication was achieved in the first (5,500 ha) milestone area (Figure 4) for more than 90% of simulations. The initial possum density and trappability parameters influenced eradication success, with simulations of higher starting possum density (0.5 possums per hectare), lower trappability ($\gamma_0 = 0.05$) and smaller home range size ($\sigma = 90$ m) having an increased time to eradication. Where eradication was not successful, the number of remaining animals nevertheless was low (i.e. less than five).

Eradication of possums from the second 11,000 ha milestone area was highly unlikely under the proposed spatiotemporal control regime. The most problematic areas were blocks 2A, 2B and 2C. Increasing the number of effective trapping nights per block from 28 nights to 56 nights reduced the population further in these blocks, but still did result in possum eradication (Figure A1, Appendix 1).

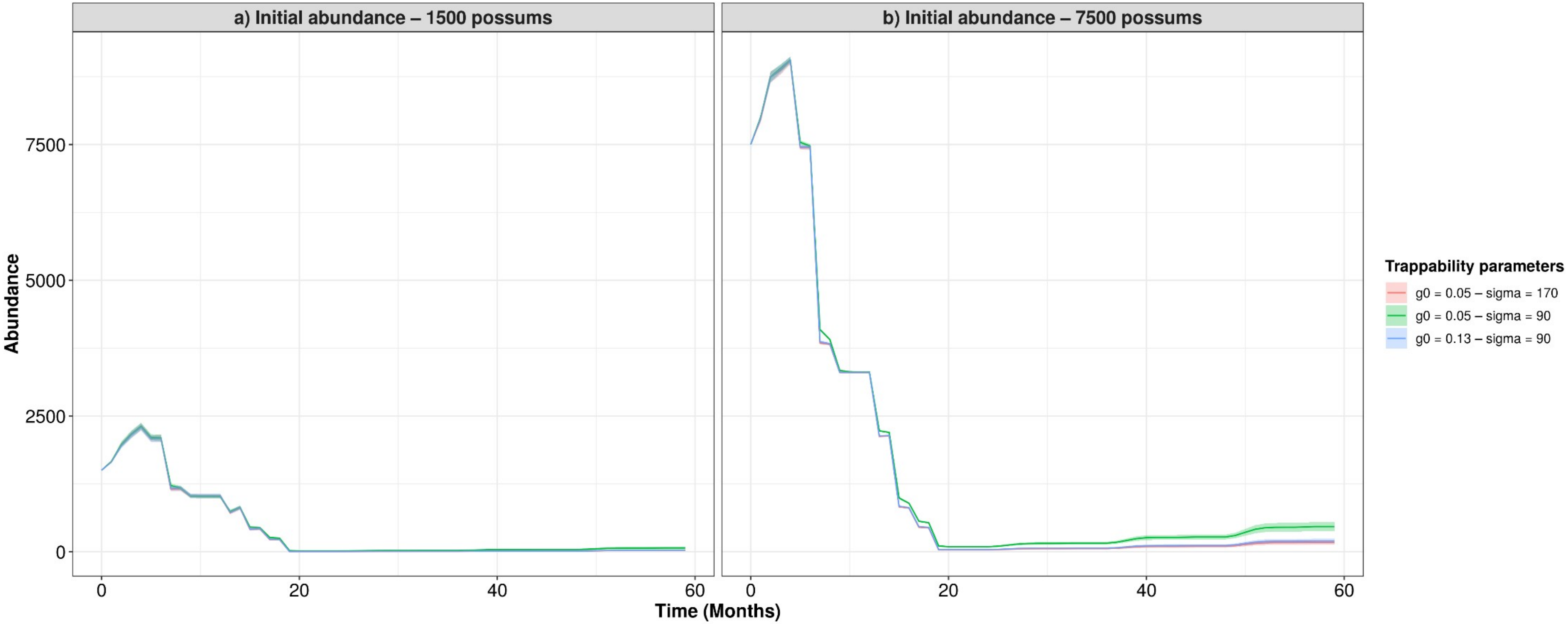

Figure 3. Predicted mean number of possums in the eradication area over 5 years. Simulations were run with starting densities of a) 0.1 and b) 0.5 possums per hectare, equivalent to 1,500 and 7,500 possums, respectively. Results are shown for simulations in which bait stations were deployed at one station per hectare for 28 effective control nights, followed by 28 effective control nights of trapping at a density of one trap per 25 hectares. The different colours show different combinations of the g_0 and σ parameters.

