



Implications of landholder buy-in for the success of regional-scale predator control: Part 1: Review of predator movements



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Summary

Project and Client

- As part of its *Cape to City* proposal, Hawke's Bay Regional Council (HBRC) intends to conduct broad-scale control of invasive predators (possums, stoats, ferrets and feral cats). Because landowner participation is voluntary, there are likely to be areas where predator control is either not applied or is less effective. HBRC contracted Landcare Research in 2014 to review existing information on predator ecology and movements in preparation for modelling how the broad-scale efficacy of pest control might be influenced by patches of land in which the target species are not effectively controlled.

Objectives

- Summarise the biological characteristics of possums, stoats, ferrets and feral cats in New Zealand that influence their ability to persist in patches of land where pest control is not effectively applied.
- Review home range and habitat use, dispersal ability and capture probability at different spatial scales with the aim of using the information to pre-empt and mitigate reinvasion.

Methods

- We collated published information on the biological characteristics of these four species of invasive predators in New Zealand likely to influence the dynamics of their metapopulations. These include:
 - Home range and habitat
 - Movement and dispersal
 - Capture probability.

Results

- The biological characteristics in question vary among predator species, and also with different times, locations and habitats for each species.
- We summarise this variation by presenting averages and ranges of values from studies conducted at different times and places throughout New Zealand.

Conclusions

- The information summarised here will allow realistic parameters to be estimated for spatial models of predator population dynamics.
- Modelling will provide estimates of how the size and spatial arrangement of non-participating properties could affect the outcomes of predator control over the broader

landscape, and will enable simulation of various scenarios for landowner ‘buy-in’ to predator control activities.

Recommendations

- Movement data (e.g. from trapping or telemetry) for possums, stoats, ferrets and cats should be sub-sampled at various time intervals to determine optimal trap spacing.
- Spatial modelling using the data summarised here should investigate how the size and spatial configuration of properties opting out of predator control could influence the overall effectiveness of the *Cape to City* programme.

1 Introduction

Hawke's Bay Regional Council (HBRC) currently controls possums over a broad area encompassing large numbers of private properties. As part of its *Cape to City* proposal, HBRC intends to broaden the focus of possum management to include invasive predators (stoats, ferrets and feral cats). Because of the large number of landowners and varying land uses in the management area, and because landowner participation in pest control is voluntary, there are likely to be areas where predator control is either not applied or is less effective. This could potentially undermine the benefits of predator control at a broad scale. Spatial modelling could be used to investigate how the broad-scale efficacy of predator control might be influenced by patches of land in which the target species are not effectively controlled. Such modelling requires realistic parameter estimates relating to the movements and capture probability of predator species. HBRC contracted Landcare Research in 2014 to review existing information on predator ecology and movements in preparation for modelling.

2 Background

If some landholders do not participate in a wide-scale predator control programme, there are a range of possible outcomes. (1) Isolated populations of pest animals may persist in untreated areas, while treated areas are effectively protected from their impacts. (2) Predators in untreated areas may continually reinvade treated areas, potentially undermining the benefits of control across the whole area. (3) Predators in untreated areas may eventually go extinct due to the inherent vulnerability of small, isolated populations.

The following factors determine whether untreated areas within a wider pest control zone undermine the effectiveness of large-scale control:

1. Size and number of untreated areas
2. Effects of predators on biodiversity at the edge of the treated area
3. Ability of pests to disperse between untreated areas (spatial configuration of controlled areas and degree of connectivity between areas with no control).

Assuming predator control is effective where it is applied, a patchwork of untreated areas will effectively form a metapopulation of predators. The ability of that metapopulation to persist in the long term depends on the extinction probabilities of the individual sub-populations, and the probability of predators moving between the sub-populations. Population viability analysis can predict the probability that a metapopulation will persist over a given time frame. The parameters for such a model can be estimated using information from the literature, including data on home range size and dispersal distances of pest species, rates of mortality and reproduction, and so on. This literature review summarises the known information on the home ranges and movements of possums, feral cats, ferrets and stoats to provide a range of realistic estimates for such a model's parameters. Based on this framework, spatially explicit modelling could then be used to estimate the likelihood of predators surviving in untreated patches, and the long-term probability that a predator metapopulation could persist within the larger management area.

3 Objectives

- Summarise the biological characteristics of possums, stoats, ferrets and feral cats in New Zealand that influence their ability to persist in patches of land where pest control is not effectively applied.
- Review home range and habitat use, dispersal ability and capture probability at different spatial scales with the aim of using the information to pre-empt and mitigate reinvasion.

