Manaaki Whenua
Landcare Research

Identifying tools and knowledge gaps to support the control of non-PF2050-targeted small mammalian predators: stakeholder perceptions of priority needs

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Identifying tools and knowledge gaps to support the control of non-PF2050-targeted small mammalian predators: stakeholder perceptions of priority needs

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1 Background

In a move to enhance information sharing in vertebrate pest management, a Small Mammal Research Collective consisting of representatives of key stakeholder groups was established in 2017 under the New Zealand's Biological Heritage National Science Challenge (the Bioheritage Challenge). A key function of the Collective is to support research into near-term improvements in small mammal control. An initial focus on tools and their strategic application has subsequently fed into the prioritisation process for the Department of Conservation's 'Tools to Market' investment.

To align with the priority-setting in the Tools to Market process, 'tools' are classified as devices (e.g. traps, toxin dispensers), toxins, lures, monitoring devices, and supporting technologies. They may include:

- new tools for predator control, eradication, monitoring, and data management
- new tools for 'scaling up' the suppression of predators in the landscape
- current tools that could be applied in new situations or environments
- current tools that could be improved to substantially lift their contribution to controlling or eradicating small mammalian predators.

A Collective workshop in September 2018 considered that although the Predator Free 2050 (PF2050) goals are being addressed through several research programmes, other research needs and wider tool development for different species – particularly those for small mammal predators that fall outside the scope of PF2050 – are not as well-resourced and could benefit from a collective approach.

2 Aims

As a first step in identifying these wider control tool needs and research gaps, the workshop group initiated a preliminary scan/survey of key stakeholders' perspectives on priorities. It was agreed that the focus would be on mice, feral cats and hedgehogs. In addition to prioritising control and monitoring tool needs, the group recognised that there are knowledge/research gaps that, if filled, could support efforts to control and eradicate these species.

This report is not a review of the current state of the published academic literature relevant to mouse, hedgehog and feral cat management. Instead, it takes a practical and operational focus, and summarises the perceptions of those who manage pests and who carry out applied research to support that management. It is not intended to initiate any immediate action as part of the Tools to Market project.

3 Methods

Stakeholder views were surveyed in two stages.

Stage 1

A stakeholder workshop was hosted by the Department of Conservation (DOC) in February 2019 as part of DOC's Tools to Market project. It was aimed primarily at capturing key stakeholder feedback on New Zealand's short- to medium-term needs for tools to control and eradicate small mammal predators (rats, mustelids, possums) in order to progress PF2050 goals.

The workshop was attended by representatives from DOC, regional councils, Predator Free 2050 Ltd, the Predator Free NZ Trust, Zero Invasive Predators Ltd, Te Tira Whakamātaki (Māori Biosecurity Network), and the Bioheritage Challenge. During the workshop participants were also asked for their opinions on potential tools and critical research questions for mice, hedgehogs and cats. Their thoughts were captured on sticky notes and grouped into categories according to the matrix shown in the Appendix.

Stage 2

Other key stakeholders (including researchers specialising in small mammalian predator ecology and management) who had not attended the February Tools to Market workshop were contacted via email in May 2019 and asked to add their thoughts to a copy of the matrix. Responses were received from DOC staff (three), regional councils (two), a mainland sanctuary, university-based researchers (three), and Crown Research Institute-based researchers (five). Of this group, nine individuals were also closely involved with research and management of one or more landscape-scale predator eradication programmes in collaboration with PF2050.

Responses from both stages were collated into a single master matrix, and it was noted where multiple respondents highlighted the same need or research gap. The most commonly mentioned needs are discussed below (full data are provided in the Appendix). Note that this study was designed as a preliminary information-gathering exercise to guide future discussions and possible prioritisation. The results were not analysed quantitatively.

