Milestone 3.3 Linking predator camera trap monitoring to biodiversity and economic benefits: how to derive density-impact functions for Cape-to-City

Follow-up report to Hawke's Bay Regional Council

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Introduction

Our recent report to Hawkes Bay Regional Council, entitled "Milestone 3.3 Linking predator camera trap monitoring to biodiversity and economic benefits: density-impact functions in principle", outlined the general principles of pest density-impact functions (DIFs), their utility for biodiversity protection, and their potential shortcomings. The current report extends these principles to Cape-to-City by outlining a framework for coupling biodiversity (or toxoplasmosis) data with predator abundance data in an ecologically meaningful way.

Ecologically-informed coupling of biodiversity and predator data

A DIF assumes a causal relationship between predators and biodiversity. Therefore, it is critical that the spatial and temporal characteristics of this causal relationship are taken into account when measures of predator abundance are linked to the biodiversity measures of interest for a given place and time. For example, only those predators that move into the home range of an individual prey will affect its chances of survival, whereas distant predators are irrelevant. We propose a simple way of selecting data for DIFs based on the mobility of prey species and the predator species that affect them.

Prey spatial data

The first step in deriving a DIF is to map where the prey species of interest is monitored. Some species, such as lizards, have small home ranges and an individual is likely to be detected at only one *monitoring site* (e.g. where a single tracking tunnel is located), whereas other species, like pāteke, move extensively and an individual could be detected at many sites. The extent to which prey species move between sites is described in a simple fashion by drawing circular halos of movement around each monitoring site – the radii of which equal the approximate home range width of individuals. If there are no overlapping circles, a single monitoring site is an independent *sampling unit*, enabling the prey data collected at this site to contribute independent points to a DIF. Overlapping circles imply non-independence at the site scale: the group of sites connected by overlapping circles constitutes an independent sampling unit. In this case, data will be averaged across the sites within the group to generate a single data point that the sampling unit can provide for a DIF.

Predator spatial data

A list of predator species that have a detrimental impact on biodiversity outcomes at Cape-to-City will be compiled. For a given prey species, data from the predator monitoring devices within the prey movement halo for each independent sampling unit (i.e. independent site or independent group of sites), will be averaged and coupled with the matching prey data. Because predators towards the edge of a prey halo can live partly outside but still affect the prey within the halo, a buffer area reflecting the approximate home range width of the predator will be added to the outside of the prey halo, and the extra monitoring devices included in the data. This larger area constitutes the 'sphere of influence' of predators on the prey monitored at each independent sampling unit.

Temporal data

Temporal aspects of the data also need to be considered when deriving DIFs as predators and prey are measured repeatedly at each monitoring site. At Poutiri Ao ō Tāne, predators, invertebrates and lizards are measured once every year. At Cape-to-City, predators (using cameras) are measured once every year in spring, while predators (using tracking tunnels and road counts), birds, invertebrates and lizards are measured twice every year in autumn and spring. The question is to what extent can repeated measures at the same site be used as independent data points in a DIF? Annual measures are probably fine for prey populations that change appreciably between measures. However, a spring measure followed by an autumn measure over a given 6-month period tend to represent the same general population at the time, and so are more likely to violate rules of independence. In fact, spring and autumn measures should probably be treated separately in DIFs as spring is the pre-breeding population and autumn includes new recruits. Also, animal detectability will be different at these times due to different behaviours (e.g. searching for mates in spring) and different climatic conditions. Clearly, matching temporal measures of predators and prey requires careful attention.

Capturing relevant data

We will use GIS technology to map spheres of predator influence around each independent prey sampling unit. For each predator species, this will generate a list of predator monitoring sites that can be coupled to each independent prey sampling unit. The list will be linked to the monitoring databases to allow rapid production of a DIF for each predator-prey combination.

