

## Cape to City and Poutiri Ao o Tāne

### Research Catalogue

January 2018

There has been a significant research funding component of the Cape to City project, with research underpinning the development of new methods and techniques. This document provides a comprehensive list of each research report, summary of findings and where to locate it.

#### *Pest Control*

(Unpublished report) Brown, S.J., Latham, C. and Warburton, B. 2016 Cape to City project: Using chew cards to map possum and predator distribution across the landscape. Unpublished Landcare Research Contract Report LC2582, prepared for Hawke's Bay Regional Council.

Brown (et al., 2016) assessed the effect of varying chew card deployment times on the number of kills per positive detection and the percentage kill achieved using detection followed by control. This includes mapping areas of low, medium and high possum abundance and mapping predator distribution across the study area comparing the sensitivity of predator chew cards and possum chew cards for detecting predators. The authors concluded that 14 days appeared to be the optimal deployment length for possum chew cards. Using chew cards in patches of possum habitat greater than 1ha plus a 100m buffer around it should detect the majority of possums. Feral cat and mustelid distribution needs further confirmation, and if camera traps are not available predator chew cards should be used for detecting feral cats and either predator or possum chew cards for detecting mustelids and rodents.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Published paper) Garvey, P.M., Glen, A.S., Clout, M.N., Wyse, S.V., Nichols, M. and Pech, R.P. 2017 Exploiting interspecific olfactory communication to monitor predators, *Ecological Applications*, 27(2): 389-403.

The authors devised a field experiment to investigate whether dominant predator (ferret) body odour would alter the behavior of three common mesopredators (stoats, hedgehogs and ship rats). They found that stoats exhibited the most pronounced responses, with kairomones significantly increasing the number of observations and time spent at the site, so that their occupancy estimates changed from rare to widespread. A long life lure derived from apex predator kairomones could have practical value, especially when there are plentiful resources that reduce efficiency of food-based lures.

*Published: Ecological Applications*

(Unpublished report) Glen, A.S. and Byrom, A.E. 2015. Implications of landholder buy-in for the success of regional-scale predator control: Part 1: Review of predator movements. Unpublished Landcare Research Contract Report LC1956, prepared for Hawke's Bay Regional Council.

Glen and Byrom (2015) collated published information on the biological characteristics of possums, stoats, ferrets and feral cats likely to influence the dynamics of their metapopulations. The authors found that the biological characteristics in question vary among species, and also with different times, locations and habitats for each species. These characteristics are summarised in the report. The information provided is a first step in allowing realistic parameters to be established for spatial models of predator population dynamics. This research underpins further modelling to provide estimates of how 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.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(submitted) Glen, A.S., Perry, M., Yockney, I., Cave, S., Gormley, A.M., Leckie, C., Dickson, R., Rakete-Stones, W., Rakete-Stones, P., Norbury, G.L. and Ruscoe, W.A. Wide-scale predator control for biodiversity conservation: a case study from Hawke's Bay, New Zealand, *New Zealand Journal of Ecology*.

Invasive predators were controlled over 6000ha of farmland adjacent to conservation reserve where intensive predator control had been in place for over a decade. Site occupancy rates of cats and mustelids, as well as hedgehogs were significantly lower than those in an adjacent non-treatment area. Occupancy of invasive rats was higher in the treatment area, while occupancy of mice showed no difference between treatments. There was evidence of positive responses of some native biodiversity, with occupancy rates of native lizards increasing significantly in the treatment area, but other invertebrates were detected in similar numbers in both areas. Results showed that low-cost predator control in a pastoral landscape can reduce invasive predator populations, with apparent benefits for some native fauna.

*Submitted*

(Published paper) Glen, A.S., Latham, M.C., Anderson, D., Leckie, C., Niemiec, R., Pech, R.P. and Byrom, A.E. 2016 Landholder participation in regional-scale control of invasive predators: an adaptable landscape model, *Biological Invasions*, 19: 329-338.

Glen (et al., 2016) developed a spatial model to estimate the effects of varying levels of landholder participation in a landscape-scale program to control invasive predators. Various scenarios for landholder participation was used, including variations in participation rate as well as the size and location of non-participating properties and how this influences the effectiveness of trapping predators.

The authors found that non-participation by owners of small properties (<25ha) had a negligible effect on the success of predator control. If owners of large properties (>800ha) failed to participate, reinvasion by predators from these properties reduced the effectiveness of control; however this could be offset by placing additional traps on the nearest participating properties.

*Published: Biological Invasions*

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Glen, A., Norbury, G., Garvey, P. and Dickson, R. 2017 Effectiveness of feral cat control using para-aminopropiophenone (PAPP) on Toronui Station, Hawke's Bay. Unpublished Landcare Research Contract Report LC2743, prepared for Hawke's Bay Regional Council.

Glen (et al., 2017) estimated the percentage reduction in the feral cat population following para-aminopropiophenone (PAPP) baiting conducted in September 2016 using camera traps three weeks before and after baiting had finished. The authors found a single application of PAPP baits reduced the relative abundance of feral cats by about 50%. It is likely that a second application would have contributed to a greater reduction and is recommended that future PAPP operations comprise two bait applications a few days apart.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(In prep) Gormley, A.M. and Warburton, B. 2015 Optimising a kill-trap network for cost-effective predator control, *PLoS One*.