4 Methods

We collated published information on the biological characteristics of these four species of invasive predators in New Zealand likely to influence the dynamics of their metapopulations. These include:

- Home range and habitat
- Movement and dispersal
- Capture probability.

5 Results

Information was collated from a wide variety of sources. Methods varied between studies, for example, information about animal movement was variously obtained from trapping data, radio-tracking and GPS tracking; therefore parameter estimates may not be comparable between studies. However, the information summarised here provides realistic estimates of maxima and minima, which are the key parameters required for spatial modelling. Maximum dispersal distances may have been underestimated because animals that move furthest are the hardest to locate, and some may not be found (Caley & Morriss 2001).

5.1 Possum

5.1.1 Home range and habitat

Possums (*Trichosurus vulpecula*) are habitat generalists, able to live anywhere there is food and cover (Cowan 2005). For shelter they can use a variety of native and introduced vegetation types, wood piles, burrows of other animals (Cowan 2005), as well as rock crevices (Rouco et al. 2013), buildings and machinery (NPCA 2000). Willow trees may help to support high densities of possums by providing preferred food and den sites (Fairweather et al. 1987; Brockie et al. 1997; Glen et al. 2012).

Home ranges vary according to habitat type (Table 1). In highly productive forest habitat home ranges are between 0.6 and 3.4 ha (Cowan & Clout 2000). Much larger home ranges have been observed in drylands (Rouco et al. 2013) and in mixed forest / farmland habitat (Green & Coleman 1986). Individual possums may travel up to 1600 m across pasture, with home ranges up to 60 ha (Brockie et al. 1997). Home range size may also be influenced by population density, and may increase when populations are reduced by control measures (Pech et al. 2010; Whyte et al. 2014).

Table 1 Home range sizes of possums in New Zealand

<i>Habitat</i>	<i>Season</i>	<i>Sex</i>	<i>Sample size</i>	<i>Home range (ha ± SE)</i>	<i>Min–Max</i>	<i>Reference</i>
South island shrub / tussock	All	F	14	4.2	0.2–11.6	Byrom et al. (2008)
		M	8	10.2	0.4–31.1	
Central Otago grassland	Autumn	M/F	205	36.2		Rouco et al. (2013)
		M/F	165	54.1		
North Island pine plantation	Autumn	M/F	112	4.4		Efford et al. (2005)
North Island beech forest (possum control)	Summer	M/F	10	10.2 ± 2.2		Pech et al. (2010)
North Island beech forest (possum control)	Winter	M/F	14	9.5 ± 1.6		
North Island beech forest (no possum control)	Summer	M/F	9	3.5 ± 0.3		
North Island beech forest (no possum control)	Winter	M/F	17	2.8 ± 0.3		
South Island farmland / beech forest	All	M	9	6.9 ± 1.1	2.8–12.8	Ball et al. (2005)
		F	9	5.1 ± 0.9	1.8–9.6	

5.1.2 Dispersal

Overall, about 20–30% of possums disperse when they reach maturity (Cowan et al. 1996; Cowan 2005). However, males are more likely to disperse than females. A spatial model of bovine tuberculosis in possums (Ramsey & Efford 2010) assumed that around 75% of juvenile males and 14% of juvenile females disperse from their natal home range. The average dispersal distance used in the model was 4 km for males and 1 km for females (Ramsey & Efford 2010). Dispersal distance averages around 5 km (Cowan & Clout 2000) but may range from 0 to 41 km (Table 2). Dispersal behaviour does not appear to be influenced by population density (Cowan et al. 1997).

Table 2 Dispersal distances of possums in New Zealand

<i>Habitat</i>	<i>Sample size</i>	<i>Median dispersal (km)</i>	<i>Min–Max</i>	<i>Reference</i>
Hawke’s Bay farmland	17	5	3–25	Cowan et al. (1996)
Hawke’s Bay farmland	15	4.3	2–12.8	Cowan et al. (1997)
South Island shrub–tussock	35	1.5	0–4.9	Glen et al. (2012)
South Island beech forest	3	4.5	3.5–10	Clout & Efford (1984)
North Island podocarp–broadleaved forest	10	3.5	2–9	Clout & Efford (1984)

5.2 Ferret

5.2.1 Home range and habitat

Home range size of ferrets (*Mustela furo*) varies between habitats (Table 3), but is typically around 140 ha for males and 100 ha for females (Byrom et al. in press). Ferrets increase the size of their home ranges at times of low food availability, for example after rabbit population control (Norbury et al. 1998a).

