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Standardised terrestrial biodiversity indicators for use by regional councils

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M3	Avian representation	Philippa Crisp, Greater Wellington RC	Deb Wilson, Landcare Research
M5	Vulnerable ecosystems	Lisa Forester, Northland RC	Barbara Anderson, Landcare Research
M6	Number of new naturalisations	Kevin Collins, Waikato RC	Lynley Hayes, Landcare Research
M7	Distribution and abundance of weeds and animal pests	Campbell Leckie, Hawke's Bay RC	Bruce Warburton, Landcare Research
M8	Change in area under intensive land use	Kirsty Johnston, Environment Canterbury	Markus Mueller and John Dymond, Landcare Research
M9	Habitat and vegetation loss	Kirsty Johnston, Environment Canterbury	Markus Mueller and John Dymond, Landcare Research
M11	Change in temperature and precipitation	Amy Rush, Environment Southland	Roddy Henderson, NIWA
M12	Change in protection of naturally uncommon ecosystems	Kirsty Johnston, Environment Canterbury	Barbara Anderson, Landcare Research
M13	Threatened species habitat: number and status of threatened species impacted by consents	Lisa Forester, Northland RC	Marie Brown, Environmental Defence Society
M14	Vegetation consents compliance	Nicky Eade, Marlborough District Council	Marie Brown, Environmental Defence Society
M15	Indigenous ecosystems released from vertebrate pests	Campbell Leckie, Hawke's Bay RC	Grant Norbury, Landcare Research
M16	Change in the abundance of indigenous plants and animals susceptible to introduced herbivores and carnivores	Kevin Collins, Waikato RC	Sarah Richardson, Landcare Research
M17	Extent of indigenous vegetation in water catchment	Craig Bishop, Auckland Council	Markus Mueller and John Dymond, Landcare Research
M18	Area and type of legal biodiversity protection	Tim Park, Greater Wellington RC	Marie Brown, Environmental Defence Society
M19	Contribution of initiatives to (i) species translocations and (ii) habitat restoration	Nancy Willems, Bay of Plenty RC	Deb Wilson, Landcare Research
M20	Community contribution to weed and animal pest control and reductions	Nancy Willems, Bay of Plenty RC	Grant Norbury, 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

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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.

interest within regions. Each indicator is described in terms of a minimum standard for all 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.

1 Indicator M1: Land under indigenous vegetation

Author: Jake Overton, Landcare Research

1.1 Introduction

While 40–50% of New Zealand's original indigenous vegetation remains, the distribution of this across land environments is very uneven. Environments that burn easily or lowland areas suitable for human activities often have very little indigenous habitat remaining, while steep, wet or high elevation environments may remain largely indigenous.

Indicator M1 is designed to measure and report on patterns of loss and retention of indigenous vegetation cover relative to potential vegetation cover, and therefore provides a fundamental indicator of environmental representation (i.e. the proportion of environments or potential habitats remaining in indigenous vegetation). This indicator requires a national layer of potential habitat types or environments to estimate original extent, and information on current land cover to estimate current indigenous extent. The indicator provides tables and maps of proportion remaining indigenous (i.e. representation) of the original habitat types, summarised nationally and regionally, and by territorial authorities, and ecological regions within local government administrative regions. Some regional councils will use summaries supplied by Landcare Research, and others will do their own analyses. Ideally, councils will refine the results for their area, by refining the habitat type descriptions for their area, and using fine-scale information on special habitats to provide more resolution of habitats. Future updates and refinements may include new classifications of environments or of potential habitat extent, updated current land cover information, revised methods for assessment of the indigenous content of land cover, and refinements of analyses and presentation.

1.2 Scoping and analysis

Indicator M1 is a fundamental indicator of environmental representation – one of the three components of ecological integrity. While other indicators address various aspects of environmental representation and change, this measure provides the overall picture of patterns of environmental representation across New Zealand. Since this indicator also considers the indigenous component of vegetation, it also addresses the indigenous dominance component of ecological integrity.

Understanding the distributions of remaining habitat types, and in particular, their distributions across environments (i.e. environmental representation) is fundamental to understanding biodiversity loss. While the overall loss of indigenous vegetation cover in New Zealand is moderate, the loss in some environments is critical. This indicator is designed to measure and report on these fundamental patterns of biodiversity, and therefore provides a fundamental indicator of environmental representation (i.e. the proportion of environments or original habitats remaining in indigenous vegetation).

Some discussion of the term 'potential habitat types' as it is used here is warranted. Potential habitat types or ecosystems are similar to – but subtly different from – original or pre-human habitat types or ecosystems. Original or pre-human habitat types are the actual habitat types that existed at some time in the past (e.g. 1000 AD). In this sense, they are an actual past configuration of habitat types that actually existed, even if we can only estimate what they were. In contrast, potential habitat types estimate what would be present currently in New Zealand, in the absence of any anthropogenic influences or large-scale natural disturbances. These are different from pre-human habitat types because conditions (e.g. climate) might have changed, or species and communities might have changed their distributions for other reasons. Potential habitats also include the influence of biogeography on the distributions of habitats and ecosystems, whereas this is not considered in purely environmental classifications. Thus, when using national potential habitat datasets, regional-based interpretation and narrative will be required.

1.3 Assessment of existing methodologies

This indicator has been developed for the Ministry for the Environment (MfE), various regional councils and the Department of Conservation (DOC) over the past twelve years. Examples of reporting land under indigenous cover, or land under indigenous cover providing context for other reports and analyses include:

- Analyses of biodiversity protection for MfE (Rutledge et al. 2004)
- Analyses of recent loss of cover and threatened environment classification and tools (Walker et al. 2006, 2008)
- Analysis of past and current indigenous vegetation cover and the justification for the protection of terrestrial biodiversity within the Manawatū–Whanganui region (Maseyk 2007)
- Report on indigenous biological diversity in the matter of hearing submissions concerning the proposed One Plan notified by the Manawatū−Whanganui Regional Council (Maseyk 2008)
- Applications to conservation planning and reporting (Overton et al. 2010a).

Most of these analyses used the Land Environments of New Zealand (LENZ; Leathwick et al. 2003) as an estimate of potential or original habitats or ecosystem patterns. Maseyk (2007, 2008) used Potential Vegetation of New Zealand (PVNZ).

Whatever the choice of habitats used for the analyses, it must provide nationally consistent predictions of original or potential habitat types or ecosystems across of New Zealand that will yield consistent predictions at sub-national (i.e. regional) scales. For this reason, habitat type classifications that provide detailed definition of habitat types, but do not provide complete coverage (such as that used by DOC for the ecosystem prioritisation process) cannot be used for this indicator. It should be noted that both LENZ and PVNZ do not include many specialist habitat types for which there is currently no national coverage of original and current extent. This indicator may be improved by individual councils where they have reliable and regionally consistent information on these habitat types not captured by the national datasets.

The basic indicator of environmental representation is the amount and proportion of each habitat type remaining in indigenous vegetation. There is usually interest in having this summarised in various ways, such as nationally, by local government administrative boundaries, and by ecological regions. Of these analyses, most have used a simple binary classification of current land cover into indigenous and non-indigenous. But Overton et al. (2010a) considered whether the current land cover was also ‘natural’ (in the sense that the habitat may consist of indigenous species, but has been induced by human interference) relative to the potential vegetation, including degradation of various indigenous habitat types.

1.4 Indicator definition, data and analysis

1.4.1 Definition

Indicator M1 requires a nationally comprehensive layer of potential or original habitat or ecosystem types, together with current land cover information. Each current land cover type is designated as either indigenous or non-indigenous. The fundamental indicator of representativeness of each habitat type is defined as the proportion of the potential or original habitat type that remains in indigenous vegetation. The total areas of original and remaining indigenous vegetation are also reported. These analyses are reported nationally, by local government administrative boundaries, and by ecological regions.

1.4.2 Data

Potential habitat types

The methodology for M1 uses the PVNZ as the potential habitat classification, augmented by each regional council with information on additional habitat types present in the region and not depicted by PVNZ. Potential vegetation predicts for all terrestrial parts of New Zealand, the vegetation that would be expected currently if humans had never arrived. Within forested areas, the predictions of composition are based upon the extensive work of John Leathwick, which modelled the potential distributions of canopy trees in relation to environmental attributes. Additional habitat types have been added from historical and palaeological evidence. The potential habitats also include important biogeographic effects that influence species distributions and ecosystem characteristics, particularly the beech gap. A number of additional habitat types have been added from information in the New Zealand Land Cover Database (LCDB; most recent iteration as LCDB4). Estimates of wetland extent have also been updated, using estimates of original wetland extent by Ausseil et al. (2008) for the Waters of National Importance (WONI) project.

More detailed methods behind PVNZ can also be found at https://lris.scinfo.org.nz/layer/289-potential-vegetation-of-new-zealand/

Each of the forest classes in PVNZ is given a name based on forest class naming standards. These are names for classes of forest, rather than an explicit description of all of the species that ought to be present, and there are only 20 such names for New Zealand, and therefore they represent broad-scale and generalised patterns only. It is expected that some of the species in a class will not be found across the entire geographic distribution of the class. For example, the class ‘Kauri/northern broadleaved forest’ has been observed to extend south of the distribution of kauri. Similarly, a class such as ‘Hall’s tōtara–miro–rimu/kāmahi–silver beech–southern rātā forest' may occur in regions where there is no southern rātā, but which do have a suite of species that are associated with southern rātā in other locations. It is reasonable for councils to amend the names of habitats in their region to make the classes more regionally valid (e.g. to remove a species from the name that does not occur in their region).

There is considerable scope for improvement of the PVNZ. There are many uncharacteristic or naturally uncommon ecosystems (cf. indicator M12) that are unrepresented in the PVNZ. It is quite feasible to include these habitat types where information on their original or potential extent is available across New Zealand, and councils may wish to update habitat types in their region if they have improved information at the regional scale. Councils will need to carefully balance incorporation of new information and integrity of the overall classification. For example, the process of updating the potential extent of wetlands based on new wetland information results in areas the PVNZ identifies as wetland now being classified as non-wetland, but there is no alternative vegetation classification offered within the PVNZ. To solve the problem in the interim, an additional class 'wetland discrepancy' has been added. This will need to be resolved by regional councils as better information specific to their region comes to light. There are also known wetland errors on the West Coast of the South Island, which should be resolved in time.

Like LENZ, PVNZ does not include many uncharacteristic habitat types. Councils with more specific information on habitat types for their region should augment the analyses for their region. Care will need to be taken to ensure the national integrity of the indicator remains.

Current land cover

Indicator M1 uses the Land Cover Database (LCDB). Worked examples developed for this report used LCDB2 but for applications of this measure in future, the most up-to-date version of LCDB should be used (currently LCDB4).

Past analyses suggest that some LCDB classifications do not provide reliable estimates of change for indigenous vegetation at the decadal time scale. This should be revisited with successive iterations of LCDB, but it is likely that use of other measures (e.g. Indicator M2, 'Vegetation Structure and Composition') will be needed in conjunction with this indicator to estimate changes in the patterns of indigenous vegetation.

Boundaries

The ecological region and local authority boundaries are used for this indicator. The 2012 versions of the regional, territorial, and unitary boundaries were downloaded from the Statistics New Zealand website and re-projected to the New Zealand Map Grid (NZMG).

Because the coastlines used differ between the layers (ecological regions and local authority boundaries) and also differ between the PVNZ and LCDB information, there are some minor variations in the predicted areas of habitat type extent from different analyses. For the same reason, some pixels do not have assigned values in one or more of the GIS layers, resulting in no values in those areas.

1.4.3 Analysis and application

Some councils will choose to use analyses provided by Landcare Research. Others will choose to perform their own analyses.

Analyses performed by Landcare Research use the data transformed into GIS raster grids. Using a custom-made extension for ArcView 3.2, the grids are combined to get all the unique combinations of potential vegetation, land cover, and the boundaries. The combinations are then used for summarising the amount of each remnant habitat type typology for each boundary (e.g. region, territorial authority, or ecological region). This grid combines results to yield a single grid with a unique ID for each combination. A table gives the values of each grid for that combination, and a count of the grid cells with that combination. Each grid cell represents a fixed areal extent, and multiplying the number of grid cells by this area yields the number of hectares for each remnant habitat in the context of each boundary type. To manage the different combinations of habitat type and boundary type effectively, the table is exported to an Access database to provide the required summaries, which are outputted as Excel files. The results of the Excel table summaries can be linked back to the GIS grid using the unique grid ID to make maps of the variables of interest, such as the proportion remaining of each habitat type, for each region.

Analyses by Landcare Research have all been done using NZMG projection. Given the New Zealand standard is to shift to the preferential use of the New Zealand Transverse Mercator projection (NZTM), future analyses will need to consider any discrepancy in the number of grids that may arise due to the slight distortion between the NZMG and the NZTM projections. (Note that all projections suffer from distortions; both NZMG and NZTM are not equal-area projections and hence, there are small errors in the resulting area values.)

Councils that use analyses provided by Landcare Research may choose to refine the results for their region. For example, the Bay of Plenty Regional Council has considerable confidence in their estimates of original and remaining duneland extent, and these differ from those provided by the Landcare Research analyses. In such cases, regional councils should replace the analyses with their own estimates for their region, and provide their information into a central resource that may be used to improve future versions of the PVNZ. Similarly, as mentioned above, councils may amend the habitat type names to better reflect the species composition in their region.

The approach of combining the LCDB2 with PVNZ to model remaining habitats by type has been successfully used by Horizons Regional Council to develop biodiversity protection policy for use in its One Plan. The habitat typologies were re-grouped (and at times re-phrased) into typologies that typically match those that are expected. For example, the very specific ‘Kahikatea–mataī/tawa–māhoe forest’ was redefined as a simpler and generic ‘Podocarp/tawa–māhoe forest’ due to the propensity for other podocarp species to appear as mixed forest types within the region. Also, for example, the ‘Kauri/taraire–kohekohe–tawa forest’ typology was re-phrased as ‘Hardwood/broadleaf’ forest because of the lack of kauri and taraire in the Manawatū–Whanganui region, and typologies such as ‘rimu–mataī–miro–tōtara/kāmahi’ and ‘Rimu–miro–tōtara/kāmahi’ are so similar that they can be merged as ‘Podocarp/kāmahi’.

The proportion (%) of former extent remaining of these re-phrased habitat types was recalculated and then scaled against two theoretical thresholds for accelerated biodiversity loss: 20% and below of former extent to identify 'Threatened' habitat types and between 20% and 50% of former extent for 'At-risk' habitat types. Habitat types above 50% were excluded from the regulatory methods of the One Plan and have thus not been assigned a threat category.

The development of the policy to protect living heritage is based on these thresholds and threat classifications (Threatened, At-risk), where any activity that results in vegetation clearance or land disturbance of threatened habitats is a 'non-complying' activity, and of at-risk habitats is a 'discretionary' activity. Both classes set a high bar for resource consenting.

The One Plan of Horizons Regional Council also provides an example of needing to supplement the identification of habitat types by the PVNZ with those known to exist in the region but not captured by the model (e.g. naturally rare habitat types).

1.5 Sampling scheme development

Indicator M1 uses spatially extensive GIS information on an existing model of potential habitat types and current land cover depicted in LCDB2. As such, sampling schemes are not germane to this measure.

However, new versions of LCDB (i.e. LCDB4) have been improved by regional councils checking the ground accuracy of the data. To improve the accuracy of LCDB, and maintain some degree of national consistency in the level of accuracy, it may be preferable that the LCDB development team propose a minimum sampling scheme requirement at all councils.

As stated above, improvements to the accuracy and value of the PVNZ relies on councils providing more finely-scaled data for the analysis.

1.6 Data management and access requirements

Indicator M1 combines a range of spatial information from different sources. It is the responsibility of the various agencies that provide the information to update the information. The use of the information in indicators may provide additional impetus or funding to update the information. All sources of information are publicly available.

1.7 Reporting indices and formats

Indicator M1 provides fundamental information on overall biodiversity status, useful for reporting and setting of policy.

Several maps should be used to present the indicator, to provide both context and status for this indicator. These are exemplified below using examples from work for Horizons Regional Council's One Plan (Maseyk 2007). The distribution of the different habitat types (Figure 1-1) provides an understanding of the potential distribution and extent of each habitat type. A map of the current remaining habitats (Figure 1-2) provides a comparison for the amount and distribution of the habitat types remaining. A simple graphing of the proportion remaining in the region for each habitat type facilitates a classification into threat categories (Figure 1-3).

Threat categories can also be mapped to provide an understanding of their extent and distribution (Figure 1-4).

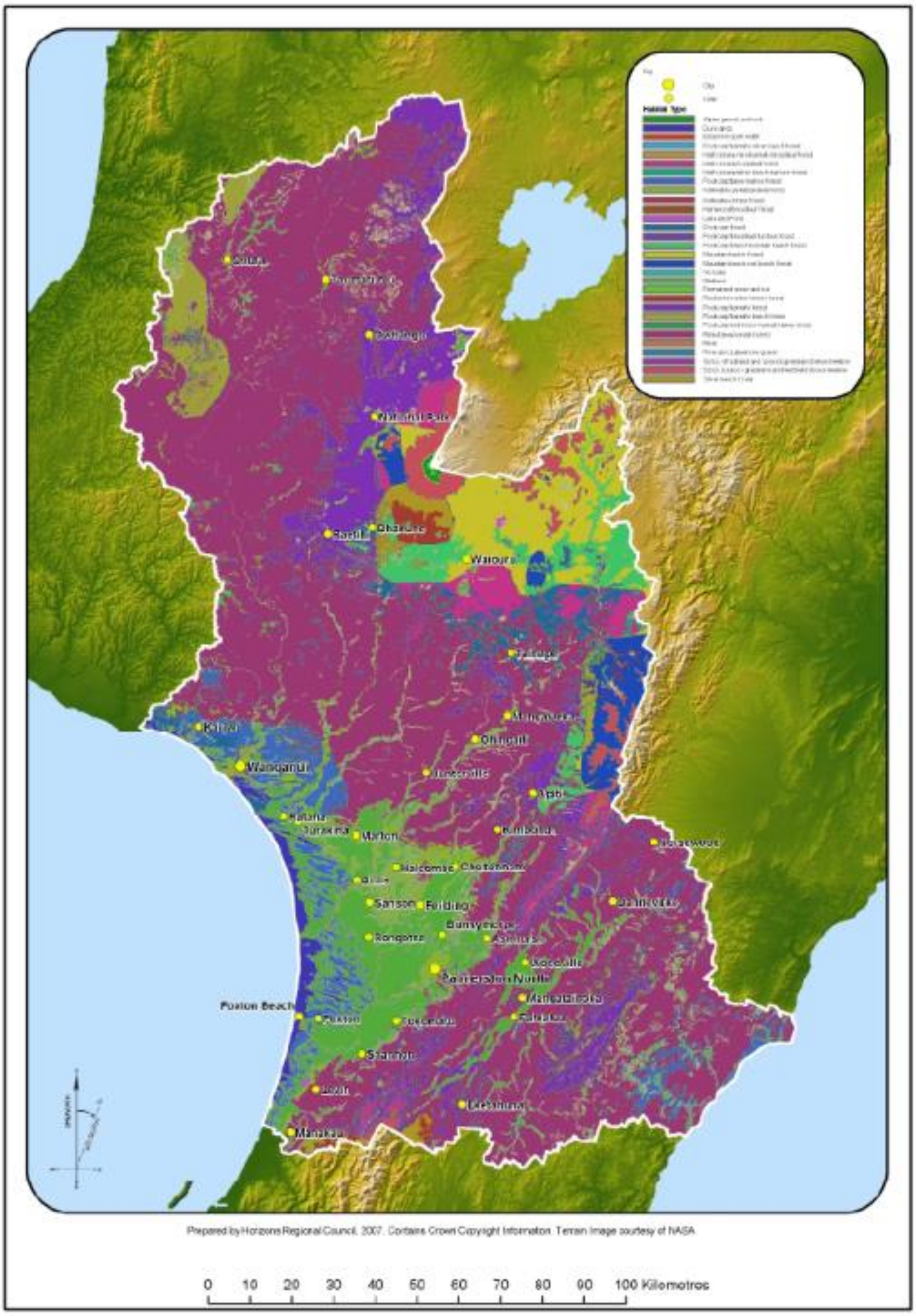

Figure 1-1 Predicted previous extent of indigenous vegetation defined by habitat type in the Manawatū–Whanganui region.

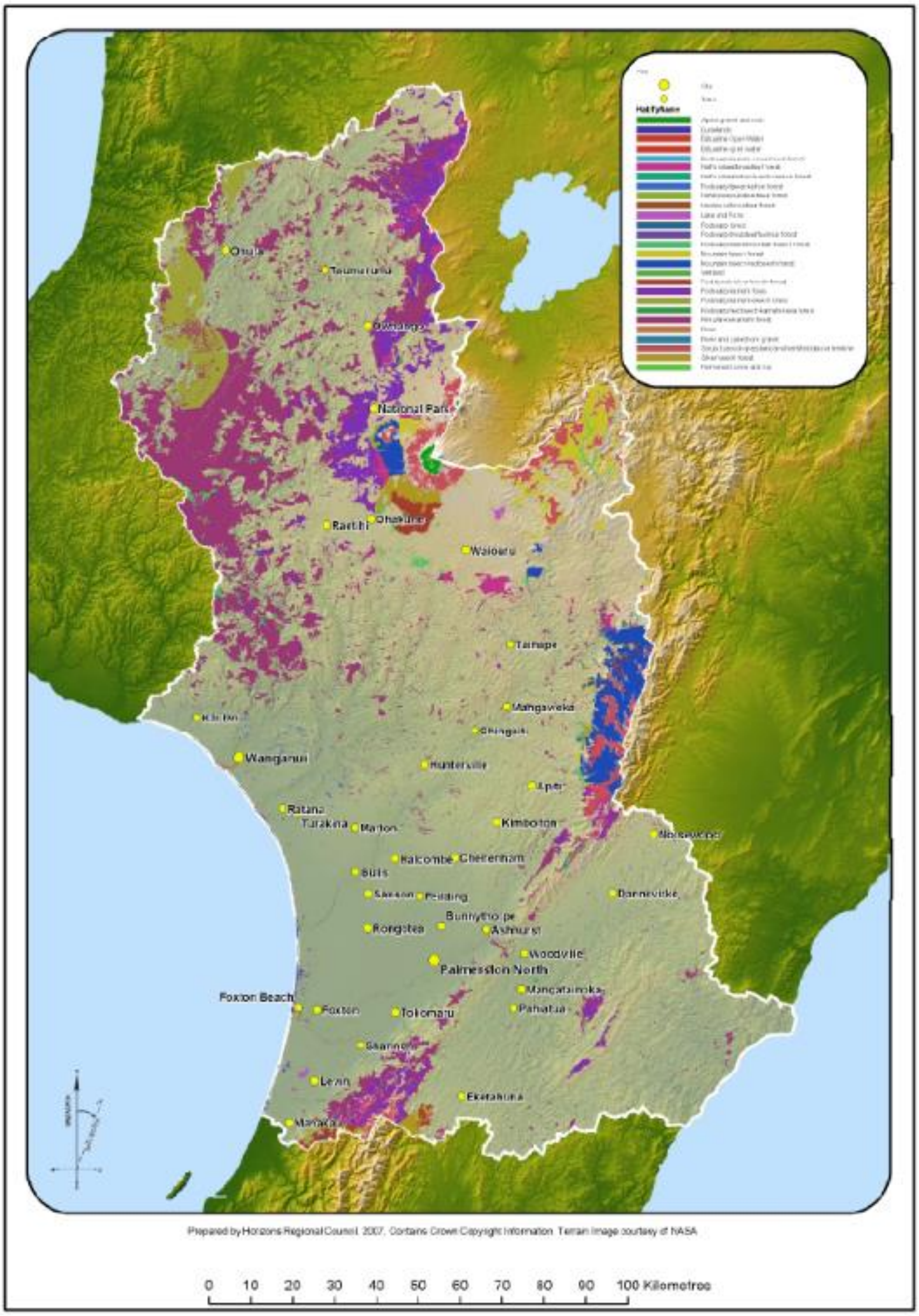

Figure 1-2 Current extent of indigenous vegetation cover defined by habitat type in the Manawatū-Whanganui region. Vegetation cover classes defined in Appendix 1..

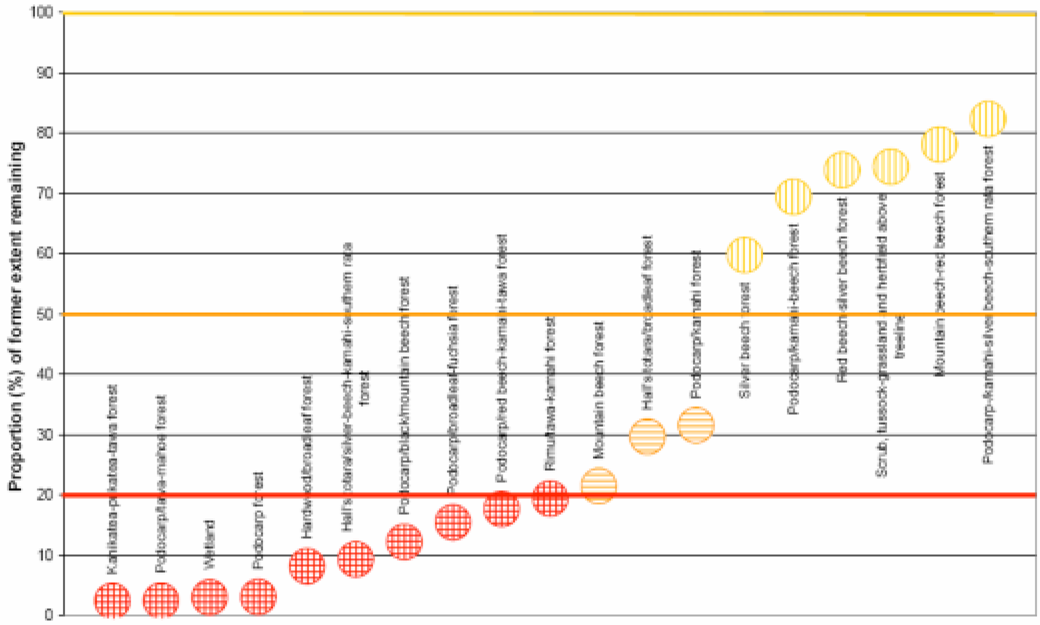

Figure 1-3 Habitat types identified in the Manawatū–Whanganui Region and remaining extent of each habitat type expressed as a proportion of previous extent. Habitat types below the horizontal red line are considered 'Threatened' habitat types (red hatched circles). Habitat types below the horizontal orange line are considered 'At Risk' habitat types (orange horizontal shaded circles). Habitat types below the horizontal yellow line are labelled 'No Threat Category' (yellow vertical shaded circles). From Maseyk (2007).

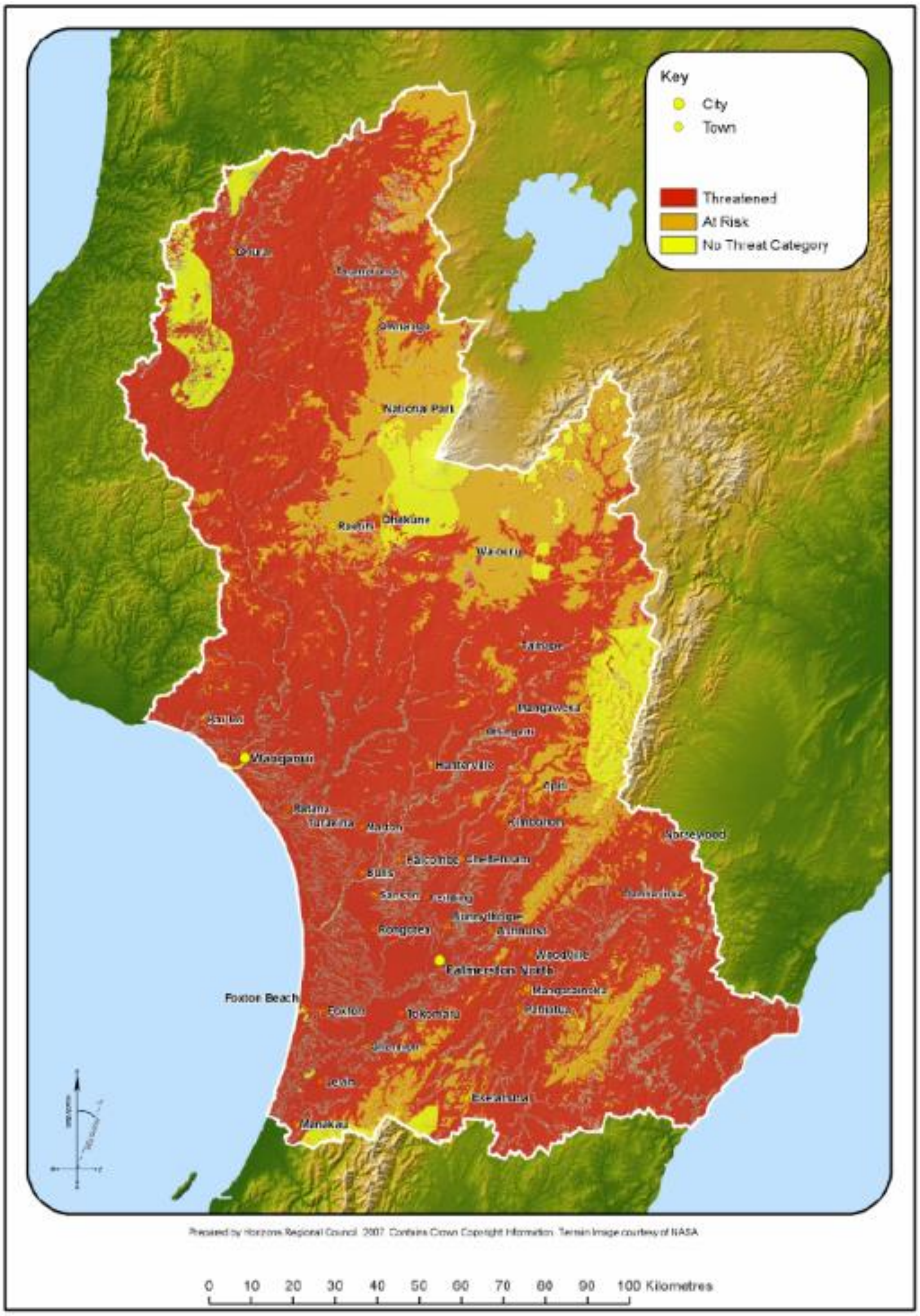

Figure 1-4 Map of the Manawatū-Whanganui Region showing the spatial pattern of Threatened, At Risk and No Threat Category habitat types at a scale of 1:1,080,000.

Behind these maps, a wide range of other applications exist. More detailed information on the breakdown of remaining indigenous vegetation needs to be provided in databases or appendices. These should include tables of the amount remaining and proportion remaining of various habitat types, summarised in various ways, including nationally, regionally, and within political region by ecological region or territorial authority. Three ways of summarising, and the variables provided for each follow:

1. Region. Summaries of the following variables are provided nationally and regionally for each habitat type:

   a. Habitat name
   b. Area Original NZ
   c. Area Remaining Indigenous NZ
   d. Percentage Remaining Indigenous NZ
   e. Area Original Region
   f. Area Remaining Indigenous Region
   g. Percentage Remaining Indigenous Region

2. Region and ecological region. Summaries of the following variables are provided nationally and regionally (a–g), and for each ecoregion within the region (h–l), for each habitat type:

   As above for No. 1–

   a. Habitat name
   b. Area Original New Zealand
   c. Area Remaining Indigenous New Zealand
   d. Percentage Remaining Indigenous New Zealand
   e. Area Original Region
   f. Area Remaining Indigenous Region
   g. Percentage Remaining Indigenous Region

   For each ecological region *i* found in the region–

   h. Ecological region *i* Area Original in Region
   i. Ecological region *i* Area Remaining Indigenous in Region
   j. Ecological region *i* Percentage Remaining Indigenous Region
   k. Ecological region *i* Percentage Contribution to Region Original
   l. Ecological region *i* Percentage Contribution to Region Remaining

3. Region and territorial authority. Summaries of variables are provided as for No. 2 above, but using territorial authority to summarise within region, rather than ecological region.

1.8 Future considerations

There are a number of considerations for the future development of this indicator. The most important are the choice of classification used for the analysis, and how the estimation of indigenous cover remaining is done.

1.8.1 Choice of classification

The choice of classification for potential habitats or environments will have a very strong influence on the results. Currently the PVNZ is used for this indicator. Many previous analyses have used LENZ Level IV, which also forms the basis of the Threatened Environment tool. One notable difference between LENZ and PVNZ is the number of classes, with LENZ Level IV having 500 classes and PVNZ only 24 (20 forest habitats, and 4 non-forest habitats). In both cases, more classes may be added by councils when information on special habitats or ecosystems is available. The larger number of classes in LENZ Level IV means that the environmental patterns are divided much more finely than for PVNZ. This means that there is much more variation in the proportion of classes remaining in indigenous vegetation in analyses done with LENZ Level IV than those done with PVNZ. The results using PVNZ can be seen as a 'coarse focus' view of the status of biodiversity, while those using LENZ Level IV are a 'fine focus'. It is, however, not entirely clear that all of this finer division is biologically meaningful. Overton et al. (2010b) report that the ability of LENZ to predict differences in both snail and beetle communities decreases with the number of LENZ classes used.

It is, of course, possible to use more than one classification, and provide comparisons of the results. Councils may find it useful to compare this indicator with the Threatened Environments classifications when reporting biodiversity statistics to their community. There is a range of other classifications that could also be considered. In particular, the environmental classification in LENZ was not directly informed by biotic data. New generations of LENZ have been generated that use biotic information to optimise the classification to best discern biotic pattern. The new generations of LENZ also include biogeographic effects, which are ignored in the original version of LENZ.

1.8.2 Estimation of indigenous cover remaining

In the current analyses, classes from the LCDB2 are considered either exotic or indigenous. In many of the classes considered indigenous, the vegetation is highly modified from the natural or potential vegetation. In many cases, this will overestimate the amount of indigenous vegetation remaining. A more sophisticated approach is to consider classes as a continuum of 'indigenous-ness' or naturalness. As discussed above, Overton et al. (2010a) developed a method to consider whether the current land cover was natural relative to the potential vegetation.

The consideration of 'indigenous' instead of 'natural' can make a significant difference in the reported statistic. For example, in Inland Otago the current analyses show c. 50% of the vegetation remaining is indigenous (Figure 1-5). This is largely because the current analyses consider highly modified tussock grasslands to be indigenous and natural, even when the potential vegetation is woodland. This contrasts starkly with the results from the Threatened Environment tool, which show much more variance in this region. Although the Threatened Environment analyses also consider tussock grasslands to be native, they use LENZ IV classification, which has a much finer division of the area.

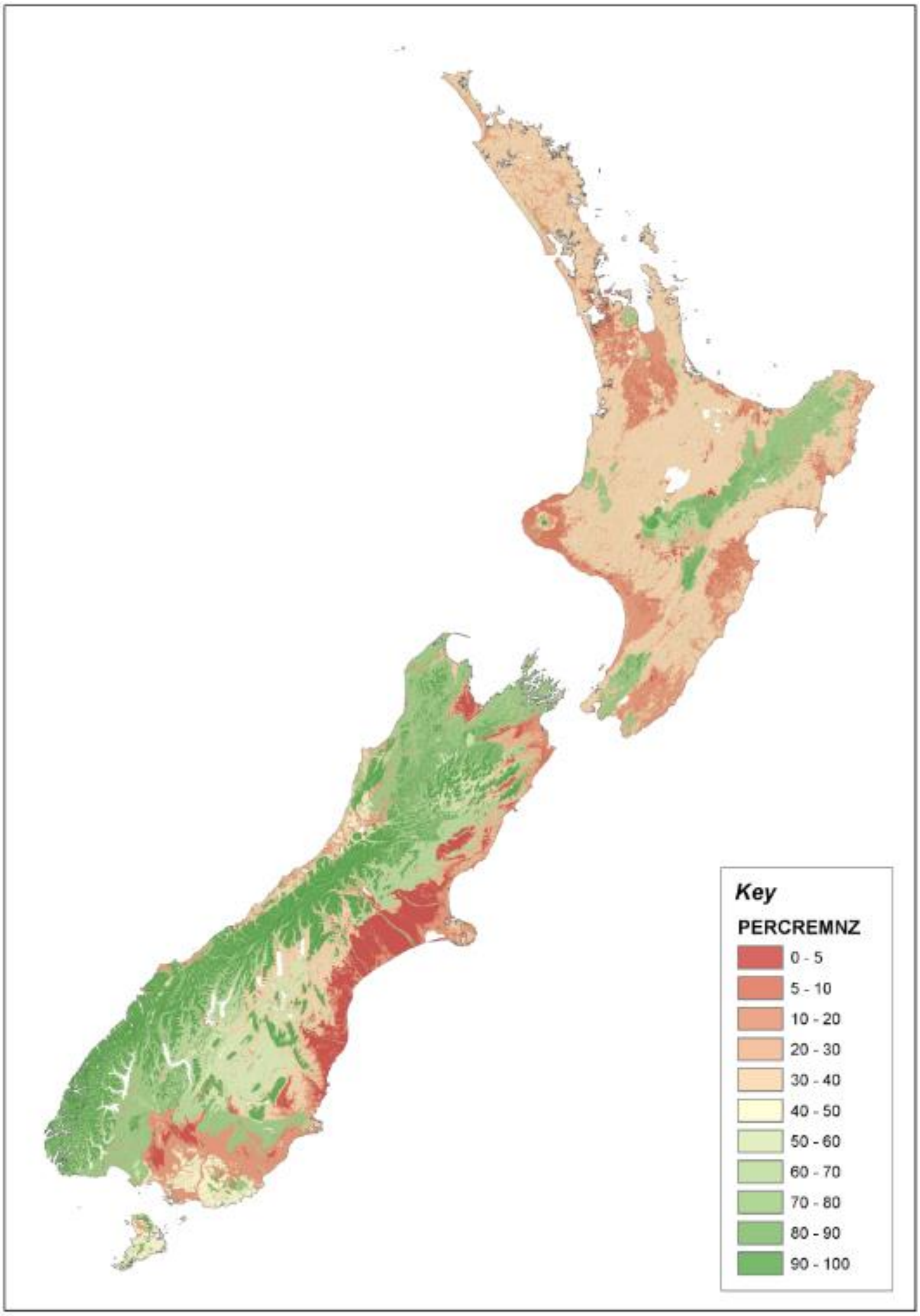

Figure 1-5 Map of proportion of potential vegetation types remaining in indigenous vegetation (PERCEMNZ) for New Zealand.

What is considered indigenous can change in different places. For example, in the analyses shown above from Horizons Regional Council, induced indigenous land cover types, such as mānuka scrub, were separated out in the estimation of areas of remaining indigenous habitat. This is another way to refine the estimation of the indigenous-ness of current land cover in these analyses.

It is worth noting that any changes in classifications or the estimation of indigenous-ness will provide different results.

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Appendix 1 – Land cover classes

Table A1-1 Land cover classes and whether they are considered indigenous in the analyses (0 = No, 1 = Yes).

Grid value	Land cover class	Indigenous
1	Build-up Area	0
2	Urban Parkland / Open Space	0
3	Surface Mine	0
4	Dump	0
5	Transport Infrastructure	0
10	Coastal Sand and Gravel	1
11	River and Lakesore Gravel and Rock	1
12	Landslide	1
13	Alpine Gravel and Rock	1
14	Permanent Snow and Ice	1
15	Alpine Gras / Herbfield	1
20	Lake and Pond	1
21	River	1
22	Estuarine Open Water	1
30	Short-roationa Cropland	0
31	Vineyard	0
32	Orchard and Other Perennial Crops	0
40	High Producing Exotic Grassland	0
41	Low Producing Grassland	0
43	Tall Tussock Grassland	1
44	Depleted Grassland	1
45	Herbaceous Freshwater Vegetation	1
46	Herbaceous Saline Vegetation	1
47	Flaxland	1
50	Fernland	1
51	Gorse and/or Broom	0
52	Mānuka and/or Kānuka	1
53	Matagouri	1
54	Broadleaved Indigenous Hardwoods	1
55	Sub Alpine Shrubland	1
56	Mixed Exotic Shrubland	0
57	Grey Scrub	1
60	Minor Shelterbelts	0

Grid value	Land cover class	Indigenous
61	Major Shelterbelts	0
62	Afforestation (not imaged)	0
63	Afforestation (imaged, post-LCDB1)	0
64	Forest – Harvested	0
65	Pine Forest – Open Canopy	0
66	Pine Forest – Closed Canopy	0
67	Other Exotic Forest	0
68	Deciduous Hardwoods	0
69	Indigenous Forest	1
70	Mangrove	1

2 Indicator M2: Vegetation structure and composition

Author: Fiona Thomson, Landcare Research

2.1 Introduction

This report concerns Indicator M2 ('Vegetation structure and composition'), which is part of the Biodiversity Condition indicator. The reporting element for M2 is the 'Presence of suitable indigenous component in all structural layers' and this measure is directly analogous to the Department of Conservation (DOC) measure 5.1.1, which examines the change in 'Size class structure of canopy dominants' (Allen et al. 2013). The regional council measure is worded to include other indigenous components – not just canopy dominants.

Five kinds of data can be used to report change in size class structure of canopy dominants using methods of Hurst and Allen (2007a) and Allen et al. (2013):

1. Size-class distributions of woody stems ≥2.5 cm in diameter at breast height (1.35 m height) (dbh), by species, based on measurements at 20 × 20 m plot scales

2. Counts of woody stems, as genets, >1.35 m tall but <2.5 cm dbh, based on measurements at 400-m^2 (20 × 20 m plot) and 25-m^2 scales

3. Counts of woody stems, as genets, <1.35 m tall, in fixed height-classes in replicated subplots (total 18 m^2 within 400 m^2; stems >1.35 m tall are included in (2), above)

4. Presence of non-woody plants, including lianas, <1.35 m tall, in fixed height-classes (≤0.15 m; 0.16–0.45 m; 0.46–0.75 m; 0.76–1.05 m; 1.06–1.35 m) in replicated subplots (total 18 m^2 within 400 m^2)

5. Cover of all plants in a 20 × 20 m plot (400 m^2) in fixed height tiers (0–0.3 m (subdividable as 0–0.1 and 0.1–0.3 m); 0.3–2 m (subdividable as 0.3–1 and 1–2 m); 2–5 m; 5–12 m; 12–25 m; >25 m; epiphytes) and cover classes within each tier (<1%; 1–5%; 5–25%; 25–50%; 50–75%; 75–100%) (Hurst & Allen 2007b).

2.2 Scoping and analysis

2.2.1 Indicator definition

For reporting at a national scale the definition of M2 ('Presence of suitable indigenous component in all structural layers') needs to be consistent among regional councils. The term 'indigenous component' could refer to individual taxonomic units (i.e. species or genera) or groups of taxa, such as canopy dominants. As long as data are collected using consistent methods, the interpretation of those data can be tailored either for individual regional councils, or to enable cross-council or cross-agency comparisons (e.g. with DOC).

Interpretation of a 'suitable indigenous component' can vary between regions, vegetation communities, and land-use types. The percentage of native species present is a suitable means of describing indigenous species' dominance (e.g. percentage basal area comprised of native trees or percentage of the cumulative cover percentage that is comprised of native species) and this will allow consistent reporting by all regions. The rationale is measures of dominance are often strongly related to the functioning of ecosystems (Grime 1998). For individual councils, the dominance of local species of interest, including taonga species, can be reported but this requires context, such as knowledge of range limits. For example, tawa (*Beilschmiedia tawa*) is a locally dominant tree in many North Island regions but is naturally rare or is absent from most of the South Island (Knowles & Beveridge 1982), so reporting low or zero dominance of this individual tree species without this context will lead to spurious conclusions. Similarly, it is naïve to expect widespread dominance of other species even within regions. For example, tāwari (*Ixerba brexioides*) is a tree of northern latitudes, of importance as a source of nectar for birds and honeybees, but it seldom occurs outside large areas of continuous forest, so it would be unlikely to occur, even in fragments, in agricultural landscapes. Therefore, its dominance is highly habitat-specific and little short of large-scale restoration is likely to alter that.

Regional councils could report vegetation structure and composition according to functional groups, such as those that provide key ecosystem services (e.g. food resources for native birds). Consistent standards for interpretation are desirable and can be developed among councils, and with other agencies, especially DOC, which already collects data from public conservation land using these methods, and also with the Ministry for the Environment (MfE) and Statistics New Zealand. This mode of reporting can be applied regionally or nationally.

Using the DOC methodology framework (DOC 2012), the definition of 'all structural layers' can be based on height tiers and/or counts of stems in defined size categories (based on diameter at breast height measurements). Subplot data can be used to examine presence in tiers at a finer scale.

2.2.2 Indicator statistic

Three examples that emphasise indigenous dominance could be according to

1. the proportion of native species present in each tier;
2. the proportion of native non-woody species present in each tier; and
3. the proportion of tree basal area (or biomass) comprised by native species.

Regional councils can report similar statistics for individual common plant species or functional groups deemed important at a regional or national scale (e.g., palatable plant species or species that provide food resources for birds). These statistics can be reported at a whole-region scale, or within major vegetation classes (i.e. Landcover Database (LCDB) classes).

2.2.3 Reporting frequencies

Regional councils should adopt the same reporting 5-yearly frequency as DOC's Biodiversity Monitoring and Reporting System (BMRS) national-scale reporting.

2.2.4 Reporting hierarchies

Plots can be aggegrated or reported at granulated scales (i.e. within LCDB classes such as indigenous forests, plantation forests, and pasture), the latter depending on statistical defensibility according to the number of sampling sites per class within the region.

2.2.5 Spatial and temporal analysis

National-scale reporting of the statistics across regional councils is possible; however, a more intense sampling design may be needed for local reporting for some regional councils. When reporting on individual species or groups of taxa within vegetation types, power analyses (e.g. Green & MacLeod 2016) will be needed to determine sampling intensity. Data from a range of vegetation types, including forested and non-forested ecosystems on public conservation land (i.e. DOC's Tier 1 data), can be used to inform power analyses pertinent to indigenous-dominated ecosystems; fewer data are currently available to support power nalayses of sampling intensities needed in production landscapes.

2.2.6 Relationships between indicators and present patterns

Indicator M2 uses identical methods to those used for the vegetation components of M16 (Table 2-1): the primary data collection for reporting M2 should be all that is necessary for reporting vegetation data for M16 ('Change in the abundance of indigenous plants and animals susceptible to introduced herbivores and carnivores'). Indicator M2 may also assist/supplement monitoring done for M6 ('Number of new naturalisations'). If species lists are collected at sites these can be used to determine whether there are any incursions of weeds in the area.

Table 2-1 Regional Council Terrestrial Biodiversity Monitoring Framework indicators related to M2: Vegetation structure and composition

Indicator	Measures	Element	Ecological Integrity	Driving forces – Pressure-State-Impact-Response	Data required and potential sources
Pest manage-ment (M16)	Change in the abundance of indigenous plants and animals susceptible to introduced herbivores and carnivores	Contribution (richness, basal area, and density) of palatable plant species (e.g. Forsyth et al. 2002) and indigenous birds (herbivores, insectivores, ground dwelling) in representative ecosystems	Indigenous dominance	State	Element: Contribution (richness, basal area, and density) of palatable plant species (e.g. Forsyth et al. 2000) and indigenous birds (herbivores, insectivores, ground dwelling) in representative ecosystems. Data: Presence/absence and density data from representative sites, including across variable levels of pest control, from, for example, the National Vegetation Survey Databank.
Weeds and animal pests (M6)	Number of new naturalisations	Number of new regional incursions/sites of nationally recognised environmental weed species	Indigenous dominance	Pressure/ Impact	Element: Number of new regional incursions/sites of nationally recognised environmental weed species Data: Requires surveillance monitoring at regional level, currently undertaken by regional councils.

2.3 Assessment of existing methodologies

2.3.1 Overview

Generalisations in this section of the report are based on the seven regional councils that responded to the online survey (screenshot of survey in Figure A2-1, Appendix 2). Of the seven regional councils, 57% of councils were dissatisfied with the current way their regional council monitored and reported on change in vegetation structure and composition. No council was completely satisfied with their monitoring techniques. Vegetation monitoring techniques varied between regional councils. Several regional councils did not report change in structure over time.

2.3.2 Field methods

Not all regional councils monitor vegetation structure and composition within their region. For those that do, methods differ among councils, projects and vegetation types. Funding, time and the preferences of the individuals designing the monitoring programme influence choice of methods. Basic vegetation monitoring may consist of taking photo points or doing a general visual assessment (often captured in a report). More complex monitoring often uses standard sized plots or quadrats along a transect to define the sample area. Plots range in size from 2 × 2 m in wetlands to 20 × 20 m in forests. Some councils use unbounded relevés (recce plots), where the sample area is defined by the observer's interpretation of an homogeneous sample of the plant community. The data on species composition and abundance may include all species occurring in the sample area (which allows estimation of species richness), or often it is a subset based on the most dominant species in the plot (e.g. rapid recces) or those species that are the focus of the study. No council mentioned their use of the Forest Monitoring and Assessment Kit (FORMAK) monitoring system for monitoring forest vegetation that was developed by PA Handford & Associates Ltd, although it may be in use.

2.3.3 Data storage

Regional councils each use different methods of data storage: Excel spreadsheets, GIS databases, and WorkSmart databases to be migrated to IRIS.

Some regional councils have used National Vegetation Survey's NVS Express to upload data collected using standard forest monitoring methods (i.e. permanent 20 × 20 m plots or relevés). NVS Express is a purpose-built Windows tool for entering and summarising vegetation data compatible with the NVS (National Vegetation Survey, https://nvs.landcareresearch.co.nz/) databank. Other methods can be added to the NVS databank, but are not currently compatible with NVS express.

There are examples of rigorous data storage protocols by some regional councils, for example:

> *Anything that can go to NVS does. In addition we store original data sheets, scanned electronic copies of data sheets, spreadsheets in our electronic document storage system, spatial database and spatial files on the network.*

2.3.4 Reporting

Over half of regional councils do not report on changes in vegetation structure and composition. One reason provided for a lack of reporting is insufficient support for return-surveys at sites. This means results are restricted to representing the current state of the environment (i.e. a snapshot in time), rather than looking at change over time.

A further problem is that for survey techniques with strong observer-experience bias, there is often no assessment of whether changes in vegetation over time are because of differences between observers. When regional councils do report change, it is often done in annual reports, or other reports (e.g. WCI reports, annual lakes reports). It can also be reported to landowners and to council committees (e.g. the Operations, Monitoring and Regulation committee). Regional councils' responses for the appropriate frequency for reporting change in vegetation structure varied, from each year to every 10 years.

2.3.5 Additional comments

Regional councils were generally positive about the need for a robust monitoring programme.

> *A commitment to monitoring is needed – one-off surveys are jolly good, but are not going to help us track changes over time! The methodologies we employ need a bit of empirical testing to see if observer differences can be constrained or if the methods are just too loose to be of any use for composition and structure change tracking.*
>
> *We're progressing well but still have some big gaps in the information! We've not yet submitted a big region-wide report on wetlands or forests (have for dunes), so am not sure how that will look yet. Hoping the monitoring framework project will solve that for me!*

Some regional councils want more clarification of the exact aims of the measure, and are interested in what the desired outcomes for the monitoring are and how the monitoring will be funded.

> *Our question is why do we need to measure or monitor? If we increase our programmes beyond the little we do now, what would we report, and to whom, for what purpose? Currently Northland has no Biodiversity Strategy which would lead to a Biodiversity Monitoring Plan. The strategy would sit under the RPS (in draft) and direct biosecurity/biodiversity resources. The monitoring plan would lead to reporting on intermediate and long term outcomes. The monitoring plan may also include monitoring for national purposes as we are required to do this.*
>
> *Because we are a council with limited resources any monitoring programmes are at present focused towards protecting values (lakes) or measuring project outcomes. Any additional future assessment of vegetation structure and composition will need to target regional priorities, e.g. the health of iconic Northland habitats such as kauri forest and coastal forest. Other monitoring of key species, e.g. phenology (related to bird numbers) may be important for ratepayers/customers who are involved in community restoration programmes. If monitoring is required for national systems we will need to find additional resources so a mandate will be required through the NPS or equivalent.*

2.4 Designing a sampling scheme

2.4.1 Alignment with existing methodology

The Department of Conservation has developed a set of biodiversity indicators, and has implemented some of these nationally through the BMRS. National-scale monitoring reporting (Tier One) focuses on simultaneous point-based measurement of vegetation, bird communities, and abundances of some pest mammals (ungulates, lagomorphs and brushtail possums). It is used to assess indigenous dominance and species occupancy across public conservation land. It includes methods for measuring vegetation structure and composition, using a regular, unbiased sampling framework across New Zealand. This framework builds upon a national infrastructure established to measure carbon, vegetation structure and composition of 1372 vegetation plots in forests and shrublands (the LUCAS network; Coomes et al. 2002). Tier One monitoring extends the LUCAS network to non-forest and non-shrubland ecosystems on public conservation land. Its point-based measurements of vegetation are directly compatible with those proposed for M2 (as are DOC's bird community measurements with M3 and those of pest mammals with M7).

Currently, many councils are not employing the methodology used by DOC to measure vegetation, perceiving it to be not feasible within budget constraints. However, DOC's approach of simultaneous, point-based assessments of multiple measures at a given sampling point, with each sample point being revisited on a 5-yearly basis, allows minimisation of costs (i.e. travel time, etc.). Regional councils need only conduct a subset of the methods that DOC and MfE apply on vegetation plots measured as part of the LUCAS programme, reducing the time and costs (i.e. there is no need for councils to measure large tree diameters (from an additional external plot), coarse woody debris (CWD) and tree heights as these are all used in national carbon assessments for MfE and are collected in forests on private land). Additonally, DOC collects data on non-vascular plant species in its Tier One monitoring, which should be optional for regional councils. The implications of altering DOC sampling protocols are discussed below.

2.4.2 Grid size

The DOC method places an 8 × 8 km grid across New Zealand: a plot is established where the gridlines intersect on public conservation land. If councils sample across their regions on the same 8 × 8 km grid it will allow inclusion of data from public conservation land collected by DOC as part of regional reporting, and it will enable ready scaling up from regional to national reporting (e.g. for national State of Environment reporting). For some regional councils the number of plots that would be established is large and might be beyond the financial constraints of those regional councils (Table 2-2 and Figure 2-1). Increasing the grid size to 16 × 16 km (Table 2-3 and Figure 2-2) greatly reduces the sampling required, but also greatly reduces the power to detect change. Individual councils may want to sample at different scales, depending on resources available. To ascertain the ability to detect change, individual councils should run power analyses for a variety of grid sizes, 4 × 4 km, 8 × 8 km and 16 ×16 km, to see how reductions or increases in sample size change power. This should be run after the first year of sampling, when regional councils will have raw data collected from their region that can be fed directly into the power analysis. The power analysis would need to include the other indicators that are associated with the proposed methods (see MacLeod et al. (2013) for an example in the Greater Wellington Region).

2.4.3 Species lists and cover scores – all or a subset?

Regional councils have measured subsets of species (usually the most dominant) on a plot to minimise the resources required to measure a plot. If regional councils are concerned with 'no net' biodiversity loss (e.g. when assessing resource consents), a comprehensive inventory of all plant species present is needed. Likewise, not recording species that are not dominant has other consequences. For example, early incursions of non-native species that may subsequently become dominant will be missed if only dominant species are recorded. Furthermore, assumptions that dominant species are those that are most important for exosystem function and services are not always correct (e.g. Peltzer et al. 2009; Mariotte 2014). Hence *a full inventory of the covers of all vascular plant species*, both native and non-native species, and including epiphytes, should be recorded within each 20 × 20 m plot. A full species list has additional utility for other measures, that is, M6, where it could be considered as part of an active surveillance program for monitoring new naturalisations in the region, and M16, where it can provide information and context for maintenance of some rare species or those under pressure (e.g. plant species that are highly palatable to introduced mammals). Full species lists provide presence/absence data, so are also useful when modelling species distributions for weed species. In addition there are so far few data on plant biodiversity in agricultural or urban systems (a focus for many regional councils), so there is little systematic information on how intensification of agriculture influences biodiversity nationwide.

Recording cover scores will allow plots to be placed into a plot-based classification of New Zealand plant communities (Wiser & De Cáceres 2013; Wiser et al. 2016). This classification was developed for DOC, and would assist regional councils in sub-setting data for reporting recognised vegetation communities. Plot-based estimates of cover of vascular plant species also provides local points of ground truth that can be integrated with remote measures (i.e. LCDB as used in M1, M8, M9 and M17).

2.4.4 Permanent marking of plots and trees

A limitation at some sites could be an inability to permanently mark plots (e.g. in pastoral farmland) and possibly to tag trees (if a landowner objected, or if tagging trees were hazardous if trees were likely to be logged in future, e.g. *Pinus radiata*). The consequence of not permanently marking plots is that a different area may be remeasured if the plot is not accurately relocated. This will increase the amount of variation between measures (e.g. plant species missed/added due to the change in plot location). The consequence of not tracking individual trees through time is an inability to report on the recruitment, growth and mortality of trees (one means of reporting change in tree size structure; Peltzer et al. 2014). Not individually tagging trees will also increase the likelihood of missing trees during the measurement. Paint can be used to semi-permanently mark trees, for example, those closest to corners, when tagging trees with nails is not possible. Using different paint colours between successive surveys can be used to help distinguish unmeasured stems that grow into the minimum size class (Sheil 1995).

2.4.5 Costs

The following estimate of costs is from a trip that sampled agricultural land, pine plantations and croplands in Marlborough in March 2013 led by Robert Holdaway, Landcare Research. This estimate also includes collecting data for M3: Avian representation.

- To do two plots per day required four people (two competent botanists, one general helper, and one bird survey specialist). Costs depend on costs of individuals, i.e. contractor rates, but an estimate of \$3000/day for labour, \$500/day for incidentals, and \$500/day for organisational logistics (pre- and post-trip).
- The team completed measuring 16 plots in a 10-day period (with two travel days either end) = \$4000 × 10 = \$40,000 per trip / 16 plots = \$2500 per plot. This estimate did not include post-sampling species ID checks, data entry, analysis, etc.

Table 2-2 Number and percentage of sampling locations within each region based on an 8 × 8 km grid, partitioned by public conservation land (sampled by DOC's Tier One) and other land, that could be sampled by regional councils. Total number of locations excludes sample points with slopes >45º (estimated using LENZ). Sample points within each cover class determined from LCDB.

Region	No. sampling locations			Percentage sampling locations									
	Total	DOC Tier One	Regional councils	DOC Tier One	Regional councils	Grassland, sedgeland & marshland	Forest	Scrub & shrubland	Bare or lightly vegetated surfaces	Slope >45°	Cropland	Artificial surfaces	Water bodies
Auckland	78	6	72	8	92	49	23	14	0	0	1	13	0
Bay of Plenty	194	60	134	31	69	19	73	6	0	2	<1	2	0
Canterbury	692	169	523	24	76	63	10	9	12	1	6	<1	<1
Gisborne	130	15	115	12	88	48	33	15	3	1	2	0	0
Hawke's Bay	216	39	177	18	82	57	30	11	0	0	<1	<1	0
Manawatū–Whanganui	349	61	288	17	83	67	23	8	<1	0	1	<1	0
Marlborough	153	73	80	48	52	48	27	12	10	3	<1	0	2
Nelson City	7	2	5	29	71	14	71	14	0	0	0	0	0
Northland	202	27	175	13	87	53	36	9	1	<1	1	0	0
Otago	480	87	393	18	82	78	10	7	5	1	<1	<1	0
Southland	478	260	218	54	46	49	39	8	4	7	0	<1	<1
Taranaki	114	26	88	23	77	56	33	8	0	0	0	4	0
Tasman	151	102	49	68	32	19	70	8	4	2	0	0	0
Waikato	369	64	305	17	83	55	35	7	<1	0	<1	2	<1
Wellington	125	23	102	18	82	49	31	14	2	1	0	4	0
Westland	346	297	49	86	14	15	65	12	7	4	0	0	0
Total no. of locations	4084	1311	2773			2126	1303	367	180	76	56	42	10
Total % of locations				32	68	52.1	31.9	9.0	4.4	<2	1.4	1.0	0.2

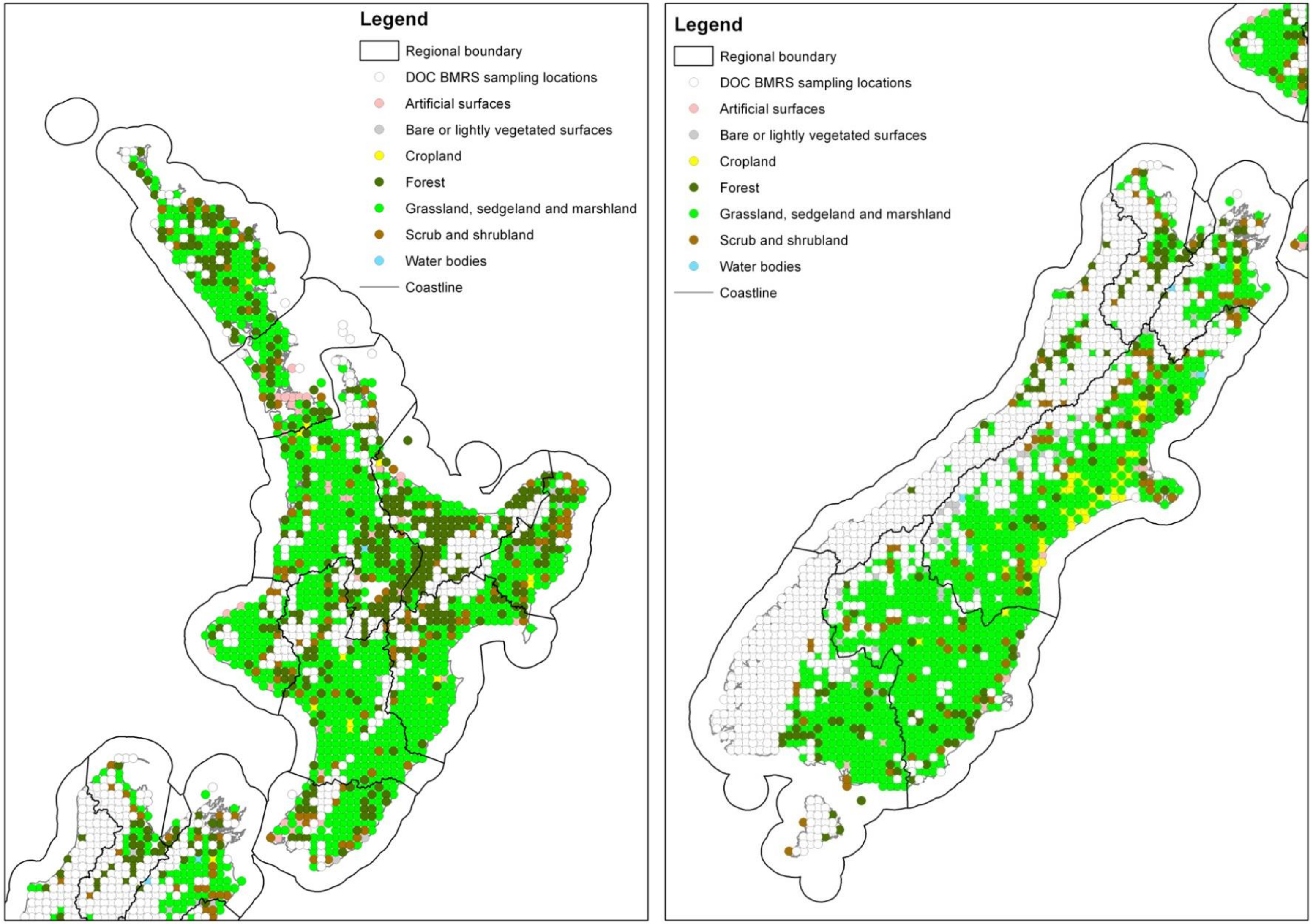
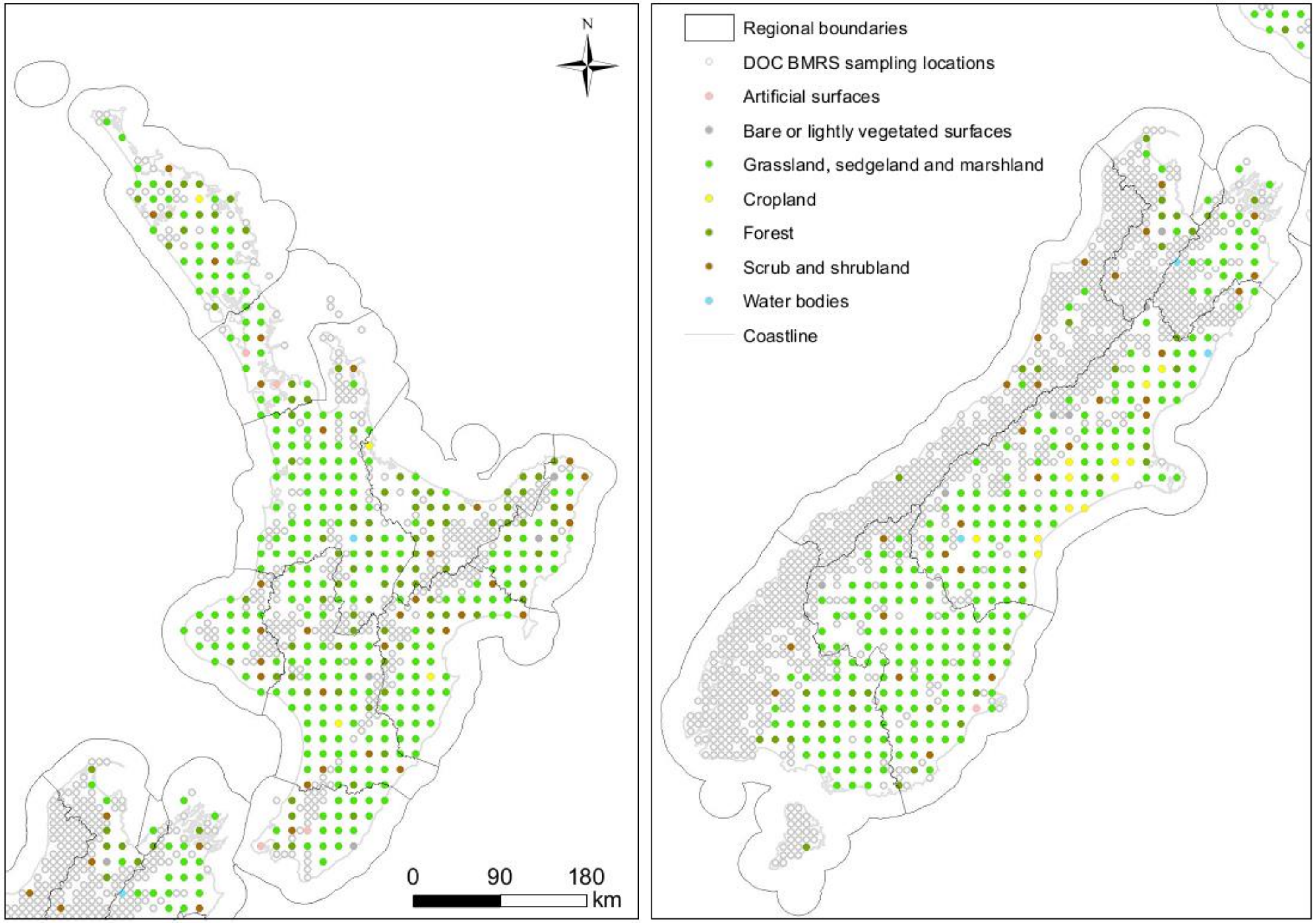


Figure 2-1 Sampling locations on the 8 × 8 km grid in relation to the regional council boundaries and land cover classification of sampling locations (see **Table 2-2**).

Table 2-3 Number and/or percentage of sampling locations within each region based on a 16 × 16 km grid, partitioned by public conservation land (sampled by DOC's Tier One) and other land, that could be sampled by regional councils. Total number of locations excludes sample points with slopes >45º (estimated using LENZ). Sample points within each cover class determined from LCDB.

Region	No. sampling locations			Percentage sampling locations									
	Total	DOC Tier One	Regional councils	DOC Tier One	Regional councils	Grassland, sedgeland & marshland	Forest	Scrub & shrubland	Bare or lightly vegetated surfaces	Slope >45°	Cropland	Artificial surfaces	Water bodies
Auckland	18	0	18	0	100	61	17	11	0	0.0	0	11	0
Bay of Plenty	49	17	32	35	65	10	84	4	0	4.1	2	0	0
Canterbury	177	47	130	27	73	63	10	10	10	0.6	7	0	1
Gisborne	32	2	30	6	94	50	31	13	6	0.0	0	0	0
Hawke's Bay	55	7	48	13	87	55	29	15	0	0.0	2	0	0
Manawatū–Whanganui	86	14	72	16	84	65	23	9	1	0.0	1	0	0
Marlborough	38	17	21	45	55	63	13	8	13	5.3	0	0	3
Nelson City	2	0	2	0	100	50	50	0	0	0.0	0	0	0
Northland	50	7	43	14	86	54	36	8	0	0.0	2	0	0
Otago	120	18	102	15	85	81	10	4	4	0.0	0	1	0
Southland	116	65	51	56	44	48	41	8	2	8.6	0	0	1
Taranaki	29	6	23	21	79	55	31	14	0	0.0	0	0	0
Tasman	36	23	13	64	36	11	69	14	6	0.0	0	0	0
Waikato	96	19	77	20	80	59	34	4	1	0.0	0	0	1
Wellington	32	7	25	22	78	50	34	6	3	0.0	0	6	0
Westland	83	72	11	87	13	10	66	16	8	3.6	0	0	0
Total no. of locations	1019	321	698			535	324	90	44	18	16	5	5
Total % of locations				32	68	52.5	31.8	8.8	4.3	1.8	1.6	0.5	0.5

Figure 2-2 Sampling locations on the 16 ×16 km grid in relation to the regional council boundaries and land cover classification of sampling locations (see **Table 2-3**)



2.5 Methods

The following text is extracted from the contract report 'Designing a biodiversity monitoring and reporting system for Greater Wellington Regional Council' (MacLeod et al. 2013) with permission from Greater Wellington Regional Council. Detailed information on field sampling protocols can be obtained from DOC.

2.5.1 Summarised field sampling protocols

A nationwide plot register is being developed (December 2015) to preserve the fundamental integrity of the 8 × 8 km grid-based sample design that has been the basis of LUCAS sampling of indigenous forests and shrublands (public and private land) and DOC's BMRS Tier One sampling of vegetation across all public conservation land. The project, led by MfE, has a goal of facilitating the expansion of the national grid sample network across New Zealand. Components of the register include:

1. Unique plot identifers for each sample location (e.g. AA138)
2. Each sample point's grid location (NZMG and NZTM)
3. An ideal randomised year of measurement (on a 5-year an a 10-year cycle)

The last of these will provide each council with a schedule of plots to measure in the year that it begins to collect data for M2. This schedule will mean that each council need not collect data from public conservation land (this will be continued by DOC's BMRS Tier One sampling) or from indigenous forest and shrubland (this will be continued through the LUCAS programme). The schedule for councils will therefore focus on sample points on private land in land cover types other than indigenous forest and shrubland.

Each sampling location should be permanently marked at the four corners of a fixed 20 × 20 m plot to allow for repeated sampling at that location (DOC 2012). In some production landscapes (e.g. High Producing Exotic Grassland), permanent marking of boundaries may not be possible. Highly accurate GPS devices will enable accurate relocation of these plots. Greater Wellington Regional Council is currently (December 2015) burying metal markers below plough depth at the four corners and using a metal-detector to enable their relocation.

The fixed 20 × 20 m plot used at each sample point for M2 is at the centre of sample points used for M3 ('Avian representation') and M7 ('Distribution and abundance of weeds and animal pests'), collected within a much larger area (220 × 220 m), using a design that radiates out from the edges of the central vegetation plot (Figure 2-4). Standardised field sampling protocols are used for both the vegetation and animal surveys (DOC 2012).

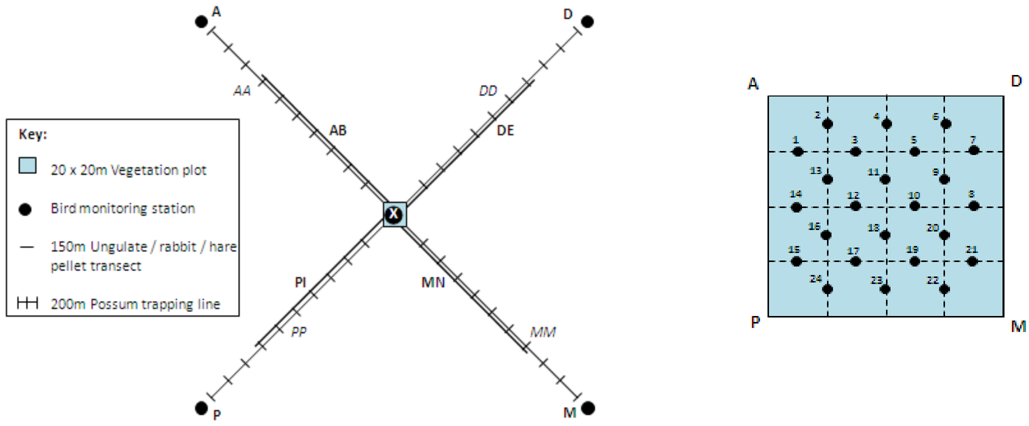


Figure 2-3 Layout of the animal-survey sampling units in relation to the vegetation plot at each sampling location, along with an outline of the 20 × 20 m vegetation plot, subdivided into 16 contiguous 5 × 5 m subplots, and each of the 24 (0.75 m^2) seedling plots within it.

Each 20 × 20 m plot used for M2 is established on a formalised layout (Figure 2-3). The assigned sample point's grid location (NZMG and NZTM) is designated for corner 'P' in the plot layout. The plot may be moved up to 5 m in any direction and consist of 75% of the original plot area if the location is too steep for safety (e.g. bluffs). Formal guidelines need to be agreed before the first field season, in consultation with regional council health and safety experts, about reasonable conditions that make a plot formally too unsafe to establish and measure. In plots that are in shrubland and some non-forested ecosystems, larger pegs can be used to designate the corners of the 20 × 20 m plot than those used currently as standard in forests.

Record metadata (including GPS location, altitude, aspect, etc.) for each 20 × 20 m plot, using standard methods. This will provide essential information that can be incorporated into analyses of status and trend assessments of the vegetation measures. Other metadata are important for relocating the plot for future remeasurements. Record bearings along each 20-m perimeter of the plot as well as absolute measured distances (to the nearest 0.1 m), to assist in future remeasurement of the plot. Take photographs of the plot from each corner (A, D, M and P), looking both inward towards the centre of the plot and outward along the transects used to assess birds and pest mammals (Figure 2-3).

Record a full inventory of vascular plant species, including epiphytes, within each 20 × 20 m plot. Use standard methods to evaluate cover of all vascular plant species, in cover classes in fixed height tiers within each 20 × 20 m plot (protocols are described fully in Hurst & Allen 2007b). Accurate identification of all species in the field is important: since this indicator evaluates indigenous dominance, it is important to be able to identify all species accurately, which can then be assigned native vs. non-native status (following http://nzflora.landcareresearch.co.nz/). For those species that cannot be determined accurately in the field, each identified taxon should be collected with an identifier on the specimen collected that can be linked readily to the field data sheet, which can be updated after the specimen is determined (Hurst & Allen 2007b; DOC 2012).

Measure all woody stems on each plot. This is needed to determine their dominance and, by tagging individuals, to determine trends in theirr growth and population dynamics. Tag all woody stems ≥2.5 cm in diameter at 1.35 m (dbh), including tree ferns and palms, within the 20 × 20 m plot using a pre-printed metal tag with a unique number (affixed using an aluminium tag, nailed 1 cm below the point of measurement), identify each stem to species, and measure the diameter to the nearest mm. This applies to all woody stems, from those within forests to single stems in a plot that is otherwise grassland. Each stem of multi-stemmed individuals of sufficient size should be tagged and connections between all connected stems should be noted. Each stem's location should be assigned to one of 16 contiguous 5 × 5 m subplots (Figure 2-3). For tree ferns and palms, measure height to the nearest 0.1 m from the ground to the point of emergence of fronds (Hurst & Allen 2007b). If permanent tagging is not possible, each stem ≥2.5 cm dbh should be identified to species, its diameter measured, and the 5 × 5 m subplot in which it occurs should be noted. Temporary markers (flagging tape or chalk) can be used to identify stems that have been measured; flagging tape should be removed once all tree measurements have been finished and the plot has been checked.

Tally saplings (i.e. woody plants (excluding lianas) and tree ferns >1.35 m tall but <2.5 cm dbh) within the 20 × 20 m plot. Saplings are not tagged. The tally of saplings is by species within individual 5 × 5 m subplots (Figure 2-3), summed for the entire plots. It is important to adopt a procedure to ensure that saplings are not missed (e.g. using chalk to mark stems once they have been counted). Stems of the same plant that fork at or above ground level are counted as a single stem (stems that may be joined below ground level, but the connection is difficult to ascertain, are counted as separate stems).

Establish 24 seedling plots (0.75 m^2 each) on a regular grid within the 20 × 20 m plot (Figure 2-3). In each subplot the presence of species is recorded in fixed tiers (tiers: ≤0.15 m; 0.16–0.45 m; 0.46–0.75 m; 0.76–1.05 m; 1.06–1.35 m). Woody species should be counted in each tier for reporting the size structures of woody seedlings. These subplots provide height frequency data, hence they provide additional information for reporting the change in canopy structure for vegetation types not dominated by woody species, allowing interpretation of canopy dominance in non-woody vegetation at whole-plot (400 m^2) and subplot scales.

2.5.2 Practical considerations for field implementation

Field training and staff scheduling are critical to the successful implementation of M2.

2.5.3 Training

A field-team coordinator, with strong project management skills, will be required to run the field programme. Specialist field teams, with relevant methodological skills (especially in plant identification), will need to be briefed on the logistical and operating protocols, as well as the field survey protocols. In addition to field safety training, field teams will need to gain technical experience handling the relevant equipment, recording relevant time-budget and operational data (to inform logistic planning and budgeting in the future) and guidelines on how to prioritise their field effort when time-constraints occur (e.g. poor weather).

2.5.4 Scheduling

Before implementing the field programme, a scoping exercise is necessary to determine the availability of the field skills and personnel required to implement the survey methods at the regional scale; training schemes will needed to address shortages (e.g. DOC's pilot study identified shortages in bird, non-vascular and grass species identification skills). Six months before the field season, a work plan should be developed to ensure cost-effective co-ordination of field teams; this should include an assessment of access issues, the feasibility of implementing surveys at each location, and field gear requirements, as well as operational and field safety planning. One month prior to the field season, relevant training workshops should be run, with field teams then assisting with the final stages of field preparations. During the field season, the field coordinator will need to oversee the daily logistic requirements of the team, regularly review their schedules and ensure that data management protocols are being maintained. Data checking, management and reporting processes should be completed as soon as possible after completing the field season. Audit protocols should be implemented, so that 10% of plots are audited throughout the field season. DOC now has an Audit Field Protocol which is available on request; note that DOC's audit methods differ from those of the LUCAS programme. Each regional council should coordinate with DOC and other regional councils to share skills, and skilled staff and contractors, if possible.

2.5.5 Data management and access requirements

An important consideration for regional councils is to determine how field data should be collected and managed (e.g. form design, datasheet recording, checking and storage, labelling and processing samples, computerisation, analysis). It is critical to ensure compatitibility of data standards and management with DOC's Tier One programme and the LUCAS programme, since these will obviate the need for regional councils to collect data from sample points on public conservation land, and forests and shrublands on private land, respectively. Any changes to sampling protocols, datasheets and databases must be clearly documented and rules must be established for managing such changes; this should include an assessment of the impact of such changes on the parameters being reported for each measure.

Enter and archive all vegetation data for M2 in the National Vegetation Survey Databank (NVS; https://nvs.landcareresearch.co.nz/). This facility is run by Landcare Research and is specifically designed to store vegetation survey data in the format used in this measure, and all vegetation data collected DOC's Tier One programme and the LUCAS programme (indigenous forests and shrublands) are in NVS. Data can be uploaded through the NVS Express platform (detailed protocols can be found in Vickers et al. 2012a). This will save regional councils costs associated with creating and maintaining new databases and data storage facilities. Some regional councils are already familiar with the NVS Express system, so using NVS Express builds upon current knowledge. This facility already has refined protocols for data management including data validation (Vickers et al. 2012a). Storing copies of field data sheets in the fire-proof vaults associated with NVS at Landcare Research, Lincoln is strongly recommended. Field data sheets contain pertinent information that is especially useful for the remeasurement of plots. Archiving copies of field data sheets in the NVS vaults is insurance against their loss elsewhere.

A particular advantage of entering vegetation data from M2 using NVS Express is that it contains an analysis module (NVS-Analysis; Vickers et al. 2012b) that has been specifically designed to be used by conservation practitioners. This includes summary statistics and analyses. NVS-Analysis has been adapted to summarise vegetation data for DOC's national-scale reporting, which is directly useful for computing statistics for M2. There may be a cost associated with further developments to meet specific needs of regional councils: for more information contact NVS directly through the website. Additional statistics included in NVS-Analysis can be used by regional councils to gain further descriptions of their sites, including analyses of individual species.

NVS Website: http://nvs.landcareresearch.co.nz/index.aspx

2.5.6 Reporting format

Use a similar format to that of Horizons Regional Council for their State of the Environment reports (Roygard et al. 2013), DOC (e.g. Bellingham et al. 2015), or MfE (MfE and Statistics New Zealand 2015) for reporting M2. These reports could include other indicators linked with M2 (e.g. M3 and M16). The report should include comparisons at both a national and regional level. Reporting for M2 could include a figure which shows change over time (e.g. Figure 2-4, for inter-annual differences).

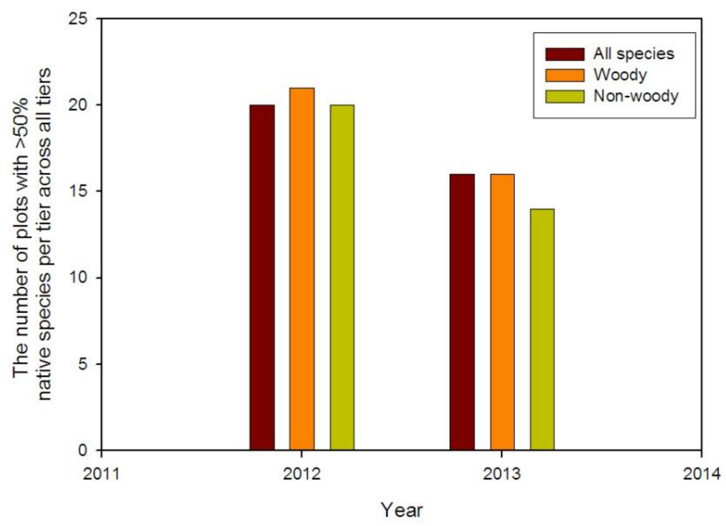


Figure 2-4 The number of plots that have >50% native species in each tier where species occur for all species (woody and non-woody combined), woody species only and non-woody species only.

Additional statistics that could be reported on include (but are not limited to) 1) DOC reporting statistics (Figure 2-5); 2) change in mean stem diameter for canopy dominants (taken from diameter measures); 3) change in mean number of stems for canopy dominants (taken from diameter measures) and 4) change in mean number of new recruits for canopy dominants (taken from seedling and sapling counts). Definitions of canopy dominants would need to be standardised across regional councils.

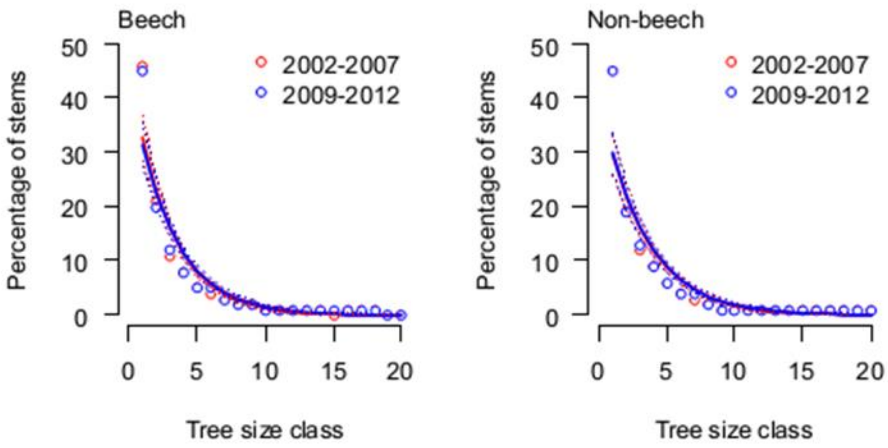


Figure 2-5 Example from MacLeod et al. (2012) showing size-class distribution of kāmahi for two periods in beech forest and non-beech forests. Fitted solid lines are general linear models of stems counts within 20 equal-sized classes. Fitted dashed lines are standard errors around fitted lines.

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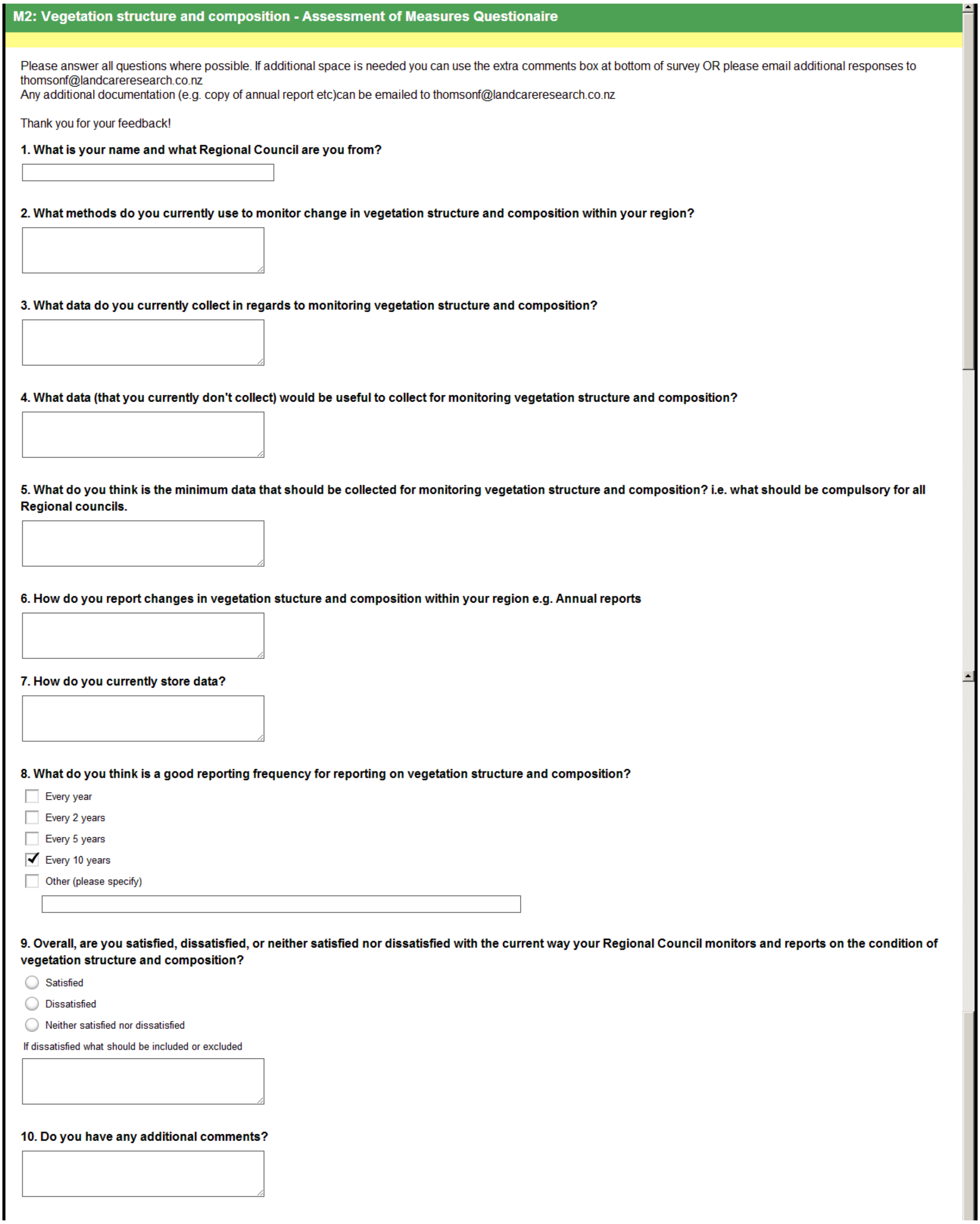
Appendix 2-1 – Assessment of measures questionnaire



M2: Vegetation structure and composition - Assessment of Measures Questionaire

Please answer all questions where possible. If additional space is needed you can use the extra comments box at bottom of survey OR please email additional responses to thomsonf@landcareresearch.co.nz
Any additional documentation (e.g. copy of annual report etc)can be emailed to thomsonf@landcareresearch.co.nz

Thank you for your feedback!

1. What is your name and what Regional Council are you from?

2. What methods do you currently use to monitor change in vegetation structure and composition within your region?

3. What data do you currently collect in regards to monitoring vegetation structure and composition?

4. What data (that you currently don't collect) would be useful to collect for monitoring vegetation structure and composition?

5. What do you think is the minimum data that should be collected for monitoring vegetation structure and composition? i.e. what should be compulsory for all Regional councils.

6. How do you report changes in vegetation stucture and composition within your region e.g. Annual reports

7. How do you currently store data?

8. What do you think is a good reporting frequency for reporting on vegetation structure and composition?

- [ ] Every year
- [ ] Every 2 years
- [ ] Every 5 years
- [x] Every 10 years
- [ ] Other (please specify)

9. Overall, are you satisfied, dissatisfied, or neither satisfied nor dissatisfied with the current way your Regional Council monitors and reports on the condition of vegetation structure and composition?

- Satisfied
- Dissatisfied
- Neither satisfied nor dissatisfied

If dissatisfied what should be included or excluded

10. Do you have any additional comments?

Figure A2-1 Assessment of measures questionnaire.

Appendix 2-2 – Feedback from regional councils

Details of the feedback from regional councils for each report. ‘Yes’ indicates that a council gave feedback regarding the report. Regional councils that were contacted were those whose contact details were provided on the key contacts list. Reports 3, 4 and 5 were sent as a group for the final report.

	Report 1	Report 2	Report 3	Report 4	Report 5
Environment Southland		Yes			
Waikato Regional Council	Yes				
Marlborough District Council		Yes			
Greater Wellington Regional Council					
Horizons Regional Council		Yes			
Otago Regional Council		Yes			
Northland Regional Council		Yes			
Taranaki Regional Council	Yes	Yes			
Auckland Council					
Bay of Plenty Regional Council	Yes	Yes		Yes	

3 Indicator M3: Avian representation

Author: Catriona MacLeod, Landcare Research

3.1 Introduction

This report focuses on M3 ('Avian Representation'), one of three measures used to inform the 'Biodiversity Condition' indicator within the framework. Recommendations for the bird monitoring design are based on review of current New Zealand bird monitoring schemes in relation to best-practice guidelines in the international literature. This work was carried out by Landcare Research for the Regional Council Biodiversity Working Group between July 2011 and December 2013.

To achieve successful conservation outcomes, a combination of biodiversity monitoring, diagnostic research, the testing and proving of management solutions, and their successful incorporation into population- or community-wide management schemes is required (Yoccoz et al. 2001; Wilson et al. 2010; Lindenmayer et al. 2012). The value of biodiversity monitoring has been clearly demonstrated in recent years, for documenting ecosystem change (Both & Visser 2001; DeVictor et al. 2010; Anderson et al. 2011), engaging public awareness in environmental issues, and providing the necessary evidential basis for conservation legislation (Butchart et al. 2010).

Although birds comprise only a small fraction of animal species, they are often selected for monitoring studies (Pereira &Cooper 2006) and to build headline indicators of biodiversity (Schmeller et al. 2012). Four main drivers for this have been identified (Furness & Greenwood 1993; Newton 1998):

- Compared with other taxa, birds are relatively easy to observe and identify, as most species are diurnal and well-known taxonomically.
- Individual nests can be monitored to measure reproductive success, and individual birds can often be fitted with a tracking device or permanently marked (using a tag or leg band), allowing data on their movements, behaviour and life-histories to be obtained relatively easily (Bairlein et al. 2012).
- As many species are high in the food chain, birds are considered good indicators for measuring the status of other taxa and also ecosystem health (i.e. how active the ecosystem is and how well it maintains its organisation and autonomy over time, and its resilience to stress; Constanza et al. 1992).
- Birds represent an iconic component of biodiversity with which policymakers and the general public alike connect.

With many ongoing monitoring programmes in place and many volunteers willing to contribute, birds are often selected as target taxa for global and regional monitoring schemes (Pereira &Cooper 2006). However, as a result, there has been a proliferation of methods and approaches in recent decades (and accompanying debates among the proponents of different approaches). This frequently makes it difficult for conservation managers (or other end-users conducting bird population monitoring) to know how best to proceed for their own specific needs. A review of 144 established bird monitoring schemes in Europe (Schmeller et al. 2012), for example, identified the following design issues as priorities for improvement:

- Ensuring unbiased spatial coverage
- Sampling effort optimisation
- Replicated sampling to account for variation in detection probability
- More efficient statistical use of the data.

3.2 Scoping and analysis

3.2.1 Indicator definition

The Indicator M3 (‘Avian Representation’) aims to quantify the presence of suitable bird species across trophic levels; it is one of three measures used to assess the status of the ‘Biodiversity Condition’ indicator (Lee & Allen 2011).1

We recommend that all species detected are recorded, rather than just one particular subset of species. This approach will allow flexibility and provide baseline data for future measurement of shifts in bird assemblages that were not anticipated at the outset, e.g. the possibility of some currently rare bird species becoming common in the future. For nocturnal species of interest (e.g. kiwi Apteryx spp. and morepork Ninox novaeseelandiae), we recommend that a separate (but complementary) system is developed.

The sampling scheme is appropriate for diurnal bird species at terrestrial sampling locations within a region. This scheme is designed for reporting primarily at the regional or national level. Some habitats currently administered by regional councils (e.g. wetland areas including coastal, braided riverbeds and dune habitats) may need to be monitored independently if species assemblages associated with these habitats are of interest. In particular, we expect that migratory and wetland species associated with these habitats will be poorly monitored by the current scheme.

3.2.2 Indicator statistic

Indicator statistics for Avian Representation could potentially be measured at the population, species or community level. We recommend that regional councils focus on the following three indicator statistics:

- Species richness (the number of species present)
- Occupancy (the proportion of locations occupied by a given species)
- Population density (the number of individuals of a given species within a hectare).

These can be measured either as static (e.g. population size or occupancy) or dynamic variables (e.g. population trend or extinction rate; Box 1).

All indicator statistics should include some measure of the precision of the estimate (e.g. the mean species occupancy or richness with 95% confidence intervals), to allow the reader to determine what confidence can be placed in those estimates and the strength of the inferences that can be drawn from them.

Box 1 Indicator statistics can be measured at population, species or community levels, and as static or dynamic variables

State variables can be the mean or variance estimates.

Population or species level:

1. *Distribution*: Specifying where birds do and do not occur, typically displayed as maps(Bibby et al. 2000) Sampling effort should be uniform (or measured and reported) otherwise the resulting maps will show the distribution of observer efforts as much as the distribution of birds.
2. *Occupancy*: Estimates the proportion of sites occupied by a given species (MacKenzie et al. 2002). Potentially more cost-effective to measure than abundance (Noon et al. 2012).
3. *Abundance*: Can be relative or absolute, with strongest inferences usually drawn from the latter Buckland et al 2008).