Example 1: Cat – lizard DIF

A cat-lizard DIF should be relatively simple to construct. Small lizards are not very mobile (tens of metres) so those living at a given lizard sampling unit (a sampling unit is shown as a cluster of purple dots in Fig. 1) will not move between units given they are at least 1 km apart. Cats, on the other hand, are quite mobile so their sphere of influence (red circles, Fig. 1) on a given lizard sampling unit will be quite large. If cameras (blue and red dots, Fig. 1) are used to index cat abundance, cameras within each sphere of influence will be coupled with the relevant lizard sampling unit. In this example, there is potential for up to 15 data points to be generated for a DIF for a given monitoring session. Figure 1 illustrates an unintended consequence of the existing distribution of predator monitoring sites. Some of the sixteen spheres of influence have many cameras (although some are temporary cameras that move in a rolling front with the predator control), many have only one or two cameras, and one lizard sampling unit has no cameras and therefore will not contribute data to a cat-lizard DIF. This illustrates the need for some extra predator monitoring that may be required to fill data gaps.

Example 2: Multi-predator – lizard DIF

Given that mustelids and hedgehogs also kill lizards, it may be more informative to pool the abundance of cats, mustelids and hedgehogs into a single DIF. This requires multiple spheres of influence around each lizard sampling unit (Fig. 2). The relevant predator monitoring data will be taken from each sphere and compiled into a single estimate. Again, this could generate up to 16 data points for a given time period. However, in this case, the camera monitoring sites would provide very uneven data on the suite of predators associated with each lizard sampling unit. For example, for the northern-most lizard sampling unit, one camera could provide data on cats but there are no cameras within the spheres of influence for mustelids or hedgehogs. The solution might be to include data from other monitoring devices. For example, tracking tunnels at the lizard monitoring sites could provide data on mustelids. Or as mentioned above, deployment of extra cameras would be needed to fill these gaps.

Example 3: Mustelid – pāteke DIF

Pāteke are quite mobile, moving often between wetland sites (indicated by yellow dots in Fig. 3). Assuming the yellow circles around wetland sites (Fig. 3) represent the extent of movements by pāteke, overlapping circles indicate a single pāteke population. Each population is indexed by averaging monitoring data for pāteke within overlapping circles. In this example, three wetland sites in the southern part of C2C constitute one sampling unit that would be used to index the southern population, and 10 wetlands sites in the north constitute a second sampling unit for the northern population. Indices of mustelid abundance would be derived by averaging data from cameras within the overlapping circles, plus those in the buffer zone outside the circles (i.e. the buffer zone extends to the blue line, Fig. 3). This example would provide only two data points for a given monitoring session. The estimates for each data point need to take into account differences in the number of monitoring sites (wetlands and camera locations) in the sampling units for the northern and southern pāteke populations.