The mean home range length in Otago and the Mackenzie Basin was 1.7 ± 0.5 km. No differences were found between males and females (Norbury et al. 1998b). Using the average range size for female ferrets (135 ha) or the smallest (73 ha) then control stations should be spaced less than 1310 m or 964 m apart, respectively. However, more than one control station per home range will probably be required to ensure all trappable residents are removed (Moller & Alterio 1999).

Ferrets show strong selection for certain habitats. In East Otago Ragg and Moller (2000) found that ferrets showed a very strong preference for denning in built structures and farmyard. Although these habitats comprised <1% of the study area they contained the majority of ferret den sites. Ferrets also selected for tree plantations and patches of gorse (*Ulex europaeus*) and matagouri (*Discaria toumatou*). Ferrets were more likely to be found close to fence lines, possibly because these are often associated with trees and shrubs (Ragg & Moller 2000).

Table 3 Home range sizes of ferrets in New Zealand. Adapted from Byrom et al. (in press)

Habitat	Season	Sex	Sample size	Home range (ha)	Min–Max	Reference
Mackenzie Basin	Varied	M	5	288	190–372	Pierce (1987)
		F	7	111	44–225	
East Otago	Autumn–winter	M	7	86	39–131	Ragg (1997)
		F	10	45	18–89	
Otago/Mackenzie Basin	All	M	34	102	19–316	Norbury et al. (1998a)
		F	28	76	16–240	
Otago Peninsula	Spring/autumn	M	6	163	95–220	Moller & Alterio (1999)
		F	10	135	73–206	
North Canterbury	Winter–spring	M	5	194	60–320	Spurr et al. (1997)
		F	10	99	50–150	
North Canterbury	Summer–autumn	M	4	139	2–220	Young (1998)
		F	4	151	62–314	
North Canterbury	Summer–autumn	M	1	80	80	Young (1998)
		F	11	128	28–265	
North Canterbury	Autumn–spring	M	1	760		Caley & Morriss (2001)
		F	5	230		
Otago Peninsula	Winter	M	1	107		Dymond (1991)
South Island shrub / tussock	All	M	5	178	63–294	Yockney et al. (2013) (adapted from Byrom et al. (2008))
		F	7	52	13–91	

5.2.2 Dispersal

Male and female ferrets are equally likely to disperse, and 50% of juvenile ferrets move more than 2–5 km from their place of birth (Caley & Morriss 2001; Byrom 2002). Most dispersal occurs during late summer (late February and early March), with no sex difference in mean dispersal distance (Caley & Morriss 2001; Byrom 2002, 2004; Byrom et al. 2008). Ferrets dispersed non-directionally across pasture habitat in North Canterbury with a mean dispersal distance of 2.1 ± 1.0 (SE) km (Caley & Morriss 2001), whereas in the Mackenzie Basin dispersal was directional, following braided riverbed channels, and mean dispersal distances were longer (males 6.7 ± 1.6 km; females, 11.8 ± 3.4 km; Byrom 2002).

In a mix of pasture, scrub and riverbed habitat in inland Marlborough, maximum distances travelled by ferrets of both sexes were 10–20 km (Byrom 2004; Byrom et al. 2008).

Movements of ferrets vary considerably between sites (Table 4) and this has considerable implications for the management of ferrets. Both the required size of ferret control operations to remove resident ferrets and the widths of depopulated buffer zones to minimise immigration will vary as a consequence (Caley & Morriss 2001).

Table 4 Dispersal distances of ferrets in New Zealand

<i>Habitat</i>	<i>Sample size</i>	<i>Median dispersal (km)</i>	<i>Min–Max</i>	<i>Reference</i>
Mackenzie Basin	34	5	0.5–45	Byrom (2002)
North Canterbury	22	1.2	0.1–21.7	Caley & Morriss (2001)
North Canterbury	10	2.5	0–10.7	Byrom (2004)
North Canterbury	19	1.0	0.3–20	Byrom et al. (2008)

5.3 Stoat

5.3.1 Home range and habitat

Stoats (*Mustela erminea*) are habitat generalists capable of living anywhere there is sufficient prey. This includes all native and exotic vegetation types at any elevation (Smith et al. 2008), as well as highly modified rural and suburban habitats. However, in farmland they prefer areas of cover such as gullies with dense scrub or patches of long grass (King & Murphy 2005).