There is a possibility that when establishing a permanent trap network, the initial number of devices is higher than required for long-term maintenance of a low density pest population. Some of the devices may have become redundant and their removal might reduce the cost of checking and maintaining the network, without reducing its effectiveness. The simulation showed that even when 75% of traps are removed, close to 80% of the actual target animals could still be captured. Figures derived are likely to be conservative because there was no attempt to selectively remove traps based on their past performance ie. 70% of traps had caught no target species in 30 months of trapping while 3.5% of traps captured at least three animals. This analysis indicates there are potentially significant savings to be made, at least in the maintenance phase of a long-term predator control programme.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished) Gormley, A. and Warburton, B. 2017 TrapSim: A decision-support tool for simulating predator trapping. Unpublished Landcare Research Contract Report LC2993, prepared for Hawke's Bay Regional Council.

The main objective of this project was to provide an online decision-support tool to simulate the trapping of target predators (stoats, ferrets and feral cats) in the Cape to City footprint. The aim is to provide managers with a way of exploring how different trap network designs can affect the relative effectiveness of predator-trapping outcomes.

For example, the brief simulations performed showed that if a species is at a density of c. 0.1/ha, then reducing the trap network to just 25% of the original traps will not be enough to suppress its population size. The simulations also highlight that species will respond differently to a trapping regime due to factors such as home range size, trappability and reproductive rates.

TrapSim is freely available at: [https://landcare.shinyapps.io/TrapSim\\_C2C/](https://landcare.shinyapps.io/TrapSim_C2C/)

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished) Latham, A.D.M., Latham, M.C. and Warburton, B. 2017 Effect of predator control at Poutiri Ao o Tāne on Boundary Stream Mainland Island, Unpublished Landcare Research Contract Report LC2824, prepared for Hawke's Bay Regional Council.

The authors aimed to analyse the benefits to Boundary Stream Mainland Island (BSMI) in terms of predator abundance indices resulting from predator control at Poutiri Ao o Tāne. However the results from the DOC database were equivocal, and so it is not possible to say with certainty whether trapping at Poutiri Ao o Tāne has reduced the number of predators trapped at BSMI. The analysis demonstrates the need to design data collection carefully to answer the question of how predator control in one area also benefits adjacent areas.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

Norbury, G.L., Pech, R.P., Byrom, A.E. and Innes, J. 2015 Density-impact functions for terrestrial vertebrate pests and indigenous biota: Guidelines for conservation managers, *Biological Conservation*, 191: 409-420.

Norbury (et al., 2015) identify the need to understand the relationship between the density of a pest and its impact on a valued resource for cost-effective management. The paper provides empirical evidence for six theoretical forms of density-impact-functions (DIFs). Five guidelines were identified to help conservation managers derive and use DIFs in a way that maximises their value without overextending their utility: 1) minimise influences of factors other than pests; 2) where necessary, undertake site-specific experiments, rather than generalising from other studies; 3) use time scales that recognise delays for biota to adjust to pest control; 4) measure instantaneous responses (e.g. demographic rates) as early indicators; and 5) use DIFs to guide short-term pest management, and trophic-interactive modelling for longer-term management.

Published: *Biological Conservation*

(In progress) Modelling the Cape to City trap data to optimise use of wireless technology.

Report not yet available

(In progress) Conduct a ferret body odour longevity trial to determine how long odour lasts, and therefore how often it needs to be refreshed in the field.

Report not yet available

(In progress) Identify the type of data that needs to be collected on Public Conservation Land and adjacent land to understand the mutual putative benefits of predator control.

Report not yet available

## Pest Monitoring

similar trapping programme in 2014 which the abundance of cats and ferrets declined by 90% after three weeks of trapping. The difference may be due to reinvasion from adjacent properties in the Cape to City area where there is no predator control.

Note: after the results of the monitoring a follow up post control trapping programme was conducted with cage traps, leg holds followed by a night shooting mop up.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Published paper) Glen, A.S., Anderson, D., Veltman, C.J., Garvey, P. and Nichols, M. 2016 Wildlife detector dogs and camera traps: a comparison of techniques for detecting feral cats, *New Zealand Journal of Zoology*, 43: 127-137.

Glen (et al, 2016) acknowledge the challenge in monitoring pest species as they decline to very low densities with effective control. The report compares the cost effectiveness of two methods, camera traps and wildlife detector dogs for detecting feral cats on two pastoral properties in Hawke's Bay. One property was subject to intensive control while the other had no recent history of pest control. Both techniques detected cats at similar rates at both sites and the total cost was comparable; however camera traps had higher set up costs and lower operating costs than wildlife detector dogs.

Published: *New Zealand Journal of Zoology*

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Glen, A., Norbury, G., Warburton, B. and Pech, R. 2016 Predator monitoring for compliance in Cape to City: Discussion paper. Unpublished Landcare Research Contract Report, prepared for Hawke's Bay Regional Council.

In the scaling up of predator control programmes across many private landowners, there is a risk from a lack control effort on some individual properties could allow predators to reinvade surrounding areas, reducing the overall effectiveness of the programme. Glen's (et al., 2016) report discusses how camera traps might be used to monitor predators on individual farms for compliance purposes. The report addresses questions of what to measure, how to measure it, when to measure it and what threshold to set for compliance/non-compliance.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Published paper) Jones, C., Warburton, B., Carver, J. and Carver, D. 2015 Potential applications of wireless sensor networks for wildlife trapping and monitoring programs, *Wildlife Society Bulletin*, 39, 341-348.

