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Indicator M7: Distribution and abundance of weeds and animal pests

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Andrew Gormley

Landcare Research

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Regional Councils' Biodiversity Monitoring Working Group

Auckland Council
Bledisloe Building, Level 2 South
24 Wellesly St
Auckland Central

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Landcare Research, Gerald Street, PO Box 69040, Lincoln 7640, New Zealand,
Ph +64 3 321 9999, Fax +64 3 321 9998, www.landcareresearch.co.nz

Reviewed by:	Bruce Warburton, Landcare Research Campbell Leckie, Hawke's Bay Regional Council
Approved for release by:	Fiona Carswell Portfolio Leader – Enhancing Biodiversity Landcare Research

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Overview

In 2010, the Technical Group of the Regional Council Biodiversity Forum worked with Landcare Research to develop the Regional Council Terrestrial Biodiversity Monitoring Framework.[1]

This framework is designed as part of 'a national, standardised, biodiversity monitoring programme, focusing on the assessment of biodiversity outcomes, to meet regional council statutory, planning and operational requirements for sustaining terrestrial indigenous biodiversity'

The terrestrial biodiversity monitoring framework adopts the same approach as the ecological integrity framework designed by Landcare Research for the Department of Conservation (DOC) and consists of three components: (i) indigenous dominance, (ii) species occupancy, and (iii) environmental representation.[2] To inform the framework, there are four broad areas: (i) state and condition, (ii) threats and pressures, (iii) effectiveness of policy and management, and (iv) community engagement.

A standardised monitoring framework ensures that data for each measure are consistent among regional councils, which allows for reliable State of Environment reporting. Furthermore, to enable national reporting across public and private land, it is also desirable that where possible, measures can be integrated with those from DOC'sBiodiversity Monitoring and Reporting System (DOC BMRS).[3] The monitoring framework covers most categories of essential biodiversity variables[4] recommended for reporting internationally, addressing species populations, species traits, community composition, and ecosystem structure adequately, but does not address genetic composition and only in part ecosystem function.

This report contains descriptions of 18 terrestrial biodiversity indicators developed within this framework by scientists who worked with regional council counterparts and representatives from individual regional councils. Each indicator is described in terms of its rationale, current efforts to evaluate the indicator, data requirements, a standardised method for implementation as a minimum requirement for each council, and a reporting template. Recommendations are made for data management for each indicator and, for some, research and development needed before the indicator can be implemented.

The terrestrial biodiversity indicators in this report are designed to enable reporting at a whole-region scale. Some of the indicators are also suitable for use at individual sites of interest within regions. Each indicator is described in terms of a minimum standard for all

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[1] Lee and Allen 2011. Recommended monitoring framework for regional councils assessing biodiversity outcomes in terrestrial ecosystems. Lincoln, Landcare Research.

[2] Lee et al. 2005. Biodiversity inventory and monitoring: a review of national and international systems and a proposed framework for future biodiversity monitoring by the Department of Conservation. Lincoln, Landcare Research.

[3] Allen et al. 2013. Designing an inventory and monitoring programme for the Department of Conservation's Natural Heritage Management System. Lincoln, Landcare Research.

[4] Pereira et al. 2013. Essential biodiversity variables. Science 339, 277–278.

councils. If implemented by all councils, each measure can then be aggregated to allow national-scale reporting (e.g., for State of Environment reports, or for international obligations such as reporting on achievement of Aichi Targets for the Convention on Biodiversity). Individual councils could add additional measurements to supplement the minimum standards recommended.

Three of the 18 terrestrial biodiversity indicators – Measures 1 'Land under indigenous vegetation', 11 'Change in temperature and precipitation', and 18 'Area and type of legal biodiversity protection' – were implemented and reported on for all regional councils in June 2014. An attempt to implement and report two others at that time – Measures 19 'Contribution of initiatives to (i) species translocations and (ii) habitat restoration' and 20 'Community contribution to weed and animal pest control and reductions' – was unsuccessful because the data needed for these indicators was either not readily available or not collected in a consistent way, and investment will be needed to remedy these issues before they can be reported successfully.

6 Indicator M7: Distribution and abundance of weeds and animal pests

Author: Andrew Gormley, Landcare Research

6.1 Introduction

This report concerns the development of Indicator M7 ('Distribution and Abundance'), which is part of the 'Weeds and Animal Pests' indicator, under the 'Threats and Pressures' area, and helps to inform the indigenous dominance component of ecological integrity. The reporting element for this measure is the (i) regional distribution and (ii) local abundance of environmental weeds and nationally listed animal pests.

This report presents a proposed general measure, and also raises a number of factors that must be considered before a final methodology is agreed upon. It is expected that **further research and development** will be required to determine the exact set of species to be monitored and the most appropriate monitoring methods for those species.

6.2 Scoping and analysis

6.2.1 Indicator definition

In this section we define the key terms contained in the element of M7.

Distribution

The distribution of a species is the range of that species across the landscape. It can be defined as the geographical extent of its occurrence, aggregated by grid, region or some other analytical unit. Because it is not possible to sample every square metre of ground to determine the exact distribution of a certain species, surveys are carried out in a subset of all possible sampling locations, and the presence/absence of the species is recorded. The proportion of sampled locations that contain the species, termed 'occupancy', can be used as a summary measure of distribution (MacKenzie et al. 2006).

This measure will use **occupancy** (the proportion of sampling locations that are occupied) as a measure of distribution.

Abundance

'Absolute abundance' is defined as the total number of individuals of a particular species within a specified area of interest. For many species it can be very difficult to obtain estimates of absolute abundance that are both unbiased and precise. Mark-recapture (i.e. photo-ID, tagging, DNA samples) and distance methods (line-transect, strip transects) have been successfully used to provide robust estimates of population size in a defined area; however, these methods are often prohibitively costly, and not always suited to some species,

especially those that are rare and/or elusive. A common alternative is to measure 'relative abundance'. This is an index that is positively and, ideally, linearly related to absolute abundance, but is easier and cheaper to measure. Although it does not provide a direct estimate of population size, relative abundance can be used to monitor population change over time or differences between areas. Examples of relative abundance include trap-catch-index (TCI) for possums (NPCA 2011) and Faecal Pellet Index (FPI) for ungulates (Forsyth 2005).

This measure will use **relative abundance** when describing abundance, with methods differing among species.

Environmental weeds

Environmental weeds are defined as alien plant taxa that invade natural vegetation, usually adversely affecting native biodiversity and/or ecosystem functioning (Richardson et al., 2000); the same definition is applied in M6 ('Number of new naturalisations'). There are 328 vascular plant species that are considered environmental weeds in New Zealand (Howell 2008). The Department of Conservation (DOC) considers a reduced set of 47 'species of concern' (Lee & Allen 2011) for which relative abundance is measured in Tier 1 of their Biodiversity Monitoring and Reporting System (BMRS). This reduced set was chosen by DOC to cover a range of functional groups, life-forms and habitat requirements.

For the purpose of this measure, we will consider the same list of 47 species of concern considered by DOC (Table 6-1). This list does not preclude regional councils from monitoring additional species that are important in their own area.

Nationally listed animal pests

There are a large number of exotic terrestrial fauna species in New Zealand across a range of taxa. There does not, however, appear to be an official designation of 'nationally listed animal pests'. For example, DOC lists a number of predominantly vertebrate pests on its website, whilst a report summarising pest animals under management by regional unitary authorities contains a number of additional species/taxa (Clayton & Cowan 2010).

For the purpose of this measure, we will consider the species/taxa listed in Table 6-2. This does not preclude specific regional councils from monitoring additional species that are important in their own region.