Community-level variables can be calculated for all species or subsets of species (e.g. different taxonomic groups or guilds). These are useful for assessing the structure and function of communities and the impacts of management on a variety of species or functional groups of species:

4. *Richness:* Measures the number of species in the community of interest. It is the simplest way to describe community and regional diversity (Gotelli & Colwell 2001).
5. *Evenness:* The equitability of the proportional abundances of the species in the community of interest (Tuomisto 2012). This can provide useful insights into the mechanisms that structure a community and the extent that it is disturbed (Studeny et al. 2011).
6. *Diversity:* Consists of two components, richness and evenness. Most are weighted sums of relative abundances of species, but also could be value-weighted according to ecosystem or economic values or taxonomic distinctiveness to inform management (Yoccoz et al. 2001).

Dynamic variables measure system function (rather than just state), so typically quantify rate parameters (Boulinier et al. 1998). Dynamic variables can be used to explain state and are relevant for both community- and species-level traits:

1. *Colonisation and extinction rates:* Measure vital rates of site occupancy dynamics for a given population or species level (MacKenzie et al. 2003). At the community level, temporal changes in species composition are measured as turnover rates (Magurran et al. 2010).
2. *Trends and rates of change:* Can be absolute or relative, but measuring the percentage change (since an arbitrary baseline year) can provide a more robust way to assess biodiversity trends (Magurran et al. 2010).
3. *Turning points and changing variance:* Turning points identify the timing of significant changes in population or community trajectories (Fewster et al. 2000). Measures of increased variability in biomass and other community attributes can be indicators of change in community composition from one state to the next (Magurran et al. 2010).

Note when measuring trends, it is important to consider these aspects:

- The ecology of the study species (e.g. is it a naturally cycling species?) (Thomas & Martin 1996) and community (e.g. what is the underlying level of temporal turnover in that community?) (Magurran et al. 2010).
- Sampling fluctuations can lead to an alert being triggered when the true reduction (if any) in the population is not of a magnitude to warrant it (Magurran et al. 2010), but smoothing splines can be used to remove short-term fluctuations in population trends (Fewster et al. 2000) and take into account the precision of the change measure within the alerts process (Magurran et al. 2010).
- Small changes in the way that the data are selected for analysis can affect the overall magnitude of trends (e.g. any resulting bias due to adding a constant to count data before log transformation is expected to decrease within increasing abundance).
- The method of trend estimation can affect the magnitude, direction and statistical significance of population trends assigned to species, thus assessing patterns of population change (rather than focusing on the magnitude of calculated trends and variance) may be more important or useful (Thomas & Martin 1996; Buckland et al. 2005).

3.2.3 Reference points for measuring change

Three types of reference points can be used to assess the state of biodiversity across a region and any spatio-temporal trends (Box 2) (Buckland et al. 2008):

- Baseline measures provide the starting points (at some time or state) against which change can be assessed
- Thresholds set some stage at which an alert is raised (e.g. a species has become threatened)
- Targets are set against agreed measurable endpoints and a specified timeline

Biodiversity measures can also be assessed against reference points, either in a static manner (i.e. distance from thresholds or targets) or a dynamic one (i.e. rates of change towards or away from thresholds or targets; Box 2).

Box 2 Setting monitoring goals: approaches, reference points and timelines

1. **Static approaches** include measures of 'population status' (e.g. population size and occupancy) against threshold measures and, at a community level, proportions of species that meet specified management targets, for example:
    - Classify species according to thresholds specified under the IUCN Red List classification system (IUCN 2008).
2. **Dynamic approaches** include the tallying of such numbers or proportions of species within various categories and monitoring changes in the status of these assemblages over time (Magurran et al. 2010). It is important to specify what levels of trend and within what confidence intervals the system aims to detect.
    - The IUCN system, for example, raises an 'amber' alert about a population if it declines by 25% over 25 years and a 'red' alert if it declines by >50% over 25 years (IUCN 2008).
    - The NeoTropical Migratory Bird Conservation Program, for example, defined an effective monitoring system as one that has 90% chance of detecting a 50% decline in a species' abundance over 25 years (Thomas & Martin 1996).
3. Assessments with respect to previously identified thresholds can also **combine both static and dynamic variables**, such as in 'alerts' approaches where sets of quantitative population criteria are used to place species on a 'red', 'amber' or 'green' alert.
    - The UK bird 'alert' listing criteria, for example, assess global conservation status, historical population decline, recent population decline (numbers and geographical range), European conservation status, rarity, localised distribution, and international importance of populations (Eaton et al. 2009).

3.2.4 Reporting frequencies

We anticipate regional councils adopting a sampling design based on a rotating-panel design, with a unique subset of randomly-selected locations (or 'panels') sampled in each year of the 5-year cycle (Table 3-1). If this design is adopted, trends in the biodiversity measures can be estimated, on an annual basis between 'panels' of locations from the second year, and within locations after the first 5-year cycle. It is important, however, that sampling locations in year two and beyond are selected randomly and not according to strata (such as land cover or environmental gradient), or else inference about trend will be confounded by the different strata measured each year.

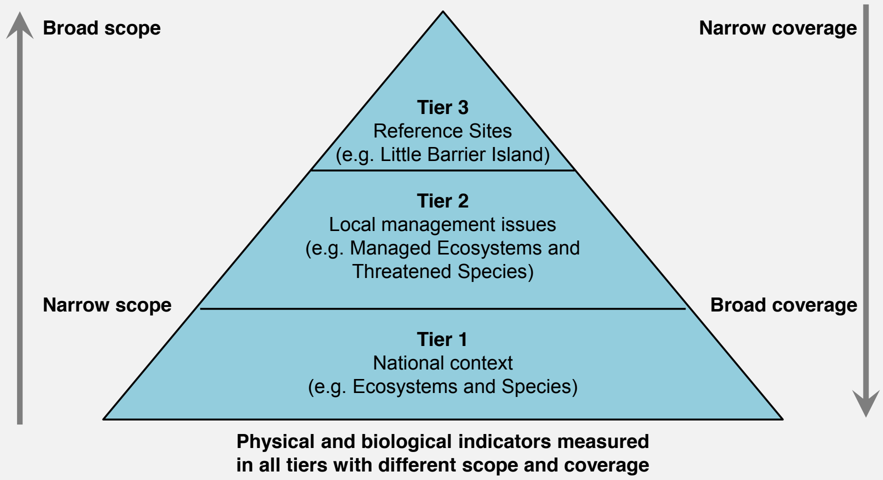
Table 3-1 Schematic specifications (Urquhart et al. 1998) for the proposed rotating-panel design, where a panel consists of a unique subset of randomly-selected sampling locations is sampled each year of the 5-year cycle

Panel	Sampling year																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2																				
3																				
4																				
5																				

Complementary systems will be required to facilitate monitoring of managed species and places. Such systems would include monitoring of rare and threatened species or communities (Williams et al 2007; Rodriguez et al. 2011; Holdaway et al. 2012), or those with confined distributions, as well as the effects of conservation management efforts at specific locations. Thus, the regional-level sampling proposed here is not intended to address these issues. Addressing specific management-effectiveness questions (e.g. testing the effectiveness of possum control management within the region) may require intensive sampling regimes (e.g. as implemented on DOC Tier 2 monitoring sites).

A trade-off between detail and scope or coverage is a practical limitation faced by all monitoring programmes. DOC uses a nested hierarchy (Box 3) to collect information with different levels of scope and coverage.

Box 3 Hierarchical nested monitoring adopted by the DOC Biodiversity Monitoring and Reporting System.



- **Tier 1.** The lowest level represented is monitoring that has broad spatial and temporal applicability (e.g. *National Ecosystems and Species*). This level provides geographic and interpretive context for data collected for *Managed Ecosystems* or *Managed Threatened Species* (Tier 2 and Tier 3).
- **Tier 2.** The middle tier indicates enhanced investigation effort that is limited in spatial and temporal extent but focused on management-driven impacts and outputs (*Managed Ecosystems* or *Managed Threatened Species*).
- **Tier 3.** Monitoring conducted intensively at a few sites (e.g. Waitutu, Eglinton, Craigieburn). These sites are useful for understanding interactions and allowing the development of predictive models. These intensive monitoring areas may become reference sites or benchmarks against which other sites may be compared. Intensive investigations aid in interpreting Tier 1 and Tier 2 data.

3.2.5 Reporting hierarchies

Information can be presented for all species, different subsets of species or individual species. Bird species can be grouped according to their origin (native or introduced) or functional traits or trophic levels (e.g. insectivores vs seed-eating species).

3.2.6 Spatial and temporal analysis

In the short term, it will be feasible to report on *Avian Representation* status at regional and national levels. Where sampling effort is sufficient, it will also be feasible to report on *Avian Representation* status within the predominant environments and land-use types at regional and national scales. After the first set of remeasurements, the system will report on the status of biodiversity measures relative to baseline measures from the initial survey at regional and national scales, as well as within predominant environments and land-use types. In the longer term, the system will report on trends in the biodiversity measures and evaluate these trends against agreed standards or limits.

3.2.7 Relationships between indicators and present patterns

We recommend integrating sampling protocols for the *Avian Representation* measure with those of the closely aligned M16 (*Changes in abundance of animals susceptible to introduced* *herbivores and carnivores*). Other measures could be used to interpret any spatial and temporal changes in the avian representation metrics. Measures of *Habitat Loss* and *Land under Indigenous Vegetation* could be used, for example, to test for evidence of land-use-change impacts (e.g. agricultural intensification and loss of indigenous vegetation) on bird populations. Similarly, the Biodiversity Protection measures could be used to assess whether areas subject to protection policies provide enhanced biodiversity outcomes relative to areas without protection. Such analyses could thus inform management and policy at regional and national scales.

3.2.8 Assessment of existing methodologies

Bird monitoring can take either surveillance or question-driven approaches, being motivated either by curiosity or by scientific questions and/or management issues (Yoccoz et al 2001; Field et al 2007; Lindenmayer & Likens 2010; Jones et al 2011; Jones et al 2013). Monitoring can be aimed either at the birds themselves or at bigger picture environmental goals (i.e. using birds as indicators) (Furness & Greenwood 1993; Newton 1998; Pereira & Cooper 2006). Different users tend to ask different questions of monitoring depending on their needs or interests (Figure 3-1), influencing the approaches (what is measured) and methods (how it is measured) chosen.

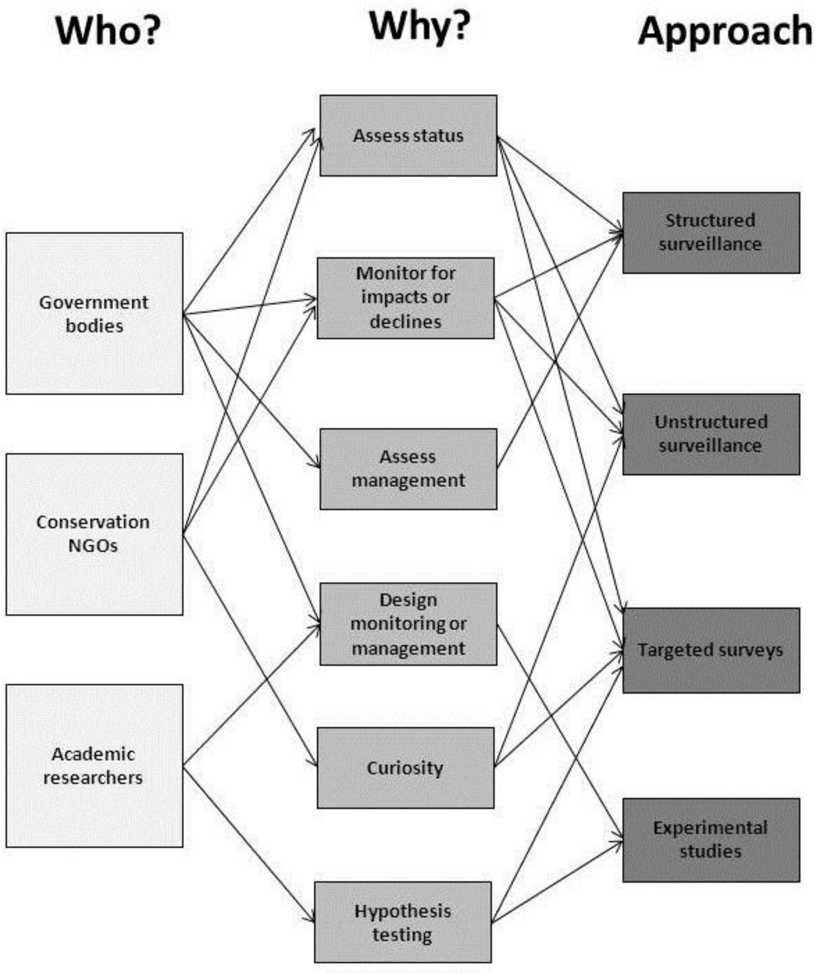


Figure 3-1 Purposes for monitoring and the approaches used.

The *Avian Representation* measure requires standardised field sampling and classification of birds into relevant guilds. A number of bird monitoring schemes are currently applied in New Zealand (Table 3-2), each using different monitoring designs and field sampling methods. There is currently no standard classification of feeding guilds for birds in New Zealand, with independent studies using their own interpretation of the literature to classify species (Hoare et al. 2012; MacLeod et al. 2012).

Footnotes to Table 3-2 (over page)

[1] Department of Conservation Biodiversity Monitoring and Reporting System; Lee et al. 2005; Allen et al. 2009b; MacLeod et al. 2012e; Macleod et al 2012a

[2] Agricultural Research Group on Sustainability; MacLeod et al. 2012c

[3] Spurr 2012

[4] Bull et al. 1985; Robertson et al. 2007

[5] Scofield et al. 2005

[6] Sullivan 2012

Table 3-2 Summary of bird monitoring initiatives in New Zealand (GOV = government, ACA = academic, IND = industry, NGO = non-government)

Approach	DOC BMRS[1]	ARGOS[2]	Garden Bird Survey[3]	NZ bird atlases[4]	eBird[5]	NatureWatch[6]
Governance	GOV	ACA, IND	NGO, ACA	NGO	NGO	NGO, ACA
Objective	Assess status Monitor for impacts Assess management Early-warning system	Assess status Monitor for impacts Assess management	Assess trend Raise awareness	Assess status	Curiosity Assess status	Curiosity
Structured surveillance?	Yes	Yes	Semi	Semi	No	No
Species variables	Species richness Species occupancy Species abundance	Species richness Species occupancy Species abundance	Species occupancy Species abundance	Inventories of species of interest Species distribution	Inventories of species of interest	Inventories of species of interest
Statistics quantified	State (and trend)	State (and trend)	Trend (and state)	State (and trend)	Usually state, occasionally trend	Usually state, occasionally trend
Reference points	Baselines from initial survey	Baselines from initial survey	Baselines from initial survey	Baselines from initial survey	Not specified	Not specified
Spatial scope	Public conservation lands at a national scale	Farmland within three sectors	Urban at national scale	National scale	Locations of interest to personnel	Locations of interest to personnel
Temporal scope	Rotating-panel design over a 5-year cycle	c. 2–3 year intervals	Annual	c. 20-year intervals	Variable	Variable
Repeated measures	Yes	Yes	Some	Possibly	Not specified	Not specified
Bird count technique	Modified 5-min Bird Count, incorporating distance sampling	Distance sampling transects & point counts	Timed counts, maximum number observed	Roving records of species lists	Ad hoc observations	Ad hoc observations
Repeated counts	Yes	Yes	No	Some	Possibly	Possibly
Detection probabilities	Yes	Yes	No	No	No	No
Record sampling effort	Yes	Yes	Yes	Yes	Typically no	Typically no
Field personnel	Professional	Professional/student	Citizen science	Citizen science	Citizen science	Citizen science
Database development	Ongoing	Established	Ongoing	Established	Established	Established
Analysis controls for sampling effort variation	Yes	Yes	No	No	Typically no	Typically no (but see Sullivan 2012)
Precision	Yes	Yes	Yes	No	No	No
Reporting	Annual	c. 2–3 years	Annual	20-year intervals	No	No

3.3 Current approaches employed by regional councils

- *Regional-scale monitoring efforts:* Currently limited to two regions: Auckland (but focusing on a subset of the landscape – remnants of woody vegetation); and Greater Wellington (a pilot study testing feasibility of using 8 × 8 km grid to sample pastoral landscapes, recognising that information on other dominant habitats is available from DOC).
- *Site-focused surveys:* Most current bird monitoring efforts are focused on measuring the impact of management such as pest control or restoration activities (e.g. Greater Wellington Regional Council; Hawke's Bay Regional Council; Environment Waikato[v]) (Fitzgerald & Innes 2013). There is potential to establish coordinated monitoring among these monitoring locations akin to a Tier 2 monitoring system (Box 3). The key challenge here is variation in management approaches and different scales of monitoring vs management.
- *Bird count methods employed:* The five-minute bird count is the primary method used, with fieldwork carried out by private contractors (e.g. Hawke's Bay) or in combination with in-house skills (e.g. Greater Wellington; Environment Canterbury) or community groups (e.g. Environment Canterbury).
- *Analytical capability available:* This varies among regional councils, with some better resourced than others. This is a specialist skill-set perhaps best provided by a third party; this is also better from an audit perspective (akin to the DOC/KPMG audit/auditor general review process).
- *Regular reporting:* There is currently only limited reporting – the primary focus being state of the environment reporting (e.g. Auckland Council). Reporting for other purposes could include community engagement projects (e.g. Hawke's Bay).

3.3.1 Monitoring objectives and sampling designs

Bird monitoring schemes currently underway in New Zealand are governed by a range of different parties (Table 3-2), including government agencies (DOC's Biodiversity Monitoring and Reporting System, DOC BMRS), academic research institutes (e.g. the Agricultural Research Group on Sustainability, ARGOS, which works closely with industry) and non-government organisations (primarily the Ornithological Society of New Zealand) or partnerships between multiple parties (e.g. the New Zealand Garden Bird Survey). Although the monitoring goals are not always explicitly stated, most schemes appear to aim to assess the status of bird populations and communities, with few being specifically designed to assess and monitor management impacts. The schemes range from highly structured surveillance designs (DOC BMRS and ARGOS) to semi-structured ones (Garden Bird Survey) to those using unstructured surveillance approaches (e.g. eBird, NatureWatch NZ).

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[v] Hamilton Halo project: http://www.waikatoregion.govt.nz/Environment/Natural-resources/Biodiversity/Hamilton-Halo/

For the regional council Terrestrial Biodiversity Monitoring Framework the key will be to select a scale, design and intensity of monitoring that are appropriate for its purpose, as this will influence the extent and strength of inferences that can be drawn from the monitoring data (Yoccoz et al. 2001). Strongest inferences are typically made when the measured variables have low bias (minor systematic under- or over-estimation) and high precision (a low level of uncertainty) (Thompson 2002; Buckland et al. 2008; Snäll et al. 2011). Having established an initial design (MacKenzie & Royle 2005; Vořížek et al. 2008), the sampling strategy should be re-evaluated given the available resources (Appendix 3-1), to ensure that it will be feasible to implement in the field and will provide adequate representation and precision to address study objectives (Gregory 2000; Field et al. 2005). If not, the objectives and design either need to be revised or the required resources secured (Magurran et al. 2010).

3.3.2 Species metrics and monitoring reference points

Different monitoring approaches will provide different species metrics (Figure 3-2). In general, atlases provide useful preliminary information about bird distributions or species inventories within a region, but to detect trends and direct management and policy, more detailed and regular surveys will be required (Bibby 1999). While smaller-scale (but more intensive) monitoring may be better suited for accurate and precise abundance measures for single species, less intensive monitoring at larger spatial scales may be better suited for community measures such as species richness, and monitoring to gain information on population trends generally needs long time-series of data to separate trend from random variance.

Most New Zealand schemes currently focus on measuring status and change relative to baselines derived from the initial surveys. Some aim to measure trend but currently do not have sufficient information to do so (except possibly the Garden Bird Survey).

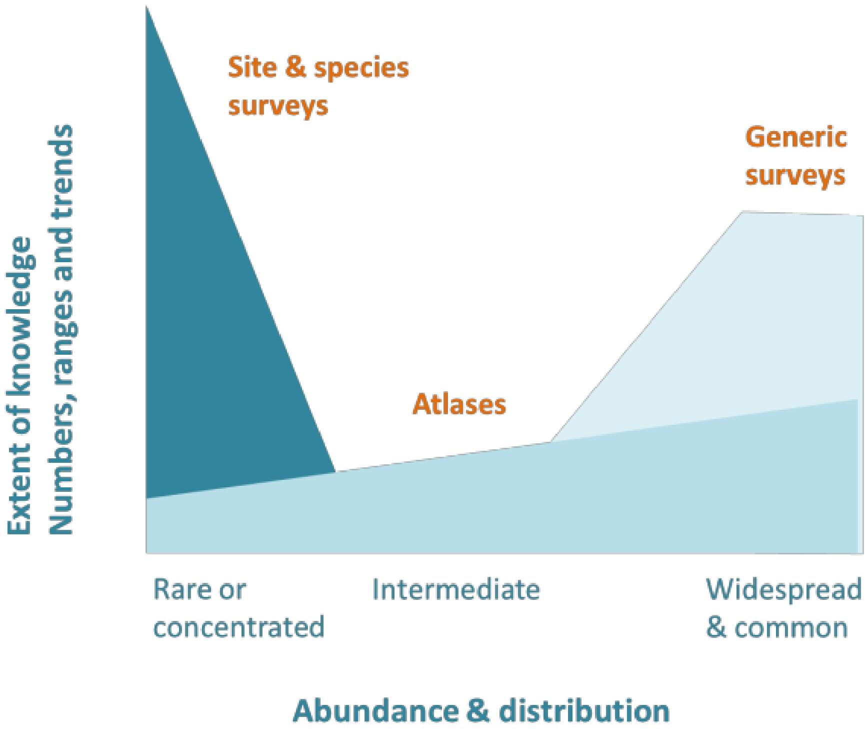


Figure 3-2 Survey design and the development of knowledge on trends and numbers of birds. Different survey approaches work differently according to the pattern of numbers and distribution of the species. Adapted from Bibby (1999).

3.3.3 Spatial and temporal scope

The spatial and temporal scope of the different bird monitoring initiatives in New Zealand vary extensively (Figure 3-3), with only the bird atlases aiming to provide information at a national scale. Some focus on particular land uses (conservation, agricultural or urban landscapes), while others concentrate on specific locations of interest to the observer. The frequency and timing of sampling events also vary widely among the schemes. These differences in spatial and temporal scope make it difficult to directly compare and collate information collected from these different schemes (MacLeod et al. 2013).[vi] In addition to considering the spatial scope of monitoring underway under other schemes, assessing the power of those schemes to realistically detect changes in bird community composition is also important (Figure 3-3).

[vi] Assessing the feasibility of drawing from multiple data sources for reporting on biodiversity status and trend information is the focus of a new MBIE-funded project, 'Trustworthy biodiversity measures – using birds as a proof-of-concept' (MacLeod et al. 2013).

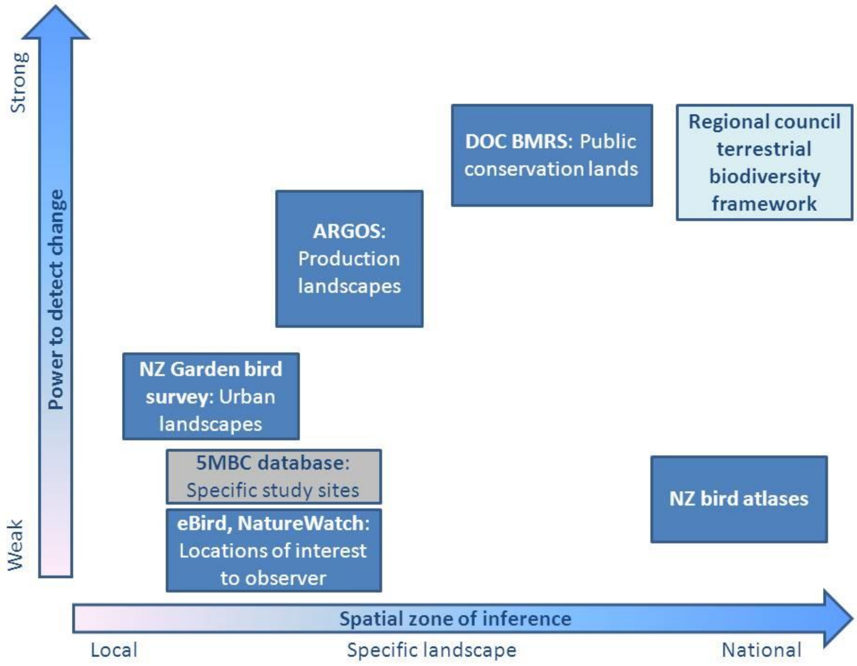


Figure 3-3 Comparing bird monitoring schemes currently implemented in New Zealand to highlight differences in their spatial zones of inference and potential power to detect change in avian community composition.

Schemes using *structured surveillance* approaches implement standardised sampling protocols at specified sampling locations and those locations are repeatedly sampled at regular intervals at a similar time of year (e.g. DOC BMRS and ARGOS). Using repeated measures from the same sampling locations over time can increase the power of a given monitoring design to detect changes in trends, relative to a design that measures a new set of locations at each sampling event (Monks & MacLeod 2013).

- *DOC BMRS:* Benefits of alignment with this scheme would include providing a representative sample across the region, with DOC covering the costs of monitoring for c. 32% locations at the national scale, although some regions will benefit more from this partnership than others (Appendix 3-2)
- *NZ Sustainability Dashboard:* This sustainability assessment and reporting tool (Manhire et al. 2012) is currently being developed[vii] for multiple primary industry sectors within New Zealand. It combines internationally-recognised frameworks and their key generic sustainability performance indicators (KPIs), with complementary KPIs developed specifically for New Zealand and the participating sectors (Hunt et al. 2013). The environmental monitoring framework design is closely aligned to the DOC and regional council biodiversity monitoring and reporting systems (MacLeod & Moller 2013). This provides an opportunity for regional councils to contribute and obtain data to assess sustainability of land management practices at regional, national and industry levels.

[vii] This initiative is being led by the Agricultural Research Group On Sustainability (ARGOS). http://www.nzdashboard.org.nz/

Semi-structured surveillance designs (e.g. the atlas of bird distribution and the New Zealand Garden Bird Survey) are likely to have reduced power to detect change (Bibby 1999; Bibby et al. 2000). This is primarily due to temporal changes in the spatial scope of sampling effort, which makes it difficult to distinguish whether any observed changes are due to real changes in bird populations or if they simply reflect changes in the areas being sampled. Also, sampling may be biased towards locations of interest.

- *New Zealand Garden Bird survey:* Extending the 8 × 8 km grid at national scale would provide a relatively small number of locations within urban landscapes (Appendix 3-2). As a good example of an indicator for reporting on community engagement, it could be a potential mechanism for overcoming difficulties in gaining access to private land for monitoring. The following potential sources of bias have not yet been formally investigated but are important considerations: (1) large variation in bird identification capabilities (e.g. Adélie penguins, an Antarctic species, being observed!); (2) the method does not currently account for variation in species detectability among and within regions; and (3) survey effort may be biased towards particular locations, for example gardens close to parks or reserves where birds are more abundant or diverse.
- *Future New Zealand bird atlases:* As the sampling protocols employed in previous iterations of the New Zealand bird atlases were flexible, observers may have targeted locations where they were more likely to encounter a wide range of species or those of conservation concern. Hence, there is opportunity to strengthen inferences that can be drawn from these data using a more structured surveillance approach.

Unstructured surveillance approaches will typically have very low power to detect change. This is because both the spatial and temporal scopes of sampling are highly dynamic and rarely specified and maintained. Alternatively, the spatial and temporal scopes can be clearly defined but will be focused on locations of interest to the observer (Sullivan 2012), hence limited inferences can be drawn from such information for regional and national reporting purposes.

- *eBird* and *NatureWatch*: There is potential to harness this citizen effort to facilitate a structured surveillance approach. Currently data are too patchy (temporally and spatially) to provide meaningful information at national and regional scales (e.g. see relevant international reviews: Snäll et al. 2011; Dickinson et al. 2010; Conrad & Hilchey 2011).
- *Five-minute bird count database:* The five-minute bird count method (5MBC) (Dawson & Bull 1975) has been the predominant bird monitoring technique used in New Zealand over the last 40 years (Hartley 2012). At least 120 000 counts are currently held in a central database (administered by DOC) but these data were primarily collected in short-term studies that were patchily distributed across the country (Figure 3-4).

Figure 3-4 Distribution of five-minute bird count studies currently held in the Department of Conservation's 5MBC database. Source: Hartley (2012).

3.3.4 Bird count techniques

Counting birds can be difficult because counts not only vary over space and time due to actual differences in species composition and abundance, but also due to differences in detection probabilities of species and individuals among counts (Box 4) and differences associated with measurement and misclassification errors (Simons et al. 2009). Given that absolute counts are rarely feasible, most studies aim to sample the community or population of interest. A large number of methods exist for counting birds. Most of the 'bird-count-method' debate is centred on the importance of detection probabilities, with counts being classified into two groups according to whether they explicitly measure and account for variation in detectability or not ('adjusted' or 'unadjusted' counts; Appendices 3–5).

The bird count methods used in New Zealand schemes (Table 3-1) encompass both adjusted (e.g. DOC BMRS and ARGOS) and unadjusted counts (e.g. Garden Bird Survey, bird atlases, eBird and NatureWatch). Adjusted counts, which account for variation in species detection probabilities (Box 4), include repeated counts (to measure species richness and occupancy; Box 5) and distance sampling methods (used to estimate population density; Appendices 4–5).

3.4 Data storage and reporting

Most regional councils (and other organisations) store their data in an ad hoc manner (e.g. using electronic spreadsheets on individual computers or local servers). However, recently some organisations have developed independent databases (e.g. OSNZ's bird atlases, DOC's 5MBC database) and online data repositories (e.g. eBird, NatureWatch, Garden Bird Survey, Global Biodiversity Information Facility) to improve data management.

Some regional councils hold a large amount of five-minute bird count data. However, this information is currently not readily locatable or available as there is no data storage system that all regional councils (or other stakeholder groups) can use to store bird data. This presents a number of data management and utilisation issues. For example, if standardised protocols for recording and storing the metadata and bird count information[viii] are not implemented, this presents difficulties for locating, mobilising and interpreting existing bird data. Overcoming these issues is particularly important for DOC and regional councils if their respective monitoring frameworks are to be compatible and able to inform on state of the environment reporting. Better data-recording and management protocols are required if multiple sources[ix] are to contribute information on a common basis for reporting regionally and/or nationally.

[viii] http://www.doc.govt.nz/conservation/native-animals/birds/five-minute-bird-counts/resources/

[ix] The BioData Services Stack project recently funded by TFBIS could provide some tools for mobilising existing bird count data held by regional councils.

Box 4 Detection probability

Definition and components

Detecting birds is often complicated because some birds move, while others are inconspicuous or actively move to avoid the counter (Elphick 2008). There are two components to detection probabilities (Alldredge et al. 2008):

- A probability that a bird is available for detection
- A probability of detection, conditional on its availability.

Bird detectability may vary in relation to three types of factors (individually or in combination (Alldredge et al. 2008; Buckland et al. 2008; Elphick 2008; Rozenstock et al. 2002):

1. Observer ability to detect and accurately identify birds
2. Environmental variables that affect bird behaviour and observer efficiency
3. Physical and behavioural traits of birds that make them more or less conspicuous to human observers.

Incorporation into abundance estimates

Bird count techniques all involve the collection of a count statistic (*C*), typically the number of birds seen or heard at a given point or along a transect (Nichols et al. 2002).This count statistic is denoted by the formula: $E(C_i) = p_i N_i$, where N_i is the true abundance and p_i is the detection probability, associated with a given location and time period that the count was undertaken (*i*).

- *Unadjusted counts* do not measure detection probability, but instead assume that detection probabilities will be similar for the times and places for each abundance comparison to be made (i.e. $p_i = p$ for all *i* in the comparison). Thus, unadjusted counts report an index (C_i) that measures the proportion of the population that is counted.
- *Adjusted counts* collect data in a manner that allows estimation of the detection probability at the given location and time period (*i*) and so permits estimation (^) of the population size: $\widehat{N_i} = \frac{C_i}{\widehat{p_i}}$. The resulting population estimate can then be used to draw inferences about changes in abundance over time and/or space.

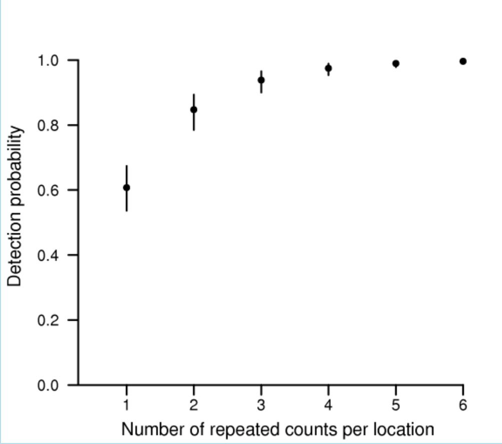
Box 5 Measuring occupancy for an iconic bird in urban parks

'Citizen science' initiatives monitoring the success of restoration activities require simple and robust tools if meaningful data are to be collected. Using an urban monitoring study of the bellbird (*Anthornis melanura*), we were able to offer advice and guidance on best practice for such monitoring schemes (MacLeod et al. 2012f).

Three independent surveys were undertaken across 140 locations in Christchurch's urban parks. Six repeat five-minute point counts were undertaken at each location per survey.

A single five-minute count had c. 60% chance of detecting bellbirds at a location where they were present, while the cumulative detection probability increased to almost one after five repeat counts per survey.

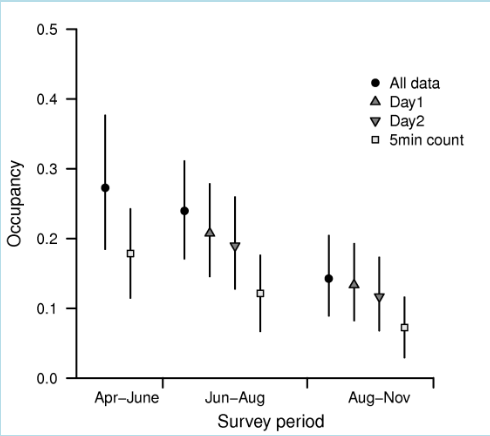
Detection probabilities were used to calculate unbiased occupancy estimates.



Occupancy estimates calculated using three replicate counts ('Day1' and 'Day2') were lower, but not statistically different, than those based on six replicates ('All data').

Robust estimates of bellbird occupancy require at least three repeat counts per location per survey within a short time frame (to minimise the risk of recording false absences).

Ideally, multiple locations should be surveyed concurrently. Prolonging the time taken to complete a survey of all locations increases the risk of bird movement occurring, and thus represents a shift from measuring occupancy to measuring the relative 'use' of different locations.



3.5 Development of a sampling scheme

3.5.1 Field sampling framework

A rotating-panel design, compatible with the New Zealand Land-Use and Carbon Analysis System (LUCAS) (MfE 2005) and the DOC BMRS (Allen et al. 2009b), is recommended for the field surveys (Appendix 3-2). Using a national infrastructure (an 8 × 8 km grid; n = 4084 sampling locations) established to measure carbon, vegetation structure and composition would provide regional councils with a regular, unbiased framework for sampling. Repeated measurements of each sampling location would occur at 5-yearly intervals, with a unique subset of randomly-selected locations surveyed in each year of the 5-year cycle.

The information collected using this framework would be suitable for integrating and reporting at both regional and national scales, with DOC surveying c. 32% of sampling locations at the national scale (but on public conservation land only) and between 8% and 86% at a regional scale (i.e. within each region, Appendix 3-2). At both national and regional scales, strongest inferences on the status and trend of biodiversity will likely be drawn for the two predominant landcover classes: forest (32%) and grassland/sedgeland/marshland (52%; Appendix 3-2).

3.5.2 Bird count methods

The optimal time for the bird surveys is mid-September to mid-October, which is early in the breeding season for most bird species and when male birds sing most consistently. Field sampling should proceed, in each year, from north to south and east to west to 'follow the spring season'. Each sampling location should be permanently marked, wherever feasible, to allow for repeated sampling at that location. Assuming that the DOC BMRS protocol is adopted, vegetation measurements are all made within a fixed 20 × 20 m plot. Data on mammal pests and common birds are collected within a much larger area (220 × 220 m), using a design that radiates out from the edges of the central vegetation plot (Figure 3-5). Standardised field sampling protocols are used for both the vegetation and animal surveys (Allen et al. 2009b; MacLeod et al. 2012e; DOC 2012).

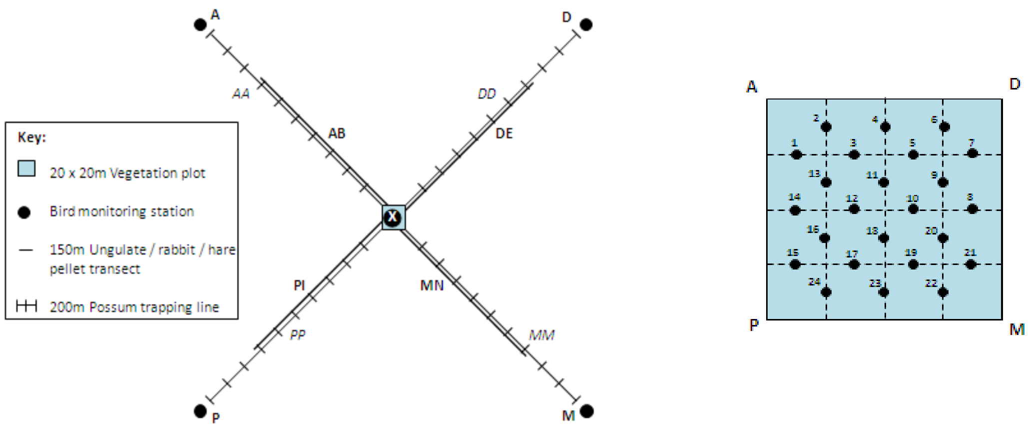


Figure 3-5 Layout of the animal-survey sampling units in relation to the vegetation plot at each sampling location.

A cluster of five count stations (200 m apart) is set up at each location (Figure 3-5), with bounded bird-point counts carried out on two consecutive days at each station (DOC 2012; MacLeod et al. 2012e). One count station is centred on the vegetation plot and one located 200 m directly away from each plot corner (Figure 3-5). Each location is considered an independent sampling unit, at which species richness, occupancy, and density are estimated (using data from the bounded bird-point counts collected from the cluster of five stations, i.e. 10 counts from five stations sampled twice).

Surveys are not undertaken in heavy rain, strong winds or poor visibility. To minimise the effects of diurnal variation in vocalisation and to ensure comparability with historical 5MBC data, all counts are initiated at least one hour after the official sunrise time for the sampling location (hence surveying only diurnal species; sunrise times for each day and location can be calculated using the 'sunriset' function in the 'maptools' package in R) (Lewin-Koh et al. 2008). Field teams should initiate counts one hour after sunrise and complete counts as quickly as possible, but the timing of bird surveys may be constrained if the same team also has to set up and check possum trap-lines (Allen et al. 2009b).

For each replicate bird survey, a ten-minute bird count (10MBC) is used. Distance-sampling procedures are incorporated into the first five minutes (5MDist) of each 10MBC, using a point-transect sampling approach (Buckland et al. 2001). During the 5MDist, the number of individuals detected (flock size) at each observation is recorded, in addition to whether individuals were initially heard or seen, and the horizontal radial distance from the count station to the point of first detection. The observer is asked to identify in which distance-band the bird was located (0–8 m; 9–16 m; 17–25 m; 26–45 m; 46–100 m; and >100 m from the count station). Birds only observed flying overhead (i.e. not associated with the sampling location) are not recorded, except for skylark, for which the horizontal radial distance to the bird is recorded. Where birds in close proximity to the count station are obviously disturbed by the approach of the observer, care is taken to note the identity and, where possible, original location of those birds. The observer also records whether or not birds moved towards them. During the 6–10 min period of the 10MBC, a modified 5MBC is to be conducted. This is a simple tally of all bird species seen or heard (including overhead observations) and recorded as either 'Near' (0–25 m), 'Far' (25–100 m) or '>Far' (>100 m) within a 5-min period over an unbounded (>100 m) distance. A rangefinder may be useful for these observations.

Habitat measures are collected within a 20 × 20 m plot at each bird count station, by carrying out a reduced Recce within the plot. We recommend following the standard Recce protocols (Hurst & Allen 2007) to characterise the topography and vegetation at each station (i.e. altitude, aspect, slope, physiography, drainage, cultural, surface and ground cover characteristics and overall vegetation tier cover classes). Overall vegetation-tier cover classes should only be provided for Tiers 1–6 as per the protocol for woody vegetation (and not subdivided Tiers 5 and 6); presence of species in Tier 7 (epiphytes) is noted. (Note: the DOC protocol (DOC 2012) recommends more detailed measures, which will require more time and specialist knowledge.)

DOC is currently investigating the feasibility of replacing observers in the field with automated recording devices for measuring bird community composition. However, these are new methodological developments, which are still in their infancy, and require comprehensive ground-truthing before they can be relied upon to cost-effectively deliver useful information (Elphick 2008). Thus we caution against adopting automated sampling protocols at this stage.

3.5.3 Trade-offs and modifications in sampling design

The rotating-panel design recommended for regional councils is a compromise between two extremes: (1) sampling the same locations each year or (2) sampling new locations each year. Repeated sampling at the same locations results in more precise estimates because of smaller variability, but the estimates will be relatively biased as a result of poor coverage across the landscape. Alternatively, sampling at different locations each year gives better coverage of locations, resulting in less biased estimates, but at the cost of increased variability due to lack of repeated sampling.

Any modifications to the sampling intensity (i.e. the number of sampling locations surveyed) should employ a grid size compatible with the 8 × 8 km grid (i.e. either a reduced or expanded subset nested within that framework). If the sampling intensity was reduced, for example, we recommend sampling a subset of the existing framework, using sampling locations occurring within the 16 × 16 km grid (n = 1019 sampling locations nationally). Alternatively, if the aim was to increase the sampling intensity, we recommend establishing the sampling grid at a finer scale that nests within the original framework, with a 4 × 4 km and 2 × 2 km grid increasing the number of sampling locations 4-fold and 16-fold, respectively.

Using existing bird data collected for forest and farmland habitats nationally, we consider the potential power of a regional scheme to detect changes in species occupancy and densities in relation to the species traits and the sampling intensity (i.e. number of locations sampled; Box 6; Appendix 3-6). We strongly recommend consistency in the bird count methods used among regions, as altering the field protocols can have significant consequences for integrating and interpreting the data (e.g. Box 7).

Box 6 Power to detect change in avian metrics

Detection probabilities vary among species, habitats and seasons (MacLeod et al. 2012 d)*, for example:*

- Only a third of species detected in farmland (*n* = 51) had detection probability ≥0.2, compared with two-thirds of species in forests (*n* = 32).
- Some native species (e.g. grey warbler, fantail tomtit, silvereye) are twice as difficult to detect in farmland as they are in forest habitats.

Metrics used to assess status and trend will depend on the information available:

- Recent national surveys of forest (MacLeod et al 2012a) and farmland (MacLeod et al. 2012c) indicate that it will be possible to calculate densities for less than half of the species detected.
- For widespread and common species, in particular introduced species, measuring changes in density may be more informative than changes in occupancy.

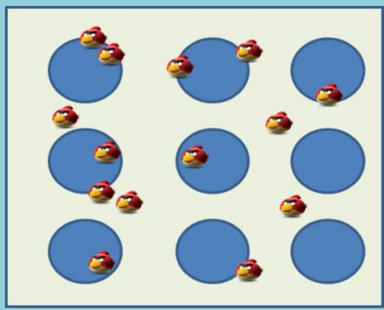
Standardised power calculations were used to test the ability of a regional scheme (MacLeod et al 2012d) *to detect (Appendix 3-6 – Informing trade-offs in sampling design):*

1. ***Absolute* changes in species occupancy between two time periods. The scheme could detect**:
   - moderate (0.25–0.45) to large (0.46–0.65) changes for c. 30% of native bird species at a regional scale, assuming c. 120 sampling locations were surveyed in each time period
   - large (0.46–0.65) changes in occupancy within forests, but not in non-forest areas, assuming c. 40 sampling locations were surveyed within each landcover class in each period
   - moderate (0.25–0.45) changes in occupancy within forests, but only very large (≥ 0.65) changes in non-forest areas, assuming c. 80 sampling locations were surveyed within each landcover class in each period.
2. ***Relative* changes in species occupancy between two time periods. The scheme could detect**:
   - moderate (25%) changes at the regional scale for most species with moderate to high detection probabilities (p ≥ 0.4) if c. 160 sampling locations were surveyed
   - moderate (25%) changes in forest and non-forest habitats for most species with moderate to high detection probabilities (p ≥ 0.4) if c. 80 sampling locations were surveyed within each landcover class.
3. ***Relative* changes in population density of a species between two time periods. The scheme could detect**:
   - small (c. 5%) to moderate (c. 10%) changes in density for native species in closed forests and common introduced species in open farmland habitats (when coefficient of variance estimates for densities are ≤20%, and ≥40 sampling locations are surveyed in each landcover class)
   - moderate (c. 10%) to large (c. 20%) changes in density for native species in closed forests and common introduced species in open farmland habitats when density estimates are less precise (i.e. coefficient of variance estimates for densities are 21–40%, and ≥40 sampling locations are surveyed in each landcover class).

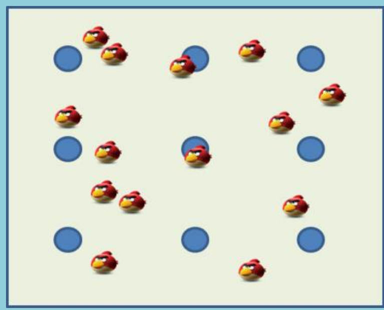
   In both cases, the power to detect changes in densities would be substantially reduced if either a different subset of sampling locations were measured at time 1 and time 2, or if two sampling locations from different landcover classes were being compared.

Box 7 Effects of changing the scale of the sampling units used

- Occupancy decreases as your sampling unit gets smaller
- This presents an issue for combining different sources of data.



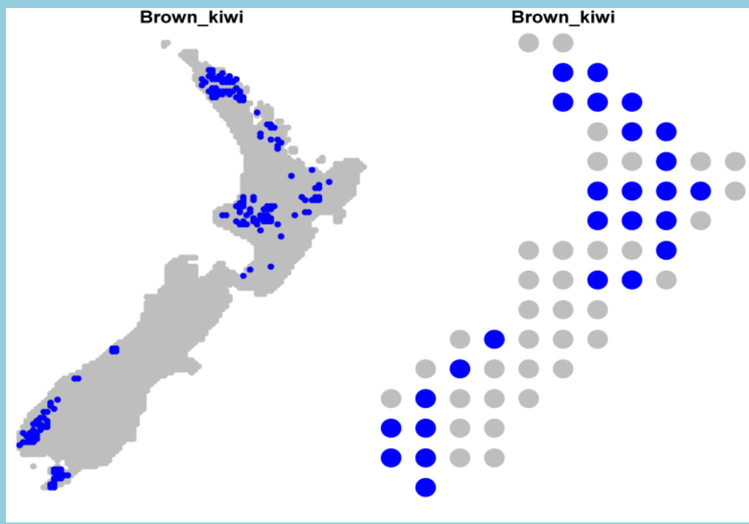
Present in 7 of 9 plots (78%)



Present in 2 of 9 plots (22%)

Brown kiwi data example from the NZ bird atlas (1999–2004) (Robertson et al. 2007)using different-sized grids:

- **10 × 10 km grid** (species detected in 176 of 3166 squares), where occupancy = **0.06** (left map)
- **100 × 100 km^2 grid** (species detected in 26 of 61 squares), where occupancy = **0.43** (right map)



3.5.4 Field delivery programmes

For the monitoring system to be successfully implemented (in the short and long term), field training and scheduling issues need careful consideration.

- *Feasibility of the methods:* Field experience in sampling vegetation in 20 × 20 m LUCAS (MfE 2005) forest and shrubland plots showed that of 1372 sampling locations nationally, 118 (8.6%) were not sampled (giving 1254 established) either because access to a location was denied or because the location was too steep to be sampled safely (Allen et al. 2009a). Steep terrain is likely to be a bigger constraint to obtaining data at sampling locations for birds, as the bird surveys sample from a larger scale (4.84 ha) than the vegetation measures (0.04 ha) (Allen et al. 2009a; MacLeod et al. 2012e). To maintain safety and also ensure that sampling can take place in some locations, the bird count stations at the end of the possum trap-lines (Figure 3-5) can be moved between 25º and 65º along the 45º bearing from a vegetation plot edge. If a slope threshold is used to exclude sampling locations, then the sampling universe needs to be specified accordingly (e.g. as those lands with slopes ≤35º). Dense vegetation can also be a constraint to obtaining accurate distance data at count stations for use in distance-based measures of abundance (Simons et al. 2009). This problem will be overcome, to some degree, by using estimates of distance in fixed classes, for both visual and auditory data. Bird survey teams will need to have excellent bird identification skills (sight and especially calls; MacLeod et al. 2012e) and distance measurement skills (Simons et al. 2009). The presence of other fieldworkers in the vicinity of a count station is expected to increase sampling error, especially in open habitats, where birds are disturbed by fieldwork activity. Such disturbance should be kept to a minimum, with the bird observer ideally completing the bird counts before other measures (e.g. for vegetation and vertebrate pests) are undertaken.

- *Training:* A field-team coordinator, with strong project management skills, will be required to run the field programme. Specialist field teams, with relevant methodological skills, must be briefed on the logistical and operating protocols, as well as the field survey protocols. In addition to field safety training, field teams will need to gain technical experience handling the relevant equipment, recording relevant time-budget and operational data (to inform logistic planning and budgeting in the future), and guidelines on how to prioritise their field effort when time-constraints occur (e.g. owing to poor weather). Note there is a risk that sampling-bias issues may arise within and between regions if field teams train and work in isolation from each other. It is important, therefore, that these teams train together and touch base regularly at regional and national scales to ensure protocols are consistent and coordinated.
- *Scheduling:* Before implementing the field programme, a scoping exercise is necessary to determine the availability of the field skills and personnel required to implement the survey methods at the regional scale; training schemes will be needed to address shortages (e.g. DOC's pilot study identified shortages in bird skills; Allen et al. 2009a). Six months before the field season, a work plan should be developed to ensure cost-effective coordination of field teams; this should include an assessment of access issues, the feasibility of implementing surveys at each location, and field gear requirements, as well as operational and field safety planning. One month prior to the field season, relevant training workshops should be run, with field teams then assisting with the final stages of field preparations. During the field season, the field coordinator must oversee the daily logistic requirements of the team, regularly review their schedules, and ensure that data management protocols are being maintained. Data checking, management and reporting processes should be completed as soon as possible after completing the field season. Audit protocols should be implemented, so that 10% of plots are audited throughout the field season. We recommend that regional councils coordinate with DOC and potentially with other regions to share skills and skilled staff and contractors if possible.

3.5.5 Cost estimates

Field cost estimates for the DOC BMRS pilot study (Allen et al. 2009a; MacLeod et al. 2012e) were high per sampling location (Table 3-3). For regional councils, we anticipate that travel times and costs should be substantially reduced:

- In regions that have a large number of readily accessible sampling locations (e.g. low elevation, open or modified landscapes).
- DOC is likely to cover costs of monitoring for c. 32% locations at the national scale, with some regions benefiting more from this partnership than others (Appendix 3-2).

The differing costs of volunteers and professionals, and whether it is worth spending money, time and resources on training volunteers, needs to be weighed up (Dickinson et al. 2010). Volunteers generally deliver poorer quality data, potentially requiring a greater investment at the analytical stage, and even then likely having less inferential power compared with professionally collected data. However, the cost of utilising professionals typically prohibits the execution of larger-scale designs. It has been recommended elsewhere that approximately 25–30% of the monitoring budget should be used for data management, assessment and reporting (Watson & Novelly 2004).

Table 3-3 Average estimates of the total number of person hours and costs per sampling location for implementing the bird field surveys, based on a pilot study (n = 18 locations) implemented on public conservation land and assuming that bird surveys will be carried out independently of the mammal pest and vegetation survey teams. (Labour costs are based on an hourly rate of $30 for all tasks except the field team logistics coordinator costs, which are charged at a rate of $40 per hour; Allen et al. 2009a)

Task	Hours	Cost ($)
Field team logistics/co-ordination	6	240
Pre-field preparation	6	180
Travel to location (and set up plot)	35	1,044
Commute to and around plot	13	380
Field survey	4	114
Wet weather day allowance (30%)	15	461
Field operating costs (incl. travel)		1,500
Data entry	10	300
Total per sampling location	89	$4,219

3.5.6 Data management

Practical considerations include determining how data should be collected and managed (e.g. form design, data handling, computerisation, and analysis) (Thomas & Martin 1996; Sergeant et al. 2012) and what additional information is required (including whether the monitoring work should be integrated with other taxa monitoring initiatives), as such contextual data are often important for interpreting and understanding trends (Gregory 2000; Pereira & Cooper 2006; Lindenmayer & Likens 2010), bearing in mind who will be collecting the data (e.g. volunteers and/or professionals) (Gregory 2000; Snäll et al. 2011; Dickinson et al. 2010; Conrad & Hilchey 2011). Any changes to sampling protocols, datasheets and databases must be clearly documented and rules must be established for managing such changes; this should include an assessment of the impact of such changes on the parameters being reported for each measure.

We recommend that the regional council system is consistent with those being used by DOC (Figure 3-6). We recommend that, rather than investing in in-house skills, regional councils should capitalise on the capabilities and investment in database development, management and analytical skills currently being developed by DOC and Landcare Research.

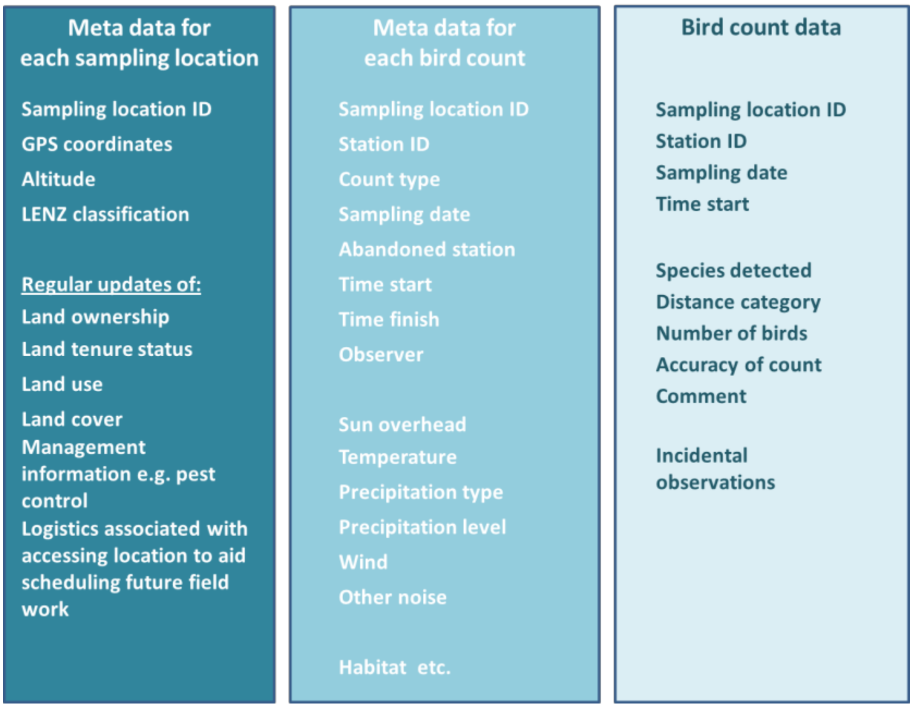


Figure 3-6 Illustration of hierarchical components of the DOC bird-count database for the Biodiversity Monitoring and Reporting System currently under development. We strongly recommend use of a relational database to ensure that the data-entry process is cost-efficient and minimises the risk of data errors.

3.5.7 Reporting indices and formats

To ensure sustained support and interest for the monitoring scheme during the vulnerable period when the benefits are lagging behind the costs (Figure 3-7), it is important to produce some tangible outputs in the short term (Watson & Novelly 2004; Sergeant et al. 2012). The derived benefits from biodiversity monitoring will accumulate over time:

- In the short term, regional councils will be able to report only on static measures of *Avian Representation* status.
- After the first set of remeasurements, the system will report on the status of biodiversity measures relative to baseline measures from the initial survey at regional and national scales, as well as within predominant environments and land-use types.
- In the longer term, the system will report on trends in the biodiversity measures and these could be evaluated against agreed standards or limits.

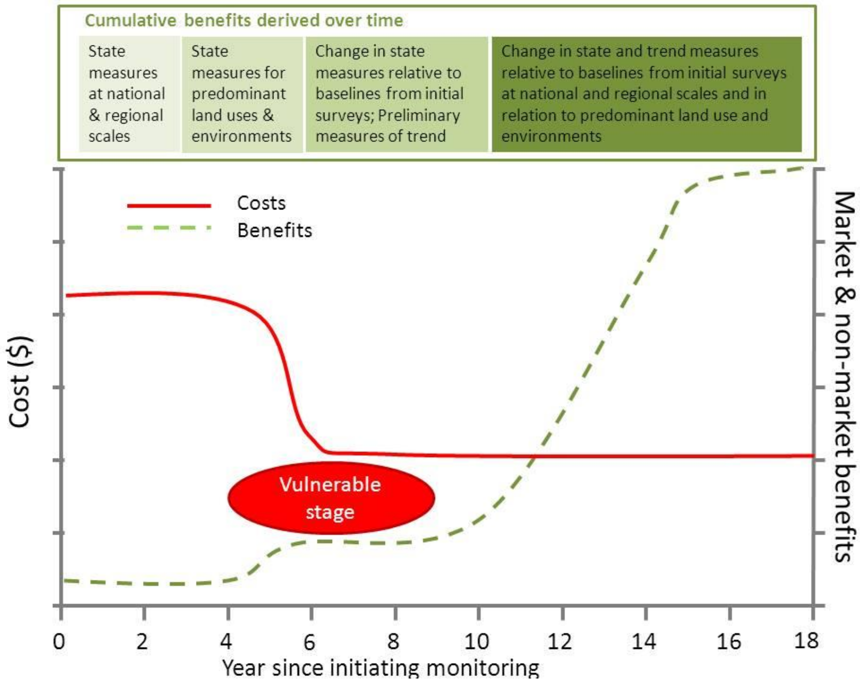


Figure 3-7 Stylised timeline of costs and benefits for biodiversity monitoring, assuming that sampling will start in earnest in the fourth year and the first change data are available in year 6. Start-up costs are higher than ongoing costs, with the vulnerable stage being from year 4 to 8 when the sampling locations are being set up but the change information is not yet available. Benefits increase rapidly as the locations are reassessed, but reach an asymptote at some stage in the future. Figure adapted from Watson & Novelly (2004).

3.5.8 Current status

Information can be presented for all species, different subsets of species or for individual species. Figure 3-8, for example, shows estimates of species richness and occupancy for native and introduced species separately. For the species richness, it shows estimates of the total number of species across all sampling locations and the mean number of species per sampling location. Similar information could be presented for different taxonomic or trophic groups across all species and subsets of native or introduced species (e.g. mean occupancy estimates; see Figure 3-9). Information collected could also be mapped to illustrate distributions of species and community-level metrics (e.g. Figure 3-10).

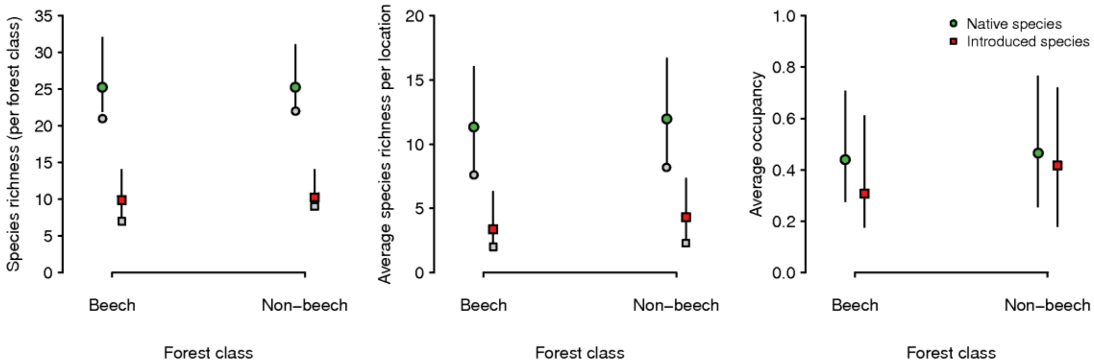
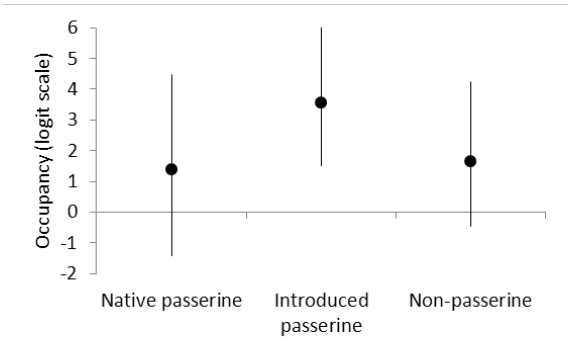


Figure 3-8 Estimates (± 95% Credible Interval) of total species richness, mean species richness and mean species occupancy for native (green circles) and introduced (red squares) species (the observed numbers of species are shown by grey circles or squares) in two forest classes (44 beech and 26 non-beech locations) (MacLeod et al. 2012a). (A credible interval is a Bayesian measure of precision of the estimate similar to a 95% confidence interval.)

(a) Species taxonomy



(b) Feeding guild

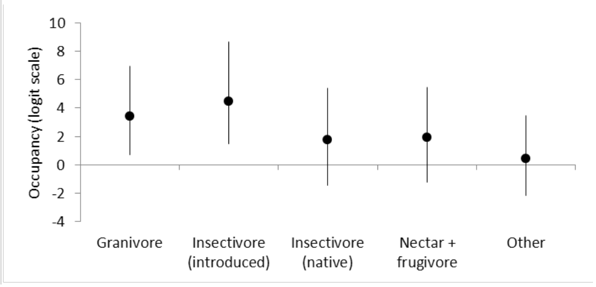


Figure 3-9 Community-level measures of occupancy (means ± 95% Credible Intervals on the logit scale) by (a) species taxonomy and (b) feeding guild for bird communities on the kiwifruit orchards in the Bay of Plenty.

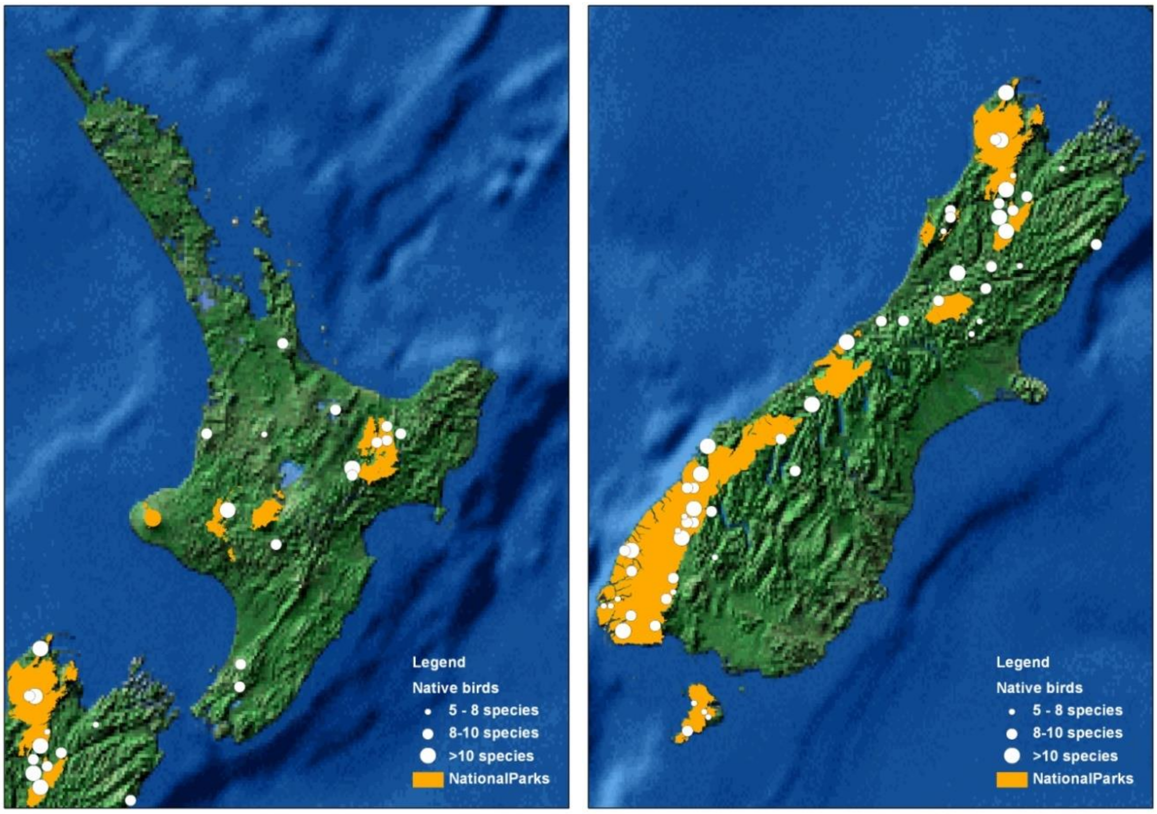


Figure 3-10 Preliminary species richness estimates for native birds for sampling locations in native forests on public conservation land in relation to national parks (MacLeod et al. 2012a).

3.5.9 Change relative to baseline measures

The initial set of measures will provide baseline information with which to compare future measures. Survey data could be used to calculate and map bird distributions at regional and national scales; this would require carefully developed modelling protocols, to ensure inclusion of relevant environmental variables and suitable mechanisms for measuring and illustrating uncertainty associated with derived estimates (e.g. Figure 3-11).

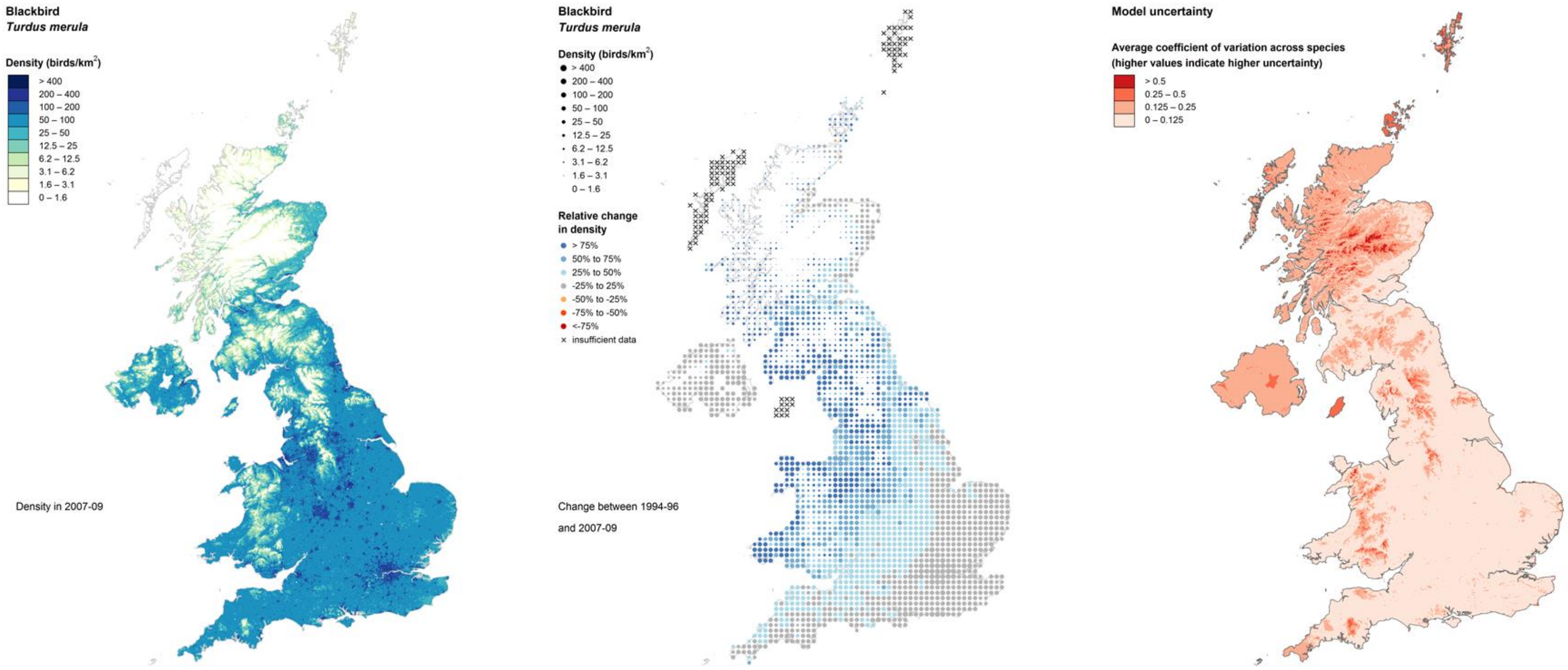


Figure 3-11 Distribution maps could be used to present a range of indicator metrics. Using blackbirds in the UK as an example, these maps show the distribution of current densities, changes in densities between two sampling periods and the uncertainty in the density estimates.

3.5.10 Temporal trends

Trend information could be presented for all species, subsets of species or individual species; for example, tallying of such numbers or proportions of species in various categories and monitoring changes in status of these assemblages over time. Figure 3-12 shows a hypothetical example of trends for all species, as well as subsets of native, endemic and introduced species at the national scale, while Figure 3-13 illustrates trends in forest specialist species relative to non-forest species. Such information could also be presented for different trophic guilds of species.

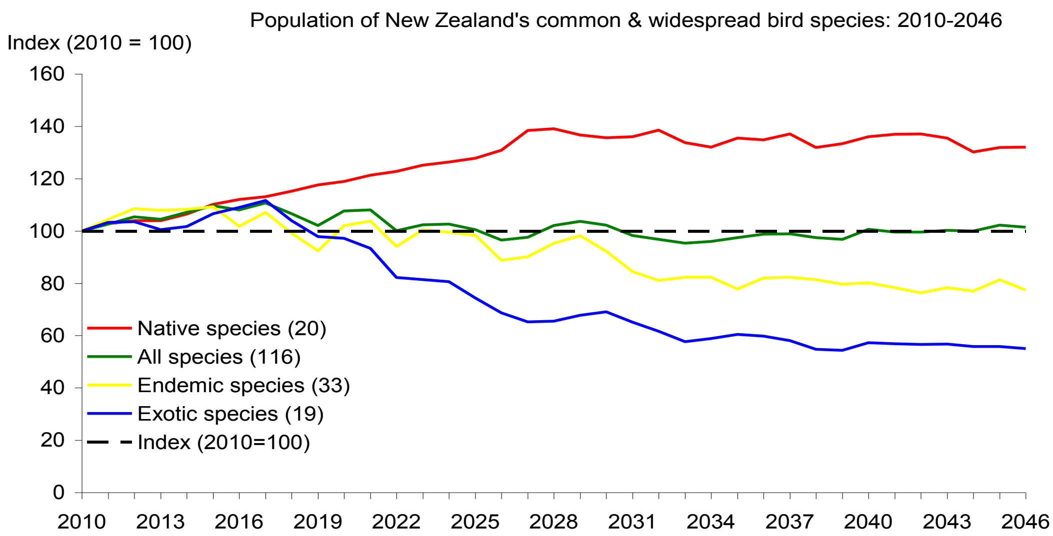


Figure 3-12 Example of overall population trends for different groups of widespread and common birds in New Zealand for the period 2010–2046, where species have been grouped according to their origin. (Based on information reported by the UK's Department for Environment Food and Rural Affairs to report on one of several sustainable development strategy indicators: http://www.defra.gov.uk/ENVIRONMENT/statistics/wildlife/kf/wdkf03.htm)

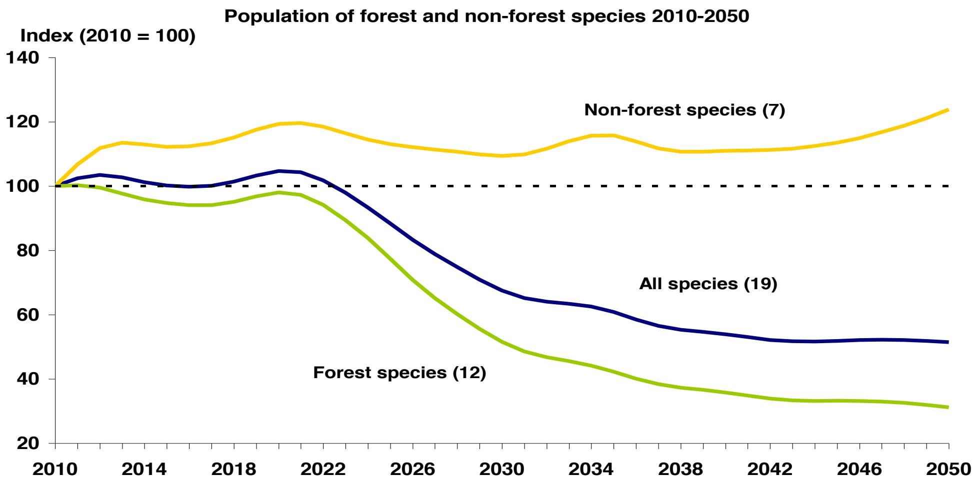


Figure 3-13 Example of overall population trends for different groups of widespread and common birds in New Zealand for the period 2010–2050, where species have been grouped according to whether they are forest specialists or not. (Based on information reported by the UK's Department for Environment Food and Rural Affairs to report on one of several sustainable development strategy indicators: http://www.defra.gov.uk/ENVIRONMENT/statistics/wildlife/kf/wdkf03.htm)

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Appendix 3-1 – Skills and logistical requirements for bird count methods

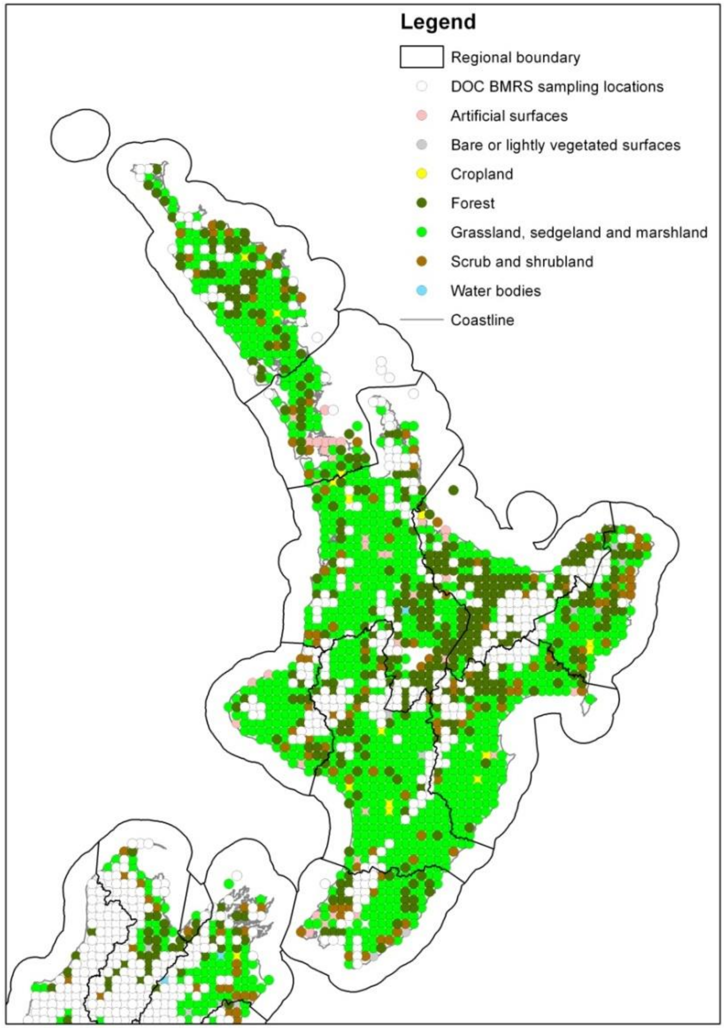
Table A3-1-1 Skill and logistical requirements for three unadjusted bird count methods, and the monitoring approaches (what is measured; **Figure 3-1**) that each method is best suited for as a result.

Components	Requirement	Territory mapping	Point counts	Transect counts
Field skills	Species identification	Basic	Moderate to complex	Moderate to complex
	Data recording	Complex	Basic	Basic
	Method application	Basic	Basic	Moderate
Field logistics	Equipment	Basic	Basic	Basic
	Labour	High	Low	Moderate
	Efficiency	Low	High	Moderate
Data processing	Skills	Basic	Basic	Basic
	Software	N/A	NA	NA
	Labour cost	Moderate	Low	Moderate
	Area sampled	Yes	Yes (for bounded counts)	Yes (for strip counts)
Monitoring approach suited		Targeted surveys Experimental studies	All	All apart from unstructured surveillance
Applied examples		Haila et al. 1996; Siriwardena et al. 1998; Gregory 2000; Gottschalk & Huettmann 2011	Link & Sauer 1998; LaDeau et al. 2007	Blank et al. 2011

Table A3-1-2 Skill and logistical requirements for adjusted bird count methods, and the monitoring approaches (what is measured; **Figure 3-1**) best suited as a result

Component	Requirement	Distance sampling				Multiple observer point counts	Time-of-detection point counts
		Line transects	Point or binomial point transects	Cue point counts	Lure point transects	Independent or dependent	Multi-observer, removal or time-interval
Field skills	Species identification	Complex	Complex	Complex	Moderate, as typically focus on specific species	Complex	Complex
	Data recording	Basic	Moderate	Moderate	Moderate	Complex	Complex
	Method application	Complex	Moderate	Complex	Moderate	Complex	Complex
Field logistics	Equipment	Moderate	Moderate	Moderate	Moderate	Basic	Basic
	Labour	Moderate	Moderate	Moderate	High	High	Moderate
	Efficiency	Very high	High	High	Moderate	Moderate	Moderate
Data processing	Skills	Moderate to high	Moderate to high	Moderate to high	Moderate to high	Moderate to high	Moderate to high
	Software	Distance	Distance	Distance	Distance	MARK	MARK
	Labour cost	Moderate	Moderate	Moderate	Moderate	High	High
	Area sampled	Yes	Yes (maximum distance to cue for binomial)	Yes	Yes	Recommended	Recommended
Monitoring approach suited		All apart from unstructured surveillance	All apart from unstructured surveillance	Targeted surveys and experimental studies	Targeted surveys and experimental studies	All apart from unstructured surveillance	Targeted surveys and experimental studies
Applied examples		Gregory 2000; Newson et al. 2005, 2008; Gottschalk & Huettmann 2011	Gregory 2000; Kissling & Garton 2006; Alldredge et al. 2007c; Moffat & Minot 1994	Buckland 2006	Buckland et al. 2006	Moore et al. 2004; Fletcher & Hutto 2006; Kissling & Garton 2006; Alldredge et al. 2007b Blank et al. 2011	Moore et al. 2004; Alldredge et al. 2007b; Reidy et al. 2011

Appendix 3-2 – Extending the DOC BMRS sampling grid across regions



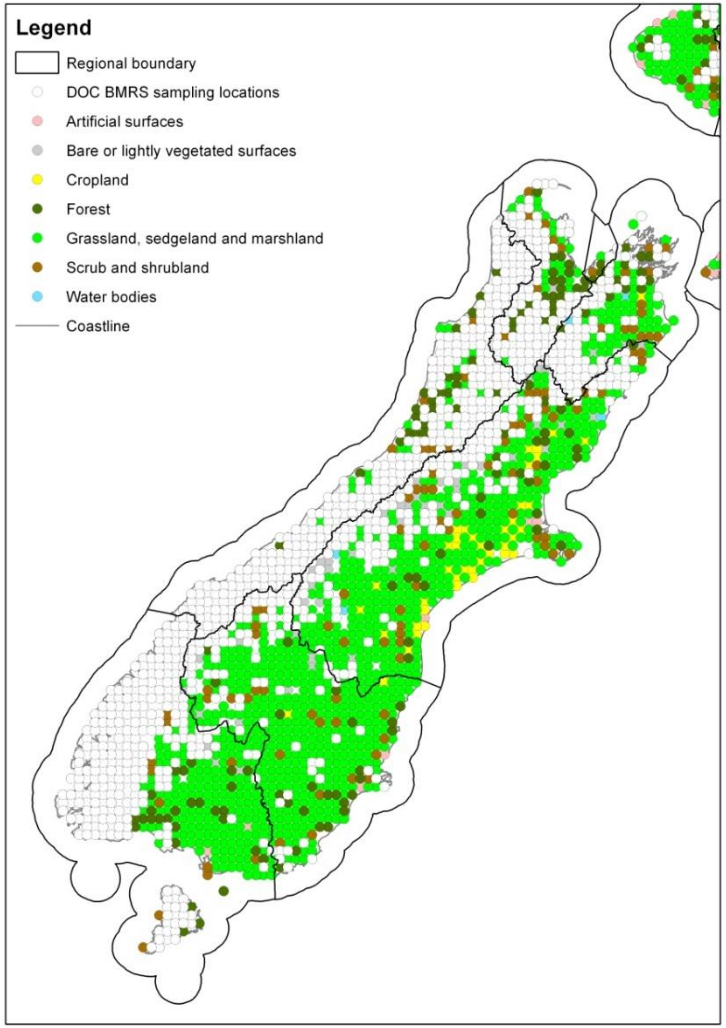


Figure A3-2-1 Sampling locations on the 8 × 8 km grid in relation to the regional council boundaries and landcover classification of sampling locations (see table below; excludes locations with slope >65º; open circles show the sampling locations covered by the DOC BMRS).

Table A3-2-1 Number and/or percentage of sampling locations on the 8 × 8 m grid within each region, sampled by the DOC BMRS or not, having steep slopes (estimated using LENZ; Leathwick et al. 2003), and within different landcover classes (based on first order land cover classes from the New Zealand Land Cover Database, LCDB2; Terralink (2004)).

Region	No. sampling locations			Percentage sampling locations									
	Total	DOC BMRS	Currently not sampled	DOC BMRS	Currently not sampled	Slope >45°	Artificial surfaces	Bare or lightly vegetated surfaces	Cropland	Forest	Grassland, sedgeland & marshland	Scrub & shrubland	Water bodies
Auckland	78	6	72	8	92	0	13	0	1	23	49	14	0
Bay of Plenty	194	60	134	31	69	2	2	0	<1	73	19	6	0
Canterbury	692	169	523	24	76	1	<1	12	6	10	63	9	<1
Gisborne	130	15	115	12	88	1	0	3	2	33	48	15	0
Hawke's Bay	216	39	177	18	82	0	<1	0	<1	30	57	11	0
Manawatū–Wanganui	349	61	288	17	83	0	<1	<1	1	23	67	8	0
Marlborough	153	73	80	48	52	3	0	10	<1	27	48	12	2
Nelson City	7	2	5	29	71	0	0	0	0	71	14	14	0
Northland	202	27	175	13	87	<1	0	1	1	36	53	9	0
Otago	480	87	393	18	82	1	<1	5	<1	10	78	7	0
Southland	478	260	218	54	46	7	<1	4	0	39	49	8	<1
Taranaki	114	26	88	23	77	0	4	0	0	33	56	8	0
Tasman	151	102	49	68	32	2	0	4	0	70	19	8	0
Waikato	369	64	305	17	83	0	2	<1	<1	35	55	7	<1
Wellington	125	23	102	18	82	1	4	2	0	31	49	14	0
Westland	346	297	49	86	14	4	0	7	0	65	15	12	0
Total no. of locations	4084	1311	2773			76	42	180	56	1303	2126	367	10
Total % of locations				32	68	<2	1.0	4.4	1.4	31.9	52.1	9.0	0.2

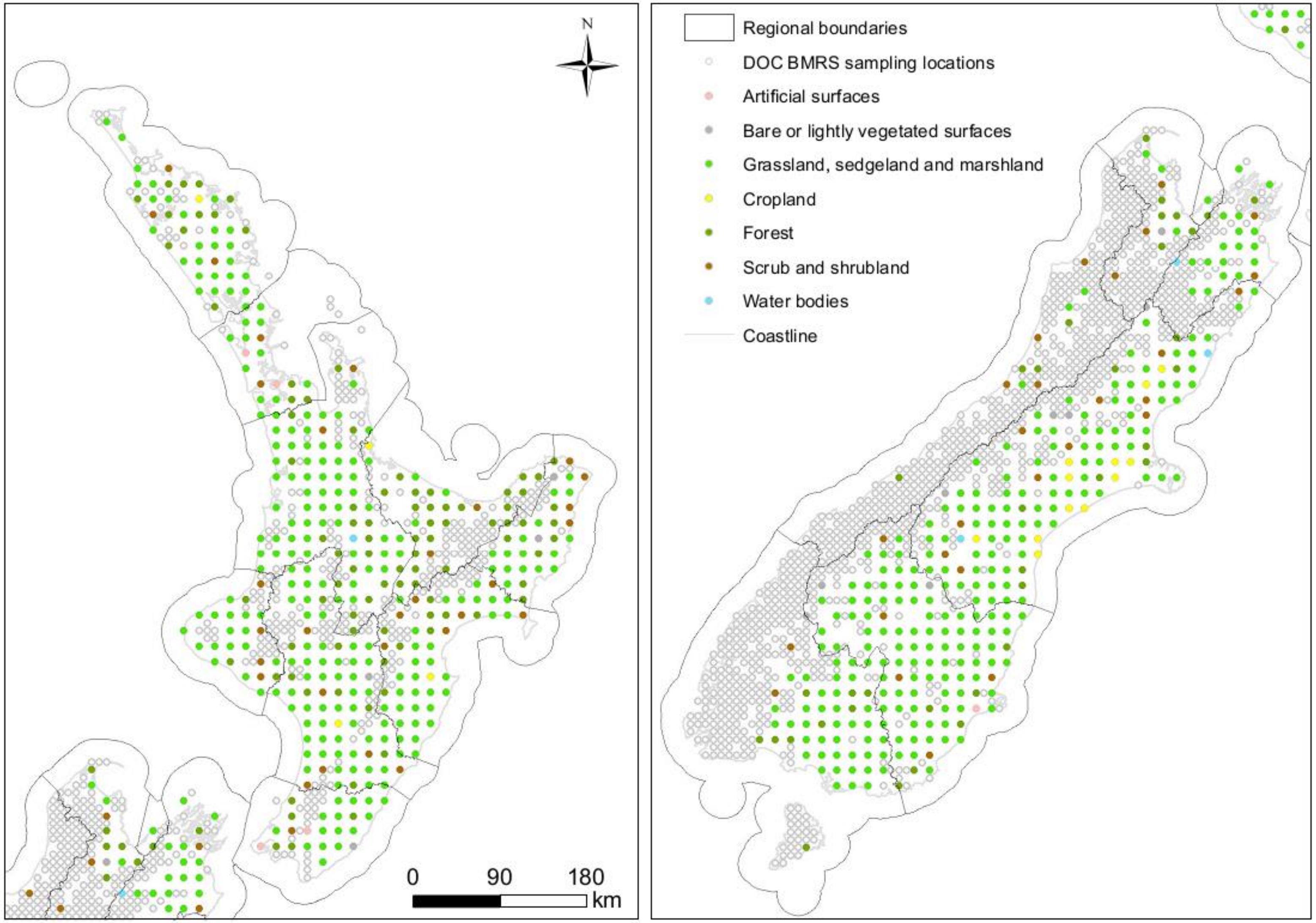


Figure A3-2-2 Sampling locations on a 16 × 16 km grid in relation to the regional council boundaries and landcover classification of sampling locations.

TableA3-2-2 Number and/or percentage of sampling locations within each region based on a 16 × 16 km grid, sampled by the DOC BMRS or not, have steep slopes (estimated using LENZ; Leathwick et al. 2003), and within different landcover classes (based on first-order land cover classes from the New Zealand Land Cover Database, LCDB2; Terralink (2004))

Region	No. sampling locations			Percentage sampling locations									
	Total	DOC BMRS	Currently not sampled	DOC BMRS	Currently not sampled	Slope >45°	Artificial surfaces	Bare or lightly vegetated surfaces	Cropland	Forest	Grassland, sedgeland & marshland	Scrub & shrubland	Water bodies
Auckland	18	0	18	0	100	0.0	11	0	0	17	61	11	0
Bay of Plenty	49	17	32	35	65	4.1	0	0	2	84	10	4	0
Canterbury	177	47	130	27	73	0.6	0	10	7	10	63	10	1
Gisborne	32	2	30	6	94	0.0	0	6	0	31	50	13	0
Hawke's Bay	55	7	48	13	87	0.0	0	0	2	29	55	15	0
Manawatū-Wanganui	86	14	72	16	84	0.0	0	1	1	23	65	9	0
Marlborough	38	17	21	45	55	5.3	0	13	0	13	63	8	3
Nelson City	2	0	2	0	100	0.0	0	0	0	50	50	0	0
Northland	50	7	43	14	86	0.0	0	0	2	36	54	8	0
Otago	120	18	102	15	85	0.0	1	4	0	10	81	4	0
Southland	116	65	51	56	44	8.6	0	2	0	41	48	8	1
Taranaki	29	6	23	21	79	0.0	0	0	0	31	55	14	0
Tasman	36	23	13	64	36	0.0	0	6	0	69	11	14	0
Waikato	96	19	77	20	80	0.0	0	1	0	34	59	4	1
Wellington	32	7	25	22	78	0.0	6	3	0	34	50	6	0
Westland	83	72	11	87	13	3.6	0	8	0	66	10	16	0
Total no. of locations	1019	321	698			18	5	44	16	324	535	90	5
Total percentage of locations				32	68	1.8	0.5	4.3	1.6	31.8	52.5	8.8	0.5

Appendix 3-3 – Unadjusted bird count methods

Table A3-3-1 Methods considerations for unadjusted bird counts (i.e. counts that do not account for potential variation in detectability).

Method	Species suitability	Habitat suitability	Key assumptions	Sources of bias	References	
					Methods	Validation
Territory mapping	Territorial species (but not semi-colonial, birds that only sing for brief periods, or non-standard mating systems)	All habitats but impractical at large scales	To decide whether a territory will be assigned for counting, a fixed ratio of registrations of a species to the number of effective visits for that species is used (e.g. ≥2 registrations for ≤8 visits or ≥3 registrations for ≥9 visits)	Edge and highly dynamic territories create problems. Density estimates vary depending on the registrations-to-visits ratio used to determine territories and minimum distance at which an observation is assumed to belong to a territory. Setting a fixed ratio for determining a territory does not allow for variation in detection probabilities among different habitat types and species	Bibby et al. 2000; Gottschalk & Huettman 2011	
Point counts (can be bounded or unbounded)	Suitable for multi-species surveys, particularly when cues mostly aural	All habitats; useful for dense habitats or difficult terrain	No bird is knowingly counted twice	Does not allow for variation in detection probabilities among different habitat types, species and seasons	Dawson & Bull 1975; Johnson 2008	
Transect counts (can be strip or unbounded)	Not suitable for silent or inactive species	Unsuitable for small, isolated blocks of distinctive habitat	All birds within strip transect are observed, where the strip width is set narrow enough to detect all cues	Temporary movement of boundary-line birds into the relatively narrow census strip. Birds are missed or distances are misjudged. Conspicuousness varies markedly from species to species; hence, each species must be dealt with as a separate entity	Emlen 1971, 1977	

Appendix 3-4 – Adjusted bird count methods

Table A3-4-1 Methods considerations for adjusted bird counts (i.e. counts that attempt to account for potential variation in detectability).