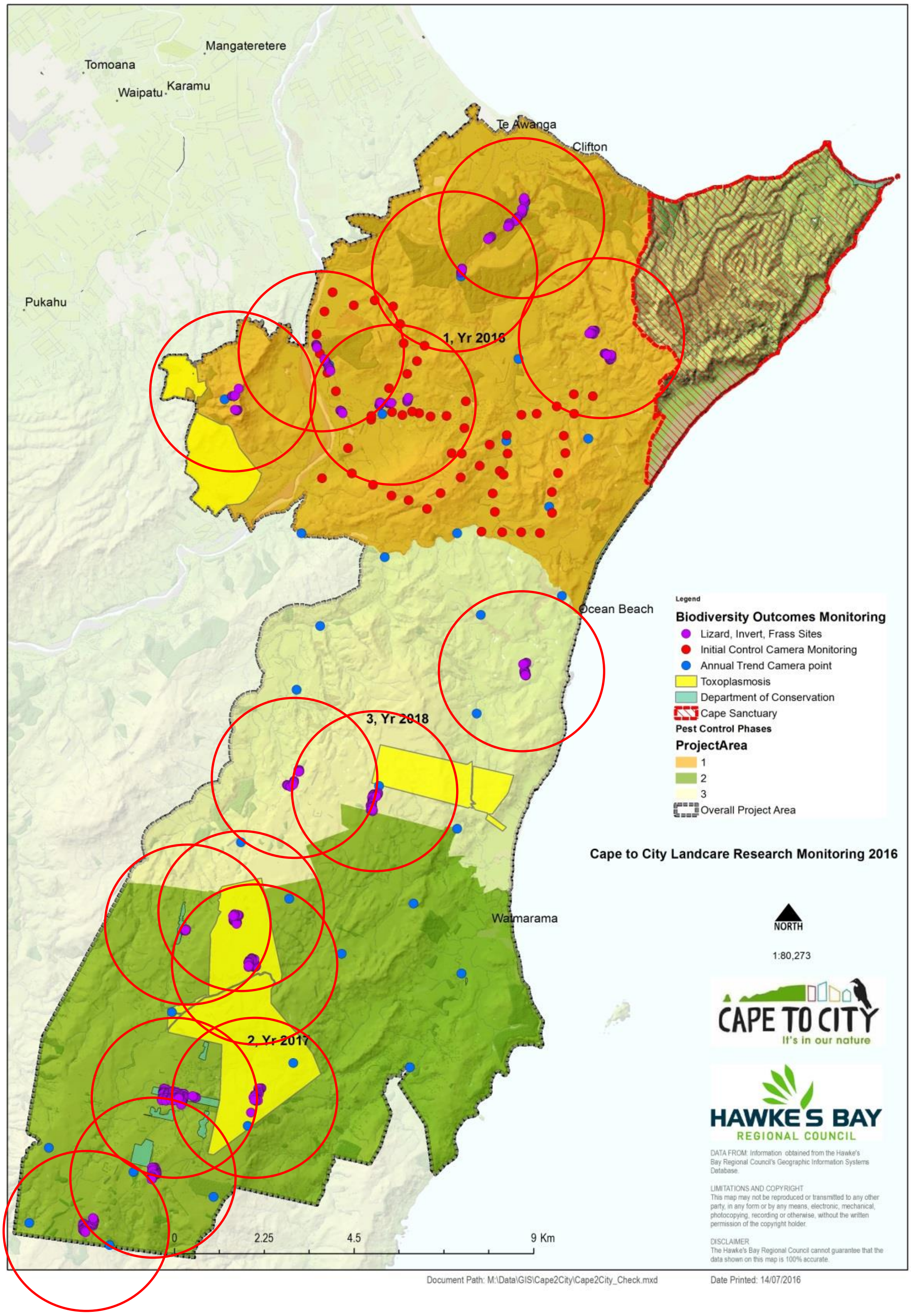

Fig. 1. 'Spheres of influence' of cats (red circles) on clusters of lizard monitoring sites (purple dots). Cat data from predator monitoring cameras (blue dots = permanent cameras; red dots = temporary cameras that move with predator control) within each sphere will be matched to the relevant cluster of lizard monitoring sites within. Lizard movement halos are tiny in this graphic as they are restricted to each cluster.