Jones (et al., 2015) identify large costs in maintaining mammal trapping programs, primarily in labour and travel costs incurred from frequently checking large numbers of traps. The authors quantified cost savings through wireless sensor networks. Using a modelled example, they found operational savings of up to 70% from use of wireless sensors. Cost savings increased with number of traps in a network, but declined as rates of sprung traps increased. A simple cost-benefit analysis showed wireless networks are justified economically, but authors identified the need to legislator requirements and long life bait are needed to capitalize on potential savings.

Published *Wildlife Society Bulletin*

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Nichols, M. and Glen, A. 2015 Camera trapping to monitor the results of predator removal on Waitere Station, Unpublished Landcare Research Report.

Nichols and Glen (2015) assessed the ability of camera traps as a non-invasive method for monitoring the presence of feral cats and determining the optimal statistical approach to estimate cat abundance. Using data from camera traps on two properties, one with and one without predator control three different modelling methods were assessed for accuracy and precision: capture-recapture, occupancy modelling, and the newly developed spatial presence-absence (SPA) model. The authors found that the SPA model gave robust estimates of change in cat abundance and the occupancy model also showed significant decrease in cat presence. Optimal spacing between each camera trap within the grid was also determined by statistically removing every second camera. These results help provide an affordable and robust procedure for monitoring feral cats.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Published paper) Nichols, M., Garvey, P., Glen, A.S. and Ross, J. 2017 Influence of horizontal versus vertical camera placement to detect feral cats and mustelids, *New Zealand Journal of Ecology*, 41 (1), 145-150.

Nichols (et al., 2017) aimed to determine the optimal camera alignment (horizontal or vertical) for detecting feral cats and mustelids. Using 20 pairs of cameras, the number of target species, non-target species and false triggers were compared. Horizontally oriented cameras captured approximately 1.5 times as many images of the target species compared with vertically oriented cameras, and also detected more non-target animals.

*Published: New Zealand Journal of Ecology*

(Unpublished report) Norbury, G., Champion, M., Brown, S. and Garvey, P. 2017 Milestone 1.5 Conduct a ferret body odour longevity trial to determine how long odour lasts, and therefore how often it needs to be refreshed in the field. Unpublished Landcare Research Progress Report, prepared for Hawke's Bay Regional Council.

This report details the preliminary findings of a chemical assay trial to determine the amount of odour compounds remaining on bedding material at various time intervals up to 12 months.

There was no discernible loss of odour over one week, and very low amounts of odour remaining on 12 month samples taken from the Lake Opouahi Kiwi Creche. The fact that some heavier components could still be detected in the old samples is encouraging. Indeed, HBRC staff could still smell ferret on these samples suggesting they may still have some attraction to predators. However, heavier compounds that remain after a year are usually only detectable if the nose is in contact or almost touching the towel. Even though compounds may still be present, their low volatility may mean they are of limited use as a lure.

Results from the synthetic lure research, in conjunction with the longevity trial, will help inform how frequently lures need to be replaced. The longevity trial has identified different decay rates for a suite of compounds, but it may be that just one or a few of these compounds attract stoats. The synthetic lure research will use pen trials to identify which compounds provoke attraction, and by

linking this to the longevity trial, can accurately assess of how long the lure remains attractive in the field.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Warburton, B., Jones, C. and Ekanayake, J. 2015 Remote monitoring of traps using wireless-based systems. Unpublished Landcare Research Contract Report LC2341, prepared for Hawke's Bay Regional Council.

Warburton (et al., 2015) reviewed wireless trial results from an operational delivery perspective. The report concludes that the integration of wireless sensor network (WSN) systems into large-scale permanent trap networks has the potential to delivery significant savings through the reduction in trap checking time. Extent of savings depends on the scale of networks, the availability of long-life bait and the capture rate.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Warburton, B. 2017 Economic assessment of using wireless monitoring for managing large scale trap networks. Unpublished Landcare Research Contract Report LC2915, prepared for Hawke's Bay Regional Council.

This report aims to determine the cost-effectiveness of using wirelessly monitored trap networks to optimise control based on a pilot trial using 99 live capture cages located over ~700ha of farmland within the Cape to City footprint. To measure the potential savings of using wireless trap monitoring, two trappers were used: one inspecting all traps (i.e. to comply with the legal trap inspection requirements), and one checking only those traps signalled as having been sprung.

Warburton concluded that using wireless trap monitoring technology can provide significant savings when live-capture traps that require daily inspections are used. As trap checking frequency declines, as it does when kill traps are used, the savings from using wireless monitoring also decline. If savings are re-invested to increase the number of traps being serviced by one trapper, there would need to be a contingency plan in case the wireless system malfunctioned, and sufficient additional staff would need to be available to inspect all traps directly. Other benefits (mostly non-monetised) could be accounted for in order to justify the use of wireless systems. Such benefits might include: increased community support and participation in the predator control programme; use of the capture data for monitoring farmer compliance and effectiveness; trap network optimisation; and possibly improved animal welfare.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Draft) Nichols, M., Gormley, A., Garvey, P., Glen, A.S. and Ross, J. Estimating abundance of feral cats: a comparison of techniques, *Methods in Ecology and Evolution*.

Report not yet available/Draft

(In Progress) Predator response monitoring at Poutiri Ao ō Tāne and Cape to City.

*Report not yet available*

(In Progress) Socially-acceptable compliance monitoring of predators. In anticipation of HBRC's extension of the RPMP to include enforceable predator control, examine socially-acceptable predator monitoring options for properties of different sizes, including options that do not necessarily involve cameras, such as use of wireless trapping.