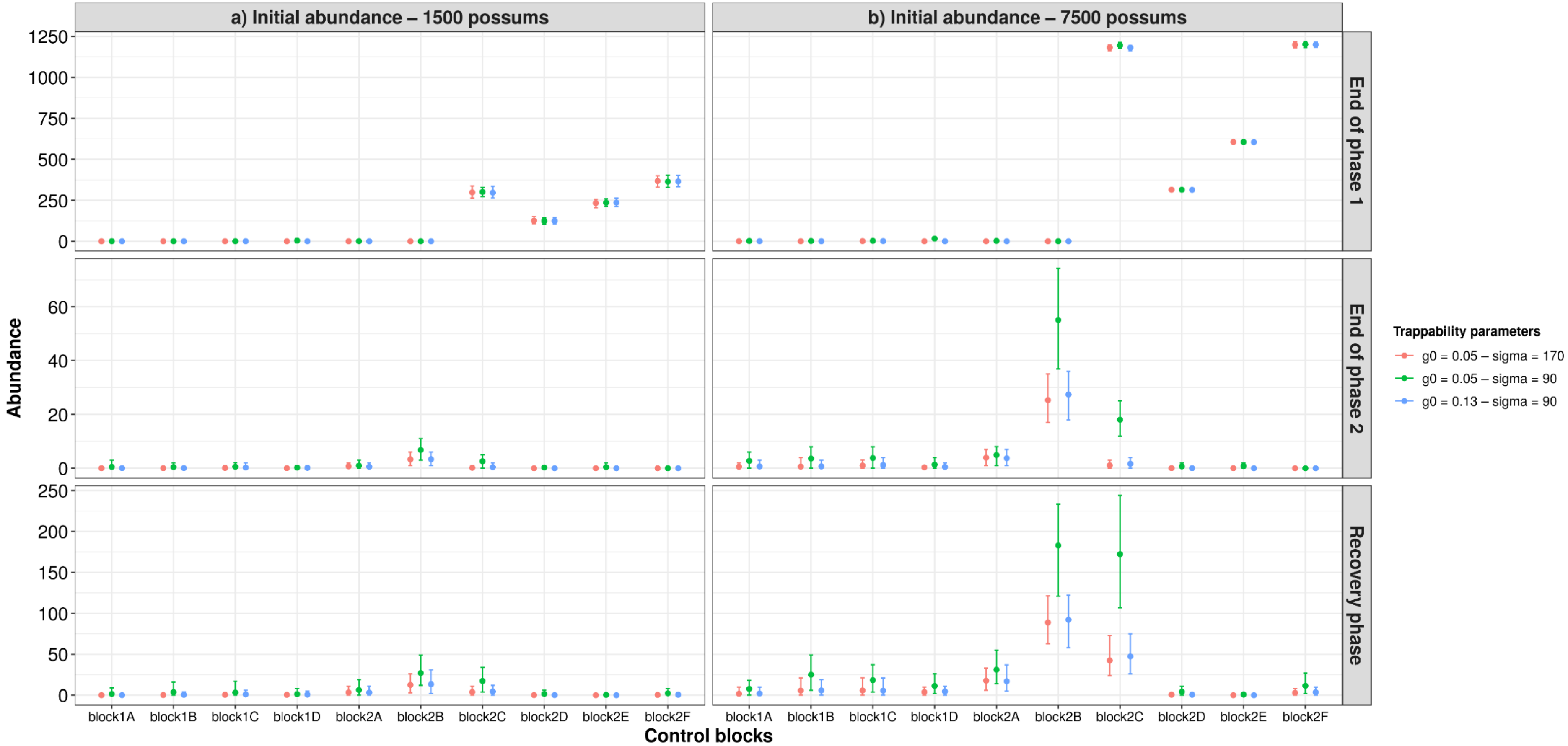

Figure 4. Predicted mean number of possums in the eradication area at the end of Phase 1 (first milestone area, 5,500 ha); end of Phase 2 (second milestone area, 11,000 ha), and 3 years after control stops in the eradication area (recovery phase). Simulations were run with possums starting at densities of a) 0.1 and b) 0.5 possums per hectare, equivalent to 1,500 and 7,500 possums, respectively. Results are shown for simulations in which bait stations were deployed at one station per hectare for 28 effective control nights, followed by 28 effective control nights of trapping at a density of one trap per 25 hectares. A bait station network buffer was also deployed in blocks 2A and 2B while eradication was underway in Phase 1 (which explains the low abundance in blocks 2A and 2B at the end of phase 1), and in block 2F while eradication was underway in Phase 2. Different colours show different levels of g_0 and σ parameters. Please note that each phase has a different y-axis scale.