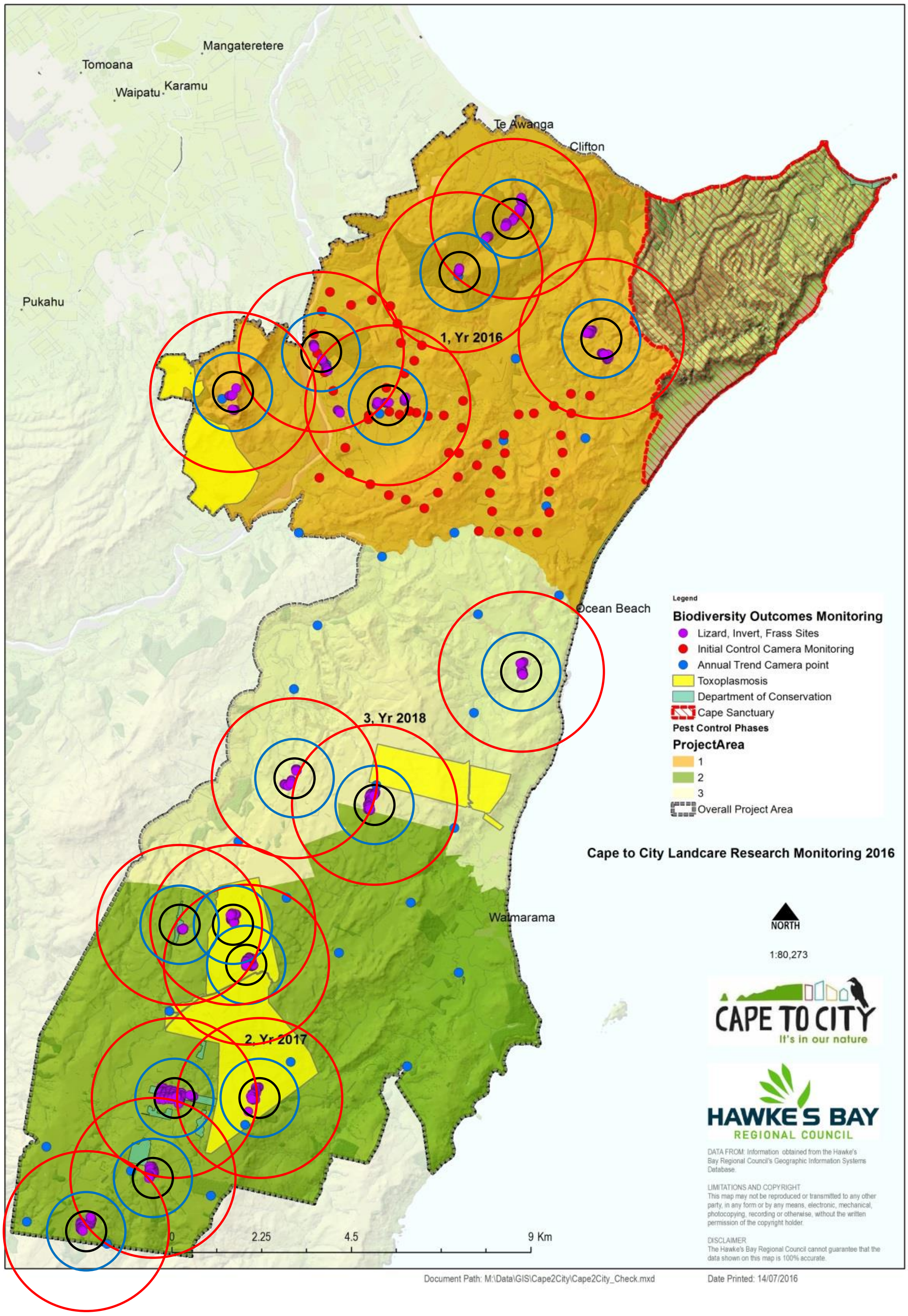

Fig. 2. 'Spheres of influence' of cats (red circles), mustelids (blue circles) and hedgehogs (black circles) on clusters of lizard monitoring sites (purple dots). Cat data will be taken from predator monitoring cameras (blue and red dots) within the red circles, mustelid data from within the blue circles, and hedgehog data from within the black circles, and collectively matched to the relevant lizard monitoring cluster within.