*Report not yet available*

### *Biodiversity Outcomes*

(unpublished report) Burge, O.R., Innes, J., Fitzgerald, N. and Richardson, S.J. 2017 Habitat availability for native New Zealand bird species within the Cape to City footprint: a preliminary assessment. Unpublished Landcare Research Contract Report LC2898, prepared for Hawke's Bay Regional Council.

Burge and others investigate the amount of habitat for native forest birds within the Cape to City footprint. Alongside this objective they also assess habitat quality and functional connectivity (species-specific connectivity) to identify areas for increasing connectivity for native forest bird species within the Cape to City footprint.

Based on conclusions drawn from the report, the authors recommend retaining mature forestry plantations in the northern portion of the footprint and encourage landowners to increase seasonal food resources available to far ranging species like tūī, bellbird and kākārīki, through planting trees across farms, or around existing ponds (and households). Also recommended is maximising the benefit of riparian plantings by selecting species that will provide food for native birds and consider whether it is possible to facilitate the use of the footprint by non-forest birds such as wetland birds and birds that use pasture of habitat.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(unpublished report) Glen, A. and Norbury, G. 2016 Biodiversity monitoring in Cape to City: lizards and invertebrates. Unpublished Landcare Research Contract Report, prepared for Hawke's Bay Regional Council.

This report addresses Te Matau a Maui contract milestone 2.2: Biodiversity response monitoring and analysis of preliminary data from C2C footprint. Design and rollout of biodiversity monitoring system in pest-controlled and untreated areas, including restored habitats along Maraetotara River. The monitoring was designed to sample two broad habitat types: forest and open 'rough' habitat. Between November 2015 and January 2016, biodiversity monitoring lines were established both within Cape to City project area and in an adjacent non treatment area. These lines consisted of various devices for detecting wildlife including tracking tunnels, tree wraps, artificial cover objects, frass funnels and artificial retreats. Baseline data on distribution and relative abundance has been obtained for native lizards and invertebrates.

(Unpublished report) Innes, J. and Fitzgerald, N. 2016 Potential bird-related research in the Cape-to-City Project, Hawke's Bay. Unpublished Landcare Research Contract Report LC2618, prepared for Hawke's Bay Regional Council.

Innes and Fitzgerald (2016) have identified the limited knowledge we have of bird movements, including natal dispersal and breeding dispersal despite these processes acknowledged to be critical components of population viability. This information is important for managers designing planting to aid bird connectivity. The authors specify three possible research avenues of habitat planting that may be useful including value of planting connecting vegetation, value of planting plantations to increase the habitat area and the value of planting food trees in residential properties. These avenues are not necessarily separate as riparian planting may fulfil all three.

The authors go on to discuss different research methods for monitoring bird movements including presence/absence of birds by basic observational surveys/acoustic recorders, bird banding and use of VHF transmitters. Additionally, five possible Cape to City bird or bird-related studies are also identified.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Published paper) Johnstone-MacLeod, L., Dickson, R., Leckie, C., Stephenson, B.M. and Glen, A.S. 2015 Possum control and bird recovery in an urban landscape, New Zealand, *Conservation Evidence*, 12: 44-47.

Johnstone-MacLeod's report analyses results from five minute bird counts conducted before and after possum control in residential Napier Hill area. They found significant increases in the relative abundance of bellbird and tui though to result from an increase in food supply with the removal of competition from possums. Kereru numbers remained stable and a significant decline in relative abundance of silvereye was recorded.

*Published: Conservation Evidence*

(Unpublished report) McLennan, J. 2017 The Cape to City programme: baseline bird counts in treatment and non-treatment areas, Prepared for the Cape to City Governance Group.

This report describes the results of bird and small mammal counts, undertaken in 2015/16, in three areas relevant to the Cape to City programme: in Cape Sanctuary, within the Cape to City footprint and in a non treatment area. The results show that the abundance of forest birds is currently influenced mainly by forest type and predator management. In general, native birds were most abundant in native forests while introduced birds were most abundant in exotic forests. Grey warbler and tui are currently the most abundant native species in the counting areas. These baseline counts have quantified the differences in bird numbers are between Cape Sanctuary, and Cape to City. Some species of Cape Sanctuary origin are already attempting to establish in the Cape to City footprint. The degree to which they are likely to succeed is discussed in the report, with pateke and kakariki identified as key indicator species.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Norbury, G. and McLennan, J. 2015 Biodiversity and predator monitoring for Cape-to-City, Hawke's Bay Project. Unpublished Landcare Research Contract Report LC2237, prepared for Hawke's Bay Regional Council.

Norbury and McLennan (2015) develop a robust biodiversity monitoring programme for Cape to City. They conclude that the inclusion of areas with no pest control is a fundamental requirement for inferring causative effects of the pest control in Cape to City. The primary tools recommended for monitoring pest numbers are camera traps and tracking tunnels. Trap catch will provide cost free data, but only from the treatment area.

Depending on the bird species, modified 5 minutes counts in forest patches, ponds and wetlands, and along country roads are recommended. Bird monitoring should include Cape Sanctuary as this is the source of a number of emigrating species into Cape to City.

Recommended methods for monitoring lizard numbers are artificial retreats and tracking tunnels in open areas, and tracking tunnels and tree wraps in forest patches where rat control is proposed.