4 Species-specific needs

4.1 Feral cats

Feral cats are currently controlled on the New Zealand mainland primarily by trapping. The National Pest Control Agencies provide guidelines on trap use (NPCA 2018; now accessible under MPI's Bionet https://www.bionet.nz/library/npca-publications/) that incorporate DOC's best practice on the use of both restraining ('live') traps and kill-traps. Different trap types and sets are based on a trapping programme's objectives (e.g. control or monitoring), the characteristics of the targeted population (e.g. feral only, or feral and owned/pet), and other local variables (e.g. the risk of by-catch). For live trapping, cage traps or Victor Soft Catch® leg-hold traps are the most commonly used. Use of live traps over large scales is relatively expensive due to the labour costs involved with checking them every day, which is a legal requirement.

The NPCA guidelines provide advice on the use of three types of traps and sets (the Belisle Super X220 in a Scott Theobald chimney tunnel; the elevated Steve Allen SS cat trap with access ramp; and the elevated Timms trap with access ramp), while a further two kill traps are also approved for use against cats in New Zealand (the 'Twizel' ground-set Conibear and the SA2 Kat Trap).

Despite there being several options currently available for kill-trapping feral cats, a new, effective trap, designed specifically for cats, was the most frequently mentioned need by participants in this survey. Respondents noted the need for reliability and that ideally the trap should be 'passive' (i.e. it should require minimal interaction for the trap to spring).

Key criteria for such a trap are that it should:

- be humane
- effectively exclude native non-target species
- be as (or more) effective at catching cats as a ground-set leg-hold trap
- require minimal operator input
- be capable of functioning in a range of New Zealand environments (C. Gillies, DOC, pers. comm.).

A trap that does not spring when encountered by non-target animals was also considered a need, both in terms of non-target species (e.g. kea, weka) and owned cats, with a suggestion that such a device could include a PIT tag reader that detects tagged pet animals, linked to a system that prevents the trap from springing when a tag is detected.

Deployment of toxic baits was also mentioned by several respondents as a priority need. This included a bait station designed specifically for cats, and a novel/modified toxin delivery system. Examples given were a Spitfire (Connovation Ltd) modified to deploy a toxin, e.g. PAPP, or a cat-specific version of the M44/canid pest-ejector system used for coyotes or foxes and wild dogs in the USA and Australia, respectively.

Initial work on modifying the Spitfire for cat use has already taken place in New Zealand, with promising results, but trials were discontinued due to limited funding (E. Murphy, DOC, pers. comm.). Similarly, Australian researchers have developed the Felixer grooming trap, a species-specific toxin delivery system that uses a discriminatory sensor arrangement and algorithm to identify species before spraying toxin onto the fur of the target animal (Read et al. 2019).[1] There is little evidence so far to suggest that feral cats are susceptible to the current ejector systems, which are targeted at, and designed to be sprung by, canids.

At present there are two toxins registered for feral cat control in New Zealand: a 0.1% 1080 fishmeal/polymer pellet bait (Animal Control Products) for use by DOC only; and para-aminopropiophenone (PAPP; marketed as PredaStop, Connovation Ltd.). PAPP is deployed as a paste in meat baits within chimney-type bait stations. Best practice

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[1] See also http://www.ecologicalhorizons.com/initiatives .

guidelines have recently been developed,[2] and initial indications suggest that it can be effective for reducing feral cat densities (Glen et al. 2017). Responses from stakeholders overwhelmingly indicated a need to maintain a focus on developing PAPP as a tool for feral cat control, including exploring the option for aerial control. Other needs identified were for an additional toxin that is effective, and potentially specific to cats. The need for a targeted delivery mechanism for 1080 and an exploration of the effectiveness of secondary poisoning by 1080 were also mentioned. It was further noted that there is a need for social licence to use toxins in controlling feral cats, because, without this, applying these tools over landscapes will be difficult.

There was considerable support for the development of a long-life cat lure. This is important because, given their relatively large home ranges and low densities, feral cats may not encounter a control device immediately after it is baited and the frequency with which baits need replacing can have a significant impact on the costs of a control programme. Recent programmes in Australia have used meat-based sausages as toxin-delivery vehicles (Eradicat, Hisstory, Curiosity). These baits are sprayed with a permethrin-based residual insecticide to limit bait degradation due to ants, but this does not mean they are 'long-life,' with recorded palatability/consumption only of 'at least 10 days' (Johnston et al. 2011).