Method	Species suitability	Habitat suitability	Key assumptions	Sources of bias	References	
					Method	Validation
Distance sampling (line transects)	Suits mobile, conspicuous species and those that flush. Difficult for multi-species surveys if observer swamped	Open habitat only	Birds on line are certain to be detected; birds are detected at their initial location; distance measures are exact; group sizes are recorded without error	Flushed birds can move either beyond the range of detectability, which can result in negative bias, or within the area of detectability, which can result in double-counting of birds	Buckland et al. 2001, 2004, 2008; Thomas et al. 2010	Bächler & Liechti 2007; Alldredge et al. 2007c, 2008
Distance sampling (point or binomial point transects)	Suitable for multi-species surveys. Also for cryptic and skulking species. Not suited to species that flee from the observer	All habitats; less useful for dense habitats or difficult terrain	Point transects: birds on point (or within radius *r* for binomial) are certain to be detected; birds are detected at their initial location; distance measures are exact; group sizes are recorded without error.	Potential overestimation; with longer count periods, there is increased potential for positive bias owing to random movement of birds, but shorter counts result in fewer detections. Flushed birds can move either beyond the range of detectability, which can result in negative bias, or within the area of detectability, which can result in double-counting of birds.	Buckland 1987; Bibby & Buckland 1987; Buckland et al. 2001, 2004, 2008; Thomas et al. 2010.	Buckland 2006, Alldredge et al. 2007c, 2008
Distance sampling (cue point counts)	Calling species that move around during typical duration of point count. Observer swamping can be problem as distance to all cues is recorded	All habitats; particularly useful for dense habitats or difficult terrain	As for point and line transects, but do not need to distinguish between individual birds.	Over-dispersed data may be an issue. Need a representative sample of birds from separate fieldwork to estimate cue rate.	Buckland et al. 2001, 2004, 2008; Thomas et al. 2010	

Method	Species suitability	Habitat suitability	Key assumptions	Sources of bias	References	
					Method	Validation
Distance sampling (lure point transects)	Species that are rare or difficult to detect when present or probability of detection decreases sharply away from the point.	All habitats; particularly useful for dense habitats or difficult terrain	Does not assume that birds at the point are detected with certainty; uses experimental data to estimate detection function taking into account whether a random sample of birds responds to a lure or not. Care needed selecting appropriate truncation distance	Edge effects possible. If birds occur in flocks, it is possible only some individuals respond to lure. Guidelines for accounting for these are provided	Buckland et al. 2006	
Multiple-observer point counts (independent or dependent)	Species with reasonable detection probabilities (e.g. >0.4)	All habitats; less useful for dense habitats or difficult terrain	Detection of a bird by primary and secondary observers is independent; observers observe the same individuals; an observer's detection probability is the same regardless of whether they are the primary or secondary observer	Primary observer may respond to cues from secondary observer, particularly at low-bird-density locations; matching detections is error prone; recommend use of fixed-radius counts to reduce potentially serious problems associated with differences in distances at which different observers detect birds	Bart & Earnst 2002; Nichols et al. 2000	Alldredge et al. 2006, 2008; Simons et al. 2009
Time-of-detection point counts (multi-observer, removal or time-interval counts)	Recommended for species with constant (and relatively frequent) singing rate. Unsuitable for wide-ranging species and areas with many species and birds	All habitats; particularly useful for dense habitats or difficult terrain	There is no change in the population of birds within the detection radius during the count; there is no double-counting of individuals; constant per minute probabilities of detection; if counts within a limited radius are used, observers accurately assign birds to within or beyond the radius used.	Species that sing in irregular bouts and stay relatively hidden - the apparent population will be significantly smaller than the true population. Long duration of counts may lead to violation of the assumption that there is no double-counting of individuals	Farnsworth et al. 2002	Alldredge et al. 2007a; Simons et al. 2009

Appendix 3-5 – Key assumptions about detection probabilities

Table A3-5-1 A summary of the key assumptions about detection probabilities underlying bird community or population parameters using data collected with unadjusted count methods

State variable	Assumptions	Key references to inform study design
Abundance	The number of birds recorded for a given species is an index that is assumed to have a consistent, positive correlation with actual bird density, i.e. the detection probability for all individuals is similar for different times, places and species for which abundance comparisons are to be made.	Buckland et al. 2008; Nichols et al. 2000
Species occupancy	The probability of detecting a species, given that it was present, is similar at the times and places where comparisons are to be made.	MacKenzie et al. 2002; MacKenzie 2005; MacKenzie & Royle 2005; Nichols et al. 2008; Guillera-Arroita et al. 2010; Efford & Dawson 2012
Species distribution	Species presence can be reliably detected given enough effort.	Bibby et al. 2000
Species richness	All species are detected, or at least are detected with equal probability (but can be biased towards abundant and widespread species, which are likely to show diminished responses).	Boulinier et al. 1998; Nichols et al. 1998, 2008; Zipkin et al. 2010; Dorazio et al. 2010
Species diversity	Individuals of all species are equally detectable and/or that all species are detected.	Yoccoz et al. 2001

Appendix 3-6 – Informing trade-offs in sampling design

Table A3-6-1 Minimum detectable absolute change in occupancy (Δψ) for bird species (classified as very large: $\Delta\psi \geq 0.65$, large: $0.45 \leq \Delta\psi < 0.65$ or moderate: $0.25 \leq \Delta\psi < 0.45$) in relation to varying the number of sampling locations (n_{loc}), detection probabilities (p), classified as high ($p \geq 0.6$), moderate ($0.4 \leq p < 0.6$), low ($0.2 \leq p < 0.4$), and land cover types (non-forest and forest; n_{spp} = total number of bird species observed in each). Species with $p < 0.2$ are excluded, bold highlights species with $p > 0.2$ in both habitats (MacLeod et al. 2012d)

<table>
<tr><th rowspan="2">p</th><th colspan="2">Native species</th><th colspan="2">Introduced species</th><th colspan="4">Δ Ψ</th></tr>
<tr><th>Forest
(n_{spp} = 23)</th><th>Non-forest
(n_{spp} = 29)</th><th>Forest
(n_{spp} = 9)</th><th>Non-forest
(n_{spp} = 22)</th><th>n_{loc} = 40</th><th>n_{loc} = 80</th><th>n_{loc} = 120</th><th>n_{loc} = 240</th></tr>
<tr><td>High</td><td>Bellbird
Silvereye
Grey warbler
NZ robin
Rifleman
Tomtit</td><td></td><td>Chaffinch</td><td>Greenfinch
Magpie
Yellowhammer
Goldfinch
House sparrow
Skylark</td><td rowspan="2">Large</td><td rowspan="2" colspan="3">Moderate</td></tr>
<tr><td>Moderate</td><td>Brown creeper
Fantail
Tūī
Whitehead</td><td>Bellbird</td><td>Blackbird
Dunnock</td><td>Chaffinch
Blackbird
Song thrush
Redpoll
Starling</td></tr>
<tr><td>Low</td><td>Kererū
Kingfisher
Parakeet species
Shining cuckoo
Long-tailed cuckoo
Yellowhead</td><td>Silvereye
Grey warbler
Brown creeper
Paradise shelduck
Welcome swallow
Harrier
Black-backed gull
Pied oystercatcher
Spur-winged plover</td><td>Greenfinch
Song thrush
Redpoll</td><td>Dunnock</td><td></td><td>Very large</td><td>Large</td><td>Moderate</td></tr>
</table>

Table A3-6-2 Minimum detectable relative change (%) in occupancy ($\Delta\psi$) for bird species in relation to varying no. of sampling locations (n_{loc}), detection probabilities (p), classified as high ($p \geq 0.6$), moderate ($0.4 \leq p < 0.6$), low ($0.2 \leq p < 0.4$) and land cover types (non-forest and forest; n_{spp} = total no. of species observed). Species with $p < 0.2$ are excluded, bold highlights species with $p > 0.2$ in both habitats. Mean occupancy estimates for each species are in brackets (MacLeod et al. 2012d)

p	Native species Forest (n_{spp} = 23)	Non-forest (n_{spp} = 29)	Introduced species Forest (n_{spp} = 9)	Non-forest (n_{spp} = 22)	Δ Ψ n_{loc} = 40	n_{loc} = 80	n_{loc} = 120	n_{loc} = 240
High	**Grey warbler (0.95)** Tomtit (0.93)			Magpie (1.00) **Yellowhammer (1.00)** Skylark (1.00) Goldfinch (0.99)	50%		25%	
	Bellbird (0.86) **Silvereye (0.75)** Rifleman (0.60) NZ Robin (0.45)		**Chaffinch (0.78)**				50%	
Moderate				**Chaffinch (1.00)** **Blackbird (0.99)** **Greenfinch (0.96)** House sparrow (0.93) **Song thrush (0.96)** **Redpoll (0.94)** Starling (0.97)	50%		25%	
	Brown creeper (0.57) Fantail (0.64) Tūī (0.58) Whitehead (0.19)	**Bellbird (0.32)**	**Blackbird (0.57)** **Dunnock (0.08)**				50%	
Low		Spur-winged plover (0.90) Black-backed gull (0.89) Harrier (0.97)					50%	25%
	Parakeet spp. (0.50)	**Grey warbler (0.67)** Welcome swallow (0.63) Paradise shelduck (0.62) Pied oystercatcher (0.62) **Silvereye (0.46)**	**Redpoll (0.39)**	**Dunnock (0.62)**				50%
	Kererū (0.35) Shining cuckoo (0.21) Kingfisher (0.14) Long-tailed cuckoo (0.22) Yellowhead (0.07)		**Greenfinch (0.14)** **Song thrush (0.31)**					

Table A3-6-3 Minimum detectable change in bird densities (small = 5%; moderate = 10%, large = 20%, very large = 50%) under different sampling scenarios and varying the precision in density estimates (measured using the coefficient of variation), number of sampling locations (n_{loc}), and (c) land cover types (non-forest and forest habitats). Density estimates were only available for six species (highlighted in bold) in both land cover types.

DENSITY ESTIMATE		NATIVE SPECIES		INTRODUCED SPECIES		MINIMUM DETECTABLE CHANGE IN DENSITY					
Precision category	CV Range	Forest	Non-forest	Forest	Non-forest	One-sample case $n_{loc} = 40$	One-sample case $n_{loc} = 80$	One-sample case $n_{loc} = 120$	Two-sample case $n_{loc} = 40$	Two-sample case $n_{loc} = 80$	Two-sample case $n_{loc} = 120$
High	5–10%	**Grey warbler** Tomtit			Skylark Yellowhammer Goldfinch	Small	Small	Small	Moderate	Small	Small
	11–15%	**Bellbird** **Silvereye**	Harrier	**Chaffinch**	**Chaffinch** **Blackbird** House Sparrow Magpie Redpoll Song thrush	Small	Small	Small	Large	Moderate	Small
Moderate	16–20%	Rifleman Tūī Brown Creeper Kākāriki spp.		**Blackbird**	Greenfinch Starling	Moderate	Small	Small	Large	Moderate	Moderate
	21–25%	**Fantail** NZ Robin	**Bellbird** **Grey warbler** **Silvereye** Black-backed gull Spur-winged plover Pied oystercatcher			Large	Moderate	Moderate	Large	Large	Moderate
Low	26–30%		Welcome swallow Paradise shelduck		Dunnock	Large	Moderate	Moderate	Very large	Large	Moderate
	31–40%		**Fantail**			Large	Large	Moderate	Very large	Large	Large
Very low	50–60%				Feral pigeon	Very large	Large	Large	Very large	Very large	Very large

4 Indicator M5: Vulnerable ecosystems

Authors: Robbie Holdaway and Susan Wiser, Landcare Research

4.1 Introduction

This measure reports on the state and condition of ecosystems that are inherently vulnerable because of their limited natural extent, unique physiography, or location on the landscape (Lee & Allen 2011; Keith et al. 2013). Vulnerable ecosystems tend to contain disproportionally high levels of endemic and threatened taxa (Holdaway et al. 2012). They are also often located in areas of high anthropogenic pressure (e.g. lowland wetlands or coastal areas), making their protection and conservation a key priority on both private and public land (Ministry for the Environment, MfE 2007).

There are two main components to M5 – *extent* and *condition*. Extent records the area occupied by each vulnerable ecosystem within the region of interest, and this requires the context of the ecosystem's historic or potential extent. Condition records the health/quality of the ecosystem in question (Lee & Allen 2011). Both extent and condition are important, as some ecosystems can be very limited in extent yet in a healthy condition, while others can be geographically widespread but suffering from severe degradation (e.g. due to weed invasion or land-use pressures).

4.2 Scoping and analysis

4.2.1 'Vulnerable ecosystem' definition

Vulnerable ecosystems are defined within this measure as:

1. Wetlands
2. Dunes and other coastal ecosystems
3. Naturally rare ecosystems[10]

These three classes mirror the National Policy Statement for Biodiversity Protection on Private Land (MfE 2007). A full list of ecosystems covered by this measure is provided in Table 4-1. Some classification overlap occurs within these three ecosystem groups, for example some naturally rare ecosystems are also wetlands, and do not need to be reported on twice. Not all vulnerable ecosystems occur in each region (Table 4-2). There will be overlap,

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[10] As defined in Williams et al. (2007). These ecosystems have been collectively referred to as 'originally rare' (Williams et al. 2006), 'historically rare' (Williams et al. 2007), and 'naturally uncommon' (Holdaway et al. 2012; Wiser et al. 2013).

but not concordance between vulnerable ecosystems and Significant Natural Areas (SNAs). Further details about vulnerable ecosystems can be found in Williams et al. (2007), Hilton et al. (2000), Johnson (1992), and Partridge (1992). Wetland definitions are in Johnson and Gerbeaux (2004). Detailed descriptions of each of the naturally rare ecosystems can be found at http://www.landcareresearch.co.nz/publications/factsheets/rare-ecosystems.

Table 4-1 List of vulnerable ecosystems included in Measure 5

Ecosystem group	Ecosystem
Wetlands[1]	Bog
	Fen
	Swamp
	Marsh
	Seepage
	Shallow water
	Ephemeral wetland
	Pakihi and gumland
	Saltmarsh
Dunes/coastal ecosystems	Coastal sand dunes & associated ecosystems
Naturally rare ecosystems	Coastal
	Active sand dunes
	Dune deflation hollows
	Shell barrier beaches ('Chenier Plains')
	Coastal turfs
	Stony beach ridges
	Shingle beaches
	Stable sand dunes
	Coastal rock stacks
	Coastal cliffs of quartzose rocks
	Coastal cliffs of acidic rocks
	Coastal cliffs of basic rocks
	Coastal cliffs of calcareous rocks
	Coastal cliffs of ultrabasic rocks
	Inland/Alpine
	Volcanic dunes
	Screes of acidic rocks
	Calcareous screes

Ecosystem group	Ecosystem
	Ultrabasic screes
	Young (<5 years) tephra plains and hillslopes
	Recent (<10 years) lava flows
	Old tephra plains (= frost flats)
	Frost hollows
	Boulderfields of acidic rocks (non-volcanic)
	Volcanic boulderfields
	Volcanic debris flows or lahars
	Moraines
	Boulderfields of calcareous rocks
	Ultrabasic boulderfields
	Cliffs, scarps and tors of quartzose rocks
	Cliffs, scarps and tors of acidic rocks
	Basic cliffs, scarps and tors
	Calcareous cliffs, scarps and tors
	Ultrabasic cliffs, scarps and tors
	Ultrabasic hills
	Inland sand dunes
	Inland outwash gravels
	Braided riverbeds
	Granite sand plains
	Granite gravel fields
	Sandstone erosion pavements
	Limestone erosion pavements
	Inland saline (salt pans)
	Strongly leached terraces and plains
	Cloud forests
	Geothermal
	Heated ground (dry)
	Hydrothermally altered ground (now cool)
	Acid rain systems
	Fumeroles
	Geothermal streamsides
	Vertebrate induced
	Seabird guano deposits

Ecosystem group	Ecosystem
	Seabird-burrowed soils
	Marine mammal rookeries and haulouts
	Subterranean
	Sinkholes
	Cave entrances
	Caves and cracks in karst
	Subterranean river gravels
	Subterranean basalt fields
	Wetlands
	Lake margins
	Cushion bogs
	Ephemeral wetlands
	Gumlands
	Pakihi
	Damp sand plains
	Dune slacks
	Domed bogs (*Sporadanthus*)
	String mires
	Blanket mires
	Tarns
	Estuaries
	Lagoons
	Seepages and flushes
	Snow banks

[1] Wetland classes from Johnson and Gerbeaux (2004).

[2] Hilton et al. (2000), Johnson (1992), Partridge (1992).

[3] As defined in Williams et al. (2007). These ecosystems have been collectively referred to as 'originally rare' (Williams et al. 2006), 'historically rare' (Williams et al. 2007), and 'naturally uncommon' (Holdaway et al. 2012; Wiser et al. 2013).

Table 4-2 Potential occurrence of naturally rare ecosystems by region

Ecosystem name	Northland	Auckland	Waikato	Bay of Plenty	Hawke's Bay	Taranaki	Manawatū–Whanganui	Wellington	Gisborne	Tasman	Nelson City	Marlborough	West Coast	Canterbury	Otago	Southland
Coastal																
Active sand dunes	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Dune deflation hollows	Y						Y							Y		Y
Shell barrier beaches ('Chenier Plains')		Y	Y	Y												
Coastal turfs						Y		Y		Y		Y	Y	Y	Y	Y
Stony beach ridges			Y					Y				Y	Y	Y		
Shingle beaches	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Stable sand dunes	Y	Y		Y			Y			Y					Y	Y
Coastal rock stacks	Y	Y				Y	Y	Y		Y	Y	Y	Y	Y		Y
Coastal cliffs on quartzose rocks													Y			Y
Coastal cliffs of acidic rocks	Y	Y	Y	Y		Y		Y		Y	Y	Y			Y	Y
Coastal cliffs of basic rocks	Y	Y	Y											Y	Y	
Coastal cliffs of calcareous rocks			Y				Y	Y		Y		Y	Y	Y		
Coastal cliffs of ultrabasic rocks	Y											Y				

Ecosystem name	Northland	Auckland	Waikato	Bay of Plenty	Hawke's Bay	Taranaki	Manawatū–Whanganui	Wellington	Gisborne	Tasman	Nelson City	Marlborough	West Coast	Canterbury	Otago	Southland
<u>Inland/Alpine</u>																
Volcanic dunes			Y				Y									
Screes of acidic rocks			Y		Y		Y			Y		Y		Y		Y
Calcareous screes										Y		Y	Y			
Ultrabasic screes										Y		Y				Y
Young (<5 years) tephra plains and hillslopes				Y		Y	Y								Y	
Recent (<10 years) lava flows		Y	Y	Y		Y	Y									
Old tephra plains (= frost flats)							Y									
Frost hollows							Y			Y			Y	Y	Y	Y
Boulderfields of acidic rocks (non-volcanic)										Y			Y	Y		
Volcanic boulderfields														Y		
Volcanic debris flows or lahars			Y			Y	Y									
Moraines							Y			Y			Y	Y	Y	
Boulderfields of calcareous rocks								Y		Y		Y	Y			
Ultrabasic boulderfields										Y		Y			Y	
Cliffs, scarps and tors of quartzose rocks										Y			Y			
Cliffs, scarps and tors of acidic rocks							Y					Y		Y		

Ecosystem name	Northland	Auckland	Waikato	Bay of Plenty	Hawke's Bay	Taranaki	Manawatū–Whanganui	Wellington	Gisborne	Tasman	Nelson City	Marlborough	West Coast	Canterbury	Otago	Southland
Basic cliffs, scarps and tors	Y		Y							Y		Y		Y	Y	Y
Calcareous cliffs, scarps and tors			Y		Y		Y	Y		Y		Y		Y	Y	
Ultrabasic cliffs, scarps and tors	Y									Y	Y	Y	Y	Y		Y
Ultrabasic hills										Y	Y	Y	Y	Y		Y
Inland sand dunes														Y	Y	Y
Inland outwash gravels														Y	Y	Y
Braided riverbeds					Y		Y	Y		Y		Y	Y	Y	Y	Y
Granite sand plains										Y			Y			Y
Granite gravel fields										Y			Y			Y
Sandstone erosion pavements										Y			Y			
Limestone erosion pavements										Y				Y		
Inland saline (salt pans)															Y	
Strongly leached terraces and plains																
'Wilderness'												Y		Y	Y	Y
Cloud forests																

Ecosystem name	Northland	Auckland	Waikato	Bay of Plenty	Hawke's Bay	Taranaki	Manawatū–Whanganui	Wellington	Gisborne	Tasman	Nelson City	Marlborough	West Coast	Canterbury	Otago	Southland
Geothermal																
Heated ground (dry)			Y	Y												
Hydrothermally altered ground (now cool)			Y	Y												
Acid rain systems				Y												
Fumeroles			Y	Y												
Geothermal streamsides			Y	Y									Y			
Vertebrate induced																
Seabird guano deposits	Y	Y	Y	Y	Y					Y		Y	Y	Y	Y	Y
Seabird–burrowed soils	Y	Y	Y	Y	Y	Y		Y	Y			Y	Y	Y	Y	Y
Marine mammal rookeries and haulouts	Y			Y	Y	Y		Y		Y		Y	Y	Y	Y	Y
Subterranean																
Sinkholes			Y							Y			Y	Y	Y	
Cave entrances			Y							Y			Y	Y	Y	
Caves and cracks in karst			Y				Y			Y			Y			
Subterranean river gravels																
Subterranean basalt fields		Y												Y	Y	

Ecosystem name	Northland	Auckland	Waikato	Bay of Plenty	Hawke's Bay	Taranaki	Manawatū–Whanganui	Wellington	Gisborne	Tasman	Nelson City	Marlborough	West Coast	Canterbury	Otago	Southland
<u>Wetlands</u>																
Lake margins	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
Cushion bogs			Y				Y	Y	Y	Y		Y	Y	Y	Y	Y
Ephemeral wetlands	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
Gumlands	Y	Y														
Pakihi										Y			Y			
Damp sand plains	Y						Y						Y			Y
Dune slacks	Y	Y					Y									Y
Domed bogs (*Sporadanthus*)			Y													
String mires															Y	Y
Blanket mires							Y						Y			Y
Tarns							Y			Y			Y	Y	Y	Y
Estuaries	Y	Y	Y	Y	Y		Y			Y	Y			Y	Y	Y
Lagoons													Y	Y	Y	Y
Seepages and flushes							Y							Y		
Snow banks						Y	Y					Y		Y		

4.2.2 Measures of extent

Characterisation of ecosystem extent is as mapped polygons of each ecosystem such that total area (ha) can be calculated.

Wherever possible, mapped polygons should be used to characterise ecosystem extent, as these provide an estimate of the area occupied by that ecosystem, as well as geo-referenced boundaries to enable quantification of any future changes. For widely dispersed ecosystems that may be high in number but small in area (e.g. ephemeral wetlands), an estimate of the percentage area occupied within grid cells (e.g. 10 km^2) could be used instead of mapping each individual location. This approach has been employed by the Department of Conservation (DOC) with their mapping of nationally rare ecosystems.

A basic measure of extent is percentage area remaining, compared with a baseline value (e.g. 50 years ago, or pre-European). This metric requires quantification of both the current and historical distribution of the ecosystems, which may be difficult in some cases. Auckland Council has managed to do this using a combination of maps of historical vegetation and of predicted vegetation classes, and expert knowledge, and this provides a good case study for how such an approach might work.

4.2.3 Measures of condition

Condition can be measured directly within the mapped ecosystems. The concept of ecological integrity (Lee et al. 2005) has been employed by DOC to assess ecosystem condition, and could be applied as part of this measure. Holdaway et al. (2012) used the ecological integrity framework to characterise condition of naturally rare ecosystems, basing this on indicators such as proportion of invasive species, indigenous dominance and water quality (Table 4-3). In the absence of site-specific data, expert knowledge and indirect forms of data (e.g. Protected National Area surveys) can be used to assign sites/ecosystems to one of the severity categories (Table 4-3). **There is an outstanding research and development need for suitable sampling methods and intensities to measure changes in the condition of many of these ecosystems**. For example, suitable methods for dynamic and unstable ecosystems (e.g. Active sand dunes) require development. Others are needed for ecosystems where conventional methods (such as for vegetation in M2) would be difficult to implement, such as on the steep slopes >45° of Basic cliffs, scarps and tors (as conducted by Wiser & Buxton 2008). For others, appropriate sampling schemes are needed that account for distinct gradients within ecosystems, for example, from sea to inland on Shingle beaches (Wiser et al. 2010) or gradients of soil temperature on dry Heated ground (Burns 1997).

4.2.4 Reporting frequency

The extent and condition of vulnerable ecosystems is unlikely to change rapidly, so this measure should be reported on every 3 years. Councils should undertake ground-based surveys between each report to better delineate each vulnerable ecosystem and to determine condition within each region. Changes over 3 years are likely to reflect (i) actual change in extent of well-characterised vulnerable ecosystems and (ii) improved knowledge of less well known vulnerable ecosystems. Reports should therefore reflect both of these in interpretive text.

4.2.5 Linkages to other measures

This measure (M5) is linked to M12 ('Change in protection of naturally uncommon ecosystems'), which reports changes in legal protection of vulnerable ecosystems, and requires spatial data on the extent of vulnerable ecosystems. Changes in extent of vulnerable ecosystems, assessed using spatial data from this measure, are reported by M9 ('Habitat and vegetation loss').

Table 4-3 Summary of potential measures of ecosystem condition based on the 'ecological integrity' concept (Lee et al. 2005), adapted from Holdaway et al. (2012)

		Ecosystem condition (at any specific location)			
Element	Indicator	Very poor	Poor	Moderate	Good
Native dominance	Native vegetation cover	≥80% decline in native vegetation cover	≥50% decline in native vegetation cover	≥30% decline in native vegetation cover	≤30% decline in native vegetation cover
	Non-native plant and animal dominance	Non-native plants considered a threat account for ≥80% of total vegetation cover	Non-native plants considered a threat account for ≥50% of total vegetation cover	Non-native plants considered a threat account for ≥30% of total vegetation cover	Non-native plants considered a threat account for ≤30% of total vegetation cover
	Water quality	≥80% decline in one or more aspects of water quality	≥50% decline in one or more aspects of water quality	≥30% decline in one or more aspects of water quality	≤30% decline in one or more aspects of water quality
	Ecosystem disruption	Alteration of disturbance regime beyond the range usually experienced by the ecosystem	Alteration of disturbance regime to the extremes of the range usually experienced by the ecosystem	Alteration of disturbance regime within the range usually experienced by the ecosystem	No significant alteration of disturbance regime
Species occupancy	Composition (plants)	≥80% decline in abundance of one or more plant functional types	≥50% decline in abundance of one or more plant functional types	≥30% decline in abundance of one or more plant functional types	≤30% decline in abundance of one or more plant functional types
	Composition (animals)	≥80% decline in abundance of one or more animal guilds	≥50% decline in abundance of one or more animal guilds	≥30% decline in abundance of one or more animal guilds	≤30% decline in abundance of one or more animal guilds
Environmental representation	Climate change	Alteration of one or more local climate variables beyond the range usually experienced by the ecosystem	Alteration of one or more local climate variables to the extremes of the range usually experienced by the ecosystem	Alteration of one or more local climate variables within the range usually experienced by the ecosystem	No significant alteration of local climate variables

4.2.6 Assessment of existing methodologies

International

Internationally, the International Union for Conservation of Nature (IUCN) has recently developed a framework for assessing extent and condition of ecosystems (Keith et al. 2013), and these criteria are highly applicable to vulnerable ecosystems in New Zealand (e.g. Holdaway et al. 2012). General guidelines are provided on how to robustly map and assess changes in ecosystem extent, as well as how to select relevant variables for assessing changes in ecosystem condition. Auckland Council has applied the IUCN criteria to ecosystems within its region to identify threatened ecosystems as part of its Unitary Plan. This demonstrates that such an assessment is possible at the regional level.

National

National layers of wetlands are available from Landcare Research. These are accessible for viewing on the 'Our Environment' website (http://ourenvironment.scinfo.org.nz/ourenvironment#home) or as spatial layers from Anne-Gaëlle Ausseil, Landcare Research, Palmerston North. This wetland dataset has its origins in the Wetlands of National Importance (WONI) project, which was part of the Sustainable Development Programme of Actions for Freshwaters, which had the goal of identifying a list of water bodies that would protect a full range of freshwater biodiversity. The prehuman extent of wetlands was produced using soil information from the Land Resource Inventory and a 15-m digital elevation model (DEM) to refine soil boundaries. Current wetlands were defined by combining existing databases including LCDB2 (Land Cover Database version 2), NZMS 260 Topomaps, existing surveys from regional councils, Queen Elizabeth II (QEII) covenant wetland polygons, DOC surveys (WERI database), and the 15-m DEM, to define a single set of wetland polygons and centre points. All these data were checked against a standardised set of Landsat imagery using the EcoSat technology and where necessary new wetland boundaries delineated. Wetlands were classified into seven groups at the hydro-class level, using fuzzy expert rules.

A national layer of dune ecosystems (dunes in the broad sense, including foredunes, dune swales, ablation surfaces, etc.) was produced in concert with Hilton et al. (2000). As a subset of these ecosystems are defined as naturally rare, DOC is currently updating this layer to achieve higher spatial and thematic resolution, as part of the mapping of naturally rare ecosystems described below.

The Department of Conservation and Landcare Research have been endeavouring to describe the spatial extent of each naturally uncommon ecosystem by GIS mapping of all occurrences of each type of naturally rare ecosystem (Wiser et al. 2013). This has involved searching the literature and databases, poring over spatial information (maps), and contacting experts to build a digital picture of the extent of each ecosystem. Digitisation has been required where maps and location points were not yet in digital format. Some maps could be produced easily using existing data layers (e.g. marine mammal rookeries and haulouts), whereas others (e.g. braided riverbeds) required syntheses of existing data layers and digitisation. Still others are more difficult to depict readily. For example, ephemeral wetlands may be very small (<100

m^2) and there could be thousands scattered widely across New Zealand. These locations are not captured in any existing spatial data layers and there is no authoritative list of localities. Currently (as at December 2013) national maps have been completed for 14 ecosystems (Shell barrier beaches, Coastal turfs, Shingle beaches, Active sand dunes, Hydrothermally altered ground, Marine mammal rookeries and haulouts, Seabird guano deposits, Seabird-burrowed soils, Inland saline (salt pans), Strongly leached terraces and plains (Wilderness), Volcanic dunes, Braided riverbeds, Young tephra plains and hillslopes), 54 ecosystems are in various stages of development, and 3 ecosystems (Subterranean river gravels, Seepages and flushes, Snow banks) are unfeasible to map given current data/resources.

Work has also been done to identify which naturally rare ecosystems are present in which region. Initial estimates give a range of 6–37 naturally rare ecosystems per region (Table 4-2) with the minimum of 6 in Gisborne and the maximum of 37 in Canterbury. This table needs to be cross-validated against regional records.

Regional

A questionnaire undertaken by phone interviews assessed existing methodologies employed by the regional councils that might be relevant to M5 (Appendix 4). Responses indicated that a range of relevant information is currently being collected by councils, and that there is little consistency across regions. The most relevant current work includes efforts to map current extent of wetlands (Bay of Plenty, Greater Wellington, Waikato, and Horizons Regional Councils) and some naturally rare ecosystems (e.g. frost flats and geothermals by Bay of Plenty and Waikato Regional Councils; see Appendix 4), as well as site-based assessments for Significant Area designation, where these areas include vulnerable ecosystems. Discrepancies in which ecosystems were monitored were apparent, but most regions were guided by the 'Protecting our Places' policy statement (MfE 2007). This aligns well with the vulnerable ecosystems considered in this measure.

A range of data storage methods are currently used. Spatial information is generally stored as GIS shape files, but there is no single repository of these nationally. Condition information (e.g. vegetation data or other survey data) is either stored in the National Vegetation Survey (NVS) Databank, in Access databases, as spreadsheets in MS Excel, or as paper copies of reports.

4.2.7 Development of a sampling scheme: what will be measured and how

Ecosystems to report on

The first step in developing a sampling scheme for vulnerable ecosystems is to identify and map the existence of the vulnerable ecosystems at a regional and national level. The list of vulnerable ecosystems to be reported on is provided (Table 4-1) and should be used to determine their presence or absence in each region: Table 4-2 presents the current (2015) state of knowledge. This includes all naturally rare ecosystems, wetlands, and coastal ecosystems (Johnson 1992; Partridge 1992; Johnson & Gerbeaux 2004; Williams et al. 2007). The list in Table 4-1 should be the national standard, updated periodically (i.e. every 10 years) as more information becomes available or if a national ecosystem classification scheme is adopted.

Quantification of extent

The first step in quantifying the extent of vulnerable ecosystems is to identify which vulnerable ecosystems are present within each region (Figure 4-1). Quantification of extent has two components: 1) current extent, and 2) current extent relative to the historical or potential extent.

The key metric of extent is area (ha) occupied by a particular ecosystem. Once the regional list of vulnerable ecosystems list is constructed, careful consideration of existing datasets, both national and regional, that could contribute to depicting ecosystem area is required before undertaking collection of additional data.This requires the area occupied by each vulnerable ecosystem should then be mapped and digitised as a GIS shape file. Some vulnerable ecosystems will have existing maps available either regionally or nationally (e.g. wetlands and dunes). These sources should be checked and integrated into the regional register of vulnerable ecosystems. The Department of Conservation is mapping vulnerable ecosystems nationally and each council should liaise with DOC to obtain updated information for its region.

New mapping of ecosystems can be undertaken using a combination of remote imagery (aerial photos, satellite imagery, Google-Earth) and field-based site assessments, and this information collated into a GIS shape file for the ecosystem of interest. In most cases, field survyes will be needed to verify these boundaries. For those ecosystems that are readily identifiable in discrete constrained units (e.g. coastal cliffs of ultrabasic rocks and heated ground (dry)) this can be achieved readily. It can be difficult to map some vulnerable ecosystems, especially those with diffuse boundaries, with subtle topographic boundaries, and which are small in extent (e.g. ephemeral wetlands and seepages). For these, diffuse mapping based on presence/absence or percentage occupied within 1-km^2 grid cells should be undertaken. This aligns with the approach taken by DOC for national mapping of these vulnerable ecosystems.

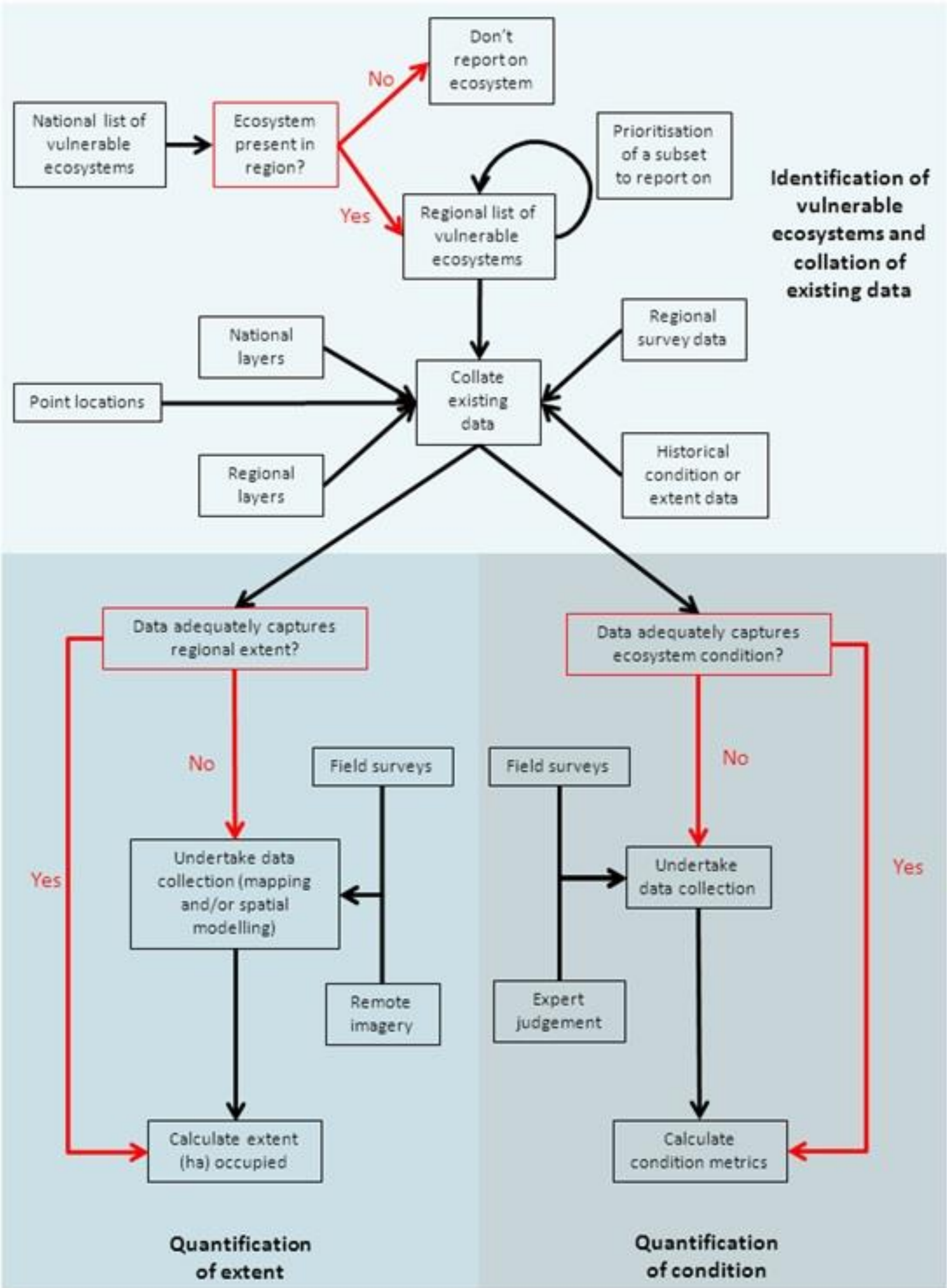

Figure 4-1 Flow diagram illustrating the steps involved in quantifying ecosystem extent and condition.

Quantification of condition

A standard approach to quantifying ecosystem condition should be employed across regions and ecosystems. An approach based on the conceptual framework of 'ecological integrity' (Lee et al. 2005) has significant merit as this is also being employed by DOC. Table 4-3 gives a summary of potential measures of ecosystem condition based on the ecological integrity concept. Additional measures of condition that fit within this framework may be developed to suit the ecosystem of interest. It is very important that the condition measures employed are representative of the key biota and ecosystem processes operating within that ecosystem (Keith et al. 2013). Not all measures will be applicable to all vulnerable ecosystems. Once the appropriate metric(s) have been decided, they can be evaluated using existing data (e.g. water quality for wetlands), or additional targeted data collection might be needed.

Condition may be quantified at different levels of detail. The minimum requirement is for condition to be assessed as a whole for each vulnerable ecosystem across a region/district using existing data and local expert knowledge. In the absence of site-specific data, expert knowledge and indirect forms of data (e.g. Protected National Area surveys) can be used to assign sites/ecosystems to one of the severity categories (Table 4-3). Where data on condition are lacking, a structured field campaign will be needed to collect the necessary data. **There is a research and development need to determine appropriate sampling regimes, measuring methods for ecosystem components and sample intensity (according to the variability of each vulnerable ecosystem). Determining the appropriate methods should be done with DOC.**

Standardisation across organisations

It is important to standardise any active monitoring methods across regional councils and to align methods with those of other organisations. Comparable data collection across multiple organisations that have jurisdiction over different parts of the landscape will provide a spatially robust dataset. Aligning ecosystem condition assessments with the concept of ecological integrity allows future integration of DOC and regional council datasets. Failure to do so will substantially reduce the potential to make an assessment of the condition of vulnerable ecosystems nationally.

Alignment with other measures

Spatial data on ecosystem extent collected as part of this measure (M5) will be used to evaluate M9 ('Habitat and vegetation loss') and M12 ('Change in extent and protection of indigenous cover or habitats or naturally rare ecosystems'). These two indicators report changes in extent and legal protection of vulnerable ecosystems.

4.2.8 Data management and access requirements

Data storage

Spatial data should be stored as shape files and compiled as a national data layer, in collaboration with DOC's team that maps rare ecosystems and wetlands. Plot-based vegetation data should be stored in NVS; site-based species lists can be stored with Nature Watch or NZ Plant Conservation network. Organism specimens should be stored at one of the major biological collection repositories. Other data (e.g. bird count data) should be stored in databases or spreadsheets that are standardised across regional councils and DOC. All data require sufficient metadata to enable repeat measurements and interpretation by other potential users.

Access to data

Data ownership is an important issue that needs to be considered. There are potential issues of both data accuracy and possible misuse owing to assumed accuracy; sensitivity of private landowners and Māori; and also a need to protect sensitive places as we do for threatened species. Data also need to be made available for use in evaluating other related measures (e.g. M9 and M12).

4.2.9 Reporting indices and formats

The primary reporting indices for this measure will be:

- current extent (ha)
- historical extent (ha)
- percentage area remaining (%)
- condition of current extent (using appropriate indicator variable).

An example of how these can be reported for each vulnerable ecosystem is shown in Table 4-4. If multiple indicator variables are used to assess ecosystem condition they all should be reported in the first instance, and, following standard Red List protocol (Keith et al. 2013), the overall state of an ecosystem determined by the variable that gives the worst assessment (i.e. most severe decline).

Table 4-4 Example reporting table for M5

	Measures of condition				
Vulnerable ecosystem	Current extent (ha)	Historic extent (ha)	Percentage area remaining[1]	Ecological integrity status	Description of integrity measure assessed
Active sand dunes	1500	6000	25	Poor	>50% decline in native dominance (weed invasion)
Saltmarsh	250	278	90	Moderate	>30% decline in water quality (nitrate levels)
Ultramafic hills	10 045	10 045	100	Good	Non-native plant and animal dominance could be future threat (wilding pines)
(etc.)	(etc.)		(etc.)	(etc.)	(etc.)

[1] Relative to data from 50 years ago or pre-European estimates

4.3 References

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Appendix 4 – Summary of input from regional/district council staff

Initial consultation

During the development of this measure feedback from regional/district councils was sought in relation to the following questions (see Table A4-1 for staff contact details):

1. Are you currently collecting any information pertinent to this measure?
2. Are you using a list to define vulnerable ecosystems? Which one? Have you altered an existing list? Derived your own?
3. Do you feel you can identify vulnerable ecosystems in the field?
4. Do you find current lists sufficiently comprehensive (i.e. ecosystems once common now rare not in typology)
5. How do you know where vulnerable ecosystems are and how extensive they are? Do you maintain site-based lists? Do you have maps of current and/or historical extent? If not, how is decision-making informed?
6. Are you carrying out any monitoring in any of these systems? What are the goals? What sorts of data are collected?
7. How do you store your data? How do you use it? Reporting? Inform resource consent making?

Table A4-1 Regional/district council contacts and date feedback was received

Council	Name	Date
Auckland Council	Stacey Byers	13 November 2012 (written response)
Tasman District/Nelson City Council	Mike Harding	10 December 2012
Bay of Plenty Regional Council	Nancy Willems	11 December 2012
Waikato Regional Council	Craig Briggs/Yanbin Deng	11/13 December 2012
Greater Wellington Regional Council	Philippa Crisp	12 December 2012
Marlborough Regional Council	Nicky Eade	12 December 2012
Horizons Regional Council	James Lambie	9 January 2013
Otago Regional Council	Richard Lord	11 January 2013
Taranaki Regional Council	Rebecca Martin	20 March 2013
Hawke's Bay Regional Council	Keiko Hashiba	21 March 2013

Summary of feedback received

1. *Are you currently collecting any information pertinent to this measure?*

Different councils are collecting a range of types of information that are pertinent to this measure. Some of this information is quite directly related, whereas in other instances it is more tangential. Information that is currently collected includes:

- Mapping of wetlands [Bay of Plenty, Wellington, Taranaki, Waikato partially done, Horizons partially done, Hawke's Bay partially done, Marlborough is planning to do this]
- Mapping of dunes [Bay of Plenty, Wellington, Waikato partially done, Horizons partially done, Hawke's Bay (handwritten, not digitised), may be included in mapping of significant coastal areas (Taranaki)]
- Mapping of naturally rare ecosystems [Bay of Plenty: frost flats, geothermals, Thornton kanuka; Waikato: geothermal ecosystems, others partially done; Waikato: relying on DOC map when it comes out; Taranaki: a subset]
- Surveys of Significant Natural Areas(SNAs), which often detect vulnerable ecosystems
- In assessments of significance, LENZ threat categories and presence of threatened species has more influence than vulnerable ecosystems, although the presence of some vulnerable ecosystems would be noted [Nelson City, Tasman District]
- Components of National Priorities (including wetlands, dunes and naturally rare ecosystems) may have been described using different terms [Marlborough]
- SNA mapping now incorporates National Priorities so includes vulnerable ecosystems [Waikato]
- Have mapped 'threatened ecosystems', which may include some vulnerable ecosystems [Auckland]

2. *Are you using a list to define vulnerable ecosystems? Which one? Have you altered an existing list? Derived your own?*

- Following 'Protecting Our Places' either intentionally or unintentionally [Tasman, Nelson City; Bay of Plenty; Marlborough; Waikato; Taranaki]
- Have derived their own list, incorporating 'Protecting our Places' [Horizons]
- Regionally threatened ecosystems, based on the unpublished Singers & Rogers list [Auckland]
- Not following a specific list [Wellington]
- Deriving a list of threatened habitat types, that is those having <20% of their original types. This includes wetlands, dunes and naturally uncommon and habitat types falling within LENZ threatened environments [Hawke's Bay]

3. *Do you feel you can identify vulnerable ecosystems in the field?*

- Yes [Tasman and Nelson City; Marlborough; Horizons; Auckland]
- Some yes, others problematic [delineation problem (shingle beaches); identifying geology (cliffs and outcrops) [Bay of Plenty]; sometimes two might occur in one place (e.g. coastal rock stacks, seabird guano deposits [Hawke's Bay]; [Taranaki]]
- Hard to know what you don't know [Wellington]
- Don't do this and no [Otago]
- Dunes relatively easy [Hawke's Bay]
- Wetlands: have a wetland specialist who does these [Hawke's Bay]

4. *Do you find current lists sufficiently comprehensive (i.e. ecosystems once common now rare not in typology)*

- Yes [Nelson City/Tasman; Waikato]. Comments: use in concert with LENZ threatened environments
- No [Bay of Plenty; Wellington; Marlborough; Horizons; Hawke's Bay]. Comments: missing some types that may have once been more common, especially lowland and coastal forest types and some shrublands (e.g. Thornton kānuka, *Streblus banksii* shrublands); forest remnants generally.
- Not sure (because of lack of information) [Taranaki]
- N/A or no answer [Otago, Auckland]

5. *How do you know where vulnerable ecosystems are and how extensive they are? Do you maintain site-based lists? Do you have maps of current and/or historical extent? If not, how is decision-making informed?*

- Maps are differentially available for wetlands, dunes, rare ecosystems, SNAs, high-value biodiversity sites and threatened ecosystems. Some efforts to map both historical and current extent
- Reliance on unmapped information such as reports, data, site-based lists, but not all councils have things such as site-based lists [Hawke's Bay]
- Because of uneven data and the ad hoc nature of data compilation for individual decisions there is the possibility that a decision-maker would not be aware of the significance of an ecosystem during the consent process
- Never get enquiries from consents people [Hawke's Bay]
- Decisions usually made on case-by-case basis, often with a site visit [Hawke's Bay]
- See also answers to Question 1.

6. *Are you carrying out any monitoring in any of these systems? What are the goals? What sort of data are collected?*

- Monitoring of selected types of high importance [geothermal, Thornton kānuka [Bay of Plenty]; geothermal [Waikato]; wetlands [Otago, Hawke's Bay, Taranaki]]
- Monitoring of managed sites, may or may not be vulnerable ecosystems [Marlborough]
- No [Wellington, Auckland, Horizons, Tasman]
- Intention to use data collected from recces as a way to monitor SNAs [Tasman]
- Intention to use optimisation approach of DOC to decide on management sites, which will then be monitored [Auckland]

7. *How do you store your data? How do you use it? Reporting? Inform Resource Consent making?*

- Hard or electronic copies of reports filed [Tasman; Wellington; probably others]
- Plot data stored in NVS [Bay of Plenty; Wellington; Auckland]
- Spatial information in GIS [Bay of Plenty; Waikato; Wellington; Marlborough; Auckland; Horizons, Hawke's Bay]
- Tabular information in spreadsheets or Access database [Bay of Plenty; Wellington; Marlborough; Auckland; Horizons; Taranaki]

How is it used: consent process

- Spatial and related data inform consent process [Bay of Plenty; Waikato; Marlborough; Wellington to a limited degree; Horizons (wetland info)]

How is it used: reporting

- Reports are done for all monitoring [Bay of Plenty] or specific ecosystems (e.g. geothermal [Waikato])
- Reports on data collected to council [Wellington]
- Reports of ecological assessments to landowners [Marlborough]
- Annual reporting [Marlborough; Horizons; Waikato to a limited degree]

How it is used: other

- Site prioritisation for protection and management [Horizons]
- Landowner grants for biodiversity protection [Marlborough]
- Data currently aren't used but will be incorporated into SOE reporting [Taranaki]
- Geothermal monitoring used for site prioritisation, SNA identification, regional plan maps and regional policy development [Waikato]

5 Indicator M6: Number of new naturalisations

Author: Fiona Thomson, Landcare Research

5.1 Introduction

Indicator M6 is defined as the number of new naturalisations, with the element described as the *'number of new regional incursions and/or sites of nationally recognised environmental weed species'*. Invasive species typically arise from the accidental or deliberate introductions of non-native plants and animals, and they act to reduce and displace indigenous biodiversity. Native species shifted beyond their natural range can have similar effects; for example, karaka, *Corynocarpus laevigatus*, introduced to forests in the southern North Island, south of its natural range, may depress the abundance of seedlings of co-occurring native trees (Costall et al. 2006). However, for simplicity, this measure will not address native species moved out of range.

Regional councils have both short-term goals to reduce the impacts of pests on biodiversity and longer-term goals to reduce the cumulative effect of invasive species. The latter is generally effectively achieved through eliminating early incursions when it is most cost effective and achievable. Indicator M6 will assist councils in identifying new environmental weed species within their region, focused on non-native species. It will also help identify the number of new naturalisations at a national level.

5.2 Scoping and analysis

5.2.1 M6: Definition of naturalisation

A key step for this measure is to obtain a relevant definition for the term 'naturalisation'. Often the term 'naturalised' is used without clear clarification of the exact definition. There are many definitions for naturalised species. Richardson et al. (2000) proposed a standard terminology for 'naturalised plants' (Table 5-1); however, this definition requires the identification of whether the plant population is self-replacing. Weed control undertaken by regional councils and other organisations (e.g. community groups and the Department of Conservation (DOC)) may make it difficult to ascertain if the plant population is self-replacing. Therefore, regional councils may want to use a simplified combination of the definitions for 'casual alien plants' and 'naturalised plants' outlined in Richardson et al. (2000; Table 5-1), such that 'naturalised species' are alien plants that may flourish and/or reproduce in an area; these may or may not form self-replacing populations.

Table 5-1 Recommended terminology in plant invasion ecology by Richardson et al. (2000).

Alien plants	Plant taxa in a given area the presence of which are due to intentional or accidental introduction as a result of human activity (synonyms: exotic plants, non-native plants; nonindigenous plants).
Casual alien plants	*Alien* plants that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations, and which rely on repeated introductions for their persistence (includes taxa labelled in the literature as 'waifs', 'transients', 'occasional escapes' and 'persisting after cultivation').
Naturalised plants	*Alien plants* that reproduce consistently (cf. *casual alien plants*) and sustain populations over many life cycles without direct intervention by humans (or in spite of human intervention); they often recruit offspring freely, usually close to adult plants, and do not necessarily invade natural, semi-natural or human-made ecosystems.
Invasive plants	*Naturalised plants* that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants (approximate scales: >100 m; <50 years for taxa spreading by seeds and other propagules; >6 m/3 years for taxa spreading by roots, rhizomes, stolons, or creeping stems), and thus have the potential to spread over a considerable area.
Weeds	Plants (not necessarily *alien*) that grow in sites where they are not wanted and which usually have detectable economic or environmental effects (synonyms: plant pests, harmful species, problem plants). 'Environmental weeds' are *alien plant* taxa that invade natural vegetation, usually adversely affecting native biodiversity and/or ecosystem functioning.
Transformers	A subset of *invasive plants* which change the character, condition, form or nature of ecosystems over a substantial area relative to the extent of that ecosystem.

Basic M6 reporting statistics

1. The total number of plant species recorded as newly naturalised across all regional councils. Statistic will be a number (e.g. 5 new species within New Zealand).

2. Number of plant species recorded as newly naturalised within a regional council's boundaries. Statistic will be a number (e.g. 3 species within Hawke's Bay Regional Council's boundaries).

Linkages to other measures

Indicator M6 has strong linkages to M7 ('Distribution and abundance of weed and animal pests', Table 5-2). Data collected for measuring M6 could also be used to inform M7. Collecting location and abundance data for M6 is advisable if it is to inform M7, which requires point-based data and assessments of abundance, (i.e. cover in the case of non-native plants). These data would also assist with the management/control of weed species.

Indicator M20 ('Community contribution to weed and animal pest control and reductions') has also been identified as being linked to M6 because community groups may play a part in identifying and reporting new naturalisations in the region.

Consultation with the scientists and regional council staff responsible for M7 and M20 is advisable.

Table 5-2 Measures that are explicitly linked to indicator M6

Indicator	Measures	Element	Ecological Integrity	Driving forces – Pressure-State-Impact-Response	Data required and potential sources
M7. Weeds and animal pests	Distribution and abundance of weed and animal pests	Based on (i) regional distribution and (ii) local abundance of environmental weeds and nationally listed animal pests	Indigenous dominance	Pressure	Data: operational techniques and data management currently vary across regions. Will require standardisation and development of some new approaches.
M20. Weed and pest control	Community contribution to weed and animal pest control and reductions	Area (ha) and habitat types with weed and animal pest control by community groups	N/A	Response	Data: information available from regional council, DOC, and local authorities.

Preliminary population of the specifics of Indicator M6 against reporting areas

Statistic(s) to report:

- Total of new *naturalisations*/incursions in the regional council's boundaries

  Proposed data to be recorded:

  - Species
  - Location of population or individuals
  - Number of individuals
  - Age: reproductive or not (seedling, adult, adult & reproducing)
  - Control or management conducted

Note: this is *new* naturalisations only; if a species has previously been recorded as naturalised in the region it will not be counted again, even if original individual/population was eradicated.

Hierarchies of measures/elements indicating usefulness for reporting defined for each indicator:

- Spatial hierarchies: national level and regional level (North versus South Island?)
- Species hierarchies: nationally recognised weeds and regionally significant weeds specific to individual regional councils
- Incursion hierarchies: from outside the region, from a source (garden/nursery) within the region.

Spatial and temporal analyses needed to interpret variability:

Clarification needed on what is a 'site', i.e. is there a maximum/minimum size?

Reporting frequency rate(s): Yearly.

The relationships between each indicator and present patterns (e.g. in relation to management or land cover): Unknown.

5.3 Assessment of existing methodologies

5.3.1 Overall Summary

Regional councils differ in current practices for monitoring new naturalisations within their respective regions. Some make little or no investment in active monitoring for newly naturalised species (primarily due to a lack of time and resources), while others have well-developed monitoring methods. Some focus on species that are nominated in the Regional Plant Management Plans (RPMP) or on those in the National Pest Plant Accord (NPPA).

All regional councils use passive observations by the public, regional council staff or staff from other agencies for monitoring new naturalisations.

Regional councils are fairly consistent in the types of data they collect. Data are stored using a variety of software products; storage formats included both spread sheets and GIS layers. All regional councils produce annual reports.

5.3.2 Summary of existing methods from response to questions and requests for methods

Sources for decisions on whether species are naturalised

All regional councils use local expert knowledge to decide if species are new to a region. Councils typically seek expertise from staff in New Zealand's herbaria to make a 'definitive call'.

Knowledge sources include: Department of Conservation, Crown Research Institutes (i.e. Landcare Research, AgResearch, NIWA, Scion), museums (especially those with active herbaria), NZ Flora, regional council staff (i.e. Biosecurity staff, Pest plant officers, Biodiversity staff), local knowledgeable botanists and ecologists, search engines and Internet resources (including Google, NZ Plant Conservation Network website, http://www.nzpcn.org.nz/).

Lists or registers of currently naturalised species

Three councils have lists of species of concern/ newly naturalised species.

Several councils highlighted that they have little time or resources to spend on looking for new naturalisations. Species listed in the NPPA and/or RPMP are monitored by all regional councils.

5.3.3 Active monitoring for new naturalisations: methods, target areas and data collection

The level of active monitoring for newly naturalised species varied greatly across regional councils. Presently, c. 30% of councils do not actively look for new naturalisations.

Most regional councils linked monitoring for newly naturalised species with monitoring for species on the NPPA, or monitoring nominated biodiversity sites. Monitoring is often targeted to habitats where specific plants occur most frequently.

Methodology varied including survey effort and intensity, and area sampled. Methods included ‘keeping an eye out’ during other monitoring work or using ‘gut feeling’ that an area needs to be surveyed. More formal methods include grid searches, transects or search surveys in target areas, surveys within areas delimited around sites of current infestations and land parcel searches (where officers are required to cover a search of the entire area). Regional councils use a variety of transport for monitoring including inspections on foot, by car or by helicopter.

Targeted areas included nurseries and their immediate surroundings, urban areas, beachside communities, sand dunes, dumps, roadsides, railway lines, markets and galas, buffer zones around biodiversity sites, wetlands (rivers, streams, estuaries and lakes), cropping areas linked to contractors that cultivate any target weed infested area, off-shore islands, high-value forests, and quarries.

Data collected when a new naturalisation was found included GPS location/address, species, description of infestation size/number of plants, area covered, density of plants, stage of maturity, habitat type, presence of other infestation sites nearby, source of infestation, number of individuals destroyed (if destroyed) and potential introduction pathway/mechanism.

5.3.4 Passive monitoring: methods, target areas and data collection

All councils use passive observations to monitor new naturalisations. Some councils emphasised this as an important source of information for monitoring. These passive observations include those by the general public, regional council staff and other agency staff (Department of Conservation, Ministry for Primary Industries, etc.).

Regional councils follow up reported sightings using staff (usually biosecurity officers). Passive observations of new naturalisations could come from web enquiries, phone calls or people bringing samples into the council for identification.

Bay of Plenty Regional Council mentioned the use of newspapers or other media articles to increase public awareness of what species to look for. This council encourages public enquiries and follow-up inspections.

Auckland Council has a Weedspotter Network (http://www.aucklandcouncil.govt.nz/EN/environmentwaste/biosecurity/Pages/pestplants.aspx), comprising Auckland Botanical Society members and other interested people, who report new taxa regularly. Auckland Council staff also regularly report new taxa, as do other people (e.g., farmers, trampers, members of Landcare Trust groups, etc.) also report new plants. Auckland Council biosecurity staff also actively survey key habitats and sites, and occasionally this uncovers new taxa. Bay of Plenty Regional Council also has a project to link more with community and agency partners (Weed Finders Project).

Passive observations by staff were identified as a key part of monitoring their regions for newly naturalised species. Specific staff training for identifying weedy species was not mentioned by many regional councils; however, training obviously plays an important role. Each year, Landcare Research offers this type of training and contributes to training on identifying NPPA species. An example of Bay of Plenty Regional Council's training included:

> *1. We always have a 'show and tell' at staff meetings where we bring say 4 plants along and have a 10- to 20-minute session of sharing our knowledge of each plant, it's distinguishing and reproduction characteristics, habitat, history and why it's a threat or problem.*
>
> *2. We also have specific informal (in the car park) learning sessions (we've just had one on animal pest traps and another on poisonous plants (will try to send some photos)). They are maybe 45 minutes to one hour long and run so that they are a collection of everyone's best knowledge (with some humour and interactive).*
>
> *3. We have occasional (2-monthly) trips to a suitable field site and point out what to look for. We recently had a 2-hour weed walk along the estuary edge and there was a new pest to notice every 5 to 10 metres (200-metre walk). We're always honest about the way (time / effort / gradual process) that we have learnt to ensure that team members don't feel overawed by others' knowledge.*
>
> *4. We have a collection of potted live plants housed in a tunnel-house and have delegated the care of the collection to different (especially new) staff members. There's nothing like seeing the plants regularly and watching their growth / flowering / etc. to become familiar with them.*

The data collected is similar to that for active methods but additional data are collected:

Property owner; the contact person's name, address and phone number; size of site (usually complete area of site, sometimes only the central point); nature of enquiry (Pest Plant, Location, Info/Advise, Request inspection, ID, Complaint, Referral); Officer responding and outcome; infestation property or map reference; compliance record and control activity.

5.3.5 Data storage and reporting

Data storage varies between regional councils. All regional councils have some sort of spreadsheet. GIS is often used to visualise data.

Formal reporting is on an annual basis for all regional councils. Often there is also informal reporting for management purposes on a weekly/monthly basis. When invasive species that are new to New Zealand are found, officials of the Ministry for Primary Industries are notified. Some regional councils indicated that surveys at some sites are not carried out on a yearly basis but rather a 2–5-yearly basis.

5.4 Development of a sampling scheme

5.4.1 Scope

New Zealand has over 2200 naturalised vascular plant species (Williams & Cameron 2006), which exceeds the number of native plant species (c. 2000 species) (Sullivan et al. 2004). For at least the last 150 years, there has been a linear rate of naturalisation of plants from a total pool of c. 25 000 plants introduced to New Zealand (Atkinson & Cameron 1999, Williams & Cameron 2006). More than 20% of the naturalised plant species have been identified as weedy species by either New Zealand government agencies or primary industries. Annual expenditure on weed species by regional councils is estimated at $21 million NZD per year (MAF 2009), with a much smaller proportion being spent on detecting new naturalisations. These budgets are small when compared with the economic costs from weedy species (e.g. annual production loss from gorse (*Ulex europaeus*) in 2008 was $31 million). Early detection of invasive species is critical to their successful management (Smith et al. 1999; Browne et al. 2009):

> *It is better to put a fence at the top of a cliff than to station an ambulance at the bottom*. – *Truby King*

5.4.2 Alignment with existing methodology

Any methods proposed for implementing a standardised measure to monitor the number of new naturalisations must be achievable and closely aligned with current regional council practices. Lack of time and resources was a major concern for some regional councils for implementing M6. A limited number of regional councils have funding available and/or partake in active (targeted, systematic) surveillance for new plant naturalisations. All regional councils use passive surveillance to monitor for new naturalisations. Therefore, it is recommended, at present, that data collected for M6 are derived from passive surveillance techniques. Data from any active surveillance should also be included in the database – but should not be compulsory for all regional councils.

Passive surveillance involves opportunistic monitoring during other weed or biodiversity management tasks. It also includes following up reports or observations of suspicious plants from the general public, landholders, Weed Spotters (for a guide, see Morton & Harris 2008), regional council staff, local experts and staff from other government organisations. Even though this data is opportunistically collected, it is important that any recorded data is standardised across regional councils.

5.4.3 Proposed standardisation of passive surveillance for detecting new naturalisations

Presence-only versus presence/absence

Presence-only data, where the presence of any newly naturalised species is collected, is the simplest possible data type for M6. This would include a species name, date and georeference for the invasion site (Basse et al. 2008). All regional councils collect more information than this basic level. (See above Assessment of existing methodologies.) This additional information is used for managing enquiries from the public and for other management purposes (e.g. weed management programs and biodiversity protection). Therefore, any proposed database should have additional information (e.g. details of the reporter and management actions).

Recording both the absences of any newly naturalised species and the presence of a newly naturalised species has several key advantages (Table 5-3). Habitat suitability models for wide-ranging and tolerant species have been found to be more sensitive to absence data (Brotons et al. 2004). Therefore presence/absence methods may be particularly important for predicting distributions of weedy species. In addition, recording presence/absence data would allow data from both passive and active surveillance to be recorded in the same database. More presence/absence data will allow evaluation of whether models of current and potential distributions of naturalised plants based on presence-only data are adequate. Presence-only data can be sufficient to estimate the current and potential distributions of established invasive species robustly when assessed alongside models that also use presence/absence data (Gormley et al. 2011). Establishing current distributions enables managers to focus control within that region, and determining potential distributions sets suitable boundaries for surveillance monitoring to detect incursions (Gormley et al. 2011).

Table 5-3 Some of the main advantages and disadvantages of presence/absence surveys. Information sourced from Greene & McNutt (2012).

Advantages	Disadvantages
A rapid field technique that requires few specialist skills	A relatively crude method of assessing trends in species abundance
Able to examine changes in distribution over very large spatial scales	Population trends in density/abundance are unlikely to be detected
Resource selection relationships addressed (if the appropriate habitat information is collected) and sites of significant weed invasion can be identified	Presence/absence data and distribution data unadjusted for detectability can only confirm presence of a species, not the certainty of absence of a species
Robust site occupancy methods, models and analysis software are available for situations where the probability of detection is <1	Methodology (particularly scale) must be standardised to ensure comparability over time

Advantages	Disadvantages
Presence/absence data can be used as a surrogate for monitoring abundance providing the monitoring objective is primarily measuring the proportion of sites occupied (spatial distribution), sample units are consistent between surveys, and the probability of failing to detect target species within surveyed areas is estimated	The method is dependent on observer effort, but observer effort is unlikely to be consistent. This can significantly bias the number of species counted and habitats surveyed within a sample unit – particularly as scale increases
Can provide baseline inventory data efficiently and for minimal cost (particularly for uncommon species), providing assumptions and inherent biases are understood	

There are several assumptions with presence/absence techniques that should be noted: 1) within each sample unit all new naturalisations are detected, 2) newly naturalised species are truly absent from the sample unit when none are detected, 3) newly naturalised species are equally conspicuous among surveys, 4) search accuracy and intensity does not vary between surveys, and 5) methodology is standardised to account for any variation in the probability of detection (Greene & McNutt 2012). Any surveyor must be confident they have found all new naturalisations within an area and are not recording 'false' negatives.

5.4.4 Definitions

Presence: Within the search area/polygon there is the presence of a non-native plant species that has not been previously recorded within the regional council's boundaries. Native species are ignored for this measure.

Absence: Within the search area/polygon, no previously unrecorded non-native plant species are present (i.e. the only non-native plant species are ones recorded previously within the regional council's boundaries). Native species are ignored for this measure.

Surveillance species list

Providing observers with a list of species not found within a regional council's area, but present in other regions (surveillance species), increases the probability of new incursions being detected. Observers can learn the key fertile and vegetative characters of the species under surveillance, leading to better identification and detection rates in the field.

From the assessment of existing methodologies, there is a **clear need for a standardised list of surveillance non-native plant species**. The list should be sourced from published information (grey or white literature) that is easily available to all regional councils. The list should be dynamic, allowing for updates (monthly or annually) of plant species that have become naturalised in a regional council's district. Each species on the list should have associated spatial data (georeferences) to allow regional councils to identify if a species has already established within their region. The list could also be flexible, allowing biosecurity and biodiversity officers to enter species that they have identified as species of concern within their region – such as species listed as environmental weeds.

The on-line eFlora (http://www.nzflora.info/) is the best source for creating a standardised list. This has an interface that allows users to create species lists based on certain criteria or filters (further information is available from Aaron Wilton, Landcare Research, Lincoln). These filters can include geographic spread and/or weed status (e.g. listed in the NPPA, or in Howell (2008)). The records are based on herbarium collections/specimens so these records have been correctly identified and are georeferenced. Regional councils currently use herbaria to identify specimens. For example, several regional councils pay an annual fee to Landcare Research for a plant identification service, in which as many specimens as are sent in are identified. This service is available to all who want to use it.

The eFlora also provides facts sheets on species including photos. An example of a weed profile from the eFlora is:
http://www.nzflora.info/factsheet/Weed/Hypericum_androsaemum.html

All suspected new naturalisations require confirmation of the plant's identification by an expert, attended by a voucher specimen lodged in an herbarium, before it can be classed as a new naturalisation.

Collecting plants for identification

Protocols for collecting plant specimens for identification by herbaria are covered in http://www.landcareresearch.co.nz/research/biosystematics/plants/plantid.asp and Hurst and Allen (2007).

Taxonomic training

Training in plant identification increases the probability of detecting rare or uncommon species and reduces the time spent surveying an area (Ringvall et al. 2005). Newly naturalising species are uncommon in the landscape; therefore, on-going training in plant identification is important in detecting new naturalisations. All regional councils should have an active program for plant identification in their staff training. Although difficult to standardise, an active training program will help increase the skills of observers in identifying new incursions.

An example of an active training programme by Bay of Plenty Regional Council includes, in addition to those described in 5.3.4:

> *They have a collection of potted live plants housed in a tunnel-house and have delegated the care of the collection to different (especially new) staff members. There's nothing like seeing the plants regularly and watching their growth / flowering / etc. to become familiar with them.*

Accounting for variation in effort between regional councils

Regional councils differ considerably in the effort and money invested in searching for new plant naturalisations. Variation in investment needs to be accounted for if M6 is to be standardised across regional councils. Therefore, the size of the area surveyed and time taken to survey the area must be recorded. This should be mapped onto a GIS layer, or through

Google maps, in a polygon format and recorded in a spreadsheet (area searched; m^2). Time taken to survey the area provides information on the search effort and the costs associated with M6. These data would allow analyses of the cost per unit area searched for detecting new naturalisations and the effort needed to detect new naturalisations. They also will provide important information on the proportion of each region (and the country as a whole) that is monitored and identify areas that have not been monitored sufficiently.

Standardising search areas/polygon size

The likelihood of a recording a 'false' negative (a polygon/search area is recorded as 'empty', i.e. no new naturalisations) increases with decreasing search effort and increasing area searched. A standard polygon size/search area will help to standardise both the method and effort taken between regional councils. Consistent plot sizes enable standard search areas across ecosystems (e.g. integration with methodology used in M2, i.e., 20 m × 20 m, e.g. Hurst & Allen 2007). Other methods also use consistent search areas, e.g. 2 m × 2 m in wetlands (Clarkson et al. 2004) and could be employed as a consistent approach within wetlands.

Database information

The data to be collected are summarised in Table 5-4.

Table 5-4 Description of data to be recorded for presence/absence surveys

Category	Measure	Definition
Data ID	Unique identifier	Initials of regional council and a unique number, e.g. Environment Southland would start at 'ES_1'.
Date	Date of record	dd/mm/yyyy
Naturalisation	Species name	Genus species. 'None' entered if no newly naturalised plants.
	Number of plants	Number of plants from 1–20 as a count, above 20 individuals becomes categories 21–50, 50–100, >100 (0 entered if no newly naturalised plants)
	Maximum maturity	Seedling, sapling, adult (no flowers or seeds), reproductive adult (presence of flowers and/or seeds). This is for the oldest individual present. 'None' entered if no newly naturalised plants.
	Potential introduction pathway	Potential pathway of spread: unknown, agricultural/horticultural escapee or garden/nursery escapee. 'None' entered if no newly naturalised plants.
	Habitat type	Enter description of habitat type
	Nearest biodiversity site (as defined by individual regional councils)	Distance measured in km
	Identification	Sample taken for formal identification (Yes/No). 'None' entered if no newly naturalised plants.
	Herbarium number	Unique Identifier

Category	Measure	Definition
Reporter	Reporter name	Last name, first name, title
	Reporter affiliation	Regional council staff, public, landowner, Department of Conservation, Ministry for Primary Industries, weedspotter, local expert
	Reporter phone	Contact phone numer (Do not put in any brackets/spaces or + symbols e.g. 033526169)
	Reporter email	Contact email address
	Reporter address	Flat number, street number, street, suburb, postcode
	Surveillance type	'Active' if data entered are part of an active monitoring programme, otherwise enter 'Passive'
	Surveillance method	Brief description of the method used, e.g. 20-m transect
Location	GPS location	Northings and Eastings at centre of infestation or centre of search site if no new naturalisations found
	Invaded area (m^2)	Defined area where the species was found, m^2 calculated off GIS layer (0 entered if no newly naturalised plants), minimum area is 1 m^2.
	Surveillance area (m^2)	Defined area where search was conducted, m^2 calculated off GIS layer
	Surveillance time	Time taken to cover the surveillance area, measured in minutes e.g. 120 = 120 minutes = 2 hours.
	Surveillance data	dd/mm/yyyy
	Property address	Flat number, street number, street, suburb, postcode.
	Property owner phone	e.g. 033526169 (Do not put in any brackets/spaces or + symbols)
	Property owner name	Last name, first name, title
	Property owner email	Email address of property owner
	Surveillance member 1	Name of surveillance officer. Last name, first name.
	Surveillance member 2	Name of surveillance officer. Last name, first name.
	Surveillance member 3	Name of surveillance officer. Last name, first name.
Management	Individuals destroyed	As a proportion of the individuals present of the site. 0 entered if no plants removed. 'None' entered if no newly naturalised plants.
	Management	What pest management has been undertaken. 'None' entered if no newly naturalised plants or no management action taken.
	Treated area (m^2)	Defined area where species management area, m^2 calculated off GIS layer. 0 entered if no plants removed. 'None' entered if no newly naturalised plants.
Photos	Photos taken	Number of photos taken and stored with the database. 0 if no photographs taken. Photographs should be labelled with the unique identifier number and then the photo number e.g. ES1_1.
Notes	Notes	Any additional information to be included here

Costs

The proposed method builds upon current work done by individual regional councils. However, recording both the presences and absences of species will mean an increase in the amount of data captured for some regional councils and an increase in time spent inspecting sites to make sure no additional species are present..

A cost estimate obtained from Environment Bay of Plenty for their data capture (this is for an active surveillance programme; passive surveillance should be less than this) is:

5.5 contractors × 1.5 hours per day × 240 days per year × $40 per hour = $79,200 per year

5.4.5 Standardisation of active surveillance techniques

Standardisation across organisations

It is important to standardise any active monitoring methods across regional councils. Furthermore, it would be beneficial to align methods for active surveillance with other organisations (e.g. DOC, Ministry for Primary Industries). Comparable data collection across multiple organisations, which have jurisdiction over different parts of the landscape, will provide a spatially robust dataset. This will give the best chance to detect new naturalisations, providing a stronger 'fence at the top of the hill'.

The Department of Conservation is currently overhauling its monitoring methods and creating a monitoring Toolbox, and plans to establish a protocol for monitoring new naturalisations (Ollie Gansell, DOC, pers. comm., 2014). It is most likely that DOC will use Generalized Random Tessellation Stratified sample designs for designing outcome monitoring studies for many of their management units. This approach has been used by Environment Southland to monitor weed species (Milne & Williams 2008).

Sampling protocols for M2 ('Vegetation structure and composition') and M7 ('Distribution and abundance of environmental weeds (and nationally listed animal pests)') provides a framework that can, in part, inform an active surveillance programme, which could augment M6. A suitable sampling design to integrate M2 and M7 in a way that best informs M6 would require additional investment.

Proposal for standardised active surveillance

This report suggests a methodology for an active surveillance programme that can inform M6 with presence/absence data, supplemented by point-based, more detailed measurements (M2 and M7). Surveys should be simple and quick to perform, and the number of sites searched should be flexible, to allow regional councils with more limited budgets the capacity to start an active surveillance programme.

Unmarked transects can be established and measured more speedily than plots because they can be measured while walking and do not require laying out of multiple tapes to measure the search area. The transect length should be short, to allow accurate searches for target species in dense vegetation along its length. The consensus recommended a 20-m transect, in which

1 m either side of the transect line is searched (20 m × 2 m = 40 m^2). A 20-m tape, anchored by a peg at the transect origin will be needed to delineate the transect.

Data collected should be presence/absence, and surveyors must have a high degree of confidence that they have thoroughly searched along a transect. To increase surveyor detection rates, a surveyor (or multiple surveyors) could walk along the same transect more than once. The number of surveyors or transect sweeps should be recorded and when a newly naturalised species is found. This could also be used to check for surveyor accuracy/detection rates.

Site selection

Site selection should be a stratified random sample of sites along gradients from known centres of plant invasions, especially urban sites (Sullivan et al. 2005) and some frequently invaded rural sites (e.g. braided rivers; Williams & Wiser 2004, Bellingham et al. 2005) and other frequently disturbed sites (e.g. recently felled plantation forests (Sullivan et al. 2006), and roadsides (Sullivan et al. 2009). Stratification should weight samples so that sampling intensity is greatest closer to sources of invasions and diminishes further from them. Sites perceived as remote should not be overlooked, since they can be invaded (Aikio et al. 2010). Generalized Random Tessellation Stratified sampling may provide a good basis for sampling an area and help structure site selection.

Once sample points are determined and assigned GPS locations, a permanent repository of these needs to be archived in each council, to allow repeated measurements of the same sample points. At each field measurement, accurate relocation of the origin of each transect is desirable, and field data capture (in field sheets or hand-held data loggers) will require fields to be completed for data and GPS location (Table 5-4).

What regional councils say would help them to establish active surveillance

Resources and guide to follow with best practice methods for establishing this type of surveillance.

Time and funds and good tools.

Clear, easy to implement methodology to carry out active surveillance (with a low price tag…)

Budget and a national standardised recording system and database.'

Knowledge that other councils or partners were also committing to the programme so the New Zealand data made sense and didn't have missed areas leading to false assumptions. Otherwise we will not collect worthwhile data.

A simple one-stop-shop where we can report sites, find out about plants for ID, management/control tools and be alerted of new incursions in neighbouring regions.

5.5 Data management and access requirements

5.5.1 Available data sources

It is useful for regional council staff to develop a relationship with staff at their nearest major herbarium (e.g. Allan Herbarium, Te Papa, Auckland Museum) and to collect and deposit voucher specimens at them that represent first naturalisations or range extensions. Regional councils can feed data from these records into the eFlora. The advantage of using the eFlora is that all records are taxonomically verified, so there is greater certainty that the record is accurate. Efforts by regional councils to find new naturalisations will contribute greatly to current knowledge of invasive species.

There are two foreseeable limitations to using the eFlora as a data repository. Firstly the speed at which herbarium records will be updated may be slow, or at least variable. The second limitation is that there is no capacity to store the additional data that regional councils collect in the eFlora database. This second limitation can be overcome by regional councils keeping additional records in their own data systems. This will allow regional councils to share up-to-date information on new naturalisations with one another on a regular, informal basis. Regional councils can set up an email alert system informing the surrounding regional councils when a new species is discovered in its region. Reminders for staff to use the system should also be set up and new staff to be made aware that the database exists.

5.5.2 Data protocols and formats

Regional councils should create a new datasheet, e.g. Excel spreadsheet or equivalent. Data formats must be kept standardised across regional councils, so that separate datasets can be easily merged for future analyses. Column headers must remain the same (in order and content) as presented in Table 5-4. If a new entry (row) is created, no blank spaces should be left (e.g. enter ‘none’ when the data is unknown or not relevant). Addition of any new columns in the future should be decided upon by all regional councils to maintain consistency across regional councils.

Data should be exportable in a .csv file format. GIS layers should be stored in a shape file format with polygons named using the unique identifier in the database. Any photos taken should also be named using the unique identifier and saved as a .jpeg file. Certain data cannot be shared between regional councils due to privacy issues, and these columns should be removed from the database if files are sent to other regional councils.

Data to be excluded:

Property address	Flat number, street number, street, suburb, postcode
Property owner phone	Digits
Property owner name	Last name, first name, title
Property owner email	Email address of property owner

5.5.3 Long-term data curation

All regional councils wanted a national, web-based database for data management of M6. Land Resources Support System (LRSS) is a database system being built by the Bay of Plenty and Greater Wellington Regional Councils, to be a central repository that all regional councils can access. This system could be ideal for storage of data from M6 because it is managed by regional councils rather than an outside group. More information is available from the Bay of Plenty Regional Council.

The National Weed Distribution Database (NWDD) may provide a data repository in the future (Cooper et al. 2010), although does not specifically focus on reports of species naturalisations. The NWDD is one of a set of five applications developed for use in tandem as regional weed management support tools. Their purpose is to enable regional councils to easily access and utilise national and international data on weeds (and potentially other pests) to make credible, scientifically-based analyses of the costs and benefits of proposed regional weed management programmes, thereby meeting the requirement of the Biosecurity Act and the National Policy Direction. An example of their use is illustrated in a cost–benefit analysis for regional management of Chilean needle grass (*Nasella neesiana*; Bourdôt et al. 2015). Although the five applications, including the NWDD, have been developed for use, they are not yet available for general use, pending a decision about which agency might host them (G. Bourdôt, AgResearch, pers. comm., June 2015).

5.6 Reporting indices and formats

5.6.1 Reporting indices and formats

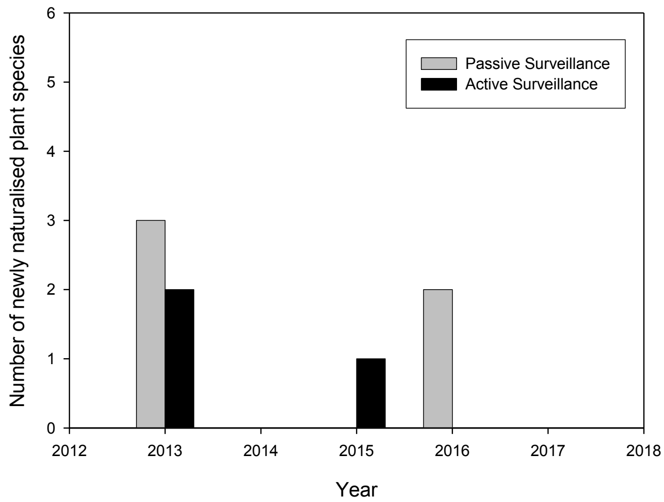
Regional councils should annually formally report the number of new plant naturalisations within their region. The numbers can be divided between those found by passive surveillance programs and active surveillance programs (if applicable). A measure of the total area searched and total time taken can also be reported. Over time graphs can be produced showing the number of new naturalisations on a yearly basis (

Figure 5-1). A national report could be coordinated to determine the total numbers of naturalised species across the country found by regional councils. The additional unreported data collected for M6 can be used for management and future analyses.

An appendix in the annual report can include more detailed data that regional councils consider relevant (e.g. species names, number of sites, invaded area, etc.).

Informal reporting of newly naturalised species in a region could be done instantaneously with the establishment of a more formal database (e.g. an email alert to say a new naturalisation has been found in the neighbouring regional council's area).

Figure 5-1 Number of new plant naturalisations in the Greater Wellington Regional Council area, from 2012 to 2018



5.7 Acknowledgments

Additional information was found through discussions with Peter Heenan and Duane Peltzer (Landcare Research); and Richard Clayton and Oliver Gansell (Department of Conservation).

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Appendix 5 – Regional council feedback

Feedback from regional councils for reports during development of M6. YES indicates that a council gave feedback or responded to the email (but didn't provide feedback) regarding the report. Regional councils that were contacted were those whose contact details were provided on the key contacts list.

	Report 1	Report 2	Report 3	Report 4	Report 5
Auckland Regional Council		YES			YES
Marlborough Regional Council	YES	YES	YES	YES	YES
Northland Regional Council		YES	YES		
Otago Regional Council		YES	YES	YES	YES
Hawke's Bay Regional Council		YES			
Tasman District Council		YES	YES	YES	
Horizons Regional Council	YES	YES	YES		YES
Greater Wellington Regional Council	YES	YES	YES	YES	YES
Waikato Regional Council		YES	YES	YES	YES
Bay of Plenty Regional Council	YES	YES	YES	YES	YES
Environment Southland	YES	YES	YES	YES	YES
Taranaki Regional Council		YES	YES	YES	

Disclaimer: this list is not 100% accurate (difficulties with tracking emails over time may mean some councils' feedback has not been recorded).

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

			Regional council	
Species/taxa	**Scientific classification**	**DOC**	**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

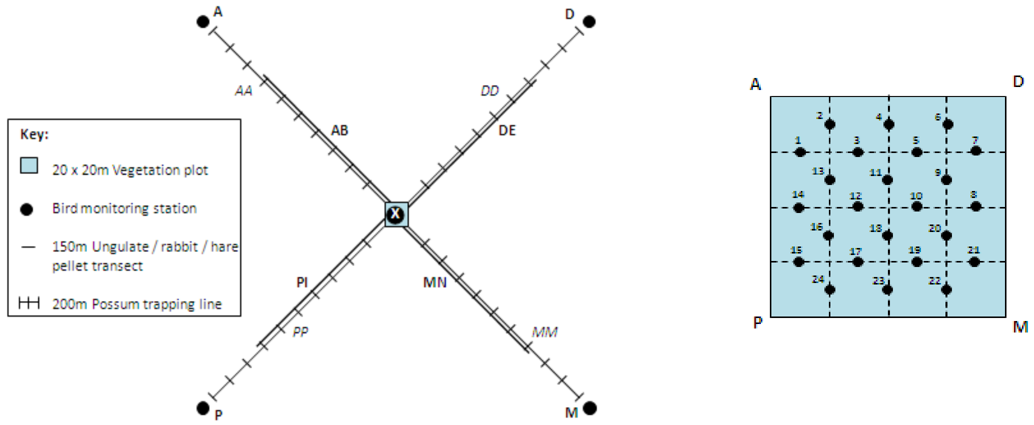

Figure 6-1 Layout of the animal-survey sampling units in relation to the vegetation plot at each sampling location, along with an outline of the 20 × 20m vegetation plot, subdivided into 16 contiguous 5 × 5 m subplots, and each of the 24 (0.75m^2) seedling subplots within it, as implemented by the Department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

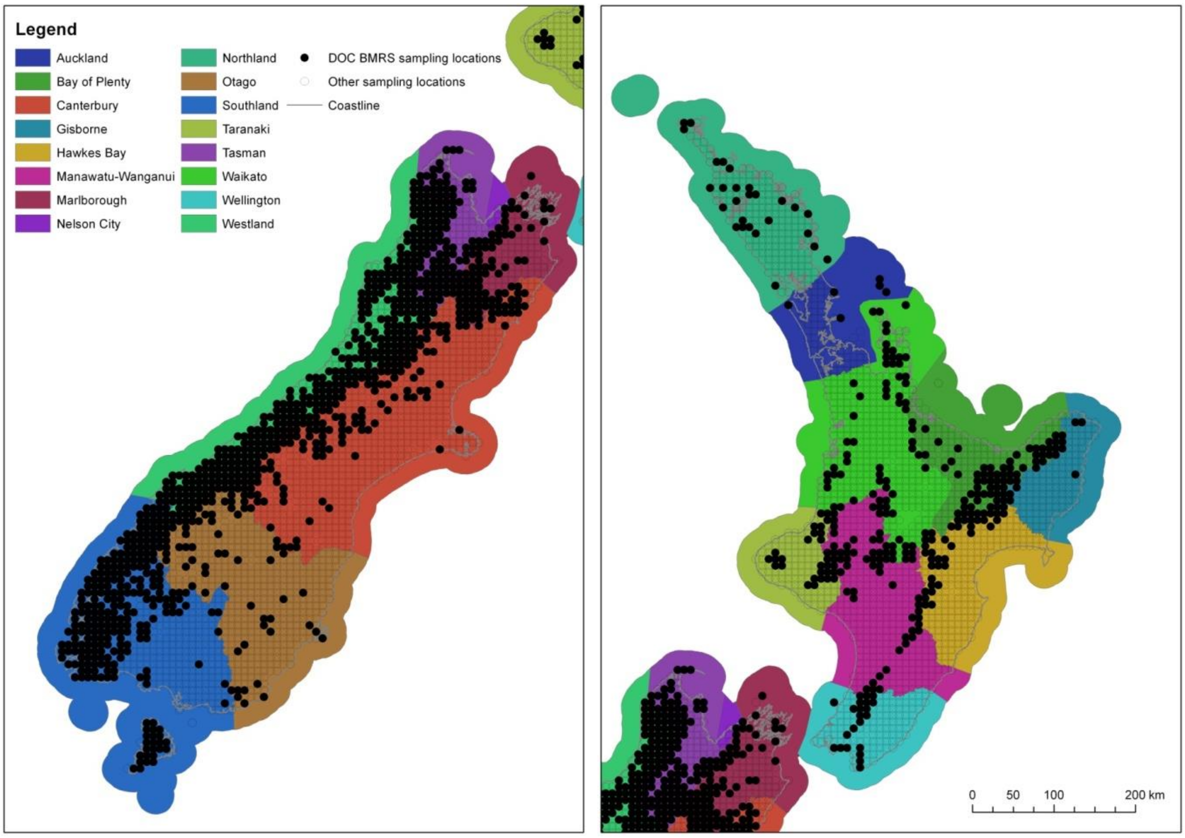

Figure 6-2 Sampling locations on the 8 × 8 km grid used by DOC BMRS in relation to the regional council boundaries (excludes locations with slope >65°).

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.

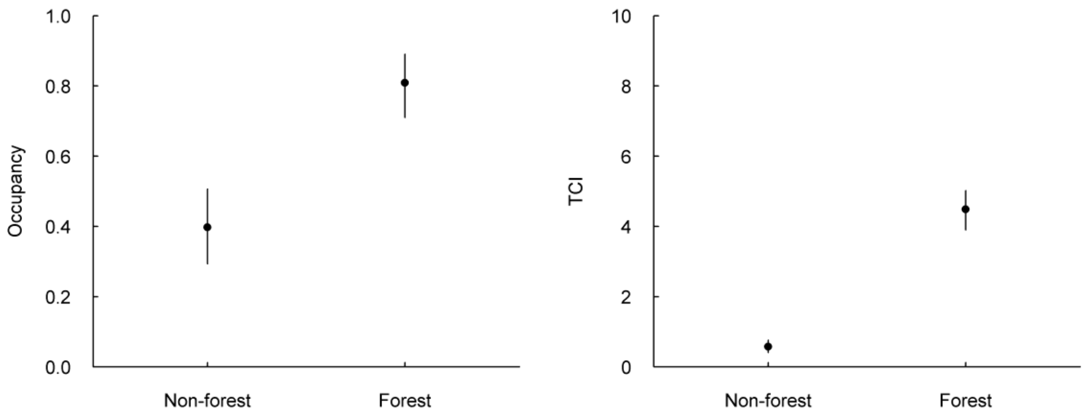

Figure 6-3 Example figure for reporting occupancy and abundance. Mean occupancy (left) and relative abundance (Trap catch Index, TCI) (right) of possums in non-forest and forest ecosystems, from Department of Conservation Biodiversity Indicators: 2013 assessment.

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

7 Indicator M8: Change in area under intensive land use & Indicator M9: Habitat and vegetation loss

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7.1 Introduction

Additional research and development is necessary before indicators M8 ('Change in area under intensive land use') and M9 ('Habitat and vegetation loss') can be standardised and used by regional councils. This will include augmentation of LCDB data, the estimation of disturbance intensities for land-cover classes, and additional calibration/sampling for both monitoring and reporting.This report describes the recommended methods and next steps for M8 and M9 before monitoring can be implemented to collect and report the necessary data.

Appendix 7-1 provides information on procedures for the estimation of disturbance intensities for land cover classes drawing from past work (Overton et al. 2010; Rutledge et al. 2004; Walker et al. 2006).

Appendix 7-2 provides notes from a 29 January 2014 workshop between Landcare Research and regional council representatives where methodology and next steps were discussed. Representatives at the workshop concluded that definition of intensive land-use, land-cover classification errors and the accuracy for estimates of land cover change will need to be resolved as part of next steps for M8 and M9, including for implementation.

Lee and Allen (2011) define M8 as a pressure indicator, with the element LCDB (Land Cover Database) cover classes within an agreed definition of 'intensive land use', for example, areas actively managed to the general exclusion of terrestrial native biodiversity (i.e. crops, roads, etc.). Data is identified as 'LCDB and re-runs, while maintaining historical compatibility of cover classes'. Lee and Allen (2011) define M9 as an impact indicator, with the element based on changes in area of land-cover classes and naturally rare ecosystems. Data is identified as 'LCDB and reruns, augmented by regional aerial mapping for habitat loss.' Indicator M9 can be seen as an evaluation of change in the indicator M1 ('Land area under indigenous vegetation'). This means both M8 and M9 are fundamental biodiversity indicators since they report on the patterns and amounts of remaining indigenous biodiversity and the patterns and rates of loss (or change). It makes sense for M9 to also report on indigenous biodiversity gain (negative loss).

Indicators M8 and M9 are addressed together in this report because of the considerable overlap between intensification and loss of habitat. While Lee and Allen (2011) consider M8 a pressure and M9 an impact, the two overlap heavily. Many types of intensification result in direct habitat loss and would be identified from the resulting land cover changes. In both cases the data is LCDB, although intensification is more of a land use issue than a land cover issue. Another area of overlap is that the data required to reliably estimate patterns and rates of loss (or gain) will require more intensive local studies to augment the LCDB and calibrate reporting.

Indicators M8 and M9 are also closely aligned with measure M1, which looks at amounts and patterns of remaining indigenous habitat types and M17, which looks at the distribution of indigenous habitats in water catchments.

7.2 Scoping and analysis

7.2.1 Inadequacy of comparisons of different versions of the LCDB to estimate loss and change

Successive iterations of the LCDB are the fundamental datasets required for M8 and M9, but there are **major research issues to be resolved to determine the circumstances where comparing different versions of the LCDB is fit for purpose as a tool to estimate biodiversity loss**. The primary purpose of LCDB is to monitor coverage of generalised land cover classes nationally; temporal trends in change in these classes and the uncertainty that attends estimates of change (i.e. between classes) require a general appraisal.

On average, the LCDB has been estimated to give good depiction of the amounts and rates of total change. Approaches for change detection implemented by Landcare Research have achieved approximately 90% overall accuracy for estimates of change. Much of this overall change is in cover classes that are relatively easy to define and detect (e.g. harvested and un-harvested exotic forest). However, a number of studies indicate that the estimates of change derived from the LCDB may be considerably less accurate for classes that are important for estimating the loss of indigenous biodiversity.

An evaluation of change in dry, indigenous grasslands using successive iterations of LCDB (Weeks et al. 2013a) found that comparisons between the LCDB1 and LCDB2 picked up very little (about 4%) of the observed loss in grasslands. However, later comparisons between the LCDB2 and LCDB3 resolved from ⅓to ⅔ of the loss. This improvement is due partly to the feedback from these studies to the LCDB methodology and resulting improvement in the way in which grassland change was depicted. These studies highlight that, at least for certain cover types, the LCDB is underestimating change and loss. The latest version of LCDB4 includes the estimates of change from the work of Weeks et al. (2013a).

Cieraad et al. (2014) provided updates of estimates of indigenous cover remaining and protection across Land Environments of New Zealand (LENZ) environments. The authors investigated the ability of the LCDB to detect changes in indigenous land cover and decided they could not provide reliable estimates. During the study, the LCDB was estimated to provide approximately 50% accuracy in detecting indigenous cover change (J. Shepherd, Landcare Research, pers. comm.).

Further, the LCDB has been shown to resolve particular land cover types poorly. For example, Davis et al. (2013) found that LCDB2 was poor at resolving wetlands, and that wetlands could only be accurately identified using other information. Since wetlands and other rare ecosystem types are important for biodiversity, this suggests a need for auxiliary information to augment the LCDB. Future iterations of LCDB may include mapped wetlands of national importance (included in the Freshwater Ecosystems geo-database; http://www.doc.govt.nz/our-work/freshwater-ecosystems-of-new-zealand/).

In the case of M8 and the intensification of land use, the LCDB cover classes will not identify many of the important types of intensification affecting indigenous biodiversity. For example, a conversion from sheep and beef to dairy may result in considerable intensification but not a change in LCDB pasture class. In fact, it is likely to be the types of intensification that do not directly lead to land cover change that are likely to be of most relevance for M8, simply because these changes will not be identified from land cover changes that are picked up in M9. As for biodiversity loss, such land cover classification issues can be addressed if more careful characterisation of intensification is done in a spatial sample of regions. These issues point to a need for a **national map of land use** in addition to a national map of land cover as a key means of interpreting change in vegetation.

Miminum mapping unit

LCDB is appropriate for 1:50,000 scale mapping and potentially to 1:25,000 scale (P. Newsome, Landcare Research, pers. comm., May 2015). There is a **research and development need** to determine a **suitable minimum mapping unit (MMU) for which to report change using the LCDB**. For example, reporting change in land cover at a 1-ha scale (one suggested MMU) is likely to be below the scale of resolution that LCDB can achieve (P. Newsome, Landcare Research, pers. comm., May 2015). Consensus is needed about desirable and feasible minimum mapping units for which to report this measure.

Measures of change at a scale below the level of resolution that LCDB can achieve leads to discrepancies in estimates of change. For example, Auckland Council conducted a study of loss from clearance in the Waitakere Ranges, west Auckland (C. Bishop, Auckland Council, pers. comm., 2014). Comparisons of the LCDB estimated an annual loss rate of indigenous vegetation of approximately 0.003% per year, whereas inspection of aerial imagery provided an estimate of 0.02% per year, about a seven times higher rate of loss. A major reason for this difference is that some of the change was occurring in small pieces less than 1 ha and therefore below the MMU of the LCDB. This pattern of lots of small change is likely to be more extreme in peri-urban areas such as the Waitakere ranges, but this pattern will occur throughout New Zealand such that there may be significant amounts of change in indigenous vegetation below the MMU of the LCDB. If reporting change at finer resolution than LCDB can achieve is a general issue across councils (rather than for reporting at fine scales within regions, such as the example from the Waitakere Ranges), there could be a **research and development need** to **evaluate the remote sensing tools most fit for purpose** (e.g. aerial imagery, LiDAR, etc.).

Together, the above issues mean that the different versions of the LCDB, and the accompanying estimates of cover class change are, by themselves, inadequate to provide reliable estimates of biodiversity loss due to land cover change or intensification. Either the LCDB must be augmented, or change estimated independently using a sample of the landscape. The two approaches are best done together to gain the benefits of each. There is considerable potential to improve the LCDB through augmentation.

7.2.2 M9 Next Steps: a sampling programme to estimate change, augment and calibrate the LCDB

It is important to note that regional or national estimates of biodiversity loss do *not* require an exhaustive nationwide depiction of observed land cover change and can in fact be achieved entirely without the LCDB or comparisons between LCDB versions. A representative sample (which may be a stratified sample) of a region or of New Zealand can be chosen and, within the sample locations (which may be points or study areas, e.g., 10 km ×10 km squares), a more careful depiction of change can be done using a wide range of information, including the LCDB, satellite and aerial imagery, consent information and local knowledge. This sample can then provide an unbiased estimate of the national change without the need to map observed change regionally or nationally. Investment in these data would contribute not only to the indicators, but more widely to the improvement of land cover and land use information that will be widely used for other purposes.

The most useful approach would be to use information derived from such a sampling program in conjunction with the extensive information from the LCDB. The estimates of change from the sampled area can then be used to:

- calibrate the LCDB;
- produce maps of estimated risk of change for all of New Zealand;
- provide statistically robust accuracy measures for change of indigenous vegetation in the LCDB;
- provide more structured and quantitative feedback to improve the LCDB.

Given successive iterations of the LCDB do not accurately estimate change in indigenous cover in some cover types, we suggest that a robust characterisation of change requires using such a sampling approach, preferably in conjunction with the LCDB. This would essentially be an extension of the approach used by Weeks and her collaborators in the grassland work described above (Weeks 2013a, b, c), and can be integrated with vegetation measures (e.g., Measure 2, Vegetation structure and composition). The choice of sample areas that are representative of regions or New Zealand will allow unbiased estimates of change across all land cover types for entire regions and New Zealand. There are opportunities to mobilise point-based measurements of vegetation to improve the accuracy of LCDB, to link the LCDB to classifications of vegetation, and to improve the capacity to resolve change. Existing data in the National Vegetation Survey databank (NVS) can improve spatial resolution beyond grid-based assessments (e.g., LUCAS and DOC's Tier One data from its Biodiversity Monitoring and Reporting programme, and data from regional councils from the implementation of M2).

Before embarking on these approaches, some initial work is required to scope the work and estimate characteristics such as the feasibility of such a sampling programme (e.g., calibration within 10 km ×10 km squares), the sample sizes required to achieve certain levels of change, and the desired sampling scheme.