Table 6-1 The 47 'species of concern' as determined by the Department of Conservation

Family	Species	Common Name*
Sapindaceae	*Acer pseudoplatanus*	Sycamore maple
Asclepiadaceae	*Araujia sericifera*	Moth plant
Asteraceae	*Ageratina adenophora*	Mexican devil
Asteraceae	*Ageratina riparia*	Mist flower
Asteraceae	*Chrysanthemoides monilifera* subsp. *monilifera*	Boneseed, Bitou bush
Asteraceae	*Erigeron karvinskianus*	Mexican daisy
Asteraceae	*Hieracium lepidulum*	Tussock hawkweed
Asteraceae	*Hieracium pilosella*	Mouse-ear hawkweed
Asteraceae	*Mycelis muralis*	Wall lettuce
Basellaceae	*Anredera cordifolia*	Madeira vine
Berberidaceae	*Berberis darwinii*	Darwin's barberry
Buddlejaceae	*Buddleja davidii*	Buddleia
Caprifoliaceae	*Leycesteria formosa*	Himalayan honeysuckle
Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle
Celastraceae	*Celastrus orbiculatus*	Climbing spindle berry
Commelinaceae	*Tradescantia fluminensis*	Wandering jew
Ericaceae	*Calluna vulgaris*	Heather
Ericaceae	*Erica lusitanica*	Spanish heath
Fabaceae	*Callistachys lanceolata*	Oxylobium, Wonnich
Fabaceae	*Cytisus scoparius*	Broom
Fabaceae	*Lupinus polyphyllus*	Russell lupin
Fabaceae	*Ulex europaeus*	Gorse
Haloragaceae	*Gunnera tinctoria*	Chilean rhubarb
Iridaceae	*Crocosmia* × *crocosmiiflora*	Montbretia
Liliaceae	*Asparagus scandens*	Climbing asparagus
Oleaceae	*Ligustrum lucidum*	Tree privet
Oleaceae	*Lycium ferocissimum*	Boxthorn
Osmundaceae	*Osmunda regalis*	Royal fern
Passifloraceae	*Passiflora tripartita*	Banana passionfruit
Pinaceae	*Pinus contorta*	Lodgepole pine
Pinaceae	*Pseudotsuga menziesii*	Douglas fir
Poaceae	*Agrostis capillaris*	Browntop
Poaceae	*Ammophila arenaria*	Marram grass
Poaceae	*Cortaderia jubata*	Purple pampas grass
Poaceae	*Cortaderia selloana*	Pampas grass

Family	Species	Common Name*
Poaceae	*Glyceria maxima*	Floating sweetgrass
Poaceae	*Nassella trichotoma*	Nassella tussock
Poaceae	*Pennisetum clandestinum*	Kikuyu grass
Poaceae	*Spartina* spp.	Cord-grass
Proteaceae	*Hakea sericea*	Prickly hakea
Ranunculaceae	*Clematis vitalba*	Old man's beard
Rhamnaceae	*Rhamnus alaternus*	Italian evergreen buckthorn
Rosaceae	*Cotoneaster glaucophyllus*	Cotoneaster
Salicaceae	*Salix cinerea*	Grey willow
Salicaceae	*Salix fragilis*	Crack willow
Tropaeolaceae	*Tropaeolum speciosum*	Chilean flame creeper
Zingiberaceae	*Hedychium gardnerianum*	Wild ginger

* Common names obtained from the New Zealand Plant Conservation Network, www.nzpcn.org.nz

Table 6-2 Pest animal species/taxa in New Zealand, whether they are listed on the DOC website, whether they receive current control by one or more regional council, and whether they are likely to receive control in the future

			Regional council	
Species/taxa	**Scientific classification**	**DOC**	**Current**	**Future**
Possum	*Trichosurus vulpecula*	Y	Y	Y
Wallaby spp.	Family Macropodidae	Y	Y	Y
Ferret	*Mustela putorius furo*	Y	Y	Y
Stoat	*Mustela erminea*	Y	Y	Y
Rabbit	*Oryctolagus cuniculus*	N	Y	Y
Hares	*Lepus europaeus*	N	Y	Y
Deer spp.	Family Cervidae	Y	Y	Y
Himalayan tahr	*Hemitragus jemlahicus*	Y	N	Y
Feral goat	*Capra hircus*	Y	Y	Y
Feral pig	*Sus scrofa*	Y	Y	Y
Rats	*Rattus* spp.	Y	Y	Y
House mouse	*Mus musculus*	N	Y	Y
Feral cat	*Felis catus*	Y	Y	Y
Hedgehog	*Erinaceus europaeus*	Y	Y	Y
Kaimanawa horse	*Equus ferus caballus*	Y	N	N
Argentine ant	*Linepithema humile*	Y	Y	Y
Great white butterfly	*Pieris brassicae*	Y	N	N

Species/taxa	Scientific classification	DOC	Regional council	
			Current	Future
Wasp spp.	*Vespula* spp.	Y	Y	Y
Magpie	*Gymnorhina tibicen*	N	Y	Y
Rook	*Corvus frugilegus*	N	Y	Y
Common myna	*Acridotheres tristis*	N	N	Y
Rainbow lorikeet	*Trichoglossus haematodus*	Y	N/A	N/A
Red-eared slider turtle	*Chrysemys scripta elegans*	N	N	Y
Rainbow skink	*Lampropholis delicata*	Y	N	Y

6.2.2 Indicator reporting statistics

The statistics used in this report are numeric measures (occupancy and relative abundance), as opposed to demographic measures (e.g. survival rates, sex ratios, population growth). Where possible, it is recommended to present estimates of both occupancy and relative abundance for each species.

For all indicator species, distribution will be characterised by *occupancy*, defined as the proportion of sites occupied by that species. Occupancy is an estimate of the proportion of sampling locations where the species (or species group) is present, corrected to account for imperfect detection (MacKenzie et al. 2006). Estimates of occupancy will be accompanied by a 95% Confidence Interval[11] (95% CI) to reflect the uncertainty associated with the estimate. For example, from the technical report of DOC's Tier 1 monitoring, it was reported that 'possums occurred in 81% of forest sampling locations on public conservation land (mean occupancy = 0.81, 95% CI = 0.71–0.89)' (Bellingham et al. 2013).

Estimates of relative abundance will similarly be reported as an estimate accompanied by a 95% CI. It should be noted that the method of measuring relative abundance will be species-specific. For example, from the DOC BMRS, relative abundance of possums was given as mean TCI, whereas relative abundance for weeds was given as the mean percentage of sapling (woody species only) and seedling subplots (all species) that are occupied per sampling location (see sampling design section).

Two additional summary statistics of environmental weeds that may be appropriate are the mean proportion of species in each plot that are exotic, and/or the proportion of cover that is due to exotic species. For example, from the DOC BMRS, the proportion of species that are exotic per location was 0.136 (SE = 0.024) in non-forest locations, compared to 0.012 (SE = 0.003) in forest locations.

[11] If analysis is carried out using Bayesian methods, the uncertainty is expressed in terms of a 95% Credible Interval

6.2.3 Reporting frequencies

It is recommended that the regional councils adopt the same reporting frequency as DOC, that is, annual monitoring at a changing subset of sampling locations, with repeat monitoring of a sampling location occurring every five years. The annual report will summarise and make inference from the accumulated data.

6.2.4 Reporting hierarchies

Regional councils can report on indicator M7 at a national and regional scale within private (i.e. non-conservation land). For some components of the measure, data can be combined with comparable data from the DOC BMRS, enabling comparison and contrasts to be made between tenure. It also may be possible for statistics to be reported within different strata, such as vegetation types (e.g. forest, shrubland, pasture) or landuse type. For example, from the DOC BMRS, it was reported that mean TCI of possums in non-forest locations was 0.6% compared to 4.5% in forest locations (Bellingham et al. 2013). However, the ability to report within various strata is dependent on the number of sampling locations within the region, as the more comparisons are being made, the smaller the sample size in each strata. Sampling of supplementary sampling locations may be required to have a large enough sample size to make inference across land cover types and/or landuse categories.

For species that are actively managed, it may be possible to compare results from sampling locations that receive pest control to those that receive no control. However, in general, it is unlikely that indicator M7 will have the statistical power to detect changes in abundance that occur as a result of management at a smaller scale. To assess the efficacy of control operations, it is recommended that more intensive monitoring take place to ensure adequate samples of control and non-control samplings locations, rather than rely on the national-scale monitoring that we propose here.

6.2.5 Spatial and temporal analysis

The intention of the framework is to enable consistent reporting at a national scale, and to enable inclusion of data from the DOC BMRS, resulting in unbiased reporting across private and public land. It is essential that inference can be made between areas (spatial comparisons) and over time (temporal comparisons). It is therefore important that data are gathered from a large enough number of sampling locations that estimates are representative of the total area, and that there is some level of resampling so that inferences can be made as to changes over time.