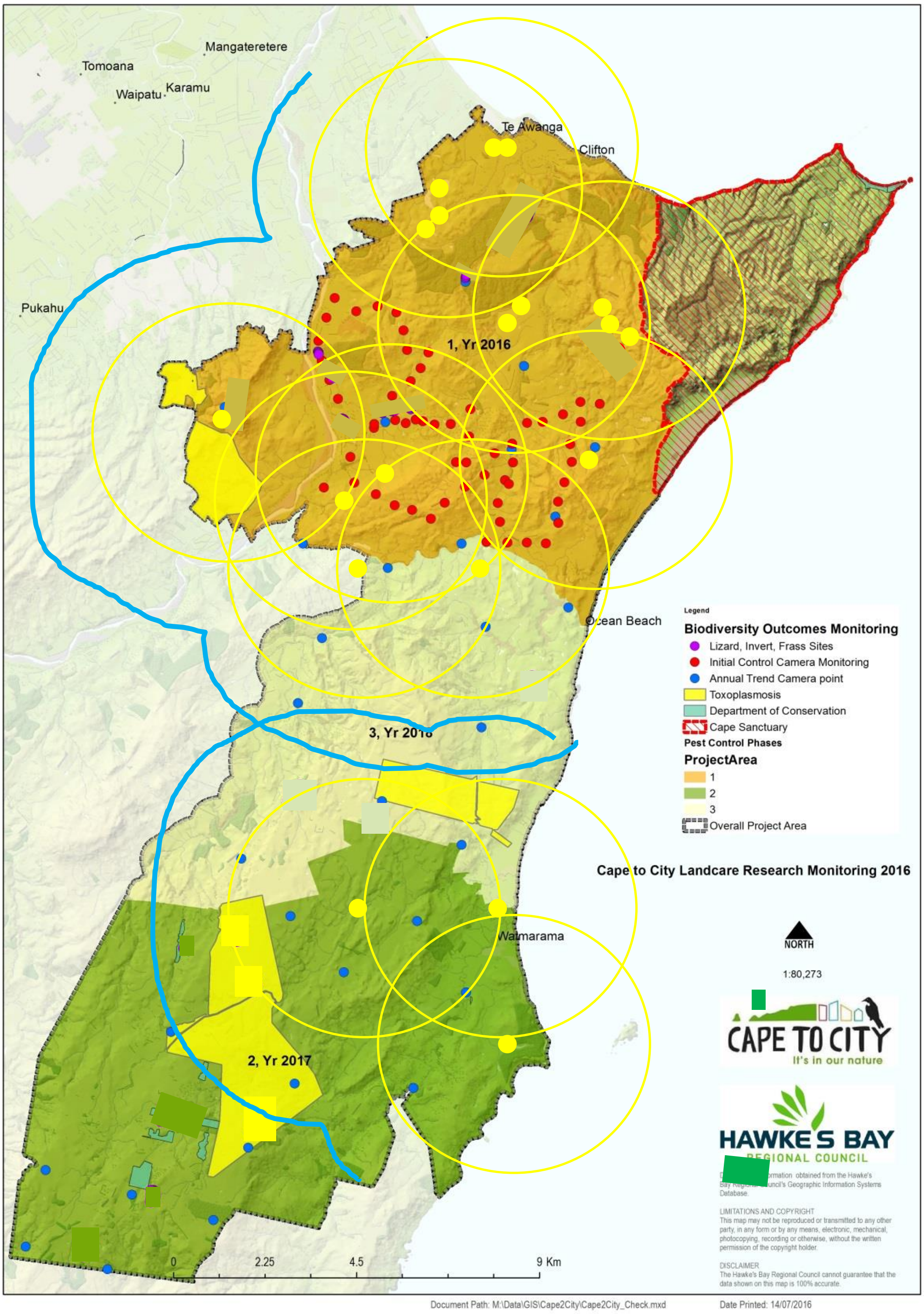

Fig. 3. 'Spheres of influence' of mustelids (within blue boundaries) on hypothetical northern and southern sampling units of pāteke sub-populations, based on overlapping pāteke movements (yellow circles) between wetland monitoring sites (yellow dots). Mustelid data from predator monitoring cameras (blue and red dots) within each sphere of influence will be matched to the relevant pāteke sampling units within.

Spreadsheet framework for coupling prey and predator data

A framework for coupling monitoring data for the examples 1 and 3 above is shown in the hypothetical spreadsheet below (Fig. 4). For a cat-lizard DIF, each 'AR' monitoring site, for example (where artificial retreats are used to monitor lizards), is an independent sampling unit that would generate data to index lizard abundance. The sphere of influence of cats has a 2000-m radius around each lizard sampling unit. Therefore, the cat monitoring devices (in this case, cameras) within a 2000-m radius of each lizard sampling unit would be used to provide an index of cat abundance. There are 16 independent sampling units for lizards: these generate 15 data points for each monitoring session (AR11 has no associated data on cat abundance).