Recommended methods for monitoring invertebrates are artificial retreats and tracking tunnels for ground dwelling species, weta houses for mid-canopy species in forest patches and funnel traps for canopy species in forest patches.

The authors also point out the critical role citizen science plays in pest and biodiversity monitoring.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Norbury, G., Glen, A. and Pech, R. 2017 Linking predator camera trap monitoring to biodiversity and economic benefits: density-impact functions in principle. Unpublished Landcare Research Scoping Report, prepared for Hawke's Bay Regional Council.

The authors have identified a gap in knowledge of knowing the control effort required to achieve desired benefits. The critical gap is the form of the relationship between pest density and pest impact, called a 'density-impact function' (DIF). The report concludes that data collected in the Cape to City and Poutiri Ao ō Tāne projects have the potential to generate DIFs for invertebrates, lizards, birds and toxoplasmosis provided they are interpreted in light of other potential influences.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Norbury, G., Glen, A. and Pech, R. 2017 Linking predator camera trap monitoring to biodiversity and economic benefits: how to derive density-impact functions for Cape to City. Unpublished Landcare Research Follow Up Report, prepared for Hawke's Bay Regional Council.

This report follows on from *Linking predator camera trap monitoring to biodiversity and economic benefits: density-impact functions in principle*.

Norbury and others extends the principles of density-impact functions to Cape to City by outlining a framework for coupling biodiversity (or toxoplasmosis) data with predator abundance data in an ecologically meaningful way.

The report goes on to discuss the causal relationship between predators and biodiversity, and the spatial and temporal characteristics that must be taken into account. Three types of data are identified: prey spatial data, predator spatial data and temporal data.

The authors use GIS 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.

Three examples of DIF's are constructed; cat/lizard, multi-predator/lizard and mustelid-pāteke.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Watts, C., Holdaway, R., Davis, C., Wood, J., Thomson, F., Thornburrow, D. and Dickie, I. 2016 Invertebrate services within Cape to City and comparison of environmental DNA with conventional invertebrate community monitoring: Research Synthesis 2015/2016. Unpublished Landcare Research Contract Report LC2541, prepared for Hawke's Bay Regional Council.

Watts (et al., 2016) review the role of invertebrates in ecosystems services, provide information on how invertebrates contribute to the diet of mammalian predators and discuss how invertebrates may respond to release from mammal predation over the short and long term. The authors also characterise the invertebrate fauna, and in particular the beetle community of Mohi Bush Scenic Reserve using conventional invertebrate community techniques and additionally use environmental DNA extracted from soil to compare the two monitoring techniques. Key recommendations that have come from the results is monitoring of large-bodied taxa, and surveying to determine whether host-specific threatened invertebrate species are habitat or predator limited. Environmental DNA can provide high detail data on entire invertebrate communities for similar cost to conventional monitoring. A number of areas for methodological improvement have also been identified.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Submitted) Watts, C., Dopheide, A., Holdaway, R., Davis, C., Wood, J., Thornburrow, D. And Dickie, I.A. 2017 DNA metabarcoding as a new tool for invertebrate community monitoring – a case study comparison with conventional techniques, *Restoration Ecology*.

Monitoring invertebrates has often lagged behind larger fauna because collecting, sorting, and identifying invertebrates using conventional monitoring techniques is often expensive, time-consuming, and restricted by expertise in diagnostics. Emerging DNA metabarcoding techniques could potentially revolutionise monitoring of invertebrates by providing the ability to characterise entire communities from a single easily collected environmental sample. Watts and others compared two DNA metabarcoding approaches and conventional monitoring to characterise the invertebrate fauna of an isolated, coastal forest fragment. The bulk invertebrate DNA metabarcoding method was able to reproduce ecological patterns observed in the beetle community detected using conventional sampling. The soil DNA metabarcoding method detected a different beetle community and a more diverse array of invertebrate taxa than conventional sampling techniques, providing additional biodiversity data at no extra cost.

*Submitted: Restoration Ecology*

*(In progress)* Glen, A. and Norbury, G. 2017 Cape to City and Poutiri Ao ō Tāne: pest and biodiversity responses. Unpublished Landcare Research Progress Report, prepared for Hawke's Bay Regional Council.

*Report not yet available*

*(In progress)* Identify best options for increasing habitat connectivity in the Cape to City footprint. Map existing woody vegetation, identify benign approaches for enhancing woody vegetation cover on private land and review the economic benefits of restoration plantings.

*Report not yet available*

*(In progress)* Pest density-impact functions. Develop a GIS-based data management system for the Cape to City project that will allow rapid comparisons of predator abundances with outcome monitoring data, and identify additional predator monitoring that may be required to fill data gaps.

*Report not yet available*

*(In progress)* National framework for pest density-impact functions. Produce a document that sets the regional and national socio-political context of DIFs, outline a national co-ordinated approach to consistent data collection procedures, and explore options for curation of meta-data at a national level.

*Report not yet available*

*(In progress)* Baseline eDNA surveys of invertebrates. Select sites and plan an invertebrate eDNA sampling project that examines the habitat value of mānuka for invertebrates.

*Report not yet available*

*(In progress)* Review threatened and iconic plant, invertebrate, lizard and bat species in Cape to City, and recommend which taxa could be selected for further survey and possible translocations, and estimate survey costs.

*Report not yet available*

*(In progress)* Re-measure toxoplasmosis levels in sheep and cats. Collect blood sera from ewes in spring, and brain samples from cats, to assess prevalence and transmission routes of toxoplasmosis on the six study farms in the Cape to City and non-treatment sites.