6.2.6 Linkages to other measures

Indicator M7 has linkages to three other measures. The environmental weeds component of M7 has linkages with measure M2 (‘Vegetation structure and competition’), with data obtained from that measure being able to inform the distribution component of M7. The component of M7 that is concerned with national listed animal pests, specifically birds, has linkages with measure M3 (‘Avian representation’), with data obtained from that measure (i.e. bird counts and/or distance sampling) being able to inform the distribution and abundance component of M7. Finally, the measure M16 (‘Change in abundance of

indigenous plants and animals'), is essentially a subset of M2 (for plants) and M3 (for birds) and therefore has linkages via those measures to M7.

6.3 Assessment of existing methodologies

6.3.1 Regional councils methodologies

Generalisations in this section of the report are based on those regional councils that responded to a survey, and may therefore not reflect the monitoring activities of all regional councils (Appendix 6). That survey found that regional councils monitor a wide array of weeds and pest animal species, and that methods varied among them. These are summarised briefly.

Pest animals

In most cases, regional councils do not carry out systematic monitoring of the type proposed for this measure, but rather monitor as a result of control activities, or for detecting incursions (e.g. biosecurity). Possums were reported as having been monitored by all respondents, using either TCI and/or detection devices such as Chew Track Cards (CTCs) or Wax Tags. Monitoring of possums was typically targeted to areas of concern or those having received control, for example, by TBfree New Zealand operations. Mustelids (ferrets, stoats and weasels) were monitored by half of the respondents, mostly using tracking tunnels, and in one case indirectly by outcome monitoring of kiwi call counts (outcome monitoring does not measure the species being controlled, e.g. mustelids, but rather the intended outcome of control, e.g. increase in kiwi). Rabbits were monitored by all respondents using either spotlight counts or the Modified-Mclean scale (see National Pest Control Agencies, NPCA 2012). Deer species were only monitored by one respondent, as part of a joint programme with DOC, but again indirectly using outcome monitoring. Pigs were monitored by one respondent, also using outcome monitoring. Other mammals such as cats, hedgehogs and horses were seldom monitored. Insects were less represented, with only ant species being monitored by half the respondents, using baited vials and tiles. No reptiles or amphibians were monitored by any respondents.

These responses are consistent with previous research that found that the majority of pest control operations and subsequent monitoring undertaken by regional councils were for possums, mustelids, rodents and lagomorphs, with fewer for cats, ungulates, wallaby and ants (Clayton & Cowan 2010).

Environmental weeds

Of the 47 environmental species of concern, an average of 40 were present within each regional council boundary. Over half of the species (27 out of 47) were present in all regions that responded. There were a total of 28 species monitored by at least one regional council, although the number of species monitored in each region ranged between 8 and 18, with only two species monitored by all respondents (Boneseed *Chrysanthemoides monilifera* subsp. *monilifera*; Nassella tussock *Nassella trichotoma*).

6.3.2 Department of Conservation methodologies

In 2011, DOC implemented Tier 1of its nationwide Biodiversity Monitoring and Reporting System (BMRS) to provide an unbiased assessment of vegetation, birds, and pest mammals (restricted to ungulates, possums and lagomorphs). The BMRS is used to assess ecological integrity across the three components of indigenous dominance, species occupancy, and ecosystem representation in public conservation land using a regular, unbiased sampling framework across New Zealand.

Sampling locations are randomly chosen from all possible sampling locations that occur from the intersections of an 8 × 8 km grid superimposed on public conservation lands nationally (Allen et al. 2013). Most sampling locations are in forests (58%), with non-forested areas (33%) and shrublands (9%) also measured.

The DOC BMRS uses a 'panel design' to monitor vegetation, pest mammals and birds (Figure 6-1). Each sampling location is permanently marked to allow for repeated sampling at that location. Vegetation measurements are made within a central 20 × 20 m plot, consisting of 16 contiguous 5 × 5 m subplots for saplings and 24 (0.75 m^2) seedling subplots.

Pest mammal monitoring occurs on lines that radiate out from the central plot. Possum abundance is measured on four 200-m trap-lines, each containing 10 leg-hold traps set at 20-m intervals as per the national possum monitoring protocol (NPCA 2011), over one fine night (Gormley et al. 2015). The trap-catch-index (TCI; the number of possums caught per 100 trap nights) is estimated for each of the four transects. This has been shown to be positively related to true abundance. For estimating relative abundance of ungulates and lagomorphs, four 150-m transects are arranged in a cruciform shape at each sampling location, and the number of intact faecal pellets in circular plots of 1-m radius spaced at 5-m intervals (i.e. 30 plots per transect) counted. The total number of pellets along each transect (Faecal Pellet Index) has been shown to be linearly and positively related to known abundances of deer. The presence of possum pellets in each of the circular plots is also recorded. Bounded five-minute bird counts are carried out at stations located at the central point (X), and at the ends of each of the pellet transect lines (A, D, P & M) for two consecutive days (Figure 6-1).

6.3.1 TBfree New Zealand

The TBfree New Zealand programme is administered by OSPRI (Operational Solutions for Primary Industries; previously by the Animal Health Board). This programme aims to eliminate bovine TB from New Zealand via a combination of livestock testing and eradication of TB in wildlife. Brushtail possums are the main wildlife host for bovine TB, and as a result are a target for control and surveillance operations. The method for eliminating TB in wildlife is to supress possums to low levels of abundance, and then to carry out surveillance to capture and test a proportion of remaining possums in order to confirm the absence of TB.

Possum data are potentially available from two sources. In forest locations, possum control operations have typically been followed by trapping surveys to estimate the Residual Trap Catch Index (RTCI), whereby trap lines are set according to a national protocol (NPCA 2011) after control operations. The surveillance component consists of setting detection devices (Chew Track Cards; CTCs) for up to seven nights. Within farmland habitat, this occurs along

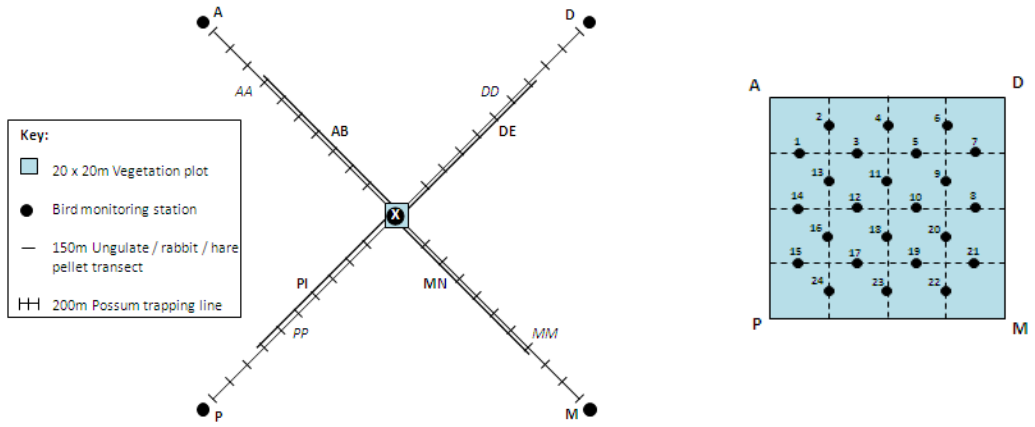

Figure 6-1 Layout of the animal-survey sampling units in relation to the vegetation plot at each sampling location, along with an outline of the 20 × 20m vegetation plot, subdivided into 16 contiguous 5 × 5 m subplots, and each of the 24 (0.75m^2) seedling subplots within it, as implemented by the Department of Conservation for their Biodiversity Monitoring and Reporting System.

transect lines with a prescribed spacing between cards and lines, although lines can meander depending on habitat availability. Where single trees occur within a farmland area (singleton), devices are set at the tree nearest to the required spacing. Chew Track Cards are checked and locations where cards returned a positive possum detection are subsequently trapped for up to three nights using four traps per location.