Home ranges are variable in size and spatial arrangement, depending mainly on prey availability. Table 5 summarises estimated stoat home ranges in a variety of seasons and habitats. When prey (and therefore stoats) are highly abundant following a mast year, home ranges may become smaller or may overlap extensively (King & Murphy 2005). Home ranges may also be very small where abundant prey are concentrated in a small area such as a colony of ground-nesting birds (Cuthbert & Sommer 2002).

Male stoats may travel beyond their usual home range while searching for mates in spring (Erlinge & Sandell 1986). Female stoats reduce movement activity during the breeding season (Murphy & Dowding 1995; Robitaille & Raymond 1995). In a live-trapping study in Fiordland inter-trap distances of recaptured stoats ranged from 0.4 to 1.6 km (King & McMillan 1982).

Table 5 Home ranges of stoats in New Zealand. Modified from King & Murphy (2005)

<i>Habitat</i>	<i>Season</i>	<i>Sex</i>	<i>Sample size</i>	<i>Home range (ha ± SE)</i>	<i>Min–Max</i>	<i>Reference</i>
South Island beech forest	Summer–autumn	M	4	206 ± 73	29–368	Murphy & Dowding (1994)
		F	5	124 ± 21	20–186	
South Island beech forest	Summer–autumn	M	3	93 ± 7	50–105	Murphy & Dowding (1995)
		F	4	69 ± 8	56–88	
South Island beech forest	Spring	M	4	223 ± 45	130–324	Alterio (1998)
		F	7	94 ± 13	54–135	
North Island podocarp forest	Winter	M	6	65 ± 15		Young (1998)
		F	3	40 ± 11		
Otago coastal grassland	Spring	M	3	110 ± 28	66–161	Moller & Alterio (1999)
	Autumn	M	3	153 ± 31	115–215	
	Autumn	F	2	84 ± 52	32–135	
South Island podocarp forest	Spring	M	8	256 ± 38	97–452	Miller et al. (2001)
	Autumn	M	2	145 ± 35	96–175	
	Winter	F	2	123 ± 6	117–129	
	Spring	F	5	79 ± 21	30–144	
	Summer	F	3	102 ± 36	32–153	
Alpine tussock	Spring	M	2	48 ± 0.2	48–48	Cuthbert & Sommer (2002)
	Summer	M	4	16 ± 2.3	13–19	
	Summer	F	2	9 ± 0.1	8–9	
Braided riverbed	Spring	M	13	313 ± 63		Dowding & Elliott (2003, unpubl. report DOC Investigation 3405)
	Autumn	M	13	185 ± 29		
	Spring	F	3	127 ± 79		
	Autumn	F	7	116 ± 21		
Alpine tussock / beech forest	Summer	M	7	127 ± 30	17–252	Smith & Jamieson (2003)
	Summer	F	4	50 ± 7	34–70	
North Island kauri / podocarp forest	Most	M	9	107 ± 20	8–209	(Gillies et al. 2007)
	Summer–autumn	F	2	81 ± 31	51–112	

5.3.2 Dispersal

Juvenile stoats disperse in summer and autumn, and may move up to 65 km (Murphy & Dowding 1995). Although a higher proportion of males than females appear to undergo long-range movements (King & McMillan 1982), the longest recorded dispersal was by a female (Murphy & Dowding 1995).

Table 6 Dispersal distances of stoats in New Zealand

<i>Habitat</i>	<i>Sample size</i>	<i>Median dispersal (km)</i>	<i>Min–Max</i>	<i>Reference</i>
South Island beech forest	7	15	6–24	King & McMillan (1982)
South Island beech forest	4	2	2–65	Murphy & Dowding (1995)

5.4 Feral cat

5.4.1 Home range and habitat

Feral cats (*Felis catus*) are found in most habitats in New Zealand (Gillies & Fitzgerald 2005), but may show a preference for areas of thick vegetation cover (Alterio et al. 1998; Harper 2007). Home ranges often overlap extensively, although individual cats usually defend a small territory at the core of their home range (Gillies & Fitzgerald 2005). Feral cats on farmland in Hawke’s Bay mainly used farm buildings or willow trees as den sites (Langham 1992).