We suggest that this could be achieved using a staged approach with the following:

1. A survey of existing more detailed information on land cover change held by councils. This together with the LCDB provides a first estimate of change, and information needed to assess sampling design and statistical power.

2. Estimates of sample sizes, stratification and methods required to adequately estimate change according to agreed criteria, under different sampling schemes and costs. From this a recommended approach would be chosen.

3. A pilot study that would trial the recommended approach in one or several regions.

4. Implementation of above, either by region or nationally.

7.2.3 M8 research and development needs: intensification as a measure of disturbance intensity

During the M8/M9 workshop (29 January 2014), extensive discussions were had on the meaning, definition and quantification of intensification (this discussion is recorded in the workshop notes). For example, intensification may refer to labour intensity, economic intensity, disturbance intensity and other sorts of intensity. Most pertinent to the biodiversity indicators is probably disturbance intensity, which incorporates a wide range of factors that displace, disrupt, remove or otherwise adversely affect indigenous animals and plants.

A range of difficulties exist in the definition and quantification of disturbance intensity. For example, different taxa or different characteristics would be affected differently by different factors, and combining these into one number would require a number of decisions. There was general consensus at the workshop that this work would focus on indigenous plants as the taxa to consider for this indicator. In addition, a current MBIE-funded project, Next Generation Biodiversity Assessment, is looking at differences in biotic composition between different land covers (sampled in 2014 and 2015; leader Robbie Holdaway, Landcare Research). Vegetation data has been collected using methods identical to M2 (stored in the NVS databank) at catchment and national scales and could provide an objective quantification of different land covers in relation to fully indigenous ones. The implementation of M2 by Greater Wellington Regional Council (since 2015) could likewise assist in an objective quantification.

Another approach is to use quantitative approaches to inform an expert estimation of disturbance intensity for land covers. This would result in a consensus table that contains the estimated disturbance intensity for each land cover class. Entries in the table would range from 0 (no disturbance) to 100 (complete disturbance). Consensus on the values in the table could be achieved by having a range of ecologists estimate the values, and then compare them to reach a consensus value for each land cover class. As with all things ecological, there are a number of complications that need to be considered:

- First, intensification is often driven by land use – if consistent information on land use becomes available, then this might supplement or replace the information on land cover for estimation of intensification.

- Second, the interpretation of land cover in terms of disturbance intensity depends on the land cover that would naturally be expected at a site. For example, whether native scrub is considered to indicate medium or low disturbance intensity will depend on whether that particular site/location would naturally have scrub or forest.

An example of how these issues have been addressed, drawn from past work, is given by Overton et al. (2010) and reproduced in Appendix 7-1.

Other options on determining intensification include qualitative information gained from consultation with landowners to determine the frequency and depth of soil disturbance, biomass removal, and use of external inputs (i.e. fertilizer, herbicide), which, in turn, influence vegetation complexity and the proportion of non-native species (Rader et al. 2014).

Finally, as noted above, disturbance factors influence different components of biodiversity differently. Choices will need to be made as to what components are being estimated.

In terms of next steps for M8, a quantitative approach for estimating disturbance intensity for land cover will be needed. To achieve this, we suggest that a number of ecologists from regional councils, Landcare Research, and universities convene and:

1. Are given a complete table with all combinations of current and potential land cover (see Appendix 7-1, Table A7-1-1, for an example partial table).

2. Independently score the land cover class combinations from 0 to 100 according to disturbance or ‘percent native’ (we suggest that a pragmatic choice of which biodiversity components to consider is to focus on impacts on vascular plants).

3. Compare their independent assessments to each other (either remotely via email or if resources exist in a targeted workshop) to compare the values and reach consensus values for a working (expert estimation) disturbance intensity table.

M8 could then be estimated from changes in land cover. Any site/ location or area would be considered to have undergone intensification if it changed land covers from a class with lower disturbance intensity to higher disturbance intensity. Furthermore, this intensification would have a continuous number from –100 to 100 that would indicate the amount and direction of intensification.

It is worth noting that this disturbance intensity table would essentially be a continuous generalisation of the tables used for M1 and M9 to estimate whether something is native or exotic. In the case of M1 and M9, land cover classes are estimated to be either exotic (0, equating to disturbance of 100) or native (1, equating to a disturbance of 0). The use of a continuous scale of native-ness has been signalled as a future possibility for M1. As more people become familiar and comfortable with such definitions and approaches, it may be that M8 and M9 are merged and use the same disturbance intensity table as does M1.

This is a step towards a more defensible and enduring national quantification of intensification that could be convened by consensus in the context of the “Biological Heritage” and “Our Land and Water” National Science Challenges.

7.3 Data requirements

7.3.1 Land cover and indigenous vegetation

The LCDB is the only nationally consistent source of information to measure extent of indigenous vegetation for M9. The reality is that the higher resolution land cover information needed is expensive to derive and data are not currently available for the whole country. This means that the LCDB is, at present, the only practical option for a national indigenous vegetation indicator. However, the difficulties in the use of LCDB for detecting indigenous change (detailed in section 2.2.1) lead us to conclude that further work (as detailed in section 2.2.2) is required to reliably estimate change in indigenous vegetation.

Many regional councils have more accurate/catchment scale digital maps of the spatial extent of indigenous vegetation or clearance of indigenous vegetation (e.g. from aerial photograph analysis and fieldwork). Where such information is available it should be used with the biodiversity indicators that require vegetation data (e.g. M1, M2, M5, M8, M9, M17). More accurate indigenous vegetation and/or vegetation clearance layer(s) can then be used to report indicators regionally. For comparative purposes nationally, however, LCDB data should still be reported for each region and the country as a whole. A good outcome of this work may be a better process by which more detailed information held by councils is made available to and incorporated into new versions of the LCDB.

7.3.2 Habitat types

Habitat types should align with M1, and preferably also align with those used by M5 and M17. Currently this is the Potential Vegetation of New Zealand augmented regionally with information on special habitats, e.g. naturally rare ecosystems.

7.3.3 Disturbance intensity for land cover classes

A consensus table of disturbance intensity for each land cover class would be generated according to the process described above.

7.4 Statistics to report and reporting indices and formats

The final choices of indices and formats to report should be made after further development of these indicators. Here we provide some indicative outputs, drawing upon past work.

7.4.1 Indicator M8

1. Tables or bar chart of per cent intensification (on scale of –100 to +100) by
    a. land cover type before intensification
    b. land cover type after intensification
    c. habitat type.

2. Table of the land cover transitions leading to the most estimated loss of indigenous biodiversity in the region
3. Map of risk of further intensification, as modelled from observed intensification over past period. A map of observed intensification is also possible, but likely to be hard to see the relatively small areas of intensification.

Text/narrative should provide information to explain the tables and map above (i.e., what the data are telling us). The text should explain the estimated overall loss in the region due to intensification. It should describe the spatial patterns of the intensification , and it should discuss any implications for biodiversity and policy.

7.4.2 Indicator M9

1. Tables or bar chart of area lost (ha) and percent remaining by
    a. land cover type .
    b. habitat type.
2. Scatterplot by habitats of per cent recent regional loss in remaining habitat versus regional total loss in original habitat. Regional total loss is from M1.
3. Map of risk of further loss, as modelled from observed loss over past period (e.g. past 5 years), and combined as needed with recent historical loss (e.g. past 20 years). See Figure 7-1 for an example. A map of observed loss can also be considered, but it is likely that it will be hard to see the relatively small areas of loss when mapped at a regional scale.

Accompanying text should discuss the above and the spatial patterns of the loss and report on the estimated overall loss in the region due to loss of native vegetation, and implications for biodiversity and policy. In particular, the scatterplot (2 above) is an excellent visual check of whether rates of loss of remaining habitat are continuing in the habitats that have already experienced the most loss. The map of risk of further loss (3 above) provides an excellent visualisation of spatial patterns of loss.

7.4.1 Reporting frequency

Overall, a 5-year reporting interval is appropriate for these indicators. If the LCDB is used, then the reporting frequency will depend on the timing of LCDB updates. A sampling approach (as defined here) would provide the possibility for other time intervals.

7.4.2 Data management and access requirements

Access to all versions of the LCDB is required. These datasets are publicly available. The information from the sampling scheme should be held both regionally and nationally.

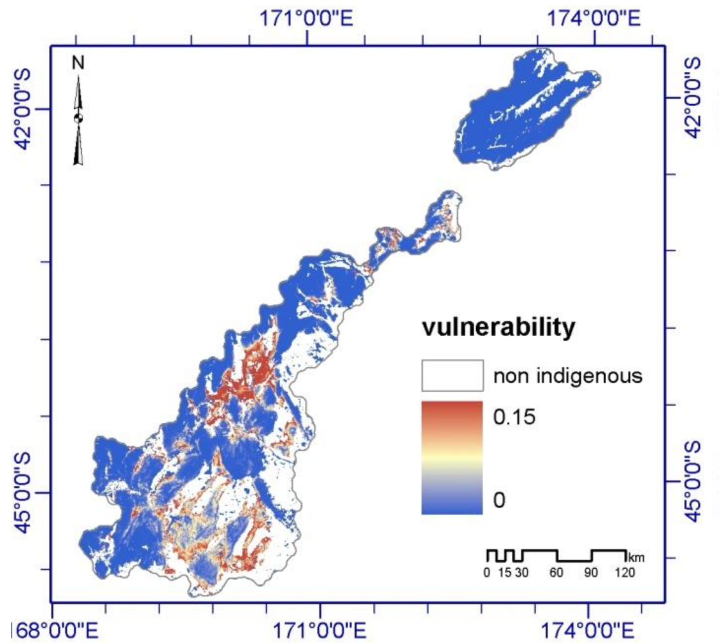

Figure 7-1 Example of estimated risk of further loss. This example is from Weeks et al. (2013a) and shows the estimated risk of loss of indigenous grasslands in dryland grasslands of inland South Island.

7.5 Conclusions

- Indicators M8 and M9 are related measures and are fundamental measures of loss of biodiversity due to changes in land use and land cover. They are dealt with here together because they are closely related and explore different aspects of the same issue.
- While the LCDB is the only nationally consistent data layer of land cover, there is considerable evidence to suggest that additional work and data will be needed to reliably estimate loss of biodiversity due to loss of native cover and intensification of land use, using the LCDB and other sources.
- In this methodology report, we outline a process to evaluate and calibrate the LCDB to enable estimates of loss of native vegetation. This involves a staged approach to further investigate rates of loss from existing information and to design a a national calibration and evaluation of the LCDB.
- We also outline a process to develop the information required to estimate intensification from changes in land cover.

7.6 References

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Appendix 7-1 – Estimation of naturalness or disturbance intensity

Here we adapt information from Overton et al. (2010) on the estimation of naturalness or disturbance intensity from a combination of current land cover and natural vegetation.

Potential-current naturalness table

This table gives the estimated proportion of native vegetation remaining for various combinations of potential vegetation and current vegetation. Each row contains a unique combination of potential and current land cover and the estimated proportion of native vegetation (native dominance) for that combination. The values in the table can be either defined or calibrated from data, or they can be assigned by expert opinion, as was done for this project. Some rows from the table used in this demonstration are shown in the table below.

To understand the logic of how and why the table was constructed, it is useful first to consider this table to be an elaboration of the simple, one-column table used in past studies to assess the amount of native vegetation remaining (e.g. Rutledge et al. 2004; Walker et al. 2006). These earlier tables assign each LCDB current land cover class to one of two possible categories ('native' or 'exotic'). Our potential-current naturalness table makes two refinements on this approach:

- We adopt a continuous measure of the proportion of native vegetation remaining, rather than a simple, binary, 'native'/'exotic' dichotomy. This allows for mixtures of native and exotic vegetation.
- We assign proportions of native vegetation remaining to a particular land cover type based on potential land cover type as well as the current type. This is done to represent the effects of human influences on a modern cover class. For example, native species-dominated non-forest land cover types such as scrub or tussock grassland that occur below treeline have often been induced by forest clearance. Elsewhere, scrub or tussock may be the natural undisturbed vegetation cover (e.g. above treeline or on valley floors subject to severe temperature inversions). In our table, areas of scrub or grassland in places where scrub or grassland would be the potential natural vegetation are considered to have higher proportions of native vegetation remaining than the same cover in areas that were predicted to be naturally (or potentially) forested.

In practice, this is simply done by finding all the unique combinations of potential cover and current cover and estimating the proportion of the original vegetation that remains by comparing the current vegetation cover to the potential vegetation cover. Many of the combinations are uncommon (see column 'count' in Table A7-1-1) and many constitute errors in either the potential vegetation or the current vegetation predictions. The values of proportion native vegetation remaining assigned to these combinations should be chosen to minimise the influence on the results.

Table A7-1-1 Example rows from the potential-current naturalness table. The complete table has many more rows. Each row shows a unique combination of predicted potential vegetation and current land cover from the LCDB2. The column Comb Val is simply an arbitrary (but unique) value assigned in the grid to a unique combination of the two covers. This value is used to link the value in the Percent Native column back into the grid. The count column gives the number of pixels (at 25-m resolution) that have a particular combination.

Comb Val	Count	Potential Vegetation	LCDB2 class	Percent Native
894	1196699	Scrub, shrubland and tussock grassland above treeline	Indigenous Forest	100
1135	18871	Scrub, shrubland and tussock grassland above treeline	Urban Parkland/ Open Space	0
970	28325	Scrub, shrubland and tussock grassland above treeline	Gorse and Broom	0
1151	30	Scrub, shrubland and tussock grassland above treeline	Flaxland	100
1146	37242	Scrub, shrubland and tussock grassland above treeline	Vineyard	0
915	6325988	Scrub, shrubland and tussock grassland above treeline	Tall Tussock Grassland	100
980	137953	Scrub, shrubland and tussock grassland above treeline	Alpine Grass/Herbfield	100
960	242228	Scrub, shrubland and tussock grassland above treeline	Sub Alpine Shrubland	100
1000	102	Alpine Gravel and Rock	Other Exotic Forest	0
992	5937	Alpine Gravel and Rock	Sub Alpine Shrubland	100
1063	1	Alpine Gravel and Rock	Fernland	100
994	240	Alpine Gravel and Rock	Mānuka and/or Kānuka	100
787	417228	Alpine Gravel and Rock	Tall Tussock Grassland	100
345	130639	Mataī–kahikatea–tōtara forest	Built-up Area	0
93	179007	Mataī–kahikatea–tōtara forest	Mānuka and/or Kānuka	30
676	33930	Mataī–kahikatea–tōtara forest	Grey Scrub	40
319	759091	Mataī–kahikatea–tōtara forest	Low Producing Grassland	5
150	3463	Mataī–kahikatea–tōtara forest	Estuarine Open Water	100
847	1071	Mataī–kahikatea–tōtara forest	Landslide	0
670	17646	Mataī–kahikatea–tōtara forest	Fernland	20
533	17151	Mataī–kahikatea–tōtara forest	Afforestation (not imaged)	0
525	28168	Mataī–kahikatea–tōtara forest	Vineyard	0
599	1152	Hall's tōtara/broadleaf forest	Urban Parkland/ Open Space	0
659	10572	Hall's tōtara/broadleaf forest	Herbaceous Freshwater Vegetation	100
853	10501	Hall's tōtara/broadleaf forest	Major Shelterbelts	0

Comb Val	Count	Potential Vegetation	LCDB2 class	Percent Native
680	827	Hall's tōtara/broadleaf forest	Transport Infrastructure	0
1066	109229	Hall's tōtara/broadleaf forest	Short-rotation Cropland	0
868	2288	Kahikatea–mataī/tawa–māhoe forest	Herbaceous Freshwater Vegetation	100
661	5699	Kahikatea–mataī/tawa–māhoe forest	River	100
368	31782	Kahikatea–mataī/tawa–māhoe forest	Other Exotic Forest	0
363	1494	Kahikatea–mataī/tawa–māhoe forest	Surface Mine	0
387	104141	Kahikatea–mataī/tawa–māhoe forest	Built-up Area	0
370	16450	Kahikatea–mataī/tawa–māhoe forest	Deciduous Hardwoods	0
1101	16	Kahikatea–mataī/tawa–māhoe forest	Sub-Alpine Shrubland	100
863	1900	Kahikatea–mataī/tawa–māhoe forest	Alpine Gravel and Rock	100
864	16531	Kahikatea–mataī/tawa–māhoe forest	Vineyard	0
921	406	Lake and Pond	Landslide	0
802	17194	Lake and Pond	Tall Tussock Grassland	100
669	2514	Lake and Pond	Alpine Gravel and Rock	100
446	310	Lake and Pond	Surface Mine	0
119	3714	Lake and Pond	Pine Forest – Closed Canopy	0
214	5619	Lake and Pond	Deciduous Hardwoods	0
797	461	Lake and Pond	Permanent Snow and Ice	100

Appendix 7-2 – Workshop notes

Meeting notes from workshop 29 January 2014 at Landcare Research, Lincoln, to discuss proposed methods prepared by Jake Overton, Landcare Research Manaaki Whenua, for M8 and M9.

Discussion notes are written up under each agenda item below. Recommended actions are noted first.

Attendees:

- Nancy Willems, Bay of Plenty Regional Council
- Ellen Cieraad, Landcare Research
- Peter Bellingham, Landcare Research
- Robbie Holdaway, Landcare Research
- Jeromy Cuff, Canterbury Regional Council
- Mirella Pompei, Canterbury Regional Council
- Kirsty Johnston, Canterbury Regional Council (Convenor)
- Philip Grove, Canterbury Regional Council
- Zach Hill, Canterbury Regional Council
- David Pairman, Landcare Research
- Jake Overton, Landcare Research
- Peter Newsome, Landcare Research
- James Shepherd, Landcare Research

Apologies:

- Emily Weeks, Landcare Research
- Susan Walker, Landcare Research

Recommended actions:

- Complete M8 and M9 methodology paper incorporating discussion points/ recommendations from workshop participants. Paper then goes out for feedback/ review by participants and BDWG. Completion, including review, July 2014 (measure delivery date). (Jake Overton, Landcare Research; Kirsty Johnston, key regional council contact).
- Following completion of methodology paper, and discussion with BDWG, prepare a pilot study/candidate project for how ground-truthing of land cover images/data might be improved upon, including for determining appropriate sampling methods for M8 and M9. This would include a regional trial and step-wise implementation process for M8 and M9. (Jake, David, James and Robbie/Landcare Research with input and peer review from Workshop participants and BDWG).

- Develop a continuum of land cover types based upon intensity of use. This would entail scoring the land cover types contained in the LCDB from 0 to 100, with 0 being pristine (no use and un-impacted biodiversity) and 100 being the highest intensity land use (e.g. mining, urban, roading infrastructure). This ranking would be used to define intensification from land cover transition matrices. Different rankings could be done for different types of intensity (e.g. disturbance to biodiversity, labour, economic), but biodiversity is the main interest of this indicator.

Workshop agenda:

- Welcome/introductions

Overview:

- Purpose of meeting was to discuss

  1. a working definition of intensive land use for biodiversity (and council SOE) monitoring, including the data sources and cover classes for indicator M8

  2. estimating indigenous habitat loss (or gain) as a measure of any transition (+ or –) between cover classes, including those agreed for intensive land use (M8).

- Background to regional councils' biodiversity indicators project
  - EnviroLink Tools project: Purpose, process and people/agencies, framework and indicator set

    (Refer to May 2011 Landcare Research report for the regional council biodiversity working group: Recommended monitoring framework for regional councils assessing biodiversity outcomes in terrestrial systems)
- Any relevant givens for M8 and M9
  - e.g. we have agreed to use LCDB indigenous vegetation classes as surrogate for indigenous 'habitats'
  - scope – regional council biodiversity/ SOE monitoring programmes
- Overview of proposed M8 and M9 methods and approach (refer to Jake's PowerPoint)

M8: Change in area under intensive land use

A definition for intensive land use, including any limitations.

Discussion notes:

Workshop participants had a free-ranging discussion about methodologies for/the ability to define, measure and report changes in 'intensive' land use. Consensus was that, even internationally, objective methods have not been developed for a measure such as M8 because of the number of factors affecting classification of intensive land use – there are limitations. Discussion points included:

- Can be a lot of variability within a land use type – community composition and distance to 'natural'. Do you assume that because there is more intensification there is a loss in biodiversity? This isn't what data always show.

- Straightforward to go between obvious change in intensification (e.g. from not irrigated to irrigated land, from vegetation to roads or urban settlement) but not when dealing with already intensive use (e.g. sheep and beef to dairy vs. urban or dairy).
- Land use: need to know what it is and isn't. Not the same as land cover. Some land use classes are inferred from LCDB, others are not.
- Need to look at land-use change first, and then look at land cover.
- Will need to list land-use classes and agree these amongst agencies/end-users as a consistent set of classes/categories for monitoring and reporting purposes.
- Want to report spatial patterns of change including location, extent, type, total intensification, total loss (or gain) in types, transitions from one type to another.
- Presentation wanted in maps, and as numbers.

Workshop participants then discussed possibilities of developing an intensive land use classification. This could include regional councils making clear what land use classes they use and then having these ranked in more or less 'intensity' on 0–100 scale (distance to native X). Time series change could be used to estimate cover transitions by type. Discussion points/steps:

- Ranking land cover classes for a defined purpose and creating a gradient for more or less 'intensive' land use possible, but would have to be fit for purpose
- Plausible steps:
    - Create a transition matrix using LCDB
    - Assign transition; 0–100 exotic: native (NB: 0–1 scale only gets loss, not intensification. To get intensification, you need the 0–100 scale, or make a cut-off as to what you consider intense versus non-intense land use within the exotic land covers/uses)
    - Identify what we need to know beyond LCDB (other data/information), for example, particular cover classes omitted (e.g. grey scrub)
    - Habitat gains/losses (equivalent (or not) to loss of biodiversity) to be identified/assigned.

Data source(s) for monitoring, mapping and reporting M8

- ***LCDB***
- ***Other***

Discussion notes:

- LCDB currently not sufficient for estimating loss of native biodiversity
- Resolution issues of LCDB to be considered (reporting/sampling cut-offs), for example, if below resolution of LCDB (1 ha) then not considered for reporting change
- Accuracy assessment needed to give a total accuracy assessment and to adjust figures.

- A useful stratified design that is fit for purpose to biodiversity needs/regional council needs must be developed (i.e. strata to design a sampling scheme and answers standardised by sampling scheme).
- As part of LCDB3 checking, Landcare Research provided regional councils with a tool to look at change polygons within scrub class – feasible thing to do (with classes and ortho photos). Not all councils participated. Change is patchy/not random. All councils need to participate in this process.
- Looking at change polygons needs to be complemented with looking at areas of no change to be correct/catch omissions.

M9: Habitat and vegetation loss

- **Data sources for estimating habitat loss (or gain), including any limitations:**
    - **LCDB**
    - **Rare ecosystems**
    - **Other**

Discussion notes:

Participants didn't discuss data sources for M9 specifically. Discussion about the LCDB and issues with its use (scale, resolution, a fit for purpose sampling scheme and accuracy assessments) apply to M9. Rare ecosystems data sources include national priorities/threatened environments.

Next steps/close meeting/thanks

- **Completing the draft methodology**
- **Peer review process**

Discussion notes

Everyone agreed that Jake Overton's PowerPoint provided a good overview of M8 and M9 methodological issues and recommended sensible next steps (i.e. the pilot study to estimate change and patterns of change in several regions) and stepwise implementation. Bay of Plenty, Canterbury, Otago and Manawatū–Whanganui were suggested as possible pilot regions.

The need to rationalise/ have one scheme of sampling for biodiversity indicators/ measures, including for M8 and M9 and the use of the LCDB was noted – key Landcare Research scientists to discuss.

After the meeting, Jake looked at data more. A good first step might be to do a more careful look around to see which councils have higher resolution data that might be used to assess change and the accuracy of the LCDB. For example, Waikato Regional Council has done a mapping exercise at 0.5 ha MMU of native vegetation for years 2002, 2007 and 2012, although not the entire region for each year. Jake has looked at this data but not had a chance to assess its suitability.

8 Indicator M11: Change in temperature and precipitation

Author: Daniel Collins, NIWA

8.1 Introduction

Several reviews have been conducted on the potential impacts of climate change for New Zealand's biodiversity (Lundquist et al. 2011, McGlone 2001, McGlone & Walker 2011). The most common predictions of ecosystem response are changes in range, phenology, species interactions, trophic interactions, and greater competitive advantages for exotic organisms (McGlone & Walker 2011). Indigenous alpine plants would become threatened with extinction due to tree line rise and the spread of closed woody vegetation (Halloy & Marks 2003). Sex ratios of tuatara are expected to become more biased towards males as temperatures rise (Mitchell et al. 2008). Northland is also vulnerable to the invasion of up to 100 weed species (Williams 2008). These predictions are indicative of other studies and of potential impacts for unstudied species and ecosystems.

It is therefore important that biodiversity management on the part of regional councils in New Zealand includes climate change as one of its many considerations (Lee & Allen 2011). This requires an understanding of how biodiversity changes may occur and what climatic data are available for the analysis, and a well-designed monitoring and research strategy (McMahon et al. 2011).The purpose of this report is to begin the provision of climatic information to regional councils so that they may start accounting for climate variability and change in their management of terrestrial biodiversity, with the ultimate goal of informing management interventions. The report's scope includes details of the climatic data, data analysis, data management and provision, as well as reporting of these data. This does not include an assessment of how changes in climatic indicators may affect biodiversity and hence which indicators and metrics are the most suitable; this is a decision for ecologists.

8.2 Scoping and analysis

8.2.1 Climate variability and change

In terms of present climatic conditions, New Zealand lies largely within the prevailing westerlies of the mid-latitude Southern Hemisphere and has a maritime climate (Salinger et al. 2004). Weather patterns follow the progression of travelling anticyclones, depressions and fronts. Average temperatures decrease towards the south and higher elevations. The greatest amounts of precipitation fall along the west coast of the South Island, due to the combination of a prevailing airflow from the west and southwest and the orographic effects of the Southern Alps, while precipitation declines towards the east. Seasonality of precipitation varies in magnitude across the country, with the North Island and the north of the South Island exhibiting winter precipitation maxima and summer minima, the east of the South Island exhibiting autumn maxima and summer or autumn minima, and the south and west of the South Island exhibiting autumn or spring maxima and winter minima. Seasonal changes in temperature and precipitation typically contribute to periods of water deficit in many parts of the country during summer.

At longer timescales, New Zealand's weather also varies naturally in conjunction with interannual climatic phenomena, such as the El Niño Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation[12] (IPO). The ENSO describes the shift between El Niño and La Niña conditions. During El Niño, the average east-west pattern in annual precipitation is generally accentuated, while La Niña weakens the gradient. The effect of IPO is to change the frequency of El Niño and La Niña conditions. During the positive phase of IPO, El Niño conditions are more common, while La Niña conditions are more common during the negative phase (Salinger & Mullan 1999). The ENSO and IPO both have substantial effects on New Zealand's climate, weather and hydrology. They have been shown to have effects on terrestrial ecosystems both in New Zealand and elsewhere (McGlone 2001; Holmgren et al. 2001; Brown et al. 1997).

On top of these natural patterns of climatic variability are the permanent changes in climate due to human activities. The most important of these is anthropogenic climate change due primarily to accelerated emission of greenhouse gases. Mean global temperatures have increased by about 0.7°C between 1906 and 2005 (Trenberth et al. 2007). New Zealand's temperature records exhibit a warming of about 0.9°C per century (Mullan et al. 2010), though no trend in precipitation data has yet been detected and attributed to climate change. Indeed, detection and attribution of climate changes are greatly inhibited by the large and incompletely understood natural variability as well as the limited extent of observations in both space and time. It should be noted, however, that microclimatic conditions can also change in response to land use change, such as increasing air temperature following urbanisation (the urban heat island effect) or large-scale land deforestation or afforestation.

In decades to come, the effects of climate change are expected to become increasingly noticeable across New Zealand (Ministry for the Environment 2008). Temperatures everywhere are expected to increase, more so in the north than the south (Figure 8-1). Changes in annual and seasonal precipitation will be more variable from region to region (Figure 8-2). Eastern and northern regions are likely to receive less precipitation and western and southern regions are likely to receive more. In regions that are currently drought-prone, droughts are likely to become more severe, particularly in the eastern parts of both islands (Clark et al. 2011). Sea levels are also expected to rise by 0.3–0.8 m by the end of the century, though greater rises cannot be ruled out (Lundquist et al. 2011).

12 The IPO is a cyclical change in the linked circulation patterns of the ocean and atmosphere in the Pacific. A characteristic circulation pattern predominates for a 20–30 year period, and then the system changes to having a different characteristic circulation pattern. These patterns are known as phases of the IPO; the IPO was in a negative phase from 1945–77 and in a positive phase from 1978–99.

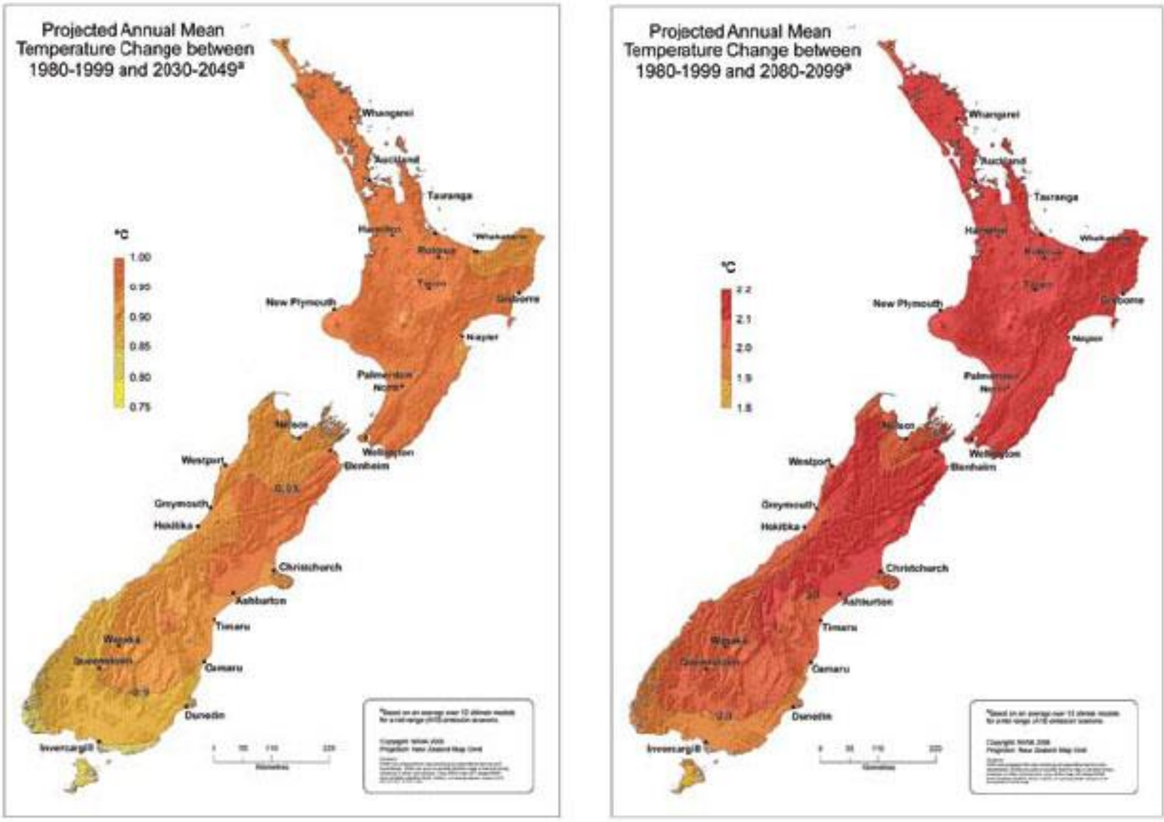

Figure 8-1 Projected mid-range changes in mean annual temperature (°C) for the 2080–2099 period relative to the period 1980–1999.

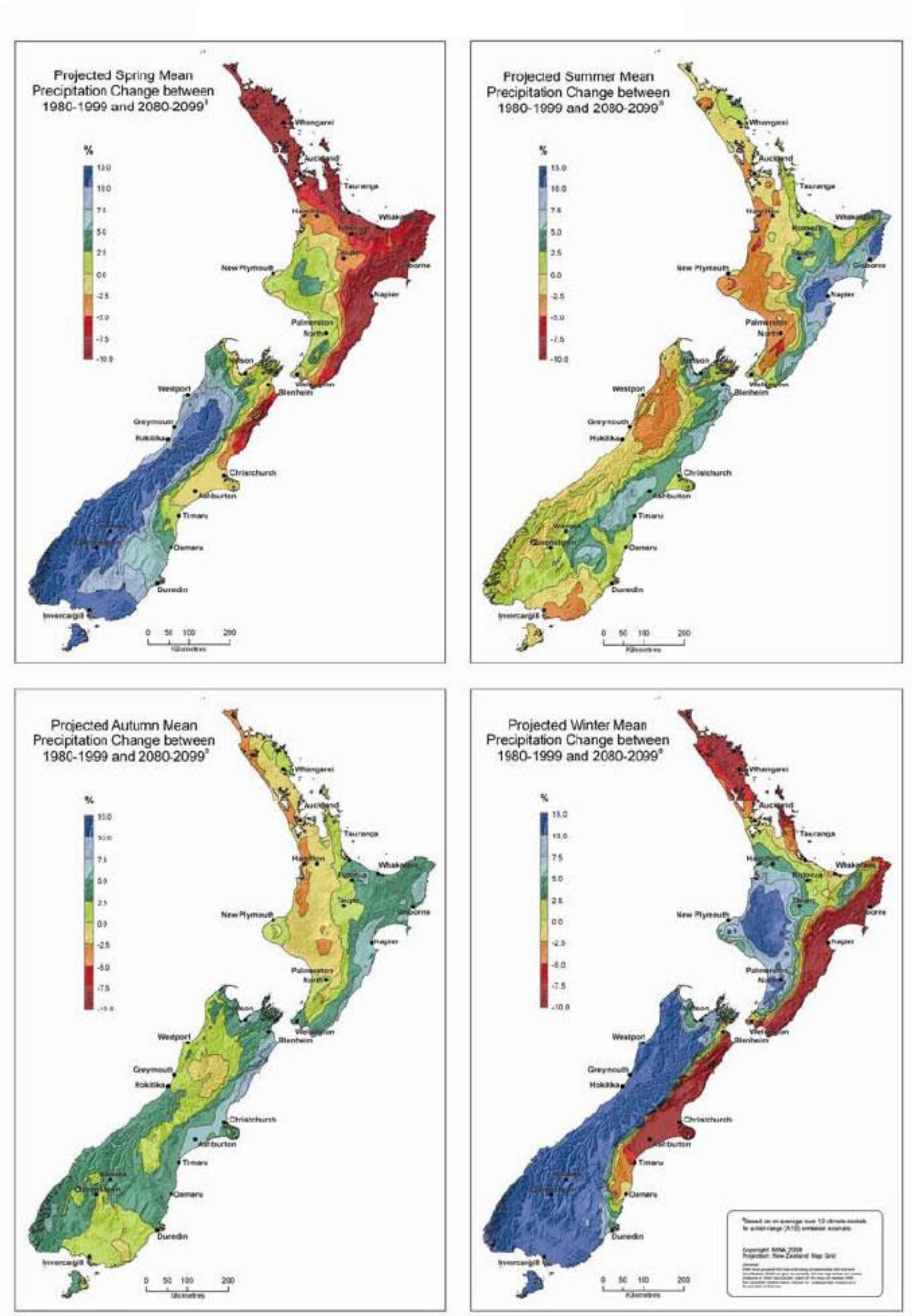

Figure 8-2 Projected mid-range changes in mean seasonal precipitation (%) for the 2080–2099 period relative to the period 1980–1999.

8.2.2 Climate indicators and measures of change

In order to successfully inform biodiversity management under climate change, it is imperative that a comprehensive list of metrics is used to express important climatic variables. The list must encapsulate the major climatic factors that drive biodiversity change in a meaningful way. They must be measureable. And they must manageable, in that there cannot be too much data to collect or too many metrics to report. They must also be able to change as new research comes to light.

Lee and Allen (2011), in a prior phase of this programme, identified a suite of metrics with the above considerations in mind. These are

- mean and extreme annual temperature
- mean and extreme annual precipitation
- mean and extreme seasonal temperature
- mean and extreme seasonal precipitation
- frost frequency, days with temperatures ≤0°C.

These metrics represent the two overarching variables of the climate system: precipitation and temperature. They also represent a range of statistical representations of the variables: means and extremes.

This set is a good set for our purposes, but it can be refined in two ways. The first, as a reflection of the frost frequency, is the frequency of high temperature days. The Ministry for the Environment (2008) represents this as the number of days with mean temperature above or equal to 25°C. This is ecologically meaningful as a representation of the conditions that may lead to heat stress.

The second refinement, and a necessary one, is a precise definition of ‘extreme’. There are many ways of quantifying climatic extremes, even of just temperature or precipitation. What is important here, though, are definitions that are able to change under climate change and are also ecologically relevant. Borrowing from aquatic ecology, where the 7-day mean annual low flow for streams and rivers is in common use, this report proposes the following:

- the minimum and maximum 7-day mean seasonal temperature (7dMinT, 7dMaxT)
- the minimum and maximum 15-day total seasonal precipitation (15dMinP, 15dMaxP).

The rationale for this is as follows. Reporting just daily extremes is unlikely to capture processes of particular importance, except for perhaps freezing. What is often more important to species are extended durations of extreme conditions. Hence, for temperature, this report suggests a period of 7 days. For precipitation, this report suggests a period of 15 days. The longer period for precipitation is because in several parts of New Zealand, it is quite normal for there to be zero precipitation for one week, but not so for 2 weeks. These metrics apply at the seasonal scale; there is little point in reporting them at the annual scale as this will essentially be a reproduction of the seasonal extremes.

The resultant climatic indicators are reproduced in Table 8-1. It is important that ecological research be conducted to identify which climatic variables and metrics are the most indicative of biodiversity change; this matter is not within the scope of the present report.

Table 8-1 Climatic metrics proposed for use in biodiversity monitoring programmes

Climatic indicator	Description	Number of variables
P	Total annual or seasonal precipitation	5
T	Mean annual or seasonal temperature	5
$N_{freezing}$	Number of days per year with mean daily temperatures equal to or below freezing	1
N_{25}	Number of days per year with mean daily temperatures equal to or above 25 °C	1
7dMinT	Minimum average temperature for a 7-day period within a given season	4
7dMaxT	Maximum average temperature for a 7-day period within a given season	4
15dMinP	Minimum total precipitation for a 15-day period within a given season or year	4
15dMaxP	Maximum total precipitation for a 15-day period within a given season or year	4

The matter of measuring changes in any of these metrics is more complicated. As described in section 8.2.1, the climate varies naturally or undergoes long-term change for several reasons: ENSO, IPO, land use change, and anthropogenic climate change. The fact that multiple sources of climatic variability interact makes it challenging to detect long-term change. The additional step of attributing any long-term change to a particular cause, such as anthropogenic climate change, is extremely challenging and not advisable for regional council staff.

What statistical representation of change is needed is a question for regional council biodiversity staff and must be matched with any biodiversity data if correlational studies are to be undertaken. It may be that a trend spanning the duration of the climate record is sought, or that the fluctuations associated with ENSO or IPO are more important. In any case, for the purpose of this report, a useful metric to use is the difference between the most recent year's climatic indicator and its long-term mean. Depending on the analytical objective, this could be extended to the latest 5 or 10 years. Ranking the last year's climatic indicator with respect to the preceding years is another way to convey information of variability or change.

8.2.3 Data sources

There are three potential data sources for the suite of climatic indicators presented in this report, all of which are archived, requiring no additional management effort on the part of the regional council staff. These data sources are the archive of climate data recorded by the various regional councils, the climate data recorded by NIWA, and NIWA's Virtual Climate Station Network (VCSN) data (Tait et al. 2006). The VCSN is a network of nodes covering the entire country at 0.05-degree intervals (latitude and longitude). Daily climatic data (e.g.

temperature and precipitation) are interpolated from actual climate observations using knowledge of how climate varies spatially. VCSN data are particularly useful in that they cover New Zealand with a spatial resolution of 0.05 degrees latitude and longitude, and for temperature and rainfall, are complete back to 1972.

For the present stage of the programme, it was decided at a programme meeting in Wellington in November 2011 that the VCSN data would be used for the analysis. This would provide a consistent source of data in more locations than actual climate stations. Should regional councils at any time decide to use direct climate observations, either because they provide a longer record or are exactly collocated with a biodiversity study site, there is little difficulty in switching.

8.2.4 Site selection

Selection of sites for the climatic metrics is a compromise between the need to represent sub-regions that have distinctly different climate change projections, sub-regions with distinctly different present climates (principally alpine/upland versus non-alpine/lowland), and the need to convey this information in a concise manner. Because of regional and sub-regional coherence in climatic patterns (Salinger et al. 2004), it is not necessary to report metrics everywhere within a regional council's jurisdiction. Relying at the present stage on the VCSN, the general location of sites in each region, and proposed VCSN nodes are listed in **Error! Reference source not found.** and illustrated in Figure 8-3. This decision is not permanent, however; adding or subtracting VCSN sites is trivial as the original data are already archived.

Only one site is recommend for Northland, Auckland and Nelson councils. In the first two instances, this is because there is little spatial variation in the climate change projections (Figure 8-1 & Figure 8-2). For Auckland and Nelson, the areas are too small to warrant many sites.

For several other regions, two sites is a recommended minimum. This applies to Bay of Plenty, Gisborne, Taranaki, and Hawke's Bay. In each case, two sites are recommended based on topographic differences: alpine or upland versus lowland.

The remaining regions are better represented by a minimum of at least three sites. In each of these cases, it is valuable to account for differences between alpine or upland sites and lowland sites as well as distinct differences in climate change projections. Wellington region, for example, includes regions with marked increases and decreases in summer precipitation by the 2090s (Figure 8-2).

Further refinement of the number and location of the sites should be made if doing so does not lead to confusion from an excess of information and if the sites are better aligned with specific biodiversity interests on the part of the regional council. In the case where sites are to be located in an urban setting, regional council staff should bear in mind that temperature may also change as a result of urbanisation and the resulting urban heat island effect.

Table 8-2 Proposed climate reference sites for each regional council. (Agent number = station identifier; Network number denotes its identifier in NIWA's Virtual Climate Station Network (VCSN)).

Region	Proposed locations			
	Description	Latitude, longitude	Agent number	Network number
Northland	Central	-35.625, 173.575	20593	P152240
Auckland	North of city	-36.625, 174.575	21795	P172220
Waikato	Coromandel Peninsula	-36.975, 175.625	29321	P193213
	Southwest coast	-38.525, 174.925	30758	P179182
	Upland	-38.575, 175.925	28870	P199181
Bay of Plenty	Northern lowland	-37.825, 176.175	30447	P204196
	Southern upland	-38.325, 176.925	27444	P219186
Gisborne	Lowland	-38.575, 177.925	30102	P239181
	Upland	-37.925, 178.075	28545	P242194
Taranaki	Alpine (Mt Taranaki)	-39.325, 174.025	30713	P161166
	Lowland	-39.425, 174.425	21750	P169164
Manawatū–Whanganui	West lowland	-40.175, 175.275	27671	P186149
	East lowland	-40.575, 176.375	29453	P208141
	Alpine	-39.325, 175.525	27191	P191166
Hawke's Bay	North upland	-38.725, 177.125	27455	P223178
	Central lowland	-39.575, 176.825	27429	P127161
Wellington	West coast	-41.225, 174.775	30178	P176128
	Central upland	-40.825, 175.325	28202	P187136
	East coast	-41.175, 175.975	27828	P200129
Tasman	Western alpine	-41.025, 172.575	21328	P132132
	Northern lowland	-41.325, 173.075	20275	P142126
	Southern alpine	-41.925, 172.675	21015	P134114
Nelson	Upland	-41.325, 173.325	20393	P147126
Marlborough	North-eastern sounds	-41.125, 174.075	21455	P162130
	South-eastern coast	-41.825, 174.125	28593	P163116
	South-western alpine	-41.825, 173.125	20311	P143116
West Coast	Northern lowland	-41.825, 171.575	15675	P112116
	Northern alpine	-41.625, 172.075	18902	P122120
	Southern lowland	-43.225, 170.225	14020	P085088
	Southern alpine	-44.075, 169.125	15018	P063071
Canterbury	Northern lowland	-42.375, 173.625	29086	P153105
	Northern alpine	-42.325, 172.725	21247	P135106
	Southern lowland	-44.775, 171.075	15244	P102057
	Central alpine	-43.175, 171.175	19507	P10408
	Mackenzie Basin	-44.075, 170.375	13948	P088071
Otago	Northern coast	-45.075, 170.875	15341	P098051
	Southern coast	-46.425, 169.625	13188	P073024
	Semi-arid central Otago	-45.225, 169.375	12937	P068048
	Inland alpine	-44.675, 168.575	10023	P052059
Southland	Western alpine	-45.275, 167.325	11210	P027047
	Central lowland	-45.775, 168.175	8631	P04403
	Southern lowland	-46.575, 168.875	12829	P058021

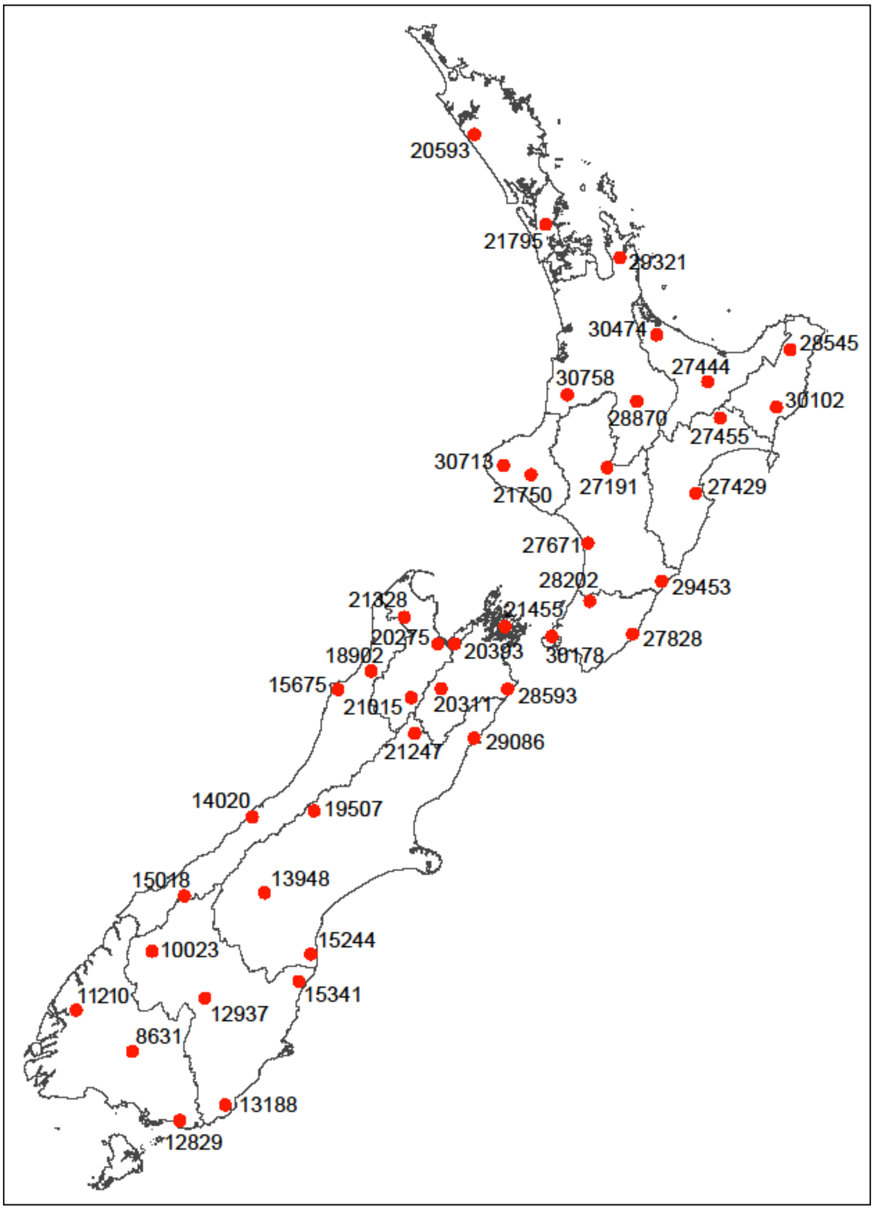

Figure 8-3 Locations of the 42 proposed VCSN nodes to be used by regional councils for biodiversity monitoring.

8.3 Reporting

8.3.1 Example analysis in full

With the climatic metrics and measure of change defined in section 8.2.2 above, and the list of proposed climate reference sites listed in

Table 8-2, an example of the analysis is provided here.

Figure 8-4 and Figure 8-5 depict the time-series of each of the 8 metrics in Table 8-1 from 1972 to 2011 for the two VCSN nodes 30474 and 11210, in lowland Bay of Plenty and alpine Southland, respectively. Differences between the two sites are readily apparent, as is the natural climatic variability. This variability provides a substantial impediment to detecting long-term change, as was discussed in section 8.2.1. The corresponding figures for all of the 42 proposed sites are contained in Appendix 8-1

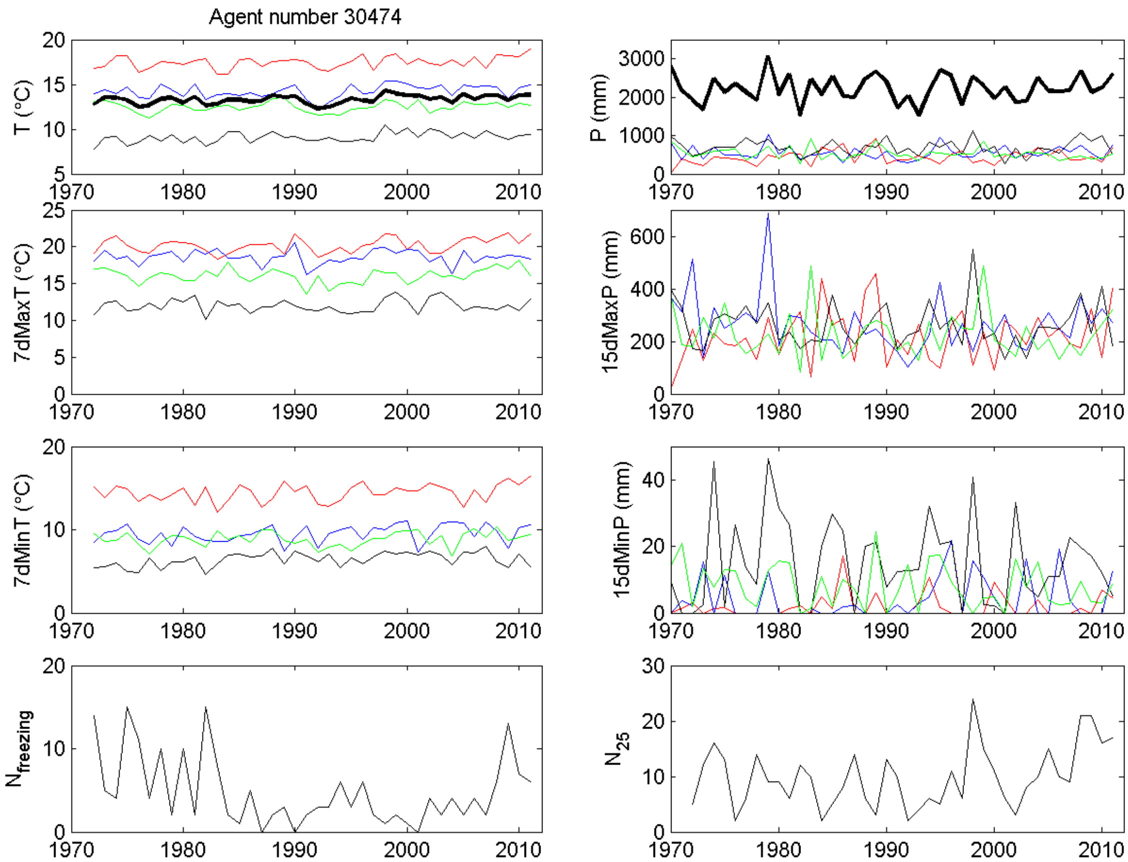

Figure 8-4 Climatic time-series for VCSN node 30474, in lowland Bay of Plenty. For the top six time-series, thick black = annual, red = summer, blue = autumn, thin black = winter, green = spring.

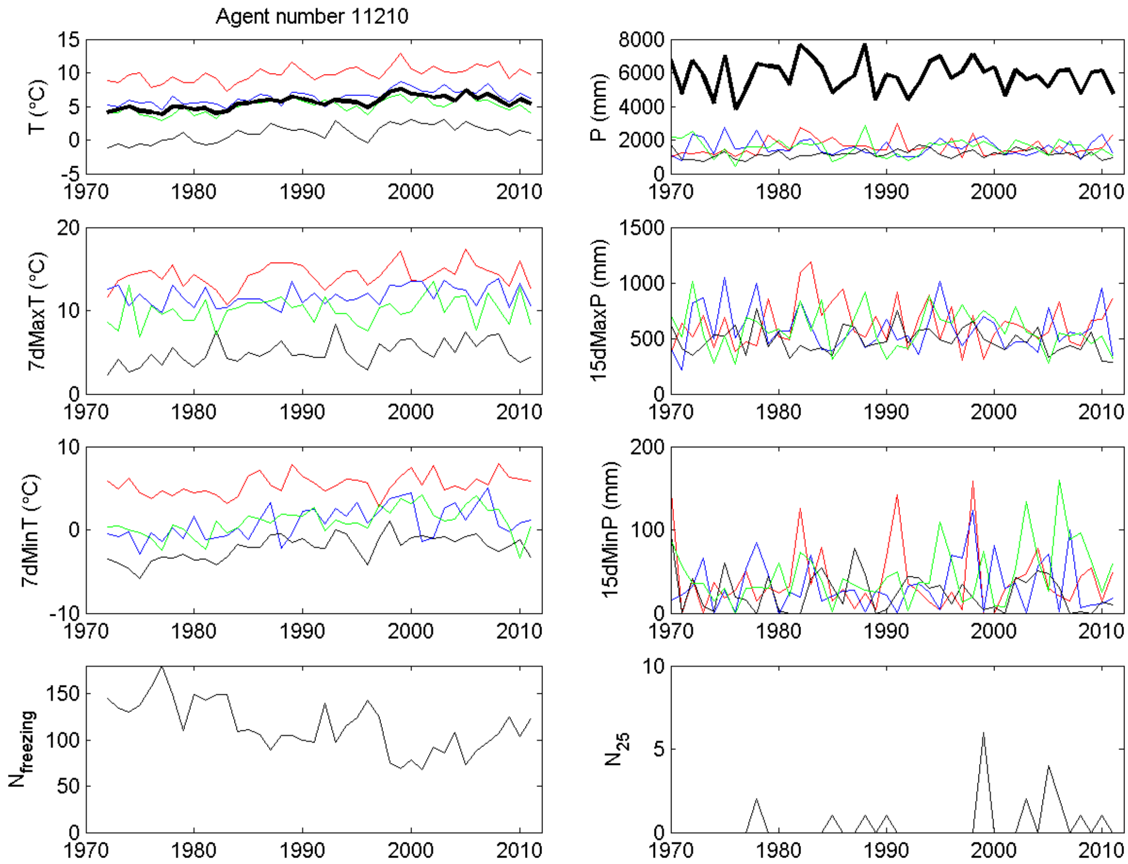

Figure 8-5 Climatic time-series for VCSN node 11210, in alpine Southland. For the top six time-series, thick black = annual, red = summer, blue = autumn, thin black = winter, green = spring.

The long-term means of these 8 metrics are reported in Table 8-3 to Table 8-5. The differences between the most recent year's metric and the long-term mean are reported in Table 8-6 to Table 8-8. Full tables with all of the 42 proposed sites are contained in Appendix 8-2.

Table 8-3 Long-term means of the temperature-based metrics (°C) for the recommended VCSN nodes in Bay of Plenty and Southland

	Mean					7dMax				7dMin			
VCSN node	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
30474	13.31	17.47	14.24	9.1	12.5	20.22	18.59	11.98	16.09	14.45	9.54	6.42	8.88
27444	11.52	16.29	12.24	6.72	10.92	19.53	17.38	10.01	15.28	12.84	6.99	3.81	6.71
11210	5.57	9.85	6.37	1.05	5.07	14.23	11.77	4.95	10.05	5.45	0.89	−2.15	0.98
8631	9.66	14.14	10.09	4.83	9.66	18.02	15.61	8.5	14.35	10.55	4.64	1.52	5.64
12829	10.01	13.37	10.56	6.38	9.76	16.55	14.91	9.33	13.61	10.45	6.11	3.61	6.52

Table 8-4 Long-term means of the number of days with mean daily temperatures below or equal to 0°C (**$N_{freezing}$**) or above or equal to 25°C (**N_{25}**) for the recommended VCSN nodes in Bay of Plenty and Southland

VCSN node	$N_{freezing}$	N_{25}
30474	4.8	9.9
27444	43.3	13.1
11210	114.8	0.5
8631	61.7	14.2
12829	17.4	3.4

Table 8-5 Long-term means of the precipitation-based metrics for the recommended VCSN nodes in Bay of Plenty and Southland

	Mean precipitation (mm)					15dMax (mm)				15dMin (mm)			
VCSN node	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
30474	2229	438	553	694	535	219	265	263	228	2	4	15	8
27444	1604	347	392	474	386	171	185	195	162	2	2	7	5
11210	5844	1569	1557	1170	1546	628	581	483	578	39	33	25	47
8631	911	252	240	200	220	95	98	81	86	5	4	4	5
12829	1137	285	307	269	276	108	117	97	96	7	8	7	8

Table 8-6 Difference in temperature-based metrics of the latest year relative to the long-term mean for VCSN nodes in Bay of Plenty and Southland. Reductions are highlighted in red.

	Δ Mean temperature (°C)					Δ 7dMax (°C)				Δ 7dMin (°C)			
VCSN node	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
30474	0.5	1.5	0.66	0.34	0.12	1.49	-0.26	0.9	-0.04	1.98	1.08	-0.87	0.51
27444	0.11	0.89	0.57	0.16	-0.5	1.57	-0.24	0.93	-1.23	1.82	1.11	-0.69	0.37
11210	-0.17	-0.16	-0.17	-0.02	-0.99	-1.58	-1.22	-0.57	-1.65	0.4	0.25	-1.15	-0.59
8631	0.07	0.42	0.09	-0.13	-0.35	-0.64	-1.36	0	-0.68	1.68	1.79	0.05	0.26
12829	0.3	0.67	0.39	0.25	-0.07	0.41	-0.26	0.34	-0.8	0.64	1.85	0.56	0.37

Table 8-7 Difference in the number of days of the latest year with mean daily temperatures below or equal to 0°C (**Δ $N_{freezing}$**) or above or equal to 25°C (**Δ N_{25}**) relative to the long-term mean for VCSN nodes in Bay of Plenty and Southland. Reductions are highlighted in red.

VCSN node	Δ $N_{freezing}$	Δ N_{25}
30474	1.2	7.1
27444	-10.3	-4.1
11210	8.3	-0.5
8631	0.3	-5.2
12829	-10.4	-2.4

Table 8-8 Difference in precipitation of the latest year relative to the long-term mean for VCSN nodes in Bay of Plenty and Southland. Reductions are highlighted in red.

	Δ Mean precipitation (mm)					Δ 15dMax (mm)				Δ 15dMin (mm)			
VCSN node	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
30474	371	227	196	-184	-12	183	8	-79	93	2	8	-10	1
27444	690	368	384	-87	-9	332	57	-16	84	-1	16	-6	-1
11210	-1063	693	-307	-233	-468	224	-232	-197	-258	10	-15	-15	13
8631	-115	4	-34	-42	34	0	-29	-11	7	2	-3	-1	-4
12829	-57	-4	-8	7	19	25	-23	13	-20	-2	5	0	0

To put the climatic patterns for VCSN nodes 3074 and 1120 into context, we can draw on an assessment of New Zealand's climate for the year 2011 (NIWA 2012).

For VCSN node 30474 in lowland Bay of Plenty, mean precipitation for summer and autumn were higher than average while winter precipitation was lower (Table 8-8). This is also broadly consistent with the pattern of La Niña that occurred during 2011 (Salinger et al. 2004; NIWA 2012). In terms of a long-term trend, Figure 8-4 suggests a relative lull in the number of freezing days from the mid-1980s to the late 2000s.

Conversely, for VCSN node 11210 in alpine Southland, temperatures indicate an increase between 1970 and 2000 (Figure 8-5), with levelling off or a decrease thereafter. The latest year of record indicates an increase in many temperature indicators relative to the long-term mean as well as more freezing days and fewer high-temperature days (Table 8-9 to Table 8-10). Almost all precipitation metrics indicate a reduction for the latest year, while summer demonstrates a substantial increase. These climatic patterns are consistent with the La Niña conditions that prevailed for much of 2011 (Salinger et al. 2004; NIWA 2012).

Table 8-9 Long-term means of the number of days with mean daily temperatures below or equal to 0°C ($N_{freezing}$) or above or equal to 25°C (N_{25}) for the recommended VCNS nodes in Bay of Plenty and Southland

VCSN node	$N_{freezing}$	N_{25}
30474	4.8	9.9
27444	43.3	13.1
11210	114.8	0.5
8631	61.7	14.2
12829	17.4	3.4

Table 8-10 Long-term means of the precipitation-based metrics for the recommended VCNS nodes in Bay of Plenty and Southland

	Mean precipitation (mm)					15dMax (mm)				15dMin (mm)			
VCSN node	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
30474	2229	438	553	694	535	219	265	263	228	2	4	15	8
27444	1604	347	392	474	386	171	185	195	162	2	2	7	5
11210	5844	1569	1557	1170	1546	628	581	483	578	39	33	25	47
8631	911	252	240	200	220	95	98	81	86	5	4	4	5
12829	1137	285	307	269	276	108	117	97	96	7	8	7	8

8.3.2 Hierarchies of reporting

Depending on the audience for the biodiversity reporting and the significance of the analysis, it may not be necessary to report all 8 metrics as was done above. In some instances, only a few metrics may suffice; in others, perhaps a dozen. The decision comes down to whether extra information is necessary to convey an important point, and whether the information can be satisfactorily conveyed to the audience in question.

To guide regional council staff in balancing information content with clarity, six levels of complexity are proposed. Each subsequent level adds more layers of detail to the metrics already included, moving progressively from the simpler, larger scale and more critical metrics to the more complex, smaller scale and less important. Each level refers to the latest year's metric in question relative to the long-term mean. The cumulative number of metrics is indicated in the square brackets. The six hierarchical levels are as follows:

1. Mean annual temperature and precipitation [2]

2. Mean temperature for summer and winter, and mean precipitation for the wettest and driest seasons [6]

3. The number of days with mean daily temperatures equal to or below 0°C and equal to or above 25°C [8]

4. 7dTMin for winter, 7dTMax for summer, 15dPMin for the driest season, and 15dPMax for the wettest season [12]

5. Mean temperature and precipitation for the remaining seasons [16]

6. 7dTMin, 7dTmax, 15dPMin, and 15dPMax for the remaining seasons [28].

In the absence of more advanced understanding of which metrics are the most useful to report particular biodiversity changes, it is recommended that councils nominally report the eight metrics from levels 1 to 3. The additional four metrics in level 4 are worth examining, but are only worth reporting if they add distinct value, bearing in mind the audience's needs. It is likely that the remaining 16 metrics would merely confuse matters and should only be included if, as with level 4, they add distinct value.

8.4 Data management and access requirements

An important part of a long-term monitoring programme is the curation and exchange of data. No additional curation effort is required by the regional councils for the original climate data, whether direct climate observations or interpolated VCSN data. The only curation that regional councils may need to undertake is the data analysis.

Provision of data to regional councils from NIWA may be carried out in one of three ways:

1. The daily climate data may be requested from NIWA and delivered in electronic format for each site of interest, either for the original climate observations or the VCSN.

2. The daily climate data may be downloaded by the regional council free of charge from NIWA's National Climate Database via the CliFlo website (http://cliflo.niwa.co.nz/).

3. Results of the climate analysis may be requested from NIWA by the RA, and delivered in electronic format.

The decision of which option to take will likely come down to whether regional council staff are comfortable with downloading and/or processing the data. Regional councils may prefer to use their own data. With analytical protocols already in place within NIWA, however, option #3 is recommended. This request is simplefor NIWA to process and need only be made as often as the climate indicators are being used in ecological analysis or are reported.

It is easy for a regional council to change the set of climate stations used in the analysis, requiring only some consultation between the regional council and NIWA as to the exact sites. Shifting the method of analysing climatic change would not be as trivial, requiring some consultation with NIWA as to what types of climatic variability or change are to be identified. This, in turn, would hinge on the particular biodiversity question of interest, which is outside the scope of the present report.

8.5 Reporting format

Given the likely and potential range of metrics to be reported, it would be difficult to clearly represent the material in a graphical form. It is thus recommended that regional councils report the metrics in tabular form accompanied by a figure that illustrates the reference site locations. An example of this reporting format is provided for Southland's three climate reference sites using the third level of reporting with eight metrics (Table 8-11, Table 8-12, and Figure 8-6).

Table 8-11 Long-term mean climatic conditions for three reference sites in Southland, based on an intermediate level of reporting. The sites are identified in **Figure 8-6**.

Location	Mean temperature (°C)			$N_{freezing}$ (days)	N_{25} (days)	Total precipitation (mm)		
	Annual	Summer	Winter			Annual	Summer	Winter
Western alpine	5.57	9.85	1.05	114.8	0.5	5844	1569	1170
Central lowland	9.66	14.14	4.83	61.7	14.2	911	252	200
South-eastern lowland	10.01	13.37	6.38	17.4	3.4	1137	285	269

Table 8-12 Indicators of short-term climatic change for three reference sites in Southland, based on an intermediate level of reporting. The sites are identified in **Figure 8-6**. Values indicate the deviation of the latest year's climatic indicator relative to its long-term mean as shown in **Table 8-10**. Decreases are highlighted in red.

Location	Δ Mean temperature (°C)			Δ $N_{freezing}$ (days)	Δ N_{25} (days)	Δ Total precipitation (mm)		
	Annual	Summer	Winter			Annual	Summer	Winter
Western alpine	-0.17	-0.16	-0.02	8.3	-0.5	-1063	693	-233
Central lowland	0.07	0.42	-0.13	0.3	-5.2	-115	4	-42
South-eastern lowland	0.3	0.67	0.25	-10.4	-2.4	-57	-4	7

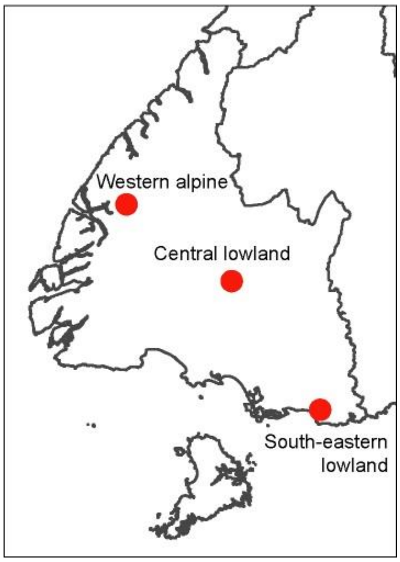

Figure 8-6 Reference climate sites for Southland.

8.6 Recommendations

As was stated at the outset, the purpose of this report is to outline a range of climatic metrics that may be used as part of a terrestrial biodiversity monitoring programme. The rationales behind the selection are largely qualitative in that experience tells us that different statistical representations of temperature and precipitation should correlate with ecological responses. At this stage, however, little work has been conducted to identify which are the best metrics to monitor and report.

It is thus strongly recommended that biodiversity monitoring on the part of regional councils be paralleled by research on the effects of climatic variability and change on physiology, population and community dynamics, and ecosystem form and function. The study of plant and animal phenology is a particularly worthwhile aspect of this research, as are ecological responses to shifts associated with ENSO.

8.7 Conclusions

Climate variability and change, whether natural or anthropogenic, can have substantial effects on biodiversity, and need to be incorporated into any regional biodiversity observation and management programme. To assist regional councils in this endeavour, a preliminary protocol for gathering, analysing and reporting climatic data has been presented in this report.

The climatic metrics recommended in this report address various statistical representations of local temperature and precipitation. They are:

- Mean and extreme annual temperature
- Mean and extreme annual precipitation
- Mean and extreme seasonal temperature
- Mean and extreme seasonal precipitation
- Frost frequency, i.e. days with temperatures ≤0 °C ($N_{freezing}$)
- Extreme heat frequency, i.e. days with temperatures ≥25 °C (N_{25})
- The minimum and maximum 7-day mean seasonal temperature (7dMinT, 7dMaxT)
- The minimum and maximum 15-day total seasonal precipitation (15dMinP, 15dMaxP)

Depending on the metrics' information content and their utility in understanding biodiversity change or threats, the metrics may be reported in one of several levels of detail (the numbers in brackets indicating the total number of metrics reported):

1. Mean annual temperature and precipitation [2]
2. Mean temperature for summer and winter, and mean precipitation for the wettest and driest seasons [6]
3. The number of days with mean daily temperatures equal to or below 0°C and equal to or above 25°C [8]

4. 7dTMin for winter, 7dTMax for summer, 15dPMin for the driest season, and 15dPMax for the wettest season [12]

5. Mean temperature and precipitation for the remaining seasons [16]

6. 7dTMin, 7dTmax, 15dPMin, and 15dPMax for the remaining seasons [28].

Short-term climatic change has been reported as the difference between the latest year's metric and its long-term mean, though other representations of change may be more suitable depending on the scientific application.

Data for the analyses may come from any long-term record, and is recommended here to come from NIWA's Virtual Climate Station Network (VCSN). Forty-eight VCSN sites around the country have been identified as representative sites for regional climatic conditions under climate change, though this selection may be modified to better suit specific biodiversity management issues. Assessments of climatic change may be reported in tabular form alongside a map of the representative climate sites.

Long-term storage of the climate data is already managed by NIWA. Transfer of the necessary data from NIWA to the regional councils is a simple matter of submitting a request for the climate sites' data and analysis, and subsequent electronic transfer.

8.8 References

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Appendix 8-1 – Time-series of the climatic indicators for the 42 recommended VCSN nodes

This appendix contains the time-series for each of the 28 climatic metrics for each of the 42 suggested VCSN nodes. For the top six time-series, thick black = annual, red = summer, blue = autumn, thin black = winter, green = spring.

Northland

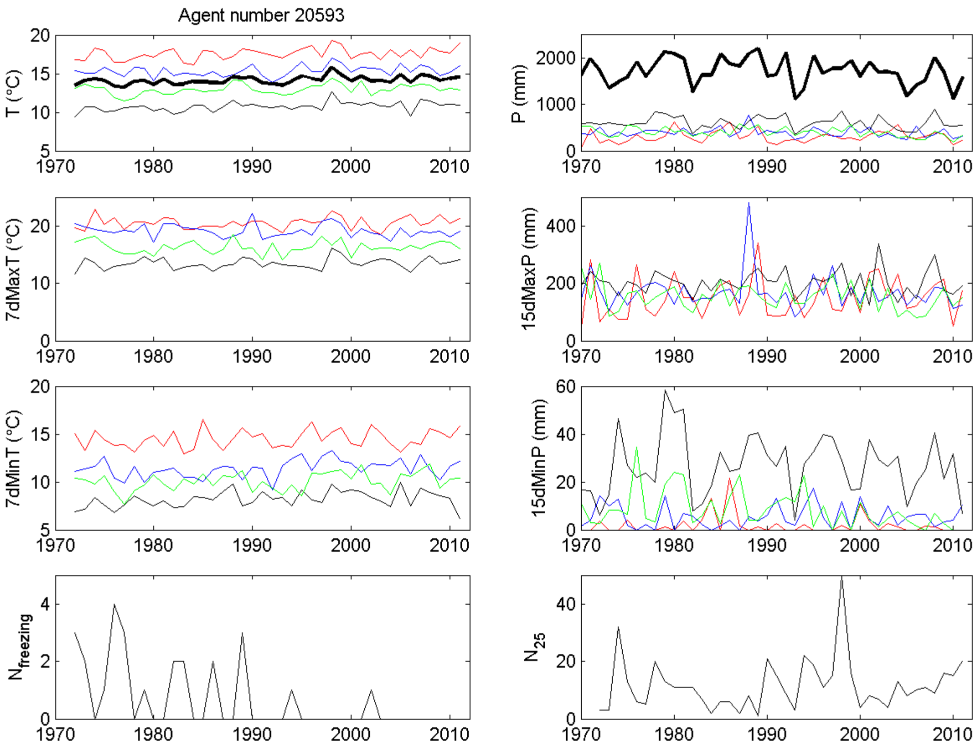

Figure A8-1-1 Climatic time-series for VCSN node 20593, Northland.

Auckland

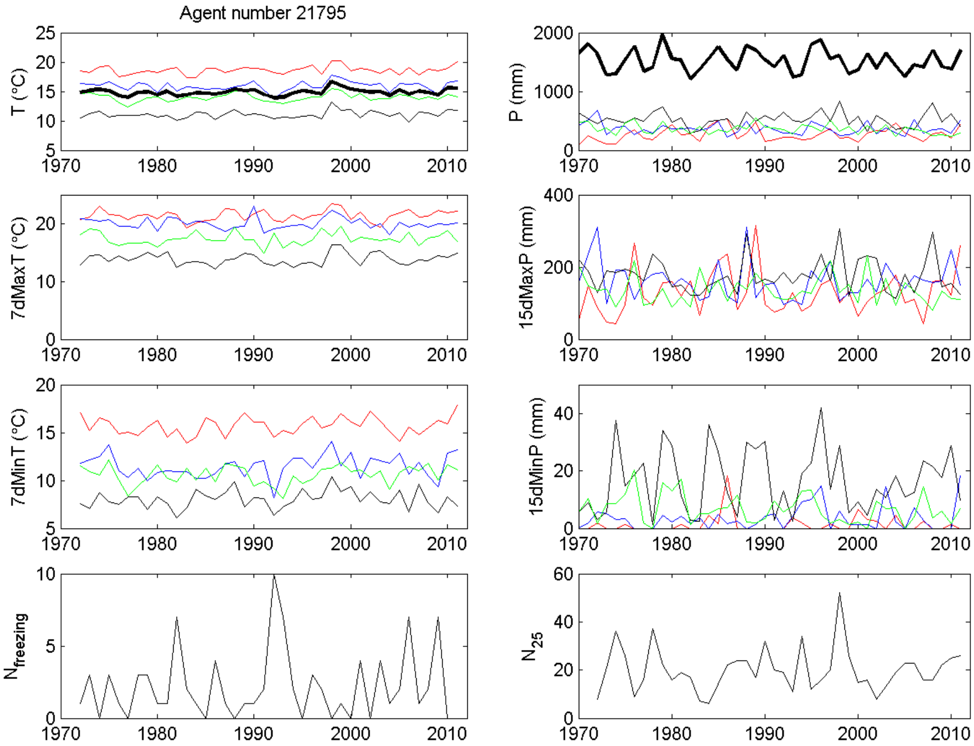

Figure A8-1-2 Climatic time-series for VCSN node 21795, Auckland.

Waikato

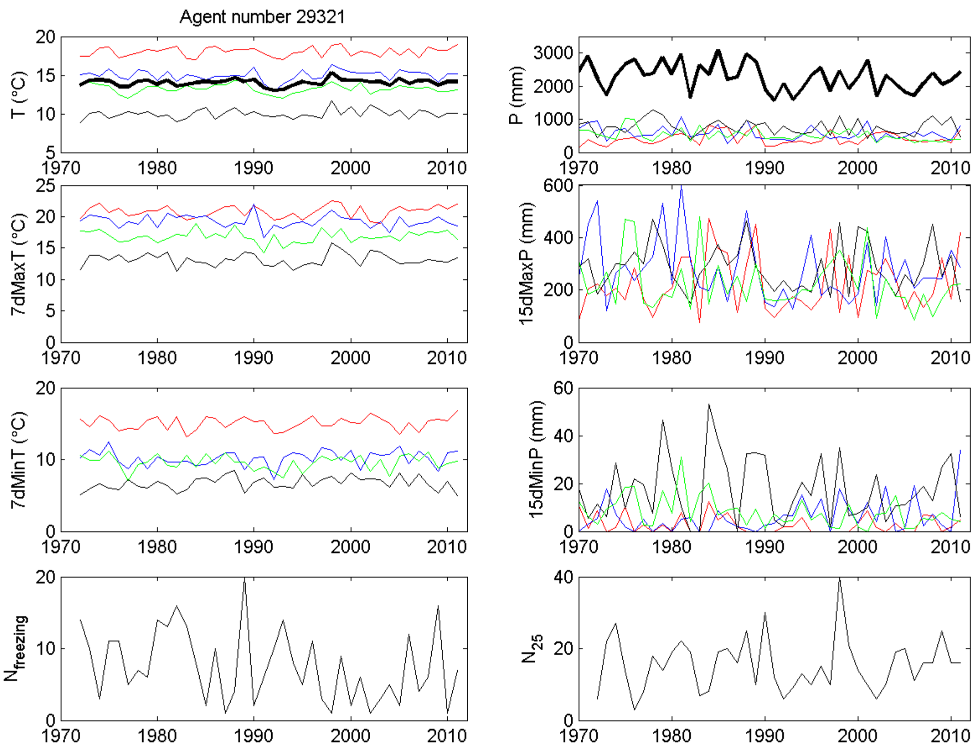

Figure A8-1-3 Climatic time-series for VCSN node 29321, Waikato.

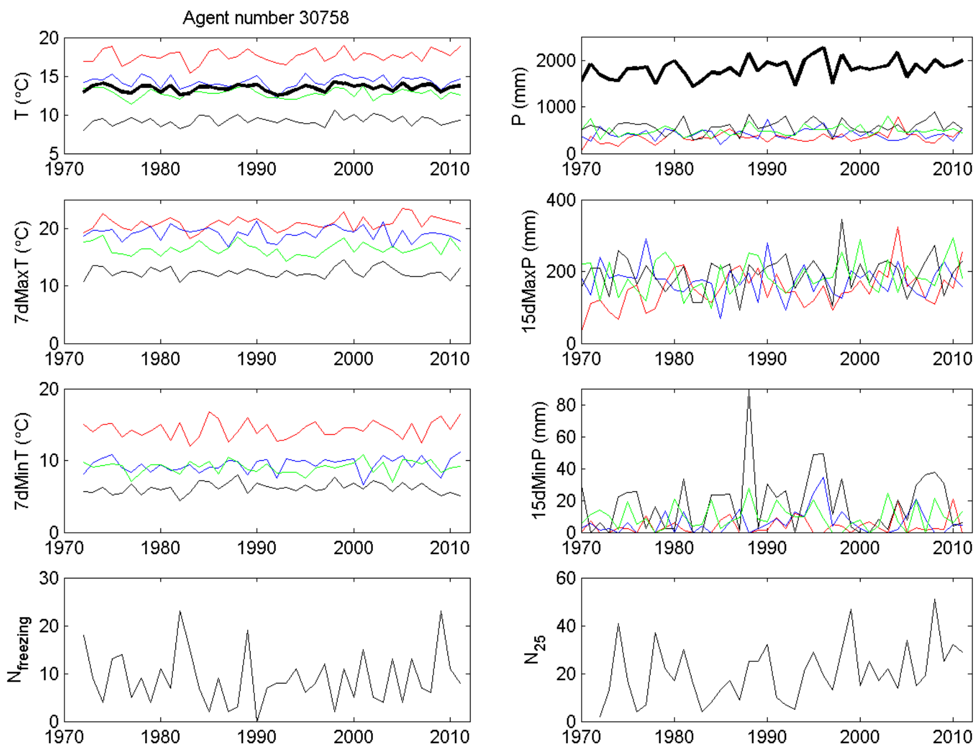

Figure A8-1-4 Climatic time-series for VCSN node 30758, Waikato.

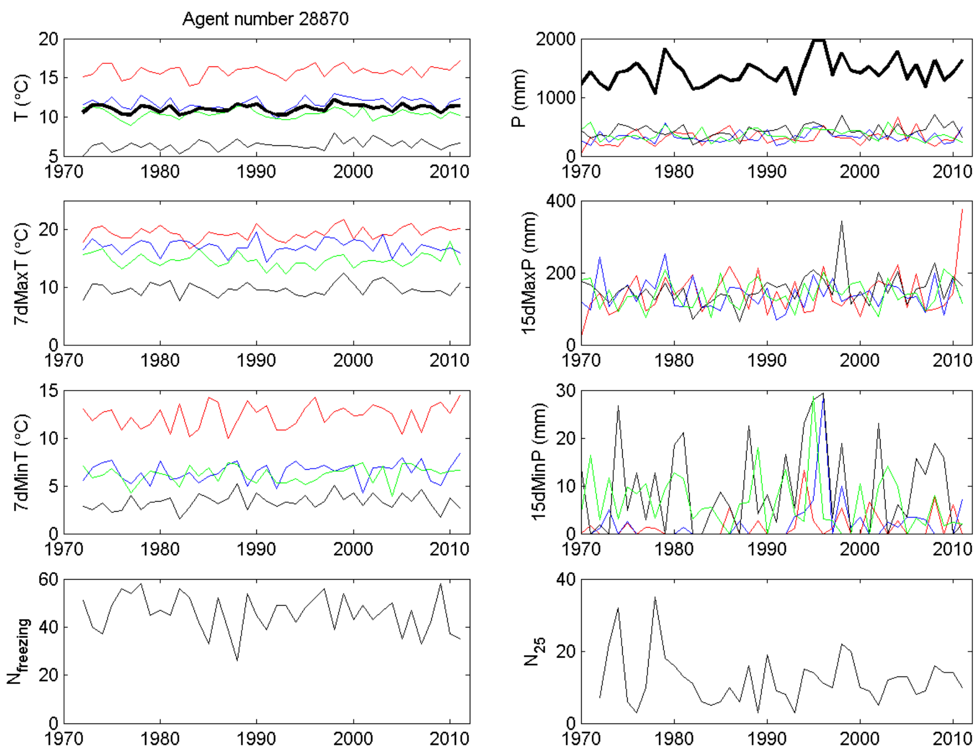

Figure A8-1-5 Climatic time-series for VCSN node 28870, Waikato.

Bay of Plenty

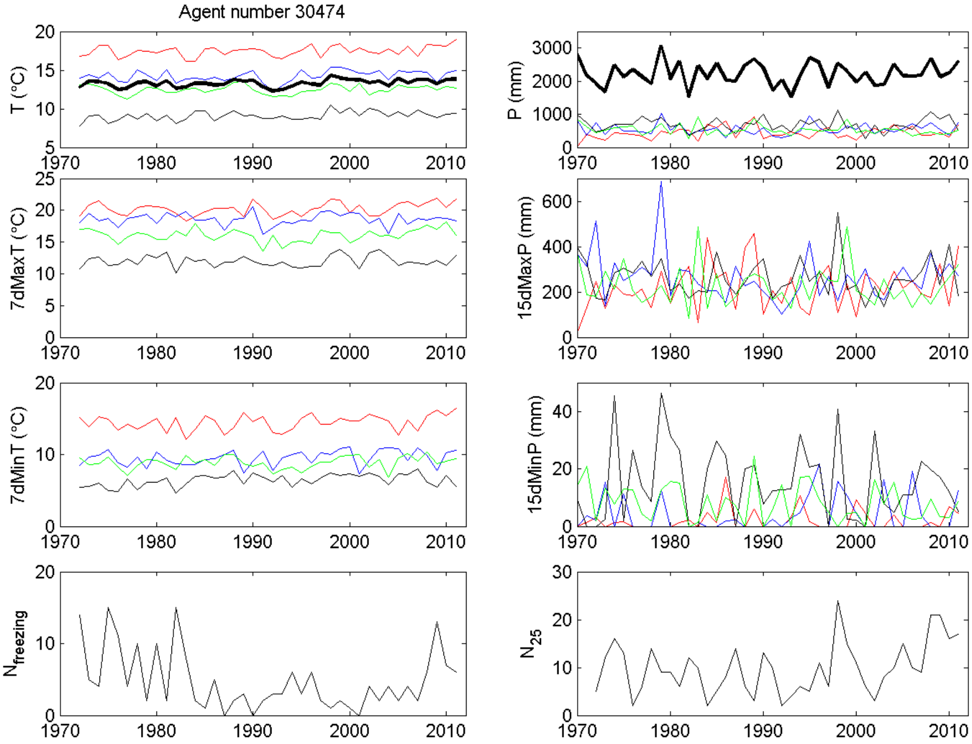

Figure A8-1-6 Climatic time-series for VCSN node 30474, Bay of Plenty.

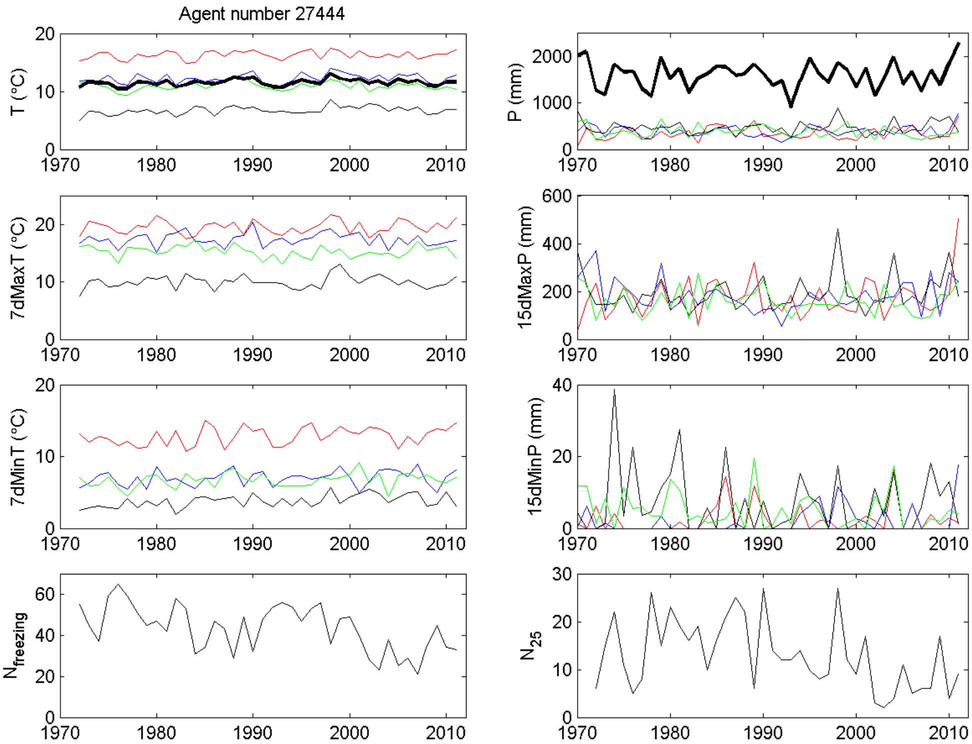

Figure A8-1-7 Climatic time-series for VCSN node 27444, Bay of Plenty.

Gisborne

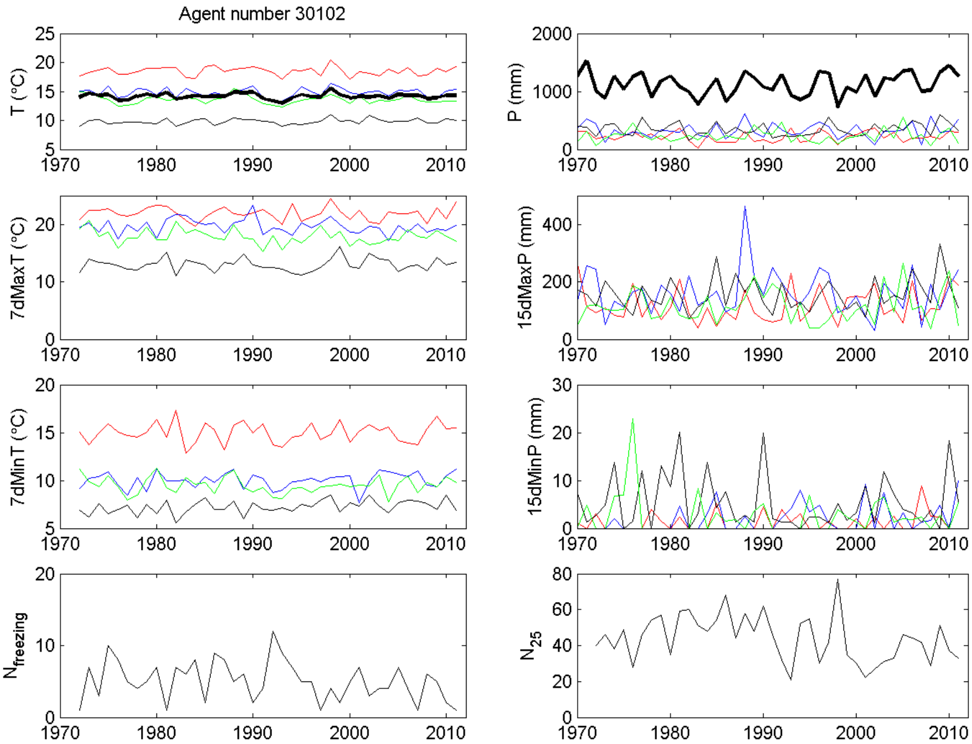

Figure A8-1-8 Climatic time-series for VCSN node 30102, Gisborne.

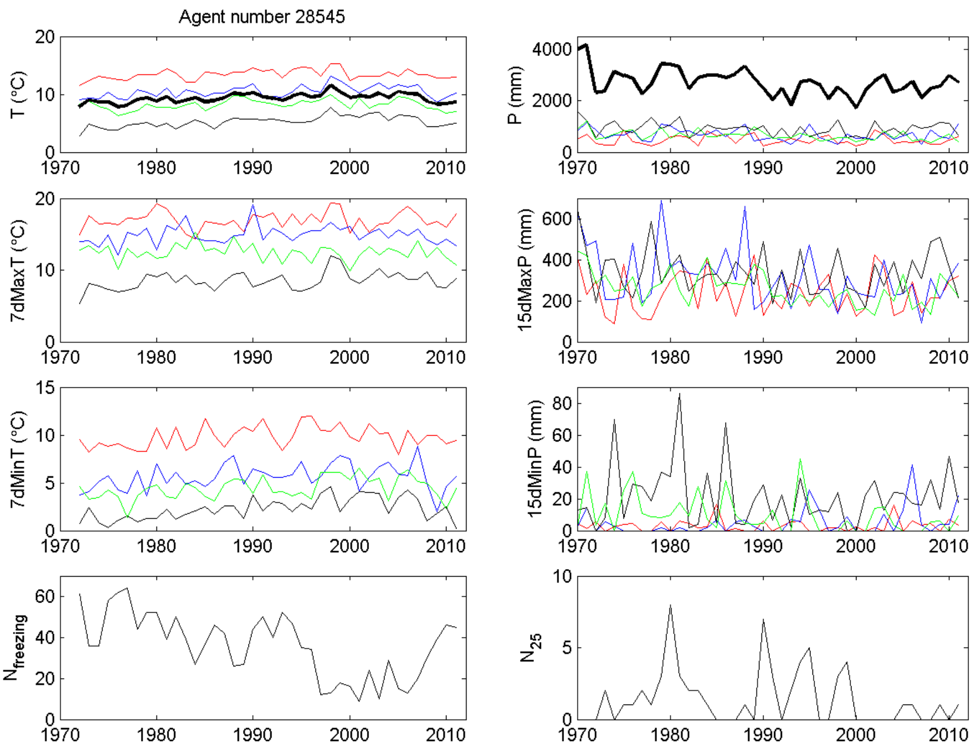

Figure A8-1-9 Climatic time-series for VCSN node 28545, Gisborne.

Taranaki

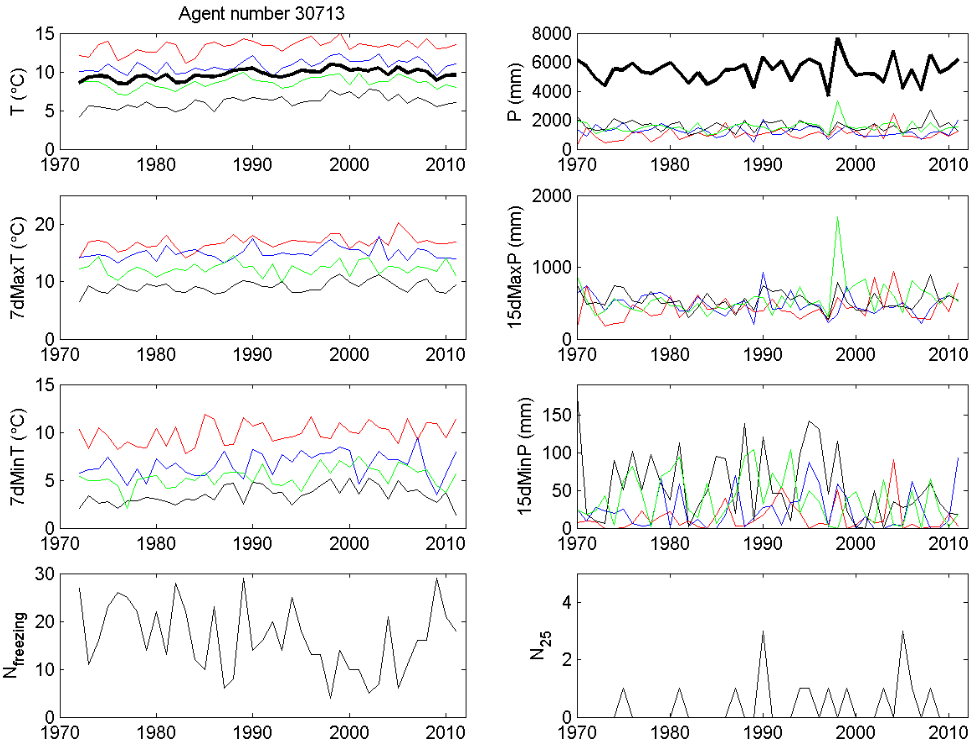

Figure A8-1-10 Climatic time-series for VCSN node 30713, Taranaki.

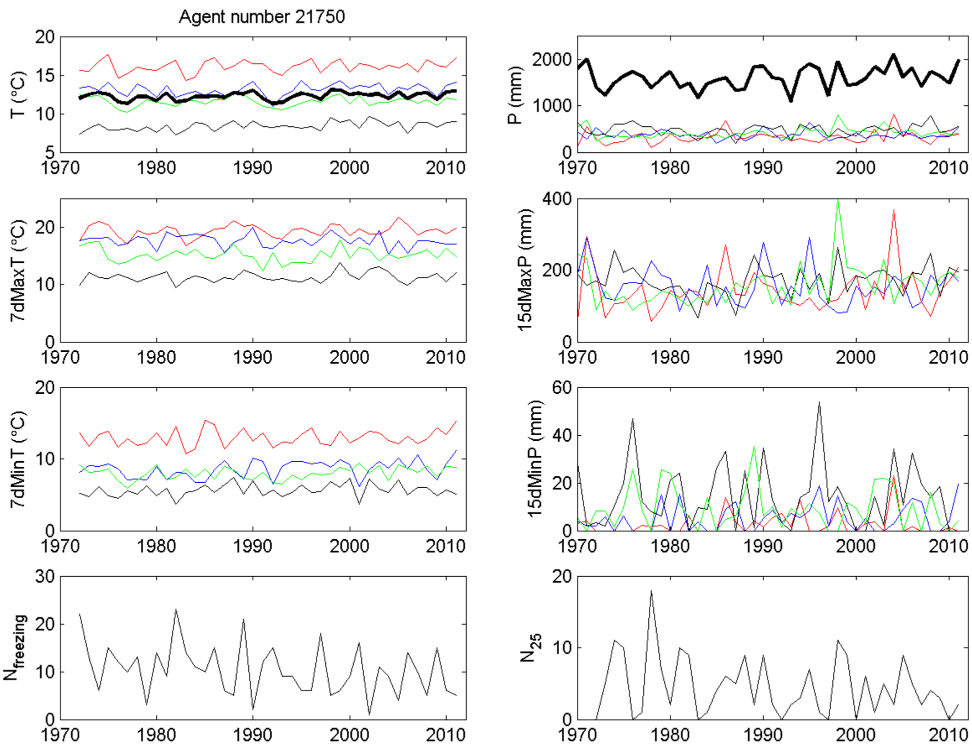

Figure A8-1-11 Climatic time-series for VCSN node 21750, Taranaki.