Unfortunately, data from TBfree New Zealand are unlikely to be appropriate for use in a systematic national monitoring programme. Firstly, areas monitored by TBfree New Zealand are unlikely to be an unbiased sample of the potential landscape as post-control surveillance monitoring occurs after control activities have already reduced possums to low densities.

Secondly, within a control area, traps and/or detection devices are generally placed in areas of suitable possum habitat, which will generally have higher than average possum densities (e.g. shelter belts adjacent to open grassland).

6.4 Development of a sampling scheme

6.4.1 Sampling framework

The reporting statistics for this measure must be consistent among regional councils, and should be able to be integrated with the information from other authorities, such as the Tier 1 component of DOC's BMRS. It is also important that any monitoring method for obtaining standardised measures of the distribution and abundance of environmental weeds and pest animals be achievable and relevant.

For this measure, (as for related measures identified in section 6.2.6), a point-based sampling scheme is required. There are not currently data available from regional councils or other groups that are consistent and robust enough to give an unbiased current assessment of the distribution and abundance of weeds and pest animals.

It is recommended that the regional councils adopt the DOC BMRS sampling framework. This framework provides an unbiased method for sampling across New Zealand and would provide a consistent approach enabling amalgamation of data and direct comparisons between public and private land.

Table 6-3 Number of sampling locations within each region based on an 8 × 8 km grid separated into public land (DOC BMRS) and private land (regional councils). The percentage of locations of each tenure, within each region is given in parentheses

		Number (%) of sampling locations by land tenure	
Region	Total	Public land (DOC BMRS)	Private land (Regional Councils)
Auckland	78	6 (8)	72 (92)
Bay of Plenty	194	60 (31)	134 (69)
Canterbury	692	169 (24)	523 (76)
Gisborne	130	15 (12)	115 (88)
Hawke's Bay	216	39 (18)	177 (82)
Manawatū–Wanganui	349	61 (17)	288 (83)
Marlborough	153	73 (48)	80 (52)
Nelson City	7	2 (29)	5 (71)
Northland	202	27 (13)	175 (87)
Otago	480	87 (18)	393 (82)
Southland	478	260 (54)	218 (46)
Taranaki	114	26 (23)	88 (77)
Tasman	151	102 (68)	49 (32)
Waikato	369	64 (17)	305 (83)
Wellington	125	23 (18)	102 (82)
Westland	346	297 (86)	49 (14)
Number of locations	4084	1311	2773
Percentage of locations	100	32	68

A further benefit of adopting the BMRS sampling framework is that DOC sampling already includes all public conservation land within each regional council's boundary (Figure 6-2). Therefore, a proportion of locations within each region is already measured (or planned to be measured) by DOC. Table 6-3 shows the number of sampling locations nationally and within each regional council boundary based on the 8 × 8 km sampling grid, separated by public land administered by DOC and private land administered by regional councils. Of 4084 potential sampling locations in New Zealand, 1311 are on public conservation land, with the remaining 2773 on private land. There are large differences between regions (i.e. ranging from 92% of potential locations within the Auckland region on private land, compared with 14% of potential locations within the Westland region). The absolute number of potential locations also varies, (i.e. ranging from 49 locations on private land in both Westland and Tasman, 523 locations in Canterbury).

For some regional councils, the number of sampling locations that result from an 8 × 8-km grid is likely to be beyond their current level of resourcing. In these cases it may be possible to sample only a proportion of locations in any five-year period. Note however, that whilst a reduced number of locations may be achievable operationally, that affordability will come at a cost in terms of reduced sample size, and therefore a reduced power (i.e. ability) to detect any meaningful change over time or difference between groups of sampling locations. Furthermore, the number of locations on an 8 × 8 km grid may be too few to detect change in some regions, in which case a finer scale grid may be required (e.g. 4 × 4 km). Formal power analyses would need to be carried out by each regional council to determine the minimum level of sampling required in order to make reliable inference at the regional council level. Power analyses would ideally be carried out before any monitoring commences, or alternatively, after the first year of sampling so that the sampling uncertainty from the initial data can be used directly in the estimate of power.

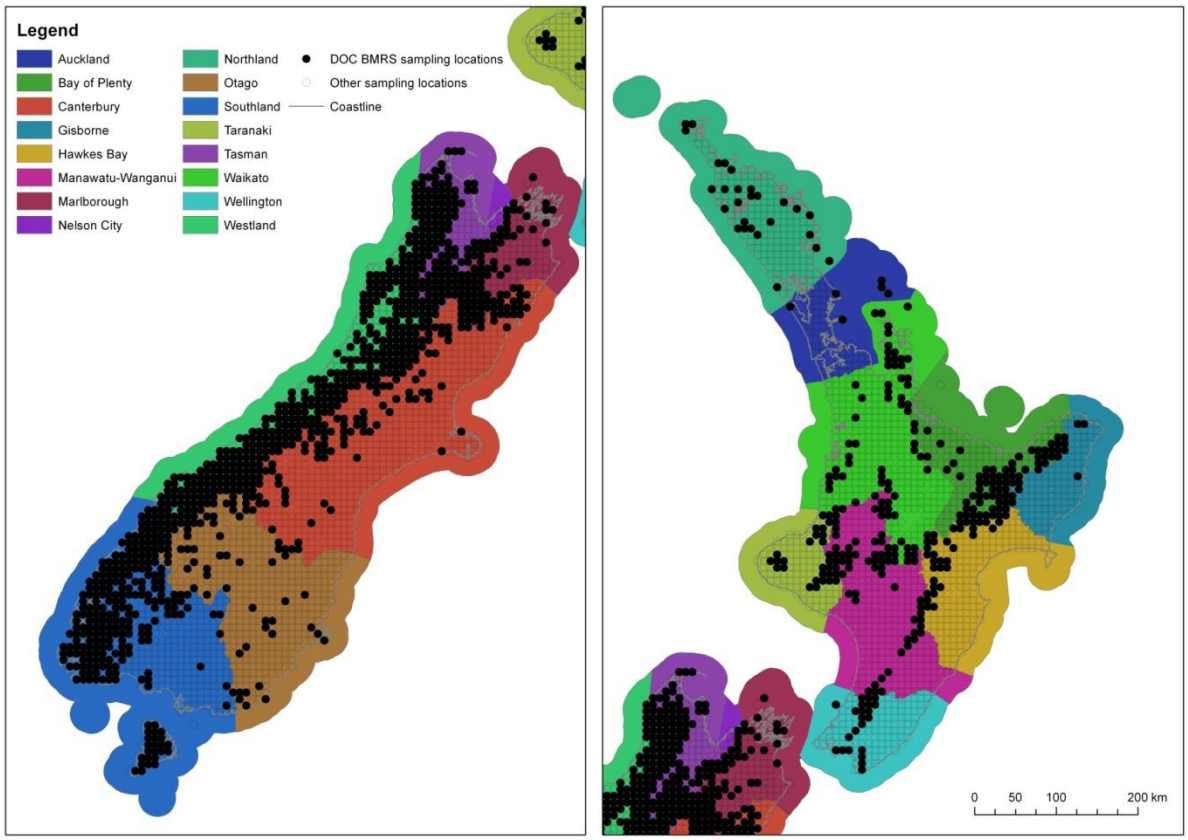

Figure 6-2 Sampling locations on the 8 × 8 km grid used by DOC BMRS in relation to the regional council boundaries (excludes locations with slope >65°).

A potentially important issue is negotiating access to private land for the purpose of sampling. Lack of access can result in estimates that are biased or not representative of reality, especially if there is a relationship between factors that influence pest/weed distribution and abundance, and the likelihood of access.

6.5 Estimating change over time

When attempting to measure changes over time, there are two broad strategies, each with their own advantages and disadvantages.

- Strategy A: Sampling the same locations each year increases the ability (i.e. power) to detect an actual change due to estimates of that change between years being more precise. However, this increased power comes at a cost: the fewer sites sampled, the more likely that the sites are not representative of the entire area about which inference is being made. The monitoring budget may be too small to ensure a large enough sample size each year.
- Strategy B: Sampling new sites each year enables a greater area to be surveyed, meaning that when aggregated, the sampled sites are more likely to be representative of the total area, allowing inference from the sampled locations to be generalised to the entire area. However, the cost of this improvement in generalizability is that because each site is not repeatedly measured, it will be more difficult to detect any real change over time. Estimates of change will have greater variance compared to strategy A.