There was also support for investigating novel lures for cats. Given recent advances in the use of artificial intelligence and associated technology, the deployment of novel scent, sound and visual lures may obviate some of the need for traditional meat-based baits.

The most commonly mentioned need across the whole survey was for a cheap, easily available camera trap for monitoring feral cats. Stakeholders also identified the associated need for a standard protocol for using camera traps for monitoring cats, and a quantitative estimate of the probability of detecting an individual animal using this technology, which is an essential component of survey design and analysis. The need for a tool to detect cats when they are at low density, and an understanding of the relationships between indices of relative abundance and true density, were mentioned by more than one stakeholder.

Feral cats are also a significant threat to biodiversity, (and other values,) in Australia. A national feral cat management workshop held in Canberra in 2015 developed a set of priorities for future work in Australia, which showed similarities with the needs identified in New Zealand (summarised in Box 1, below). It would be advisable to develop links with Australian pest managers and researchers so that any tool development in New Zealand can both learn from, and not unnecessarily replicate, efforts across the Tasman.

Key research gaps identified to support cat management included estimates of cat densities and an understanding of how these vary with habitat. The need to quantify space use by cats (i.e. home ranges and their spatial modelling correlate, sigma) and how this varies according to habitat, density and season was also noted as important in order to guide control strategies. Cats' interactions with other species, particularly other predators,

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[2] https://www.bionet.nz/assets/Uploads/PredaSTOP-for-feral-cats-guidelines-28052018.pdf

also need to be better understood; for example, the biodiversity benefits of removing cats from a system should be compared to the risk of ecological release of smaller predators, such as rats, resulting from their removal.

The need to quantify ecological threats from cats was mentioned by several stakeholders, as better knowledge of these can help drive longer-term strategic decisions about control. Such decisions frequently have a significant social component, and there were a number of research needs identified that fell into this category, including an assessment of the effectiveness of trap-neuter-release in the New Zealand context, consideration of legislative instruments to better control cats, social licence for toxin use, and the practicalities of reducing cat impacts in mixed-use areas where feral and owned cats are sympatric. Technological questions raised included those relating to the impacts of toxoplasmosis carried by cats.

Respondents reported little current cat-focused research, despite the fact that cats are of interest in other programmes, including DOC’s research into predator guild responses following 1080 use east of the Southern Alps, Manaaki Whenua’s ongoing trap welfare and effectiveness trials, and detector dog research at Waikato University. A recent MSc thesis (Auckland University) looked at interactions between domestic cats and rats in urban areas.

Box 1. Trans-Tasman similarities: recommended priorities for future work from the Australian 2015 National Feral Cat Management Workshop

Full proceedings are available at: https://www.pestsmart.org.au/wp-content/uploads/2015/09/2015CatWorkshop_Proceedings_FINAL.pdf

Impacts

1 Quantify impacts of feral cats on other species, especially natives

2 Better understand spatial variations in cat impacts

3 Conduct studies on predation rates by cats, including the development of improved camera collars to discover kill rates

4 Review the disease-related impact of cats on people and livestock (e.g. sarcocystis, toxoplasmosis)

5 Assess the overall economic impacts of cats (including impacts on agriculture and tourism)

6 Explore Aboriginal cultural approaches to managing impacts

Monitoring

1 Develop guiding principles for feral cat and threatened species monitoring

2 Design and implement a national monitoring network for cats and threatened species

3 Review cat monitoring methods, and establish standards

4 Develop improved monitoring tools, including automated recognition, improved use of cameras, and improved management and analysis of data (e.g. Bayesian approaches, a package of analytical techniques)

5 Investigate the use of eDNA as a monitoring technique for predators and prey

6 Develop detection probabilities for established and commonly used monitoring methods (including camera traps, spotlighting)

Control tools

1 Develop a grooming trap for feral cats

2 Review the feasibility of biocontrol agents for cats (including gene drive technology and technical, ecological, and social considerations)

3 Develop improved baiting tools and strategies, including implants, lethal collars, kill traps, and national registration and adoption

4 Update standard operating procedures (animal welfare) for cat control methods

5 Develop support tools (improved adoption, multimedia, decision support tools)

4.2 Mice

At the landscape scale, mice are controlled primarily by toxins. Aerially broadcast brodifacoum was used successfully to eradicate mice from 46,000 ha Auckland Island. However, due to its lack of target specificity, secondary poisoning and bioaccumulation risk, brodifacoum is only available for aerial eradication programmes of this scale on offshore islands, and occasionally for limited-area, one-off operations at fenced sites on the mainland.