Manawatū–Whanganui

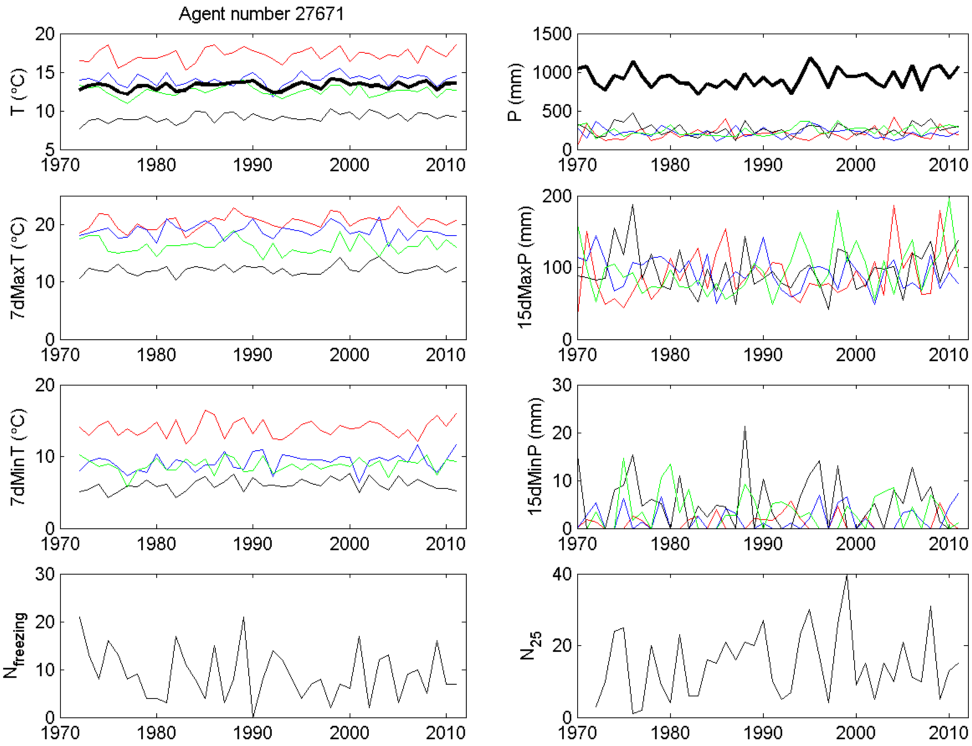

Figure A8-1-12 Climatic time-series for VCSN node 27671, Manawatū-Whanganui.

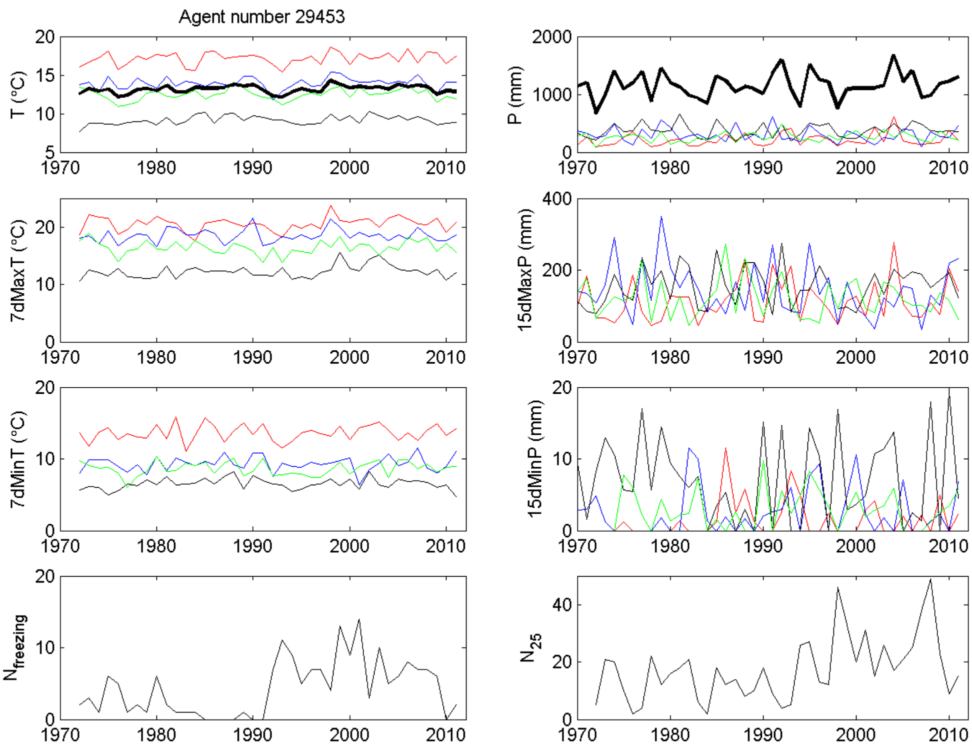

Figure A8-1-13 Climatic time-series for VCSN node 29453, Manawatū-Whanganui.

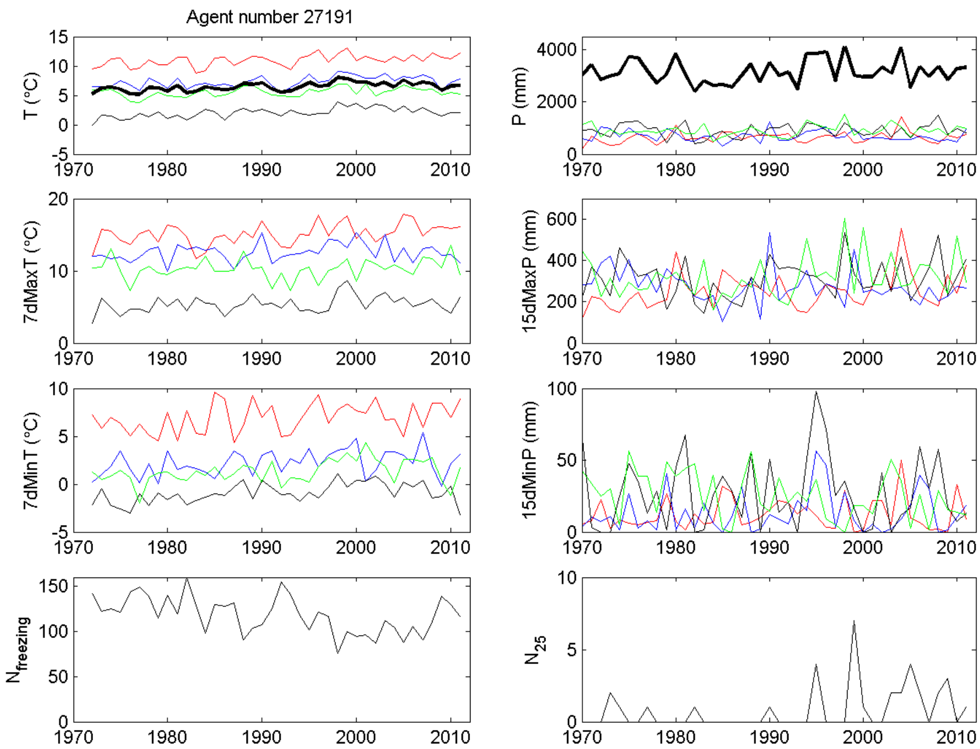

Figure A8-1-14 Climatic time-series for VCSN node 27191, Manawatū-Whanganui.

Hawke's Bay

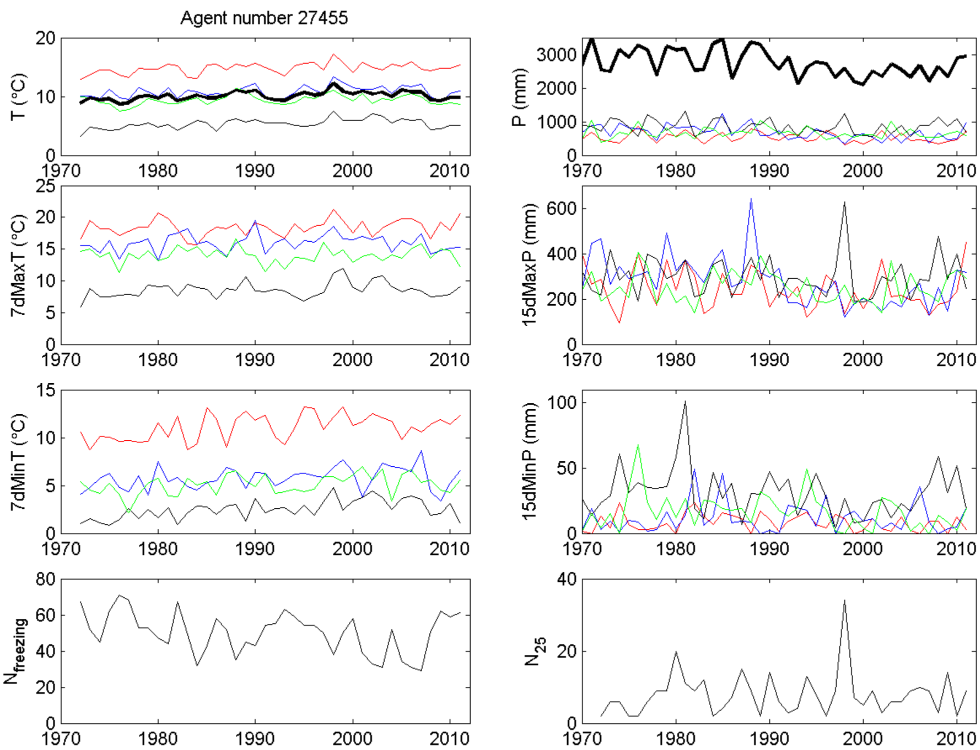

Figure A8-1-15 Climatic time-series for VCSN node 29025, Hawke's Bay.

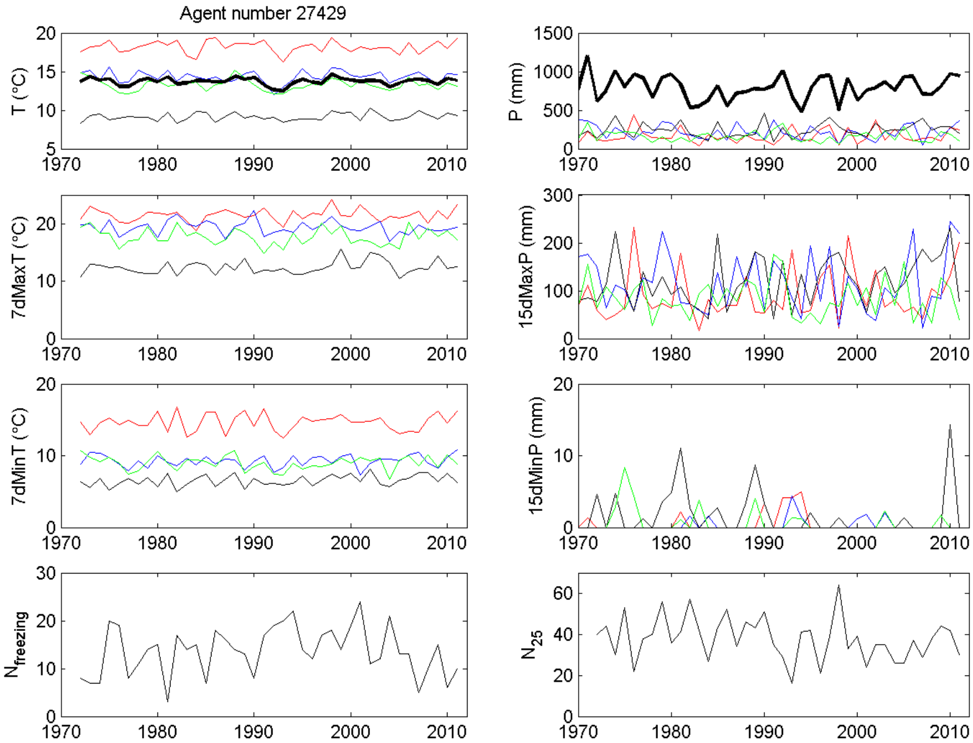

Figure A8-1-16 Climatic time-series for VCSN node 27429, Hawke's Bay.

Greater Wellington

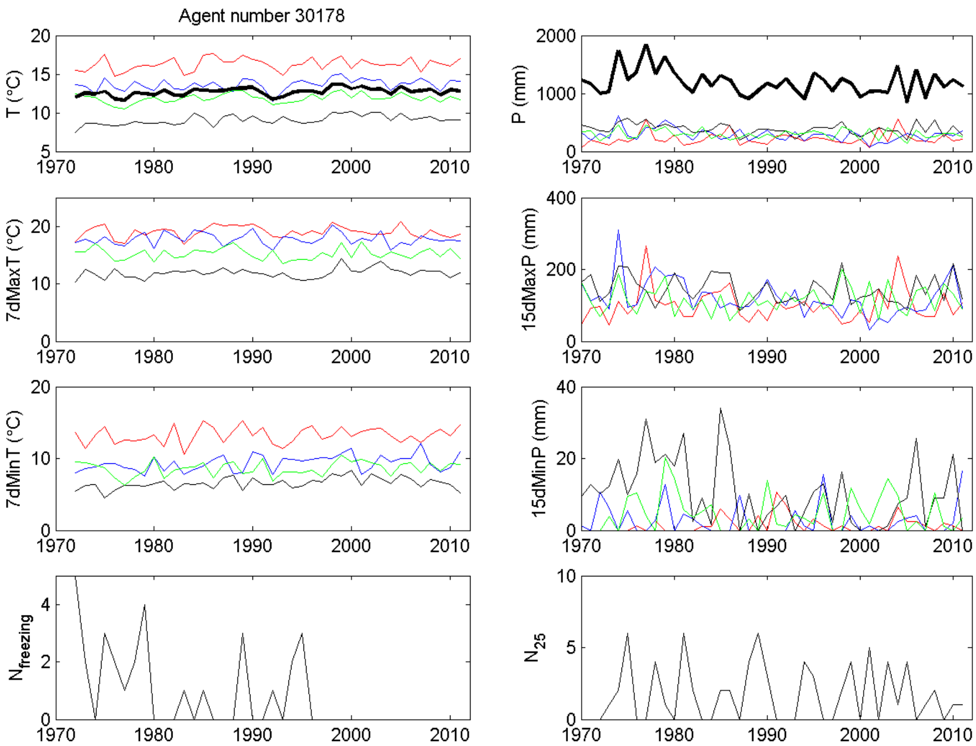

Figure A8-1-17 Climatic time-series for VCSN node 30178, Greater Wellington.

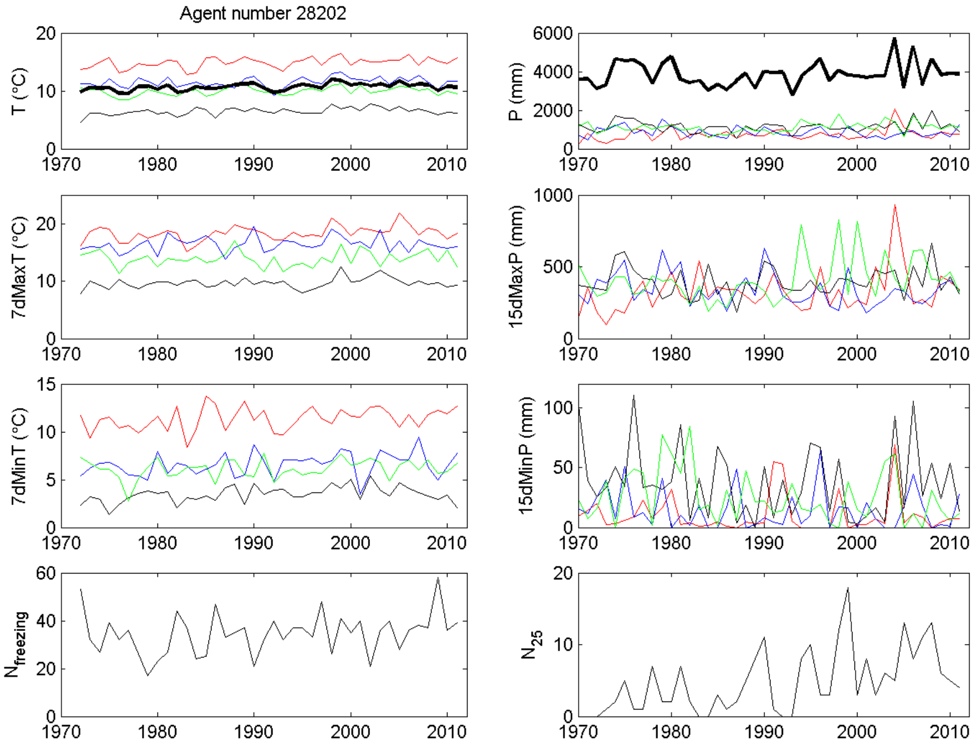

Figure A8-1-18 Climatic time-series for VCSN node 28202, Greater Wellington.

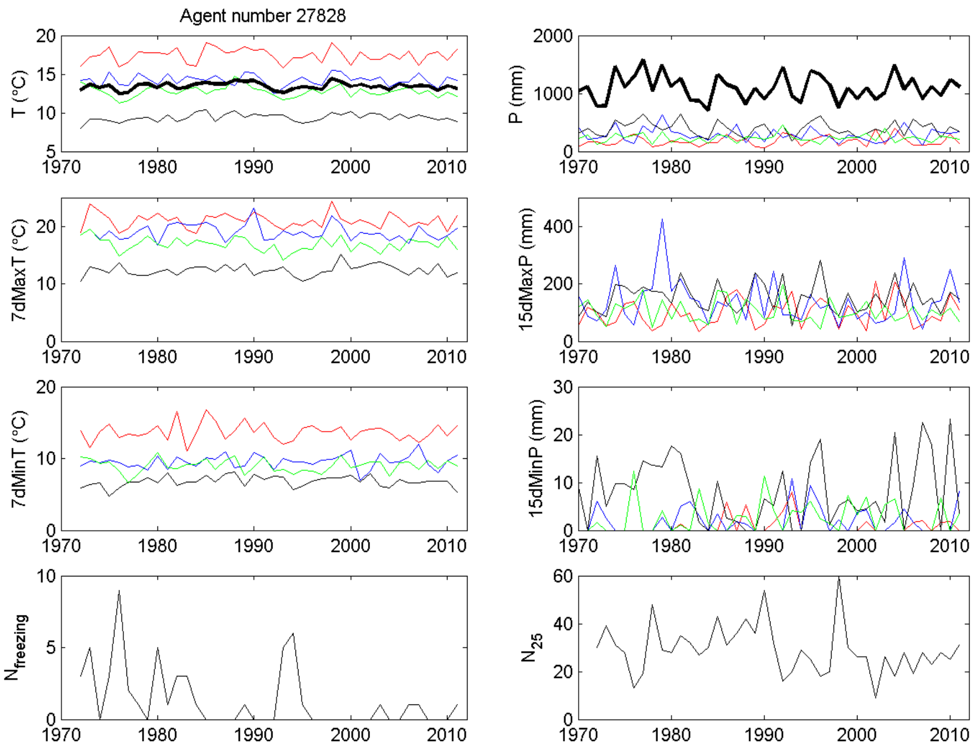

Figure A8-1-19 Climatic time-series for VCSN node 27828, Greater Wellington.

Tasman

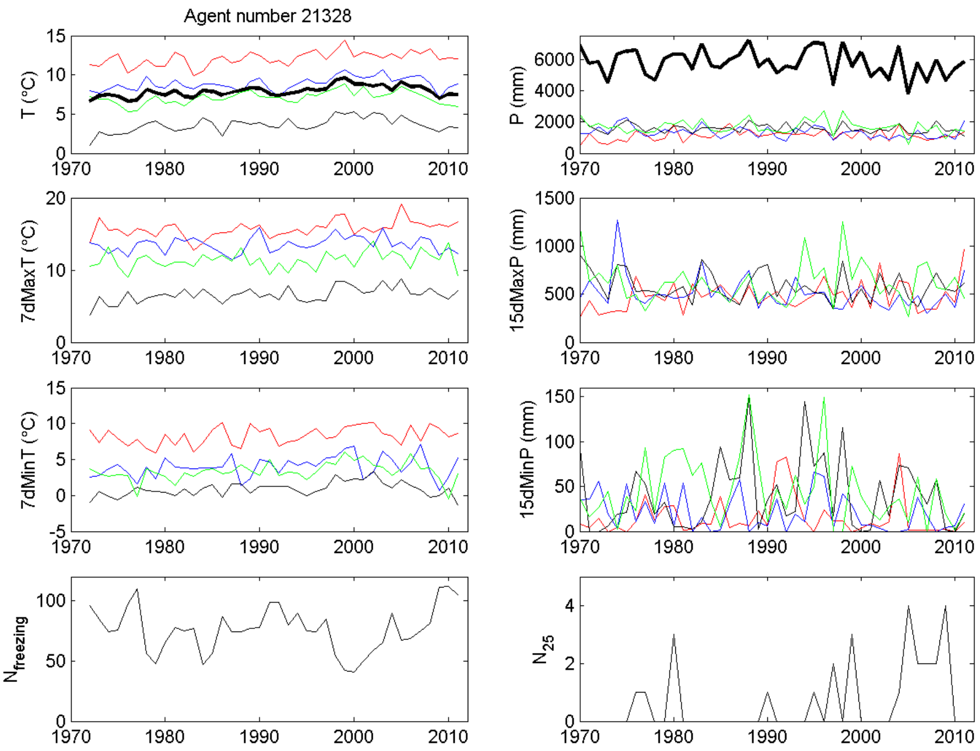

Figure A8-1-20 Climatic time-series for VCSN node 21328, Tasman.

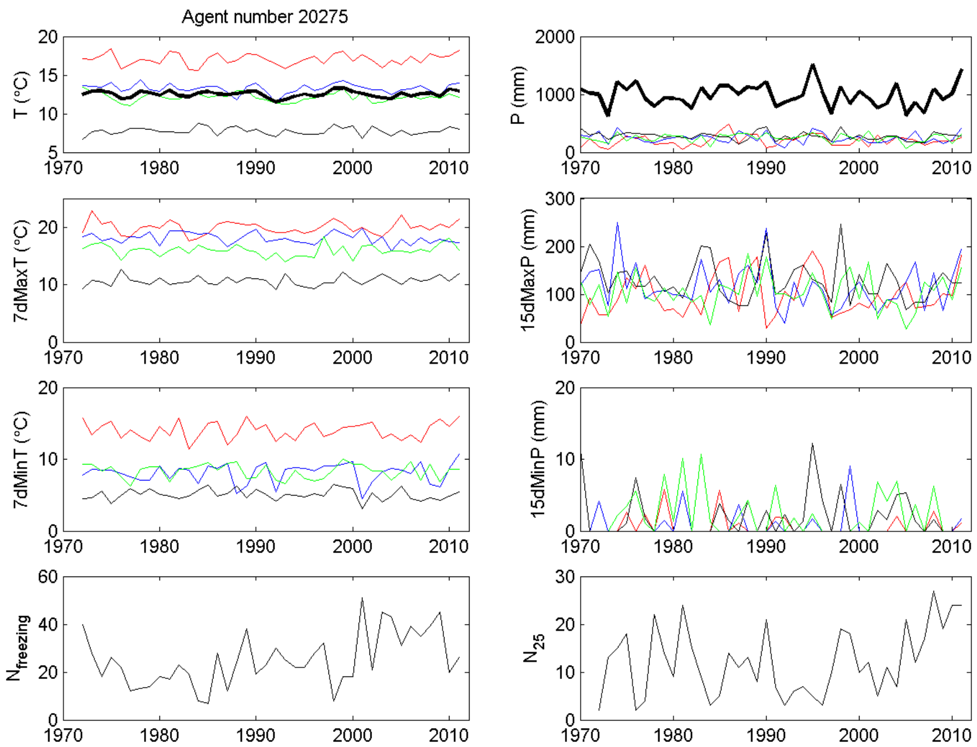

Figure A8-1-21 Climatic time-series for VCSN node 20275, Tasman.

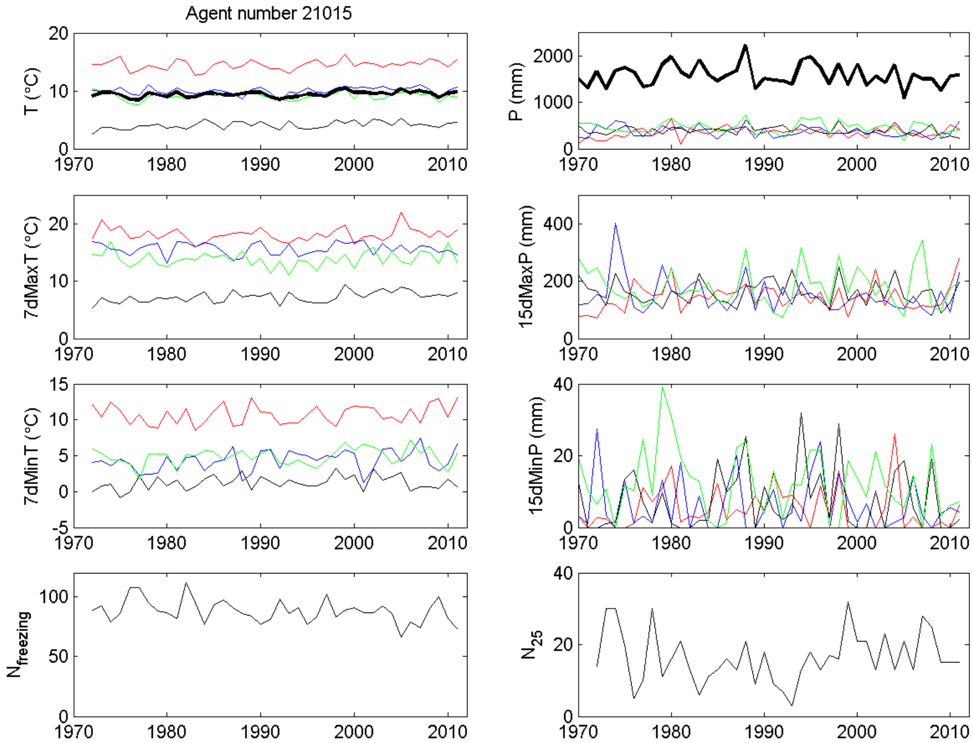

Figure A8-1-22 Climatic time-series for VCSN node 21015, Tasman.

Nelson

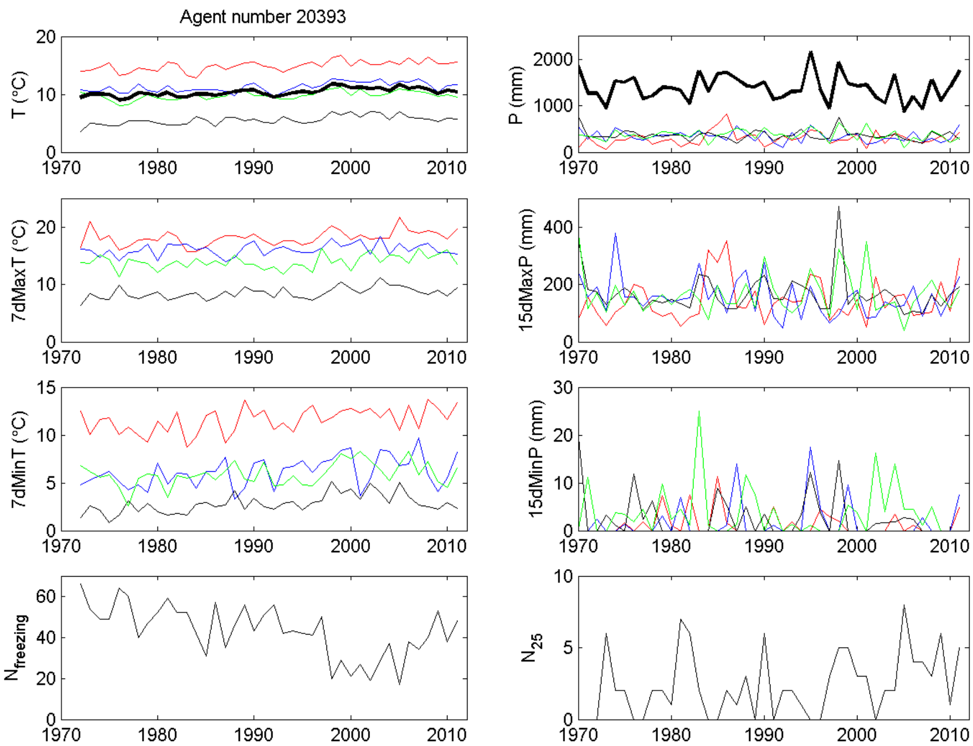

Figure A8-1-23 Climatic time-series for VCSN node 20393, Nelson.

Marlborough

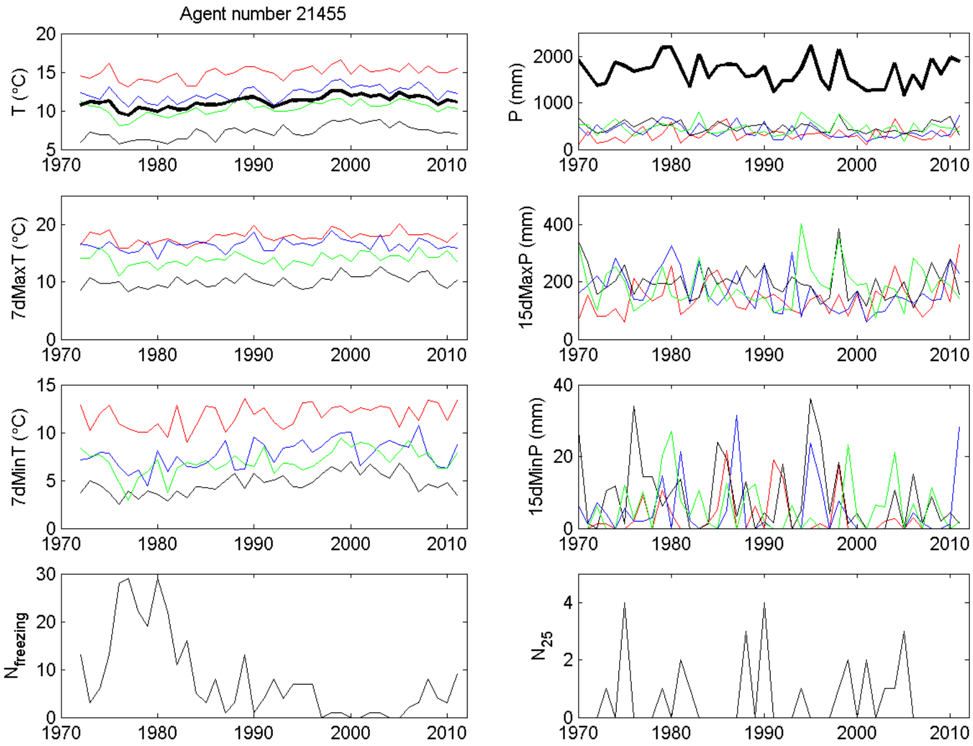

Figure A8-1-24 Climatic time-series for VCSN node 21455, Marlborough.

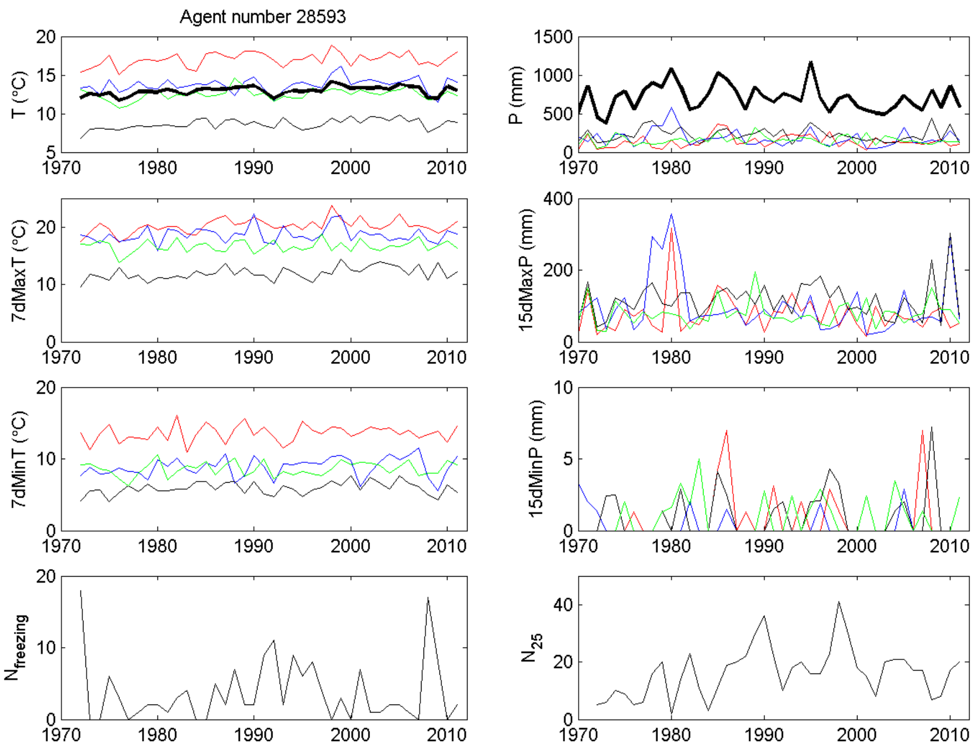

Figure A8-1-25 Climatic time-series for VCSN node 28593, Marlborough.

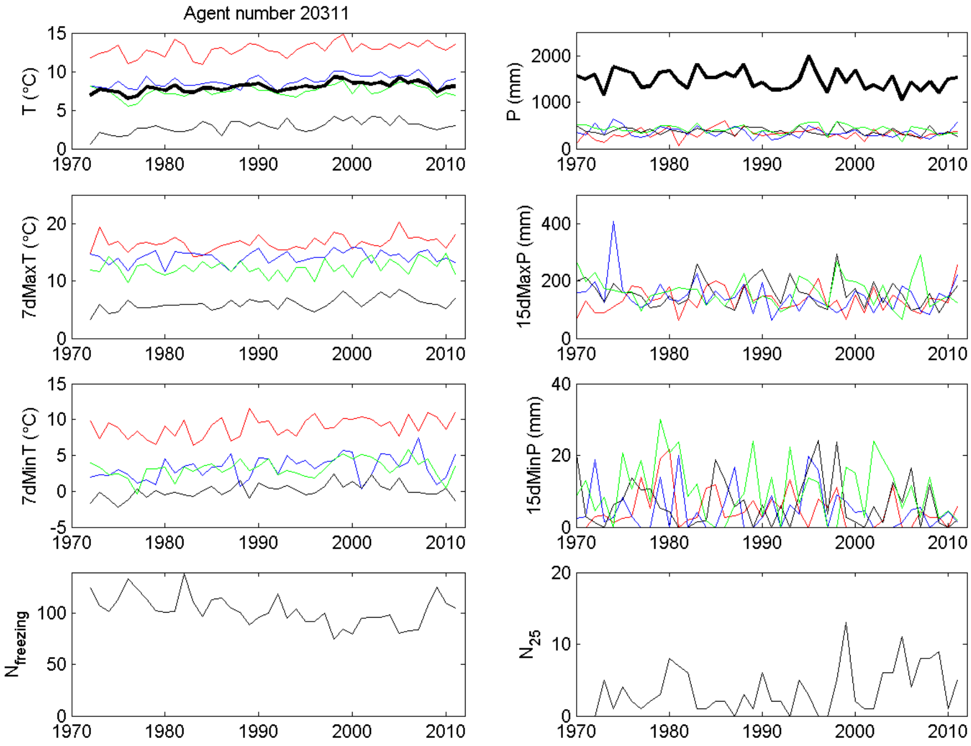

Figure A8-1-26 Climatic time-series for VCSN node 20311, Marlborough.

West Coast

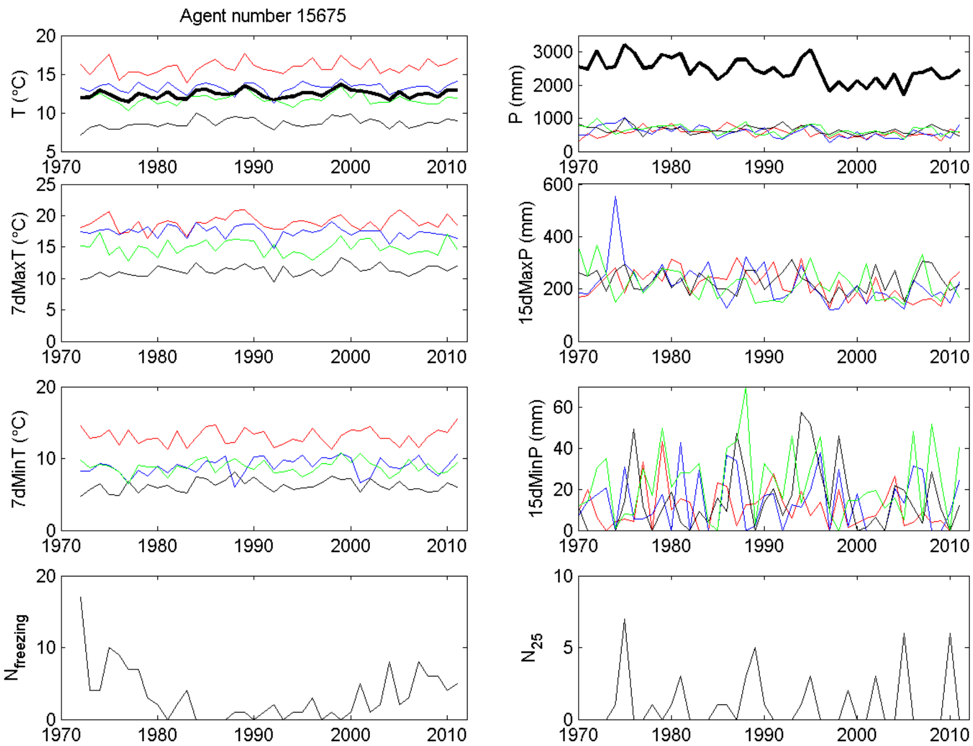

Figure A8-1-27 Climatic time-series for VCSN node 15675, West Coast.

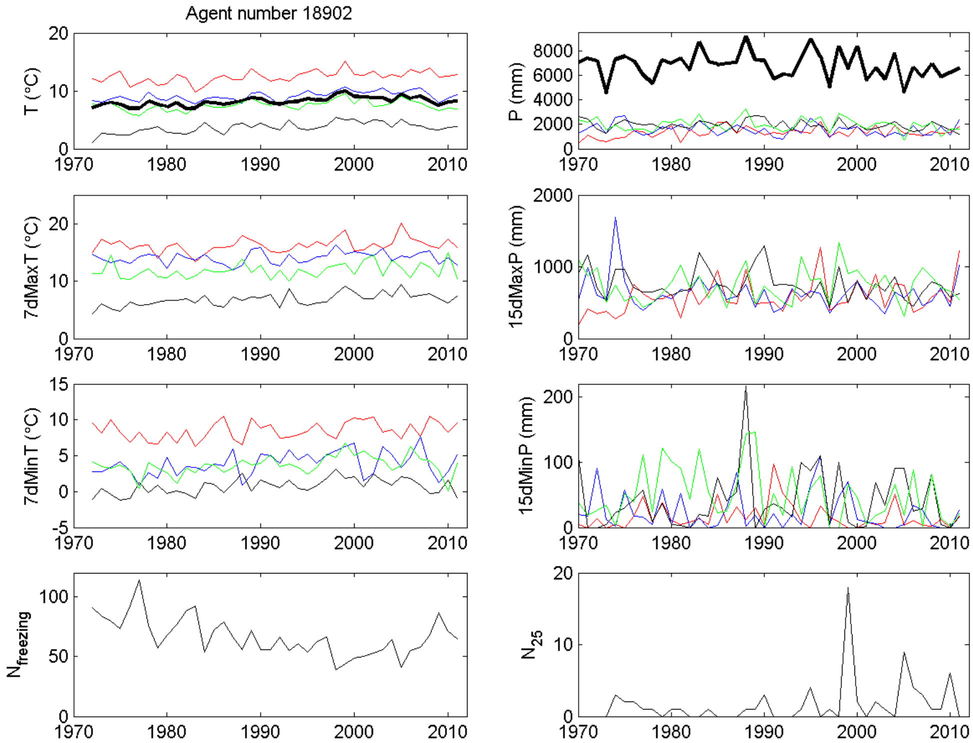

Figure A8-1-28 Climatic time-series for VCSN node 18902, West Coast.

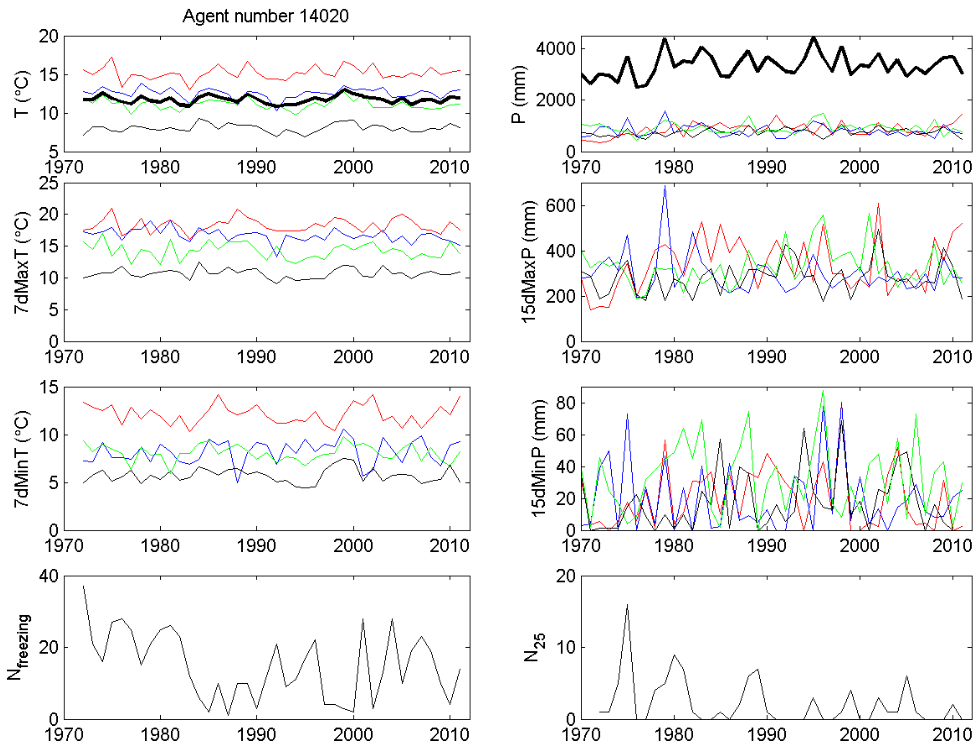

Figure A8-1-29 Climatic time-series for VCSN node 14020, West Coast.

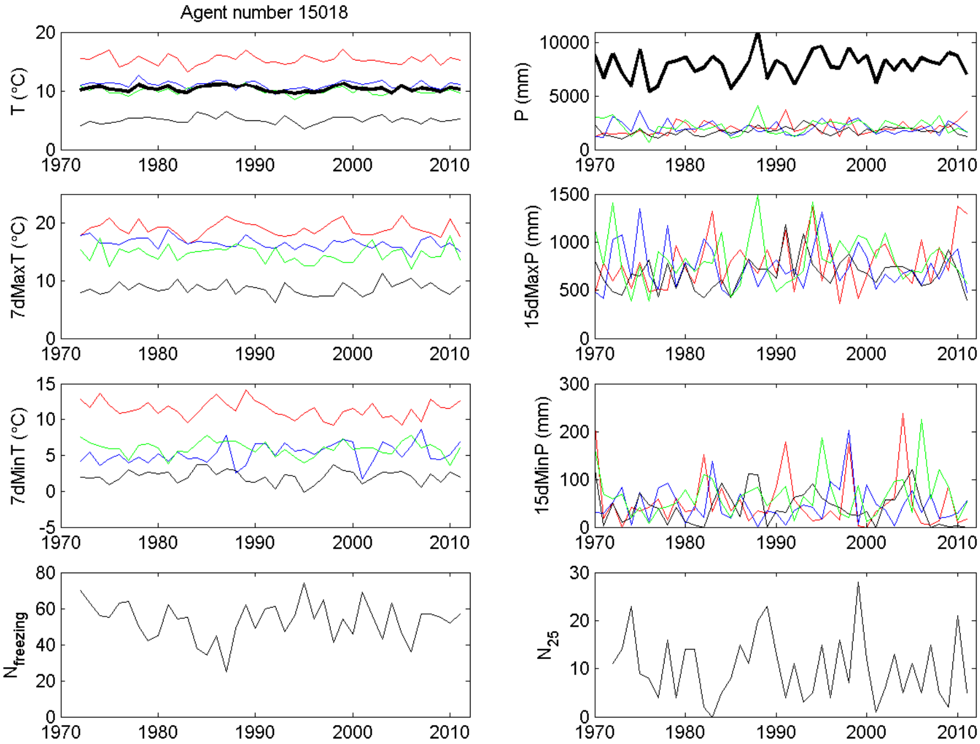

Figure A8-1-30 Climatic time-series for VCSN node 15018, West Coast.

Canterbury

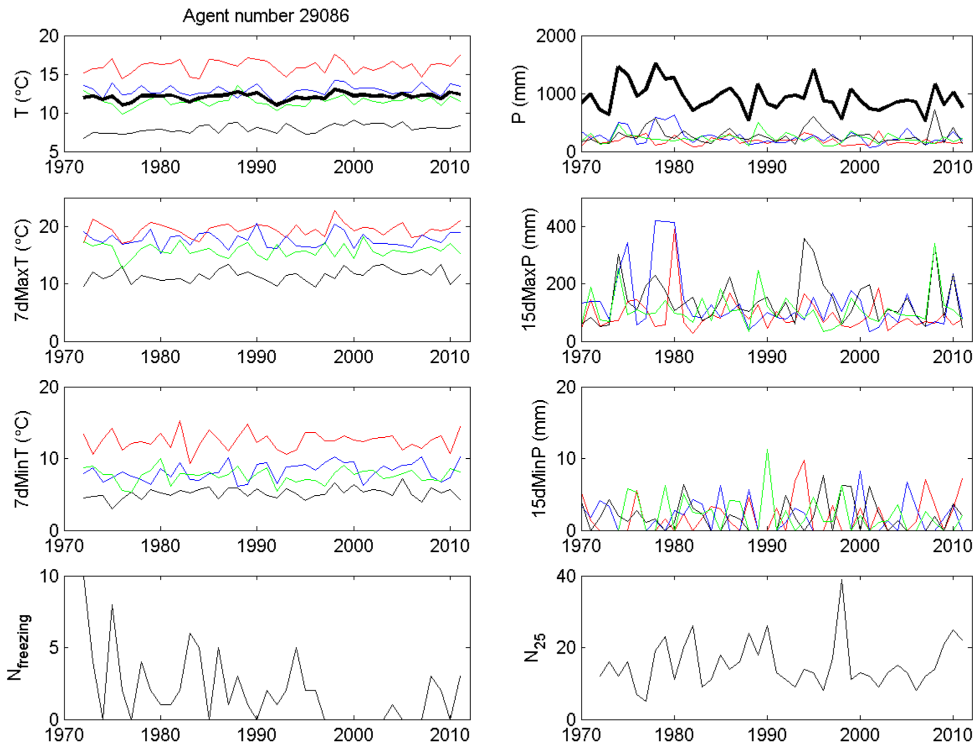

Figure A8-1-31 Climatic time-series for VCSN node 29086, Canterbury.

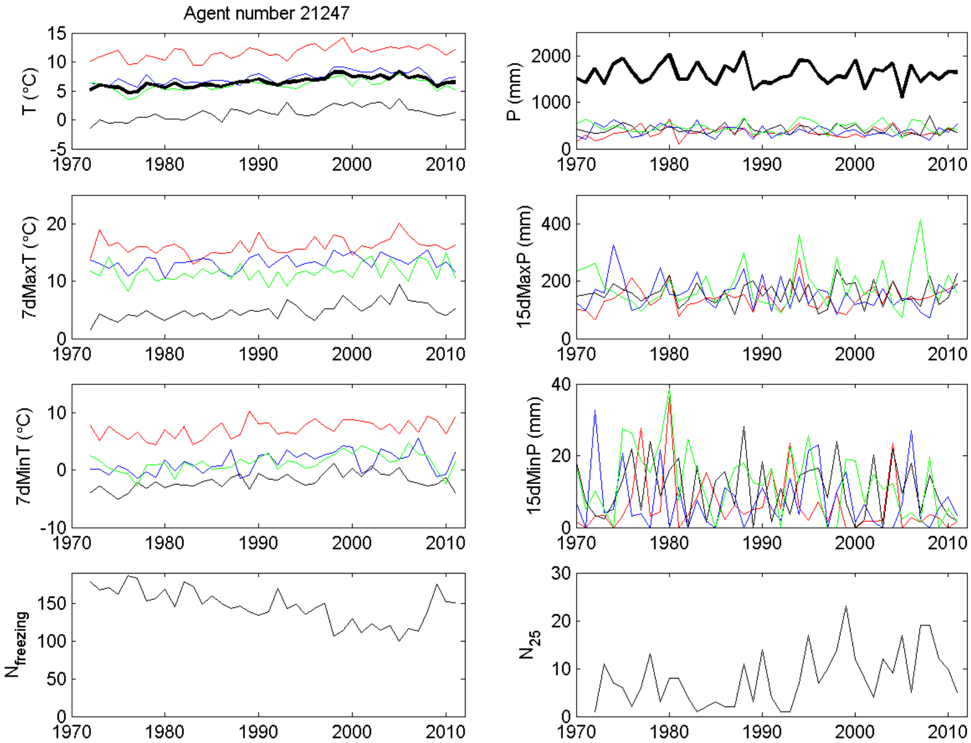

Figure A8-1-32 Climatic time-series for VCSN node 21247, Canterbury.

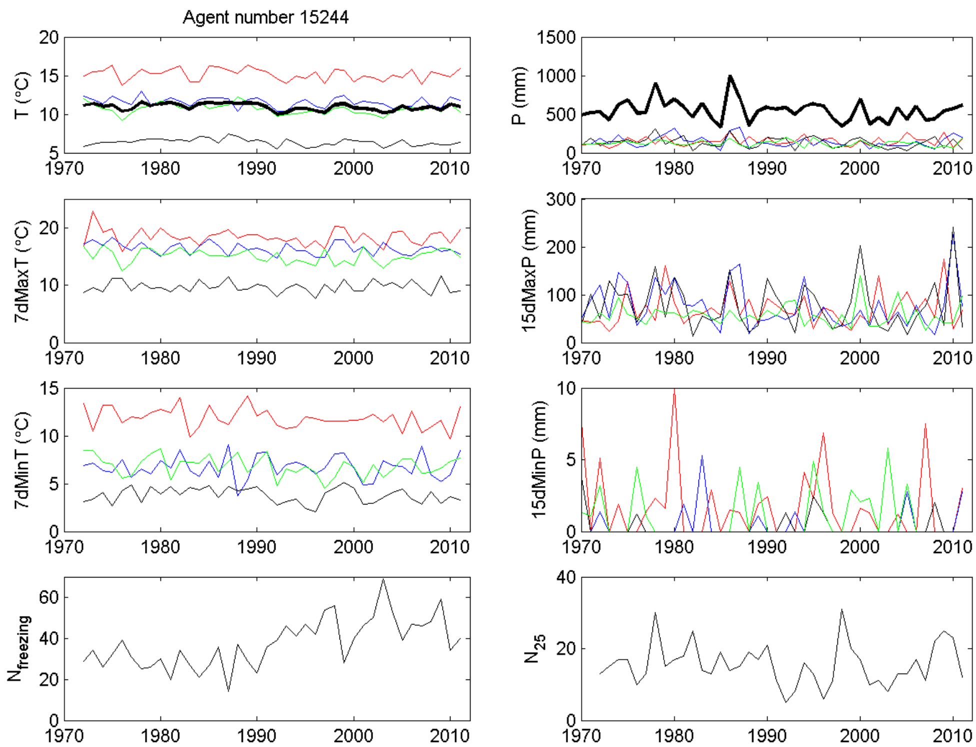

Figure A8-1-33 Climatic time-series for VCSN node 15244, Canterbury.

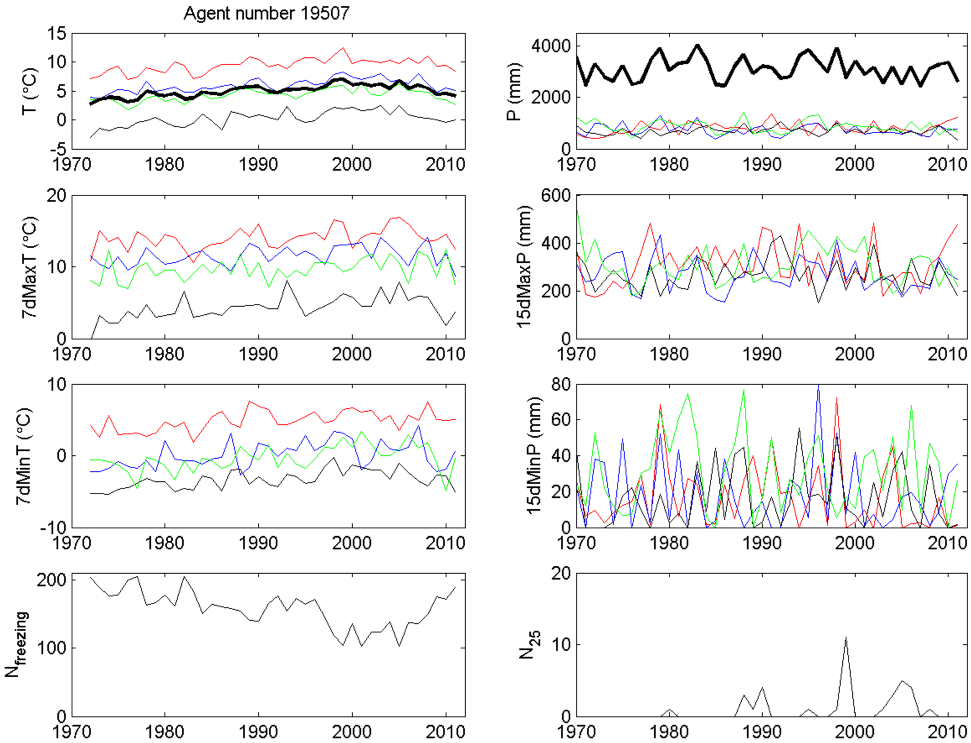

Figure A8-1-34 Climatic time-series for VCSN node 19507, Canterbury.

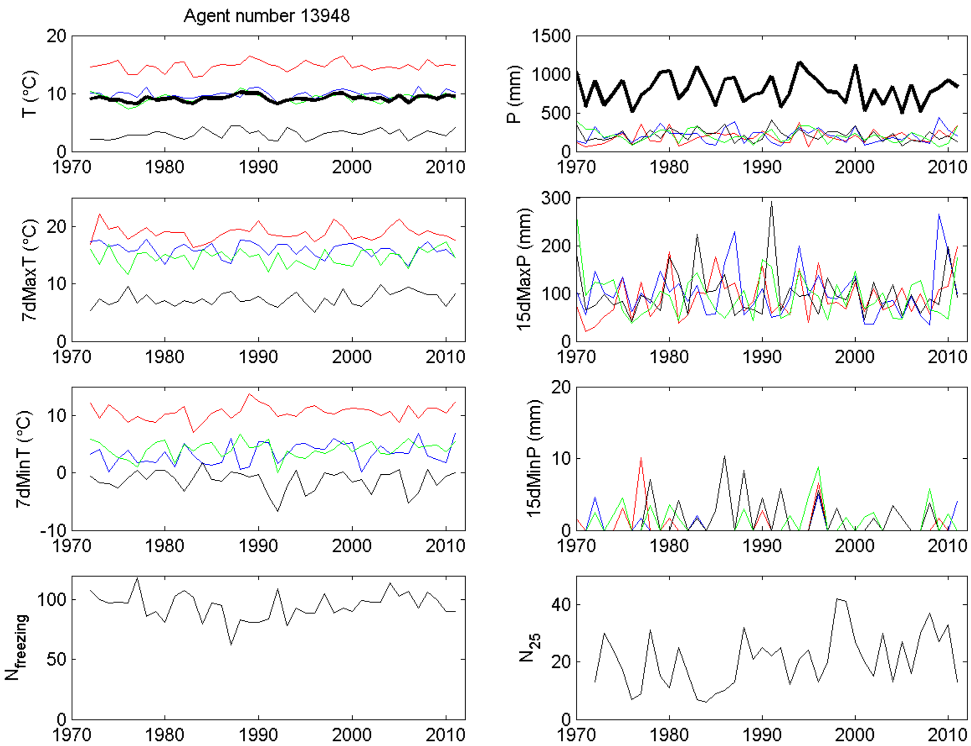

Figure A8-1-35 Climatic time-series for VCSN node 13948, Canterbury.

Otago

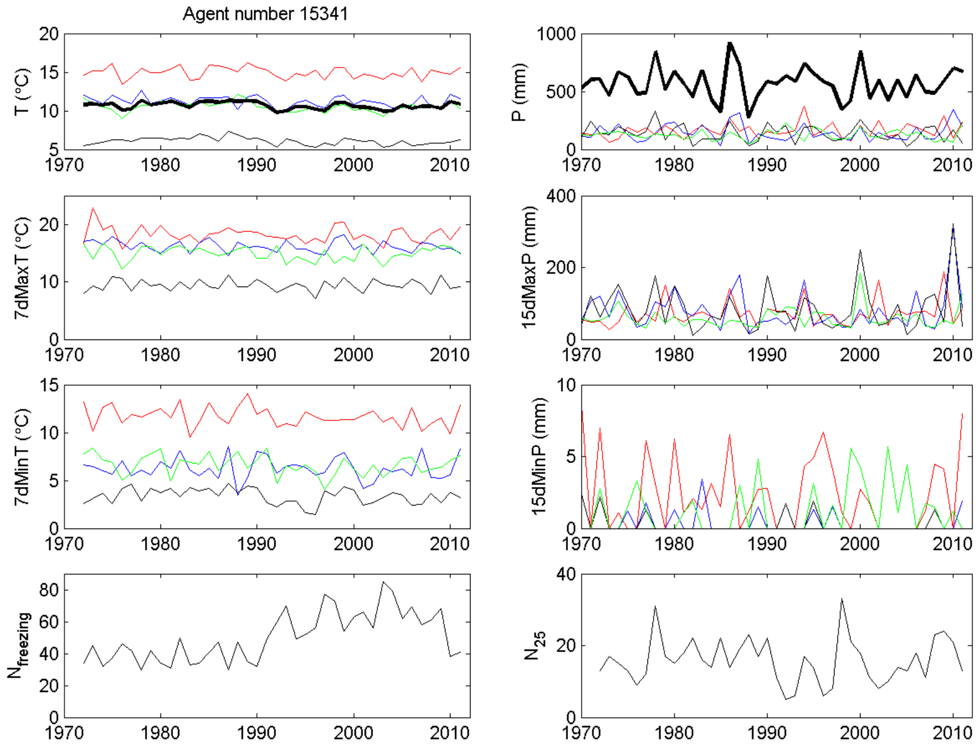

Figure A8-1-36 Climatic time-series for VCSN node 15341, Otago.

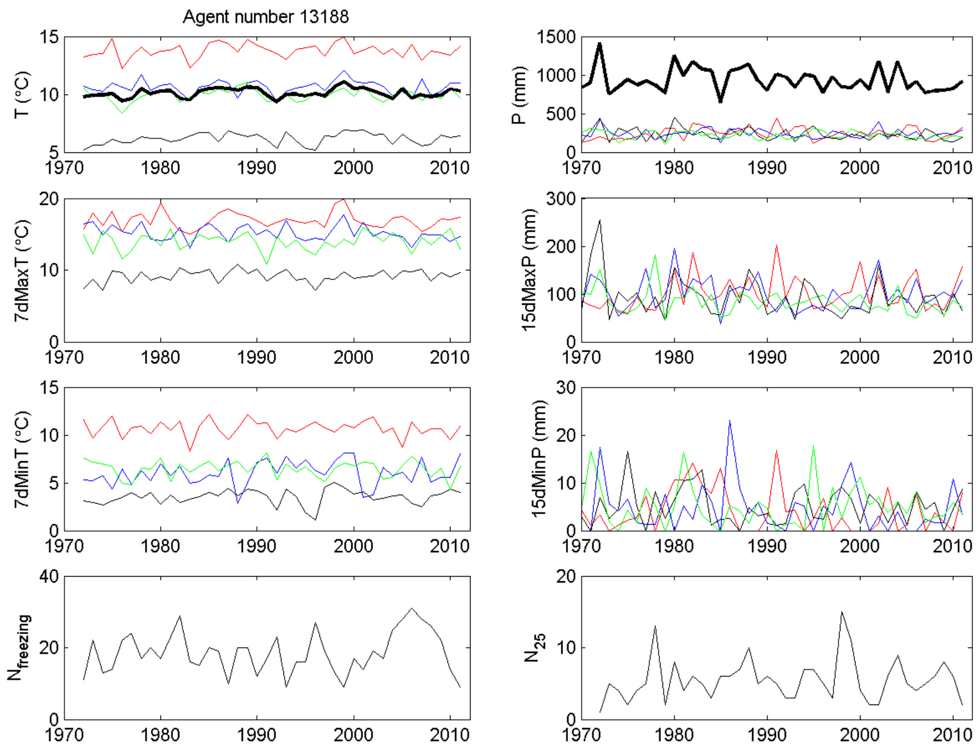

Figure A8-1-37 Climatic time-series for VCSN node 13188, Otago.

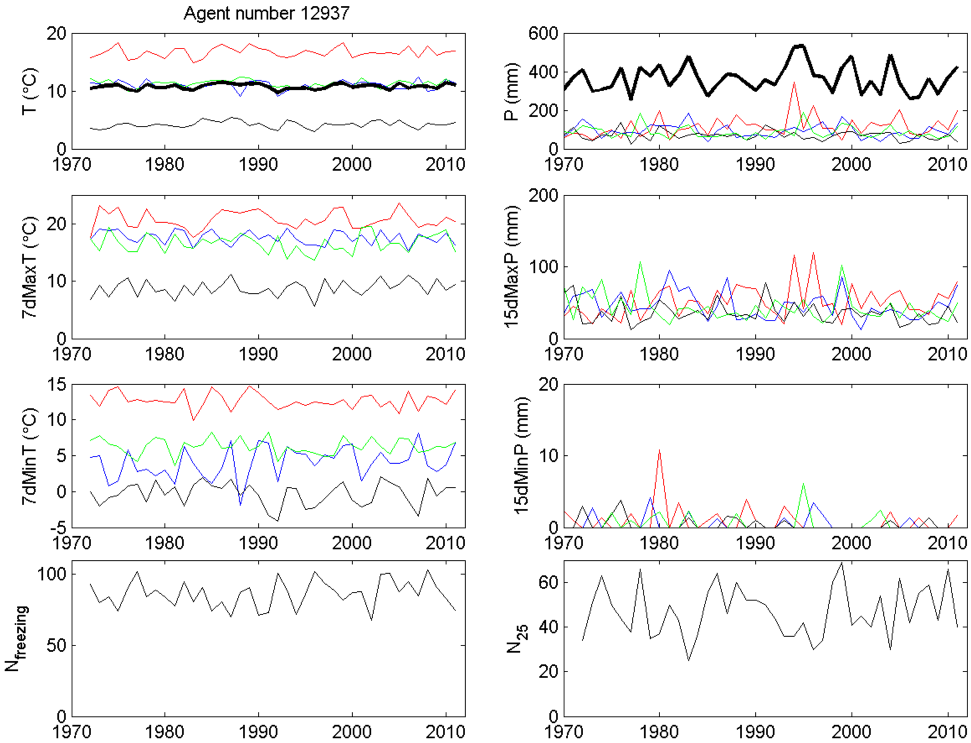

Figure A8-1-38 Climatic time-series for VCSN node 12937, Otago.

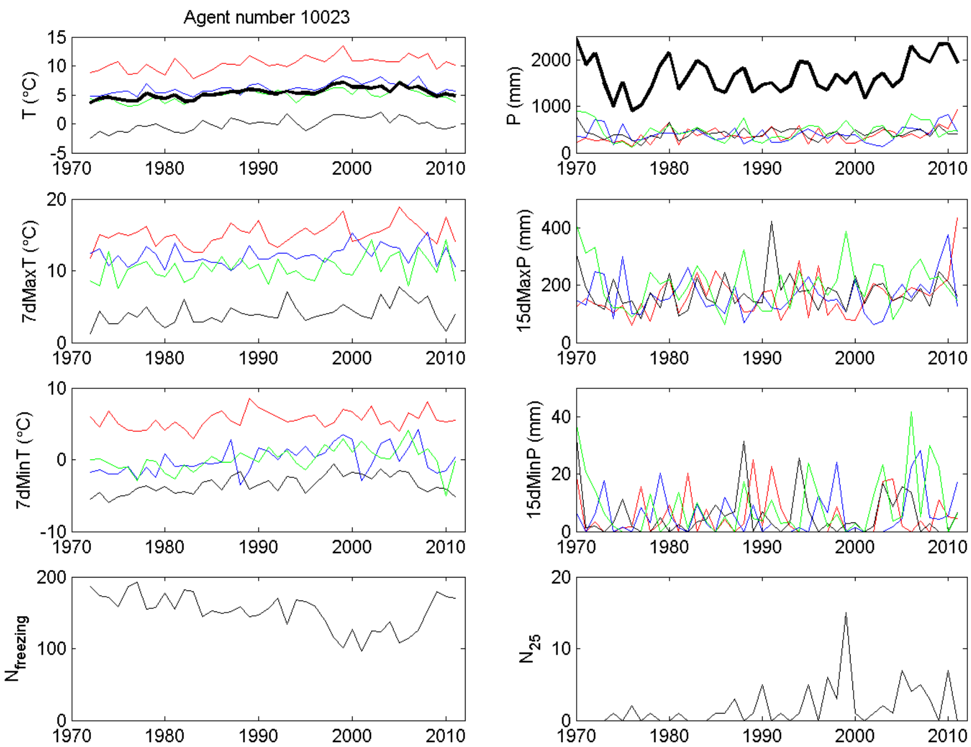

Figure A8-1-39 Climatic time-series for VCSN node 10023, Otago.

Southland

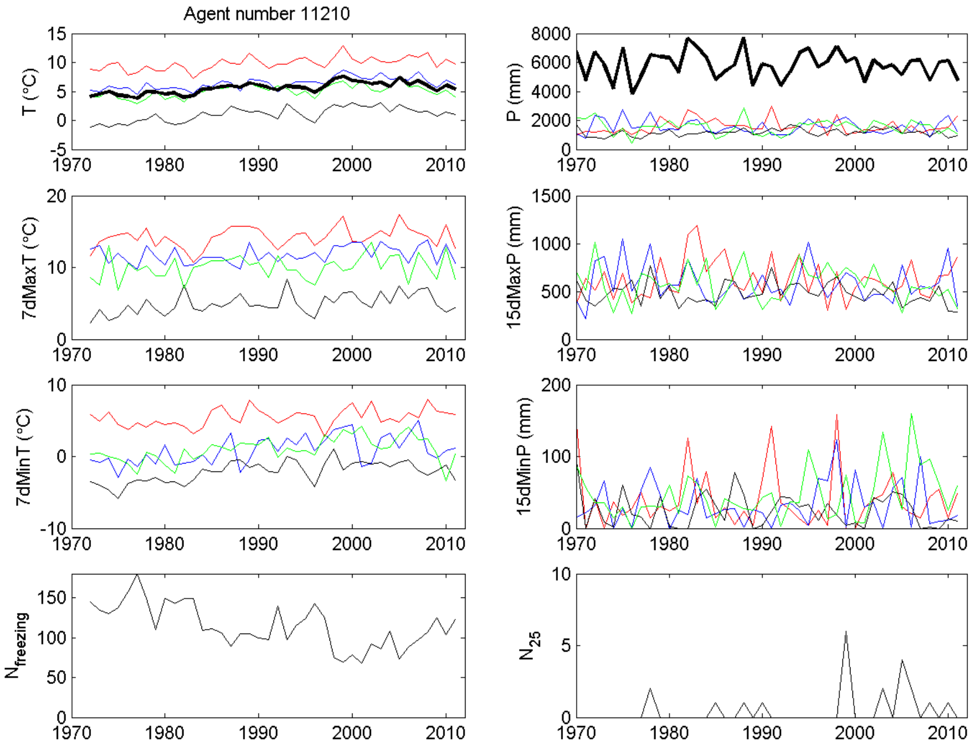

Figure A8-1-40 Climatic time-series for VCSN node 11210, Southland.

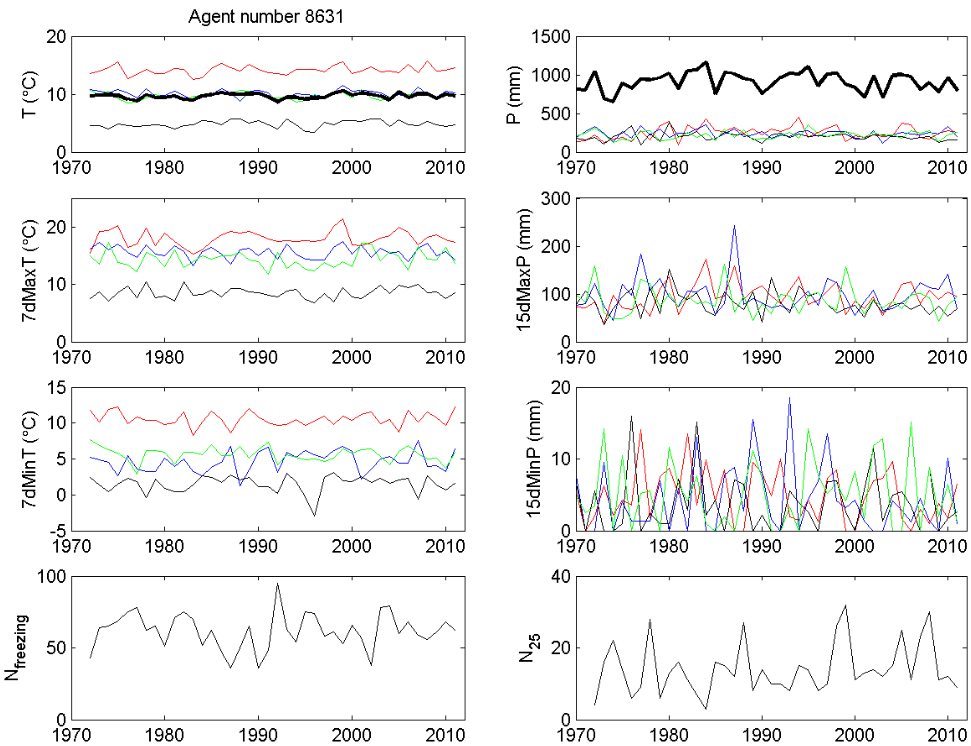

Figure A8-1-41 Climatic time-series for VCSN node 8631, Southland.

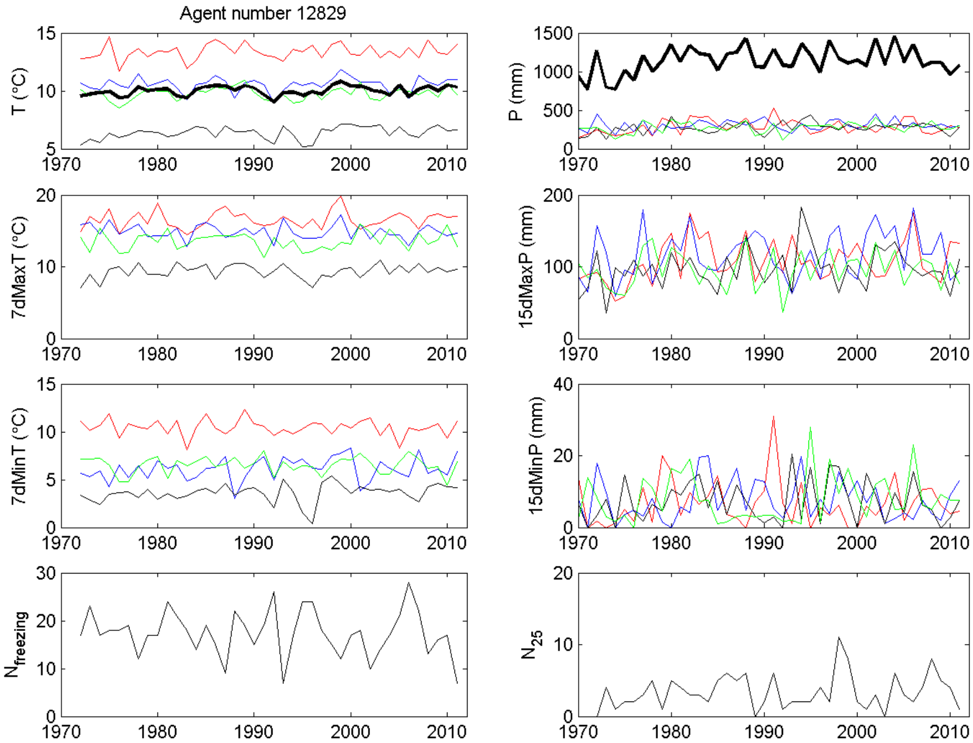

Figure A8-1-42 Climatic time-series for VCSN node 12829, Southland.

Appendix 8-2 – Long-term means and measures of short-term climatic change

This appendix includes the tables of the long-term means and changes in the climatic metrics in 2010 compared to the long-term mean.

Table A8-2-1 Long-term means of the temperature-based metrics (°C)

	Mean temperature					7dMax temperature				7dMin temperature			
VCSN node	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
20593	14.14	17.58	15.34	10.73	12.98	20.5	19.14	13.44	16.29	14.51	11.41	8.19	10.09
21795	14.88	18.62	15.92	11.08	13.98	21.41	20.04	13.89	17.41	15.69	11.49	8.04	10.59
29321	14.04	18.04	14.97	9.98	13.25	20.78	19.26	13.16	16.84	15.06	10.19	6.68	9.58
30758	13.44	17.59	14.29	9.21	12.76	20.87	19.12	12.34	16.46	14.35	9.41	6.15	9.07
28870	11.06	15.83	11.73	6.39	10.38	19.34	17	9.67	14.67	12.33	6.5	3.33	6.19
30474	13.31	17.47	14.24	9.1	12.5	20.22	18.59	11.98	16.09	14.45	9.54	6.42	8.88
27444	11.52	16.29	12.24	6.72	10.92	19.53	17.38	10.01	15.28	12.84	6.99	3.81	6.71
30102	14.17	18.52	14.82	9.81	13.62	21.86	19.63	12.99	17.88	15	10.03	7.24	9.5
28545	9.33	13.42	10.46	5.28	8.23	16.95	14.91	8.5	12.48	9.77	5.65	2.28	4.44
30713	9.68	13.27	10.81	6.1	8.59	16.75	14.93	9.08	12.26	9.9	6.63	3.47	5.35
21750	12.27	16.11	13.09	8.38	11.55	19.33	17.61	11.25	15.13	12.95	8.61	5.62	8.01
27671	13.21	17.22	14.03	9.13	12.55	20.45	18.84	12.12	16.21	13.95	9.22	6.04	8.78
29453	13.15	17.14	13.92	9.14	12.48	20.55	18.52	12.22	16.43	13.61	9.32	6.52	8.65
27191	6.46	10.98	7.33	2.06	5.55	15.13	12.57	5.41	10.29	6.93	2.24	-0.94	1.3
27455	10.07	14.79	10.82	5.35	9.42	18.39	16	8.55	14.02	11.07	5.76	2.5	5.1
27429	13.72	18.2	14.33	9.14	13.29	21.49	19.37	12.38	17.72	14.65	9.27	6.54	8.99
30178	12.71	16.29	13.64	9.08	11.9	19.03	17.79	11.88	15.24	13.25	9.37	6.55	8.64
28202	10.68	14.89	11.49	6.47	9.95	18.35	16.43	9.67	13.91	11.35	6.57	3.46	6.12
27828	13.43	17.42	14.21	9.39	12.76	20.98	18.98	12.35	16.88	13.7	9.57	6.79	9
21328	7.9	12.09	8.87	3.62	7.1	15.68	13.55	6.6	11.38	8.29	4	0.87	3.34
20275	12.53	17.04	13.26	7.74	12.15	19.96	18.07	10.67	15.96	13.99	8.09	5.07	8.35
21015	9.42	14.5	10.03	4.08	9.15	18.16	15.66	7.25	13.83	10.72	4.33	1.21	4.9
20393	10.36	14.93	11.24	5.55	9.8	18.13	16.09	8.52	13.95	11.55	6.15	2.82	5.9
21455	11.16	14.91	12.23	7.26	10.33	17.77	16.44	10.12	13.92	11.76	7.73	4.69	6.99
28593	12.95	17.02	13.71	8.63	12.5	20.18	18.64	11.94	16.64	13.57	8.87	5.9	8.61
20311	7.97	12.88	8.75	2.88	7.47	16.63	14.16	6.05	12.3	8.99	3.32	0.07	3.21
15675	12.39	15.91	13.26	8.67	11.77	18.88	17.41	11.22	14.89	13.06	8.94	6.19	8.83
18902	8.16	12.45	9.09	3.68	7.51	16.23	14.07	6.81	11.85	8.51	3.9	0.73	3.67

	Mean temperature					7dMax temperature				7dMin temperature			
VCSN node	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
14020	11.7	15.15	12.55	8.04	11.12	18.25	16.71	10.68	14.26	12.1	8.2	5.73	8.08
15018	10.35	15.32	11.02	5.05	10.09	18.96	16.47	8.6	14.63	11.41	5.26	2.08	5.97
29086	12.06	16.01	12.86	7.94	11.51	19.42	17.67	11.46	15.8	12.45	8.21	5.17	7.61
21247	6.5	11.61	7.25	1.19	6.03	16.07	13.27	4.85	11.54	7.14	1.32	-1.95	1.32
15244	10.93	15.16	11.57	6.38	10.7	18.4	16.38	9.67	15.06	11.85	6.71	3.79	6.84
19507	4.95	9.41	5.94	0.25	4.25	14	11.57	4.31	9.66	4.85	0.13	-3.33	-0.34
13948	9.16	14.73	9.79	3	9.21	18.82	15.95	7.37	14.59	10.55	3.35	-1.29	4.1
15341	10.68	14.95	11.23	6.09	10.52	18.26	16.19	9.38	14.92	11.66	6.25	3.37	6.63
13188	10.11	13.77	10.64	6.17	9.93	16.94	15.2	9.18	13.97	10.69	6.01	3.52	6.47
12937	10.73	16.65	10.96	4.19	11.24	20.69	17.58	8.79	16.59	12.68	4.04	-0.28	6.3
10023	5.32	10.4	6.12	-0.04	4.86	15.11	12.19	4.1	10.43	5.57	0.01	-3.44	0.08
11210	5.57	9.85	6.37	1.05	5.07	14.23	11.77	4.95	10.05	5.45	0.89	-2.15	0.98
8631	9.66	14.14	10.09	4.83	9.66	18.02	15.61	8.5	14.35	10.55	4.64	1.52	5.64
12829	10.01	13.37	10.56	6.38	9.76	16.55	14.91	9.33	13.61	10.45	6.11	3.61	6.52

Table A8-2-2 Difference in temperature-based metrics (°C) in 2010 relative to the long-term mean. Reductions are highlighted in red.

	Δ Mean temperature					Δ 7dMax temperature				Δ 7dMin temperature			
VCSN node	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
20593	0.4	1.42	0.68	0.18	-0.1	0.84	-0.08	0.61	-0.34	1.31	0.76	-2.04	0.31
21795	0.63	1.45	0.87	0.74	0.13	0.79	0.03	1.01	-0.43	2.12	1.72	-0.72	0.47
29321	0.11	0.98	0.17	0.02	-0.18	1.24	-0.74	0.32	-0.5	1.7	0.95	-1.69	0.21
30758	0.26	1.25	0.32	0.06	-0.23	-0.06	-1.36	0.71	-0.25	2.07	1.81	-1.09	0.15
28870	0.34	1.37	0.62	0.31	-0.22	0.76	-1.02	1.03	-0.84	2.09	1.89	-0.69	0.42
30474	0.5	1.5	0.66	0.34	0.12	1.49	-0.26	0.9	-0.04	1.98	1.08	-0.87	0.51
27444	0.11	0.89	0.57	0.16	-0.5	1.57	-0.24	0.93	-1.23	1.82	1.11	-0.69	0.37
30102	0.16	0.76	0.61	0.23	-0.28	1.97	0.24	0.45	-0.88	0.5	1.14	-0.38	0.26
28545	-0.62	-0.51	-0.28	-0.3	-1.22	0.9	-1.48	0.35	-1.77	-0.31	-0.02	-2.1	0.01
30713	-0.09	0.29	0.28	-0.11	-0.62	0.12	-0.96	0.4	-1.22	1.5	1.34	-2.1	0.32
21750	0.64	1.16	1.02	0.59	0.2	0.53	-0.61	0.8	-0.3	2.25	2.51	-0.5	0.88
27671	0.37	1.3	0.52	0.1	0.12	0.18	-0.81	0.34	-0.17	1.96	2.39	-0.83	0.53
29453	-0.31	0.31	0.11	-0.24	-0.62	0.3	0.06	-0.17	-0.93	0.62	1.78	-1.74	0.3
27191	0.21	1.23	0.41	0	-0.34	0.97	-1.47	0.95	-0.84	1.97	0.91	-2.27	0.42
27455	-0.25	0.58	0.1	-0.24	-0.79	2.15	-0.73	0.5	-1.85	1.23	0.75	-1.4	0.43
27429	0.11	1.08	0.3	0.15	-0.17	1.8	-0.02	0.15	-0.6	1.56	1.49	-0.26	-0.21
30178	0.09	0.67	0.38	-0.01	-0.17	-0.42	-0.34	0.07	-0.9	1.46	1.53	-1.4	0.58
28202	-0.05	0.87	0.18	-0.31	-0.4	0.05	-0.36	-0.43	-1.39	1.32	1.16	-1.39	0.56
27828	-0.35	0.75	0	-0.54	-0.66	0.95	0.73	-0.38	-0.88	0.88	0.87	-1.5	-0.1
21328	-0.43	-0.03	-0.01	-0.34	-1.15	1.02	-1.26	0.56	-2.17	0.32	1.23	-2.19	-0.33
20275	0.37	1.13	0.74	0.27	-0.08	1.53	-0.75	1.17	0.05	1.92	2.6	0.37	0.24
21015	0.4	0.96	0.65	0.41	-0.29	0.72	-1.09	0.77	-0.66	2.33	2.26	-0.51	0.41
20393	0.09	0.7	0.37	0.13	-0.34	1.56	-0.83	0.96	-0.46	1.8	2.09	-0.46	0.66
21455	-0.06	0.59	0.04	-0.3	-0.11	0.73	-0.61	0.14	-0.47	1.6	0.99	-1.22	0.83
28593	0.11	0.98	0.36	0.19	-0.21	0.86	0.08	0.26	-0.37	0.98	1.43	-0.6	0.63
20311	0.09	0.67	0.31	0.16	-0.51	1.37	-0.94	0.83	-1.06	1.93	1.82	-1.4	0.3
15675	0.54	1.08	0.77	0.33	0.11	-0.39	-0.96	0.73	-0.21	2.49	1.68	-0.16	0.57
18902	0.05	0.34	0.29	0.12	-0.61	-0.4	-1.27	0.53	-1.45	1.04	1.25	-1.54	0.24
14020	0.25	0.32	0.4	0.08	-0.02	-0.71	-1.51	0.3	-0.46	1.85	1.08	-0.67	0.08
15018	0	-0.08	0.06	0.19	-0.49	-1.23	-1.49	0.46	-1.1	1.15	1.63	-0.09	0.04
29086	0.33	1.39	0.53	0.42	-0.09	1.52	1.23	0.09	-0.47	2	2	-0.95	0.47

	Δ Mean temperature					Δ 7dMax temperature				Δ 7dMin temperature			
VCSN node	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
21247	0	0.62	0.11	0.18	-0.75	0.24	-1.57	0.36	-0.91	2.09	1.71	-1.99	0.18
15244	0.02	0.77	0.18	0.01	-0.37	1.28	-1.02	-0.6	-0.2	1.16	1.72	-0.5	0.85
19507	-0.87	-0.94	-0.84	-0.24	-1.59	-1.59	-2.82	-0.68	-2.07	0.2	0.42	-1.74	0.04
13948	0.35	0.11	0.38	1.13	-0.13	-1.2	-1.45	0.94	0.02	1.76	3.54	1.24	1.27
15341	0.13	0.61	0.35	0.2	-0.21	1.24	-1.19	-0.25	-0.07	1.18	2.04	-0.16	0.99
13188	0.14	0.43	0.32	0.26	-0.25	0.42	-0.52	0.5	-1.07	0.21	2.04	0.48	0.23
12937	0.16	0.25	0.49	0.36	-0.46	-0.34	-1.32	0.61	-1.43	1.47	2.72	0.83	0.56
10023	-0.42	-0.2	-0.46	-0.34	-1.13	-0.97	-1.66	-0.15	-1.81	-0.04	0.29	-1.67	-0.28
11210	-0.17	-0.16	-0.17	-0.02	-0.99	-1.58	-1.22	-0.57	-1.65	0.4	0.25	-1.15	-0.59
8631	0.07	0.42	0.09	-0.13	-0.35	-0.64	-1.36	0	-0.68	1.68	1.79	0.05	0.26
12829	0.3	0.67	0.39	0.25	-0.07	0.41	-0.26	0.34	-0.8	0.64	1.85	0.56	0.37

Table A8-2-3 Long-term means of the number of days with mean daily temperatures below or equal to 0°C (**$N_{freezing}$**) or above or equal to 25°C (**N_{25}**)

VCSN node	$N_{freezing}$	N_{25}
20593	0.6	11.7
21795	2.2	20.1
29321	7.6	15.6
30758	9	20.5
28870	45.7	12.2
30474	4.8	9.9
27444	43.3	13.1
30102	5.1	44
28545	36	1.5
30713	16.5	0.4
21750	10.4	4.6
27671	9.1	14.8
29453	4.3	17.6
27191	118.2	0.9
27455	50.1	8
27429	13.7	38
30178	0.8	1.8

VCSN node	$N_{freezing}$	N_{25}
28202	34.6	5
27828	1.3	29.2
21328	76.3	0.7
20275	25.2	12.2
21015	88.1	16.5
20393	43.2	2.5
21455	7.9	0.7
28593	3.8	16.3
20311	102.9	3.7
15675	3.3	1.1
18902	66.7	1.8
14020	14.9	2.2
15018	53.3	10.2
29086	2	15.4
21247	145.7	8.1
15244	37.5	15.6
19507	158	0.9
13948	94.6	20.7
15341	50.2	15.9
13188	18.6	5.5
12937	86.3	47
10023	151.6	2
11210	114.8	0.5
8631	61.7	14.2
12829	17.4	3.4

Table A8-2-4 Difference in the number of days in 2010 with mean daily temperatures below or equal to 0°C (**$\Delta N_{freezing}$**) or above or equal to 25°C (**ΔN_{25}**) relative to the long-term mean. Reductions are highlighted in red.

VCSN node	$\Delta N_{freezing}$	ΔN_{25}
20593	-0.6	8.4
21795	-2.2	5.9
29321	-0.5	0.4
30758	-1	8.6
28870	-10.7	-2.2
30474	1.2	7.1
27444	-10.3	-4.1

VCSN node	Δ $N_{freezing}$	Δ N_{25}
30102	-4.1	-11
28545	9	-0.5
30713	1.6	-0.4
21750	-5.4	-2.6
27671	-2.1	0.2
29453	-2.3	-2.6
27191	-1.2	0.2
27455	10.9	1
27429	-3.7	-8
30178	-0.8	-0.8
28202	4.4	-1
27828	-0.3	1.8
21328	28.7	-0.7
20275	0.8	11.8
21015	-15.1	-1.4
20393	4.8	2.5
21455	1.1	-0.7
28593	-1.8	3.7
20311	2.1	1.3
15675	1.7	-1.1
18902	-1.7	-1.8
14020	-0.8	-2.2
15018	3.8	-5.2
29086	1.1	6.6
21247	5.3	-3.1
15244	2.5	-3.6
19507	30	-0.9
13948	-4.6	-7.7
15341	-9.2	-2.8
13188	-9.6	-3.5
12937	-11.3	-7
10023	18.4	-2
11210	8.3	-0.5
8631	0.3	-5.2
12829	-10.4	-2.4

Table A8-2- 5 Long-term means of the precipitation-based metrics (mm)

VCSN node	Mean precipitation (mm)					15dMax precipitation (mm)				15dMin precipitation (mm)			
	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
20593	1720	307	394	611	403	149	168	203	153	2	5	27	8
21795	1526	268	366	524	363	129	162	178	137	1	4	17	7
29321	2281	413	577	762	522	223	277	285	225	3	6	17	8
30758	1829	344	414	575	489	152	175	194	187	4	6	18	9
28870	1434	315	324	430	360	142	139	153	140	2	2	9	7
30474	2229	438	553	694	535	219	265	263	228	2	4	15	8
27444	1604	347	392	474	386	171	185	195	162	2	2	7	5
30102	1128	221	327	347	232	118	162	156	115	1	2	5	3
28545	2724	477	679	920	645	239	318	338	259	3	5	21	10
30713	5417	1028	1244	1589	1533	432	489	541	559	13	23	56	38
21750	1607	323	376	487	415	143	155	171	157	3	5	15	9
27671	918	201	214	260	241	90	92	96	96	1	2	5	4
29453	1152	213	299	375	263	114	144	155	122	1	3	7	3
27191	3159	641	693	910	910	254	274	312	320	12	13	27	25
27455	2739	532	684	854	664	242	280	300	253	8	12	31	17
27429	794	166	220	245	162	91	116	121	85	0	0	2	1
30178	1191	218	285	385	299	100	121	144	117	1	3	10	5
28202	3864	742	862	1150	1103	324	342	395	408	11	14	38	25
27828	1096	179	289	393	232	100	138	153	104	1	2	8	3
21328	5775	1139	1336	1591	1690	479	511	585	620	16	21	40	44
20275	986	201	247	282	248	99	116	129	105	1	1	2	2
21015	1586	348	367	401	464	144	150	161	179	5	6	8	12
20393	1392	295	345	369	372	144	156	168	166	1	2	3	4
21455	1668	320	397	484	459	143	170	198	184	3	5	9	6
28593	703	139	181	224	156	77	99	117	79	1	0	1	1
20311	1483	325	357	375	420	134	146	158	162	5	5	7	10
15675	2450	563	585	653	643	218	217	229	219	11	13	15	23
18902	6848	1332	1575	1951	1970	581	633	751	740	16	23	41	49
14020	3334	858	808	744	919	341	297	281	329	20	19	17	32
15018	7897	2016	2006	1707	2158	782	745	673	818	53	47	42	67
29086	933	180	254	271	226	92	133	142	111	2	2	2	2
21247	1621	351	383	418	465	141	155	158	181	6	7	11	12
15244	547	148	143	133	123	69	76	77	57	2	0	0	1

VCSN node	Mean precipitation (mm)					15dMax precipitation (mm)				15dMin precipitation (mm)			
	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
19507	3103	806	735	693	865	312	268	268	308	17	18	16	30
13948	799	184	205	207	201	91	102	101	95	1	0	2	1
15341	570	161	144	138	126	72	80	84	60	2	0	0	1
13188	934	242	240	231	222	102	100	93	84	4	5	5	5
12937	363	115	92	69	87	52	46	36	43	1	0	0	0
10023	1667	379	402	418	467	161	164	176	202	5	6	6	9
11210	5844	1569	1557	1170	1546	628	581	483	578	39	33	25	47
8631	911	252	240	200	220	95	98	81	86	5	4	4	5
12829	1137	285	307	269	276	108	117	97	96	7	8	7	8

Table A8-2- 6 Difference in precipitation (mm) in 2010 relative to the long-term mean. Reductions are highlighted in red.

VCSN node	Δ Mean precipitation (mm)					Δ 15dMax precipitation (mm)				Δ 15dMin precipitation (mm)			
	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
20593	-121	-88	-79	-55	-61	23	-44	-12	-2	-2	5	-20	-8
21795	179	165	139	-123	-70	130	-12	-54	-26	-1	15	-7	0
29321	152	252	216	-293	-117	197	9	-131	-2	2	28	-11	-4
30758	187	182	122	-33	-54	101	-17	34	-6	-4	-1	-12	4
28870	200	179	175	-106	-120	232	-24	11	-24	-2	5	-7	-5
30474	371	227	196	-184	-12	183	8	-79	93	2	8	-10	1
27444	690	368	384	-87	-9	332	57	-16	84	-1	16	-6	-1
30102	139	70	185	-22	-122	72	79	-48	-66	-1	8	0	3
28545	-7	111	407	-248	-237	83	65	-123	-38	0	17	-4	0
30713	767	238	742	-317	16	350	50	-1	-39	-11	69	-37	-20
21750	392	71	163	60	-2	65	15	26	21	-3	14	-10	-5
27671	148	-7	15	43	43	35	-14	42	5	-1	5	-4	-2
29453	152	0	160	-15	-48	26	88	-33	-60	1	4	-3	3
27191	156	130	242	-77	68	124	-8	92	-26	-3	6	-14	-14
27455	202	189	284	-179	-64	209	38	-54	37	-5	8	-12	2
27429	147	83	140	-45	-58	110	104	-43	-46	0	0	-2	-1
30178	-69	-8	68	-104	-50	7	-28	-26	-27	-1	14	-10	-1
28202	7	8	368	-276	57	16	-5	-80	-82	-3	13	-25	-13

VCSN node	Δ Mean precipitation (mm)					Δ 15dMax precipitation (mm)				Δ 15dMin precipitation (mm)			
	Annual	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
27828	16	-35	48	-58	-20	9	-2	-6	-34	-1	6	-5	1
21328	45	246	721	-478	-258	488	234	31	-162	-6	10	-20	-24
20275	446	47	173	3	64	84	77	-5	50	0	1	-2	-2
21015	1	77	220	-169	-56	137	79	37	18	1	-2	-5	-5
20393	372	133	240	-93	-50	148	72	24	14	3	6	-3	-4
21455	228	178	330	-159	-75	185	60	-41	-41	-3	24	-7	-4
28593	-118	-30	-22	-99	-24	-24	-34	-46	-25	-1	0	-1	1
20311	60	49	215	-114	-79	121	75	24	-37	1	-3	-5	-8
15675	-1	7	226	-173	-48	48	8	-14	-49	-11	11	-3	18
18902	-234	511	781	-740	-330	643	391	-120	-194	1	3	-25	-28
14020	-317	588	-93	-268	-138	179	-18	-95	-71	-17	6	-17	-3
15018	-821	1581	-377	-504	-452	511	-265	-278	-251	-36	7	-42	-13
29086	-169	-33	-54	-136	-2	-15	-56	-93	-33	5	-2	0	0
21247	35	6	152	-63	-54	51	35	70	-22	-4	-4	-9	-10
15244	68	32	63	-83	63	-2	0	-45	41	1	2	0	-1
19507	-491	415	44	-342	-203	165	-23	-88	-90	-15	17	-14	-4
13948	33	145	0	-84	119	106	-2	-10	78	-1	4	-2	-1
15341	99	75	53	-85	104	12	9	-47	67	6	2	0	-1
13188	-18	78	46	-43	-18	55	28	-27	-11	4	-1	4	-1
12937	60	82	39	-31	27	27	28	-13	7	1	0	0	0
10023	274	556	66	-16	17	274	-36	-15	-56	-1	11	1	-3
11210	-1063	693	-307	-233	-468	224	-232	-197	-258	10	-15	-15	13
8631	-115	4	-34	-42	34	0	-29	-11	7	2	-3	-1	-4
12829	-57	-4	-8	7	19	25	-23	13	-20	-2	5	0	0

9 Indicator M12: Change in protection of naturally uncommon ecosystems

Authors: Robert Holdaway and Susan Wiser, Landcare Research

9.1 Introduction

Indicator M12 reports change in protection (area and type) of naturally uncommon ecosystems. This definition is reduced in scope from the original ‘change in extent and protection of habitats or naturally uncommon ecosystems’ to avoid overlap with other measures, particularly M9 (‘Habitat and vegetation loss’) and M18 (‘Area and type of legal biodiversity protection achieved on private land’). Spatial data on legally protected areas are available from the Protected Areas Network (PAN-NZ) spatial layer or an equivalent spatial layer maintained by the regional councils. The six classes of legal protection described in M18 will also be employed here (section 15, Table 15-6). A list of naturally uncommon ecosystems is provided in Table 4-1 (section 4.2.2 ‘Vulnerable ecosystem definition’). The capacity to report change in protection (area and type) of naturally uncommon ecosystems comprehensively in any region is entirely contingent on comprehensive mapping of all naturally uncommon ecosystems in each region (needed for M5). Evaluating this measure (M12) simply involves overlaying these two spatial layers to estimate the area and type of legal biodiversity protection for each ecosystem type. The basic M12 reporting statistics are

- a list of ecosystems to be reported on (based on results of M5)
- dated estimates of extent (ha) occupied by each ecosystem (based on repeat assessment of M5)
- dated estimates of extent (ha) with legal protection, by protection class, for each ecosystem
- percentage of the total area protected for each ecosystem (by protection class, for two time periods)
- percentage change in area protected for each ecosystem (by protection class). This should be expressed as an annual rate of change (hectares per year).