4.3 Assessing hotspots of possum activity after control, and forecasting reinvasion from uncontrolled blocks to controlled blocks

The likely density of possums and expected number of captures vary in both time and space (Figure 5). The number of captures is expected to be the highest in Phase 2, when possum densities are expected to be the highest. For all trapping scenarios (i.e. different deployment periods for control devices and trappability parameters), possum recovery after control followed a consistent spatial pattern, with population abundance increasing initially in blocks 2C, 2B and 2A, and recovery delayed at the bottom of the peninsula. This delay suggests that dispersal from adjacent non-controlled areas, in particular from block 2C to block 2B and block 2E/2D to block 2C (animated simulations attached), supported population recovery during Phase 2. As there are no natural barriers to hinder dispersal of potential re-invaders from Phase 2 to Phase 1 areas, juveniles could disperse southwards and recover the population at the bottom of the peninsula.

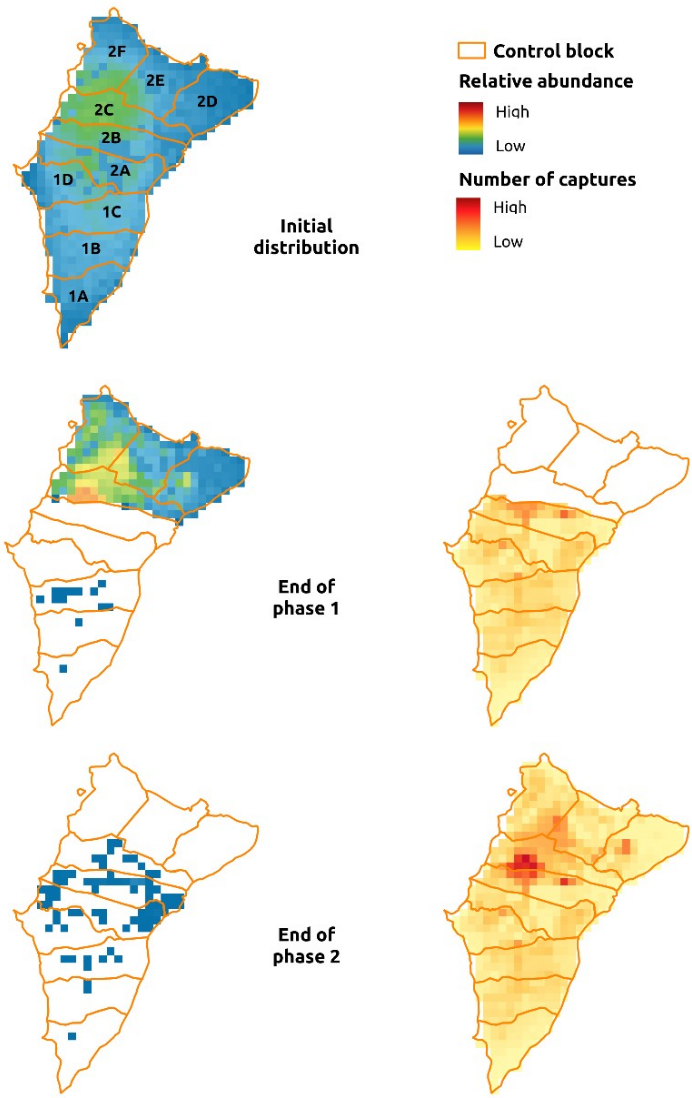

Figure 5. Predicted mean number of possums, and number of possums trapped, in the eradication area. The gradient of colours from blue to red indicates the predicted number of possums at

different times (initial distribution; end of Phase 1 and end of Phase 2). The gradient of colours from yellow to red indicates the total number of individuals poisoned or trapped in the 2 years of control. Results are shown for simulations in which bait stations were deployed at one station per hectare for 28 effective control nights, followed by 28 effective control nights of trapping at a density of one trap per 25 hectares. The different control blocks are delimited by the orange boundaries.