For a mustelid-pāteke DIF, pāteke move between wetlands up to 4000 m apart, for example. By this definition, there is a southern population that is monitored at a sampling unit comprising three wetland sites, and a northern population whose sampling unit comprises 10 sites. Mustelids have a sphere of influence that extends 1000 m further out from the pāteke movement halos. Therefore, cameras within 5000 m of each sampling unit are used to monitor mustelid abundance. The data are averaged across camera sites to generate 2 data points for a given monitoring session.

									Predator monitoring devices to estimate predator abundance				
				Predator mobility	Cats	Mustelids	Hogs	Rats	Cats	Mustelids	Hogs	Rats	
				HR width (m)	2000	1000	500	100	yes	yes	yes		Trap catch
										yes	yes	yes	TTs
					Radius of predator sphere of influence (m)				yes	yes	yes		Roads
					= prey mobility + predator mobility				yes	yes	yes	yes	Cameras
Prey	Monitoring sites	Habitat	Mobility	Key predators	Cats	Mustelids	Hogs	Rats					
Lizards	AR1	grass	0	C M H R	2000	1000	500	100	1				
Lizards	AR2	native forest	0	C M H R	2000	1000	500	100	5				
Lizards	AR3	grass	0	C M H R	2000	1000	500	100	4				
Lizards	AR4	grass	0	C M H R	2000	1000	500	100	12				
Lizards	AR5	grass	0	C M H R	2000	1000	500	100	24				
Lizards	AR6	grass	0	C M H R	2000	1000	500	100	2				
Lizards	AR7	grass	0	C M H R	2000	1000	500	100	2				
Lizards	AR8	grass	0	C M H R	2000	1000	500	100	1				
Lizards	AR9	grass	0	C M H R	2000	1000	500	100	1				
Lizards	AR10	grass	0	C M H R	2000	1000	500	100	2				
Lizards	AR11	grass	0	C M H R	2000	1000	500	100	0				
Lizards	AR12	grass	0	C M H R	2000	1000	500	100	1				
Lizards	AR13	grass	0	C M H R	2000	1000	500	100	2				
Lizards	AR14	grass	0	C M H R	2000	1000	500	100	1				
Lizards	AR15	grass	0	C M H R	2000	1000	500	100	3				
Lizards	AR16	grass	0	C M H R	2000	1000	500	100	3				
Pateke	Wetland1	wetland	4000	C M	6000	5000							
Pateke	Wetland2	wetland	4000	C M	6000	5000							
Pateke	Wetland3	wetland	4000	C M	6000	5000							
Pateke	Wetland4	wetland	4000	C M	6000	5000		10 sites pooled		70			
Pateke	Wetland5	wetland	4000	C M	6000	5000							
Pateke	Wetland6	wetland	4000	C M	6000	5000							
Pateke	Wetland7	wetland	4000	C M	6000	5000							
Pateke	Wetland8	wetland	4000	C M	6000	5000							
Pateke	Wetland9	wetland	4000	C M	6000	5000							
Pateke	Wetland10	wetland	4000	C M	6000	5000							
Pateke	Wetland11	wetland	4000	C M	6000	5000		3 sites pooled		8			
Pateke	Wetland12	wetland	4000	C M	6000	5000							
Pateke	Wetland13	wetland	4000	C M	6000	5000							

Fig. 4. Hypothetical spreadsheet that couples data from predator and prey monitoring sites. The 16 independent lizard monitoring sites in example 1 are highlighted in yellow. These link to a variable number of cat monitoring cameras (maximum of 24 for site AR5, minimum zero for site AR11) around each lizard site. The wetland monitoring sites for the northern and southern sub-populations of pāteke in example 3 are highlighted in blue. Ten monitoring sites in the north comprise one sampling unit (consisting of 70 cameras), and 3 sites in the south comprise a second sampling unit (consisting of 8 cameras).