Issues of data access and data sensitivity are important and will need to be taken into consideration, particularly for sensitive ecosystems on private land. The accuracy of the spatial layers used also needs to be considered, and any information derived from these layers should be treated as indicative only and should not be used to guide policy decisions about a particular site without a site visit.

9.2 Scoping and analysis

Indicator M12 was originally defined as ‘change in extent and protection of habitats or naturally uncommon ecosystems’ (Lee & Allen 2011). We have narrowed this definition to ‘change in protection (area and type) of naturally uncommon ecosystems’. This was done to avoid overlap with other measures, particularly

- M9 ('Habitat and vegetation loss'), which measures change in extent of LCDB habitat types and naturally uncommon ecosystems
- M18 ('Area and type of biodiversity protection achieved on private land'), which measures area protected and change in area protected for LCDB habitat types.

By protection, we refer to *legal* protection. We are cognisant of two limitations. First, not all forms of legal protection assure the same degree of protection for conservation purposes. For example, mining can potentially be allowed on certain parts of the land administered by the Department of Conservation (DOC). Second, legal protection does not necessarily directly equate with biodiversity protection. Legal protection does not necessarily guarantee that the ecological condition of a particular site will be good; ongoing degradation to a protected site can proceed for a number of reasons, such as the impacts of exotic plants and animals or disturbances such as fire and climate change.

Assessing the change in legal protection of naturally uncommon ecosystems requires two sets of spatial information available from other measures. Spatial layers of extent of naturally uncommon ecosystems will be derived as part of M5 ('Vulnerable ecosystems'). Spatial data on legally protected areas are available from the Protected Areas Network (PAN-NZ) spatial layer or an equivalent spatial layer maintained by the regional councils (Note: it is recommended that a single national layer such as PAN-NZ is used and continuously updated by all councils; see M18 section 15).

Current extent of legal protection (area and type) can be assessed with single point-in-time spatial layers of ecosystem extent and protected areas. Change in extent of legal protection requires spatial data from two points in time. The requirements for two sets of spatial data and the fact that both ecosystem extent and legal protection are unlikely to change rapidly means that this measure should be reported every 3 years, as the data become available through implementation of M5 and M18.

The caveat that legal protection does not necessarily directly equate with biodiversity protection is relevant for both M12 and M18; both use legal protection for practical reasons. Changes in legal protection may falsely give the impression that some positive action is occurring. Legal protection does not necessarily mean that basic standards of care are in place. For example, it can be difficult for communities to seek external funding for reserves where the Crown is unable to fund any basic actions such as fencing. Another example is the extra process involved to plan actions on land with high degrees of legal protection including restricted access (e.g. nature reserves, scientific reserves). The relationship between legal protection and biodiversity protection therefore needs to be taken into account when interpreting the results of M12.

9.3 Assessment of existing methodologies

A questionnaire was undertaken by phone to assess existing methodologies employed by the regional councils that might be relevant to M12 (see responses in Appendix 9). As this measure is reliant on data from M5 and M18, comments provided on those measures are relevant here as well. In general, change in extent of legal protection of naturally uncommon ecosystems was not currently reported on by any council.

National-level data exist that are relevant to this measure. The PAN-NZ spatial layer is available from the 'Our Environment' website hosted by Landcare Research at http://ourenvironment.scinfo.org.nz/home, and provides the necessary spatial data on legal protection. Draft national-scale layers for naturally uncommon ecosystems are also available from DOC for some ecosystems. Additionally, some councils have mapped the extent of a least a subset of the naturally uncommon ecosystems that occur within their jurisdictions (Bay of Plenty, Waikato, Taranaki); further details are in section 4 (Indicator M5: Vulnerable ecosystems).

9.4 Development of a sampling scheme

A list of naturally uncommon ecosystems, based on Williams et al. (2007), is listed for M5 (section 4.2.2, Table 4-1). Spatial layers of protected areas can be sourced from the national PAN-NZ data layer (see M18: Area and type of legal biodiversity protection; section 15). Indicator M12 simply involves overlaying the spatial layers of both M5 and M18 to estimate the area and type of legal biodiversity protection for each ecosystem type. The six classes of legal protection described in M18 will also be employed here. These six classes form a ranking scale from 0 to 5, with 0 being no legal protection and 5 being a wildlife sanctuary, which is the highest form of legal protection.

9.5 Data management and access requirements

Data storage and data ownership issues will be similar to those listed for M5 (section 4). Spatial data should be stored as shapefiles and compiled as a national data layer, in collaboration with DOC's team that maps rare ecosystems and wetlands. Associated data should be stored in databases directly linked to the spatial shapefiles in a GIS system. All GIS shapefiles should contain sufficient metadata to enable repeat measurements and interpretation by other potential users.

To enable accurate assessments of change over time, efforts must be made to ensure standardisation of field methods, data storage, and data formats across time. This will facilitate rapid and reliable comparison of data over time.

Three aspects of these data raise issues of data access.

1. Many of these ecosystems are highly sensitive and revealing locations to the general public is unwise. This is much the same problem encountered with threatened species. As an example, the New Zealand Speleological Society (NZSS) holds a spatial layer of cave systems throughout the country that could be used to inform mapping of several naturally uncommon ecosystems that are subterranean or semi-subterranean. However, the Society and its members are generally reluctant to provide information to external parties, largely to conserve/protect caves and karst landforms, but also due to cave search and rescue concerns. These give rise to several confidentialty implications: (a) MOUs for data sharing between agencies should be developed governing how any data so exchanged are used; (b) staff within an agency with access to these data may need to be bound by confidentiality agreements; and (c) data display needs to be controlled. One solution might be to hide the specific data points from public view for a specific layer at a certain map scale, but retain the information for

data analyses to calculate the indicator. It is important to recognise that, even with caveats, there can be problems sharing such sensitive information. As the NZSS wrote regarding the use of its cave system data layer:

> *Once specific location data has been placed in a large organisation like DOC, we ultimately lose control of its security. One manager's well-meaning assurances may disappear when he/she leaves or is promoted. Even if the information is kept strictly within the Department, that still makes it accessible to a very wide group of people. This is a case where making sensitive information available for positive management could very easily lead to further degradation, both of the ecosystem of interest and the caves beyond.*

2. Many occurrences of naturally uncommon ecosystems are on private land, so there may be landowner privacy issues as well. This depends on how the data are used and displayed. If the data are used in a general way that does not link a location with a property owner's name, the risk is lower. An even better approach is to keep publicly available information to a broad scale that does not allow for specific locations to be identified with any accuracy.

3. The spatial layers are likely to contain error. At the national scale, current spatial layers of naturally uncommon ecosystems have been created by combining pre-existing spatial layers, by spatial modelling, or by digitisation based on aerial imagery. None of these layers has been ground-truthed. This means that any information derived from them is indicative only and cannot be used to guide policy decisions regarding a particular site without undertaking a site visit.

9.6 Reporting indices and formats

Basic M12 reporting statistics are

- a list of ecosystems to be reported on (based on results of M5)
- dated estimates of extent (ha) occupied by each ecosystem (based on repeat assessment of M5)
- dated estimates of extent (ha) with legal protection, by protection class, for each ecosystem
- percentage of the total area protected for each ecosystem (by protection class, for two time periods)
- percentage change in area protected for each ecosystem (by protection class). This should be expressed as an annual rate of change (hectares per year).

An example of a reporting table combining results from M12 and M18 is given in section 15 (Indicator M18: Area and type of legal biodiversity protection). Here, we provide an example of a reporting table linking M12 to M5 (Table 9-1).

Table 9-1 Example reporting table linking M12 to M5

Naturally uncommon ecosystem	Current extent (ha)	Area protected by legal protection class						Total area protected (%)	Percentage	
		1	2	3	4	5	6		Ecological integrity status	Description of integrity measure assessed
Ecosystem 1										
Ecosystem 2										
(etc.)										
(etc.)										

9.7 References

Lee WG, Allen RB 2011. Recommended monitoring framework for regional councils assessing biodiversity outcomes in terrestrial ecosystems. Landcare Research Contract Report LC144 for the Regional Council Biodiversity Forum Technical Group. 29 p.

Williams PA, Wiser S, Clarkson B, Stanley MC 2007. New Zealand's historically rare terrestrial ecosystems set in a physical and physiognomic framework. New Zealand Journal of Ecology 31: 119–128.

Appendix 9 – Summary of input from regional/district council staff

Initial consultation

During the development of this measure, feedback from regional/district councils was sought in relation to the following questions (see Table A9-1 for staff contact details):

1 Do you have a data source for protected areas in your region? Does the Protected Natural Areas GIS layer (available on the Landcare Research 'Our Environment' website) suit your needs or is there a mismatch with what land tenure decisions you feel results in protection?

2 How often do you feel you need to report on this?

3 Are you currently assessing this in any way? How is your data stored?

Table A9-1 Regional/district council contacts and date feedback was received

Council	Name	Date
Auckland Council	Stacey Byers; Craig Bishop	13 November 2012; 17 January 2014
Tasman District/Nelson City Council	Mike Harding	10 December 2012
Bay of Plenty Regional Council	Nancy Willems	11 December 2012
Waikato Regional Council	Craig Briggs / Yanbin Deng	11/13 December 2012
Greater Wellington Regional Council	Philippa Crisp	12 December 2012
Marlborough Regional Council	Nicky Eade	12 December 2012
Horizons Regional Council	James Lambie	9 January 2013
Otago Regional Council	Richard Lord	11 January 2013
Taranaki Regional Council	Rebecca Martin	20 March 2013
Hawke's Bay Regional Council	Keiko Hashiba	21 March 2013

Summary of feedback received

1. Do you have a data source for protected areas in your region? Does the Protected Natural Areas GIS layer (available on Landcare Research 'Our Environment' website) suit your needs or is there a mismatch with what land tenure decisions you feel results in protection?

- Where such assessments are made, each council is collating data sources independently to derive protection layers – usually combining layers depicting public conservation land, QEII covenants, Ngā Whenua Rāhui and council reserves [Nelson City, Bay of Plenty, Wellington, Auckland, Horizons, Taranaki, Hawke's Bay].
- Issue that not all 'protected' areas protected to the same degree

- Information is also only collated for specific areas of interest, not the entire region [Auckland].
- Don't all land have titles with protection status? Why doesn't LINZ manage this?
- There is often supplemental, site-based information on land where the owners are undertaking conservation management, but the land does not have a legal conservation status [Bay of Plenty, Waikato].
- Other councils have layers of SNAs (Significant Natural Areas), but these are not necessarily protected [Marlborough].

2. How often do you feel you need to report on this?

- Auckland Council: 3–5-yearly
- Bay of Plenty Regional Council: Annually
- Nelson City Council: 3-yearly
- Greater Wellington Regional Council: 5-yearly
- Marlborough Council: 5-yearly
- Waikato Regional Council: 5-yearly
- Horizons Council: 5-yearly
- Taranaki Regional Council: 5-yearly
- Hawke's Bay Regional Council: Annually for lowland areas, 5-yearly for the entire region
- Tasman District Council: Don't know
- Otago Regional Council: Don't have the need

3. Are you currently assessing this in any way? How is your data stored?

- Data stored in GIS systems with ancillary data stored in databases or spreadsheets [Wellington, Waikato, Bay of Plenty, Nelson City, Taranaki]
- Some assessments made for specific districts (e.g. Waitakere Ecological District) but data not collated for the entire region [Auckland]

10 Indicator M13: Threatened species habitat: number and status of threatened species impacted by consents

Authors: Robert Holdaway and Susan Wiser, Landcare Research

10.1 Overview

Indicator M13 (Threatened species habitat) reports on the number and status of threatened species impacted by consents. This measure complements M5 (Vulnerable ecosystems) because threatened species may be found in ecosystems that are not in themselves vulnerable.

Conceptually, this measure is straightforward to understand. Threatened species and their threat status (e.g. Critically Endangered, Endangered, and Vulnerable) are identified and defined by the Department of Conservation (DOC) using the New Zealand Threat Classification System. The local authority consenting process should consider the presence and potential impact of the proposed activities on threatened species. This measure combines these two data sources to report the number and status of threatened species impacted by consents.

Implementation, however, will be challenging owing to

a) lack of legislation specifying protection of some groups of threatened species (e.g. plants)

b) legal responsibility for threatened species conservation lying outside of the local authorities

c) responsibility for consenting and biodiversity protection residing in different administrative groups within local authorities

d) differences in responsibilities of regional, district, city and unitary councils in administration of the different types of consent applications that may impact on threatened species.

The primary reporting indices for this measure, in order of increasing detail, are:

a) The total number of consents applied for and approved

b) Percentage (and number) of consents approved in the previous year where threatened species were listed as occurring in the area affected by the proposed activity

c) Percentage (and number) of consents approved in the previous year where threatened species were listed as occurring in the area affected by the proposed activity, separated by the maximum potential impact on any one species, designated as low, medium or high

d) Percentage (and number) of consents approved in the previous year where threatened species were listed as occurring in the area affected by the proposed activity having mitigation or monitoring requirements, by maximum potential impact class

e) Percentage (and number) of all consents approved in past years where threatened species were listed as occurring in the area affected by the proposed activity having mitigation or monitoring requirements that are in compliance with these requirements.

10.2 Scoping and analysis

10.2.1 Introduction

This measure reports on the number and status of threatened species impacted by consents (see Appendix 10-1 for a summary of Biodiversity Working Group decisions on the scope of M13). Indicator M13 is one of a set of measures that indicates the effectiveness of policy and management in protecting biodiversity (Lee & Allen 2011). It is consistent with the 2007 statement of national priorities for protecting rare and threatened native biodiversity on private land (National Biodiversity Priorities) issued jointly by the Ministers of Conservation and the Environment[13]. Although not statutory, this statement provides guidance to local authorities, communities and private landowners about the types of ecosystems and habitats on private land that, from a national perspective, are most threatened and hence in need of protection. National priority 4 is to protect habitats of acutely and chronically threatened indigenous species.

The resource consent process can affect threatened species by permitting (or preventing) a range of activities such as habitat destruction (e.g. vegetation clearance) and alteration of habitat quality (e.g. changes in flow regimes and water quality of rivers). Threatened species are inherently range restricted, sparse where they do occur, or vulnerable to disturbance and human activities (Walker et al. 2006; Townsend et al. 2008; Holdaway et al. 2012). This makes them potentially vulnerable to even localised consented activities.

Conceptually, this measure is straightforward to understand. Threatened species and their threat status (e.g. Critically Endangered, Endangered, and Vulnerable) are identified and defined by DOC using the New Zealand Threat Classification System (Townsend et al. 2008). The local authority consenting process should take into account the presence and potential impact of the proposed activities on threatened species. This measure combines these two data sources to report the number and status of threatened species impacted by consents.

[13] See http://www.biodiversity.govt.nz/pdfs/protecting-our-places-brochure.pdf

10.2.2 'Threatened species' definition

The Department of Conservation is responsible for the listing of threatened species at the national level[14]. As stated by DOC 'The New Zealand Threat Classification System's long-term goal is to list all extant species that exist here according to their threat of extinction. The system is made up of manuals and corresponding taxa status lists. The status of each species group (birds, plants, reptiles, etc.) is assessed over a 3-year cycle.' Lists from the 2012–2014 listing cycle pertain to freshwater invertebrates, freshwater fish, bats, frogs, birds, vascular plants and reptiles (Appendix 10-3). Earlier lists provide status assessments for groups not included in the recent cycle (e.g fungi). The DOC measures progress in their requirement to ensure persistence of threatened species through three indicators: extinct species, status of threatened species, and the status of at risk species.

10.2.3 Identification of consents involving threatened species

This measure involves the identification of consents that have the potential to impact on threatened species. There are two stages to this. The first stage is identification of the broad categories of consents that may impact threatened species. For example, vegetation clearance could impact on habitat availability for threatened species, and effluent discharge consents could potentially impact threatened fish species. The broad ambit of the Resource Management Act 1991 is likely to make assessment of risk from activity categories difficult in many instances. The second stage is to identify particular consents where the potential to impact threatened species is known. For example, an activity that involves clearance of a wetland that is known to provide habitat for threatened bird species compared to an application to clear a small area of forest that, according to the best current knowledge, does not contain any threatened species when they might be expected to be present[15].

The level of knowledge about a particular site is an important consideration. Information on the distribution of threatened species can be obtained from a variety of sources, such as DOC, regional databases and reports concerning significant natural areas, national collections, the ecological literature or expert knowledge. However, this information is unlikely to be complete and may not specifically relate to the target site. Specific information may exist in ecological assessments done as part of the consenting process or from wider council environmental monitoring,

A lack of data does not necessarily indicate absence of threatened species at a site, but conversely detailed assessments of every location may be impractical. This measure therefore needs to be robust to incomplete knowledge about the distribution of threatened species. The quality of the threatened species data is also important to consider as threatened species are often cryptic and in low abundance and thus could be easily missed by untrained observers.

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[14] See http://www.doc.govt.nz/publications/conservation/nz-threat-classification-system/

[15] This therefore accounts for temporary occupation of areas, e.g. breeding grounds.

10.2.4 Quantification of the impact of consents on threatened species

Knowing that a consented activity affects an area or location known to contain threatened species does not necessarily mean that the consented activity will *impact* threatened species. Assessment of impacts of activities (or proposed activities) on threatened species are made to varying levels of detail. Impact may be assessed as a simple yes/no, as a categorical variable (e.g. high, medium, or low impact), or quantitatively (e.g. 25% decline in species abundance). Impacts can also be assessed at different stages in the consenting process. *Potential impacts* can be assessed during the application phase or after the consent has been issued while taking into account any mitigating actions (i.e. potential impact assuming mitigation activities occur as planned). *Actual impacts* can be assessed directly but are much harder to capture accurately as they depend on the nature of the consented activity and it actually taking place, potentially confounding factors or ecological processes, and the success of any mitigation measures undertaken.

There are a range of established methods available to assess potential impacts of activities on threatened species. However, standardisation of these methods across consent applications both within and among local authorities is a significant challenge. Standardised impact assessment categories (or categories that are robust to methodological variation) are essential for reporting this measure at a national scale.

10.2.5 Reporting frequency

Due to the continuous nature of the consenting process and the inherent vulnerability of threatened species, indices associated with consent approval should be reported on an annual basis. Indices relating to on-going compliance with mitigation or monitoring requirements are likely to be more data intensive and should be reported every 2–5 years or as the data become available.

10.2.6 Roles and responsibilities

A challenge with both developing and implementing this measure is the different roles and responsibilities among local authorities and DOC, between different types of local authorities (regional councils, territorial authorities (i.e. district and city councils), unitary authorities) and between different departments or divisions within each local authority.

Assessing the potential impact of a consented activity on threatened species requires specific expertise and is covered by more than one statutory mandate. Councils do not have specific responsibility for the protection of individual species from direct harm, but have a legal role in protecting their habitat and maintaining biodiversity.

The Department of Conservation has a broader role, on and off public conservation land, including the general advocacy role that it exercises through their involvement in consenting. Because DOC is frequently asked for input from local authorities regarding consent applications and threatened species and also makes submissions on such consents, efforts are underway at DOC to enable their responses to be more consistent nationally. These include improving the information base that supports these responses, especially via readily available spatial layers (Chris Rendell, Senior National Advisor, RMA, DOC, pers. comm.).

The Regional Council Biodiversity Working Group includes representatives from both regional councils and unitary authorities. A ‘unitary authority’ has the combined responsibilities, duties and powers of a regional council and a district or city council conferred to it (Department of Internal Affairs 2011). Councils have somewhat different roles. Territorial authorities have the responsibility for controlling the effects of land use on indigenous biodiversity, especially vegetation clearance and the effects of activities on the surface of lakes or rivers, whereas regional councils are responsible for managing the effects of using freshwater, land, air or coastal waters and managing rivers.

There are areas of overlap, such as when regional councils deal with consents regarding vegetation clearance is when this involves wetlands or aquatic systems or where it otherwise invokes other rules (e.g. earthworks controls). Across New Zealand, the degree of integration between regional councils and territorial authorities with jurisdiction over the same areas of land is variable. For some activities, applications must go to both the district and region because the proposed activity might require a consent given the rules in both the district plan and the regional plan. Other activities may be subject only to rules in one plan.

Within local authorities, the responsibility for managing the consents process lies with the person or people who process consents, whereas the the expertise to determine and appropriately monitor impacts on threatened species may reside in completely different departments or divisions within the local authority, or not be retained at all. The level of interaction between these different groups varies across the different local authorities as does the knowledge of each other’s processes and data collection.

10.2.7 Linkages to other measures

Indicator M13 is linked to M5 (‘Vulnerable ecosystems’) (Holdaway et al. 2014), which reports on the state and condition of wetlands, dunes and other coastal ecosystems, and naturally rare ecosystems. Vulnerable ecosystems tend to contain disproportionally high levels of endemic and threatened taxa and are often located in areas of high anthropogenic pressure. However, threatened species may also be found in ecosystems that are not in themselves vulnerable and therefore M13 is complementary to M5. This is particularly likely given that the RMA specifically directs councils to protect the significant habitats of indigenous fauna, irrespective of the habitat’s specific significance.

Data on consents issued collected as part of M14 (‘Vegetation consents compliance’) can be used to inform M13. Also, the process of collecting, storing and sharing consent information for M14 will have significant overlap with M13.

This measure (M13) is also linked to other measures relating to M9 (‘Habitat and vegetation loss’), as vegetation clearance, changes in ecosystem extent, and habitat loss may all impact threatened species. In the future additional explicit linkages between these measures could be developed e.g. improving spatial data may allow threatened species distributions, vegetation clearance maps, and resource consent boundaries to be overlain.

10.3 Assessment of existing methodologies

10.3.1 Regional councils and unitary authorities

We developed a questionnaire and conducted phone interviews or received written responses to assess existing methodologies employed by the local authorities that might be relevant to M13. Here we summarise the answers by each of the eight questions and a list of the people interviewed and which authority they represent, and their complete responses are provided in Appendix 10-2.

1. Do you collect any information relevant to this measure? If so, can you describe this?

Only one local authority (Tasman) answered 'yes' to this question whereas all others stated that they collected some information, but that it is not directly relevant. This is because species *per se* are not included in the regulatory plans, whereas habitats are included. Information pertinent to threatened species may include a) spatial layers of species observation records (but these can be incomplete); b) spatial layers of habitats or Significant Natural Areas (SNAs) that may support threatened species); c) inferred presence of the threatened species in SNAs, Significant Ecological Areas (SEAs), coastal protection areas or habitat types that are themselves defined by the threatened species; d) recorded presence in freshwater fish surveys.

Information pertinent to consents would be primarily derived from the ecological assessments prepared for the consent application. At the most informative end of the scale a thorough analysis of likely impacts of the activity on threatened species will be included. However, assessments do not necessarily consider threatened species, even when they are present, depending on the expertise or thoroughness of the assessor. Many types of consents do not require an ecological assessment, so impacts on threatened species cannot be detected, much less have their severity determined.

2. If you don't collect any information relevant to this measure, do you have any suggestions on how such information could be collected?

Suggestions included a) developing a standard template (referred to as 'Practice Notes' by one local authority) for conducting ecological assessments for consent applications and biodiversity assessments of natural areas. This template would include an assessment of the presence/absence of threatened species and potential impacts of the activity on them; b) formalising and standardising the information and knowledge of the environmental and monitoring groups in the local authority, as well as that collected by different organisations (e.g. DOC, Landcare Research) so they are available to the consenting planner; c) creating/using a spatial layer of polygons depicting where a consented activity will take place and intersecting this with spatial layers depicting threatened species or habitats/SNAs/SEAs etc. known to contain threatened species.

3. What triggers a consent application being sent to your team?

This ranges from formalised mechanisms where lists of all consent applications are circulated weekly or biweekly, to as-needed referrals where consent applications are circulated when there is an emergent issue judged to require biodiversity/ecological expertise (e.g. an SNA or receiving environment or threatened species habitat will be impacted), to consent applications not being sent on to biodiversity teams at all, even though they may have biodiversity impacts.

4. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded? Is there a database of consents and what does it contain?

For local authorities with no database of consents, every consent would need to be examined individually. Where consent applications are in electronic form, keyword searches on species, or conditions expected to affect them may be an option, but this would not necessarily return all relevant consents. Where consent databases exist, they may include conditions of the consent regarding the rule being broken and compliance records, but these databases do not have flags for threatened or individual species. To narrow such a search, one could focus on consents where the nature of the activity triggered specific rules (e.g. vegetation clearance, wetland modification, discharging contaminants for pest control, any activities, impacting freshwater or coastal areas) that are known to potentially impact threatened species. Alternatively, simply asking staff for instances where they highlighted threatened species in their decision letters approving a consent could achieve this.

5. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

This is not currently feasible for any local authority, although it would be theoretically possible to add a tick box to the consent application and so capture in local authority consent databases. A salient issue is whether the local authority consenting divisions would be motivated to do this. Currently national (DOC) threat status listings are followed (except for one local authority that does not follow any lists); all threat ranks are considered. One local authority has a regional-scale list; others felt a regional-scale list would be useful.

6. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

This is highly variable between consents and between local authorities. In some local authorities impacts on all threatened species noted in the application or ecological assessment would be summarised, in others impacts are more likely to be summarised if multiple threatened species will be affected. For some local authorities discussions with the consents division and monitoring teams would be required to more definitively answer this question.

7. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

All local authority representatives answered ‘Yes’. The methods used to assess compliance is assessed and the thoroughness of this assessment varies depending on both the nature of the consents and the individual local authority.

In some local authorities the monitoring reports prepared by or on behalf the consent holder may be filed, but not reviewed.In others the reports are reviewed, but monitoring audits are rare. In some instances, compliance audits are not routine but are triggered by complaints from the public. At the most thorough end, local authorities have enforcement teams and audits are routine. For some local authorities discussions with the consents division and monitoring teams would be required to more definitively answer this question.

8. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the local authorities? Does DOC do any reporting that is relevant to this measure?

The level of communication and involvement of DOC varies widely across local authorities, contracted ecologists and DOC offices and the consent notification level (dependent on plan rule(s) that apply and the anticipated level of adverse effects). DOC involvement may be restricted to a formal response to the consent application as an affected party or may involve an additional collaborative relationship that includes a) DOC reviewing consent reports and involvement with round-table discussions; b) DOC providing advice around the necessity to protect threatened species, mechanisms to protect species via new or altered local authority rules, or how to mitigate potential impacts of the activity on particular species or species groups

10.3.2 Department of Conservation

The primary legislative protection for indigenous animals is contained in the Wildlife Act 1953, which is administered by DOC. This act applies to all wildlife, regardless of land tenure. The primary legislative protection for indigenous plants is contained in the Reserves Act 1977, National Parks Act 1980 and Conservation Act 1987, which apply to public conservation land and the Queen Elizabeth the Second National Trust Act 1977 and Resource Management Act 1991, which apply to land of other tenure (De Lange et al. 2010). This means that the primary activities related to the protection of threatened species fall under the responsibilities of DOC.

As part of this responsibility DOC maintains threat listings for species at the national level, carries out inventory and monitoring of specific threatened species and maintains, to varying degrees, databases of known locations of threatened species occurrences. DOC and local authorities are working to devise an approach for assessing the conservation status of indigenous plants and animals at regional scales. The approach is modelled on the national threat classification system and builds on the legacy of regional threat lists (Rolfe 2015).

10.3.3 Other relevant agencies (district/city council that are not part of unitary authorities, consents teams within local authorities)

District and city councils that are not part of unitary authorities will potentially consider impacts on threatened species for consents that pertain to vegetation clearance and land use impacts on aquatic ecosystems.

10.4 Development of a sampling scheme: what will be measured and how

In this section we describe the type of data that needs to be collected and collated to support this measure. The types of data needed to report this measure are:

- Numbers of consents approved/rejected that involve threatened species
- Name and threat status of species potentially impacted by consents
- Severity of the potential impacts of activities on threatened species
- Record of conditions placed on consents and compliance with those conditions

A process diagram outlining the steps involved in implementing this measure is provided in Figure 10-1.

10.4.1 Identification of consents involving threatened species

The most direct approach would be to add a field to the databases of consents so that when summary information regarding consents is captured, whether threatened species are present in the area that will be affected by the proposed activity is also captured. At a minimum, this would be populated by a Yes/No response. To be more informative, this could capture the name of the taxon or taxa being impacted. Links with the New Zealand Organisms Register (NZOR) species identifier could be included to make the system robust to synonyms and future taxonomic revisions.

The scope of taxa considered should follow the current cycle of the NZ Threat Classification System lists, maintained by DOC and published as the New Zealand Threat Classification Series. The publications from the 2012–14 cycle are listed in Appendix 10-3; full publications can be downloaded from the DOC website[16]. NZOR provides threat status information according to these lists providing a ready mechanism to link a taxon name with threat status.

Councils may wish to incorporate threatened species information (if they do not already) into their initial assessments of consent applications. This will require overlaying spatial layers depicting locations of observations of threatened species and their breeding and non-breeding habitats with areas of proposed consented activities. Where it is considered likely that threatened species may be affected (and is not initially highlighted by the applicant), further information could be sought. However, this assumes that a) threatened species spatial layers are fully accurate and up-to-date and that b) there are no off-site impacts of the proposed activity and therefore is not a substitute for appropriately qualified expert involvement.

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[16] http://www.doc.govt.nz/about-us/science-publications/conservation-publications/nz-threat-classification-system/nz-threat-classification-system-lists-2012-14/

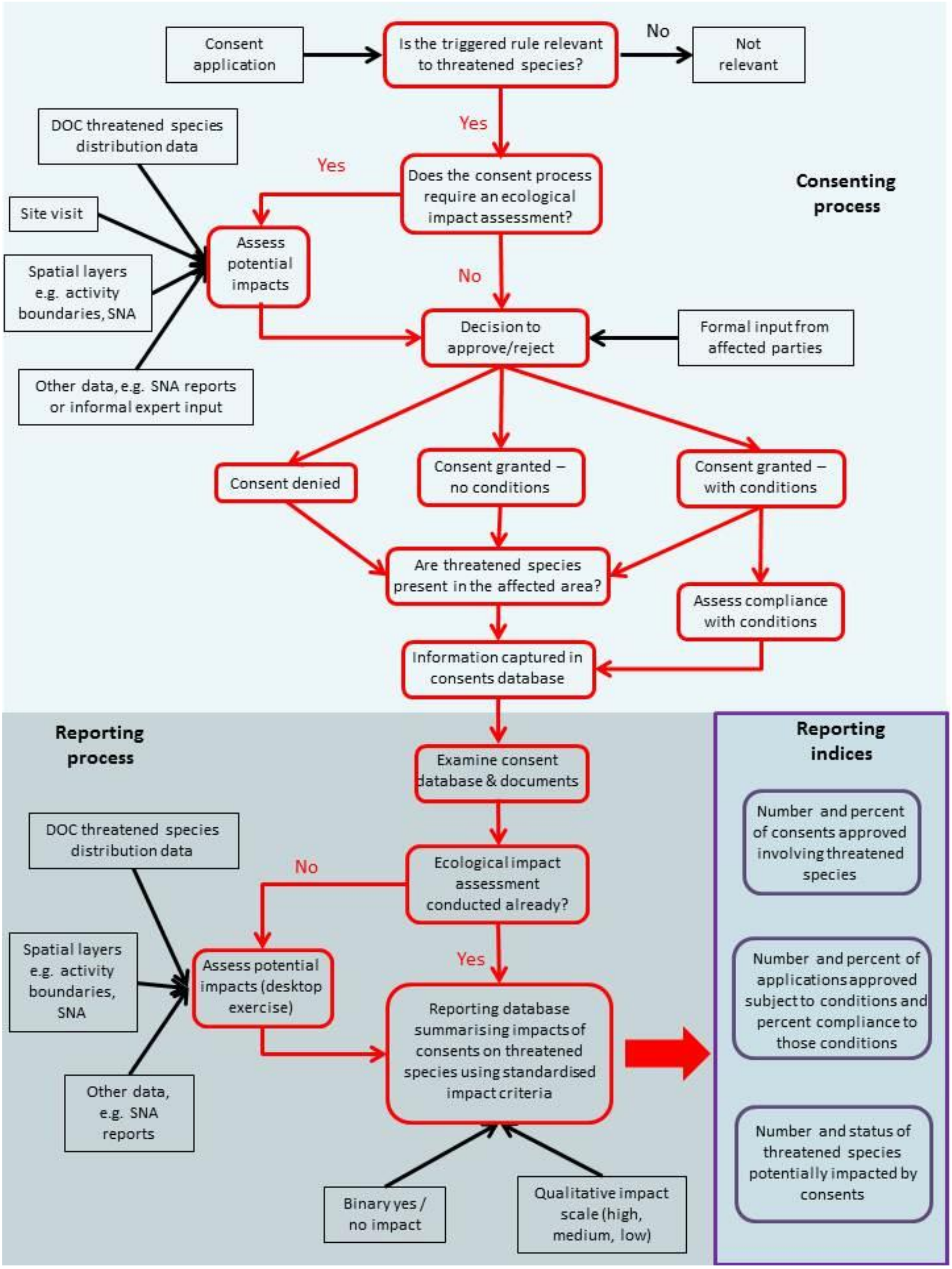

Figure 10-1 Flow diagram summarising the consenting process and the steps involved in implementing M13.

10.4.2 Collating data on potential impact on threatened species

Capturing whether a proposed activity will impact a threatened species does not indicate the potential severity of the impact. Impact can be assessed in terms of the likelihood that the species will persist in the long term given the results of the activity. Because of the challenges in making quantitative assessments of potential impacts compounded by the lack of comparability across species and regions, potential severity of impact would be captured qualitatively as 'high', 'medium' or 'low' following these definitions:

- High = the activity will result in direct mortality of threatened species and/or permanent destruction of breeding habitat or the ability of the species to persist in that locality.
- Medium = the activity may result in direct mortality of threatened species and/or will temporarily affect either breeding habitat or the ability of the species to persist in that locality.
- Low = the activity will not result in direct mortality of threatened species, but will reduce overall habitat quality.

The assignment of these categories would be based on manually examining documents pertaining to consents identified as impacting threatened species using the consents database or from the indirect spatial query. Once determined, it is suggested that medium – high ranked impacts are immediately notified to the appropriate office of DOC.

Impacts on threatened species specifically are the concern of DOC. Links between DOC and consenting agencies can be opaque or non-existent. This measure could perform a useful policy function whereby it mandates notification to DOC where an impact is possible, and records their response.

10.4.3 Data on consent conditions and whether they have been met

Information on whether consent conditions have been met should be captured during the consent approval and monitoring process and this information should be stored in the consents database. This will provide a record of

1) whether compliance with a consent condition has been assessed
2) the motivation for the assessment (e.g. complaint by the public or random check)
3) whether the consented activity took place and
4) whether the conditions were met or not.

Ideally, all consents involving medium and high risk to threatened species and conditions relevant to threatened species should be assessed for compliance as a matter of priority. The frequency of any additional monitoring requirements should be determined at the outset and enshrined within the consent conditions.

10.4.4 Data on actual impacts

Quantification of the actual (realised) impacts of consented activities on threatened species would require detailed pre and post-activity monitoring of threatened species populations in the area affected, and in adjacent control sites. This is unlikely to be achievable within the scope of the Regional Council Biodiversity Monitoring programme, and is more aligned with the mandate of DOC and the exercise of council compliance and enforcement functions (ideally working together). For M13, data on ‘potential impacts’ will therefore be used as a surrogate for ‘actual impacts’.

10.4.5 Standardisation across local authorities

Standardisation across local authorities is needed to ensure the ability to report on M13 both within and across regions. In particular, the following components should be standardised where possible:

- The data fields used to capture threatened species information in the consents database
- The reference source used to designate threatened species (e.g. threat classification based on the most up to date NZ Threat Classification System lists and species names where identified based on NZOR,)
- The method and/or categories used to assess the magnitude of the impact of consented activities on threatened species.

10.4.6 Reporting change: standardisation across time

Reporting changes in M13 over time is sensitive to a number of factors. The ratio of consents approved to those declined is robust to temporal variability in the number of consent applications, but the percentage or number of consents in compliance is sensitive to changes in approaches used to assess compliance. In addition, a comparison across years requires the application of the same impact assessment criteria each year.

The threat status of individual taxa may change over time. This could result in the total number and distribution of threatened species within a local authority’s jurisdiction changing accordingly. It will be important to partition the influence of such changes on the value of the indicators over time from changes due to levels of restriction in granting consents.

10.4.7 Alignment with other measures

Methods for assessing compliance and data on consents collected as part of M14 (Vegetation consents compliance) should be used to inform M13, and the systems developed simultaneously for both measures. In particular both should anticipate the need for ongoing assessments of compliance.

10.5 Data management and access requirements

10.5.1 Data storage

As proposed in section 10.4.1, basic information on whether threatened species are present in the area that will be affected by the proposed activity is best stored in consents databases. Standardised work flows could ensure that taxa names are standardised and can be readily linked to threat status and can allow the impact of both changing taxa names and threat status on the measure to be assessed over time. A means for storing the information extracted manually from consents will be required. This might best be a (flat) database of consents and the associated species that provides threat status at the time the consent was granted, potential impact scores, etc. as needed to calculate reporting metrics. This database could be shared among local authorities to allow national-scale reporting.

10.5.2 Access to data

Locations of threatened species is potentially sensitive information that should not be widely shared. The use of a consent identification that is meaningful to the relevant local authority would allow specific threatened species and consent details to be located by approved individuals and enable these to be tracked as required over time (e.g. transparency audits).

10.6 Reporting indices and formats

10.6.1 Primary reporting indices

The primary reporting indices for this measure, in order of increased resolution, are:

a. The total number of consents approved;

b. Percentage (and number) of consents approved in the previous year where threatened species were listed as occurring in the area affected by the proposed activity;

c. Percentage (and number) of consents approved in the previous year where threatened species were listed as occurring in the area affected by the proposed activity, separated by the maximum potential impact on any one species, designated as low, medium or high;

d. Percentage (and number) of consents approved in the previous year where threatened species were listed as occurring in the area affected by the proposed activity having monitoring requirements, by maximum potential impact class;

e. Percentage (and number) of consents approved in the previous year where threatened species were listed as occurring in the area affected by the proposed activity having mitigation requirements, by maximum potential impact class;

f. Percentage (and number) of all consents approved in past years where threatened species were listed as occurring in the area affected by the proposed activity having monitoring requirements that are in compliance with these requirements.

g. Percentage (and number) of all consents approved in past years where threatened species were listed as occurring in the area affected by the proposed activity having mitigation requirements that are in compliance with these requirements.

Examples of how these should be reported are shown in Table 10-1. Where data permit, each of the above indices should be further broken down by species threat status as shown in Table 10-2. Indices (a-d) should be reported annually. Index (e) should be reported every 2–5 years.

Table 10-1 Example high-level reporting table for M13

Reporting index	Consents issued 2014	Consents issued 2013[1]
Total number of consents issued	156	148
Total number of consents declined	14	11
Total number of consents approved involving threatened species	35	30
Percentage of approved consents involving threatened species	22	10
Percentage (and number) of consents involving threatened species where the maximum potential impact is:		
High (%)	40 (14)	20 (2)
Medium (%)	14 (5)	20 (2)
Low (%)	40 (14)	40 (6)
Not assessed (%)	6 (2)	20 (2)
Percentage (and number) of consents with mitigation requirements by potential impact class:		
High (%)	14 (2)	100 (2)
Medium (%)	40 (2)	50 (1)
Low (%)	0 (0)	0 (0)
Percentage (and number) of consents complying with monitoring requirements	75 (3)	100 (3)
Percentage (and number) of consents complying with monitoring requirements:		
High (%)	14 (2)	50 (1)
Medium (%)	20 (1)	50 (1)
Low (%)	0 (0)	0 (0)
Percentage (and number) of consents complying with mitigation or monitoring requirements	67 (2)	100 (2)

[1]Data from previous years to provide multi-year context

Table 10-2 Example reporting table for M13 divided by species threat status

Reporting indicies for 2014	Species threat status			
	Critically Endangered	Endangered	Vulnerable	Total
Total number of consents issued				156
Total number of consents approved involving threatened species	1	4	30	35
Percentage of approved consents involving threatened species	0.5	2.5	19.0	22
Percentage (and number) of consents where the maximum potential impact is:				
High (%)	100 (1)	25 (1)	40 (12)	40 (14)
Medium (%)	0 (0)	50 (2)	10 (3)	14 (5)
Low (%)	0 (0)	25 (1)	42 (13)	46 (16)
Not assessed (%)	0 (0)	0 (0)	8 (2)	6 (2)
Percentage (and number) of consents with mitigation requirements by potential impact class:				
High (%)	100 (1)	100 (1)	0	14 (2)
Medium (%)	0	100 (2)	0	40 (2)
Low (%)	0	0	0	0 (0)
Percentage compliance with mitigation requirements	100 (1)	66 (2)	0	75 (3)
Percentage (and number) of consents with monitoring requirements by potential impact class:				
High (%)	100 (1)	100 (1)	0	14 (2)
Medium (%)	0	50 (1)	0	20 (1)
Low (%)	0	0	0	0 (0)
Percentage (and number) of consents complying with mitigation or monitoring requirements	100 (1)	50 (1)	0	67 (2)

[1]Data from previous years to provide multi-year context

10.6.2 Additional (optional) reporting indices

To be more informative these tables could be further broken down to report separately on different phyla or groups of threatened taxa, for example, threatened plants versus threatened animals. They could also be supplemented with a list of the actual threatened taxa impacted by consents. This would provide valuable information for conservation planning by identifying the species most at risk from consented activities. It is likely that implementing this aspect of the monitoring framework may be very resource intensive, and not plausible for all councils.

10.7 Future development

Many activities that impact threatened species may require permission from both regional and district or city councils. In this research, we only liaised with regional and unitary authorities. If we are to make progress on this measure, the remaining district and city councils would need to be involved. In addition, engagement with consenting functions of councils and indeed, DOC in totality has not been a feature of this work.

The Department of Conservation also has much knowledge, authority and involvement with threatened species and consents. If we are to make progress on this measure, DOC needs to be involved.

10.8 References

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Appendix 10-1 – Summary of Biodiversity Working Group decisions on the scope of M13

Two discussions have been had at the biodiversity working group meetings surrounding the revised scope of M13. The first discussion was on the 2nd December 2013 (Wellington). The second discussion occurred on the 20 February 2014. Both discussions are documented in 'Key decisions reached_biodiversity monitoring tools project_12December2013.pdf':

Decision reached 02 December 2013

Measure/Issue

M13. Threatened species habitat.

M13 contains two components:

1. change in habitat and populations of threatened taxa; and
2. number and status of threatened taxa impacted by consents

Suggestion by Robbie Holdaway and Susan Wiser (key scientists for M13) that "change in habitat and populations of threatened taxa" should no longer be a part of M13 as it is aimed at reporting change in the state indicator (M4) which was merged with M5 [see decision #1]. This aspect could be covered more generally within M12 (Change in extent and protection of indigenous cover or habitats or naturally rare ecosystems). M13 could be developed to only focus on the second aspect of the measure – "number and status of threatened taxa impacted by consents".

Decision

Retain some ability to report on threatened habitat and species. "Threatened species habitats" will be reported in the context of *wetlands, dunes and naturally uncommon ecosystems* with the caveat that this does not include all habitats for threatened taxa. Retain the "threatened species habitat impacted by consents" aspect of M13.

Justification

Caveat on definition of threatened species habitat is required to acknowledge:

- that threatened taxa might be found in exotic habitat; habitat not dominated by indigenous species, or habitat not formally associated with that taxa
- that some threatened taxa are mobile across multiple habitats
- that some threatened taxa may have seasonal variances in their habitat requirements/preferences

Local authorities with greater capacity to report over and above the minimum of wetlands, dunes and naturally uncommon ecosystems are able to do so. While many local authorities might struggle to report "threatened species habitat impacted by consents" this does not mean it should not be kept as a valid indicator.

Decision reached 20 February 2014

Measure/Issue

M13. Threatened species habitat

Further to above decision made by BDWG on 2-December-2013, concern was raised by Susan Wiser and Robbie Holdaway that the BDWG decision (see Decision #13) was ecologically untrue to M13, if the first component (change in habitat and populations of threatened taxa) of the measure was retained as threatened ecosystems are not synonymous with threated taxa.

Secondly, M5 (vulnerable ecosystems) reports on the state and condition of wetlands, dunes and other coastal ecosystems, and naturally rare ecosystems. So this shift in the first part of M13 could simple be seen as the 'change' version of M5, and confuses the focus (threatened taxa) of M13.

A very strong recommendation from the LCR scientists involved in this measure was to retain the integrity and focus of M13 by either:

- If retaining the BDWG 2/12/13 decision: Add a new indicator to cover the change aspect to threatened ecosystems that the BDWG decision attempts to bring to M13 (i.e. the 'change' version of M5) OR
- To retain the focus on threatened taxa in M13: Drop the first component of M13 if this is beyond the scope of regional councils core work

Decision:

Retain the intention of M13 to focus on threatened taxa.

It was noted that the BDWG decision was made in the context of core council work (not typically in sspecies management) while acknowledging the importance of monitoring and reporting on threatened taxa.

Therefore the first component of M13 is to be dropped, with the second retained:

1. ~~change in habitat and populations of threatened taxa; and~~
2. number and status of threatened taxa impacted by consents

Justification:

It was agreed that it was undesirable to muddy M13 with M5 or undertake monitoring under M13 that did not truthfully report on the intent of M13. The second component of M13 can be retained as this cuts to the core of regional council business, while the first component is more suited to the Department of Conservation's mandate, and many councils will not have the ability to report on this.

Those councils that do undertake threatened species work, can 'add-on' monitoring and reporting to complement the minimum set of indicators developed under this project.

Appendix 10-2 – Summary of input from regional/district council staff regarding assessment of existing methodologies

We conducted phone interviews or received written responses to specific questions from May to October 2014 with the individuals listed in Table A10-2-1 who were the designated contacts for this measure.

Table A10-2-1 Designated council representatives contacted in May-October 2014

Council	Type of local authority	Representative
Unitary Authorities		
Auckland Council	Unitary authority	Alastair Jamieson
Marlborough District Council	Unitary authority	Nicky Eade
Nelson City Council	Unitary authority	Reuben Peterson
Tasman District Council	Unitary authority	Lindsay Vaughan
Regional Council		
Bay of Plenty Regional Council	Regional council	Nancy Willems
Hawkes Bay Regional Council	Regional council	Malcolm Miller
Horizons Regional Council	Regional council	James Lambie
Northland Regional Council	Regional council	Lisa Forester
Otago Regional Council	Regional council	Richard Lord
Taranaki Regional Council	Regional council	Halema Jamieson
Waikato Regional Council	Regional council	Yanbin Deng
Wellington Regional Council	Regional council	Philippa Crisp

Waikato Region: Yanbin Deng

1. Do you collect any information relevant to this measure?

- No do not collect directly. In SNA assessment collect threatened species info at that site level. When there is a resource consent that applies to that SNA, then the presence of threatened species would be included in the assessment.
- If the resource consent is not applicable to an SNA or sometimes the company directly contracted someone to make an ecological assessment of the site. This person then may or may not record the presence of threatened species. There is no standard template for ecological assessment so threatened species could readily be missed. Such a standard is badly needed including such things as vegetation/habitat type and threatened species.
- Sometimes based on habitat type, there would be an expectation that there are threatened species (c. 600 year podocarp forest and presence of long-tailed bats in south of Waikato district). If they weren't mentioned initially, then would send back the application for the applicant to do further assessment.

- Not all resource consent applications require an ecological assessment but all should include a recording of at least vegetation/habitat type and threatened species, if there is vegetation habitat there.
- Consideration of the impact of the consent on threatened species is a DOC expertise, DOC's advice is very important.

2. If you do, can you describe this?

- See above

3. If you don't, do you have any suggestions on how this information could be collected?

- See above

4. What triggers a consent application being sent to your team? [not asked in this interview]

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded?

- Don't know how this would be done. Yan Bin doesn't see that much consent.
- Approved consents would be filed with Resource Use group. So they would have to be looked through there. No clear idea of how much consent would need to be examined.

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- Only knows about the one that her office sees. Other people might see other consents that cover threatened species. Yan bin would see all ecological assessments for consents. Wetland person would see other consents that would involve threatened species. Right now she is seeing them, but that is usually outside of the requirements of her position.
- Use the national publications – plants, birds, frogs, freshwater database, DOC bioweb. It is challenging when threat status changes
- Also have a regional list (each district has a list)
- Species of any threat status considered
- When threatened species present, the consent is less likely to be granted and increase the level of mitigation to reduce risk to the species. May have a strategy to relocate species or increasing predator control nearby etc.

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- She thinks so.

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Yes. Compliance assessed by requiring one or more monitoring reports. Might include accounting of expenditure, e.g. on possum control. Assess success of planting, degree of animal control, bird counts etc. If they are not compliant – she hasn't encountered this yet.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the local authorities? Does DOC do any reporting that is relevant to this measure?

- DOC is involved for all threatened species. Usually reviews report.
- Includes both non-DOC and DOC land
- DOC provides advice about mitigation and protection of threatened species
- Council sends threatened species part to DOC to review and DOC sends feedback. Then there may be roundtable discussions between company, DOC, Resource use people
- Not sure if DOC does any reporting relevant to the measure.

10. Additional comments:

- Would like a standard template regarding information that must be provided regarding threatened species on resource consent applications
- Would like a set of priorities around threatened species – which species are such high priorities that no consents should be granted?
- Would be good to have qualified ecologist list nationwide for Councils to provide to the landowners or companies who want to assess the biodiversity values on their land for the recourse consents.

Bay of Plenty Regional Council: Nancy Willems

1. Do you collect any information relevant to this measure?

- Not really. They do have some spatial depiction of threatened species/threatened habitats. This could potentially be linked to locations of consents. Currently the latter is depicted as points based on the address of the consent applicant, rather than a polygon depicting where the activity will take place.

2. If you do, can you describe this?

- See above

3. If you don't, do you have any suggestions on how this information could be collected?

- A buffer could be established around the point locations of the consents and intersected with species/ecosystem distribution information to give a first indication, or vice versa – buffer around the ecosystems or records of threatened species and intersected with consents.

4. What triggers a consent application being sent to your team [not asked in this interview]

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded?

- The current consents database doesn't have the capacity to search the contents of the submitted documents, e.g. to allow a search for the string 'threatened' or for a particular species names. The database may contain activities that are related to the consent. These are collected by the applicant checking tick boxes on the application form. One could focus on particular activities that could impact threatened species, e.g. geothermal activity, vegetation clearance, earthworks, modification of wetland.

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- At the current time this isn't done. One solution is to add a tick box on the consent application forms where threatened species are impacted, or in the database so that you can generate a report. It's unlikely our council would invest in even this adjustment to the current database as we're looking to upgrade to an alternative (possibly IRIS).
- For threatened species, the threat rankings from the DOC system are used.
- Which threatened species are considered (i.e. the level of threat ranking) will vary according to who has written the application. Generally speaking, if it has a threat ranking of any level it will be considered.
- It is not clear how much the presence of threatened species affects the decision. However, this will trigger the consent application coming across Nancy's desk. This results in a technical audit of the application to make sure it is adequate. I suspect it would also trigger DOC being an affected party and thereby having some input.

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- Don't know. It probably varies depending on the activities and the potential impacts.

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Any mitigation/monitoring requirements would come through as conditions of the consent.
- Theoretically compliance is assessed, but to varying levels. The compliance monitoring cycle is not closed. Monitoring is done by the consent holder or a person contracted by them. The consent holder then delivers a report to the council. A person in the council checks that it has been received, but they may not read it or determine whether the

consent holder is in compliance with the consent requirements, or if there is an effect on a threatened species even if they are complying. There is no audit to determine the adequacy of the monitoring or the results and whether or not some further action might be needed.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- YES, even for land not on DOC estate. This is required under the Wildlife Act or where there is a potential or actual effect on anything indigenous biodiversity or the public conservation estate, so activity could be adjacent or nearby. Communication with council comes through as a formal response during the consent process. DOC is required to respond even when they have no objection (I think – the process is that if they are an affected party and they don't respond within the timeframe I think that triggers a notification process).
- Don't know about DOC reporting.

10. Additional comments

- District consents and Regional consents often are handled quite separately by two separate organisations (unless you're a unitary authority) as the district and regional councils cover different functions and activities. Across regions, the degree of integration is variable. For some activities, applications must go to both District and Region because it might trigger rules in the district plan and a regional plan; others are only required to go to one or the other. In BOP have it set up so that certain triggers make a consent come to the region (e.g. indigenous biodiversity affected).
- This isn't going to be an easy measure to gather info on and I'm thinking will require some changes or additions to our processes, so we (the regional councils) might have to do some thinking around systems we might put in place. Establishing a baseline would be difficult too, although if we're only reporting on an annual basis (sorry can't quite remember) as in how many consents were granted that affect critters, then that would make it a little easier.

Nelson City Council: Reuben Peterson

Do you collect any information relevant to this measure?

- No, not directly. Indirectly, council staff get involved with threatened species, but not so much with consents and not very often. Council also has survey information of flora species within Significant Natural Areas which not if a rare species is within that area – these however are confidential at this stage.

1. If you do, can you describe this?

- N/A

2. If you don't, do you have any suggestions on how this information could be collected?

- Would need to set up a baseline database. Start with information from DOC as the holder of knowledge for threatened species in the area. Would be delivered through SOE monitoring.

3. What triggers a consent application being sent to your team? [not asked in this interview]

4. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded?

- Threatened species not mentioned in applications very often, unless the applicant was aware of threatened species in the area. So would be difficult to determine which consents to examine. However threatened species may be mentioned in the decision. Could narrow down to consents that triggered rules (e.g. freshwater, wetlands, indigenous forest, and coastal areas) to determine which consents decisions to examine. Probably the best way to proceed would be to raise at a team meeting level to identify staff who have highlighted threatened species in decision letters.

5. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- N/A re: consent applications, but see above re: decision letters. Would follow the DOC list. Since awareness of the presence of threatened species would be raised by DOC, would have to ask DOC what threat levels they would be considering.

6. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- Yes. Discussion in consent letter would say why it was approved despite species being present.

7. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Yes. Also there may be conditions on consent to prevent any impacts on threatened present. There is an enforcement team that checks whether conditions are being met.

8. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- Any time there is a trigger (as listed above) DOC becomes involved (along with iwi and Fish & Game, depending on details of consent). This happens even if the site is not on DOC land.
- Don't know about DOC reporting.

Taranaki Regional Council: Halema Jamieson

1. Do you collect any information relevant to this measure?

- Probably not – see notes under 'Additional information'. There is a person who deals with freshwater fish who may be knowledgeable but she hasn't been able to contact him. There is a system in place (see Resource Consent Practice Notes Indigenous Biodiversity, 2010, sent to me), but it doesn't appear to be implemented. This includes info on how to determine if any area is significant or whether threatened species may be impacted.
- In the TRC, the Biodiversity section has been amalgamated with Biosecurity (now all in the Environment Services Team). The Scientific Officer Ecology role has emerged from a recent restructure and is essentially a reconfiguration of a previous SO biodiversity role that used to sit in a technical services section of the TRC. This new role will work will work more closely with the biosecurity and biodiversity teams and may also be able to facilitate the implementation of the Resource Consent Practice Notes. [I need to do is look at these practice notes and reference them regarding the questions below].

2. If you do, can you describe this?

- See above

3. If you don't, do you have any suggestions on how this information could be collected?

- The first step would be to implement the practice notes. For example a recent application for land drainage had the potential to affect a wetland and there was monitoring required, but it didn't mention threatened species per se although they may have been there.
- There is a biodiversity condition assessment protocol (see new document being sent) that is currently used by the biodiversity team to assess areas of forest, wetland or coastal ecosystems (including private land) as part of a voluntary programme to protect key areas of biodiversity in the region. This system has scope for capturing information about threatened species that could be used in site assessment as a consequence of a consent application being filed. However it isn't specifically being used in the consent process now.
- Probably most relevant work is being done by the freshwater people (biodiversity should be involved with wetlands and are very occasionally involved if consents affecting them are brought to their attention) – as these ecosystems are most likely to be affected by applications for discharge, drainage or realignment of a watercourse.

4. What triggers a consent application being sent to your team? [not asked in this interview]

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded? Is there a database of consents and what does it contain?

- Currently not likely to be mentioned in site assessments or decision. If they are mentioned, they would be difficult to find buried within the documents.
- The database seems to be quite detailed, but no specific flag on threatened species

[One issue is that the designated contact person for this measure is generally a biodiversity person and may not be sufficiently involved with consents to be able to answer my questions]

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- Not readily given the way the data is being collected. Biodiversity team and SO ecology have a database of known threatened species and habitats for the region. Species lists are updated regularly when species are reassessed through the DOC NZTCS. Regionally important species are also included from local information. Unclear if or how this information is used by consents team.
- There are GIS layers of SNA and other important native ecosystems in the region (Key Native Ecosystems - KNE), but no layers for threatened species distributions. Could use KNE as indicators of potential distribution of threatened species, as the descriptions of these ecosystems include lists of threatened species. Then could intersect with locations of approved consents. Generally this is not done during the approval process as it is too fiddly? (Not sure why this isn't done so not sure we can say this. Would be something we (biodiversity/ecologist) would do if we were involved)
- Don't know if threatened species presence changes considerations around consent.
- If identified, then yes but unsure how often consents are fully assessed for impacts on terrestrial threatened species

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- For the most part doesn't know, but would have to ask consents people. There are conditions regarding freshwater fish passage, for example. Again, if identified, then yes they should be

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Yes and area is monitored to assess compliance.
- Would need to talk to consents people and compliance and monitoring team for details.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- Doesn't know, would need to contact DOC people. See email forwarded from ex NP DOC RMA ranger. When she worked for DOC in Auckland City Council are, local DOC office was not contacted unless the activity was near to DOC land, in contrast to my earlier answers. DOC Conservancy statutory land management team may have had further input.
- This issue affects herpetofauna greatly, Society for Research on Amphibians and Reptiles in NZ (Herpetological society of NZ (not to be confused with NS Herpetological Society), a voluntary group with a strong academic and research bent) or Technical Advisory Group for lizards (DOC TAG group) are putting together a toolbox for information and are developing guidelines for Councils, developers and consultants about how to identify lizard habitat and mitigate impacts. (Both groups have put together information toolboxes and the TAG are developing the guidelines for Developers, Councils and consultants)

- Feedback from Chris Rendall, who was the ranger dealing with RMA issues in the nearby DOC. Current position is Senior National Advisor, RMA.
  - DOC involvement is variable in terms of both DOC offices and Councils. TRC will usually ask us about stream modification especially if there are threatened (e.g. at risk) fish species present. I am going to be working with some lizard people in regards to how to improve RMA engagement etc. – NPDC chats to us and the Herpetological Society if they are going to clear flax etc. but don't usually approach us if private individuals are getting consent to clear vegetation etc. (unless it's a Significant Natural Area (~25 in the district) in the district plan there are no specific rules attached to vegetation clearance).
  - DOC is involved when area affected is on or outside the DOC estate, but this varies between different DOC offices.
  - DOC communication with Councils varies - depends if it is a s95E or a notified consent... (local office vs shared services)
  - As for DOC reporting that is relevant to this measure would need to ask S&C but that's more of a Council monitoring role...
  - In terms of the variability in DOC involvement, I am hoping to make us more consistent – e.g. the attached documents I have put together, the GIS link below. I am also hoping to work with the S&C teams in wellington to better map things like lizard distribution so that it can be better incorporated in plans. Note if someone kills wildlife protected by the wildlife act (ei clear vegetation with protected species in it without the appropriate permit) they can be prosecuted but we seldom have sufficient evidence to follow this up.

- I have also been working with one of the GIS guys to make a quick GIS check for whether we have an interest in a proposal e.g. when someone approaches us with an s95E. If the site shows up as red then it warrants further consideration. \\Wgnhosvr1\groups$\RMA_Ranger

10. Additional comments:

- It seems that there is little or no reporting of threatened species impacted by consents from here. The majority of consents dealt with here are for discharges to air, land, water or for water take. There are likely to be impacts to some habitats and/or species from some of these consents but I am unclear as yet on how these are dealt with. Do you have contacts for the District councils? It would be good to know how they deal with their consents as they may have more dealings with habitats and veg clearance.
- Note: Although both Regional and District Councils have management responsibilities relating to indigenous biodiversity under the RMA, the Regional Policy Statement for Taranaki indicates responsibility for controlling the use of land to maintain indigenous biodiversity is with the District Councils (New Plymouth DC, Stratford DC and South Taranaki DC), EXCEPT where the use of land relates to the Regional Councils functions under the RMA.
  - Under s30 of the RMA, these are:
  - The control of water (includes taking, using, damming and diverting)
  - The control of air
  - The control of land for the purposes of soil conservation, water management, natural hazards avoidance and hazardous substances management
  - The investigation of land for the purposes of identifying and monitoring contaminated land
  - The control of the coastal marine area (in conjunction with the Department of Conservation)
  - The control of the discharge of contaminants to the environment
  - The control of activities in relation to river and, lake beds.

Tasman District Council: Lindsay Vaughan (response provided via Mike Harding)

1. Do you collect any information relevant to this measure?

- Yes, but only for the small proportion of consent applications that contain an ecological assessment (generally larger projects).

2. If you do, can you describe this?

- Through analysis of the assessment of effects and/or through advice from staff and contract ecologists.

3. If you don't, do you have any suggestions on how this information could be collected?

- Information about the location and extent of threatened species is gathered through TDC Native Habitats Tasman project (a District-wide survey of significant indigenous vegetation and habitat for RMA section 6(c)).

4. What triggers a consent application being sent to your team? [Not asked in this interview]

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded?

- Consents for drainage, vegetation clearance, road construction and land development. Local knowledge.

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- National published lists. No, all species on lists are considered, based on advice of ecologists.
  Potential adverse effects are considered for all consents.

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- Yes.

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Yes. Depends on the nature and type of the consent.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- Advice is frequently sought from DOC by Councils staff or contract ecologists. No, there is ongoing liaison with DOC, most often through contract ecologists. DOC communicates with councils through staff contact and contract ecologists.

Wellington Regional Council: Philippa Crisp

1. Do you collect any information relevant to this measure?

- For terrestrial not directly, main reason is that Regional Council doesn't deal with vegetation clearance, only deal with wetlands and aquatic. Consents around roading may go through Regional Council (e.g. Transmission Gully). District councils deal with vegetation clearance. One option is for Regional Councils to gather this information from the relevant District Councils. In some places (ARC) now all one, but this isn't the norm around the country.

- One issue is that locations for threatened species are poorly known. Consultants preparing the consent application may miss threatened species in their surveys and they may not have had the background information to know what to look for in the first place. So if we do improve this knowledge, may see an increase in threatened species impacted by consents, but this will be because of information base improving rather than necessarily a true increase.

2. If you do, can you describe this?
- In few consent applications that their office has reviewed, they have found threatened species missing.

3. If you don't, do you have any suggestions on how this information could be collected?
- Could improve processes. See suggestions above re: Regional vs. District Councils. Not so many consents coming in that affect threatened species so it isn't a huge ask to improve the processes.

4. What triggers a consent application being sent to your team?
- It should as a matter of course, but if the applicant has used consultants then the consenting officer may feel the knowledge is sufficiently complete to not warrant further scrutiny.

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded? Is there a database of consents and what does it contain?
- Don't know.
- Could probably exclude those with no biological component. Might actually need to talk to consents people to identify the biological/non biological divisions around consent types.
- Doesn't think there is a database.

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?
- Not that she knows of.
- Main concern is nationally threatened (national critical, vulnerable, endangered, not the lower level rankings). There is no regional level threat listing, although this would be a good idea (may not be practicable though).

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?
- Has only been involved in a limited number where this is the case, but in those, yes potential impacts have been summarised

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Yes (e.g. Transmission Gully). The consent holder has to prepare a report pursuant to the management plan required by the consent.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- Weren't involved with Transmission Gully. In this region may be primarily focussed on DOC estate. DOC isn't always asked about consents, so they would need to find out about ones that are relevant to threatened species in another way.

Marlborough District Council: Nicky Eade

1. Do you collect any information relevant to this measure?

- Not really, we do collect some info on Threatened Species through different processes, but not directly through the consent process. These include
  - SNA surveys
  - Freshwater surveys
- The consenting group circulates a list of consent applications fortnightly, so then science staff can comment (based on their knowledge gained elsewhere, see above). They are a unitary council which makes communication easier. The consents planner wouldn't have access to this information (i.e. threatened species lists) directly
- The comments of the biodiversity team on consents are not tracked formally, would depend on consent planner and how far they want to take this.

2. If you do, can you describe this?

- See above

3. If you don't, do you have any suggestions on how this information could be collected?

- Not really. But there should be a better system for formalising and standardise the knowledge of the environmental science and monitoring group (maps, checklists) that could be available to consenting planner. Could target the easiest, most obvious species first (e.g. weka, seabirds), but unclear the degree to which activities which affect them (i.e. a subdivision bringing in dogs and cats) could be restricted.

4. What triggers a consent application going to you?

- Get a full list of consents to review (fortnightly). Consents offices will approach their office about specific consents if they suspect that there is an issue. But threatened species have not really emerged as a big issue. Existence of SNAs would be more noticed.

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded? Is there a database of consents and what does it contain?

- The consents database brings up the conditions of the consents.
- Information on threatened species wouldn't be flagged in the database. Not a searchable factor. She isn't an expert in using the database.

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- Not right now. Might need to talk to consents officer. Follow the current up-to-date classification from DOC (national lists). Would be nice to have a regionally-based list – both species occurring in the region and regional priorities (e.g. southern Marlborough has hardly any native species left so just about everyone is important).
- Threatened species can be given consideration in the consent process (e.g. recent king salmon hearings, a threatened species of shag got a big hearing owing to submissions). Marine mammals would have an influence.

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- Could be if the presence of threatened species was raised as an issue, but in some cases the issue might have never been raised in the first place.

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Yes. Not all consent conditions end up being followed up on.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- They could have. Probably took a stronger advocacy role in the past than now. Probably would if it were on their land. Council has a good relationship with DOC but with restructuring some of the contact points have broken down.
- Should it be DOCs job to come up with regional lists of threatened species and feed into the process?

10. Additional comments

- Biodiversity role of Regional councils – Biomanagers group have been asked to review regional council roles in Biodiversity. It could be important to look at this in relation to this issue.

- Is this getting too far into DOC territory? But who else has a role with private land? So attention needs to go into the processes.
- Highlighted in 2007 Priorities statement, has been integrated into District plans somewhat (wetlands, threatened environments), threatened species and naturally rare could be emphasised further.

Hawkes Bay Regional Council: Malcolm Miller [Consents Manager]

1. Do you collect any information relevant to this measure?

- Not consistently. We may issue consents which include conditions seeking avoidance of areas of habitat but we don’t actively follow up and gather data on these. We may request some reporting of species loss.

2. If you do, can you describe this?

- Some consents may require reporting of effects; e.g. for consents for pest control using 1080 we have included a condition requiring reporting of any reported loss of untargeted species:

  > (a) Summary (including type and number) of any reported non-target species birds and animals that were killed within the operation area, where this death is potentially attributable to the direct or indirect consumption of 1080.

- The Ruataniwha Water Storage Scheme (RWSS) dam construction consent has conditions requiring pre and post construction monitoring of eels. This is to verify if conditions requiring trap and transfer of eels to and above the dam are working. This decision is still draft decision from the EPA appointed Board of Inquiry. The RWSS has also proposed a comprehensive Integrated Mitigation and Offset Programme. This includes the establishment of a Ruataniwha Biodiversity Advisory Board to oversee delivery and the development of a monitoring strategy. If you wish to sight the details refer to the Ruataniwha Water Storage Conditions Document, Schedule 2 Conditions 5 -9.

http://www.epa.govt.nz/Publications/Volume_3_of_3_(pt_2_Conditions_Schedule_1-3).pdf

This project depends on whether the dam proposal is proceeded with.

3. If you don’t, do you have any suggestions on how this information could be collected?

- See above

4. What triggers a consent application going to you?

- We are receiving all consents that fall within the jurisdiction of the Regional Council. If the proposal is in an area known or identifiable as having importance as a habitat for endangered species this will be considered in the assessment of effects. If necessary HBRC will seek expert advice on the values from in house science or from external experts.

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded? Is there a database of consents and what does it contain?

- This would not be straight forward. Consents to discharge contaminants for pest control, to dam water bodies, do works in waterways, or in the coastal environment may all raise issues of the effects on endangered species.
- It would be possible to do a key word search of conditions to pick up key conditions that reference endangered species. But many consents may not specify threatened species and may rather be addressing the habitat requirements that lend themselves to sustaining threated species. E.g. fish passage, riparian margins etc.
- There is a data base of consents. It tracks the progress of the consent from initial application to being issued. It links to previous consents which have been superseded. It provides access to the officer's report and consent document. It tracks subsequent compliance with conditions.

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- I consider it would be possible to flag consents where threatened species are mentioned. We don't currently so would need to consider what lists to use and how this will benefit the Council. We would be guided by any Biodiversity Strategy and National and Regional Policy.
- In processing a consent we will have regard to the effects on any threatened species or their habitats and work to condition the consent to avoid, remedy or mitigate these effects.

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- Yes, typically.

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Yes, typically. It will depend on the conditions of consent. HBRC may require works to occur outside spawning or breeding periods. The times of the works can be observed via compliance monitoring. Works may be required to avoid nesting birds. This may require a trained person to go on site and mark out no go areas. Otherwise compliance may rest with the operator. Or compliance may rely on responding to complaints from the public. As mentioned above the RWSS proposal to establish a water storage and irrigation supply scheme in the Tukituki catchment and the Ruataniwha plains area has included resource consents that will lead to damming areas of indigenous habitat including bat roosts and falcon nests. Conditions are proposed that require offsetting of these lost habitats. Monitoring of these before and after is required.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- Depending on the initial assessment of effects, DOC may be informed or notified where it is considered there are effects that may be of concern to them. DOC has participated in some consents often around effects of water takes on instream habitats or wetlands or on coastal areas. This is more than just being involved on issues related to the DOC estate. We will meet DOC staff from time to time informally to discuss matters e.g. Tukituki water take consent renewals and coastal protection works. They have formally submitted on consents and have engaged in hearings on occasion. They are participating in a non-statutory Catchment Management Plan initiative that has arisen out of a water allocation consenting process in the Poukawa catchment (in order to enhance management of Lake Poukawa). DOC is participating in the Regional Plan development process for the Heretaunga Plains and catchments (TANK). Restructuring seems to have moved some of the RMA / advocacy staff functions away from the Hawke's Bay to Waikato, reducing our frequency of contact.

Otago Regional Council: Richard Lord

1. Do you collect any information relevant to this measure?

- Not really – but ORC do a lot of annual water quality monitoring which includes electric fishing and recording fish species. Rare or threatened species can be picked up through this activity.

2. If you do, can you describe this?

- See above

3. If you don't, do you have any suggestions on how this information could be collected?

- There is certainly information out there – but mostly collected by other people (DOC, Landcare, consultants, District Councils) but there is no mechanism to pull it together.

4. What triggers a consent application going to you?

- Generally more about biosecurity issues, effluent discharges is a permitted activity – do inspections of dairy farms, so no consent application required. Generally does not receive consent applications that may have a biodiversity impact.

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded? Is there a database of consents and what does it contain?

- Would point them in the direction of the resource consent offices. His team does the audit of those consents (is the compliance team). So they could provide some help as well. The kinds of consents that should be examined – those regarding water and coastal (probably highest priorities) and air; probably best to not ignore any classes of consents. Land disturbance is at the District Council level.

- There is a database. Called 'Objective'. Has a consent number and a brief description of what the consent is for. ARC-GIS viewer layer to show location of consents. Could search individual consents, once you open that particular file (e.g. the pdf file). It would be hard for someone outside their office to extract the relevant information as in their office they hold a lot of knowledge and familiarity with consents based on their long experience and work with the consent process.

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- Otago Council has never identified a threatened species list specific to their area. They don't apply the national lists (i.e. those compiled and administered by DOC). So this would not be easy to do, because for the most part threatened species wouldn't be mentioned in a consistent way. But may come out in officers report

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- Probably would come out in consent officers report

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Yes they would. Compliance is done through audits (periodic basis) or if a complaint is received.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- For all notified consents DOC has the opportunity to make a submission. They can make submissions regarding proposed activities both on and off the DOC estate as they are treated like any other submitter. Yes there is some communication between DOC and their office. Often consultation during the notification period. DOC does reporting on their own land, but unlikely to do reporting off their land.

Auckland Council: Alastair Jamieson

1. Do you collect any information relevant to this measure?

- Possibly, but not directly or routinely. Might be the odd consent with threatened species information in it.

- Marine: coastal protection areas – a number of these are defined based on the presence of international significant wading birds. Here information on these threatened species may be more readily captured, but the biodiversity team is not really involved with marine things (CPAs). Those offices that were responsible have been recently restructured, so is unclear which team is handling this now.

2. If you do, can you describe this?
- See above

3. If you don't, do you have any suggestions on how this information could be collected?
- How to do that given the complex structure of the organisation is not all that clear. Couldn't really happen unless there were rules around threatened species.

4. What triggers a consent application going to you?
- This is based on Auckland operative plans as applies to schedules of significant natural areas and now the proposed Auckland Unitary Plan that defines significant ecological areas. Consents divisions would make a judgement of whether the consent should come to the Biodiversity office, so referral isn't necessarily automatic. Species *per se* aren't recognised in the regulatory plans, but threatened species information is one of the factors that has gone into determining significant ecological areas. SEAs may have threatened species but as of yet the identity of all of them may be unknown. There also could be threatened species outside of SEAs. Once species are under the jurisdiction of Wildlife act is no longer council responsibility (responsibility is DOC). DOC would only know about potential violations of the Wildlife Act if the consent was notified. For example, it is unknown where all threatened lizards are and there are vegetation clearance rules outside of SEAs where the primary concern is erosion, for example. In this case no-one would know that lizards were there to be considered in the first place. So while killing the lizards is an offence under the wildlife act, this might never be discovered. Basically if an area isn't scheduled as an SEA or SNA then threatened species will fall between the cracks as far as council considerations go.

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded? Is there a database of consents and what does it contain?
- Most consents were mapped in the past (not sure about this now). It is unclear whether they are mapped only at the property scale or provide detail of the part of the property to which the consent applies. Could intersect these maps with maps of SEAs and then potentially figure out which SEAs had threatened species recorded. There would be a reasonable amount of work involved with this. Some interpretation would be required as to whether the nature of the consent would actually impact the threatened species present.
- To be able to do this would probably require a change in the regulatory processes.

- There probably are a few databases of consents. Probably not yet amalgamated from the original component councils. Unlikely to have the information that would be relevant to this measure.

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- Don't know how searchable the databases would be, probably not. For the consents that come to the Biodiversity office – could potentially set up an EXCEL spreadsheet. However, the Biodiversity office does not know whether all the consents that should come to them actually do.
- For unitary plan they used DOC national list and a regional list (for plants made by Botanical Society and DOC, probably constructed by Euan Cameron and Peter De Lange; for animals may have been prepared by the old DOC Conservancy).
- If threatened species present, ecologists would provide advice to planning team but wouldn't know what actually happened with this advice. The Biodiversity office is most effectual around SEAs, less effectual around wildlife act.

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- The Biodiversity office doesn't see them, but potentially they would be. Probably under the radar for small-scale vegetation clearance. Would be widely variable the degree to which such impacts would be summarised.

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Can be mitigation where there is vegetation clearance, have been rules about transferring animals (e.g. various road construction and golf course developments have required lizards to be translocated). Compliance teams sit within the regulatory department. Compliance is budgeted within the consent fees, but generally is quite a low amount and may not be sufficient for the monitoring that is really required. If there is a planting plan (restoration) one of the Biodiversity team might be involved to see if the planting meets the requirements of the consent.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- Would need to talk to DOC.

10. Additional comments:

- Biodiversity team is quite separate from regulatory divisions. Still lots of legacy structures from the old councils, so not everything is connected up.

Horizons: James Lambie

1. Do you collect any information relevant to this measure?

- Not in a way that would be easy to answer these questions. We have policies around assessing site significance of aquatic ecosystems where significance is defined by specific indicator species that are in themselves threatened (fish and whio (blue duck). There is a list of SNA sites. For terrestrial ecosystems the approach is not around identifying SNAs per se. Rather there is a schedule of habitat types and some of these are defined by the presence of a listed threatened species (e.g. *Powelliphanta* habitat, some shrubs). If the area under consideration for a resource consent includes a listed habitat that defines the site as significant.

2. If you do, can you describe this?

- See above

3. If you don't, do you have any suggestions on how this information could be collected?

- They do get unevenly distributed, ancillary info about threatened species that is revealed during the consent process.

4. What triggers a consent application going to you?

- Terrestrial ones where there may be an activity such as vegetation disturbance/clearance in one of the listed habitats.
- But won't see consents for activities in non-listed habitats (e.g. beech forest) that may contain threatened species.
- Aquatic ones: discharges (direct sewage, indirect (earthworks, diffuse pollutants – intensive farming), disturbance of the riverbed or margin, water takes (including ground water) – consents team will decide whether receiving environments will be affected.
- The issue that is relevant to this measure is that there are no direct rules around threatened species.
- Some RMA background: Initially the responsibility as outlined by the RMA of controlling activities of vegetation clearance/disturbance with Districts, as they were responsibility for earthworks, land use etc. Later RMA amendment made Regional Councils responsible for biodiversity protection (so Regions can write regional policy statements that Districts have to adhere to and give effect to in their District Plans. However, this amendment did not give Regional Councils the power to control activities that might impact biodiversity unless the Districts agreed to delegate this power to the Regions.
- Horizons decide the District Council Plan process and focus on SNAs wasn't giving effect to their policy of no net loss of biodiversity, so they wrote some rules around this. So now consents involving vegetation clearance can go to both the Districts and the Region.
- If Horizons ecologists visit a site subject to a consent application, they would record what is important about site that needs to be protected from impacts of the activity. This would include noting any threatened species that were observed.

- Their rules focus on habitat, rather than species. This is because the RMA specifies that local governments should be focussed on habitats whereas responsibility for species is DOCs.

5. If one wanted to summarise which approved consents had threatened species mentioned in either the initial application or somewhere in the approval process, how would one determine which consents to examine? Are there any types of consents that could be excluded? Is there a database of consents and what does it contain?

- Would have to go through all of them. Would focus on certain activity types – e.g. vegetation clearance and then within that activity on the rule that might be broken that would be so indicated in the consent application. Example rules focus on threatened habitats, SOSA (Site of significance aquatic) or SOSR (Sites of significance riparian), for example. This would be time-consuming task
- Yes there is a database. In relation to this measure it includes the activity type and then the rule being broken. A future version of the database will hold conditions of the consent (mitigation, monitoring).

6. Would it be possible to flag the consents where threatened species are mentioned? What threatened species list is used? Are only the species with the highest threat status considered? Are consents where threatened species are an issue given special consideration?

- Manual process would be required. Could a flag for threatened species be created in new database? YES. They probably should. Responsibility for maintaining and adding this to the database would be the consents people. If the flag doesn't add information that the consents people feel they need (e.g. breaking the rule) then they wouldn't want to spend the time capturing it. Addition of this flag would have to be promoted as required for compliance with the 'no net loss of biodiversity' policy.
- Although ticking a box sounds easy, finding the information in the consent might be challenging. Whether this is being done properly might need to be determined by the ecologists. Adding info such as the actual identity of the threatened species might be better done by the ecologists as this would be both challenging for the consents people and they may not feel this is part of what they should be doing.

7. When a consent is approved for an area containing a threatened species, are potential impacts summarised in the decision?

- Can be. Not all the time. Might be an application that will affect multiple threatened species. So there will be a collective impact that would be described. Some of older decisions (before the rule on biodiversity protection) might not summarise potential impacts. Modern ones might not if the species was missed in the assessment (e.g. species is cryptic (*Dactylanthus taylorii*) or assessment done by an ecologist who would not record taxa outside of their specialty.

8. Does the consent decision summarise mitigation and monitoring requirements for the consent holder? If so, how is compliance assessed?

- Yes. Compliance – generally don't go back to older consents. The compliance team spends more effort on instances where rules are being broken rather than ensuring that monitoring or mitigation is being carried out. Also depends on nature of consent e.g. compliance for Dairy sheds very rigorously assessed, but consents for forest harvesting may not be checked, especially if sites are in remote areas where checking on compliance would be costly. The resource consent decision has no provisions for the consent holder to pay for the compliance checking.

9. What involvement does DOC have with consents that cover areas where threatened species occur? Is DOC only involved when the area being affected is DOC estate? How do they communicate with the councils? Does DOC do any reporting that is relevant to this measure?

- DOC is involved when it's on DOC estate. Off the DOC estate -- if an application comes through that they know is a threatened species that DOC is actively working on trying to conserve then DOC are contacted as an affected party. Planners generally come to James – it comes down to understanding the degree to which the activity might result in harm to the threatened species population.
- For fish, for example, DOC helped write the rule that Horizons implemented. DOC is happy that Horizons is following the rule, so DOC does not need to be contacted.
- What about threatened species (e.g. plants) that DOC isn't actively working on? Answer is "yes" that DOC would usually be contacted. But there is no formality around this. No obligation on the part of the council to contact DOC except for those species for which there is national law (e.g. lizards, whitebait).

Northland Regional Council: Lisa Forester

All of these questions are best answered by our Consents Department as, I'm afraid I am not involved closely enough with the consents process to understand exactly what information is recorded. We do process the consents through our IRIS database but I am not aware that there are any records specifically for impacts on threatened species other than incidental capture of data through the AEE process. The person to talk to is Geoff Heaps – geoffh@nrc.govt.nz

Our team receives a spreadsheet of new applications every Monday morning which enables us to follow up on any applications we are interested in. Occasionally, where processing officers deem it necessary, they approach me or any of the other specialists for advice on particular applications. In the case of

Excavating for swamp kauri our field officers maintain a relationship with logging companies particularly in the far North. We encourage an approach in the pre-application stage to discuss the need for a consent as well as appropriate environmental standards. This is because of a number of incidents that have been raised by the public post logging where wet paddock sites end up looking like wetlands.

[No further response received. Unable to schedule an interview with Lisa; contacting further people, e.g. Consent Officers, was beyond the scope of this project]

Appendix 10-3 – NZ Threat Classification System lists 2012–14

Conservation status of New Zealand hornworts and liverworts, 2014.
Peter J. De Lange, David Glenny, John Braggins, Matt Renner, Matt von Konrat, John Engel, Catherine Reeb and Jeremy Rolfe 2015. *New Zealand Threat Classification Series 11*. 31 p. (PDF, 686K (opens in new window))

Conservation status of New Zealand earthworms, 2014.
Thomas R. Buckley, Stéphane Boyer, Scott Bartlam, Rod Hitchmough, Jeremy Rolfe and Ian Stringer 2015. *New Zealand Threat Classification Series 10*. 10 p. (PDF, 575K (opens in new window))

Conservation status of New Zealand marine invertebrates, 2013
Debbie Freeman, Kareen Schnabel, Bruce Marshall, Dennis Gordon, Stephen Wing, Di Tracey and Rod Hitchmough 2014. *New Zealand Threat Classification Series 9*. 20 p. (PDF, 664K (opens in new window))

Conservation status of New Zealand freshwater invertebrates, 2013
Natasha Grainger, Kevin Collier, Rod Hitchmough, Jon Harding, Brian Smith and Darin Sutherland
New Zealand Threat Classification Series 8. 28 p. (PDF, 748K (opens in new window)) Supplemental data (XLSX, 125K (opens in new window))

Conservation status of New Zealand freshwater fish, 2013

Jane M. Goodman, Nicholas R. Dunn, Peter J. Ravenscroft, Richard M. Allibone, Jacques A.T. Boubee, Bruno O. David, Marc Griffiths, Nicholas Ling, Rodney A. Hitchmough and Jeremy R. Rolfe 2014. *New Zealand Threat Classification Series 7*. 12 p. (PDF, 599K (opens in new window)) Supplemental data (XLSX, 48K (opens in new window))

Conservation status of New Zealand bats, 2012

C. O'Donnell, J. Christie, B. Lloyd, S. Parsons and R. Hitchmough 2013. *New Zealand Threat Classification Series 6*. 8 p. (PDF, 552K (opens in new window)) Supplemental data (XLSX, 21K (opens in new window))

Conservation status of New Zealand frogs, 2013

Don Newman, Ben Bell, Phillip Bishop, Rhys Burns, Amanda Haigh and Rod Hitchmough 2013. *New Zealand Threat Classification Series 5*. 10 p. (PDF, 566K (opens in new window)) Supplemental data (XLSX, 23K (opens in new window))

Conservation status of New Zealand birds, 2012.
Hugh Robertson, John Dowding, Graeme Elliott, Rod Hitchmough, Colin Miskelly, Colin O'Donnell, Ralph Powlesland, Paul Sagar, Paul Scofield, Graeme Taylor 2013. *New Zealand Threat Classification Series 4*. 22 p. (PDF, 620K (opens in new window)) Supplemental data (XLSX, 98K (opens in new window))

Conservation status of New Zealand indigenous vascular plants, 2012.

Peter de Lange, Jeremy Rolfe, Paul Champion, Shannel Courtney, Peter Heenan, John Barkla, Ewen Cameron, David Norton and Rodney Hitchmough 2013. New Zealand Threat Classification Series 3. 70 p. (PDF, 793K (opens in new window)) Supplemental data (XLSX, 410K (opens in new window))

Conservation status of New Zealand reptiles, 2012.

Hitchmough, P. Anderson, B. Barr, J. Monks, M. Lettink, J. Reardon, M. Tocher and T. Whitaker 2013. *New Zealand Threat Classification Series 2*. 16 p. (PDF, 650K (opens in new window)) Supplemental data (XLSX, 39K (opens in new window))

11 Indicator M14: Vegetation consents compliance

Author: Fiona Thomson, Landcare Research; Marie Brown, Environmental Defence Society

11.1 Overview

Indicator M14 (Vegetation consents compliance) reports on the number of resource consents issued by each council over a reporting period that allow vegetation clearance, the total area that this affects, and the number of resource consents for vegetation clearance that concern scheduled sites, along with their total area.

11.2 Scoping and analysis report

Background information

The Regional Council Biodiversity Working Group (BDWG) agreed that the 'ecological integrity' framework used by the Department of Conservation (DOC, Allen et al. 2013) was appropriate for regional councils (Lee & Allen 2011). The working group identified a suite of 10 biodiversity indicators, and related measures, relevant for biodiversity monitoring requirements in terrestrial ecosystems (Lee & Allen 2011). This report concerns *M14 Vegetation consents compliance* which is part of the Biodiversity Protection indicator. Measure 14 was included to directly assess for the influence of compliance with vegetation consents and plan rules more generally on extent of vegetation (Lee & Allen 2011).

Indicator definition

For reporting at a national scale the definition of M14 ('Compliance with vegetation-related resource consents and any planning rules restricting vegetation clearance consent (most particularly on scheduled sites')) needs to be consistent between regional councils and unitary authorities.

Consent definition

The word *consent* refers to a resource consent. Resource consent is permission (usually with conditions) from a council for an activity that is not allowed as of right in the district or regional plan. The Resource Management Act (RMA), specifically Sections 6 (c), 30 (Box 1), gives regional and local councils biodiversity responsibilities.

RMA Section 6

Matters of national importance

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall recognise and provide for the following matters of national importance:

c. the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna.

RMA Section 30

Functions of regional councils under this Act

(1) Every regional council shall have the following functions for the purpose of giving effect to this Act in its region:

(a) the establishment, implementation, and review of objectives, policies, and methods to achieve integrated management of the natural and physical resources of the region:

(b) the preparation of objectives and policies in relation to any actual or potential effects of the use, development, or protection of land which are of regional significance:

(c) the control of the use of land for the purpose of—

(iiia) the maintenance and enhancement of ecosystems in water bodies and coastal water:

RMA Section 31

Functions of regional councils under this Act

(1) Every territorial authority shall have the following functions for the purpose of giving effect to this Act in its district:

(a) the establishment, implementation, and review of objectives, policies, and methods to achieve integrated management of the effects of the use, development, or protection of land and associated natural and physical resources of the district:

(b) the control of any actual or potential effects of the use, development, or protection of land, including for the purpose of—

(iii) the maintenance of indigenous biological diversity:

Box 1 http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM231907.html accessed 24 January 2013.

Reporting compliance

Vegetation clearance rules are not nationally consistent because the statutory roles concerning these rules are devolved to district and city councils (Ministry for the Environment 2004). Section 35 of the RMA requires that councils monitor the effectiveness of their policies and plans (Box 2) and councils are required to report on certain aspects of that to the Ministry for the Environment as part of the National Monitoring System. Relevant measures for this indicator include the number of compliance FTEs employed and the number of infringement fines issued, among others.

RMA Section 35

Duty to gather information, monitor, and keep records

(1) Every local authority shall gather such information, and undertake or commission such research, as is necessary to carry out effectively its functions under this Act or regulations under this Act.

(2) Every local authority shall monitor—

(a) the state of the whole or any part of the environment of its region or district—

(i) to the extent that is appropriate to enable the local authority to effectively carry out its functions under this Act; and

(ii) in addition, by reference to any indicators or other matters prescribed by regulations made under this Act, and in accordance with the regulations; and

(b) the efficiency and effectiveness of policies, rules, or other methods in its policy statement or its plan; and

(c) the exercise of any functions, powers, or duties delegated or transferred by it; and

(d) the exercise of the resource consents that have effect in its region or district, as the case may be

(2A) Every local authority must, at intervals of not more than 5 years, compile and make available to the public a review of the results of its monitoring under subsection (2)(b).

Box 2 http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM231907.html accessed 24 January 2013.

Indigenous vegetation definition

Measure 14 does not specify that the vegetation to be cleared must be indigenous to be included in the measure. Regional councils may already have an agreed definition for indigenous vegetation within their existing policy and planning framework. In the absence of an existing definition, councils may adopt the suggested definition below (proposed by the Ministry for the Environment in the *Proposed National Policy Statement on Indigenous Biodiversity: Evaluation under section 32 of the Resource Management Act 1991*(2011) (Box 3).

Indigenous vegetation: indigenous vegetation means any local indigenous plant community through the course of its growth or succession consisting primarily of native species and habitats normally associated with that vegetation type, soil or ecosystem or having the potential to develop these characteristics. It includes vegetation with these characteristics that has been regenerated with human assistance following disturbance or as mitigation for another activity, but excludes plantations and vegetation that have been established for commercial harvesting.

Box 3 Definition of indigenous vegetation (Ministry for the Environment 2011)

Scheduled sites definition

Consistent reporting across regional councils requires standardised criteria for assessing whether sites are 'scheduled sites' for the purposes of monitoring. Currently the names for and definitions of 'scheduled sites' differ throughout local government agencies. A clear definition is suggested that should capture what a 'scheduled site' is, despite the variation and considering the purpose of the measure:

'A scheduled site is defined as any area that is identified in the relevant plan or proposed plan (inc for the purposes of protection under section 6 of the Resource Management Act'

11.3 Indicator Statistic

Measure 14 should report:

The rules controlling vegetation removal

Whether there are rules in the plan or plans that control the removal of vegetation from any areas (include a checkbox) for reporting at a national scale (Yes/No)

Consents requesting removal of indigenous vegetation

a. The number of resource consents applied for, that request permission to remove indigenous vegetation
b. The number of resource consents applied for that request permission to remove indigenous vegetation from a scheduled site
c. Total area of indigenous vegetation (ha) for which resource consents have been submitted for clearance.
d. The proportion of the area in 'c' that is within scheduled sites

Consents approving removal of indigenous vegetation

a. Number of resource consents approved that allowed removal of indigenous vegetation

b. Total area of land (ha) where resource consents were approved to remove indigenous vegetation.

Compliance with consent requirements

1. Number of resource consents where compliance was met, with compliance defined as not more than the allowed area and extent of vegetation was removed at the time of assessment

2. .Number of resource consents where compliance was not met, where compliance not being met is defined as the vegetation cleared exceeded what was allowed in the consent and was not otherwise lawful

3. .Total area of land (ha) where resource consents have been given and compliance has been met (i.e. vegetation clearance occurred according to the terms of the consent).

Compliance with plan requirements (i.e. activities outside of consents)

a. Number of complaints relate to the alleged removal of unlawful indigenous vegetation received by council

b. Number of complaints substantiated as involving removal of indigenous vegetation without permission

c. The proportion of substantiated complaints that took place all or in part within a scheduled site

d. The total area of vegetation clearance that occurred which should have had consent but did not.

These statistics should be reported for the region. Consistent reporting of the statistics among regions will enable aggregation to a national level of reporting. Caveats related to compliance reporting will require multiple fields to assess compliance more than once, sometimes over a period of many years.

11.4 Reporting frequencies

Regional councils should report the statistics annually. Five-yearly summaries could be reported incorporating more detailed statistics and looking at land-use clearance over time, e.g. vegetation type of land cleared over time. Reporting frequencies should be integrated with those proposed for Measure 9 and other reporting frameworks such as the National Monitoring System.

11.4.1 Reporting hierarchies

Regional councils can report on resource consent compliance with vegetation clearance rules regionally, allowing aggregation of reports at a national scale. This would require cooperation of district councils that undertake the majority of land use regulation. Statistics could also be reported within each region of removal of indigenous vegetation within vegetation classes dominated by indigenous cover, e.g. forests, shrubland, grasslands, and wetlands, using LCDB definitions.

11.5 Spatial and temporal analysis

Summary maps of area of vegetation cleared over time could be created for long-term monitoring of changes in extent of indigenous vegetation. Loss and gain in extent of indigenous vegetation should – where possible – be divided into LCDB classes and expressed as both a whole figure and a proportion of vegetation cover at a regional level. Regional councils may also wish to use this data to inform their assessments of the effectiveness of regional and district level policies and programmes over time.

11.6 Relationships between indicators and present patterns

Linkages to other measures

Indicator M14 has links to M8, M9 and M18 (

Table 11-1). Data collected for M8, M9 and M18 could be used to inform land-use types, help with monitoring vegetation clearance and defining *scheduled sites*. Measure 9 will provide data on vegetation and habitat loss that can be compared with the amount of vegetation cleared through the resource consent process.