On the mainland, brodifacoum and other rodenticides are usually distributed in bait stations or hand sown where appropriate. 1080 appears to be of limited use in suppressing mouse numbers, possibly due to the ability of mice to detect and learn aversion to it. Given the relatively high densities that local mouse populations can attain (up to c. 50/ha in mainland forests; Wilson et al. 2018) and their small home ranges, trapping is not currently a practical control method.

Aside from acknowledging the need for a multi-kill mouse trap, most emphasis in the stakeholder responses was on the need for effective toxins. This included a recognition of the need for an alternative to brodifacoum/anticoagulants, particularly for use on the mainland. There was also support for re-evaluating/refining 1080 as an aerial control option for mice, including the development of a mouse-specific 1080 bait. Zinc phosphide and diphacinone + cholecalciferol) were mentioned as potential alternatives.

In terms of bait/lure needs, the availability of masking agents in baits to increase toxin uptake was noted, and, as with cats, there was interest in exploring social and other lures that may operate over greater distances than traditional cereal baits.

Mice are most commonly detected and monitored using tracking tunnels or single-catch kill-traps. There is currently no consensus on whether tracking rates (the most commonly used index) reflect population density accurately. This uncertainty may be due to the variation in the methods used in the range of published studies (Nathan et al. 2013; Wilson et al. 2018). As for cats and hedgehogs, the need for understanding the relationship between monitoring indices and density was mentioned.

Difficulties were noted about applying standard monitoring protocols (based on minimum distances between lines of tunnels) in small habitat fragments that, despite being of conservation value and containing mouse populations, may not be large enough to accommodate the multiple lines of tunnels required to index numbers reliabily. Detecting and monitoring mice at low densities, or when mouse activity is suppressed by the presence of ship rats, were the most commonly mentioned monitoring needs.

Some of the identified research gaps for mice were clearly linked to the applied monitoring and control tool requirements described above. Respondents also noted the need to better understand and quantify how mice use space, both in terms of estimating home ranges/sigma and how these vary with habitat, season and local density; and how mice use three-dimensional space (e.g. arboreality) and the likely impacts of these factors on control strategies.

The most frequently noted research needs were those relating to the interactions of mice with other species, both as predators (impacts, thresholds and density-impact functions) and as prey, particularly the effects of reduced stoat and/or rat densities on space use and mouse impacts. Regarding mouse control, understanding why kill rates of mice are so variable using current approaches is needed.

Relevant research that is underway or planned for the near future included a trial of the efficacy of zinc phosphide as a mouse toxin, which is complete but yet to be published (Lincoln University), and a planned trial of cholecalciferol (DOC). Zealandia sanctuary is carrying out monitoring to detect spatial and temporal mouse 'hotspots' within its boundaries.

4.3 Hedgehogs

Over the past decade hedgehogs have become increasingly recognised as a potentially serious threat to native biodiversity in New Zealand, and are now targeted in many predator control programmes rather than their traditional perception as by-catch. They are by far the most frequently trapped small mammal in many trapping programmes, but the effect of these captures on local densities has not been quantified. As well as being susceptible to a range of commonly employed trap types, hedgehogs can be killed with brodifacoum, although initial indications are that they can tolerate reasonably high levels before it becomes fatal. There are also anecdotal reports of hedgehogs' susceptibility to alphachloralose, but these are yet to be confirmed by formal investigation. There are currently no best-practice guidelines available for the control of hedgehogs in New Zealand.