5 Discussion

We used a spread model (Lustig et al. in press) to predict the distribution and abundance of possums across the Mahia Peninsula and the effects of various control regimes. The modelling forecasted the relative abundance of possums and the number of captures at regular time intervals. It also provided new opportunities to explore some of the mechanisms by which possum populations might recover after control operations.

The model located the highest levels of possum activity in control blocks 2B and 2C, and in control blocks 1B and 1C, corresponding to areas of high-quality habitat of the Whakatipu Mahia eradication area. It is therefore likely that eradication will be more difficult to achieve in these four control blocks. Priority should be given to validating the abundance map, since it forms the basis for all subsequent analyses. To this end, it will be important to compare this abundance map with detailed possum observations from a variety of devices (bait take, trap catch, video surveillance, chew cards, etc.) as the first data come in.

The results from the simulations suggest that possum eradication could be achieved in the first 5,500 ha milestone area (Phase 1) with a control regime involving a network of bait stations set at a density of one per hectare for 4 weeks, followed by 4 weeks of trapping at a density of one trap per 25 hectares. A control buffer, involving a bait-station network at one station per hectare, deployed across blocks 2A and 2B (July to October 2019), could minimise the reinvasion risk from untreated areas of the peninsula while eradication is underway in the 5,500 ha milestone area.

This control strategy achieved eradication in the first 5,500 ha milestone area in more than 90% of simulations. These results confirm the recommendations by Howard and Gormley (2019), suggesting that possum eradication could be achieved using trap spacings of 100 × 100 m or less (i.e. one per hectare or less). Where modelled eradication was not successful (i.e. for 10% of simulations), the number of remaining animals was low (i.e. less than five). Surviving possums were most likely to be found in control block 1C. It is worth noting that Stage 2 of control (the targeted control phase) was not included in the model. The likelihood of possum eradication is expected to increase from additional bait stations and/or leghold traps in Stage 2.

In contrast, the results from the simulations suggested that eradication in the second 11,000 ha milestone area (Phase 2) is unlikely to be achieved under the proposed control regime. For all trapping scenarios, possum recovery after control followed a consistent spatial pattern, with population abundance increasing initially in blocks 2A, 2B and 2C, and recovery delayed at the bottom of the peninsula. The model suggested that dispersal from adjacent non-controlled areas, particularly from block 2C to block 2B, and from blocks 2E and 2D to block 2C, initiated possum recovery in these areas. One possible explanation is that the model overestimated the number of juveniles trapped relative to the number of adults, and a kill-trap network at one trap in 25 hectares did not fully prevent dispersal from 2C to 2B. The model suggested limited exchange between the controlled and uncontrolled areas. Therefore, maximising the use of barriers to dispersal between control blocks 2C and 2B, and between blocks 2E/2D and 2C, could prolong treatment persistence. For example, a buffer of bait stations or kill traps at one station/trap per hectare could be maintained in blocks 2C and 2B while eradication is underway in blocks 2D, 2E and 2F. These features would need to be accounted for in subsequent modelling work.

It is important to note that the current modelling exercise assumed a ‘closed population’ and therefore does not include immigration from untreated areas outside the eradication area, which, if present, would compromise the effectiveness of any eradication programme. These features would need to be accounted for in subsequent modelling work and could help assess the effectiveness of the immigration barrier that will be constructed across the narrow neck of the peninsula to limit reinvasion risk.

This study combines a rigorous mathematical modelling framework with detailed spatial information on habitat distribution, population dynamics and levels of control. Nevertheless, the conceptual validity of the model still inevitably rests on its assumptions. The main assumptions were the carrying capacities of possums in various classes of habitat, and the trapping probabilities for juveniles and adults. Estimates of carrying capacity in each habitat are based on mean density values and are assumed to be fixed over time. The model also assumes a fixed probability of removing an individual, and does not incorporate variability in trappability of control devices and lures, or the effects of sex/age, time of the year, and population density.

In particular, the model currently assumes that all individuals have the same level of trappability. However, there may be sub-sets of the population that are much harder to capture, thereby making the goal of eradication more difficult. This variable trappability (especially low trappability of the last survivors) could result in a significant difference between the simulation predictions and reality. In addition, there were no data available to assess the extent to which trappability parameters could vary with control devices. Research on the causes and consequences of variable trappability of small mammal populations is currently underway and will probably become an important addition to the model.

6 Recommendations

Maximising the use of barriers to dispersal between control blocks 2C and 2B, and between control blocks 2E/2D and 2C, could prolong treatment persistence in the Mahia Peninsula.