Essentially there is a trade-off between the generalizability and precision of estimates depending on whether (A) the same sites are sampled repeatedly, thereby reducing variance or (B) new sites are sampled each year, increasing representativeness. There are intermediate sampling designs, such as that proposed here, where a set of sites is sampled cyclically over a fixed period (e.g. 5 years), such that a subset of new sites is sampled each year, and each site is returned to for repeat sampling once over the fixed period (e.g. once every 5 years). Other sampling designs have a mix of new and repeated sites each year.

A further consideration is that the ability to detect a specified level of change over time will depend greatly on the species being studied. Detecting population-level change over time for a species with a low population growth rate will potentially take many years, especially if there is considerable variation in the estimates of relative abundance.

6.6 Considerations when estimating distribution and abundance

6.6.1 Variation and bias

Whenever we measure changes or difference in distribution or abundance we are faced with two issues: *variability* and *bias*.

There are two types of variability: sampling and process. Our estimates will contain both of these, meaning that detecting changes in a population, (or differences between populations) can be difficult, and may require long-term monitoring.

Sampling variation

Whenever we estimate a population size, there is a degree of uncertainty due to our sampling method. We can never know the true population size, but we estimate it with a degree of uncertainty. For example we may estimate an abundance of N = 50, but allow for the fact that

it may be as low as 30 and as high as 100 (as indicated by 95% CIs). Sampling variation is unavoidable; however, we can minimise it by using methods that are reliable and repeatable, and by having a large enough number of sampling locations.

Process variation

The true population size will change over time due to the combination of survival and reproductive rates, even in the absence of any long-term increase or decrease. Species that have low survival and high reproductive rates (e.g. mustelids, rodents and lagomorphs) will typically have populations that fluctuate more widely than species with high survival and low reproductive rates (e.g. ungulates). These natural fluctuations make it difficult to determine whether an observed change in abundance is a signal of a long-term increase or decrease, or just part of the natural pattern of variation. For these highly variable species, care must be taken when making inference about changes over time and a relatively longer-term dataset must be obtained before a real change can be reliably detected (e.g. we would not conclude a population is in decline if the population went from 100 one year to 80 the next). Species with high reproductive rates can often take advantage of favourable conditions, such as mast years, resulting in short-term 'plagues'.

Bias

Bias exacerbates the difficulty in making reliable inference. Although we may have an estimate of abundance that is precise as it is from data from a large number of locations, our estimate may be biased due to issues such as detectability (species being present but not detected), our analytical method, or behaviour of the species (a few individuals being detected multiple times giving the impression of a large population). Bias can be reduced by using appropriate sampling and analytical methods, and by ensuring enough locations are sampled so that they are representative of the region.

6.6.2 Occupancy

A fundamental ecological theory is that there is a relationship between occupancy and abundance: as the abundance of a population increases, so does its distribution (Gaston 1996). Where estimates of species abundance are difficult to obtain, identifying changes in occupancy may be a sufficient proxy for identifying changes in the underlying abundance (MacKenzie & Reardon 2013). However, changes in occupancy between periods or differences between regions may not be apparent even when there is a real change/difference in abundance. For species subject to pest control, populations may be reduced 80–90%, yet the species remains widespread. Similarly, a species may be distributed widely across two different areas at vastly different densities. In both these cases, estimates of occupancy may not differ even though the underlying abundance does. In these situations, occupancy does not provide a reliable measure of changes occurring within a population. Similarly, measuring the distribution of species that are highly abundant and widespread (e.g. rats) may not be useful, as the estimate of occupancy will equal one as the species is present at some level in all sampling locations.

A major issue when estimating occupancy is that a species may be present at a sampling location, but go undetected by the sampling methods used. Ignoring imperfect detectability, and simply reporting the proportion of locations where the species was observed will lead to negatively biased estimates of occupancy. If detectability is related to some environmental gradient, differences in observed occupancy across that gradient may be due to differences in detectability. Fortunately, replication, either spatial or temporal, can be used to obtain an unbiased estimate of occupancy whilst explicitly accounting for imperfect detection (MacKenzie et al. 2006). This established methodology is now common in the ecological sciences and is straightforward to implement. However, to account for imperfect detection, more intensive sampling is required at each site, either in the form of multiple devices, or sampling over multiple closely spaced time periods (e.g. nightly).

Detection probability: multiple samples vs multiple methods

In theory, we can estimate the probability of detection from multiple samples using $p_{all} = 1 - (1 - p_1)^n$, where n is the number of replicates and p_1 is the detection probability of a single sample. For example, $p_1 = 0.6$ means that if the species is present, there is a 60% chance of detecting it. In this case, the chance of detecting the species at least once from two samples is 0.86, and from four samples is 0.97. In the latter case, if we detect nothing, we are almost certain it is absent.

In practice, however, the chance of each repeat sample detecting or not detecting a species is not independent. It is often better to use two different devices or sampling methods than two replicates of a single method. For example, the Tier 1 possum monitoring by DOC uses information from trap-lines and pellet-lines for estimating occupancy. Estimates of possum occupancy from trap-lines and pellet-lines were 0.6 in forest/non-forest locations on the conservation estate (Bellingham et al. 2013) but estimates of occupancy from trap-lines only decreased to 0.43, even though replicates were used (four lines) to theoretically account for imperfect detection. Similarly, estimates of possum occupancy from pellet-lines only were only marginally lower (0.57) than data from trap- and pellet-lines combined. (Possums were detected at fewer sites using trap-lines only than by pellet-lines only). Therefore, increasing the number of trap-lines would make little difference to overcoming issues of detection, and for possums, it appears that to maximise the chance of detection, a combination of sampling methods is preferable to repeatedly sampling using one method.

6.6.3 Abundance

A related issue is that estimates of relative abundance from different methods are generally not comparable. For example, Jones and Warburton (2011) found that for three methods of estimating possum relative abundance (TCI, Chew Card Index, and Wax Tags), although estimates from the different methods were positively related to one another, the high levels of uncertainty of estimates meant that calibrating one method to another was impossible. Furthermore, the relationships between methods differed between different areas. Their findings mean that it is somewhat unreliable to compare estimates of abundance from two different areas or time periods if different methods have been used, and therefore no correction factor exists to reliably convert one index to another across a range of habitats.

6.7 Which sampling methods to use

There are a number of features to consider when selecting appropriate sampling methods for a monitoring programme. Consideration of these features will assist in deciding which species can reliably be measured.

1. *Reliable*: The key requirement is that any sampling method provides a reliable, unbiased estimate of what is being measured. For example, estimates of relative abundance that arise from a particular sampling method must be positively related to true abundance.

2. *Invariant to gradients*: The sampling method must be unbiased across factors such as environmental gradients. For example, if the method for measuring a species is less reliable with increasing rainfall, then a false relationship between species abundance and rainfall will likely result, potentially leading to incorrect inference.

3. *Consistent*: Sampling methods must have a standardised protocol so that different practitioners will obtain the same results.

4. *Multi-species*: A method that can measure multiple species at once has logistical advantages over one that can only measure a single species. However, it is critical that the detection of one species does not prevent the detection of another.

5. *Simple*: It is preferable that any monitoring method is relatively simple to carry out so that misdetections or misclassification are minimised or negligible.

6. *Quick*: Ideally, sampling should be able to be carried out quickly. All other things being equal, a method that can be carried out within a single day is preferable to one that requires multiple days and/or multiple visits.

7. *Cost*: Any sampling scheme will benefit from having measurements across a higher number of sampling locations. Therefore, the cheaper the sampling method, the more locations that can be measured.

It is critical that **features 1–3 are the most important focus** when deciding on a sampling method. If a method is not reliable or invariant to gradients, increasing the number of sampling locations by using cheaper and quicker methods may still lead to results that are meaningless. It is more beneficial to have reliable data from fewer locations than poor data from more locations.

Another consideration related to possum TCI that may be important when measuring distribution and/or abundance is to use a sampling method that differs from that used for control. For example, it is possible that possums that were not caught during ground control trapping have a behavioural difference that makes them less likely to be caught in traps. If this is the case, then using trap-catch as an independent measure of relative abundance post-control may result in estimates that are biased low due to survivors being much less likely to be captured.