*Report not yet available*

(Unpublished report) Cowan, P. and Warburton, B. 2016 Economic outcomes of broadscale predator control in the Hawke's Bay region. Unpublished Landcare Research Contract Report LC2738, prepared for Hawke's Bay Regional Council.

Cowan and Warburton (2016) review integrated economic outcomes of predator control by building on existing work already completed, identifying conditions that may need to change to optimize outcomes, and outlining knowledge gaps. The authors conclude that:

- Most of the direct economic benefits in the medium term are likely to accrue from possum control – the value of benefits is likely to greatly exceed the costs of predator control.
- Where rabbit numbers are high, control of ferrets for TB eradication may also have economic benefit but this has not been estimated.
- Control of feral cats to reduce impacts of toxoplasmosis has significant potential economic benefits, but likelihood and cost needs to be evaluated and compared to efficacy and cost of vaccination.
- Economic value of mitigating impacts on biodiversity values is poorly quantified. Nevertheless, contingent valuation and willingness-to-pay approaches consistently show New Zealanders attach a high value to native plants and animals.
- Evidence from market and sector surveys indicate many international markets value biodiversity and “clean-green” sources for primary products, but there are no dollar estimates available of how much these “green-credentials” are worth

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Tompkins, D.M. 2014 Potential of Feral Cat Control to Reduce the Incidence of Toxoplasmosis on Sheep Farms, Report Addendum

Tompkins (2014) considers the benefits of feral cat control through reduced sheep production losses due to toxoplasmosis and its management, in light of the recent epidemiological modelling literature. The report concludes that feral cat control is able to locally eradicate toxoplasmosis from sheep farms in the Hawke's Bay region, the estimated cost to the regions farming community in sheep vaccination against this disease as \$336 000 per annum would no longer be necessary to prevent the estimated \$1,032,180 per annum of lost lamb production.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) White, D. 2016 *Toxoplasma gondii* screening in cats and mice using PCR as part of the Cape to City initiative. Unpublished Landcare Research Report prepared for Hawke's Bay Regional Council.

This study aims to determine the impact of feral cat control on the prevalence of *Toxoplasmosis gondii* in ewes, and associated abortion rates, by reducing the abundance of this definitive host, thereby reducing opportunity for infection. A PCR assay was optimised for *T. gondii* using a vaccine as a positive control, and developed an effective *T. gondii* DNA extraction protocol from the brain tissue of cats and mice (an intermediary host).

Available on request

(Unpublished report) Tompkins, D. 2017 Progress report on impact of cat trapping on prevalence of *Toxoplasma gondii* in one year old ewes as part of the Cape to City initiative. Unpublished Landcare Research Report prepared for Hawke's Bay Regional Council.

This study is two years into a five year project, after feral cat trapping was initiated at case farms from April 2017. 60 ewes are tested for exposure to *T. gondii* using a serological assay in each of 6 farms – 3 case farms within the Cape to City footprint that included trapping, and 3 control farms outside the footprint that had no trapping. During August – November 2017, observed *T. gondii* seroprevalence in ewes ranged from 48.3% to 93.3% across the 6 study farms. *T. gondii* seroprevalence was greater in both case study and control farms in 2017 (an average of 69.2 %) than when previously assessed in 2015 (39.4 %). Mean relative increase in case farms ( $\Delta = 27.2\%$ ) was slightly less than in control farms ( $\Delta = 32.2\%$ ). In addition, monthly rainfall over 2015 and 2017 has been reviewed so that possible environmental drivers of *T. gondii* infection can be considered.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

### Unexpected Outcomes

(Published paper) Norbury, G. and Jones, C. 2015 Pests controlling pests: does predator control lead to greater European rabbit abundance in Australasia? *Mammal Review* 45, 79-87.

Norbury and Jones (2015) review evidence in the literature over concerns of rural landowners that local predator control to protect indigenous biota exacerbates European rabbit problems on their land. In New Zealand predators appear to have relatively little effect on rabbit numbers compared with other factors leading to mortality, such as disease, flooding of burrows and burrow collapse. However where rabbit numbers are low following drought or major epizootics, predation can limit population recovery. The authors also identify a key unresolved question whether circumstances where predator control might lead to increases in rabbit populations can be identified with enough certainty to allow reliable predictions to be generated.

Published: *Mammal Review*

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Published paper) Pech, R. and Maitland, M. 2016 Conservation of native fauna in highly invaded systems: managing mammalian predators in New Zealand, *Restoration Ecology*, 24: 816-820.

Pech and Maitland (2016), through a review of existing literature, investigate unexpected outcomes from mammalian predator control such as ecological release of other uncontrolled pest species and the creation of novel ecosystems by selective predator control and reintroductions of locally extinct or depleted native species.

They identify implications for practitioners as the need to consider using newly developed tools for controlling entire suites of invasive predators, routine long term monitoring of conservation outcomes and expansion of predator control across natural and agricultural areas of New Zealand.

Published: *Restoration Ecology*

Ruscoe, W., Glen, A., Perry, M., Dickson, R. and Forrester, G. 2016 Impacts of rabbit grazing on pasture in Hawke's Bay, New Zealand, *Wildlife Research*, WR16016.