While we have demonstrated how the modelling framework could be used to help inform the success of an eradication campaign, the model could be readily extended to incorporate the effects of the immigration barrier that will be constructed across the narrow neck of the peninsula to help assess its effectiveness to limit reinvasion risk. In addition, with improved or new parameter estimates, the model could readily be extended to investigate how variability in trappability parameters could affect eradication success.

7 Acknowledgements

We would like to thank Campbell Leckie, Natalie de Burgh, and Wendy Rakete-Stones from Hawke's Bay Regional Council for valuable discussions and clarification on the eradication plan, and for providing the trap network data used in the modelling exercise; Dr Grant Norbury for helpful comments on an earlier draft; and Professors Mike Plank and Alex James for useful discussions on the original ideas and design of the study. This work was supported by funding from the Strategic Science Investment Fund, Ministry of Business Innovation and Employment, Predator Free 2050 and Predator Free Hawke's Bay.

8 References

Glen AS, Byrom AE 2014. Implications of landholder buy-in for the success of regional-scale predator control: review of predator movements. Report LC1956. Manaaki Whenua – Landcare Research.

Hawke's Bay Regional Council 2019. Hawke's Bay Regional Council 2019 Whakatipu Mahia Operational Plan.

Howard S, Gormley A 2019. Whakatipu Mahia possum eradication modelling. Report LC3378, Manaaki Whenua – Landcare Research.

Lustig A, James A, Anderson D, Plank M. Pest control at a regional scale: identifying key criteria using a spatially explicit, agent-based model. Journal of Applied Ecology, in press. https://doi.org/10.1111/1365-2664.13387

National Pest Control Agencies 2005. Trap-catch for monitoring possum populations. Wellington, National Pest Control Agencies.

Warburton B, Cowan P, Shepherd J 2009. How many possums are now in New Zealand following control and how many would there be without it. Report. LC0910/060, Manaaki Whenua – Landcare Research.

Appendix 1: model parametrisation

We used the most recent field-based estimates to calibrate life-history and control parameters. Values are reported in Table A1 and were extracted from Lustig et al. in press. The probability that an adult in the grid cell(x,y) was captured within k nights of trapping was expressed as:

$$P_{adults_{(x,y)}} = 1 - e^{-2\pi\gamma_o\sigma^2 k \rho_{(x,y)}}$$

where γ_0 is the probability of capture by a trap placed at the centre of the animal's home range, σ is the spatial decay parameter for a normal home-range kernel to model decline in encounter probability with distance between the home range centre and trap, and ρ is the density of traps (i.e. traps per unit area) in the grid cell.

Dispersing juveniles had a probability of being trapped in each grid cell they travelled through during the dispersal phase, which was expressed as:

$$P_{juveniles_{(x,y)}} = 1 - e^{-A\gamma_1\rho_{(x,y)}}$$

where γ_1 is the probability of a juvenile being captured by a trap, and A is the area covered by a dispersing juvenile as it passes through one grid cell. More specifically, we assume that juveniles encounter a trap if it is within a distance W of its path. Therefore, the area A covered by a juvenile was given by:

$$A = VW\,\partial t, \text{ with } \partial t = \frac{R\,t_{max}}{d_{max}}$$

where R is the spatial resolution, V the mean velocity of a juvenile during dispersal, d_{max} the maximal dispersal distance, and t_{max} the maximal time of dispersal. More details about trapping probability are given in Lustig et al. in press.

Table A1: Animal and trappability parameter values

Parameter	Abbreviation	Value		
Spatial parameters				
Spatial resolution	*R*	500 m		
Life history parameters				
Life expectancy	*l*	12 years		
Reproduction rate	*r*	0.77 (0.51–1.05) / year		
Maximum dispersal distance	d_{max}	12,000 m		
Control parameters				
Probability of capture of an adult		0.05	0.05	0.13
Spatial decay parameter	γ_0	90 m	170 m	90 m
Probability of capture of a juvenile	σ	0.05	0.05	0.13
Area covered by a dispersing juvenile per grid cell	γ_1	0.037 ha	0.037 ha	0.037 ha
	A			

We investigated the effect of different control efforts by estimating the success of leaving the control devices in place in each control block for 28 effective control nights (Figure 3 and Figure A1), compared with 56 effective control nights (Figure A1).