Stakeholders identified a lack of knowledge of best practice and the effectiveness of currently available traps and sets for controlling hedgehogs. Indeed, one respondent questioned the need for a new device as opposed to better understanding how to target hedgehogs with current traps. A targeted toxin delivery system was proposed, and a number of respondents pointed out the need for effective toxins, with a couple of suggestions made for identifying a species-specific toxin. As with toxins, there was a clearly identified need for best-practice information about the best lures for attracting hedgehogs.

With respect to monitoring, 11 of the 14 responses in this category referred to the need for standardised, best-practice protocols for monitoring hedgehogs, whether with tracking tunnels or camera traps. Other suggestions were based on the application of monitoring data, such as how this relates to density, and how it can be used to evaluate control effectiveness.

The most commonly asked research questions raised about hedgehogs reflected our lack of knowledge about hedgehog densities in New Zealand habitats, and their impacts in different habitat types. Relationships between these two factors are poorly understood. Research needs for management related to space use by hedgehogs and the application of this information to guide control and how control requirements might vary spatially and seasonally.

As with cats and mice, there were few reports of current or recent hedgehog-focused research in New Zealand. A master's project at Otago University is looking at densities on the Otago Peninsula, and a recent master's at Auckland University examined hedgehog diet and potential impacts in urban forest fragments (published recently: Nottingham et al. 2018a, b). DOC and Manaaki Whenua are planning research on control tools for hedgehogs in the central South Island.

5 Summary

For each species there was a group of tool-based needs that were mentioned more frequently. If we assume the frequency with which a need was mentioned is an indicator of perceived relative importance, then the 'most important' needs for each species are summarised in the table below, along with those needs and research questions that were common to all three species.

Table 1. Summary of the most frequently mentioned common and species-specific control tool and research needs

	Cats	Hedgehogs	Mice
Species-specific needs	New, effective, cat-specific traps (passive/non-entry/pet-safe)	Guidance on effective traps	
	Develop PAPP (or alternative toxin)	Guidance on effective toxins	Efficient, non-anticoagulant aerial/ground toxin for mainland use
	Long-life/novel lure(s)	Best-practice monitoring	Detection at low densities
Common needs	Understand intra-guild relationships (responses following removal of selected predator species from a system)		
	Estimates of space use (estimates of parameters for trap-design and proof-of-eradication models)		
	Quantify impacts; develop density–impact relationships (variation with conditions)		
	Quantify relationships between indices and true density		
	Cheap, reliable camera trap with SOP		
	Understanding social challenges of control		

6 Acknowledgements

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Appendix 1 – Full response matrix

	Cats	Mice	Hedgehogs
Devices	• New, effective (passive, non-entry) trap to target feral cats****** • Modified Spitfire (PAPP vs. cats)* • Kea- and weka-safe traps for cats • Barriers to movement (traps and other devices) • Community/farmer-friendly cat trap • Improved bait station design for cats* • Explore use of dogs** • PIT-tag-reading traps to protect domestic cats* • Cat-specific version of the M44 coyote trap[#]	• Glue-board replacement for island biosecurity • Multi-kill mouse trap • Effective exclusion (better fences) • Explore use of dogs	• What control devices/sets are most effective vs. hedgehogs?** • Current devices eradicate in sanctuaries • Targeted toxin delivery system* • Explore use of dogs • Modification/best-practice set for traps (e.g. DOC200) • Do we need a dedicated trap or just better use of existing ones?
Toxins	• Another VTA for cats (other than 1080 and PAPP)* • Cat-specific toxin • Aerial toxin** • Need for social licence re. cat toxins • Maintain focus on PAPP******** • Targeted 1080 delivery • Effectiveness of secondary 1080	• Non-anticoagulant mouse toxin* • Effective aerial toxin for wide-scale/landscape use** • Mouse-specific 1080 bait • Alternative to brodifacoum for mainland use** • Measure/refine effectiveness of aerial 1080 vs. mice* • Test cholecalciferol, D+C; zinc phosphide	• Effective toxins (anecdotal reports of alphachloralose effectiveness)?***** • New toxin targeting specific insectivore metabolism*
Baits/lures	• Still a need for long-life cat lure****** • Explore use of novel (social, visual, sound, integrated?) lures***	• Effective lure over >> spatial range • Explore social lures** • Masking agents to increase toxic bait uptake	• What are the best lures for hedgehogs?******* • Liquid egg dispenser as per Scentinels
Monitoring	• Remote reporting adaptation for leg-hold/cage traps for cats • Low-density detection** • How to assess effectiveness of feral cat management?	• Detection when high rat densities • Reconcile current tools (how to use in small fragments?) • Sensitive tool for detecting survivors/reinvaders at	• How to monitor hedgehog numbers (standardised measure?)**** • Species-specific protocols for t-tunnels and cameras***** • Relationships between indices and