Ruscoe (et al., 2016) undertook a grazing exclusion experiment to (1) estimate the impact of rabbit grazing on pasture biomass in Hawke's Bay, North Island, New Zealand, (2) estimate the cost of rabbit grazing in terms of lost livestock production, and; (3) compare this with the cost of rabbit control.

The study found that depending on their relative abundance, rabbits consumed enough pasture to support an additional 6.2-17.5 ewes ha<sup>-1</sup>. The estimated net annual benefit of controlling rabbits ranged from \$577ha<sup>-1</sup> at low rabbit abundance to NZ\$1707 ha<sup>-1</sup> at high abundance concluding that rabbit control is economically justified in Hawke's Bay even when rabbit abundance is relatively low.

*Published: Wildlife Research*

*(In progress)* Review potential for perverse ecological outcomes of the Cape to City programme.

Report not yet available

(In prep) Garvey, P., Nichols, M., Glen, A.S., Pech, R.P. and Clout, M.N. Response of mesopredators to removal of feral cats, *Journal of Applied Ecology*.

*Report not yet available/Draft*

## Social Reports

## Citizen Science

(Unpublished report) Gormley, A.M. and MacLeod, C.J. 2016 Assessment of Data Sources for Monitoring Birds in Cape to City, Landcare Research Contract Report LC2622.

Gormley and MacLeod (2016) identify that there has been a vast increase in the amount of species observations by members of the public. These citizen science records are arguably as valid as those collected by professional technicians. Issues arise however when we attempt to aggregate these 'unstructured' data into a metric for reporting purposes. Because they are often gathered opportunistically, there is little or no information on the observation process. There are some analyses that can be applied to unstructured data in order to mitigate the effects of the observation process. However, the authors conclude that if we wish to use citizen science data for reporting, we would ideally design a monitoring programme where methods are standardised and the collection process is coordinated in order to achieve good spatial coverage and result in a metric that is robust and repeatable.

The report goes on to describe the sources of bias and potential solutions associated with aggregated unstructured citizen science data and includes conclusions and recommendations for utilising such data sources.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

## Social Drivers

(Unpublished report) Brown, P. 2016 Cape to City project community survey – short report. Unpublished Landcare Research Contract Report, prepared for Hawke's Bay Regional Council.

Brown's community survey was designed to measure changes in the awareness, knowledge, and behaviour of the general public resulting from the Cape to City project. The survey was conducted November-December 2015. The report concludes that the Cape to City project is not yet well known, even inside the footprint. Respondents inside the footprint report seeing a greater variety of native birds and reptiles than those outside. Respondents inside the footprint also had a greater orientation towards environmental protection and are statistically more likely to donate to environmental causes, to permanently protect private land, to plant native trees in their gardens, and to engage in environmental teaching than those outside the footprint.

Available Cape to City website <http://capetocity.co.nz/resources/reports/>

(Unpublished report) Niemic, R. 2015 Resident perceptions related to Predator Control in the Cape to City Region: Results from the Rural Survey. Unpublished Report.

Niemic used a cross-sectional survey among 68 landowners to examine the willingness of rural landowners in the Cape to City region to engage in the Cape to City project, as well as the motivations and barriers that may be influencing landowners' decision-making regarding predator control. Findings concluded that the majority of landowners are likely to become engaged in Cape to City's initial control efforts, and a fair number of landowners are likely to continue maintenance control after an initial knockdown. The findings also suggest possible ways in which the programme could target outreach and education efforts to increase the likelihood that landowners will engage in the program.

Available on request

(Published paper) Niemiec, R.M., Pech, R., Norbury, G. and Byrom, A.E. 2017 Landowners' Perspectives on Coordinated, Landscape-Level Invasive Species Control: the Role of Social and Ecological Context, *Environmental Management*, 59:477-489.

Niemic conducted in person and mail surveys of 68 landowners in and adjacent to the area of proposed invasive predator control program. The study found that landowners consider the potential socio-economic and ecological benefits of invasive species control and express a strong desire to enhance native biodiversity. However, the study also found that landowners also consider the complexity of local social and ecological context of the programme. They consider 1) the level of contribution by other landowners and urban residents who are benefiting from collective control efforts; 2) the potential for the programme to upset the local "ecological balance", leading to increases in other pests; and 3) the probability that the program will be successful given the likelihood of others participating and control tactics being effective.

Published: *Environmental Management*

Niemiec, R.M., Pech, R., Norbury, G. and Byrom, A.E. 2017 Policy recommendations based on landholder's perspectives on co-ordinated pest control. Hawke's Bay Regional Council Policy Brief 2/1/2017.

The policy brief summarises Niemic's study background, key findings and policy recommendations. The brief contains policy recommendations addressing concerns about the potential for the program to be successful, concerns about fairness in contributions to the program and concerns about unintended increases in other unwanted pests.

*Available on request*

Ozarski, J.N. 2015 Cooperation for mutual benefit: opportunities for Primary Industry and the New Zealand Department of Conservation, Fulbright New Zealand: Wellington.

Ozarski's (2015) report tells the story of existing public-private sector partnerships and perceptions between the DOC and primary industry including lessons learned, opportunities for the future, and comparison with a relevant partnership example in the United States. Poutiri Ao ō Tāne was one of the case studies analysed. Ozarski (2015) concludes that there is "tremendous opportunity" for DOC to continue and expand partnerships with primary industry, and that the case studies and interviews have shown an interest by industry.