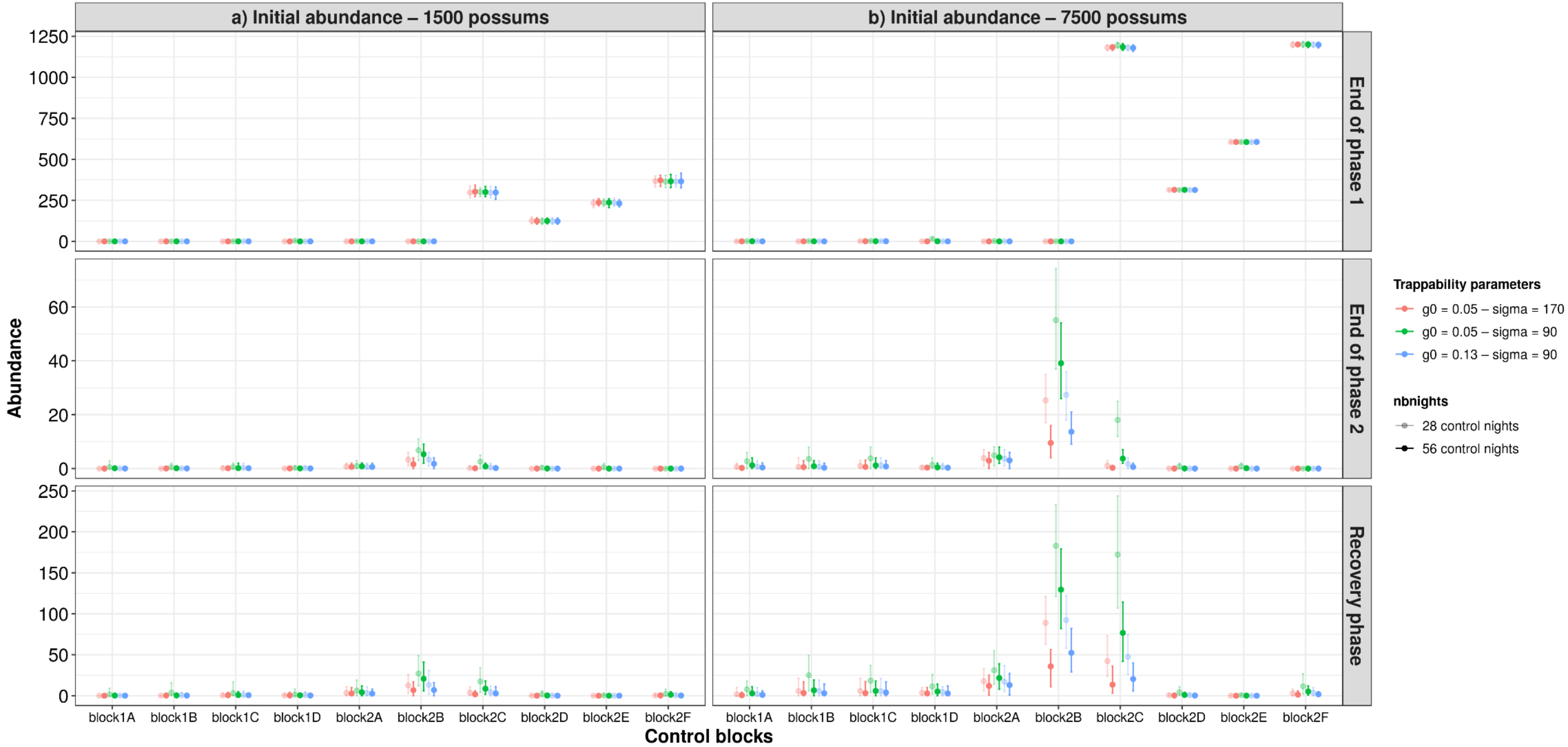

Figure A1. Predicted mean number of possums in the eradication area at the end of Phase 1 (5,500 ha milestone area); end of Phase 2 (11 000 ha milestone area) and 3 years after control stopped in the eradication area (recovery phase). Simulations were run with possums, starting at densities of a) 0.1 and b) 0.5 possums per hectare, equivalent to 1,500 and 7,500 possums, respectively. Results are shown in bold for simulations in which bait stations were deployed at one station per hectare for 56 effective control nights, followed by 56 effective control nights of trapping at a density of one trap per 25 hectares. Different colours show different levels of g_0 and σ parameters.