	• Relationships between indices and density?* • Cameras – availability/cheap (estimating g0; use standard protocol)********** • New passive tool for cats	low density** • Relationships between indices and density	density* • How to evaluate control effectiveness?
Fundamental research gaps	• Social challenges of cat (and hedgehog) control** • Abundances/densities of feral cats vs. habitats** • Secondary control via dependence on rodents as prey • Relationships between cats and rabbit numbers (prey-switching?) • Genome mapping • Control strategies for different contexts* • Non-lethal control? • Effectiveness (or not?) of trap-neuter-release strategies in NZ context • Legislative status/change – cats not protected off-property/micro-chipping/curfews?* • Space use (estimating sigma/HR) to guide control in different habitats/densities/seasons*** • Quantify threat from cats (vs. location)/DIFs*** • Net outcomes of the trophic triangle between cats, ship/Norway rats, and birds (i.e. does the good that cats do by killing rats outweigh the bad they do by killing birds themselves?) Answer obviously site-dependent, so study site needs careful selection* • Toxoplasmosis impacts on wildlife etc.* • Conservation gains from removing wild/feral cats but not pet cats from urban/peri-urban areas? • How to remove feral/wild cats from mixed-use areas • Anti-fertility drug for where toxins cannot be used • Intra-guild relationships (incl. post-control)***	• 3-D habitat use (arboreality) and effective control • How do space use (see above) and impacts change when rat and mustelid numbers drop?******* • Better understanding of impacts and impact thresholds/DIFs**** • Estimating g0 in tracking tunnels • Density estimates vs. habitat/season? • Space use (estimating sigma/HR) to guide control in different habitats, densities and seasons* • Describe/quantify threats vs. habitats and land uses** • Why are kill rates inconsistent in current programmes? • Immunocontraception (*sensu* previous CSIRO efforts) • How to target control at every home range	• How high are densities across landscapes?******* • What are the impacts of hedgehogs on native biota in different habitats (predation, competition)?****** • How to control at a range of scales?*** • What are the density–impact relationships in different systems?****** • We trap lots: is it making a difference?** • Biocontrol for hedgehogs? • Seasonality in impacts and control?* • Space use (re-invasion behaviour; estimating sigma/HR) to guide control in different habitats/densities/seasons** • Responses to removal of other predators* • Social challenges of (cat and) hedgehog control* • For councils – need to understand more to include in operational decision-making

Current research	• Welfare testing (kill traps) (Manaaki Whenua – Landcare Research) • Detector dog research unit (University of Waikato) • Urban cat ecology/impacts (University of Auckland) • Guild-shift vs. 1080/trapping in Arthur's Pass (DOC – Graeme E.) • Cameras and faecal DNA monitoring on Auckland Islands (DOC – Paul Jacques)	• Efficacy of zinc phosphide for mouse control (Lincoln University) • Auckland Island eradication-linked (University of Auckland) • Trial of available toxins (chole first) at small scale/ground (DOC – James Reardon) • Spatial monitoring to detect spatial and temporal hotspots (Zealandia)	• MSc on densities on Otago Peninsula (University of Otago) • Urban hedgehog ecology (University of Auckland) • Tools in Mackenzie (DOC – Richard Maloney)

Notes: * indicates where additional respondents made a similar comment; g0 and sigma are spatial modelling parameters referring to the probability of 'capturing' an individual by a device at the centre of its home range, and the decay in this probability with distance from that point, respectively; DIF = density-impact function, a quantitative relationship between the density of a pest and its impact on a resource or prey population; HR = home range.