Table 11-1 Regional council terrestrial biodiversity monitoring framework indicators related to M14: Compliance with vegetation clearance rules, especially on scheduled sites

Indicator	Measures	Element	Ecological Integrity	Driving forces – Pressure-State-Impact-Response	Data required and potential sources
Habitat loss **(M8)**	Change in area under intensive land use	LCDB cover classes within an agreed definition of 'intensive land use', e.g. areas actively managed to the general exclusion of terrestrial native biodiversity (i.e. crops, roads, etc.)	Environmental representation	Pressure	Data: LCDB and re-runs, while maintaining historical compatibility of cover classes.
Habitat loss **(M9)**	Habitat and vegetation loss	Based on changes in area of land cover classes and naturally rare ecosystems	Environmental representation	Impact	Data: LCDB and reruns, augmented by regional aerial mapping for habitat loss.
Protection and restoration **(M18)**	Area and type of biodiversity protection achieved on private land	New areas (ha) protected through initiatives on private land.	N/A	Response	Data: Permanent Forest Sink Initiative, QEII covenants and regional council and DOC reserves/covenant data.

11.7 Assessment of existing methodologies

Overall summary

Four regional councils responded with current methods for monitoring vegetation consents compliance, making it difficult to get a national-scale picture. Currently, both the consent process and the monitoring of consents is very variable among regional councils. Data are currently not shared between councils.

Summary of existing methods from response to questions and requests for methods

- What data do you currently collect for monitoring vegetation consents compliance? Please place in order of importance.

  'No compliance data collected. SOE monitoring has involved identifying wetlands on orthophotos and recording shape files. Some wetlands have been recorded on oblique aerial photos.'

'Don't issue consents for vegetation clearance, only have one rule regarding the exposure of more than 10% of the sub soil when clearing more than 5 ha of vegetation on slopes over 28 degrees (permitted activity). If the sub soil can't be revegetated then a site erosion and sediment control management plan must be submitted and the activity becomes controlled. Consent monitored if a controlled activity. See Regional Soil plan rule on website.'

'Visual comparison of the area authorised for consent with the actual area cleared – an aerial map is attached to the consent showing the area and boundaries subject to the consent.'

- What data (that you currently don't collect) would be useful to collect for monitoring vegetation consents compliance?

'Photopoints would provide a useful record. Standard methods for measuring wetland and swamp forest health would be useful for key sites but are resource hungry.'

'Area'

'Not sure what SOE monitoring we do'

- What is the minimum data that should be collected for monitoring vegetation consents compliance? I.e. what should be compulsory for all Regional councils.

'Area, vegetation type, dominant vegetation cover'

'Vegetation description, habitat, fauna, area, LENZ, slope, LUC unit'

'Visual comparison of the area authorised for consent with the actual area cleared.'

Data storage and reporting

- Summary: data storage varied between regional councils. Information may be held in reports as photos or data with hard and electronic copies or in a database. Data storage for monitoring vegetation clearance is currently not shared between regional councils.

11.8 Development of a sampling scheme

Summary

Consistent collection of data when consents are submitted, when they are approved and during post-consent monitoring is critical to the successful implementation of M14. In parallel, general monitoring of unlawful vegetation removal is required.

For many councils, database development will be required to store consent information in a way that is accessible for this type of data analysis (and should include data on consents declined). Links to GIS layers to define areas of vegetation and storage for photographs of the areas would also be helpful.To accurately assess compliance, provision for ongoing recording and records management will be necessary.

Database information

The data to be collected is summarised in Table 11-2. **There is a need to agree consistent data standards and defintions, and consistent data curation among councils** as a prerequisite to implementing M14.

Table 11-2 Description of data to be recorded for monitoring vegetation consents compliance

Category	Measure	Definition
Data ID	Unique Identifier	Initials of regional council and then a unique number e.g. Environment Southland would start at 'ES_1'
Consent Process	Consent ID	Identifier that councils use for monitoring consents
	Submission	Yes (this will be used to count the number of submissions)
	Type of Consent[1]	
	Approved	Yes or No
	Date of Approval	DD/MM/YYYY
	Approving Officer	Name of officer. Last name, first name.
	Compliance met	Yes or No
	Compliance Officer	Name of officer. Last name, first name
	Enforcement action	If compliance was not met list the enforcement action taken.
Reports	Report Identifier	If a report was written the correct citation for the report is entered here
Photos	Photos taken	Number of photos taken and stored with the database. 0 if no photographs taken. Photographs should be labelled with the unique identifier number and then the photo number, e.g. ES1_1
Location	GPS location	Northings and Eastings at centre of clearance area
	Submitted clearance area (ha)	Defined area which was submitted in the consent to clear, hectares calculated off GIS layer
	Approved clearance area (m^2)	Defined area where approval was given to clear vegetation, hectares calculated off GIS layer
	Area cleared (ha)	Defined area where vegetation was actually cleared, hectares calculated off GIS layer
Scheduled Sites	Submitted scheduled site clearance area (ha)	Defined scheduled site area which was submitted in the consent to clear, hectares calculated off GIS layer
	Approved scheduled site clearance area (ha)	Defined scheduled site area where approval was given to clear vegetation, hectares calculated off GIS layer

Category	Measure	Definition
	Area of scheduled site cleared (ha)	Defined scheduled site area where vegetation was actually cleared, hectares calculated off GIS layer
	Type of scheduled site	Description of scheduled sites
Property details	Property address	Flat number, street number, street, suburb, postcode
	Property owner phone	033526169 (do not put in any brackets/spaces or + symbols)
	Property owner name	Last name, first name, title
	Property owner email	Email address of property owner
Notes	Notes	Any additional information to be included here

[1]Many consents for vegetation removal also apply to a range of other activities/breaches, which means this may be hard to collect info on. Possible option is to have a categorical spread of activity types under 'purpose of clearance' (i.e. subdivision, infrastructure, mining etc)

Compliance (must allow for continuous assessment)

Date of compliance visit		
Compliance met	Yes or No	
Area removed (compliant) ha	Non-scheduled site	Scheduled site
Area removed (non-compliant) ha		
Compliance Officer	Name of officer. Last name, first name	
Enforcement action	If compliance was not met list the enforcement action taken.	

Costs

The costs associated with this measure will be dependent on the extent to which vegetation removal is controlled through the relevant plan, the development pressure in the area and the number of consents applied for (and monitoring required of compliance). The quality and scope of any given council's present recording system – and the availability of suitably qualified staff - will also determine the capital investment required to track this data. For some councils, much of the above will already be collected in some form – while for others much more change to process and expenditure will be required.

11.9 Data management and protocols

Data protocols and formats

A national-scale, web-based database for data management of M14 is recommended. Currently there is no consistent database structure used by regional councils to store data on vegetation clearance or consents. Land Resources Support System (LRSS) is a database system being built by the Bay of Plenty and Greater Wellington regional councils, with the aim that it will be a central repository that all regional councils can access. This would be the best place for data from M14 to be stored because it is managed by regional councils. For more information including standardised data protocols, contact Bay of Plenty Regional Council.

In the short term, regional councils should create individual datasets that can be incorporated later into the LRSS. Data formats must be kept standardised across regional councils, so that separate datasets can be easily merged for future analyses. Column headers must remain the same and in the same order as presented in Table 11-2. If a new entry (row) is created then no blank spaces should be left (i.e. enter 'none' when the data are unknown or not relevant). Addition of any new columns in the future should be decided upon by all regional councils to maintain consistency across regional councils. Data sheets created should be in excel or equivalent, with data exportable in a .csv file format.

GIS layers should be stored in a shape file format with polygons named using the unique identifier in the database. Data storage of GIS data should follow the same protocols for Measure 9. Any photos taken should also be named using the unique identifier and saved as a .jpeg file. Certain data cannot be shared between regional councils due to privacy issues and these columns should be removed from the database if files are sent to other regional councils or the data suitably aggregated to avoid identification.

Data to be excluded:

- ***Property address*** Flat number, street number, street, suburb, postcode
- ***Property owner phone*** [9 or 10 digits]
- ***Property owner name*** Last name, first name, title
- ***Property owner email*** Email address of property owner

11.10 Reporting indices and formats

At a regional scale, using the database developed above, regional councils should sum individual entries to calculate the total areas and total numbers required for the indicator statistics (Table 11-3). A map of the region can be developed showing the total area of land where resource consents have been submitted, approved and where the vegetation has been cleared. Descriptions of the vegetation types cleared (e.g. LCDB cover classes) will aid interpretation. National-scale reporting should compare between regions, and also sum totals across regions. Comparison of data from M14 with data from M9 (total loss of vegetation over the region) would allow regional councils to assess how much unconsented vegetation loss has occurred.

Table 11-3 Example reporting format for M14

	Number of resource consents	Total area (hectares)	Number of resource consents concerning scheduled sites	Total area concerning scheduled sites (hectares)
Submitted	12	15	1	0.05
Vegetation clearance approved	10	8	1	0.05
Vegetation clearance taken place	9	7.5	1	0.05
Compliance has been met	9	7.5	1	0.05
Compliance has not been met	0	0	0	0

11.11 References

Allen RB, Wright EF, MacLeod CJ, Bellingham PJ, Forsyth DM, Mason NWH, Gormley AM, Marburg AE, MacKenzie DI, McKay M 2013. Designing an Inventory and Monitoring Programme for the Department of Conservation's Natural Heritage Management System. Landcare Research Contract Report: LC1730 for Department of Conservation, Wellington, New Zealand.

Land Resources Support System Scope. Bay of Plenty Regional Council and Greater Wellington Regional Council. http://dataversity.org.nz/r/file/32117-2012-06-05T000141Z. Accessed 11 July 2012.

Lee WG, Allen RB 2011. Recommended monitoring framework for regional councils assessing biodiversity outcomes in terrestrial ecosystems. Landcare Research Contract Report LC144 for the Regional Council Biodiversity Forum Technical Group. 29 p.

Ministry for the Environment 2004. A snapshot of council effort to address indigenous biodiversity on private land: a report back to councils. Wellington, New Zealand. ME Number 523.

Ministry for the Environment 2011. Proposed National Policy Statement on Indigenous Biodiversity: Evaluation under section 32 of the Resource Management Act 1991. Wellington, New Zealand. ME Number 1032.92. 33 p

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Appendix 11 – Feedback from regional councils

Feedback from regional councils for each report. YES indicates that a council gave feedback regarding the report. Regional councils that were contacted were those whose contact details were provided on the key contacts list. Reports 3, 4 and 5 were sent as a group for the final report

	Report 1	Report 2	Report 3	Report 4	Report 5
Waikato Regional Council	YES	YES			
Marlborough District Council	YES	YES			
Greater Wellington Regional Council					
Horizons Regional Council				YES	
Otago Regional Council					
Northland Regional Council					
Taranaki Regional Council					
Auckland Council					
Bay of Plenty Regional Council	YES	YES		YES	
Tasman District Council	YES	YES			

12 Indicator M15: Indigenous ecosystems released from vertebrate pests

Author: Dave Latham, Landcare Research

12.1 Introduction

Indicator M15 reports the area and number of indigenous ecosystems fenced to exclude vertebrate pests and in which pest control against veterbrate pests has been conducted. This definition is reduced in scope from the original 'indigenous ecosystems released from pests' to render reporting tractable, i.e. not requiring councils to report on areas and numbers of ecosystems in which weed control or exclusion has been conducted, likewise of invertebtrate pests and diseases. Evalating this measure requires each council to coordinate records from their own vertebrate pest control activities in spatially explicit databases. It also requires reporting these activities in the context of indigenous ecosystems consistent with their definitons in other measures (i.e. M1, Land under indigenous vegetation and M5 Vulnerable ecosystems).

12.2 Scoping and analysis

12.2.1 Definitions

A primary requirement for providing a national, standardised method of reporting Indicator M15 is to obtain consensus on appropriate definitions for the terms used in the description of the Measure and Element. Regional council experts were contacted and invited to respond to questions relating to the terms used in this measure. We summarise their responses and recommend definitions.

1. *M15 definition* – it was agreed that the definition of the measure should change from 'indigenous ecosystems released from pests' to 'indigenous ecosystems released from *vertebrate* pests'. Although weeds and non-vertebrate pests are also recognised as important, as currently described in the Element, M15 will initially consider only vertebrate pests for national reporting. An additional factor relating to the definition is that councils must decide whether an ecosystem has been released from vertebrate pests if (a) a key focal pest species is removed/intensively controlled or (b) all vertebrate pest species have been removed/intensively controlled.

   M15 element – we have included the word 'pest' in the element to emphasise that it is vertebrate pest densities that are of interest, not vertebrate densities *per se*. We have removed the word 'predator' from the element because intensive control can target vertebrate pests (e.g. brushtail possums) that incidentally depredate some native animal species. We define 'intensive control' as exclusion fencing, trapping or poisoning that is sufficient to meet the outcomes defined by regional councils for indigenous ecosystems (see 3 and 4 below).

2. *Indigenous ecosystem* – critical to reporting area and land cover class or habitat released from vertebrate pests is defining what is meant by 'indigenous ecosystems'. The definition of 'ecosystem' will suffice as 'a biological community plus all of the abiotic factors and processes influencing that community'. Measure 15 requires further refinement of the definition as an 'indigenous ecosystem'.

   Definition of 'indigenous ecosystem' – we recommend that this definition must include recognition that the ecosystem has indigenous dominance. Indigenous dominance should be defined as ecosystems comprised predominantly of native fauna and flora. Following M1, tables of exotic/indigenous vegetation by LCDB classes relative to natural vegetation, as well as field site inspections (used in conjunction with implementation of M2 and M3), should be used to determine indigenous dominance.

3. *Released from vertebrate pests* – the term 'released' implies that vertebrate pest populations are being monitored to assess whether control programmes have reduced their densities to a level where target objectives or thresholds set by the council are being met. Determining such thresholds is challenging. For most species and ecosystems, acceptable thresholds or target densities are non-linear functions, with benefits accruing only at very low pest densities (Norbury et al. 2015). For others, thresholds or target densities are unknown. Where applicable, pest target densities should be estimated using national monitoring protocols, such as the National Pest Control Agencies protocol for monitoring possums and the modified MacLean scale rabbit index.

   Requirement – councils must recognise that for M15 to be useful (i.e. ecosystems can be termed released from pests), they must demonstrate that vertebrate pest densities have been reduced sufficiently in the indigenous ecosystems they manage to produce a change in pest impact. However, setting up rigorous population monitoring programmes can be difficult and expensive. Consequently, we recommend that councils keep and report details on what vertebrate pest population monitoring they do in the indigenous ecosystems they manage, and whether target objectives set by the council are being met (see Table 12-1). Initially councils might not be able to implement rigorous pre- versus post-control vertebrate pest population monitoring programmes for all indigenous ecosystems managed as part of M15. However, the aim should be to progressively increase the amount of population monitoring done, with the intent of demonstrating that indigenous ecosystems have been released from vertebrate pests.

4. *Outcomes of exclusion fencing or intensive vertebrate pest control* – vertebrate pests should be controlled for beneficial outcomes for indigenous ecosystems. Thus, councils must define intermediate and longer-term outcomes, as well as the indicators or impact measures they will use to demonstrate the effectiveness of their vertebrate pest control. Methods of defining outcomes for regional councils have been developed for New Zealand, and we direct those councils that have not yet defined outcomes to the following website: http://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/vertebrate-pests/measuring-performance. Outcome monitoring can be reported in a similar way to population monitoring, using indicators such as M2 and M3, or other methods focused on taxa of interest (see Table 12-1).

Table 12-1 An example method of recording site-specific population and outcome monitoring details for M15. Using this system, regional councils can easily report the total area (ha) included in M15, as well as details about how much of the total area has received vertebrate pest population monitoring and whether defined outcomes have been achieved. *Note: this table is not for national reporting purposes; rather it should be used as a guide to compiling statistics to be reported for M15 (see Table 12-2). Councils can add data to additional columns in this table for intra-regional purposes, if required*.

Indigenous ecosystem	Area released (ha) [a]	Area treated (ha) [b]	Monitoring of pest population – based on national or best practice protocols	Defined outcomes met – evidence of release from pests
Rimu Downs	275	350	Yes	Yes
Kauri Flats	2,785	3,500	Yes	No
Gecko Gorge	765	0	No	No

[a] Area released is the total area of the indigenous ecosystem released from vertebrate pests.
[b] Area treated is the total area of the indigenous ecosystem *and* any buffer surrounding that indigenous ecosystem that needed to be treated in order to achieve release.

5. *Spatial data* – M15 requires reporting of the area and land cover class or habitat where vertebrate densities have low ecological impacts following exclusion fencing or intensive control. Area should be reported in hectares. We recommend that land cover classes rather than habitat should be used for national reporting for M15. In addition, broad-scale land cover classes for M15 should align with those identified in M1, M8 and M9. Regional councils can further stratify land cover classes for intra-regional purposes if deemed necessary, and report within naturally uncommon ecosystems and wetlands (as defined in M12); regional assessments within widespread naturally uncommon ecosystems and wetlands can be aggregated nationally.
6. *Community group contributions* – we recommend that where community groups are (1) contributing to vertebrate pest reductions (i.e. as defined in M20) in indigenous ecosystems, and (2) using comparable monitoring methods to estimate reductions in those areas, these data should also be included in M15.

12.3 Statistics to report

1. The total number and total area (ha) (plus mean and range) of indigenous ecosystems within a region in which councils are reducing vertebrate pest densities with the aim of releasing the site from pests for indigenous ecological benefits. This requires spatially explicit databases of areas in which pest control has been applied for each vertebrate pest species.
2. The number of indigenous ecosystems, and their total area (ha; defined in indicators M1 and M5), also expressed as percentages of the total number of indigenous ecosystems and their total area (ha) in a region (a) in which councils are conducting rigorous, ongoing vertebrate pest population monitoring, and (b) where defined outcomes for indigenous ecosystems have been achieved (see Table 12-1 above).

   Note that outcome monitoring should only be conducted if vertebrate pests are being intensively controlled; thus, the percentage of sites where both types of monitoring occurs should match the percentage of sites where outcome monitoring occurs.

Councils might choose to monitor ecosystem condition when no pest control is carried out but such sites should not be included in M15.

3. The total area (ha) of indigenous ecosystems that have been (a) fenced to exclude only livestock; (b) fenced to exclude livestock and wild ungulates; (c) fenced to exclude all vertebrate pests; and (d) where intensive pest control has occurred (i.e. poisoning or trapping).
4. The top five vertebrate pest species that are being controlled for indigenous ecosystem protection, reported as a percentage of the total area of each indigenous ecosystem in which each vertebrate pest species is being controlled.
5. A summary of broad land cover classes where vertebrate pest control or exclusion fencing is occurring (reported as total hectares for each broad land cover class, as used in M1). If there are too many land cover classes in a region to report all of them, then the three most common broad land cover classes and two representative vulnerable ecosystems (as defined in M5) could be reported. Note that reporting for this statistic will be dependent upon selected land cover classes, as used in M1, M8 and M9.

We provide an example half-page schematic of how to present these five summary statistics at the end of this document (Table 12-2).

12.3.1 Reporting frequency

Regional councils should update statistics relating to Indicator M15 on an annual basis, and these should be incorporated into a national report and made available to the public.

12.3.2 Hierarchies

Reporting for M15 should be at the level of vertebrate species. Outcome monitoring is not the purview of M15.

12.3.3 Spatial and temporal analyses

The time-series of the number and area of indigenous ecosystems released from vertebrate pests should be used to assess changes across years. Similarly, time-series of spatial data should be used, delineating the boundaries of indigenous ecosystems released from vertebrate pests, colour coded by land cover classes.

12.3.4 Relationships with present patterns and other measures

It would be useful to compare GIS overlay of sites where indigenous ecosystems are being released from vertebrate pests with sites where similar control is being undertaken by DOC or other agencies. This would show the full extent of the area within each region where vertebrate pests are being managed in indigenous ecosystems, albeit with possible differences in methodology, intensity and rigour. Spatially explicit definitions of indigenous ecosystems derive directly from indicators M1 and M5.

As previously mentioned, where community groups (M20) contribute to vertebrate pest reductions in indigenous ecosystems, this information should be summarised, and included by regional councils for national reporting of M15.

12.3.5 Assessment of existing methodologies

A questionnaire was sent to experts of participating regional councils. From their responses, we collated information on how regional councils define indigenous ecosystems and how they (1) quantify reductions in vertebrate pests in those areas and (2) determine release from vertebrate pests.

For the purpose of providing a national, standardised method of reporting M15, we provide standard definitions for the main terms and components of M15 (see section 12.2.1).

12.3.6 Development of a sampling scheme

There is no sampling scheme associated with M15. Regional councils must report the total number and total area (ha) of all indigenous ecosystems that they manage to reduce vertebrate pest densities (i.e. it is a census).

Regional councils must develop a common data collection framework for population monitoring and outcome monitoring for M15 so that it can be aggregated for national reporting purposes.

12.3.7 Data management and access requirements

Initially, data collected on (and aggregated from) M15 should be from regional councils and unitary authorities only, not other agencies. This does not preclude data being collected from additional agencies in the future and included in regional council national reporting once the regional council data collection and reporting process is operational. These could include activities of government agencies (especially DOC), quangos (e.g. TBfree NZ), NGOs and community groups. We recommend coordination with DOC and TBfree NZ to develop consistent data standards for reporting M15.

If community groups contribute to vertebrate pest reductions in indigenous ecosystems (see M20), relevant data should also be included in M15. Councils therefore need to coordinate reporting of M15 and M20.

Consideration will need to be given to management and access of regional council data, and the resulting recommendations will likely need to be aligned with other Indicators.

12.3.8 Reporting indices and formats

For national reporting, councils should report annually the area (ha) and land cover classes where vertebrate pest densities have low ecological impacts following exclusion fencing or intensive control. Information about pest population monitoring and outcome monitoring should be stored and updated as required in a spreadsheet similar to Table 12-1. The simple summary statistics reported in Table 12-2 can be derived from information stored in Table 12-1.

Methods to evaluate pest populations and outcomes that support M15 require further research and development. There has been considerable investment in this research across a range of ecosystems; we recommend a consensus approach across regional councils, DOC and research providers so that a consistent, defensible data set on pest populations and biodiversity outcomes supports the data tabulated in item 2 of Table 12-2.

Table 12-2 Example half-page schematic of how to present the five summary statistics that need to be reported for Indicator M15

1. Indigenous ecosystems released from vertebrate pests	
Total number	16
Total area of indigenous ecosystems	6768 ha
Mean and range of above	390 (27–638) ha
Total area treated to achieve release (includes buffers surrounding indigenous ecosystems)	12,965 ha
2. Percentage and area of indigenous ecosystems with:	
Vertebrate pest population monitoring	65%; 4,279 ha
Defined outcomes achieved[1]	37%; 2,542 ha
3. Total area of indigenous ecosystems that have been:	
Fenced to exclude only livestock	501 ha
Fenced to exclude livestock and wild ungulates	763 ha
Fenced to exclude all vertebrate pests	1,453 ha
Poisoned or trapped to reduce vertebrate pests	5,315 ha
4. Top five vertebrate pests and the percentage of sites at which they are being controlled:	
Possums	100%
Ship rats	100%
Feral cats	63%
Stoats	58%
Hedgehogs	40%
5. Total area of key indigenous land-cover classes in sites where vertebrate pests are being controlled:	
Indigenous forest	5,834 ha
Subalpine shrubland	479 ha
Dunes	265 ha
Coastal wetlands	143 ha

12.4 Reference

Norbury GL, Pech RP, Byrom AE, Innes J 2015. Density-impact functions for terrestrial vertebrate pests and indigenous biota: guidelines for conservation managers. Biological Conservation 191: 409–420.

13 Indicator M16: Change in the abundance of indigenous plants and animals susceptible to introduced herbivores and carnivores

Authors: Catriona MacLeod, Fiona Thomson, Peter Bellingham, Landcare Research

13.1 Introduction

This report concerns M16 (‘Change in the abundance of indigenous plants and animals susceptible to introduced herbivores and carnivores’) that is part of the Pest Management indicator.

Indicator M16’s reporting element is the ‘Contribution (richness, tree species basal area, and density) of palatable plant species (e.g. Forsyth et al. 2002) and indigenous birds (herbivores, insectivores, ground dwelling) in representative ecosystems’. Indicator M16 is analogous to the two Department of Conservation (DOC) indicators: 5.1.3 ‘Representation of plant functional types’ and 5.1.4 ‘Representation of animal guilds’ (Lee et al. 2005), both currently in use in DOC’s Biodiversity Monitoring and Reporting System (BMRS). The measurements of plant communities employed at national and local scales by DOC employ long-established methods (Hurst & Allen 2007a, b), and use many identical methods to those used in indigenous forests and shrublands measured as part of the Ministry for the Environment’s (MfE’s) Land Use and Carbon Analysis System (LUCAS; Payton et al. 2004; Payton & Brandon 2011).

13.2 Scoping and analysis

13.2.1 Indicator definition

Palatable plants

Palatable plant species are those on which herbivores feed preferentially, and the focus for M16 is those species that are palatable to widespread, introduced pest mammalian herbivores (e.g. brushtail possums, goats, deer, pigs, hares and rabbits). Ascribing palatability to individual plant species is best achieved through studies of diet, but there is also a growing understanding that a range of whole-plant and leaf traits are linked to the palatability of plants to herbivores. Using these traits together as an aggregated index can provide a measure of the overall palatability of vegetation at regional to national scales, and it can be used as a measure of how the overall palatability of vegetation changes in response to management. We advocate an approach that utilises responses of individual native plant species known to be palatable, especially species ‘selected’ by individual herbivores based on meta-analyses (Forsyth et al. 2002; Allen et al. 2013a), coupled with an approach based on leaf traits to place local results in regional context. Use of leaf traits also allows evaluation of change at broader scales that transcend the ranges of individual species, some of which are very narrow. An aggregated index of leaf traits across species can be applied at regional to national scales.

This does not preclude reporting of individual palatable species within regions, but limits reporting to those with a sufficiently large regional sample.

Birds

This measure focuses on bird species because they are directly susceptible to introduced carnivores and indirectly to the effects of introduced herbivores. Introduced carnivores prey upon eggs, nestlings, juveniles or adults, but they can also be competitors for food resources. Introduced herbivores can affect birds indirectly, by modifying the vegetation structure and altering availability and quality of key food resources (invertebrate, fruit, nectar, seed and other foliage components) and nesting habitats. We recommend grouping bird species according to traits related to their vulnerability to introduced carnivores, and to the impoverishment of their habitat by introduced herbivores. This can be further disaggregated to the native and introduced birds within these groupings.

Representative ecosystems

Statistics should be reported within ecosystems across the whole region. Land cover classes as defined by the New Zealand Land Cover Database (LCDB; see M1) should be used to define 'representative ecosystems' (e.g. natural forests, shrublands, plantation conifer forests, and pastures). The ability to report within land cover classes depends on there being a sufficient number of sampling locations to produce defensible estimates for both palatable plant species and birds. We recommend reporting only within broad classes to enable aggregation to a national scale. Some land cover types, especially natural forests and shrublands, are sampled nationally across public conservation land (DOC's BMRS), and other land cover classes in primary production, mostly on private land, have been sampled at catchment scales for vegetation and birds in Marlborough District (R.J. Holdaway, pers. comm., Orwin et al. 2016) and, since 2015, by Greater Wellington Regional Council (P. Crisp, pers. comm.). Individual councils could choose to sample some land cover classes at greater intensity (e.g. Auckland Council presently samples natural forests at a finer sampling intensity than a national 8 × 8 km grid) or report finer units of divisions within some land cover classes (e.g. various classifications of natural forests, e.g. Wiser et al. 2011; Singers & Rogers 2014).

13.2.2 Indicator Statistic

Palatable plant species

We advocate a whole-community approach (i.e. collecting information about all plants present at a sampling location – palatable and unpalatable), and that while disaggregated data should be collected at each sample point (i.e. at the species level), indicator statistics should be reported by aggregating species (i.e. across all palatable plant species).

A standard plot size (i.e. 20 × 20 m) should be used for region-wide reporting of M16 across all vegetation types, which will ensure consistency with M2 and methods used by DOC in its Tier One monitoring across all public conservation land. The following statistics should be reported.

1) Change in the proportion of species richness of palatable species to that of unpalatable species per plot, for woody species, non-woody species, and all species combined.

2) Change in the proportion of the density of palatable to unpalatable woody species. Density is the number of individuals divided by the area (400 m^2), so density can only be calculated for palatable and unpalatable woody species.

3) Change in the proportion of the basal area of palatable to unpalatable woody species. The basal area (ba) of each woody stem is calculated from its diameter at breast height (dbh):

$$\boldsymbol{ba = \left(\frac{dbh}{2}\right)^2 \times \pi}$$

   The basal areas of all palatable and unpalatable species are summed per plot and a proportion of palatable to unpalatable species' basal areas derived accordingly.

4) Change in frequency of seedlings of palatable woody species. Frequency of occurrence can be determined by the number of seedling subplots (24 systematically located 0.75-m^2 plots per 400-m^2 plot) that seedlings of palatable woody species occupy.

5) Change in frequency of palatable non-woody species. Frequency of occurrence can be determined by the number of seedling subplots (24 systematically located 0.75-m^2 plots per 400-m^2 plot) that palatable non-woody species occupy. Regional councils could report the change in mean percentage cover (using cover-class mid-points) for non-woody species.

All of these statistics, in association with plant traits (e.g. fibre content; Forsyth et al. 2005), allow calculation of whole-plant-community-level metrics of palatability to particular herbivores (see section 13.13.1).

The emphasis is on regional reporting of M16, but this measure can also be used to evaluate effectiveness of management at local scales (e.g. Bellingham & Mason 2012; Richardson et al. 2013; see Appendix 13-1).

Bird species

For subsets of bird species, grouped according to traits associated with feeding preferences or their susceptibility to predation (i.e. feeding guilds and predation risk), we recommend reporting:

1) mean species richness (number of species present) for all species, and split by native and introduced species.

2) mean occupancy (the proportion of location occupied by a given grouping of species) for all species, and split by native and introduced species

3) mean and/or total population density (the number of individuals of a given grouping of species within a hectare) for all species, and split by native and introduced species.

13.3 Reporting Frequencies

Regional councils should adopt the same 5-yearly reporting frequency as DOC.

13.4 Reporting Hierarchies

Regional councils can report on the contribution (richness, tree species basal area, and density) of palatable plant species (e.g. Forsyth et al. 2002) and indigenous birds (herbivores, insectivores, ground dwelling) at regional scales. Statistics could be reported within broad vegetation types (e.g. natural forests, shrublands, plantation conifer forests, and pastures, as defined by LCDB; see M1), depending on the number of sampling locations. The methods described will also be useful for evaluating the effectiveness of management at key sites (e.g. those that are subject to sustained pest control).

13.5 Spatial and temporal analysis

The basic framework for regional reporting of M16 entails regional councils extending the 8-km grid used for sampling carbon in natural forests and shrublands (LUCAS) and for sampling biodiversity (the same data as used for M2, M3, M7 and M16) on public conservation land (DOC's BMRS). This will give systematic spatial coverage across all regional councils, and will allow aggreggation to a national scale. The capacity to report M16 in land cover types and ecosystems other than natural forests and plantation forests depends on investment in quantifying plant traits and, for birds across the whole landscape, the development of a defensible classification for bird traits (see section 13.9.2). To determine temporal change in M16 vegetation and bird communities can be compared either at a regional scale or within LCDB classes (where there is adequate replication) using paired *t*-tests or similar. More complex generalised linear models can incorporate environmental and biotic covariates in analyses (e.g. Bellingham et al. 2014). The greater the number of 5-yearly measurements of M16, the greater will be the confidence in determining trends. In all cases, additional power will be gained by using covariates, including environmental and biotic data, to detect change in M16.

13.6 Relationships between indicators and present patterns

The primary data for M16 will be derived entirely from data collected for M2 and M3 (Table Table 13-1). Other measures could be used to interpret any spatial and temporal trends in M16. Under the 'Weeds and animal pests' indicator, measures of the distribution and abundance of animal pests (M7) will be particularly relevant in interpreting changes in the metrics of M16. Indicator M16 could also be used to assess whether areas subject to protection policies have enhanced biodiversity outcomes relative to areas without protection, potentially in conjunction with M6 ('Biodiversity Protection') and M12 ('Changes in the extent and protection of indigenous cover or habitats or naturally uncommon ecosystems'). Such analyses, could thus inform management and policy at regional and national scales.

Table 13-1 Regional council terrestrial biodiversity monitoring framework indicators related to M16

Indicator	Measures	Element	Ecological Integrity	Driving force(PressureStateImpactResponse)	Data required and potential sources
Biodiversity Condition	Vegetation structure and composition (M2)	Presence of suitable indigenous component in all structural layers	Species occupancy	State	Element: Presence of appropriate indigenous component in all structural layers Data: Requires standardised field sampling, e.g. augmenting LUCAS plots, and agreement of focal species and parameters.
Biodiversity Condition	Avian representation (M3)	Presence of suitable bird species across trophic levels	Species occupancy	State	Data: Requires standardised field sampling and classification of birds into relevant guilds.

13.7 Assessment of existing methodologies

The field data collected for M2 and M3 is the main information required for M16. Trait-based information on palatable plant species and indigenous bird species susceptible to predation is required to allow the field data from M2 and M3 to be analysed suitably to report M16.

13.7.1 Current approaches employed by regional councils

Palatable plant species

Regional councils differ considerably in the amount of vegetation monitoring they conduct. They also use a variety of methods to monitor vegetation including photopoints, general visual assessment (captured in a report), 20 × 20 m permanent plots, 5 × 5 m relevé ('recce') plots, wetland monitoring plots that include a 10 × 10 m temporary relevé, 2 × 2 m permanently marked relevé plots (Clarkson et al. 2004), Scott-height frequency methods along a transect (Wiser & Rose 1997), and rapid relevés (recording a subset of species present at a site). The methods used depend on the type of area being monitored (e.g. wetlands, geothermal regions, forests) and arbitrary preference for methods employed.

Indigenous bird species

Regional councils often rely on citizen science data for information on birds. Regional councils that monitor birds use a range of sampling designs and count methods typically focussing on site-specific surveys (see M3 report). Only two regions implement regional-scale monitoring initiatives (Auckland and Greater Wellington). The five-minute bird count is the primay bird count method employed.

13.8 Monitoring objectives and sampling designs

We recommend implementing M16 regionally using the 8 × 8 km sampling framework used nationallyby DOC and MfE. This systematic sampling can be supplemented by other schemes, from unstructured (e.g. NatureWatch, eBird) to semi-structured schemes involving citizen science (e.g. Garden Bird Survey) that can add value (i.e. extending spatial and temporal inference; e.g. MacLeod et al. 2015).

13.9 Spatial and temporal scope

13.9.1 Palatable plant species

The spatial and temporal scope of measuring palatable plant species in New Zealand varies widely, broadly being either focused on individual highly palatable plant species or on the whole plant community, including both palatable and unpalatable components. Measuring highly palatable plant species alone, without context, is appropriate for palatable plant species that are highly sensitive to effects of introduced herbivorous mamals (e.g. some of the mistletoes (Sweetapple et al. 2002) and *Dactylanthus taylorii* (Ecroyd 1996)). Such examples are rare: even species such as kōtukutuku (*Fuchsia excorticata*) that can be browsed severely by possums in some parts of their range (e.g. in Wellington Region; Urlich & Brady 2005) are resilient to browsing by possums in others (e.g. Banks Peninsula). Most of the highly sensitive individual plant species that can be used as indicators of the effects of herbivores are also highly habitat-specific (e.g. Ecroyd 1996; Sweetapple et al. 2002), which restricts their widespread utility. Region-wide reporting using such species is difficult, although they can make illuminating case studies.

Many palatable plant species are naturally patchy in their distribution. Many occur in greatest abundance in recently disturbed sites, such as along natural forest margins, landslides, and in gaps caused by falling trees in forests (e.g. Sweetapple & Burns 2002; Bellingham & Lee 2006; Mason et al. 2010). These sites are typically more resource-rich (e.g. in light and often in soil nutrients). Many of these communities are not only patchy but also transient in space and time, therefore tracking young successional plant communities in which these species occur will be challenging as they mature and naturally change in composition. Furthermore, concentrating efforts in these communities alone will produce a biased view of the maintenance of palatable plant species.

Even for palatable plant species that are longer-lived and widespread, and which persist in old-growth stands, following the fates of individual plant species can be problematic. For example, kāmahi (*Weinmannia racemosa*) is a widespread, long-lived tree that is common throughout most of New Zealand, except in the far north and drier regions, and it is palatable to ungulates and possums. A recent study that followed the fate of individual kāmahi trees in old-growth forests found that mortality rates of the trees in one of two sites where possum control took place were lower than in a site where no control took place (Gormley et al. 2012). However, it is challenging to distentangle herbivory as a driver of mortality from other probable drivers (Peltzer et al. 2014). The observed mortality of kāmahi in old-growth forests could result from a legacy of past disturbances (Allen et al. 2013b). For example, forests in the central North Island are adjusting from large-scale disturbances (such as vulcanism) or more recent Māori fires. These disturbances are likely to have promoted the abundance of kāmahi, and its mortality in old-growth stands is consistent with hypotheses that predict its replacement with more shade-tolerant trees, such as tawa (*Beilschmiedia tawa*) (McKelvey 1963). A landscape-level evaluation of kāmahi populations can reveal that even in regions where its mortality is attributed by some to mammal herbivory, such as in central Westland, recruitment of young individuals in recently disturbed sites more than offsets the mortality of kāmahi trees in old-growth stands (Bellingham & Lee 2006).

These examples underscore the need for understanding the plant community within which palatable plant species occur and its stage of development. For these reasons , we advocate a whole-community approach to reporting (i.e. collecting information about all plants present at a sampling location – palatabale and unpalatable) to add interpretive value to such data as comparative abundance of palatable species, or apparent under-representation in certain life stages (e.g. low levels of seedling regeneration in forests). Community-scale evaluations also permit more nuanced interpretations, for example, that higly palatable plant species may persist in some circumstances where they are rare and co-occur with unpalatable plants species (Bee et al. 2009).

Collecting information about the entire plant community is also valuable for determining trends, since the composition of plant communities is dynamic in space and time. Drivers of change include broad-scale and fine-scale drivers. At broad scales, we can expect more rapid turnover of trees in New Zealand's more northern forests compared with those in cool temperate southern latitudes (Bellingham et al. 1999), and probably across rainfall graidents from wet to dry. The abundance and distribution of many palatable species and the dynamism of their populations are also likely to be governed by soil nutrient availability resulting from variation in geology and soils at regional scales (e.g. Reif & Allen 1988; Laughlin et al. 2015), to variation in fertility that arises from resource quality at fine scales (e.g. Richardson et al. 2008). This highlights the need to use existing environmental data (or to collect primary environmental data such as soil samples at sample points) to aid interpretation of status in trends in populations of palatable plant species. For example, the rate of change in the representation of palatable species in forests on fertile soils is more rapid than on infertile soils (Forsyth et al. 2015), and in young successional communities there can be very large differences between the biomass of palatable species in grazed and ungrazed areas over a decade, as shown in a simulated experiment (St John et al. 2012). The same applies broadly to non-forested communities.

Current national-scale evaluation of status and trends in palatable plant species extends only to natural forests. Use of consistent methods nationally through two assessments of LUCAS in natural forests (2002–2006 and 2009–2014; the latter also as part of DOC's BMRS) allows determination of population trends and size structures in palatable trees (i.e. those that reach at least 2.5 cm in diameter at 1.3 m tall) (see Bellingham et al. 2014). The emphasis on natural forests also reflects that most research investment has been made in determining the palatability of native plants species (e.g. Fitzgerald 1976; Owen & Norton 1995; Forsyth et al. 2002; Sweetapple & Nugent 2004).

Although reporting status and trends in individual palatable plant species is possible at a national scale (e.g. for palatable tree species across natural forests sampled on an 8-km grid), the same sampling intensity is likely to be inadequate for reporting the same species within many individual regions, especially those with a small area of the plant's habitat. Conversely, for some individual palatable plant species, their abundance may be sufficient in a given region but be naturally restricted to it, which mitigates against their use in determining pan-regional status and trends.

An approach that enables wider interpretation and maximises use of data is to evaluate the data provided by plot-based samples in terms of leaf traits (see Appendix 13-1, Definition of palatable plant species). Amongst the plant traits that characterise palatable plant species are thin, short-lived leaves that have high total nitrogen and phosphorus concentrations and low investment in defence (e.g. in content of fibre or defence chemicals). The information that currently supports the capacity to determine status and trends of palatable plants is biased heavily towards forests. Furthermore, established relationships between plant traits and their palatability is strong in the case of ungulates (goats and deer; e.g. Forsyth et al. 2005) but there is a key **research and development need** to determine the *plant traits that are best related to the known diets of the omnivorous brushtail possum* (as well as other locally important herbivores, e.g. dama wallabies (*Macropus eugenii*) in the Bay of Plenty Region).

Generally, the capacity to report status and trends of palatable native plants species beyond forests is limited. Many of New Zealand's non-forested landscapes below treeline have complex mixtures of native and non-native plant species, and there is poor understanding about the species that dominate successions. Introduced herbivores are likely to influence change in these ecosystems but in most of them it is unknown whether they are the predominant driver of change. Studies that determine which plant species are 'selected' and 'avoided' by a particular introduced herbivore in a particular vegetation type or geographic area are painstaking and require significant investment, and there have been few conducted outside natural forests in New Zealand (but see Glimore 1965; Flux 1967; Glen et al. 2012). Hence, the primary information on which species are palatable based on dietary studies is limited and from few sites. Moreover, determining the palatability status of New Zealand's c. 2360 indigenous plant species (de Lange et al. 2009) with respect to each of 29 introduced herbivorous mammals (King 2005) is most unlikely to happen. Ecological research worldwide during the last 15 years has seen a major movement from interpretation of species-specific (and site-specific) studies towards interpretation based on the traits of species as a means of predicting changes in plant communities in response to environmental drivers, including herbivory.

This emphasises a further **research and development need** to **determine *plant traits* in ecosystems outside forests** as the most promising means of evaluating palatability. There are plant trait data from some non-woody ecosystems (e.g. Richardson et al. 2012), but a systematic approach is needed to augment this, using protocols that are well developed and in widespread use worldwide (Pérez-Harguindeguy et al. 2013). A key goal is to identify the palatability of native plants. However, if a community-scale evaluation of palatability is to be included, it would be naïve to ignore the contribution of non-native plants, and to separate trends in palatable native species from trends in co-occurring palatable non-native species. Non-native plants are, in most circumstances, either uncommon or of low biomass in natural forests, but this is not the case in shrublands and non-woody ecosystems. Moreover, most primary production landscapes are dominated by non-native plants that, especially in agriculture, have been selected for and bred to be palatable (e.g. to ungulates), yet also resilient to grazing (i.e. their rate of production of new foliage offsets the amount consumed); examples include widespread, common pasture grasses such as ryegrass (*Lolium perenne*) and cocksfoot (*Dactylis glomerata*). Pasture species feature in the diet of pest mammals (e.g. Gilmore 1965; Harvie 1973; Nugent 1990), and a recent study showed that adjacent, high-producing, pasture grasslands boost numbers of rabbits in largely native-dominated grasslands (Norbury et al. 2013). Plantation forests provide habitat for some native palatable plant species (e.g. Ogden et al. 1997), but possums also feed directly on *Pinus radiata*, the most widespread plantation forestry species (Clout 1977). All of these features underscore the need to quantify plant traits across all species, native and non-native, across the whole landscape support the implementation of this measure.

13.9.2 Indigenous bird species

The spatial and temporal scope of different bird monitoring initiatives in New Zealand differ extensively (see M3 report). Only the bird atlases currently provide national-scale information on species distributions, with more recently established citizen science initiatives (eBird and NatureWatch) aspiring to providing similar data, albeit in a more ad hoc manner. While these data hold potential to provide information on species distribution, the power of these data sources to detect changes in bird community composition at the spatial and temporal scales of interest is still to be determined.

Currently there is no definitive database or objective classification for bird traits in New Zealand, with different researchers using their own interpretations of these data for their own specific research purposes (e.g. Elliot et al. 2010; Hoare et al. 2012; MacLeod et al. 2012a). There is a key **research and development need** to develop such a resource to ensure a **harmonised system for comparing bird traits** across jurisdictions. The Department of Conservation has collated some information to inform their own indicator development (i.e. suitable for reporting across public conservation land only). A broader view will be needed to ensure that the information that underpins M16 also includes traits that are relevant across the whole New Zealand landscape. A trait database has also been developed (Wood et al. 2016) that could provide the basis for an objective classification (see also Barnagaud et al. 2014). Some candidate traits of birds that should be considered for M16 are those that are related to:

- predation risk by carnivores, including body size, flight capabilities, and preferred nesting locations (hole-, crevice- and ground-nesters; Hoare et al. 2012; Monks et al. 2013). A recent study shows that hole-nesting (cavity-nesting) is the key trait among New Zealand's endemic forest birds that relates to contracting of their ranges (Parlato et al. 2015)

- the impoverishment of their habitat by introduced herbivores, i.e. feeding guilds (frugivores, nectar-feeders, herbivores and granivores; e.g. Elliott et al. 2010).

An example of the use of some of the traits that could be used for the reporting of M16 are shown in Fig. 13-2, that is, bird species grouped according to their feeding types and their most frequent nesting sites.

13.10 Data storage and reporting

Currently regional councils store plant and bird data in a variety of ways (e.g. excel spreadsheets, GIS databases or in published reports).

13.10.1 Palatable plant species

Some regional councils use the NVS Express application (available through the National Vegetation Survey (NVS) databank website: https://nvs.landcareresearch.co.nz/Data/dataentry) to upload data collected using the standard monitoring methods (i.e. permanent 20 × 20 m plots) or vegetation inventory (i.e. relevé) methods that underpin M2, DOC's BMRS, and LUCAS (from which the data can support M16). NVS Express is a purpose-built Windows tool for entering and summarising vegetation data compatible with the NVS databank. Data from the NVS databank allows reporting of palatable species at a range of scales (e.g. Bellingham et al. 2014). Other methods can be added to the NVS databank, but are not currently compatible with NVS Express.

13.10.2 Indigenous bird species

Improvements in the protocols and infrastructure for capturing, managing and storing five-minute bird count data collected by regional councils are currently underway. These improvements have largely been motivated by the Biodata Services Stack project, which is developing mechanisms for federating and sharing such data among regional councils (Jerry Cooper and Jamies Lambie, pers. comm.). Whereas NVS is a suitable repository for plant community data, there is no national repository for bird species data. However, DOC is developing an appropriate system, and regional councils should consider coordinating with DOC to invest in the design and implementation of a centralised repository.

13.11 Development of a sampling scheme

To obtain regional coverage and to integrate with other initiatives, the national 8-km grid employed in LUCAS (for natural forests and shrublands, including those on private land) and DOC's BMRS (Tier One measurement schema) provides the most cost-effective means of integration of multiple indicators. This is a systematic sampling scheme with simultaneous collection of data for multiple point-based measures at intersects of a national 8-km grid; the sampling framework and methods developed can readily be extended to include non-conservation lands, as demonstrated for Greater Wellington Regional Council (MacLeod et al. 2012b). Using the same framework across all regional council lands, collecting data for M2 (vegetation) and M3 (birds) will supply data needed to report M16 at a regional scale, and allow aggregation to a national scale. Integrating with DOC's BMRS and LUCAS and will obviate the need for regional councils to collect data on M2 and M3 from public conservation land, and for M2 from most natural forest and shrubland sites on private land, as long as DOC and MfE continue to share the data with regional councils. Data for M2 and M3 have been collected across a range of land-use classes in Marlborough District, much of it on private land, using a grid-based systematic sampling technique during 2013 (Dr R.J. Holdaway, Landcare Research, pers. comm.; see also Orwin et al. 2016).

13.11.1 Palatable plants

The capacity to report status and trends in palatable plant species, as a component of M16, will be limited in the short term to natural forests and plantation forests within and across regions because of the biases in the available database. Investment in quantifying traits and linking these to dietary studies will enable other land cover classes to be reported. If M2 is implemented nationally, some of the key data required for reporting M16 are available (i.e. plant community composition and structure). Available data for M2 could allow status and trend of the palatable plant component of M16 to be reported more broadly than natural plantation forests, if investment is made to quantify plant traits from a broader range of plant species from ecosystems outside forests. That is, the immediate implementation of M2 throughout all landscapes in all regions would still allow retrospective application of trait-based approaches to determining changes in palatable plant species, allowing broad-scale reporting of M16.

Power analyses can be conducted to determine the sampling intensities that are likely to be adequate for reporting status and trends in individual palatable plant species; see MacLeod et al. (2012b) for examples of several palatable, native, woody plant species in the Greater Wellington Region, and Allen et al. (2013a) for examples at national and regional scales. In the Greater Wellington Region, analysis of data from forests and shrublands (LUCAS data) found a mean species richness of 7.62 ± 0.70 (SE) for those species that are selected preferentially by goats, 10.65 ± 0.68 for possum-selected species, and 10.58 ± 0.62 SE for deer-selected species (MacLeod et al. 2012b). Power analyses show that a very high sampling intensity would be needed to detect small changes (<5%) in the mean species richness of woody plant species palatable to introduced herbivores in the Greater Wellington Region (c. 544 sample points needed for goat-selected species, c. 263 for possum-selected species, and c. 222 for deer-selected species; MacLeod et al. 2012b). Much lowere sampling intensities would be required to detect very large changes (≥25%) in mean richness (c. 23, c. 12, and c. 10 sample points needed for the same sets of species; MacLeod et al. 2012b); however, such large changes in mean richness of palatable woody plants are unlikely in all but exceptional circumstances. An approach based on reporting community-weighted plant traits is likely to be more sensitive to change (e.g. Mason et al. 2010), and thus will require lower sampling intensities, although these remain to be determined for individual regions.

13.11.2 Birds

Standardised methods for collection of the primary data needed for M16 are described in detail in the report for M3. These methods include determining occupancy (of all bird species) and abundances (of more common bird species). The exact equivalent of M3 has been implemented nationally by DOC (DOC's Measure 5.1.2; Allen et al. 2013a) throughout public conservation land (i.e. including natural forests, shrublands, and non-forested landscapes). The same methods of measuring bird communities have been implemented in agricultural production landscapes at local scales (MacLeod et al. 2012b), catchment scales (Wairau Valley), and in the Greater Wellington Region since 2014. It will not be possible to report status and trends in occupancy and density of bird species for M16 until investment is made in a defensible schema to determine the traits linked to vulnerability and habitat requirements. However, if the primary data is available from national implementation of M3, then both status and trend information to report M16 is likely to be possible across all landscapes, once a schema based on traits is available.

(i) *Occupancy*: For a given level of sampling effort, detection and occupancy probabilities vary among and within bird species (MacLeod et al. 2012a), habitats and seasons (MacKenzie & Royle 2005), with probabilities of detection ranging from 0.02 to 0.8 and occupancy from 0.02 to 0.99 (MacLeod et al. 2012b). On farmland sites sampled at various sites throughout New Zealand, there were more species (n = 51) but much fewer of these had detection probabilities ≥0.2 (35%) compared with natural forests sampled nationally (66% of 32 species; MacLeod et al. 2012b). Also, for the same species in different habitats, there are differences in detection probabilities, for example, some native passerines (e.g. grey warbler, fantail, tomtit, silvereye) were twice as difficult to detect in farmland as in natural forest, but in natural forests, introduced species (e.g. blackbird, song thrush, greenfinch) were less likely to be detected (MacLeod et al. 2012b).

For Greater Wellington Region, an 8 × 8 km sampling framework yields 127 sampling locations, and power analyses showed that it should be feasible to detect across these (1) moderate to large (>25%) changes in occupancy for 29% of native bird species at the regional scale and (2) large changes (>45%) in occupancy within forests but not in non-forest habitats (where n = 40 sampling locations; MacLeod et al. 2012b).

Once trait groups for birds are agreed for M16, similar calculations can be used to determine the adequacy of the 8 × 8 km sampling framework in any given region to report change in occupany (and shifts in community composition within trait groups) at a regional scale, and, as for Greater Wellington Region, within habitats within the region.

(ii) *Abundance*: For measuring changes in the status of widespread and common species, we expect that abundance will be more informative for measuring change than occupancy (MacLeod et al. 2012c). To estimate densities of bird numbers (as a measure of abundance, using distance detection functions based on point-count data), a minimum of c. 80 detections per species is required. Across 70 sampling locations across public conservation land, density estimates could be calculated for c. 38% of the 32 species detected (MacLeod et al. 2012a), and across primary production landscapes (sheep and beef, dairy, and kiwifruit), densities could be estimated for less than half the bird species detected (using distance detection functions based on line-transect data; MacLeod et al. 2012c). However, as more information becomes available over time, the number of species for which density estimates can be calculated should increase, as multiple measurements can be combined to generate estimates of density for each sampling event.

The precision of density estimates will vary among species, habitats and season (MacLeod et al. 2012c). This will influence the monitoring system's ability to detect spatial and temporal changes in densities. For Greater Wellington Region, an 8 × 8 km sampling framework (n = 127 sampling locations) is sufficient to detect small (c. 5%) to moderate (c. 10%) changes in density for native species in closed habitats and common introduced species in open habitats (when coefficients of variation for density estimates ≤20% and ≥40 sampling locations are surveyed per stratum). For the same sampling design, but where species' density estimates are less precise (21%–40%), it will only be feasible to detect moderate (c. 10%) to large (c. 20%) changes in density (MacLeod et al. 2012c).

13.12 Data management

The vegetation and bird data collected for M2 and M3 will support the ability to report M16. These data sources and associated trait-based information should be in keeping with existing protocols and data management systems.

13.12.1 Palatable plant traits

Analysis of status and trends in palatable plants can be reported in terms of individual plant species where sufficient numbers are sampled, using lists of species determined from dietary studies (e.g. Forsyth et al. 2002). The available information to support these lists is strongly biased towards natural forests.

The primary data needed to support analyses of vegetation for status and trends in leaf traits are held by Landcare Research and are being added to. This includes larger numbers of species, and data are typically added with relevant ancillary data relating to climate, soil nutrients, etc., all of which can influence leaf traits; this is especially relevant for species that have widespread distributions, some of which exhibit considerable intraspecific variation in leaf traits (e.g. Wardle et al. 2009). Most species included in the plant traits database (leaf traits included) are native woody species. Implementation of the palatable plants component of M16 has been achieved at local scales using plant traits in forest patches in the Bay of Plenty region (Bellingham & Mason 2012; Richardson et al. 2013).

13.12.2 Palatable plant species data

The vegetation data for M16 (and M2, which supports M16) should be stored in the National Vegetation Survey Databank (NVS). This facility is run by Landcare Research and is specifically designed to store vegetation survey data in the format used for M2.

Some regional councils are already familiar with the NVS express system, so using NVS express builds upon current knowledge. Using NVS was recommended because it would save regional councils costs associated with creating new databases and data storage facilities and because NVS already has refined protocols for data management, including data validation (Vickers et al. 2012a). An additional advantage of using the NVS express system is that it contains an analysis module (NVS-Analysis; Vickers et al. 2012b) specifically designed for conservation practitioners. This includes the ability to create summary statistics and analyses.

Tools to analyse palatable and unpalatable species for M16, each delineated on the basis of leaf traits, could be included as part of the NVS-Analysis module. The standardised reporting statistics could be adapted to specifically include the palatability indicator statistics for M16. There is likely to be a cost associated with development of a regional council module; for more information contact Susan Wiser (NVS manager, Landcare Research, Lincoln). Additional statistics included in NVS-Analysis can be used by regional councils to gain further descriptions of their sites, including analyses of individual species. There is a **research and development need** for development and ongoing maintenance of a **national plant traits database**.

13.12.3 Indigenous bird species

Storage of the primary data on bird occupany and abundances that are needed for M16 is addressed in the report for M3. Briefly, a system is needed that is consistent across all regional councils and also consistent with those being used by DOC. We recommend that, rather than investing in in-house skills, regional councils should capitalise on the capabilities and investment in database development, management and analytical skills currently being developed by DOC and Landcare Research.

13.12.4 Bird species traits

Until an objective classification for bird traits in New Zealand is developed (see Section 13.9.2), the scope and fields of a database needed to support the bird component of M16 are unclear. The bird trait database has been developed (Wood et al. 2016)). There is a **research and development need** for the development and ongoing maintenance of the **bird trait database** to support M16.

13.13 Reporting format

Indicator statistics can be mapped or graphed to show change in the statistics over space and time. Reporting should include data at a national scale and at a regional scale.

13.13.1 Palatable plant species

Summaries of traits of palatable species

Reporting changes in palatable species is currently restricted to forests, but the principles are generally applicable. Traits can be weighted by the abundance or proxies for biomass (such as cover or, in the case of trees, basal area) of individual species. These produce community-weighted averages for individual traits. These can be compared between measurement intervals (as in Table 13-2), and as trends once there are sufficient measurements (Statistics NZ suggest a minimum of six measurements before inferring trend). In Table 13-2, significant increases over time in this forest community's leaf phosphorus concentrations, coupled with significant declines in leaf mass per unit area, declines in defence chemicals in leaves (phenols, tannins), and declines in investment in fibre and lignin indicate a general trend towards a more palatable community over time.

Table 13-2 Leaf traits, weighted by the number of stems per plot, in 12 plots in natural forests in the Ōhope Scenic Reserve, Bay of Plenty Region, in 2007 and 2011 (mean values ± standard errors) and the mean percentage change (reproduced from Mason & Bellingham 2012). All but leaf nitrogen and cellulose concentrations differ significantly (paired *t*-tests, $P < 0.05$) between measurements.

Leaf trait	2007	2011	Percentage change
Leaf phosphorus concentration	0.127 ± 0.008	0.129 ± 0.005	+1.7
Leaf nitrogen concentration	1.60 ± 0.09	1.61 ± 0.08	+0.9
Leaf mass per unit area	94.7 ± 0.89	92.5 ± 3.9	–2.1
Leaf phenolics concentration	2.60 ± 0.46	2.50 ± 0.17	–3.2
Leaf tannin concentration	1.05 ± 0.20	0.99 ± 0.10	–5.0
Leaf cellulose content	23.1 ± 0.4	23.0 ± 0.4	–0.3
Leaf fibre content	39.9 ± 0.9	39.3 ± 0.9	–1.4
Leaf lignin concentration	16.0 ± 0.7	15.5 ± 0.6	–2.8

Summaries of individual palatable species

If samples of individual palatable plant species are adequate within a region, it is possible to report attributes of their population and, in the case of tagged tree stems ≥2.5 cm diameter at 1.3 m height, their demography (e.g. whether mortality rates exceed recruitment rates). If populations of individual palatable plant species are sampled adequately, for those species a summary table, such as Table 13-3, can be produced for a council's main report. Supporting statistical analyses should be included in technical supplementary material to the summary table (online or in an appendix).

Table 13-3 Change in abundance, demography and population structure of widespread tree species that are palatable to introduced herbivores. Key to symbols: → = remained the same between measurements; ↓ = declined significantly between measurements; ↑ = increased significantly between measurements; R = recruitment; M = mortality.

Species name	Name	Total number of stems in the survey	Basal area	Stem density	Recruitment to mortality ratio (R/M)	Changing size class structures
Pseudopanax arboreus	Lowland five-finger (whauwhaupaku)	+ 31 %	→	→	→	Yes
Pseudopanax colensoi	Mountain five-finger (orihou)	+ 9%	→	→	↑ (R > M)	→
Schefflera digitata	Patē	- 5%	→	→	→	Yes
Dysoxylum spectabile	Kohekohe	-12 %	→	→	→	→
Griselinia littoralis	Broadleaf (pāpāuma)	-3 %	→	→	↓ (M > R)	→
Podocarpus laetus	Upland tōtara	+ 6%	→	→	↑ (R > M)	→

13.13.2 Indigenous bird species

Information can be mapped for subsets of species, grouped according to their traits. For example, Figure 13-1 shows for 155 sampling locations on public conservation lands in 2013, 61% (n = 64) contained at least one hole-nesting bird species (Bellingham et al. 2013); this value includes cavity- and crevice-nesting bird species, which are of interest to DOC because, like hole-nesting species, they are vulnerable to introduced predatory mammals. Consistent with expectation, hole-nesting species occurred most frequently in forest ecosystems (40% of sampling locations) and were least frequent in ecosystems that were deforested by human activities).

Similarly, trend information can be shown for different subsets of species over time (Figure **13-2**).

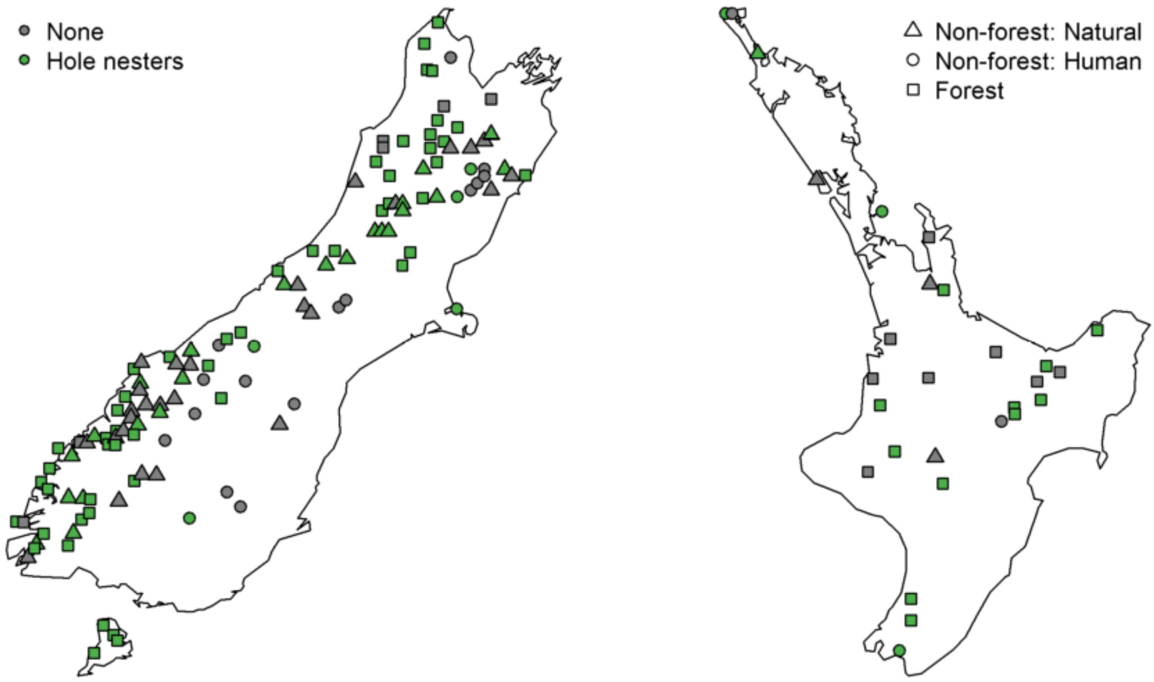

Figure 13-1. Presence and absence of hole-nesting bird species in forested ecosystems, naturally non-forested ecosystems, and ecosystems that were deforested by human activities, focusing on New Zealand's public conservation lands (Bellingham et al. 2013).

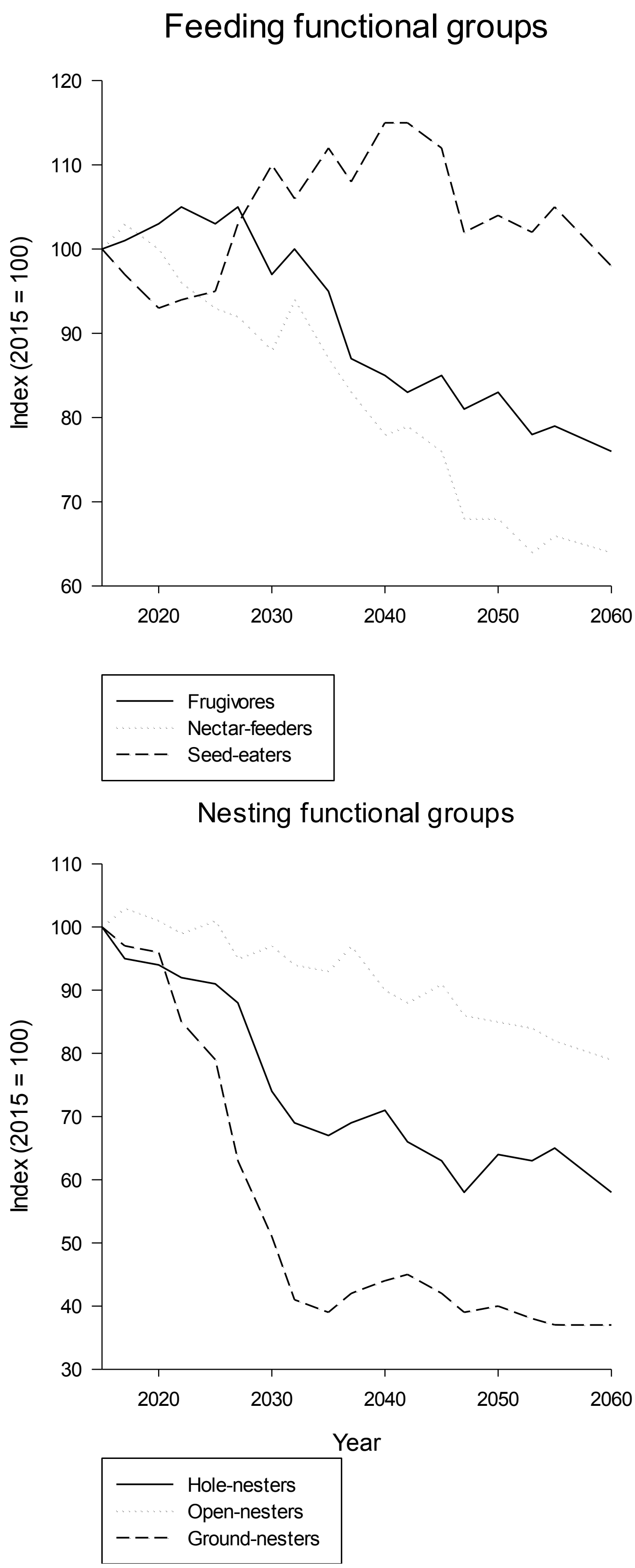

Figure 13-2 Hypothetical dataset showing trends (since 2015) in abundance of different subsets of indigenous bird species grouped according to their feeding and nesting traits and, therefore, their susceptibility to herbivory and predation, respectively.

13.14 References

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Appendix 13-1 – Definition of palatable plant species

Palatable plant species are those consumed disproportionately to their abundances by herbivores (i.e. herbivores consume them preferentially), and the focus for M16 is those species that are palatable to introduced pest mammalian herbivores, including brushtail possums, goats, deer, pigs, hares, etc. Ascribing palatability to individual plant species is best achieved through studies of diet, for example, of rumen or gut samples of mammals from which foliage is identifiable. Ascribing whether herbivores select palatable species preferentially therefore requires both information about their diets (e.g. from gut samples) and information about the relative abundance (or biomass) of species in the herbivore's habitat (e.g. Mitchell et al. 1987; Nugent & Challies 1988; Nugent 1990; Sweetapple et al. 2004; Glen et al. 2012).

The results from many of these studies have been synthesised so that a general view emerges of plant species that are 'selected' (i.e. consumed disproportionately greatly relative to their abundance) and 'avoided' (i.e. plant species that are abundant or form a great proportion of the biomass but which are seldom, if ever, consumed). Such syntheses allow greater confidence in the assignment of palatability classes and allow generalisation beyond single studies. One such synthesis pertains to the diets of introduced ungulates in New Zealand (Forsyth et al. 2002). Another (Allen et al. 2009) provided lists of species that that are 'selected' and 'avoided' by three groups of pest herbivores and omnivores: goats, deer (all deer species combined) and possums. The 'selected' and 'avoided' species lists in that study were based on a range of published papers, unpublished data and expert opinion, with a preference for field studies that measured both pest diet and the surrounding vegetation for 'selected' species and cafeteria trials for 'avoided' species. Most of the plant species listed in Allen et al. (2009) are indigenous forest species because that is where most studies have been conducted, although there are exceptions, especially in the case of possum diets (e.g. Gilmore 1965; Harvie 1973; Glen et al. 2012).

Studies in non-forested habitats have often emphasised the importance of non-native plants in the diets of possums, for example, clover (*Trifolium* spp.) in their diets in pasture (Gilmore 1965; Harvie 1973) or crack willow (*Salix fragilis*) in their diets in deforested central Otago (Glen et al. 2012). Therefore, although the focus of this measure is on indigenous plant species that are indicators of pressure of pest mammals, as more information is revealed about the ecology of pest mammals in other land uses and vegetation, a broader perspective might be taken in future as the measure is refined and developed. Regional councils may wish to invest in a project to identify palatable species in non-forest environments that are commonly found in regional councils' regions. This will be especially useful in agricultural settings, where pasture grasses that have been selected for their palatability to mammals predominate, so that interpreting change in the proportion of indigenous palatable species in this matrix is difficult.

An approach using plant traits can improve the capacity to report status and trends in palatable native plants. For example, woody native plant species in New Zealand forests that have low fibre content in their leaves are much more palatable to red deer than those with high fibre content (Forsyth et al. 2005). There is a growing understanding that a range of leaf traits are linked to the palatability of plants to herbivores. These include

1. leaf mass per unit area (LMA) where, in general, species with thin leaves (low LMA) are often palatable
2. concentrations of nitrogen (N) and phosphorus (P) in leaves, since more palatable species typically have higher nutrient concentrations
3. concentrations of defence chemicals (tannins and phenolics) in leaves, since palatable species are often poorly defended
4. fibre content of leaves, since palatable species are often low in fibre
5. lignin and cellulose content of leaves, since palatable species often have high concentrations of both (Mason et al. 2010).

Using these traits together as an aggregated index can provide a measure of the overall palatability of vegetation, which can be used as a measure of how the overall palatability of vegetation changes in response to management. For example, there was an overall change in forest composition towards a greater proportion of species with traits associated with greater palatability after intensive suppression of mammalian herbivores, especially possums, over five years at the Ōhope Scenic Reserve, Bay of Plenty (Bellingham & Mason 2012; Table 13-2). In another example from the Bay of Plenty, leaft traits were used to evaluate change in forest vegetation from the coast to the interior along the Manawahe Ecological Corridor. The vegetation was highly heterogeneous: on average any pair of plots shared only 25% of species. By using leaf traits associated with palatability, it was possible to overcome this heterogeneity: weighted mean leaf nitrogen and phosphorus concentrations increased *outside* the managed corridor relative to inside over c. 5 years, but no other weighted mean leaf trait showed a statistical difference (Richardson et al. 2013).

An example of use of leaf traits at a national scale was an evaluation of change in forest vegetation in fenced plots (to exclude browsing deer, goats, and pigs) compared with adjacent unfenced plots throughout New Zealand (Mason et al. 2010); areas were fenced between 5 and 28 years. The aggregated response of a range of leaf traits was towards a greater biomass of palatable vegetation within the fenced areas, as could be expected, but the strength of the change was not universal. The forests that showed the greatest response in the biomass of palatable vegetation were those that had been subject to recent disturbance of their canopies. Fenced areas in undisturbed, old-growth forest showed comparatively far less change towards more palatable vegetation alongside adjacent unfenced areas.

Appendix 13-2 – Aligned DOC biodiversity indicators and measures

Palatable Species

Indicator M16 focuses on the species richness of palatable plant species, tree species basal area, and density of native palatable species. The measure relates closely to DOC's Measure 5.1.3 (Lee et al. 2005), which employs three reporting statistics (Allen et al. 2009):

1. the percentage of indigenous species that are palatable
2. species-richness of palatable indigenous species
3. the percentage of plots where at least one palatable species is present (occupancy).

The Department of Conservation has also reported the size structure and density of palatable tree species (MacLeod et al. 2012).

Indigenous Birds

The DOC Measure 5.1.4 representation of animal guilds uses reporting statistics on birds, aggregated according to traits associated with nesting sites (Bellingham et al. 2013).

14 Indicator M17: Extent of indigenous vegetation in water catchment

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14.1 Introduction

The definition of indicator M17 in Lee and Allen (2011) is a state indicator, with the elements (i) percentage of catchment and (ii) extent of riparian zone under indigenous cover. It is the only indicator for ecosystem services, although there is considerable interest in ecosystem services from councils. While the ecosystem services that this indicator refers to are not specified in Lee and Allen (2011), we can infer that water quality and supply, and the tangible and intangible benefits of indigenous biodiversity are important. Of course, the implementation of this indicator is not confined to this original definition, but it does provide the starting point for its development.

This indicator, like all indicators, uses a variable that is fairly easy to measure to provide information on something else of interest that is harder to measure. The classic analogy used for biodiversity indicators is that of the canary in the coal mine. The death of canaries taken into coal mines provided an early warning of dangerous methane levels before effective methane monitors were developed. Canaries were less useful as warnings of other safety risks, such as the risk of roof collapse.

The degree to which indigenous vegetation in catchments and riparian areas reflects ecosystem services will depend on the patterns and types of indigenous vegetation in the catchment, the physical environment of the catchment (e.g. gradient and geology), the surrounding land uses, and the choice of the ecosystem service. For example, indigenous forest in a catchment will generally increase water quality, lower erosion, decrease flooding, but decrease water quantity (e.g. Grip et al. 2005). Indigenous vegetation also provides habitat for a range of native plants, animals and microorganisms. However the absolute 'value' of the biodiversity-related ecosystem services provided by a given patch of vegetation will be very dependent on its composition, history of modification, size and shape, location within the catchment, and location in relation to other vegetation remnants if the landscape is a modified one.

Forested riparian areas might increase some components of water quality via shading and temperature reduction, but may have little benefit for the removal of some nutrients, especially if livestock are not excluded. For any given ecosystem service, it could be possible to estimate the benefits of indigenous biodiversity in the catchments and riparian areas – in some cases using existing models – but these results would differ for each ecosystem service.

The above discussion suggests that an explicit choice should be whether to implement the elements as defined by Lee and Allen (2011) and accept that they will have a variable and unknown application to various ecosystem services of interest, or to choose specific ecosystem services and make detailed estimates of the contribution of indigenous biodiversity to supplying those services. The latter would require choosing each service, and tailoring an estimation to each.

A second important decision is whether to report on their state only (e.g. ecosystem services provided, or the indicators of them) or to also report on their change. Reporting change is appealing, but the current data are unlikely to provide useful estimates of change. The reliable estimation of change is likely to require detailed studies. These can be done in conjunction with M8 and M9.

Together, the above choices exemplify options spanning a broad range of cost and detail. At its simplest, this indicator could be little more than an elaboration of M1, which characterises the distribution of vegetation in catchments and riparian areas by catchment units. At its most complex, this indicator could estimate the contribution (and change in contribution) of indigenous biodiversity to a range of ecosystem services.

In discussions within the working group, it was decided that this iteration of M17 should focus on simple indicators of ecosystem services arising from indigenous vegetation and water quality. The method presented below has some significant limitations in terms of its ability to provide a full and accurate assessment of ecosystem services. For example, there will probably be little coverage of first order streams for most regions, there is no consideration of grazing or any other land-use intensity effects, and there is no consideration of the ecosystem services provided by largely exotic habitat (e.g. plantation forest) or the negative impact of some NZ Landcover Database (LCDB) classes (e.g. roads and dumps) on ecosystem services. Nevertheless, it is able to be implemented nationwide and provides a starting point for future consideration of indicators of ecosystem services. A separate set of indicators that can more accurately depict the level of other ecosystems services and those provided by all ecosystems, including possibly non-indigenous dominated ones (e.g. low production pasture vs urban land cover) can be considered at a later date, or in regions where other suitable data are available.

14.2 Scoping and analysis

14.2.1 Data requirements

Landcover and indigenous vegetation

The various versions of the LCDB are the most suitable data sources to measure extent of indigenous vegetation for this measure. LCDB is not designed for monitoring changes in land cover by catchment and, therefore, its ability to detect change at this scale is limited. However, higher resolution land cover information can be expensive to derive and is not available for most regional councils; therefore, LCDB is the only practical option for a national indicator.

In landscapes where indigenous vegetation clearance occurs as a large number of relatively small clearances (i.e. 'death by a thousand cuts') and all at a scale of resolution below the detection scale of the LCDB, this indicator will 'lag' behind actual clearance. Small clearances of <0.5 ha are below the practical detection scale of LCDB; a number of these small changes would have to accumulate contiguously or close to each other before their larger combined clearance was detected by LCDB comparisons.

Some individual regional councils have more accurate digital maps of the spatial extent of indigenous vegetation (e.g. from aerial photograph analysis and fieldwork) at the regional or sub-regional scale. Where this information is available, the same riparian indicators outlined below should be reported also using the more accurate indigenous vegetation layer(s). However, even when more accurate data are available, LCDB data should be reported for the whole region, to allow comparisons across regions, and to allow aggregation nationally.

Catchment and watercourses

For regional catchment and watercourse maps it is best to use the River Environment Classification (REC) version 1, which provides national coverage. Individual regional councils may have better quality digital catchment and watercourse data available such as LIDAR, terrain modelling, and/or fieldwork. These data should be used to define the catchment boundaries and watercourses where appropriate.

Future iterations of this measure may consider more comprehensive information on the ecosystem services and pollutants/sediment/nutrients, etc. 'provided' by all land cover classes (i.e. including non-indigenous vegetation) with better physical data from terrain modelling to derive more accurate indicators. For example, the Auckland region terrain attributes model divides the region into eleven different landform attributes: ridge, shoulder, valley, slope, foot-slope, back-slope, channel, hollow, spur, terrace and plateau. The relative contribution of each hectare of a catchment to ecosystem services such as water quality, water quantity, sediment load, provision of indigenous biodiversity, carbon sequestration, removal of aerial pollutants, etc. will depend on the interaction between its physical location and land cover.

14.2.2 Definitions

For the indicator 'extent of indigenous vegetation', extent is defined as the percentage cover of indigenous vegetation in the specified area. Indigenous vegetation is defined according to Table 14-1.

Table 14-1 Definition of indigenous vegetation cover by data source

Data-source	Indigenous vegetation	Not indigenous vegetation
LCDB1, 2 & 3...	Indigenous forest Mānuka and kānuka Broadleaved indigenous hardwoods Flaxland Herbaceous freshwater vegetation Herbaceous saline vegetation Mangrove, River, & Lake or pond	All other LCDB classes not listed under indigenous vegetation. Open space LCDB classes such as 'Gravel or rock', 'Sand or gravel' and 'Landslide' are included in this class.
Sub-regional mapping	Indigenous vegetation mapped as part of more detailed vegetation survey(s). Indigenous vegetation includes forest, shrubland and scrub stature vegetation (as defined in Atkinson 1985) with >75% cover of indigenous plants in the canopy tier and smaller stature vegetation (e.g. herbfield, grassland, rushland, etc.) with >25% cover of indigenous plants in the uppermost/ canopy tier.	All vegetation not fitting the definition of 'indigenous vegetation' outlined for sub-regional mapping.

The LCDB class 'Estuarine Open Water' should be excluded from the analysis

For the indicator 'water catchment', the water catchments within the region should be selected as follows: (1) List all catchments in the region, from largest to smallest; (2) Starting with the largest catchment, calculate the proportion of the region covered by this catchment; (3) Continue 'adding' individual catchments, starting with the next largest and continuing in decreasing size order, until the cumulative total area of catchments to be included in the measure is >80% of the total area of the region.

Catchments shared between regions have their 'catchment boundary' along the regional political boundary. Some regions may wish to aggregate or split catchments to ensure this indicator includes a practical number (typically 50–200) of different catchments. Multiple, small, co-located catchments that share similar landforms and development pressures can be combined. In some regions, very large catchments may need to be split into sub-catchments for reporting purposes.

Each water catchment that is included in the analysis should also have a digital 'water course line(s)' associated with it. These lines will be used to calculate indigenous vegetation within the riparian zone of water courses.

For the indicator 'riparian area' or 'riparian zone', riparian area, zone or extent is defined as the land within 20 m either side of a water course. For larger rivers and streams the 20 metres is taken from the edge of the digitised watercourse line.

Two **research and development needs** arise:

1. The recommendation of *cumulative total area of catchments* to be included in the measure at >80% of the total area of the region is provisional, and requires testing and acceptance in other regions.
2. The definition of *riparian area* as land within 20 m either side of a water course is provisional, pending further testing of this methodology in other regions, especially with respect to the 20-m distance rule.

14.2.3 Statistics to report

The statistics or elements to report by catchment are (1) the proportion of total catchment in indigenous vegetation, and (2) the proportion of catchment riparian area in indigenous vegetation.

14.2.4 Reporting frequency

Regional councils should update statistics relating to M17 as new LCDB information is released, and these should be incorporated into a national report and made available to the public. Sub-regional analyses should be compiled and distributed to other regional councils by the Biodiversity Working Group on an annual basis, as they are completed.

14.3 Development of a sampling scheme

There is no sampling scheme associated with M17. It might be more efficient for a single, central agency to provide GIS analysis and indicator values for some regional councils, particularly those that lack specialist GIS expertise.

14.4 Data management and access requirements

There should not be any issues with data access for this measure as it draws on two national datasets that have been widely disseminated in the past. These are the New Zealand Landcover Database, and the digitised NZMS 260 map series for catchment and stream boundaries. The digitised NZMS 260 map series provides a minimum national standard as a framework in which all councils can report and this will allow aggregation to a national scale. Individual councils might have their own catchment and/ or stream layers that provide better information than the NZMS 260 data; if so they can report in this framework in addition to reporting in the framework of the NZMS 260 map series.

14.5 Reporting indices and formats

For the region, the two statistics defined above would be reported in map and tabular form.

1. Two maps of region showing catchments with (1) the proportion of catchment in indigenous vegetation, and (2) proportion of catchment riparian area in indigenous vegetation
2. Table showing the two elements displayed in figures. If desired, this can be presented for hierarchical catchments (e.g. entire Waikato catchment and sub-catchments within it, and sub-catchments within those).

Example analysis: Auckland region

Table 14-2 shows the percentage of the whole catchment area that is characterised by native vegetation cover in LCDB4 (column 2). Column 3 shows the percentage of the 20 m riparian buffer area within each catchment that has native vegetation cover according to LCDB4. Columns 2 and 3 are based on 50 aggregated catchment data for the Auckland region. The table shows actual figures for the 25 aggregated catchments that collectively cover just over 80% of the land area of the Auckland region. Example maps from the Auckland region show indigenous in major catchments (Figure 14-1) and sub-catchments (Figure 14-2), and riparian vegetation in major catchments (Figure 14-3) and sub-catchments (Figure 14-4).

Table 14-2 Analysis of %catchment area covered by native vegetation for Auckland region

Catchment name	% native LCDB cover in catchment	% native LCDB cover in 20 m riparian	Cumulative % of regional land area
Hauraki Gulf Islands	76	82	9.6
Hoteo	19	27	17.9
Pahurehure	7	14	25.8
Wairoa	27	34	32.4
Kaipara	10	16	37.9
Upper Waitemata Harbour	14	23	41.8
Awhitu	15	19	44.8
Okiritoto	8	24	47.6
Makarau	19	28	50.3
Taihiki River	2	4	53
Okahukura	13	29	55.5
Kaukapakapa	18	23	57.9
Oruawharo	12	16	60.3
Waiuku River	5	12	62.6
Araparera Stream	24	26	64.9
West Kaipara	17	18	67.1
Tamaki River	2	7	69.2
Henderson	37	56	71.3
Mahurangi	22	35	73.1
Auckland	3	24	74.8
North Kaipara	15	44	76.4
Te Arai	12	22	78
Orere	51	62	79.5
Waitakere	74	82	80.9
Tawharanui	28	47	82.2

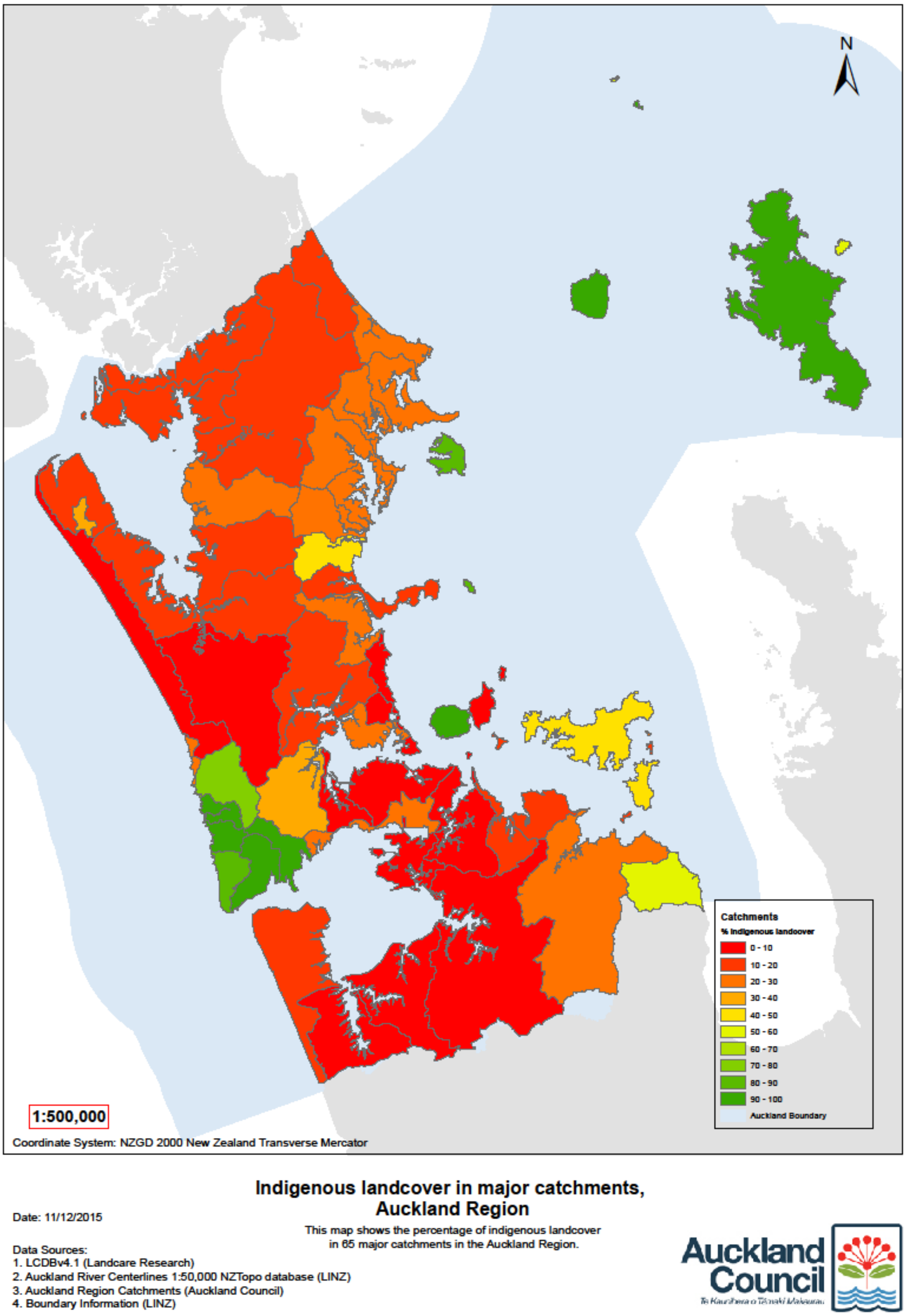

Figure 14-1 Indigenous land cover in major catchments in the Auckland Region.

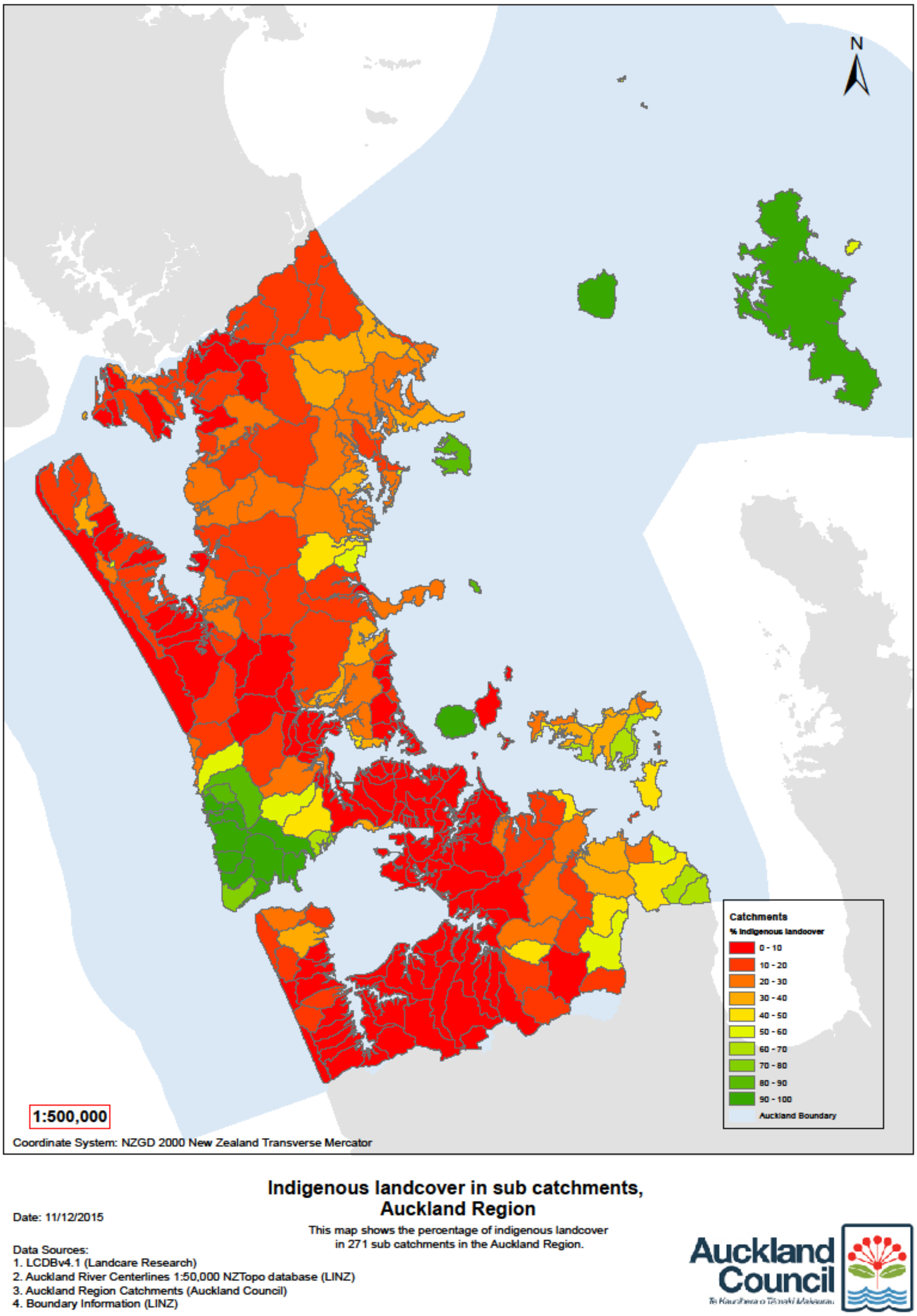

Figure 14-2 Indigenous land cover in sub-catchments in the Auckland Region.

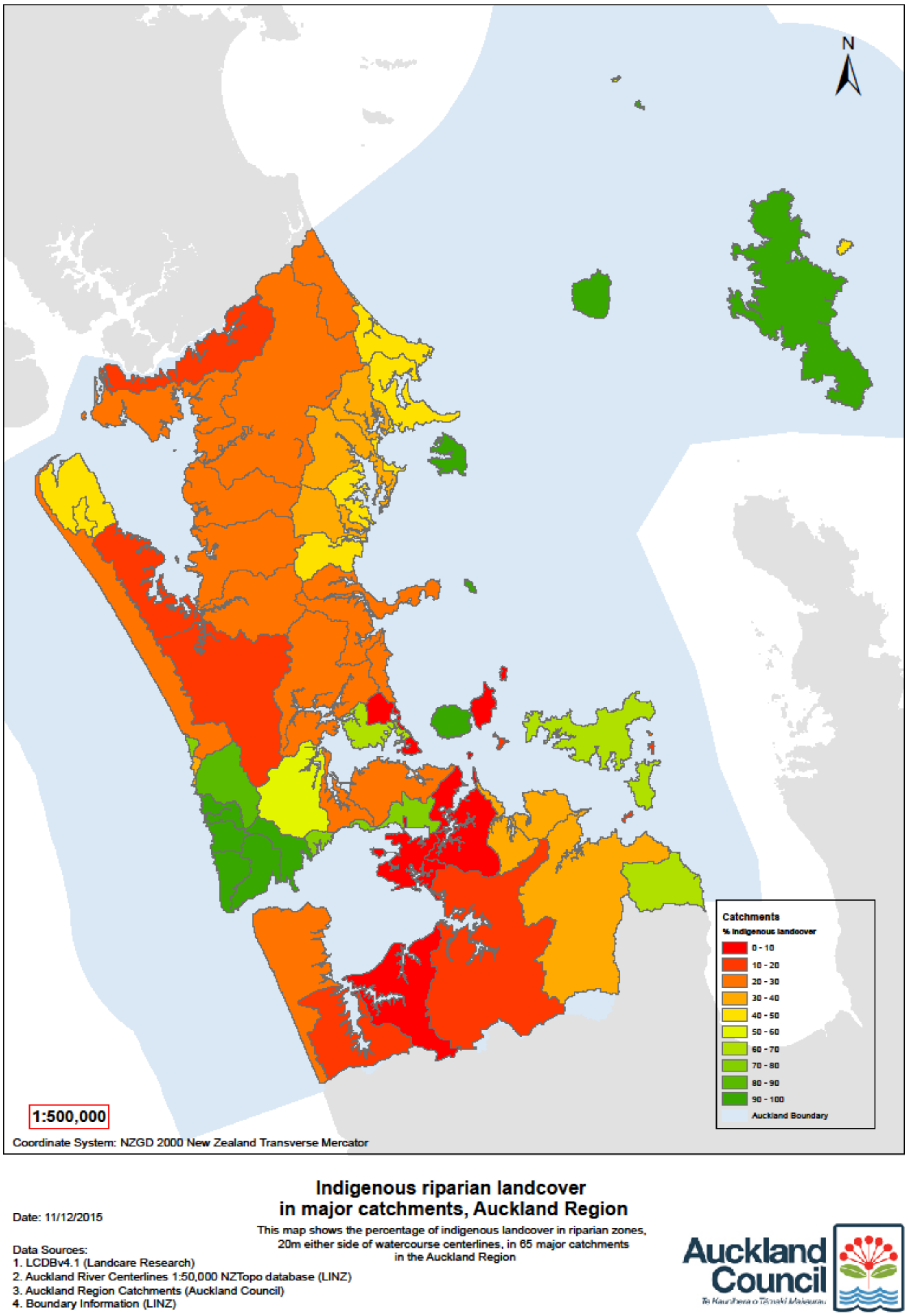

Figure 14-3 Indigenous riparian land cover in major catchments in the Auckland Region.