A final consideration is that where methods differ from those used by DOC (e.g. potentionally those described in section 6.6.3), estimates of relative abundance would not be directly comparable with estimates on public conservation land from the BMRS.

6.7.1 Weed methods

We propose that the methods used by the regional councils are those used by DOC for the Tier 1 of the BMRS, and are the same as those proposed for indicator M2 ('Vegetation structure and competition'). Briefly, data from relevé plots (also known as reconnaissance or recce plots) can be used to report on each weed species at each sampling location. The protocol for measurement of relevé plots requires that the cover of all plant species is recorded within fixed height tiers (0–0.3, 0.3–2, 2–5, 5–12, 12–25, >25 m) in each subplot of the 20 × 20 m vegetation plot, and that the cover of each plant species in each height tier is assigned within percentage classes (0–1%, 1–5%, 5–25%, 25–50%, 50–75%, >75% cover). The proportion of subplots that contains the species within a sampling location can be used as a measure of relative abundance. The data can be easily summarised to obtain an observed presence/absence for each sampling location, thereby enabling an estimate of occupancy either at the national or a regional council scale.

6.7.2 Animal methods

We outline some common sampling methods for monitoring pest animals. Some of these are species-specific whereas others can be more generally applied. It is outside the scope of this report to provide a critical assessment as to the reliability of each of these methods.

Note that any method that can be used to provide an estimate of abundance can also be used to provide an estimate of occupancy; however, the reverse is not true. Estimating occupancy requires at least one individual to be detected, as the unit of interest is the presence of the species. Data from relative abundance can therefore be aggregated in an observed absence when no individuals were detected and a presence when at least one individual was detected.

Trap catch index (possum only)

Trap-catch index (TCI) is based on the number of possum captures per 100 trap-nights from standard trap-lines (i.e. 10 traps per line spaced 20 m apart; NPCA 2011). The NPCA protocol exists to minimise differences in how traps are set, thereby enabling more reliable comparisons.

The DOC BMRS requires four standard trap-lines be set for one fine night at each sampling location in order to reliably estimate possum trap-catch-index (Gormley et al. 2015). This sampling protocol means at least two days are required at each sampling location.

A likely issue with trapping is the suitability of setting traps on private land, especially on land inhabited by livestock.

Chew devices

Chew/bite detection devices (Chew-track cards (CTCs) and WaxTags) are intended to detect small mammalian pests at low densities. They are normally set for seven nights and are recovered at the end of that period. They are primarily a mapping tool rather than one of density index, although estimates of relative abundance may be possible. There is a positive association with TCI for possums, although there is significant variation (Jones & Warburton 2011). The Department of Conservation is currently (2015) trialling the use of detection devices instead of traps for monitoring possums in non-forest habitats.

An issue with chew devices is that the presence of some species may prevent the detection of another. For example, rats at high densities will chew cards to such an extent that possum chew marks are chewed over. Furthermore, in farmland areas with livestock, detection devices may have to be attached above the reach of stock, but this will decrease the sensitivity of the devices.

Detection devices can be used in conjunction with tracking tunnels (see below) so that the animal footprints can be identified and used to more accurately determine the species.

Tracking tunnels

Tracking tunnels are intended to give a coarse index of relative abundance of small mammals such as rodents and mustelids (NPCA 2007). The longer the tunnels are left out, the more chance of a species using it; however, this is offset by the greater chance of invertebrate species using the tunnels, making the cards unreadable. Tracking tunnels are generally suitable for detecting changes in relative abundance over time at a collection of sites or differences between groups of sites. For mustelids, lines of five tunnels at 100-m spacings are set, with at least 1000 m separation between lines (NPCA 2007). This method provides estimates of occupancy, and a coarse index of relative abundance.

Faecal pellet sampling

Faecal pellet sampling for ungulates has a number of strengths including indices being positively related to abundance (Forsyth et al. 2010), fast and easy to carry out, requiring only basic equipment, and not requiring a repeat visit. Standard pellet-lines consist of 30 circular plots of 1-m radius spaced at 5-m intervals. A study of sambar deer distribution and abundance in Victoria, Australia, used three methods (faecal pellet counts, sign surveys and camera traps), and found faecal pellet-lines were the most appropriate method for monitoring the distribution of that species (Gormley et al. 2011). A disadvantage is that faecal pellets cannot be used to reliably differentiate species, so estimates relate to ungulates as a whole and cannot differentiate between individual deer species or between deer and feral goats. A further potential issue is that if the rate at which pellets decay varies with environmental conditions, such as temperature, rainfall, and vegetation type, measured differences between areas with different conditions may not reflect true differences in abundance.

The Department of Conservation uses four standard pellet-lines per sampling location to provide estimates of occupancy and relative abundance for ungulates, rabbits and hares for Tier 1 of the BMRS. The presence of possum pellets in each circular plot is also recorded. Preliminary data show that the proportion of pellet plots that contained possum faecal pellets

was linearly related to TCI. Furthermore, the estimate of occupancy (i.e. the proportion of plots occupied) was higher when pellets were used alone compared to traps alone (i.e. possums present in a sampling location were more likely to be detected by faecal pellets than they were to get caught in traps). Further work is required to determine whether the proportion of plots with faecal pellets can be used instead of TCI.

Faecal pellet sampling is also recommended as a method for monitoring wallabies (NPCA 2008a), where the proportion of faecal pellet plots with pellets is used as a measure of relative abundance. The recommendation is to use 50 plots at 15-m intervals on a 750-m line, with plot sizes of 40- and 80-cm radius (NPCA 2008a).

Faecal pellet sampling in farmland may be confounded by livestock, especially on goat and deer farms.

Camera trapping

Camera trapping has been used by various regional councils in the course of project work. Cameras have the advantage of being able to monitor a wide range of pest animals, but typically they are set to maximise the 'capture' of a few target species. An advantage, especially in the monitoring of ungulates, is the ability to determine particular species occupancy rather than a broad taxonomic group (Allen et al. 2015). Data collection from cameras requires each site to be visited twice (once to set up and once to retrieve the cameras). Cameras are relatively more expensive than other lower-tech detection methods. New research is occurring to enable automatic identification to species level (i.e. for mammals using analysis of texture and reflectivity of their fur), but that is not likely to be available in the near future. There are a large number of factors that will affect the detection probability associated with camera traps, including the shutter speed, trigger speed, sensor type, type of flash and number of cameras per location (Glen et al. 2013).

Spot-light counting

Spot-light counting is often used for a range of species, including rabbits in New Zealand (NPCA 2012) and wallaby in Australia, and is proposed for feral cats (NPCA 2011). It can be subject to differences in operator and land use type. Generally it is intended to provide a measure of change over time for a single area rather than a difference between areas. Results are given as the mean number of animals per km of transect, or per km^2 of the area covered by the spotlight. Spot-lighting is often performed from vehicles along roads and therefore may not be possible at all sampling locations, and is likely to be unacceptable at some times, especially in the presence of livestock.

Modified McLean Rabbit Infestation Scale

The Modified McLean scale is a measure of rabbit infestation (NPCA 2012), and is currently used by a number of regional councils. It is an eight-point scale based on observations of rabbits, sign, and faecal pellet heaps. The scale is intended to provide an index of rabbit density to make comparisons across areas with similar habitat or to determine changes over time. For monitoring over time, the metric is given as the mean score for each stratum/property. An advantage of this method is that it can be carried out during the day.

Guildford Scale for Wallabies

Similar to the McLean Scale is the Guildford Scale for Wallabies (NPCA 2008a). This is a 5-point scale based on observations of wallaby, sign, and faecal pellets.

6.8 Which species to measure

Due to the large number of potential species, a major consideration for this measure is which of those species to measure. The final list of species to measure will depend on the natural variability in the population, and the methods used for sampling.

6.8.1 Environmental weeds

For environmental weeds, the approach outlined in indicator M2 ('Vegetation structure and composition') will ensure that the distribution of many of the species of concern can be reported on. In M2, the survey of the vegetation plots records all vascular species, thereby enabling the occupancy for each of the 47 species of environmental concern to be determined. Similarly, for relative abundance, measurement data at the subplot scale can be summarised for each of these species.