A secondary goal of the piece of research was to whether the quantified concepts of natural capital and ecosystem services applied to decision-making by business about public-private sector partnerships. Ozarski's research concluded that economic calculations and "bottom-line" numbers were not an important factor for any of the case studies or industry interviews. Instead partners were motivated by other factors such as personal relationships, a shared appreciation and dedication to the land, and being a good neighbour or corporate citizen.

*Published: Fulbright New Zealand*

### *Social-ecological Modelling*

(Unpublished report) Pech, R. 2016 Social, economic and biophysical thresholds with highest priority for generating outcomes, Unpublished Landcare Research Contract Report, prepared for Hawke's Bay Regional Council.

The success of the Cape-to-City programme (C2C) depends on effective control of predators through an initial co-ordinated programme and the subsequent efforts of individual landholders and the wider community. C2C is expected to result in enhanced native biodiversity and flow-on benefits from ecosystem services. Experience and research have shown that it is likely there are minimum management thresholds that need to be met to achieve these goals (e.g. Glen et al. 2016). One approach to estimating critical thresholds is via a social-ecological model that represents the factors that motivate people to participate in pest control and the effects of management intervention to suppress predators and re-establish native avian, reptile and invertebrate communities. The aim is to use this model to predict the outcomes of varying the types and level of intervention in supporting landholder engagement in C2C and in conducting predator control and biodiversity monitoring.

*Available Cape to City website <http://capetocity.co.nz/resources/reports/>*

*(In progress)* Set appropriate restoration goals to achieve biodiversity and cultural aspirations. Improve bird and cultural connectivity in the Maungaharuru ki Tangitu hapu by planning appropriate restoration methods. Report outcomes of hui with Maungaharuru ki Tangitu hapu, and provide written biodiversity inventory and restoration recommendations in conjunction with LCR's MBIE-funded Vision Matauranga.

*Report not yet available*

*(In progress)* Social networks for socio-ecological modelling. Research on landholders' influence on one another, agencies influence on landholders, and key influential landholders who might help catalyse actions, by providing data that couples landowners' actions during the Cape to City trapping roll-out with their views expressed in the rural survey.

*Report not yet available*

*(In progress)* Kaupapa Maori. Provide advice on how best to support Maori engagement through the research programme.

*Report not yet available*

### *Case Study*

(Unpublished report) Greenaway, A. 2015 Cape to City: A case study of socio-ecological transformation, Landcare Research Contract Report.

*2015: Project outline and purpose.*

Central questions for this case study includes documenting the changes in society that take place as a result of the Cape to City project and how these are linked to the success of the ecological restoration outcomes sought. Secondary questions include what challenges or opportunities do the processes of social change bring?

The case study documents the process of organising and implementing Cape to City from the social perspectives of those involves. It provides the project documentation from the individual perspectives of those involved in the project in a variety of ways.

Additionally, the case study can be aligned with the surveys to help communicate to future land managers, community groups, and researchers how practices valuing biodiversity are changing through socio-ecological transformation in the Hawke's Bay.

*Available on request*

(Draft) Reynolds, F. and Greenaway, A. 2017 Implementing social-ecological transformation through Cape to City and Poutiri Ao o Tāne: an interim case study report. Unpublished Landcare Research Contract Report prepared for Hawke's Bay Regional Council.

Using interviews thematically analysed and a literature review, the authors examined how social-ecological transformation is enabled through Cape to City and Poutiri Ao o Tāne. The authors conclude that the project appears to be around halfway through a potential transformation, and overall governance and project management is working well. Monitoring and evaluation, Maori engagement, context awareness, and leadership diversity are the biggest areas to improve.

*Available on request*

(In progress) Continue case study of C2C programme. Conduct third round of interviews with core management team members, including new people recently involved in the project, and run a reflective conversation workshop with members.

*Report not yet available*

## Education

(Unpublished report) Flood, S. 2017 Education review for Te Matau A Maui – Cape-to-City and Poutiri Ao o Tāne. Project discussion document. Unpublished Landcare Research Report prepared for Hawke's Bay Regional Council.

This report provides a proposed evaluation design to carry out an education review of Cape to City and Poutiri Ao o Tāne. Three overarching project milestones are to; (1) evaluate how gains are being made in the programmes by providing a baseline for evaluating the short to medium term persistence of programme effectiveness measured by learner and teacher attitudes and behaviours; (2) to develop a self-sustaining model for educational institutions to engage with the project; (3) record information which could support the project position in seeking external funding for development of long-term sustainable development initiatives.

*Available on request*

(Unpublished report) Flood, S. 2017 HBRC Aotearoa PFNZ: Project 5.1: Education review for Te Matau A Maui – Cape to City and Poutiri Ao o Tāne: Report on initial data analysis. Unpublished Landcare Research Contract Report, prepared for Hawke's Bay Regional Council.

The education review project is aiming to provide a baseline for evaluating the short to medium term persistence of the environmental education programme's effectiveness, measured by learner and teacher attitudes and behaviours in the Cape to City and Poutiri Ao o Tāne projects using interviews, questionnaires and other qualitative research methods. This report provides a review of evaluation data gathered over the life of the projects. These data provide invaluable lessons and insights for developing and executing the review over the next twelve months (to project completion).

*Available on request*



(In process) Evaluate changes resulting from the C2C and Poutiri Ao o Tane education programmes. Complete compilation of student and teacher actions, collate DOC data on evaluation feedback, conduct electronic surveys of teachers involved, including phone interviews, and provide literature review of the value of environmental education in improving student learning.

*Report not yet available*