5.4.2 Dispersal

Young male cats disperse from their maternal home range at 1–3 years of age (Fitzgerald & Karl 1986; Gillies & Fitzgerald 2005). Young cats have been recorded to disperse outside their previous home range (Langham & Porter 1991), but their subsequent fate is unknown; therefore we are unaware of any estimates of dispersal distance for feral cats.

Table 7 Home range sizes of feral cats in New Zealand. Adapted from Gillies & Fitzgerald (2005)

<i>Habitat</i>	<i>Sex</i>	<i>Sample size</i>	<i>Home range (ha ± SE)</i>	<i>Min–Max</i>	<i>Reference</i>
North Island mixed forest / farmland	M	14	446 ± 82	122–1053	Gillies et al. (2007)
	F	7	117 ± 40	19–274	
Peri-urban kauri–podocarp forest	M	2	275	210–340	Dowding (1997, unpubl. report to DOC [Waitakere Ranges])
	F	1	160		
Farmland with bush fragments	M	7	48 ± 8	16–74	Dowding (1998, unpubl. DM Consultants report to DOC Auckland Conservancy [Motuihe])
	F	7	46 ± 19	12–141	
Hawke’s Bay farmland (nocturnal)	M	4	239 ± 97		Langham & Porter (1991)
	F	9	154 ± 21		
Hawke’s Bay farmland (diurnal)	M	7	134 ± 85		
	F	12	91 ± 67		
North Island mixed podocarp–broadleaved forest	M	4	155 ± 56	50–310	Fitzgerald & Karl (1986)
	F	5	84 ± 24	20–170	
Braided riverbed	M	5	705 ± 125	490–1192	Pierce (1987)
	F	6	635 ± 196	272–1571	
South Island tussock grassland	M	9	189 ± 73	42–742	Norbury et al. (1998b)
	F	13	249 ± 58	79–840	
South Island tussock grassland	M	2	190	180–200	Baker (1989)
	F	2	99	52–145	
Coastal grassland	M	7	207 ± 37	90–358	Moller & Alterio (1999)
	F	3	148 ± 36	75–186	
Mixed forest / shrubland	M	4	2083 ± 915	1210–3317	Harper (2007)
	F	3	1109 ± 92	1031–1210	
Braided river valley	M	5	876 ± 423	178–2486	Recio et al. (2010)
	F	1	908		
Braided river valley (autumn)	M	5	490 ± 210		Recio & Seddon (2013)
	F	4	371 ± 59		
Braided river valley (spring)	M	4	1209 ± 261		
	F	3	121 ± 3		
Braided river valley (summer)	M	4	878 ± 232		
	F	3	305 ± 77		
Braided river valley (winter)	M	6	821 ± 317		
	F	5	246 ± 144		

6 Spatial detection parameters

The likelihood of capturing/killing or detecting an animal with a trap or other detection device depends on:

- How far apart the traps are placed
- How far the animal moves in the course of its daily activities
- How long the traps are in place.

The optimal trap spacing to capture animals will therefore depend on two spatial detection parameters, known as $g\theta$ (g-naught) and σ (sigma). $g\theta$ is the probability that a device placed at the centre of the animal's home range will detect that animal on any given day (Efford 2004).

Moving away from the home range centre, detection probability decreases until we reach the edge of the animal's home range. At this point the detection probability approaches zero because the animal is unlikely ever to visit that location. For an animal with a large home range, detection probability will only decline gradually with increasing distance from the home range centre; for an animal with a small home range it will decrease sharply. This rate of decline in detection probability is known as σ (Efford 2004).

The higher the $g\theta$, the greater the probability of each trap capturing an animal on a given night. Therefore, a high $g\theta$ means that relatively little trapping effort should be required; this may mean small numbers of traps and/or trapping only for short periods. Conversely if $g\theta$ is low we can expect that large numbers of traps would need to be set for long periods to increase the probability of catching the target animal.

A high value for σ means that a trap does not have to be very close to the animal's home range centre to have a high probability of catching the animal. The higher the σ , the further apart traps can be spaced. On the other hand, if σ is low the animal is unlikely to be caught unless a trap is placed near the middle of its home range. In this case traps must be set close together to ensure every resident animal has at least one trap close to the centre of its home range.

Based on mark-recapture data, values of $g\theta$ and σ have been estimated for a range of mammals in New Zealand (Byrom et al. unpubl. data). Table 8 summarises estimates of $g\theta$ and σ for possums, ferrets and stoats. No data are available for feral cats. Computer modelling would be required to estimate the optimal trapping effort and trap spacing for each species but, as an example, the data for ferrets in Table 8 suggest that traps spaced ~400 m apart and left in place for 2 weeks would have a high probability of catching most resident ferrets.