6.8.2 Animal pests

For this measure, the animal pests to be considered by regional councils should contain at least those monitored by the DOC BMRS (i.e. brushtail possums, ungulates (goat and deer spp.), and lagomorphs (rabbits and hares)). Mustelids (ferrets, weasels and stoats) were excluded by DOC as they were considered to have population dynamics that were too variable for national-scale monitoring (see section 6.6.1 above). Similarly rodents (rats, mice) were also excluded by DOC due to having population dynamics that are too variable, preventing useful measures of abundance, and because they are pervasive across New Zealand, preventing useful measures of distribution (see section 6.6.2 on issues with occupancy). However both these taxa should be considered for inclusion.

Possums

From the initial survey of regional councils, all respondents agreed that possums should be monitored in the future. Current monitoring was typically only in response to management activities, but there was an indication from one respondent that a systematic grid-based approach, such as that proposed for this measure, was warranted.

Ungulates

Ungulates can be monitored using faecal pellet transects as indicated above. However, with this method identifying to species level is not reliable, and therefore, inference can be drawn only about ungulates as a group. Identifying to species level would require collection and DNA analysis of pellets, or additional supplementary techniques that permit species identification, such as camera trapping or spotlight surveys.

Feral pigs

Feral pigs can be monitored using a range of index methods; however, none have been calibrated against true abundance (NPCA 2008b). These include faecal pellet counts, catch per unit effort and inspection for field sign or soil disturbance. Although faecal pellet counts can be used as an index of abundance, they are likely to be insensitive at low population densities and are more appropriate to use as a measure of occupancy.

Lagomorphs

Lagomorphs were considered to be important to monitor by most regional councils and rabbits were currently monitored by all of them. A range of methods exists (NPCA, 2012); therefore, it is important a consistent method is used by all regional councils. The use of faecal pellet counts would enable comparisons to the DOC BMRS data and would be able to be gathered at minimal additional effort and cost if carried out for ungulate monitoring. Some councils have permanent spotlight transects for monitoring trends in rabbit abundance. However, currently rabbits are monitored using the Modified McLean scale (section 6.7.2), which is another option, but which is used primarily for compliance inspections to ensure landowners are maintaining rabbit numbers below the requirement stipulated in the Regional Plant Management Plans (RPMP).

Mustelids and rodents

Mustelids and rodents can be monitored using tracking tunnels. However, their highly variable population dynamics may result in estimates of relative abundance that were of little use. Estimates of occupancy could be derived; however, for pervasive species such as rats and mice, estimates would typically be near 100%. The value of this type of estimate would need to be carefully considered.

Feral cats

Cats are monitored by a small number of regional councils via the use of tracking tunnels and one council is trialling camera traps. Spot-light counts can be used, although it is difficult to obtain reliable estimates of feral cat abundance with them (NPCA 2011). Scat counts can also be used, talthough they are likely to be very sparsely distributed and difficult to identify. Camera-trapping has been used with large wild cats (tigers and leopards) as well as feral cats in Australia (Robley et al. 2009), and may be a viable option for feral cats in New Zealand.

Wallabies

Respondents to the survey generally agreed that monitoring of wallaby was warranted, but for presence/absence rather than relative abundance.

Hedgehogs

Survey respondents did not consider it important to monitor hedgehogs directly, although they indicated that monitoring other species using tracking tunnels could easily provide information on occupancy at no additional effort.

Birds (common myna, rook, Australian magpie)

Pest bird species will be monitored as part of indicator M3 ('Avian representation'). In that measure, the recommendation is that all species are recorded during sampling at five count stations as per the DOC BMRS (Figure 6-1). The sampling methodology enables estimates of occupancy and density for each species, although the latter depends on the number of detections that are obtained and is therefore not possible for species at lower overall densities.

Tracking tunnels and faecal pellet-lines would provide estimates of distribution for most species (Table 6-4); however, further research and development would be required to determine the reliability of the estimates obtained from these methods for each species for the purposes of reporting at a national and/or regional level.

Table 6-4 Pest mammals and potential monitoring methods, indicating whether they are suitable for distribution only (D), distribution and abundance (A), or neither (blank). Species denoted with an asterisk are monitored by DOC as part of their BMRS

Pest mammal	Trapping	Chew Device	Tracking Tunnels	Faecal Pellet	Camera	Spotlight	McLean/ Guildford Scale
Possum*	A	D	D	A	D		
Deer*				A	D		
Goats*				A	D		
Feral pigs				D			
Rabbits*		D?		A		A	A
Hares*		D?		A		A	
Rats		D	D				
Mice		D	D				
Mustelids			D		D		
Feral cats			D		D	A	
Wallaby				?	D	A	A
Hedgehogs			D				

6.9 What cannot be inferred from the data?

Indicator M7 is intended to provide information that can be aggregated at regional and national scales. To report on specific activities, such as the efficacy of control activities, it is likely that finer-scale information must be gathered independently. For example, if a particular regional council carries out rabbit control activities, determining the effectiveness

of that control will likely not be possible from estimates of Faecal Pellet Index at controlled vs uncontrolled locations from the systematic sampling described here. Firstly, it is unlikely that the scale of sampling will provide enough controlled sites to be able to make reliable inference about any changes. Secondly, the five-year period between re-measurements at any one location will likely be too long to be of use. Therefore, for finer-scale activities, it is more appropriate to carry out targeted monitoring, such as pre-control and post-control surveys. That is not to say that no inference whatsoever can be made regarding the effectiveness of control activities. The 2013 assessment of the DOC biodiversity indicators (Bellingham et al. 2013) compared possum occupancy and abundance at non-forest and forest locations subject to control within the last five years to those that had received no control during that period. There were no differences in occupancy as a result of possum control; however, possum TCI values were significantly lower in forest locations subjected to control than those areas with no control.

Indicator M7 is not intended to detect incursions of new pest and weed species. The measure is focused on pests and weeds that are already present and established in New Zealand. Detecting incursions of species of concern to border security is considered in M6 ('Number of new naturalisations') for weeds.

6.10 Other potential uses of the data

As mentioned previously, it is not possible to sample every square metre of ground to determine the distribution and abundance of target species, and a representative subset of sampling locations is measured instead. However, it is possible to 'fill in the gaps', by constructing a species distribution model. (This models the distribution and/or abundance of a species as a function of one or more biophysical variables (e.g. land cover type, mean temperature, annual rainfall), and then uses the resulting coefficients to estimate the likely distribution/abundance at all locations including those that were not sampled (see Gormley et al. 2011 for an example of distribution mapping).

6.11 Data management and access requirements

It is important that field data should be collected and managed in a manner consistent with the processes used by DOC and LUCAS. As indicated in the report for M2, it is recommended that vegetation data should be stored in the National Vegetation Survey Databank (NVS), a facility run by Landcare Research designed to store vegetation survey data in the format used in that measure. Data can be uploaded through the NVS express platform (https://nvs.landcareresearch.co.nz/Data/dataentry); detailed protocols can be found in Vickers et al. (2012a). By adopting this process, there will be no need for regional councils to create a new database and data storage facilities.

Data for pest animals currently monitored by DOC as part of its BMRS should be entered on the same field sheets as those used by DOC. Data for additional species will need to be developed. All data would need to be entered electronically into a central database accessible by all regional councils.

6.12 Reporting indices and formats

All indices will be reported at the regional council scale and aggregated to give a national estimate. An estimate of occupancy will be presented for all measured species (environmental weeds and pest animals) and estimates of relative abundance will be presented where possible (i.e. depending on the method used; Table 6-4). For environmental weeds, two additional measures (the proportion of species and of cover that is exotic) will also be given (see also section 2.5.6).

All estimates will be presented as means and 95% CIs, (see section 6.2.2). For example, 'possums occurred in 81% of sampling locations (mean occupancy = 0.81, 95% CI = 0.71–0.89), with a relative abundance, as measured by TCI (mean TCI = 4.5, 95% CI = 2.8–12.4)'.