Trap placement may also be guided by animal movement data from trapping or telemetry. Byrom et al. (unpubl.) sub-sampled movement data for ship rats at time intervals of 1–28 days. This allowed inference on how trap spacing affected the likelihood of rats encountering a trap.

Table 8 Spatial detection parameters $g0$ and σ for possums, ferrets and stoats using various detection devices in a range of habitats. Adapted from Byrom et al. unpubl. data

<i>Species</i>	<i>g0 (min–max)</i>	<i>σ (min–max)</i>	<i>Device</i>	<i>Season</i>	<i>Reference</i>	<i>Location(habitat)</i>
Possum	0.05	63	Victor #1 leg-hold traps	May–December	Ball et al. (2005)	Mt Somers
	0.093–0.115	39.8–40.5	Live-trap	Varied	Efford (2004)	Orongorongo Valley
Stoat	0.024–0.113	162–482	Hair tube/ genotype ID	Summer	Efford et al. (2009)	Matakitaki Valley (red beech forest)
	0.03	518	Hair tube/ genotype ID	Winter	Clayton et al. (2011)	Resolution Island (mixed coastal forest to alpine)
	0.040–0.077	429–891	Live-trap (Elliott B with nest box, & Edgar)	Summer	Smith et al. (2008)	Fiordland (beech forest)
	0.017–0.047	521–726	Live-trap (Elliott B with nest box, & Edgar)	Summer	Smith et al. (2008)	Fiordland (alpine grassland)
Ferret	0.079	466	Victor #1 leg-hold traps	Summer and autumn	Norbury & Efford (2004)	(semi-arid dry grassland)

7 Patchiness of predator control

Individual properties that do not take part in regional-scale pest control are likely to harbour predators that could continually reinvade the controlled area. Based on the information presented above on movement behaviours and capture probabilities, modelling should be able to predict the maximum property size that could be excluded from wide-scale pest control in Hawke's Bay without compromising the overall effectiveness of the *Cape to City* programme. In addition, modelling could simulate different spatial configurations of properties. For example, if two adjacent properties of 1000 ha each decline to take part in predator control, the risk to overall success will be higher than if they are 100 km apart.

8 Core and halo effects

When pest control is applied to a defined area, animals (both native and invasive) may move into and out of that area. Therefore the area over which pest control has a measurable effect is usually not the same as the area over which control effort is actively applied.

The term 'core effect' (or 'edge effect') refers to a situation where pest species continually reinvade an area from which they are being removed. Because of reinvasion the benefits of pest control may apply only within a smaller 'core' near the centre of the treated area (Glen et al. 2013; Nathan 2013).

The opposite of the core effect is the 'halo effect' (or spillover effect), in which the benefits of pest control extend beyond the treated area (Glen et al. 2013; Nathan 2013). This may occur, for example, if pest animals living in adjacent areas are captured during occasional forays into the treated area. Strong halo effects may mean that control is effective over a broader landscape despite the fact that some properties do not participate.

There is evidence for both core and halo effects occurring at the same time. For example, in the Waitakere Ranges the biodiversity benefits of rat control extended beyond the boundaries of the control area. At the same time, however, there was less biodiversity at the edge of the control area than at its centre (Nathan 2013).

9 Next steps

Collating movement data of predators is the first step towards allowing us to make inference about the maximum property sizes that could be excluded, and also to simulate the spatial configuration of properties that could be excluded. The next step will be to model spatially various configurations of such scenarios in order to determine the maximum property size, or combinations of property sizes, that can be excluded without compromising regional-wide gains in key predator control.

10 Conclusions and recommendations

- The information summarised here will allow realistic parameters to be estimated for spatial models of predator population dynamics.
- Modelling will provide estimates of how the size and spatial arrangement of non-participating properties could affect the outcomes of predator control over the broader landscape, and will enable simulation of various scenarios for landowner 'buy-in' to predator control activities. Movement data (e.g. from trapping or telemetry) for possums, stoats, ferrets and cats should be sub-sampled at various time intervals to determine optimal trap spacing. Ideally this would use data obtained from *Cape to City* project area; however data from similar habitats may still be indicative.
- Spatial modelling using the data summarised here should investigate how the size and spatial configuration of properties opting out of predator control could influence the overall effectiveness of the *Cape to City* programme.

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