Results could also be presented as figures with mean estimates with 95% CIs. An example is shown in Figure 6-3 for possums on public conservation land. In that figure, possum occupancy and abundance are separated into non-forest and forest; however, other groups could be used, such as regional council or land cover type.

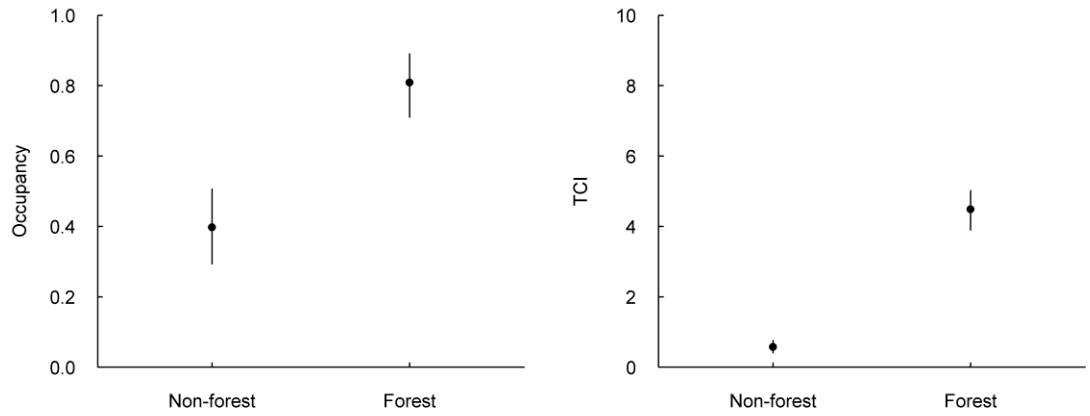

Figure 6-3 Example figure for reporting occupancy and abundance. Mean occupancy (left) and relative abundance (Trap catch Index, TCI) (right) of possums in non-forest and forest ecosystems, from Department of Conservation Biodiversity Indicators: 2013 assessment.

6.13 Critcial requirements before widespread implementation of M7

Research and development is required before the measure can be implemented by regional councils across all landscapes:

1. Further research and development of the potential monitoring methods is needed to assess their suitability on private land, especially land used for agriculture and in urban areas. This is the case even for those methods used by DOC due to differences in habitat types between public and private land.

2. Research is needed to determine how results from different methods can be harmonised. For example, if possum abundance is measured by TCI in natural and plantation forests and by detection devices (e.g. chew cards, WaxTags) in non-forest or agricultural habitats, how are the results to be reported? Is calibration necessary?
3. Implementation of M7 would require a single database for storing the data. Furthermore, standardised analytical methods are needed so that the indices can be reported consistently among councils and DOC.

6.14 References

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Appendix 6 – Regional council responses to questionnaire

A questionnaire was sent to all regional councils to obtain information on which pest animal and environmental weed species have been previously monitored, are currently monitored, and opinion as to which species require monitoring in the future. Responses were obtained from six regional councils (Hawke's Bay, Greater Wellington, Waikato, Marlborough, Northland and Horizons; one only responded to weed survey), and therefore may not be representative of other councils.

For the 26 pest animals queried, an average of 38% had been, or were currently being, monitored, although responses ranged from 19% to 58%. A higher percentage of species (mean = 46%, range = 19–92%) was thought to require monitoring in the future . Pest mammals (especially possums, mustelids and rabbits) were generally viewed by all respondents to require monitoring.

For the 47 environmental weeds, councils monitored on average 12 species, with responses ranging from 8 to 18 species. As with pest animals, the number of species that were believed to require monitoring in the future was higher (mean = 19%, range = 9–31%). Of the 47 species queried, 28 (59%) were currently monitored by at least one council, dropping to 14 (30%) currently monitored by at least two councils.

Summary of responses from the five regional councils that responded to the survey on pest animals. Figures indicate the number of regional councils that indicated that the species was currently monitored and also whether it still required monitoring

Species/taxa	Scientific classification	Currently monitored	Monitoring required
Possum	*Trichosurus vulpecula*	5	4
Wallaby spp.	Family Macropodidae	1	3
Ferret	*Mustela putorius furo*	3	4
Stoat	*Mustela erminea*	3	4
Rabbit	*Oryctolagus cuniculus*	5	5
Hares	*Lepus europaeus*	1	2
Deer spp.	Family Cervidae	2	2
Himalayan Tahr	*Hemitragus jemlahicus*	0	1
Feral goat	*Capra hircus*	3	3
Feral pig	*Sus scrofa*	2	2
Rats	*Rattus* spp.	4	4
House mouse	*Mus musculus*	2	2
Feral cat	*Felis catus*	1	2
Hedgehog	*Erinaceus europaeus*	2	1
Kaimanawa horse	*Equus ferus caballus*	0	0
Argentine ant	*Linepithema humile*	3	3
Great white butterfly	*Pieris brassicae*	0	0

Species/taxa	Scientific classification	Currently monitored	Monitoring required
Wasp spp.	*Vespula* spp.	1	1
Magpie	*Gymnorhina tibicen*	2	1
Rook	*Corvus frugilegus*	4	4
Common myna	*Acridotheres tristis*	0	1
Rainbow lorikeet	*Trichoglossus haematodus*	NA	NA
Red-eared slider turtle	*Chrysemys scripta elegans*	0	1
Rainbow skink	*Lampropholis delicata*	0	2

Summary of responses from the six regional councils that responded to the survey on environmental weeds. Figures indicate the number of regional councils that indicated that the species was currently monitored and also whether it still required monitoring

Species	Common Name*	Currently monitored	Monitoring required
Acer pseudoplatanus	Sycamore maple	1	1
Araujia sericifera	Moth plant	5	5
Ageratina adenophora	Mexican devil	0	3
Ageratina riparia	Mist flower	1	4
Chrysanthemoides monilifera subsp. *monilifera*	Boneseed, Bitou bush	6	5
Erigeron karvinskianus	Mexican daisy	0	1
Hieracium lepidulum	Tussock hawkweed	0	2
Hieracium pilosella	Mouse-ear hawkweed	1	2
Mycelis muralis	Wall lettuce	0	0
Anredera cordifolia	Madeira vine	3	5
Berberis darwinii	Darwin's barberry	4	4
Buddleja davidii	Buddleia	1	1
Leycesteria formosa	Himalayan honeysuckle	0	1
Lonicera japonica	Japanese honeysuckle	1	2
Celastrus orbiculatus	Climbing spindle berry	5	5
Tradescantia fluminensis	Wandering jew	1	1
Calluna vulgaris	Heather	1	2
Erica lusitanica	Spanish heath	0	1
Callistachys lanceolata	Oxylobium, Wonnich	0	1
Cytisus scoparius	Broom	1	2
Lupinus polyphyllus	Russell lupin	0	0
Ulex europaeus	Gorse	2	2

Species	Common Name*	Currently monitored	Monitoring required
Gunnera tinctoria	Chilean rhubarb	4	4
Crocosmia × crocosmiiflora	Montbretia	0	0
Asparagus scandens	Climbing asparagus	1	3
Ligustrum lucidum	Tree privet	1	2
Lycium ferocissimum	Boxthorn	0	0
Osmunda regalis	Royal fern	0	4
Passiflora tripartita	Banana passionfruit	3	4
Pinus contorta	Lodgepole pine	3	4
Pseudotsuga menziesii	Douglas fir	0	4
Agrostis capillaris	Browntop	0	0
Ammophila arenaria	Marram grass	1	3
Cortaderia jubata	Purple pampas grass	1	2
Cortaderia selloana	Pampas grass	1	2
Glyceria maxima	Floating sweetgrass	0	2
Nassella trichotoma	Nassella tussock	6	5
Pennisetum clandestinum	Kikuyu grass	0	1
Spartina spp.	Cord-grass	5	5
Hakea sericea	Prickly hakea	0	3
Clematis vitalba	Old man’s beard	4	3
Rhamnus alaternus	Italian evergreen buckthorn	5	5
Cotoneaster glaucophyllus	Cotoneaster	0	2
Salix cinerea	Grey willow	0	0
Salix fragilis	Crack willow	0	0
Tropaeolum speciosum	Chilean flame creeper	1	4
Hedychium gardnerianum	Wild ginger	4	2