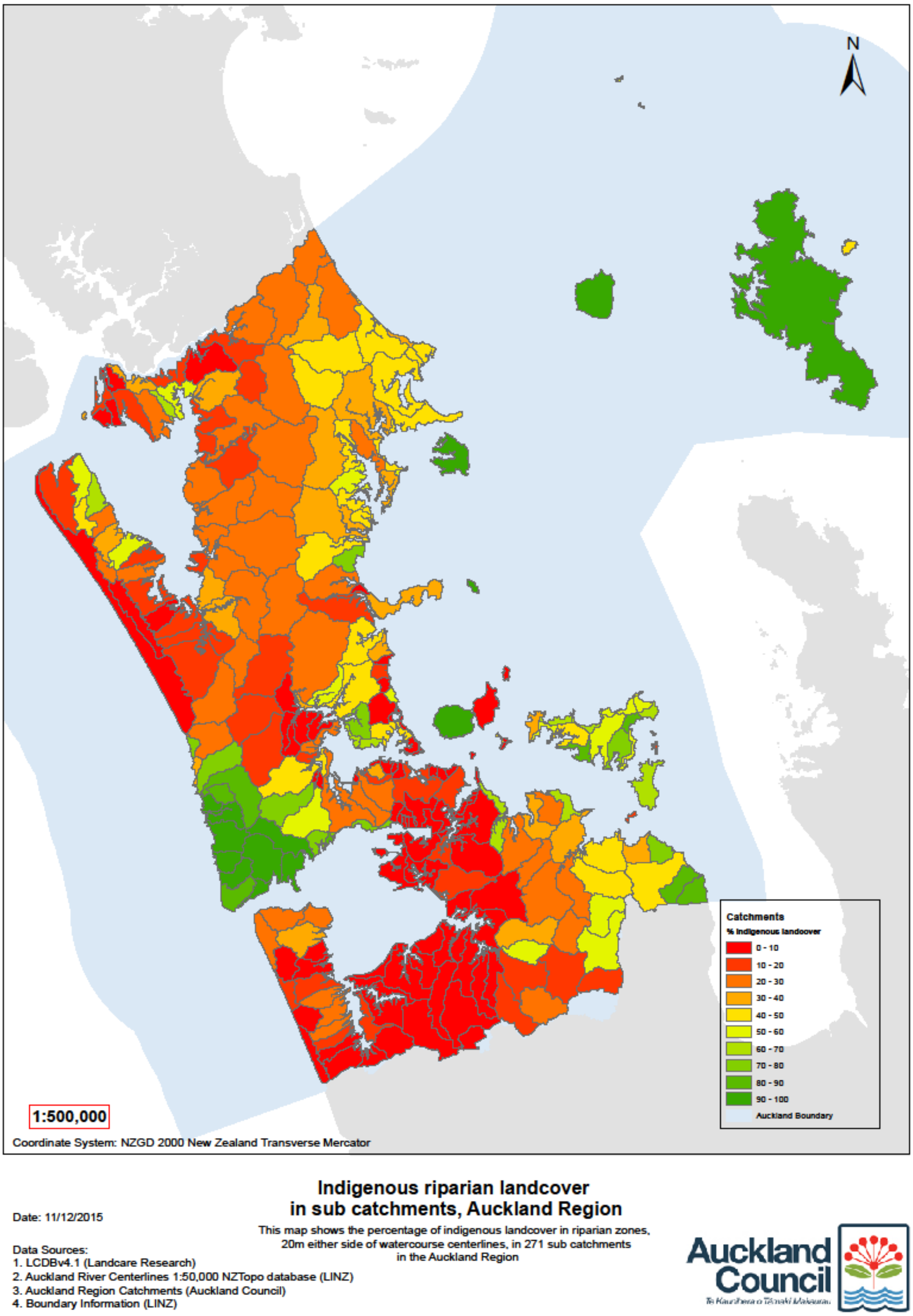

Figure 14-4 Indigenous riparian land cover in sub-catchments in the Auckland Region

14.1 References

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15 Indicator M18: Area and type of legal biodiversity protection

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15.1 Introduction

Biodiversity protection is complex, given that 'protection' encompasses how intent (reason for protection) and implementation (method of protection) combine to produce the outcome (result of protection). Complexity arises because different combinations of intent and implementation produce different outcomes, both expected and unexpected.

Specific areas are designated and delineated with the intent of protecting native/indigenous biodiversity worldwide. The extent of protected areas has increased over time globally (Chape et al. 2005) and within New Zealand (MfE 2010a). Much biodiversity protection occurs via legal mechanisms, such that the places protected become owned and managed by the Crown. A little over one-third of New Zealand's land area (defined as the North, South, Stewart and inshore islands) is public conservation land managed by numerous Crown agencies, principally the Department of Conservation (DOC), but also regional and local councils, for various purposes including biodiversity protection. Biodiversity protection also occurs on privately owned land. This includes lands owned and managed by non-governmental organisations (e.g. Native Forest Restoration Trust, www.nznfrt.org.nz), businesses, or individuals (e.g. forestry companies, iwi, farmers).

Biodiversity protection can also unintentionally result when intent and implementation are lacking. For example, natural succession processes can re-establish on abandoned lands and thereby benefit biodiversity.

15.2 Scoping and analysis

15.2.1 Elements informing Indicator M18

Within New Zealand, biodiversity protection occurs via a number of pathways that vary based on the combination of intent and implementation, leading to various outcomes. Monitoring trends will require knowing the extent to which different kinds of intent and implementation change over time. Therefore, we need the following *elements* to inform the indicator:

1. Area
2. Type of biodiversity protection
   a. Intent
   b. Implementation

3. Land status
   a. Public
   b. Private
      i. Business
      ii. Non-governmental organisation
      iii. Iwi
      iv. Family or individuals.

Below, we consider each of the three elements, including what they represent, how they might be measured, and any issues for discussion.

Area

Presumably, the spatial extent over which a particular type of biodiversity protection applies will be measured in hectares. However, we will need to consider whether or not to include or report on point data (e.g. protection of individual organisms such as a native tree).

We also need to consider the vertical axis, as protection might may or may not include belowground or aboveground aspects. For example, legal protection at the surface may not extend to mineral rights belowground, which could have implications should those mineral rights be exercised in a way that involves substantial ground disturbance.

Type of biodiversity protection

This will probably prove to be the most challenging aspect of the indicator given the various combinations of intent and implementation that currently exist and the outcomes that result. Table 15-1 provides a preliminary set of possible values for intent, implementation, and outcome.

Table 15-2 combines the different values of intent and implementation to produce a matrix of possible types of biodiversity protection (e.g. Primary-Voluntary). For each type, the table provides a basic definition, the timespan of implementation, and real-world examples.

Table 15-1 Possible values for intent, implementation, and outcomes for biodiversity protection

Aspect	Type	Comment
Intent	Primary	Biodiversity protection is the main purpose.
	Secondary	Biodiversity protection is a secondary purpose or one of several purposes.
	None	Biodiversity protection is not the purpose.
Implementation	Legal	Biodiversity protection occurs via formal legal mechanisms, such as laws, statutes, or rules.
	Informal	Biodiversity protection occurs via informal (e.g. voluntary) mechanisms, such as initiatives of landowners or land managers.
	Economic	Biodiversity protection occurs via market-based mechanisms (e.g. carbon markets, nutrient markets).
Outcome	Total	Biodiversity is protected relative to the stated intent.
	Partial	Biodiversity is partially protected relative to stated intent.
	None	Biodiversity is not protected relative to the stated intent.

Table 15-2 Potential types of biodiversity protection based on considerations of intent and implementation

		Implementation		
		Legal	Voluntary	Economic
Intent	Primary	Areas protected via laws, statutes, or rules specifically to protect biodiversity Timespan: varies; in NZ ranges from 25 y (some Ngā Whenua Rāhui kawenata) to indefinite/in perpetuity (national parks, reserves Examples: National parks, reserves, legal covenants, regional parks	Areas where biodiversity is protected as a result of voluntary choices of land owners/managers Timespan: varies according to preferences of land owner Examples: Community restoration projects, landowner fencing of forest fragments, etc.	Areas protected for economic reasons specifically to protect biodiversity Timespan: varies Examples: biodiversity offsets
	Secondary	Areas protected to conserve/manage other assets or values but where biodiversity also benefits as a result Timespan: varies according to rules or plans Examples: Water quality protection in Wellington and Nelson city	Areas where land management results in biodiversity protection as a secondary or multiple outcome Timespan: dependent on continuation of a particular land use management/practices Examples: riparian planting, wetland restoration for water quality	Areas where biodiversity protection results from market-based mechanisms Timespan: varies based on market conditions/rules Examples: Carbon markets (e.g. Permanent Forest Sinks Initiative), nutrient markets (e.g. Lake Taupō)
	None	Areas where biodiversity protection occurs unintentionally as the result of legal mechanisms Timespan: depends on the period of time that the legal mechanism remains in force Example: Consent conditions that inadvertently provide biodiversity benefits	Areas where biodiversity benefits unintentionally from voluntary actions or inaction of the land owner/manager Timespan: depends on the longevity of the action/inaction Example: Neglect leading to restoration of biodiversity	Areas where biodiversity benefits unintentionally from economically motivated decisions Timespan: depends on the longevity of a particular decision Example: land abandonment from agriculture returning to forest

Land status

Land status refers to the owernship and/or management of the land: what organisation or entity controls the activities or use of the land? A simple definition of public land would be 'any land owned by the Crown.' Conversely, a simple definition of private land would be 'any land not owned by the Crown'. Typically, the delineation between public and private land is made by separating the public conservation land managed by DOC from all other lands, usually because that is most practical given the availability of spatial data (i.e. a GIS layer) that delineates public conservation land managed by DOC. However, other government agencies manage public land for various purposes including biodiversity protection, especially several regional councils that manage significant areas of public land as networks of regional parks.

Private land therefore encompasses land owned and/or managed by truly private entities (e.g. businesses, families, iwi). However, it would also encompass a range of 'intermediate' institutions (i.e. those that straddle the concept of public/private to varying degrees). We will need to agree how to classify land owned by those intermediate institutions.

The following is a (non-exhaustive) list of land status types organised along a gradient from public to private.

1. Public
    a. Department of Conservation
    b. Territorial Local Authorities
        i. Regional councils
        ii. Unitary authorities
        iii. City councils
        iv. District councils
    c. Land Information New Zealand (LINZ), with respect to unallocated Crown Land
2. Intermediate
    a. State Owned Enterprises (e.g. Solid Energy, Landcorp)
    b. Crown Research Institutes
    c. Universities
    d. Housing NZ
    e. Council-controlled organisations (e.g. Ports of Auckland)
3. 'Truly' private
    a. Businesses (corporations, companies)
    b. Trusts
    c. Families
    d. Individuals
    e. Iwi

Table 15-3 populates the specific attributes needed for M18 according to the five reporting areas outlined in the document 'Regional council terrestrial biodiversity monitoring framework'.

Table 15-3 Preliminary population of the specifics of M18 against reporting areas

Statistic(s) to report	Area (hectares) of each type of biodiversity protection on private land Number of living specimens preserved on private land outside any other protected area on private land Ratio of area of type of biodiversity protection on private land protected to total area of private land in the region/district Ratio of total area of all types of biodiversity protection on private land to total area of private land in the region
Hierarchies of measures/elements indicating usefulness for reporting defined for each indicator	Not specified at the time pending further discussion of the considerations raised
Spatial and temporal analyses needed to interpret variability	Time-series of spatial data that tracks the temporal development of protected areas including start time and stop time, with the latter being either observed in the case of already expired areas of legal protection or expected future longevity in years
Reporting frequency rate(s)	At least annually; some elements may be updated more frequently, e.g. QEII covenants are updated quarterly
The relationships between each indicator and present patterns (e.g. in relation to management or land cover)	GIS overlay of types of protected areas and land cover Time-series data already exists for some types of biodiversity protection

15.2.2 Revision of M18

Following discussions at a project workshop with regional council representatives held on 25 October in Wellington, the Regional Council Biodiversity Working Group (RCBWG) revised the definition of M18 to include only legal biodiversity protection on private land (Maseyk 2011), as the forum recognised that voluntary or similar types of protection were too variable among regions to be consistently monitored and reported across regional councils. In addition the RCBWG indicated that M18 should clearly define what 'protection' and 'achieved' means. In light of those revisions, the scope of M18 was slightly modified to become 'Area and type of legal biodiversity protection on private land.'

At a subsequent meeting on 20 March 2012, the RCBWG further decided (RCBWG 2012) that

1) M18 should include biodiversity protection across all land (i.e. public and private)

2) M18 should use a NZ-specific framework solely based on the degree of legal protection of biodiversity while developing a parallel approach to categorise protection in the International Union for the Conservation of Nature (IUCN) framework to enable international reporting[17].

[17] The IUCN Protected Area classification system was assessed, but was deemed to be inappropriate for this purpose as it incorporates many drivers for protection other than biodiversity, which confuses the intent of this indicator measure.

By agreement, the revised definition of M18 is 'Area and type of legal biodiversity protection.'

15.3 Assessment of existing methodologies

15.3.1 Biodiversity protection measurement in New Zealand to date

Below is a brief overview of biodiversity protection reporting and measurement in New Zealand. The overview covers the period 1997 to the present summarised into four periods, which are discussed in more detail below:

1. 1997: New Zealand State of Environment Report
2. 2000: Bio-what?
3. 2004–2007: Snapshot of biodiversity protection and subsequent analyses
4. 2007 to current: New Zealand State of Environment Report 2007 and report cards.

Earlier reporting and measurement also occurred but are not summarised in this report.

1997: New Zealand State of Environment report

The 1997 State of Environment Report (MfE 1997) reported on the state of biodiversity protection in New Zealand. It reported a total of 7 976 475 hectares of protected land including 61 670 hectares of private land as reserved under conservation covenants or private agreements (pp. 9–146). Methods used to compile those data were not provided. The report noted that at least another 70 000 hectares of private land were committed for protection as of mid-1996 but were not yet gazetted. The report also categorised New Zealand's protected land, both public and private, into one of six categories according to the system used by the IUCN (Appendix 15 – provides the updated definitions for the current categories used as part of the World Database on Protected Areas (Dudley 2008) administered by the United Nations World Conservation Monitoring Centre in Cambridge, United Kingdom[18], and the associated classification of New Zealand's protected areas).

In 1998 the Ministry for the Environment's (MfE) Environment Performance Indicators Programme published a summary report on biodiversity indicators that included a proposed indicator for percentage/area of each of New Zealand's different environments under legal protection (MfE 1998, p. 14).

2000: Bio-what?

The next assessment to measure and quantify biodiversity protection on private land occurred as part of the *Bio-what?* project undertaken in the late 1990s by the Ministerial Advisory Committee for the Protection of Biodiversity on Private Land (Ministerial Advisory

[18] World Database on Protected Areas website: www.wdpa.org

Committee for the Protection of Biodiversity on Private Land 2000). The committee's report included an appendix listing estimates of indigenous forest occurring outside public conservation land managed by DOC in each region and district/city council. The estimates were based on a separate study (Froude 2000) that combined data on council land area, Māori land title, public conservation land, QEII covenants, and land cover (Land Cover Database Version 1, LCDB1). The committee reported (p. 19) that 205 000 hectares of private land were known to be protected by covenant or other legal protection (QEII, Ngā Whenua Rāhui, DOC covenants and protection via the Nature Heritage Trust). Both reports noted that it was not known what proportion of privately protected land received active and ongoing management such as weed or pest control, hence statistics on the amount of legal protection were to be taken as broad guidelines only.

2004–2007: Snapshot of biodiversity protection and subsequent analyses

The next round of analysis measuring protection of biodiversity on private land occurred in support of a joint 'snapshot' by the MfE, DOC and Local Government New Zealand to assess the status of biodiversity protection on private land (MfE et al. 2004). For that project repeatable methods and tools were developed (Rutledge et al. 2004) that combined data including land cover as a surrogate for ecosystem condition (Table 15-4), extent of legal protection, land environments (Leathwick et al. 2002) and territorial authority boundaries to evaluate representation of ecosystems in New Zealand's protected areas network (Figure 15-1). The analysis produced a database (Protected Areas of New Zealand, PAN-NZ) that identified unique combinations of input data layers (Figure 15-2) linked to their location via a raster (gridded) data layer (Figure 15-3). The database and grid layer can be queried to answer a range of questions. The PAN-NZ spatial layer is available from the 'Our Environment' website hosted by Landcare Research at http://ourenvironment.scinfo.org.nz/home.

For the snapshot project, the analysis determined the amount of remaining indigenous ecosystems (i.e. indigenous or native land cover) that was legally protected or not protected. Protected areas in the analyses included the public conservation land, regional parks (initially Auckland and Wellington, but later including new parks in Bay of Plenty and Whanganui–Manawatū regions), and private covenants (QEII and Ngā Whenua Rāhui covenants). Reporting of results occurred across a range of scales (national, regional, and local), extents (e.g. DOC conservancies, region and district boundaries), and land environments. The resulting database provided statistics on the amount of private land under legal protection for biodiversity benefits, typically reported as simply protected or not protected.

Table 15-4 New Zealand Land Cover Database Land Cover classes considered as native cover for analysis purposes

Alpine Grass/Herbfield	Grey Scrub	Mānuka and/or Kānuka
Alpine Gravel and Rocks	Herbaceous Freshwater Wetland	Matagouri
Broadleaved Indigenous Hardwoods	Herbaceous Saline Vegetation	Permanent Snow and Ice
Coastal Sand and Gravel	Indigenous Forest	River
Depleted Grassland	Lake and Pond	River and Lakeshore Gravel and Rock
Estuarine Open Water	Landslide	Sub-alpine Shrubland
Fernland	Mangrove	Tall Tussock Grassland
Flaxland		

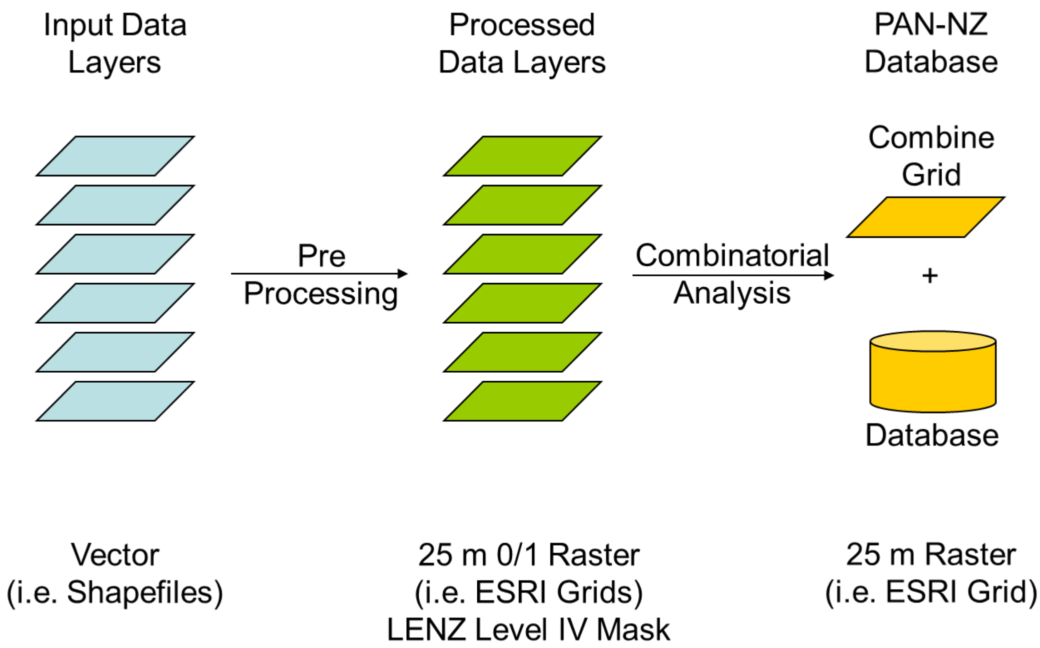

Figure 15-1 Schematic of methodology used to underpin biodiversity representation analyses.

Value	Count	Protected	arcnz_v02	doc_v2	nhf_cov2	qeii_v02	nwr_cov2	gw_cov2
1	127163881	1	0	1	0	0	0	0
2	289443166	0	0	0	0	0	0	0
3	659657	1	0	0	0	1	0	0
4	3361	1	0	1	0	1	0	0
5	1098571	1	0	0	0	0	1	0
6	128610	1	0	1	0	0	1	0
7	599826	1	1	0	0	0	0	0
8	51	1	1	0	0	1	0	0
9	651	1	1	1	0	0	0	0
10	58197	1	0	1	1	0	0	0
11	169259	1	0	0	1	0	0	0
12	105006	1	0	0	0	1	1	0
13	501	1	0	1	0	1	1	0
14	113	1	0	1	1	0	1	0
15	152342	1	0	0	0	0	0	1
16	2037	1	0	1	0	0	0	1
17	3	1	0	0	0	1	0	1
18	2381	1	0	1	1	1	0	0
19	9227	1	0	0	1	1	0	0

Figure 15-2 Example of database output from the combinatorial analysis used in biodiversity representation analyses. The values in column 1 are unique values that correspond to values in the associated raster (gridded) data layer.

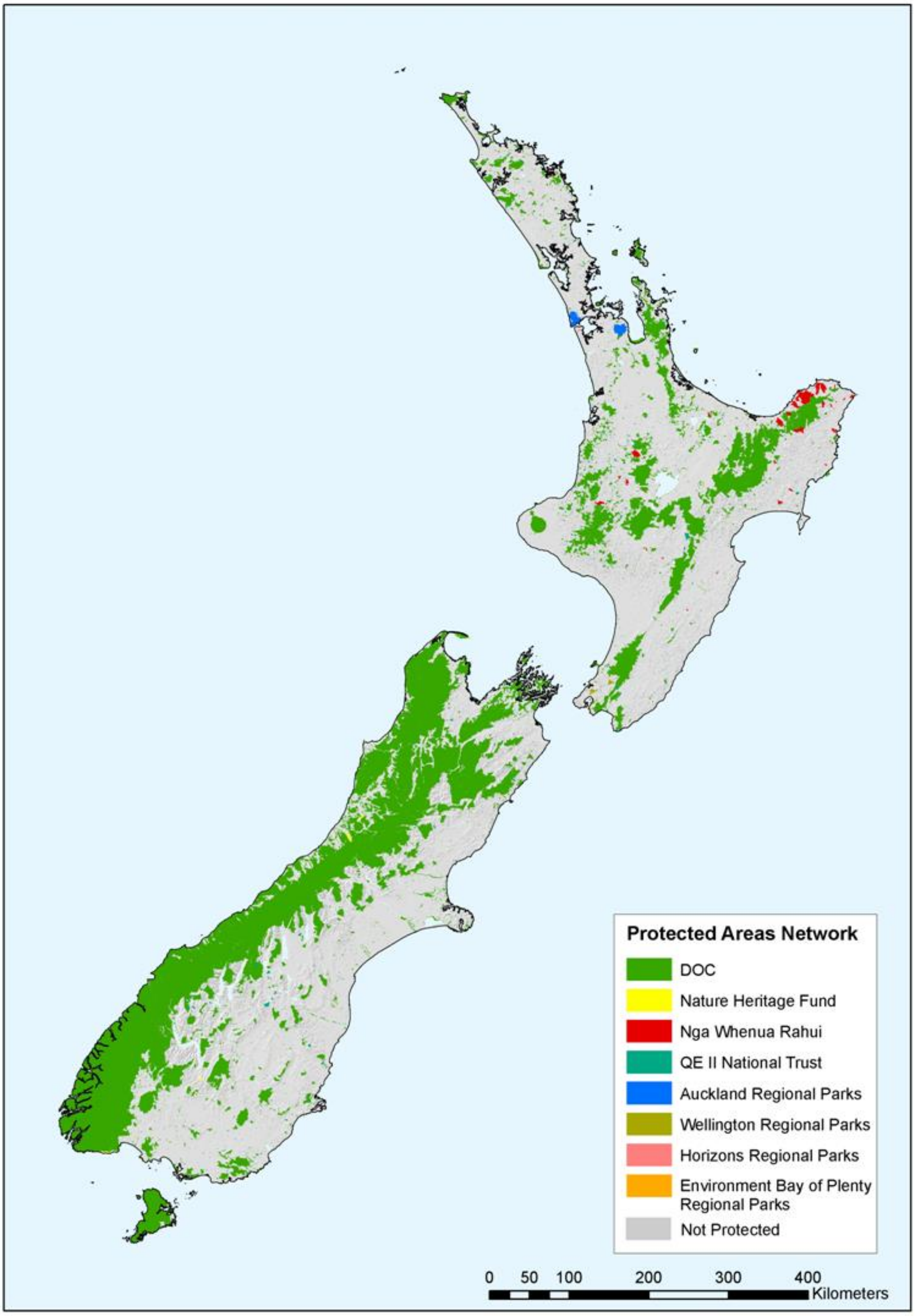

Figure 15-3 Example map showing New Zealand's Protected Areas Network.

The methods developed for the council snapshot report became the foundation for ongoing assessments of biodiversity protection on public and private land and have underpinned a series of analyses and development of guidelines across a range of scales including:

- classification of threatened land environments (Walker et al. 2006, 2007, 2008)
- condition and trends in coastal environments (Rutledge et al. 2007)
- national priorities for biodiversity protection on private land (MfE and DOC 2007)
- West Coast Region threatened environments analysis (Price & Briggs 2008).

2007 to current: New Zealand State of Environment report 2007 and report cards

The MfE produced a second national State of Environment report (MfE 2007) using the Council Snapshot methodologies and the most recent datasets at the time. The report indicated a total of 8 313 446 hectares of native land cover were legally protected, or about 62.41% of all native land cover. The amount reported represents an increase of 336 971 (4.2%) hectares of area protected since the 1997 State of Environment report. The increase represented 1.3% of New Zealand's total area (three main islands plus inshore islands), or an annual rate of protection of 0.13% (c. 3400 hectares per annum).

The MfE is now committed to producing a national state of environment report every five years. In the intervening period, the MfE publishes 'environmental report cards' that provide updated information on the extent of New Zealand's protected areas networks. The MfE produced a protected areas environmental report card in 2010 (MfE 2010a, b). The report card indicated that 8 763 300 ha of native land cover, defined as land under LCDB land cover types considered native or indigenous, were legally protected, of which public conservation land accounted for 8 525 000 ha and private conservation land accounted for 238 300 ha. Overall, legally protected area increased by 449 854 hectares from 2007 to 2010, a gain of c. 4.9%. The report card attributed three-quarters of that gain to results of the High Country Tenure Review process, in which land leased by the Crown primarily for grazing was either transferred to public conservation land or made freehold.

In addition to state of environment reporting, the methods and derived indicators support a number of biodiversity policy initiatives including the proposed National Policy Statement on Biodiversity as well as several regional and city/district council biodiversity monitoring and reporting efforts (e.g. Greater Wellington Regional Council, Kapiti Coast District Council, Whangarei District Council, etc.).

Protected Areas Network survey

In 2008, a survey was undertaken to assess the state of data on protected lands across New Zealand, with a particular focus on estimating protected areas held by city and district councils (Rutledge et al. 2008). Based on the results of a survey, it was estimated that at least 85 000 hectares of legally protected area were not included in the datasets used to undertake the above analyses. Furthermore, that figure was considered an underestimate given that only a portion of councils responded to the survey. Some portion of the missing data will include private land protected under conservation covenants or other conservation agreements and hence would be relevant to M18.

15.3.2 Conclusion

The methodologies to measure, analyse, and report on the area and type of biodiversity protection on private land are well in hand and have been used in an ongoing manner for the past eight years. Landcare Research maintains an unofficial database on New Zealand's protected areas (current at July 2014) that include readily available data sources (public conservation land from DOC, regional parks, QEII covenants, Ngā Whenua Rāhui covenants). With the release of the cadastral database, we now also have access to parcel information that includes previously unavailable data on local parks and reserves that could be included in future analyses. Furthermore, future analyses can be enhanced by including procedures to reclassify New Zealand protected areas into the international system used by the UN World Conservation Monitoring Centre for the World Database on Protected Areas (i.e. IUCN system) to facilitate international monitoring, reporting and data sharing.

The main challenge to calculating and reporting M18 will be obtaining the outstanding data to complete the protected area network dataset, particularly data from city and district councils. This will include information on extent of protection (i.e. spatial boundaries) and purpose of protection. Some regions and districts have compiled spatial datasets delineating protected areas, although as the results of the recent survey indicated, the availability, quality and currency of the data varies widely.

15.4 Methodology and reporting format

15.4.1 13.3.1 Introduction

In New Zealand legal protection for biodiversity occurs via several mechanisms, ranging from national legislation with the direct purpose of protecting biodiversity to indirect protection of biodiversity via a range of other legal mechanisms including plans, consents, and memorandums of understanding. Direct protection results when actions are taken under legislation in which biodiversity protection is the main or one of the main purposes. Indirect protection results when actions are taken to satisfy legal requirements (e.g. erosion control) in which biodiversity protection is not the primary or even the intended purpose but is nonetheless an outcome of the action.

15.4.2 Legal mechanisms for protection for biodiversity

In New Zealand legal mechanisms for biodiversity protection ultimately derive from national legislation. The pathway can be direct in that legislation can specifically target biodiversity protection as a main purpose, either individually or in combination with other purposes. The pathway can be indirect in that legislation targeting other goals or purposes also leads to beneficial biodiversity outcomes.

Table 15-5 below summarises the nationally relevant legislation that provides for biodiversity protection, either directly or indirectly.

Table 15-5 National legislation providing for biodiversity protection and associated pathways

Legislation	Pathway to Protection
Conservation Act 1987	Direct
Land Transfer Act 1952	Direct
Local Government Act 2002	Indirect
National Parks Act 1980	Direct
Marine Reserves Act 1971	Direct
Public Reserves Act 1881	Direct
Queen Elizabeth II National Trust Act 1977	Direct
Reserves Act 1977	Direct
Resource Management Act 1991	Direct and Indirect
River Boards Act 1908	Indirect
Soil Conservation and Rivers Control Act 1951	Indirect
Te Ture Whenua Māori Act 1993	Direct
Waitangi Endowment Act 1932-33	Indirect
Wildlife Act 1953	Direct

Legislation may also have one or more mechanisms for biodiversity protection. For example, the National Parks Act provides for biodiversity protection singly through designation of areas as national parks, whereas the Reserves Act includes several different types and pathways for biodiversity protection on both public and private land.

The legal mechanism establishes the potential for biodiversity protection as well as the duration of protection. Most direct forms of legal protection are for an indefinite time period. In some cases the word ‘perpetuity’ is used.

As well as the nationally relevant legislation, there are also several Acts that enable the protection of biodiversity values at a local or regional scale. The mechanisms that they enable should also be classified accordingly based on the degree of protection that they provide for biodiversity as provided for below. Examples of local or regionally relevant legislation are: Waitangi Endowment Act, Waitakere Ranges Heritage Area Act, Wellington Regional Water Board Act 1972, Wellington (City) Town Belt Reserves Act 1908, and the City of Dunedin Lands Vesting Act 1906.

15.4.3 Classification of areas legally protected for biodiversity for reporting purposes

A six-level (0–5) ranked classification scheme was developed to report on legal protection for biodiversity protection, in consultation with council representatives (Table 15-6). A recommended scheme is provided for ranking specific types of legal protection for biodiversity (e.g. wildlife sanctuaries, Ngā Whenua Rāhui kawenata) within the classification. The ranks span a range from ‘high’, in which biodiversity protection is the main or one of the main goals, to ‘low’, in which some degree of biodiversity protection may occur indirectly or unintentionally. Overall, areas with higher rankings tend to be more effective at retaining habitat, primarily by placing more stringent restrictions on human activities. The highest rank (5) represents areas where biodiversity protection is the main purpose or is ranked equally with a limited number of other compatible purposes. The lowest rank or protection (1) represents areas where some legal protection of biodiversity occurs fortuitously and is not the main purpose. A rank of zero (0) indicates legal protection is absent. The ranking also reflects the duration of protection. Higher ranked areas tend to have longer durations of protection, including many that have indefinite (i.e. ‘in perpetuity’) protection. In contrast, lower ranked areas tend to have shorter durations of protection or/and a lower level of security.

Table 15-6 Classification for areas legally protected for biodiversity

Rank	Description	Example
5	High degree of biodiversity protection; protection is the main purpose or is ranked equally with a limited number of other compatible purposes	Wildlife Sanctuary
4	Moderately high degree of biodiversity protection; protection is a main purpose but is shared with other, less compatible purposes (i.e. recreation)	Conservation Park
3	Moderate degree of biodiversity protection; protection is a desired purpose but subject to compatibility with a different main purpose or may be less comprehensive (i.e. only some aspects of biodiversity protection are targeted)	Ecological Area
2	Moderately low degree of biodiversity protection; some biodiversity protection is achieved but it is of secondary importance	Recreation Reserve
1	Low degree of biodiversity protection; protection results indirectly and fortuitously as a result of other activities	Road Reserve
0	No legal protection for biodiversity	c. 65% of New Zealand

Table 15-7 provides guidance for the classification of specific types of biodiversity protection as shown in Table 15-6. The majority of the types listed appear directly in legislation (

Table 15-5) targeting biodiversity protection to some degree. The remainder include types of biodiversity protection that arise indirectly from other activities.

Table 15-7 Classification of areas legally protected for biodiversity purposes

Class	Designation	Legal Mechanism
5	**National Park**	**National Parks Act 1980**
	Purpose: s 4 Preserving areas in perpetuity as national parks, for their intrinsic worth and for the benefit, use, and enjoyment of the public, areas that contain scenery of such distinctive quality, ecological systems, ornate natural features so beautiful, unique, or scientifically important that their preservation is in the national interest; including that they shall be preserved as far as possible in their natural state and native plants and animals shall as far as possible be preserved and the introduced plants and animals shall as far as possible be exterminated	
5	**Nature Reserve**	**Reserves Act 1977**
	Purpose: s 20 (1) Protect and preserve in perpetuity indigenous flora or fauna or natural features that are of such rarity, scientific interest or importance, or so unique that their protection and preservation are in the public interest.	
5	**Sanctuary Area**	**Conservation Act 1987**
	Purpose: s 22 Preserve areas in their natural state indigenous plants and animals in it, and for scientific and other similar purposes shall be preserved as far as possible in its natural state.	
5	**Scientific Reserve**	**Reserves Act 1977**
	Purpose: s 21 (1) Protect and preserve in perpetuity for scientific study, research, education, and the benefit of the country, ecological associations, plant or animal communities, types of soil, geomorphological phenomena, and like matters of special interest; (2) (a) indigenous flora and fauna shall as far as possible be preserved and the exotic flora and fauna shall as far as possible be exterminated; (c) where scenic, historic, archaeological, biological, or natural features are present those features shall be managed and protected to the extent compatible with the principal or primary purpose of the reserve; (d) to the extent possible compatible with the principal or primary purpose, maintain value as a soil, water, and forest conservation area; (e) with consent, manipulate for experimental purposes or to gain further scientific knowledge.	
5	**Water Conservation Order**	**Resource Management Act 1991**
	Purpose: s 199 (1) The purpose of a water conservation order is to recognise and sustain – (a) outstanding amenity or intrinsic values which are afforded by waters in their natural state: (b) where waters are no longer in their natural state, the amenity or intrinsic values of those waters which in themselves warrant protection because they are considered outstanding. (2) A water conservation order may provide for any of the following: (a)the preservation as far as possible in its natural state of any water body that is considered to be outstanding: (b) the protection of characteristics which any water body has or contributes to, and which are considered to be outstanding, – (i) as a habitat for terrestrial or aquatic organisms: (ii) as a fishery: (iii) for its wild, scenic, or other natural characteristics: (iv) for scientific and ecological values: (v) for recreational, historical, spiritual, or cultural purposes.	
5	**Wilderness Area**	**Conservation Act 1987**
	Purpose: s 20 Preserve areas for their indigenous natural resources and exclude machinery, buildings, livestock, vehicles, motorised vessels, roads, tracks and trails.	
5	**Wildlife Management Area**	**Conservation Act 1987**
	Purpose: s 23B Protect areas for their wildlife and wildlife habitat values (including the capacity for the movement of wildlife, genetic material of indigenous plants, and genetic material of wildlife)	
5	**Wildlife Sanctuary**	**Wildlife Act 1953**
	Purpose: (s 10) Preserve areas where all wildlife shall be absolutely protected; s 9 (2) prohibit or restrict (a) right of entry, (b) hunting or killing, capturing, disturbing, harrying, molesting, or worrying, taking eggs or spawn of any creature, taking for any purpose of or interference with vegetation of any	

Class	Designation	Legal Mechanism
	description, or introduction or liberation of any living creature or the eggs or spawn of any living creature, or introduction or planting of any vegetation of any description or the spores or seeds of any vegetation of any description, (c) burning or clearing by any means whatsoever of any trees, shrubs, grasses, or other plant life, (d) camping or any other specified form of sport or relaxation, (e) lighting of fires or the doing of anything likely to cause a fire, (f) use of boats and vehicles, (g) wilful disturbance of wildlife in the sanctuary by flying aircraft over the sanctuary or by noise in the vicinity, (h) use of firearms or explosives, (i) taking or keeping of domestic animals or domestic birds into or in the sanctuary, (j) depositing of rubbish and the leaving of litter, (m) cutting, construction, or maintenance of private roads, tracks, tramways, or other means of access or communication, (n) pollution of any by means of rubbish, sewage, industrial waste, mining debris, saw mill refuse, or any other means, (o) other matters as may be considered necessary for the control of the sanctuary or for the protection and wellbeing of any wildlife or vegetation therein.	
4	**Amenity Areas**	**Conservation Act 1987**
	Purpose: s 23A Protect areas for their indigenous natural and historic resources, facilitate people's appreciation of them, and foster recreational activities.	
4	**Conservation Covenant**	**Reserves Act 1977**
	Purpose: s 77 Any private land or any Crown land held under Crown lease that should be managed so as to preserve the natural environment, or landscape amenity, or wildlife or freshwater-life or marine-life habitat, or historical value, and that the particular purpose or purposes can be achieved without acquiring the ownership of the land, or, as the case may be, of the lessee's interest in the land, for a reserve, may treat and agree with the owner or lessee for a covenant to provide for the management of that land in a manner that will achieve the particular purpose or purposes of conservation.	
4	**Conservation Park**	**Conservation Act 1987**
	Purpose: s 19 Protect natural resources while facilitating public recreation and enjoyment.	
4	**Māori Reservation (Wetland or Scenic Reserve)**	**Tu Ture Whenua Māori Act 1993**
	The chief executive may, by notice in the Gazette issued on the recommendation of the court, set apart as Māori reservation any Māori freehold land or any General land—(a) for the purposes of a village site, marae, meeting place, recreation ground, sports ground, bathing place, church site, building site, burial ground, landing place, fishing ground, spring, well, timber reserve, catchment area or other source of water supply, or place of cultural, historical, or scenic interest, or for any other specified purpose; or (b) that is a wāhi tapu, being a place of special significance according to tikanga Māori.	
4	**QEII Open Space Covenant**	**Queen Elizabeth II National Trust Act 1977**
	Purpose: s. 2 Preserve any area of land or body of water that serves to preserve or to facilitate the preservation of any landscape of aesthetic, cultural, recreational, scenic, scientific, or social interest or value. (These are usually in perpetuity.)	
4	**Protected Private Land**	**Reserves Act 1977**
	Purpose: s 76 Land possessing such qualities of natural, scientific, scenic, historic, cultural, archaeological, geological, or other interest that its protection is desirable in the public interest, or that rare species of indigenous flora or fauna are on the land, and the preservation of such flora and fauna is in the public interest, and that the land is sufficiently fenced or is otherwise protected from damage by stock.	
4	**Scenic Reserve**	**Reserves Act 1977**
	Purpose: s 19 (1) (a) protecting and preserving in perpetuity for their intrinsic worth and for the benefit, enjoyment, and use of the public, suitable areas possessing such qualities of scenic interest, beauty, or natural features or landscape that their protection and preservation are desirable in the public interest; (b) providing, in appropriate circumstances, suitable areas which by development and	

Class	Designation	Legal Mechanism
	the introduction of flora, whether indigenous or exotic, will become of such scenic interest or beauty that their development, protection, and preservation are desirable in the public interest; (2) (a) the indigenous flora and fauna, ecological associations, and natural environment and beauty shall as far as possible be preserved, and for this purpose, except where determined otherwise, exotic flora and fauna shall as far as possible be exterminated; (b) the public shall have freedom of entry and access to the reserve; (c) to the extent compatible open portions of the reserve may be developed for amenities and facilities where these are necessary to enable the public to obtain benefit and enjoyment.	
4	**Watercourse Area**	**Conservation Act 1987 § 23**
	Purpose: s 23 Protect the wild, scenic, and other natural or recreational characteristics present when considered with the associated river, lake, or stream concerned.	
4	**Wildlife Refuge**	**Wildlife Act 1953**
	Purpose: s 14 (3) Areas where it is unlawful for any person to hunt or kill for any purpose, or molest, capture, disturb, harry, or worry any wildlife in the wildlife refuge, or to take, destroy, or disturb the nests, eggs, or spawn of any such wildlife, or for any person to bring onto the wildlife refuge or have in his possession or discharge in the wildlife refuge any firearm or explosive, or have in his possession or control in the wildlife refuge any dog or cat, or to do anything likely to cause any wildlife to leave the wildlife refuge; (1)(f) prohibit or restrict the pollution by means of rubbish, sewage, industrial waste, mining debris, saw mill refuse, or any other means, (1A) prohibit or restrict the use of boats; (2) authorised persons may keep or bring domestic animals; keep or bring firearms or explosives; discharge firearms or explosives; destroy any animals specified, perform any other acts necessary for the carrying on of the normal use of the land, subject to any specified conditions.	
3	**Ecological Area**	**Conservation Act 1987**
	Purpose: s 21 Managed to protect the values for which it is held	
3	**Government Purpose Reserve (Ecological or Wildlife)**	**Reserves Act 1977**
	Purpose: s 22 (1) providing and retaining areas for such Government purpose or purposes as are specified in any classification of the reserve; (2) may be classified for wildlife management or for other specified wildlife purposes; (4) (a) where scenic, historic, archaeological, biological, cultural, scientific, or natural features or wildlife are present on the reserve, those features or wildlife shall be managed and protected to the extent compatible with the principal or primary purpose of the reserve; (b) to the extent compatible with the principal or primary purpose, value as a soil, water and forest conservation area shall be maintained; (5) may prohibit access to the whole or part of the reserve, or, as the case may be, the whole or any specified part of that part of the reserve, and no person shall be entitled to enter the reserve or, as the case may be, the part specified in the notice, except under the authority of a permit	
3	**Māori Reservation (Conservation or Conservation of Native Bush)**	**Tu Ture Whenua Māori Act 1993**
	The chief executive may, by notice in the Gazette issued on the recommendation of the court, set apart as Māori reservation any Māori freehold land or any General land—(a) for the purposes of a village site, marae, meeting place, recreation ground, sports ground, bathing place, church site, building site, burial ground, landing place, fishing ground, spring, well, timber reserve, catchment area or other source of water supply, or place of cultural, historical, or scenic interest, or for any other specified purpose; or (b) that is a wāhi tapu, being a place of special significance according to tikanga Māori.	
3	**Ngā Whenua Rāhui Kawenata**	**Reserves Act 1977**
	Purpose: s 77A (1) (a) Māori land or Crown land held under a Crown lease by Māori managed to preserve and protect – (i) the natural environment, landscape amenity, wildlife or freshwater-life or marine-life habitat, or historical value of the land; or (ii) the spiritual and cultural values which Māori associate with the land, (b) a Ngā Whenua Rāhui kawenata under this section may be in perpetuity or	

Class	Designation	Legal Mechanism
	for any specific term or may be in perpetuity subject to a condition that at agreed intervals of not less than 25 years, and usually for a term renewable after a 25 year period.	
3	**Local Purpose Reserve (Ecological)**	**Reserves Act 1977**
	Purpose: s 23 (1) providing and retaining areas for such local purpose or purposes as are specified in any classification of the reserve; (2) (a) where scenic, historic, archaeological, biological, cultural, scientific, or natural features or wildlife are present on the reserve, those features or wildlife shall be managed and protected to the extent compatible with the principal or primary purpose of the reserve; (b) to the extent compatible with the principal or primary purpose, value as a soil, water and forest conservation area shall be maintained; (3) where vested in a local authority or where the administering body is a local authority, may prohibit access to the whole or any specified part of the reserve, and in that case no person shall enter the reserve or, as the case may be, that part, except under the authority of a permit issued by the local authority; (4) may prohibit access to the whole or any specified part of the reserve, and in that case no person shall enter the reserve or, as the case may be, that part, except under authority of a permit	
3	**Stewardship Area**	**Conservation Act 1987**
	Purpose: s 25 Managed so that natural and historic resources are protected.	
3	**Wildlife Management Reserve**	**Wildlife Act 1953**
	Purpose: s 14 (3) Impose conditions in relation to all or any of the matters specified in s 9(2) (see Wildlife Sanctuary above)	
2	**Esplanade Reserve or Strip**	**Resource Management Act 1991**
	Purpose: s 229 An esplanade reserve or an esplanade strip has 1 or more of the following purposes: (a) to contribute to the protection of conservation values by, in particular – (i) maintaining or enhancing the natural functioning of the adjacent sea, river, or lake; or (ii) maintaining or enhancing water quality; or (iii) maintaining or enhancing aquatic habitats; or (iv)protecting the natural values associated with the esplanade reserve or an esplanade strip or (v) mitigating natural hazards; or (b) to enable public access to or along any sea, river, or lake; or (c) to enable public recreational use of the esplanade reserve or esplanade strip and adjacent sea, river, or lake, where the use is compatible with conservation values. s 230 An esplanade reserve 20 metres in width shall be set aside… along the mark of mean high water springs of the sea, and along the bank of any river or along the margin of any lake.	
2	**Historic Reserve**	**Reserves Act 1977**
	Purpose: s 18 (1) protecting and preserving in perpetuity such places, objects, and natural features, and such things there on or therein contained as are of historic, archaeological, cultural, educational, and other special interest; (2) (c) where scenic, archaeological, geological, biological, or other scientific features, or indigenous flora or fauna, or wildlife are present on the reserve, those features or that flora or fauna or wildlife shall be managed and protected to the extent compatible with the principal or primary purpose; (d) to the extent compatible with the principal or primary purpose of the reserve, its value as a soil, water, and forest conservation area shall be maintained; (e) except where otherwise determined, the indigenous flora and fauna and natural environment shall as far as possible be preserved	
2	**Local Purpose Reserve (Other – various)**	**Reserves Act 1977**
	Purpose: s 23 (1) for the purpose of providing and retaining areas for such local purpose or purposes as are specified in any classification of the reserve. (2) Every local purpose reserve shall be so administered and maintained under the appropriate provisions of this Act that – (a) where scenic, historic, archaeological, biological, or natural features are present on the reserve, those features shall be managed and protected to the extent compatible with the principal or primary purpose of the reserve.	

Class	Designation	Legal Mechanism
2	**Māori Reservation (Various purposes related to Recreation, Camping, Water Supply, Meeting Places, Historic Significance, etc.)**	**Tu Ture Whenua Māori Act 1993**
	The chief executive may, by notice in the Gazette issued on the recommendation of the court, set apart as Māori reservation any Māori freehold land or any General land—(a) for the purposes of a village site, marae, meeting place, recreation ground, sports ground, bathing place, church site, building site, burial ground, landing place, fishing ground, spring, well, timber reserve, catchment area or other source of water supply, or place of cultural, historical, or scenic interest, or for any other specified purpose; or (b) that is a wāhi tapu, being a place of special significance according to tikanga Māori.	
2	**Marginal Strip**	**Conservation Act 1987**
	Purpose: Part 4A s 24 (1) Any strip of land 20 metres wide extending along and abutting the landward margin of (a) any foreshore; or (b) the normal level of the bed of any lake not subject to control by artificial means; or (c) the bed of any river or any stream (not being a canal under the control of a State enterprise within the meaning of section 2 of the State-Owned Enterprises Act 1986 and used by the State enterprise for, or as part of any scheme for, the generation of electricity), being a bed that has an average width of 3 metres or more; (2) any land extending along and abutting the landward margin of any lake controlled by artificial means a strip of land that – (a) is 20 metres wide; or (b) has a width extending from the maximum operating water level to the maximum flood level of the lake – whichever is greater	
2	**Consent Notice**	**Resource Management Act 1991**
	Purpose: s 221 (1) Where a subdivision consent is granted subject to a condition to be complied with on a continuing basis by the subdividing owner and subsequent owners… the territorial authority shall… issue a consent notice specifying any such condition. (4) Every consent notice shall be deemed – (b) to be a covenant running with the land when registered under the Land Transfer Act 1952, and shall… bind all subsequent owners of the land.	
2	**Recreation Reserve**	**Reserves Act 1977**
	Purpose: s 17 (1) providing areas for the recreation and sporting activities and the physical welfare and enjoyment of the public, and for the protection of the natural environment and beauty of the countryside, with emphasis on the retention of open spaces and on outdoor recreational activities, including recreational tracks in the countryside; (2) (b) where scenic, historic, archaeological, biological, geological, or other scientific features or indigenous flora or fauna or wildlife are present, those features or that flora or fauna or wildlife shall be managed and protected to the extent compatible with the principal or primary purpose of the reserve; (c) those qualities of the reserve which contribute to the pleasantness, harmony, and cohesion of the natural environment and to the better use and enjoyment of the reserve shall be conserved; (d) to the extent compatible with the principal or primary purpose, its value as a soil, water, and forest conservation area shall be maintained	
2	**Regional Parks**	**Local Government Act 2002**
	Purpose: s 139 (1) (a) means land – (i) owned by regional councils; and (ii) acquired or used principally for community, recreational, environmental, cultural, or spiritual purposes; and (b) includes land within the meaning of paragraph (a) that is – (i) reserve within meaning 2(1) of the Reserves Act 1977; or (ii) otherwise held or administered under the Reserves Act 1977 or any earlier corresponding enactment	
1	**Māori Reservation (Various purposes related to Marae, Pā Sites, Papakāinga, Urupā, Wāhi Tapu, etc.)**	**Tu Ture Whenua Māori Act 1993**

Class	Designation	Legal Mechanism
	The chief executive may, by notice in the Gazette issued on the recommendation of the court, set apart as Māori reservation any Māori freehold land or any General land—(a) for the purposes of a village site, marae, meeting place, recreation ground, sports ground, bathing place, church site, building site, burial ground, landing place, fishing ground, spring, well, timber reserve, catchment area or other source of water supply, or place of cultural, historical, or scenic interest, or for any other specified purpose; or (b) that is a wāhi tapu, being a place of special significance according to tikanga Māori.	
1	**River Bed**	**River Boards Act 1908**
	Purpose: 73 (1) All rivers, streams, and watercourses within any river district constituted under this Act, whether or not the same are navigable or are altered by the ebb and flow of the tide, shall be to all intents and purposes within and subject to the jurisdiction of the Board, so far as may be requisite for the construction or maintenance of any works necessary to prevent or lessen any damage which may be occasioned by the overflow or the breaking of the banks of the same.	
1	**Road Reserve**	**Reserves Act 1977**
	Purpose: s 111 (1) Where any land is vested in the Crown or in any local authority for the purposes of a road reserve and the land is required for the purposes of a road, the land may be dedicated as a road by notice under the hand of the Minister or, as the case may be, by resolution of the local authority, and lodged with the District Land Registrar. (2) For the purposes of this section the term road includes any road, street, access way, or service lane; and the expression road reserve has a corresponding meaning.	
0	**No legal protection**	

15.5 Data management and access requirements

Data management and access consists of four interrelated considerations: sampling, analysis, reporting, and curation, which together comprise the work flow needed to inform M18 (Figure 15-4 and Figure 15-5).

- Sampling – acquiring and compiling the data required to inform M18
- Analysis – the calculation of M18 following agreed methods and protocols
- Reporting – communication of the results of the analyses
- Curation – the long-term (permanent) storage of the fundamental data, methods, results of analyses, and/or resulting indicators and associated reports.

Historically, management and access for data on areas legally protected for biodiversity occurred primarily in a federated fashion. To varying degrees, different organisations have acquired data for areas legally protected for biodiversity for which they have responsibility. Periodically different organisations, including regional councils, have then compiled and analysed available data on areas legally-protected for biodiversity to support various policy and planning, monitoring and reporting requirements.

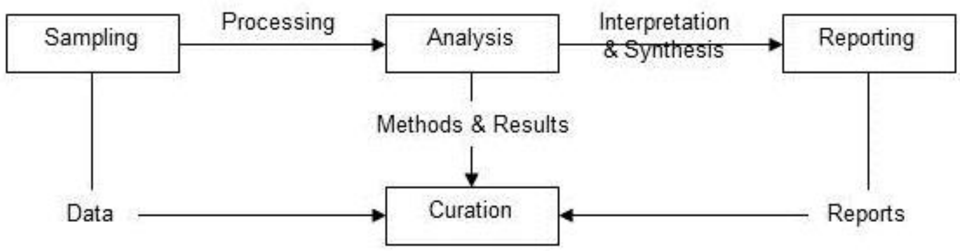

Figure 15-4 Overview of work flow for Indicator M18.

Of the four elements, data acquisition is currently and will continue to remain for the foreseeable future the responsibility of each organisation that administers or manages areas legally protected for biodiversity. Those organisations principally include DOC, the Queen Elizabeth II National Trust, Ngā Whenua Rāhui, regional councils, unitary authorities, and city and district councils.

15.5.1 Current Data Management

Currently all four elements occur in a federated manner, in the sense that regional councils (and other organisations) independently sample (acquire and compile), analyse, report and curate information on the status of areas legally protected for biodiversity within their own jurisdiction. As result, data are replicated and curated across regional councils, and analysis and reporting varies across councils as well (Figure 15-5).

For national analyses, MfE and Landcare Research, working independently or together, have carried out similar processes to analyse areas legally protected for biodiversity. The main difference from regional council efforts is that both MfE and Landcare Research efforts resulting centralised storage of data for legally-protected areas for biodiversity. In particular, Landcare Research methods produced a comprehensive, spatially-referenced database (PAN-NZ) that can be queried and augmented to address a range of questions across a range of scales (see section 15.3.1 for more details on the methodology).

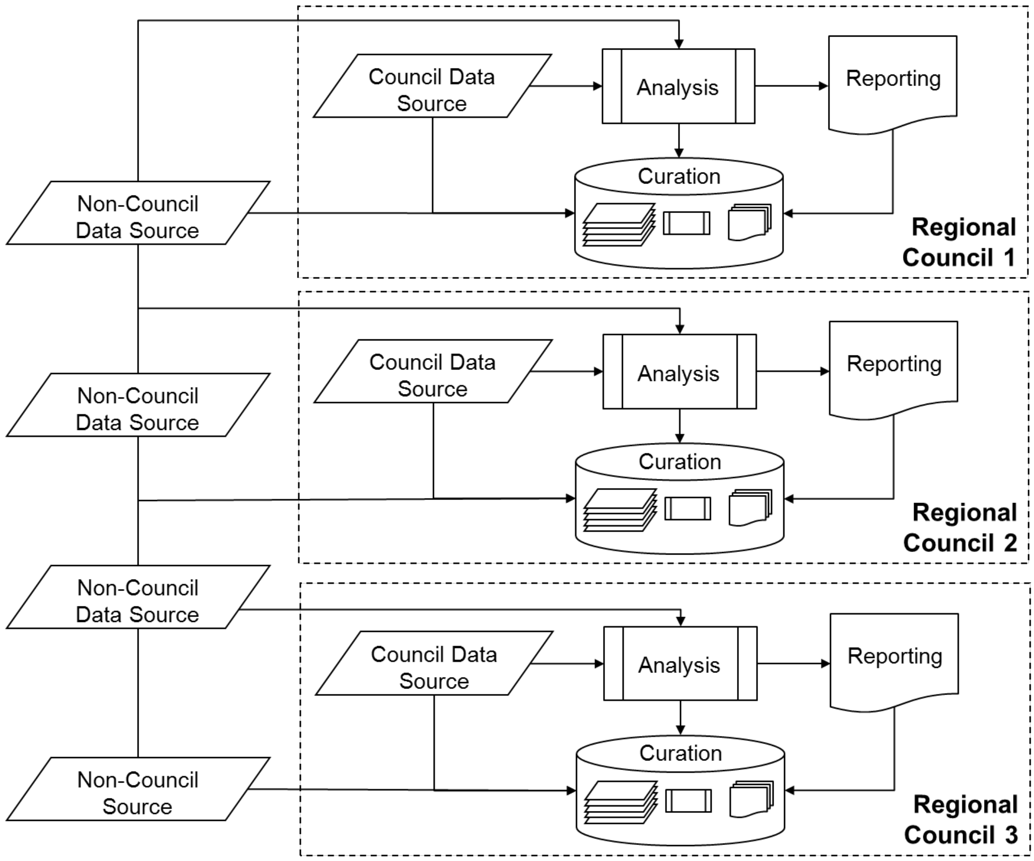

Figure 15-5 Conceptual illustration of the current approach to analysis and reporting of areas legally protected for biodiversity by regional councils. Only three regional councils are shown for simplicity.

During the project participants discussed sharing of data and results to support broader (i.e. national) analyses. While council representatives broadly supported the idea during development of M18, they agreed to postpone its further consideration.

Note that data compiled for M18 are needed to inform M12 ('Change in extent and protection of indigenous cover or habitats or naturally rare ecosystems'). Data compiled for M18 also inform M13 ('Extent of legal protection of threatened species habitat').

15.5.2 Data Management: A Proposed Short-term Solution

The fundamental data, methods, and results of analysis should be properly curated to support longitudinal analyses and evaluation of trends in areas legally protected for biodiversity over time. Proper curation will help ensure that as new data becomes available we can accurately assess and partition how the protected areas network changes because of a) real additions or subtractions from the network or b) new data becoming available that identifies previously unidentified protected areas. In the latter case, a revision of previous estimates would be required to avoid spurious changes in extent of protection or at least to attribute the changes to the appropriate point in time. As highlighted above, the current approach results in duplication of effort as well as proliferation of datasets across regional councils. This can lead to issues of consistency, accuracy, reliability, and longevity.

In the long term, several initiatives show promise for developing a more coordinated, repeatable and robust process for analysing and reporting on the areas legally protected for biodiversity by regional councils. The most relevant initiatives include the proposed national environment reporting initiatives, the Land Resources Support System and the Integrated Biodiversity Management System.

However, those initiatives will not come to fruition in time to support the current project. An interim, simple, short-term solution to facilitate data management for M18 will meet the immediate needs of the regional councils while also supporting a long-term transition to a more coordinated system.

In the interim, all key non-council data consisting of public conservation estate data (managed by DOC), Ngā Whenua Rāhui kawenata data (obtained directly rather than as part of the public conservation estate dataset, and QE II covenant data (obtained via regular QEII updates), analysis methods, and reporting formats are stored in a centralised location (Figure 15-6). Some data on protected areas managed by entities (e.g. public trusts) that may not be funded or otherwise able to provide data will not be included at this point and indeed may be extremely difficult to source at all in the future.

Each regional council accesses non-council data, methods and reporting standards from the centralised location using secure downloading facilities. Each council then undertakes its own analysis using available in-house capabilities or with tools provided by Landcare Research. After completing the analysis and generating reports following agreed standard formats, each council uploads its own data, analysis results, and reports. A council may also choose to curate data, methods, and results in-house.

The interim solution aims to streamline access to data and to promote consistency of analysis and reporting until such time as more sophisticated methods become available (e.g. semi-automated data sharing or web-enabled work flows).

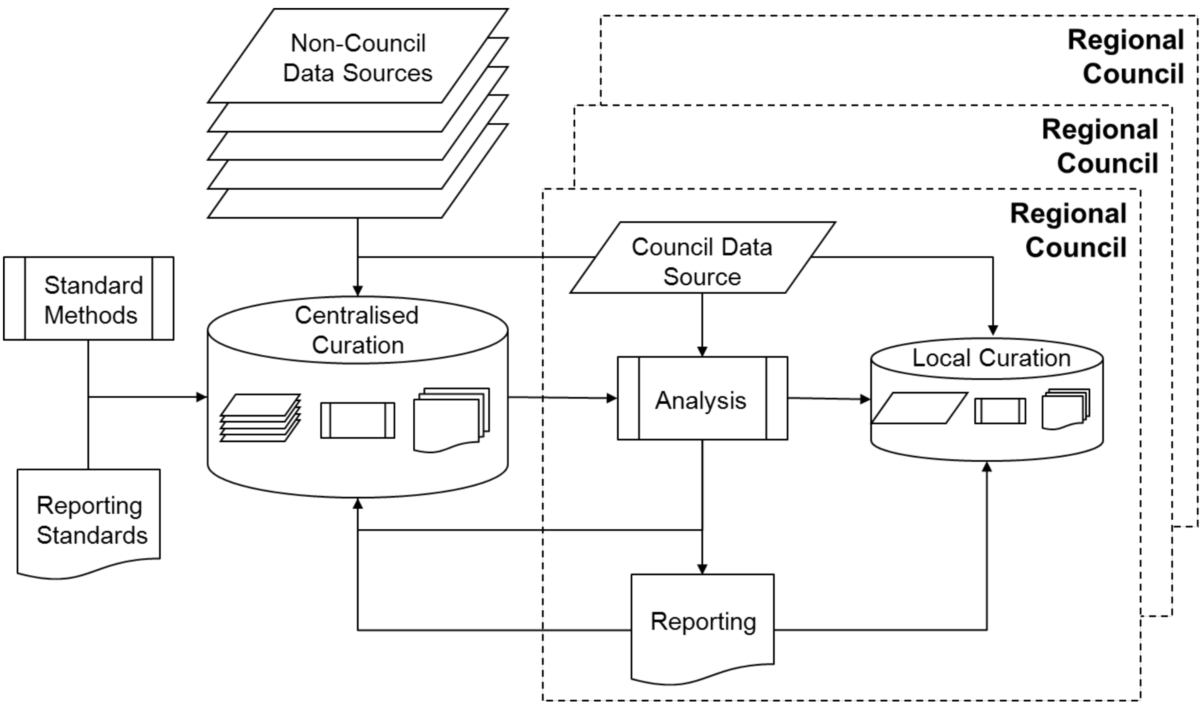

Figure 15-6 Proposed short-term interim solution for data management for M18.

15.5.3 Conclusion

Regional councils need to **formulate, agree and implement a more formal approach to ensure consistency, credibility and accountability**. This will require decisions regarding how much or how little data management and access should eventually be centralised versus federated, and development of relevant standards and protocols. In the long term, emerging approaches and methods in informatics and data interoperability coupled with various initiatives at the national and regional level may partly or wholly address data management and access issues by establishing a relatively seamless process and rendering moot the choice between centralisation and federation.

The interim solution that allowed reporting of M18 in July 2014 was that Landcare Research collected and curated all available data on areas legally protected for biodiversity in a centralised repository and made that data available, subject to any limitations stipulated by the data owners, to all regional councils via a simple secure download facility. This interim solution could be repeated in future, with regional councils in turn analysing and reporting on M18, using the centrally stored datasets as the basis for analysis. Reporting will follow agreed content and format as outlined in section 15.7. Regional councils will then upload their reports to the secure facility for further use by other councils or agencies. The interim solution would require that Landcare Research curates the data, methods and reports until a more permanent system is available.

15.6 Methodology for calculating M18

The methods for classifying and calculating the status of areas legally protected for biodiversity in a region are outlined in Table 15-8.

For the initial generation and reporting of M18, councils could choose to use existing applications available from Landcare Research: LANDCLASS (LANDscape CLassification and Analysis Support System) and a combinatorial analysis software programme (Figure 15-7). The LANDCLASS tool will assist with reclassifying input data into the six-category legal protection classification following consistent classification rules. The combinatorial analysis uses the reclassified data as input and produces a database showing all unique combinations of input data and an associated spatial data layer (raster or grid layer). The database and spatial data layer can be queried as needed to generate desired indices and produce a variety of associated supporting reports and maps.

Regional councils are free to use their own analytical procedures, provided they are consistent. However, LANDCLASS provides the advantage that all councils can develop, share, and work from a single set of methods, thus avoiding any questions of inconsistency.

Table 15-8 Methodology for calculating M18

1	Develop a database of spatially referenced information for all protected areas in the region.	Information on some protected areas may already exist (e.g. public conservation land layer maintained by DOC). Based on previous research on protected areas, information on other protected areas may not exist yet in a spatially referenced form and may require investment to develop.
2	Reclassify areas of legally protected areas into the six-level classification scheme in Table 15-6.	Within a geographic information system, this would involve creating an additional field as an integer variable of the attribute table (e.g. of an ESRI shapefile) and coding the field for each record with the appropriate classification number from Table 15-6.
3	Overlay the reclassified regional protected areas spatial data layer with a regional boundary spatial data layer.	Exact overlay procedures vary depending on the analysis package used and whether analysis is done in a vector or raster environment. Landcare Research recommends use of a Union analysis to retain all information from both sets of input data to enable identification of spatial mismatches, e.g. areas where protected areas boundaries may fall outside regional boundaries due to differences in representation of the coastline. District boundaries could also be included to generate statistics at the district level.
4	Calculate the total area of each class of protected area occurring in each region for use in reporting.	Exact calculation procedures vary depending on the analysis package. Most packages include facilities for performing summary statistics that report total area for a selected field for either all records or a selected subset of records.

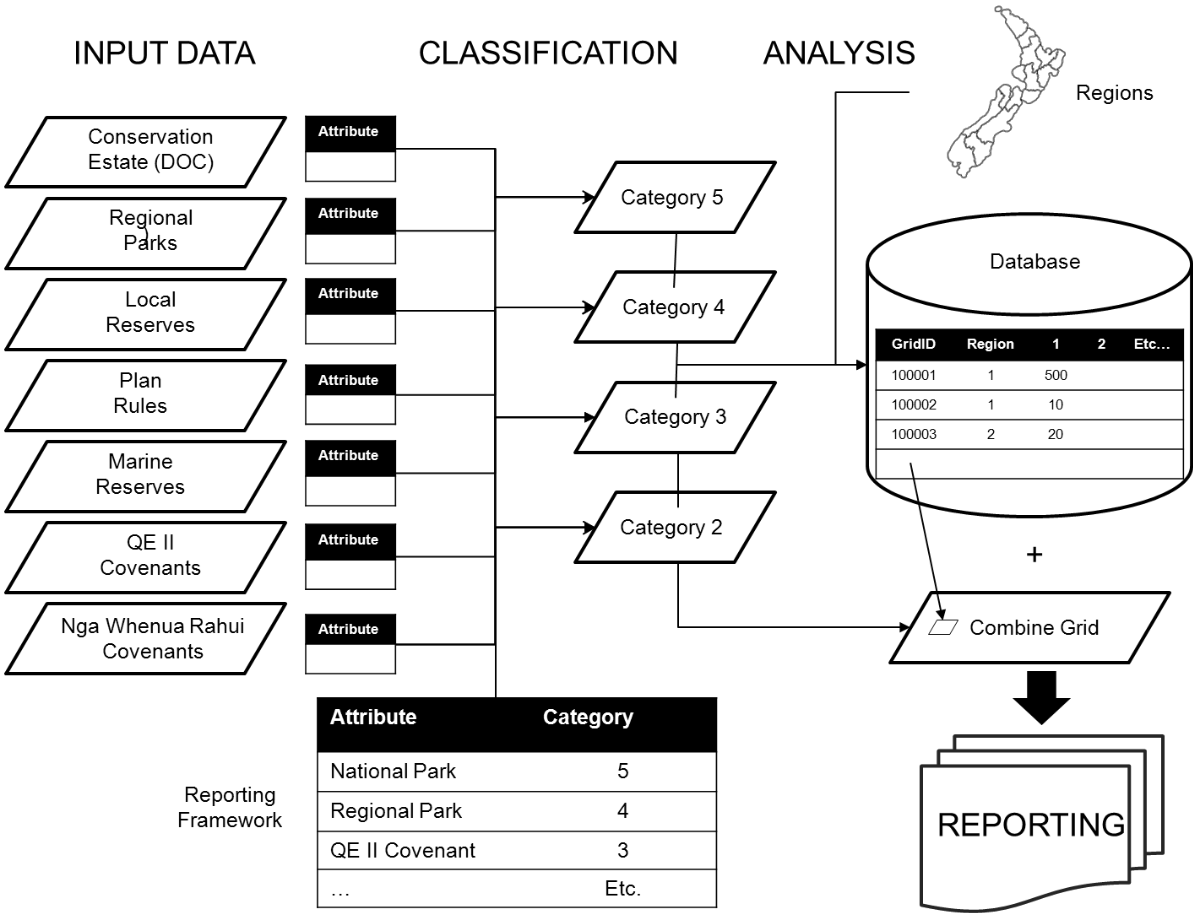

Figure 15-7 Schematic representation of the work flow for generating and reporting M18.

15.7 Reporting format

For reporting M18, we recommend following a similar format to that used by the MfE in their 'Snapshot Reports' prepared as part of national state of the environment reporting[19]. The report would be structured as follows:

1. Key points
2. Brief introduction
    a. Overview of legal protection classification
3. Current status of areas legally protected for biodiversity
    a. Short explanatory paragraph
    b. Map of current location of legal protection by the six-level classification

[19] http://www.mfe.govt.nz/environmental-reporting/report-cards/biodiversity/2010/index.html

   c. Table summarising current statistics, i.e. total area for each legal protection class within the region. Note that the combinatorial analysis programme mentioned earlier would also facilitate reporting at the district level

4. Trends

   a. Short explanatory paragraph
   b. Map showing gains, losses and unchanged areas of legal protection since the last report
   c. Transition matrix showing changes from/to different classes (or notable changes in types) of legal protection
   d. Graph showing trends in legal protection both overall and for each category of protection. The graph should show all available historical data. Over time the graph should show an increasingly longer time span. The map and transition matrix will summarise the changes between the current time and the previous report

5. Overview of methods (or perhaps as an appendix)

6. References

15.8 Relationship to other biodiversity indicators

The information on legally protected areas compiled for M18 is relevant to other biodiversity indicators already completed or under development for the project.

Indicator M12 ('Change in extent and protection of indigenous cover or habitats or naturally rare ecosystems') will also need protected areas data to determine the extent to which indigenous land cover and naturally rare ecosystems are legally protected within a region. Indicators M12 and M18 could be linked to produce a matrix that facilitates reporting of extent and protection of indigenous land cover and naturally rare ecosystems by the six-level legal protection classification (see

Table 15-9 for an example).

Other indicators involving assessment of areal extent of different biodiversity components such as M13 (‘Threatened species habitat’) will benefit from analysis with protected area data to help gauge the security of those components depending on the degree of legal protection currently afforded and used to identify future conservation targets.

Table 15-9 Example reporting format linking Indicators M12 and M18

Indigenous cover class or naturally rare ecosystem	Extent in region (hectares)	Area protected by legal protection class (hectares)						Total area protected (hectares)	% Area protected
		0	1	2	3	4	5		
Class 1									
Class 2									
Class 3									
Etc…									
…									
…									

15.9 References

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Appendix 15 – IUCN Protected Area management categories

Code	Name	Description	New Zealand Protected Areas*	
Ia	Strict Nature Preserve	Category Ia protected areas are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring	National Parks Act of 1980	Specially protected areas
			Conservation Act 1987	Ecological areas Sanctuary areas
			Reserves Act 1977	Nature reserves Scientific reserves
			Wildlife Act 1987	Wildlife sanctuaries
			Marine Reserves Act 1971	Marine reserves
			Marine Mammal Protection Act 1978	Marine mammal sanctuaries
			Fisheries Act 1983 & Harbours Act 1950	Marine parks
			Sugar Loaf Islands Marine Protected Area Act 1991	Marine protected areas
Ib	Wilderness Area	Category Ib protected areas are usually large, unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.	National Parks Act of 1980	Wilderness areas
			Conservation Act 1987	Wilderness areas
II	National Park	Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities.	National Parks Act of 1980	National parks (balance)
			Conservation Act 1987	Conservation parks
			Reserves Act 1977	National reserves
III	National Monument or Feature	Category III protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.	Reserves Act 1977	Historic reserves Scenic reserves Wildlife purpose reserves

Code	Name	Description	New Zealand Protected Areas*	
IV	Habitat/Species Management Areas	Category IV protected areas aim to protect particular species or habitats and management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.	Conservation Act 1987	Stewardship areas Private land reserved under conservation covenants or private agreements
			Wildlife Act 1987	Wildlife refuges and management areas
			Reserves Act 1977	Private land reserved under conservation covenants or private agreements
V	Protected Landscape/ Seascape	Category V protected areas are where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.	Reserves Act 1977	Recreation and other reserves
VI	Protected area with sustainable use of natural resources	Category VI protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level, non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.		

* Refer to New Zealand State of the Environment Report 1997, Tables 9–38, Pages 9–146.

16 Indicator M19: Contribution of initiatives to (i) species translocations and (ii) habitat restoration

Author: John Innes, Landcare Research

16.1 Introduction

Indicator M19 has two parts, (i) documenting community-led liberations of native animal (and rarely plant) species to a region, and (ii) documenting community-led habitat restoration. Some aspects of M19 were addressed by the Biodiversity Forum Technical Working Group in November 2011. It was clarified to be (i) deliberate and managed reintroductions of species, and (ii) habitat restoration undertaken by community groups, the latter excluding individual landowner- and council-led initiatives such as retiring land. Successful implementation of M19 and other measures depends on smart standardisation of definitions of key words across measures. The following definitions are derived from those forged collectively between participants in the last 3 years, and are consistent with those used in M20 ('Community contribution to weed and animal pest control and reductions').

Definition of Community: A community is two or more people (i.e. a group) undertaking translocations or habitat restoration to enhance native biodiversity values or sites of environmental importance. A single private landowner implementing either process on their own land is not a 'community' (i.e. is not the purview of M19) unless they are part of a community group as previously defined. Communities must be formally registered with their respective regional council, but need not have legal status.

Habitat is a famously broad concept. A sub-group of the national Regional Council Biodiversity Technical Working Group convened on 24 April 2012 to agree on a definition of 'habitat' for all indicators.

Definition of Habitat: Fine- and even broad-scale habitat characteristics will differ between many regions. Experts suggested that for national reporting purposes, 'basic' or 'broad' habitat categories are most appropriate. For M19, vegetation cover is used as a surrogate for habitat, and vegetation cover is classified according to the Land Cover Database (LCDB). This ensures consistency with other regional council measures (e.g. M1 'Land under indigenous vegetation').

Ideally, ecosystem restoration is about intentionally altering a site to establish a defined, indigenous, historic ecosystem (Balaguer et al. 2014) but this is frequently unattainable (Hobbs 2007). A more practical vision is to embark on natural recovery, in which the ecosystem will regain desirable attributes once a pressure (such as pests) is removed, combined with active interventions, such as planting or translocation, if required. Attributes of both natural recovery and active interventions can both be described well using two elements of ecological integrity – increasing indigenous dominance and indigenous species occupancy (Lee et al. 2005). I suggest that for reporting purposes, 'restoration' be considered primarily as a process (being actively restored) rather than requiring some completed predetermined state to be achieved. At present the word appears in no other measures, and it may be better to replace it with 'enhancement', but I do not yet recommend this.

Definition of Restoration: The active process of altering a site towards a defined, indigenous, historic ecosystem.

16.2 Scoping and analysis M19 (i)

Documenting community-led releases of native animal and plant species to a region

Given that this measure is an indicator of protection and restoration, I suggest that it include all translocations undertaken by community groups listed under Conservation Translocation (Figure 16-1). The vast majority will be population reintroductions or reinforcement, and there may rarely be some ecological replacements (e.g. North Island kōkako for South Island kōkako). Assisted colonisation (e.g. translocating to pre-judge climate change distribution shifts) is controversial and will predictably be very uncommon.

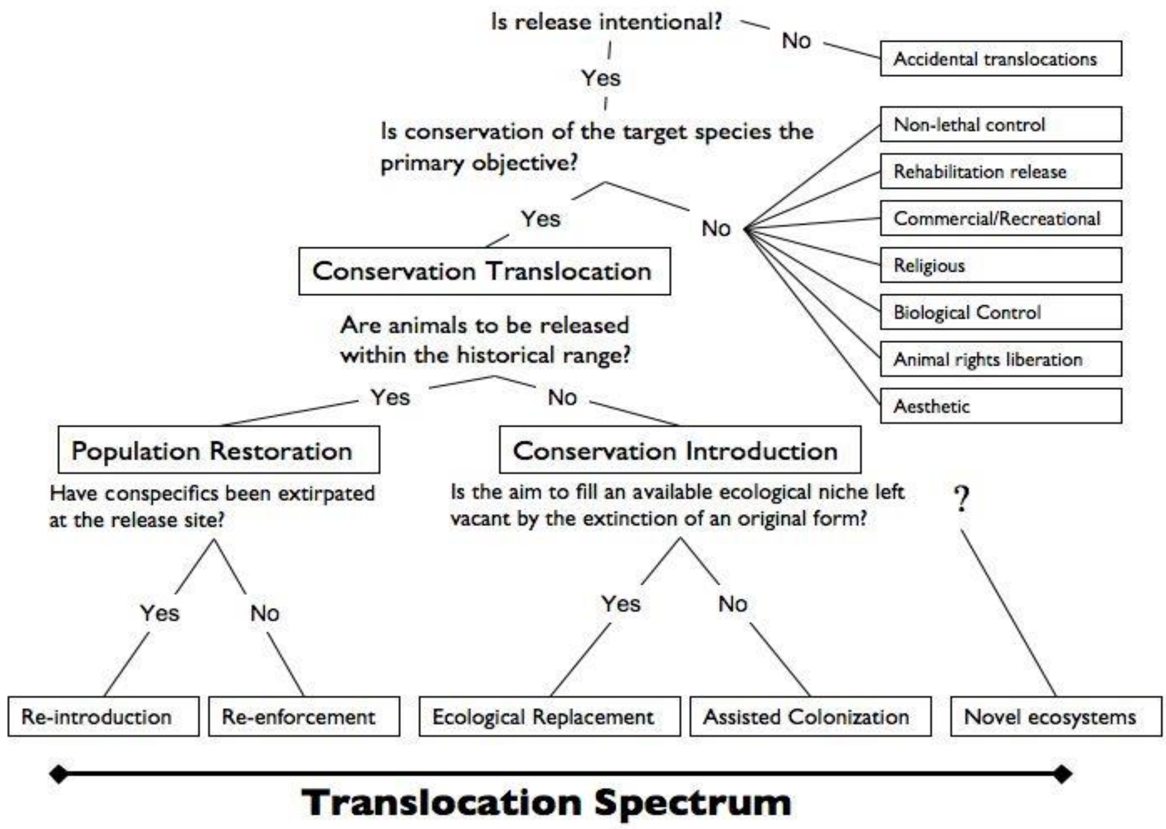

Figure 16-1 A classification of translocation types across a spectrum from reintroduction (i.e. original presence) to novel introduction (taxon never there previously); from Seddon et al. (2012).

16.2.1 Statistics to report

This measure relates to translocations to private land, or to public land if community-led or partnered, but not to those undertaken entirely by DOC to DOC land.

1. The number of community groups that have undertaken translocations and the mean number of volunteers per community group. This is requested also for M20, and many of the groups that conduct animal (and plant) species translocations may be the same as those doing weed and pest control, so these data would be shared between measures in each reporting year.

2. The total number of separate translocations undertaken to private land, or to public land if community-led, for each species in the region in the preceding 2 years, initially classified as: *Reintroduction* (return of species to place where it used to be), *Reinforcement* (supplementing a population that is already present), *Ecological Replacement* (release of a native species outside its historic range to fill an ecological niche left vacant by another locally extinct native species) or *Assisted Colonisation* (translocation of species to favourable habitat beyond its native range to protect it from human-induced threats) per Figure 16-1 (Seddon et al. 2012). Releases of the same taxon from the same source site to the same destination site within 30 days of each other are to be regarded as part of the same translocation.

3. The total area (hectares) of sites to which translocations have occurred, by species. Note this does not equate to the actual area occupied by translocated species ('critter hectares'). In large, continuous forests, it means the area of habitat managed and suitable for the species (e.g. a pest control area).

16.2.2 Reporting frequency

The reporting frequency should be every 2 years. In the DOC database (all approved translocations 2002–2012), there were on average 31 translocations per DOC Conservancy (range 8–61), and of those, only 39% on average per Conservancy were either conducted by non-DOC staff or jointly with DOC staff. In the period, there were on average 44 translocations nationally per annum. Two years therefore is frequent enough to observe trends without reporting being onerous.

16.2.3 Hierarchies

This measure contributes to ecological integrity through species occupancy (species that used to be there are returned) and perhaps indigenous dominance (if the returned species are dominant in abundance or biomass, or have key ecological roles e.g. pollination, seed dispersal, predation). One approach to measuring species occupancy is to tabulate all species of a group (e.g. birds) that used to be present at a site, and score the percentage now present. This number will rise with each translocation. Dedication of a translocation to a specific GIS site would also enable integration with other contributions to indigenous dominance, such as exotic weed and pest control.

16.3 Spatial and temporal analyses

If collected uniformly and biennially by all regional councils, all of the suggested statistics are comparable regionally and additive nationally and would show clear trends in time. If a translocation could be specified to a particular site by GIS, then it could be one component of data and interventions registered to that site and recalled by computer search.

16.3.1 Relationships with present patterns and other measures

Like M20 ('Community contribution to weed and animal pest control and reductions'), it would be useful to compare community translocation contributions with those from DOC and other agencies to obtain a total picture. This could readily be done using DOC's database. M19 has much in common with M20, which also measures community contributions, and also with M18 ('Area and type of biodiversity protection achieved on private land'), which also measures non-agency contributions.

16.4 Assessment of existing methodologies

There is no methodology in use by regional councils that documents native animal and plant species translocations. However, DOC requires community groups and others to have an approved translocation proposal (in addition to permits) before carrying out some types of translocation, most commonly translocations of indigenous/protected wildlife and threatened land plants (DOCDM-363788 32 'Translocation guide for community groups', last updated May 2011). DOC maintains a translocation spreadsheet, which is an internal document that records basic information on all approved translocation proposals since 2002 (DOCDM 33810 'Translocation spreadsheet', Pam Cromarty, DOC, pers. comm.). It includes data on indigenous land animals (including invertebrates) and some indigenous plants. The Translocation guide for community groups describes which types of species are and are not covered by DOC's translocation process. The Translocation spreadsheet already classifies translocation proposals according to the proposer: DOC, non-DOC or Joint. However, it is an internal document, and only those with access can reach the live document and use the hyperlinks to other internal documents. This means that to implement M19 (i), council staff will need to request the current copy of DOCDM 33810 from local DOC staff.

Note that the spreadsheet lists approved translocation proposals; one proposal can cover multiple translocations, source or release sites, or even species. Transfer and monitoring reports may need to be consulted to verify whether or how a proposal was actually implemented.

The Department of Conservation also encourages community and DOC staff to send summary information about translocations to the NZ Reintroductions Database (http://www.rsg-oceania.squarespace.com/nz/) manager. This database is publically available but inevitably is less complete than the DOC one.

The Department of Conservation's 'Translocation spreadsheet'is likely to be an adequate existing source of data for M19 (i) and it should be readily accessible to regional councils.

16.5 Sampling scheme development

Indicator M19 (i) should be a complete listing of all translocations in a region and so no sampling will be required. Acquiring the relevant information is a desk exercise. In addition to the information provided by DOC's 'Translocation spreadsheet', the additional key data needed are the identity and structure of registered care groups/community groups, and availability of GIS files of release sites. Assuming all of these data are readily available, it should take one person less than a week to complete the task.

16.6 Data management and access requirements

If the measure recommended here is accepted by councils, a formal agreement of access to DOC's 'Translocation spreadsheet' for the foreseeable future should be sought from DOC (arranged through the regional councils' Biomanagers' group on behalf of all regional councils).

16.6.1 Reporting indices and formats

Indicator M19 is to document community-led releases of animals or plants to private or public land, evaluated every 2 years for the purpose of obtaining a national account of translocation activity by community groups. A group should report all translocations that they or someone representing them led in the 2-year period. All translocations of threatened species require DOC approval and should eventually be described in DOC's 'Translocation spreadsheet' (Troy Makan, DOC, Wellington, pers. comm.). Most community-led releases should therefore also appear in DOC's 'Translocation spreadsheet', but obtaining the data independently from community groups will provide an up-to-date biennial picture of national activity on council-administered land that complements the DOC view. Data to be compiled for reporting are listed in Table 16-1.

Group name: Name of community group (e.g. Puketapu Landcare Group. It is important that the same group name be retained across separate measures if reporting the same community group in M18, M19, and M20).

Number of volunteers: Number of people who have participated at least once in the group's activities in the last year (with these data checked to be consistent across M19 and M20).

Translocation type: *Reintro* = Reintroduction (i.e. return of a species to a place where it used to be); *Reinforce* = Reinforcement (i.e. supplementing a population that is already present); *Ecol replace* = Ecological replacement (i.e. release of a species outside its historic range to fill an ecological niche left vacant by a native species); *Assist colonis* = Assisted colonisation (i.e. translocation of species to favourable habitat beyond their native range to protect them from human induced threats) (Figure 16-1; Seddon et al. 2012).

Species translocated: Common name of species (e.g. North Island kōkako, forest gecko, kākā beak) and the scientific name, especially if ambiguity is possible.

Source location: e.g. Tiritiri Mātangi Island.

Release location: e.g. Cape Sanctuary.

Release land ownership: Private, DOC, other public land.

Release date: e.g. March 2013. If there were several releases over a period of time, give time span (e.g. March 2013 to May 2014).

Number released: If there were several releases over a period of time, give the total number released.

Area managed for the translocated species: Area in hectares.

Proposal writer and organisation: Name of person who wrote or led the translocation proposal, and which organisation they represented at the time. (e.g. Bill Smith, Hamilton Zoological Society).

In a previous draft, we planned to classify all translocations as *new* or *previously noted*, and at each reporting time councils would check on all previous translocations and note their success, in terms of *known survival of released animals*, *known breeding by released animals*, *population establishment*, *translocation failed*, or *unknown*. This would enable each council and the nation to report on translocation success, but would require ongoing tracking of individual translocations, which would in turn demand that a unique number be given to each translocation. The Department of Conservation does not routinely gather this information. Individual councils could consider reporting these additional data for this measure.

Items to report nationally on Indicator M19 (i)

1. Total number of community groups that have made translocations
2. Mean number of volunteers per group
3. Total number of translocations made
    a) Reintroductions
    b) Reinforcements
    c) Ecological replacements
    d) Assisted colonisations
4. Total area managed for the translocated species (ha)

Table 16-1. Example recording of the data needed to report M19 (i)

a) For each council

Group name	Financial year	No. of volunteers[1]	Translocation type[2]	Species translocated	Source site	Release site	Release land ownership	Release date	No. released	Managed area (ha)	Proposal writer and organisation
KDF	2014	37	Reintro	North Island kōkako	Hauturu	Whakatane Kiwi Sanctuary	100% private	March 2014	27	867 ha	Wayne Smith, Acme Consultants

[1] Number of people who have participated at least once in the group's activities during the period of reporting.
[2] Reintro = return of species to where it used to be; Reinforce = supplement a population that is already present; Ecol replace = release outside historic range to fill vacant niche; Assist colonis = place species beyond native range to protect them from threats (Figure 16-1)

b) Nationally

Total no. groups	Mean no. volunteers/group	Total Reintroductions[1]	Total Reinforcements[1]	Total Ecological replacements[1]	Total assisted colonisations[1]	Total managed area[2] (ha)

[1] Defined as per Figure 16-1
[2] Area of release site managed for the species, not the area to which the species spreads subsequently.

Table 16-2: Example template for reporting M19 (i)

BAY OF PLENTY REGION	
M19 (i) Contribution of community initiatives to species translocations	July 2015
Overview and current status From July 2012 to June 2014, volunteer-led community groups involving XX volunteers undertook XX translocations of XX animal species to XX sites in the Bay of Plenty region. These consisted of XX Reintroductions, XX Reinforcements, XX Ecological replacements and XX Assisted colonisations. The total habitat area managed to support the translocations was XX ha. This is the first year for which data have been taken; trends can be collated from taking the same data biennially into the future.	
Map 1: Bay of Plenty sites that received translocations in 2012–2014 <Insert map here>	
Number of translocations by community groups through time <Insert bar graph with time on the X-axis and the four translocation types having different shading on each column>	

16.6.2 Status of indicator M19 (i) in July 2015

Most of the data needed for the template (Table 16-2) are supposed to be collated continuously on DOC's 'Translocation spreadsheet', which council staff can ask to access. Additional data will need to be obtained directly from community groups. However, there will be few translocations in each region, and this job should be small.

Each council needs **to have a list of the community groups in their region and the numbers of volunteers in each**; this is required also for M19 (ii) and M20. They will also **need access to DOC's 'Translocation spreadsheet'**, which at December 2014 was actively used by DOC and available upon request. Indicator M19 (i) may be unusual in reporting biennially and up to one year retrospectively; this is to give time for projects to be entered in the DOC 'Translocation spreadsheet'. There are likely to be so few translocations there should be no other barriers to M19 (i) being reported.

16.7 Scoping and analysis M19 (ii)

Habitat area restored by community groups

Indicator M19 (ii) applies to revegetation undertaken primarily by community groups or jointly between councils and the groups. This outline avoids the expression ‘council-led’ (i.e. it does not declare whether it is council or the community group that is leading a project). Rather the measure is of community group *participation* in habitat restoration.

Based on clarification from the Biodiversity Forum technical working group (November 2011 and earlier meetings), this measure excludes land retirement (fencing) by community groups, and it excludes habitat restoration conducted by councils and by individual landowners (e.g. individual dairy farmers conducting riparian planting of native species). It also excludes revegetation comprised of exotic vegetation (e.g. willows, poplars, and lupins).

16.7.1 Statistics to report

1. The number of community groups that are undertaking habitat restoration and the mean number of volunteers per community group. This statistic is the same as for M19 (i) and M20.

2. The mean size and total area (square metres, aggregating to ha) of habitat being restored by community groups, classified separately by habitat (LCDB classes) and environment (LENZ Level IV). The LCDB class selected should be what the site is intended to become after restoration (e.g. ‘Other native vegetation’ or ‘Indigenous forest’).

As for M19 (i) and M20, national reporting of M19 (ii) should include where the habitat restoration is occurring, in a GIS framework, rather than just the number and hectare measures above. This will identify actual restoration sites as managed by the owner or user.

16.7.2 Reporting frequency

Indicator M19 (ii) should be reported annually. If projects are documented in a spreadsheet through the year, end-of-year reporting could be primarily a rapid desktop job.

16.7.3 Hierarchies

This measure contributes to ecological integrity through species occupancy (species that used to be there are returned, e.g. by planting) and indigenous dominance (e.g. nutrient cycling, dune formation, litter production and other processes will be dominated by indigenous rather than exotic species).

16.8 Spatial and temporal analyses

If collected uniformly and annually by all councils, all the suggested statistics are additive regionally and nationally and would show clear trends in time. As noted above, if restoration could be specified to a particular site by GIS, it could be one component of data and interventions registered to a site, which could be recalled by a computer search.

16.9 Relationships with present patterns and other measures

Using LCDB cover classes as habitat surrogates and adding a LENZ environment classification confers direct links with M1 (‘Indigenous land cover’). In time, links with M8 (‘Change in area under intensive land use’), M9 (‘Habitat and vegetation loss’), M12 (‘Change in extent and protection of indigenous cover or habitats or naturally rare ecosystems’) and perhaps M18 (‘Area and type of biodiversity protection on private land’) may be possible.

16.10 Assessment of existing methodologies

At present, areas of habitat being restored or enhanced by community groups are not methodically collated by councils, although areas associated with some groups with whom councils work jointly are known.

16.11 Sampling scheme development

Indicator M19 (ii) should be a complete listing of all areas being restored by community groups and so no sampling will be required.

16.12 Data management and access requirements

Data should be collated in one MS Excel spreadsheet per council with columns for regional council name, year (1 July–30 June), care group name, number of volunteers, GIS site reference, area planted (square metres or hectares), and an LCDB classification of what the site is intended to become. If GIS data are recorded for each site, all sites can be placed into a LENZ classification at any LENZ level, depending on the particular query. Consideration will need to be given to data management and access.

16.13 Reporting indices and formats

The following derived statistics should be collated annually for national reporting (Table 16-3):

- the number of community groups undertaking habitat restoration, and the mean number of volunteers per community group (also required for M19 (i) and M20)
- the mean size and total area (square metres, aggregating to hectares) of habitat being restored by community groups, classified separately by habitat (LCDB classes) and environment (LENZ Level IV).

Table 16-3: Example recording of the data needed to report M19 (ii)

a) For each council

Group name	Financial year	No. of volunteers[1]	Planted site name	Site GPS	Area restored in this year (m^2)[2]	LCDB cover class[3]	LENZ environment	Site type[4]	Planting site ownership[5]	Planting date[6]	Project leader
KDF	2013	67	true left Wehi River below Te Hapo marae		330	Broadleaved indigenous hardwoods		Riparian	Private	March 2013	Will Scarlett

[1]Number of people who have participated at least once in the group's activities (as in M19 (i) and M20)

[2]Record only plantings larger than 0.5 ha (5000 m^2), and with plants at maximum 2-m spacings. If plantings occur over several years, report when the planted area reaches 1000 m^2.

[3]Vegetation that the site will become

[4]Record as Riparian, Wetland or Non-wetland

[5]Private, DOC, Non-DOC public land.

[6]If planting occurs over several months, give time span e.g. March–May 2013

b) Nationally

Total no. groups	Mean no. volunteers/group	Total number restoration sites	Total area 'Indigenous forest' restored in this year	Total area 'Other native vegetation' restored in this year	Total area restored, both habitat types

Table 16-4 Example template for reporting M19 (ii)

<table>
<tr><td colspan="2">BAY OF PLENTY REGION</td></tr>
<tr><td>M19 (ii) Habitat area restored by community groups</td><td>July 2015</td></tr>
<tr><td colspan="2">Overview and current status
From July 2014 to June 2015, volunteer-led community groups involving XX volunteers undertook restoration planting totalling XX ha at XX sites in the Bay of Plenty region. These consisted of XX m^2 of future Indigenous forest, and XX m^2 of other native vegetation. Of the total planted area, XX% was on riparian sites, XX% on wetland sites and XX% on non-riparian, non-wetland sites. This is the first year for which these data have been reported; trends can be determined by collecting the same data biennially into the future.</td></tr>
<tr><td colspan="2">Map 1: Bay of Plenty sites that received restoration planting in 2014–15

<Insert map here></td></tr>
<tr><td>Figure 1: Total number of sites at which restoration planting occurred in Bay of Plenty region

<Simple line graph inserted here to show trend with time></td><td>Figure 2: Total area of restoration planting undertaken by Community groups

<Simple line graph inserted here to show trend with time></td></tr>
</table>

16.13.1 Status of indicator M19 (ii): July 2015

Indicator M19 (ii) cannot be implemented at present. Barriers to its implementation are that the data required for Table 16-4 **do not readily exist** and will need to be derived by direct enquiry of the groups doing the planting. Each councils needs **to have a listing of the community groups in their region and their number of volunteers**; this is required also for M19 (i) and M20. Pan-council agreement is needed to **determine data standards** and then an active approach across councils is needed to **collate and curate data** in a way that allows repeated reporting. Nature Space (www.naturespace.org.nz) could may be a suitable repository for data to report on M19 (ii). If so, councils **need a plan to engage and negotiate** with its designers and organisers for access to suitable data, and to assess how much additional data councils would need to collect to report successfully on M19 (ii).

16.14 References

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16.15 Acknowledgements

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17 Indicator M20: Community contribution to weed and animal pest control and reductions

Author: David Latham and Bruce Warburton, Landcare Research

17.1 Introduction

Indicator M20 concerns community contribution to weed and animal pest control and reductions. It reports the community contribution in terms of numbers of community groups and participants in those groups, and an estimate of the hours contributed, aggregated across the sites in which the community groups conduct weed and animal pest control. It also reports the number of sites at which the groups work, and the total area in which they work. Repeated measurements should allow tracking of effort by community groups that conduct these activities by each regional council.

17.2 Scoping and analysis

17.2.1 Definitions

The primary considerations associated with M20 relate to defining 'communities' and their 'contributions'. That is, responses to a questionnaire sent to council experts highlighted the different definitions and approaches that regional councils have adopted with regard to communities and their contribution to weed and animal pest control and reductions. Inconsistencies relating to how terminology in M20 is defined could result in statistics not being comparable between regions. Thus an important first step towards providing a national, standardised method of reporting M20 is defining a 'community' and what constitutes a 'contribution' from that community. We base this process on responses from council experts to key terminology.

1. *Community* – in general, expert responses suggested the word 'community' is used loosely. A 'community' is defined strictly as a group of people living in the same locality, under the same government, and often sharing a common cultural or historical heritage. From this larger social group, smaller groups may decide to volunteer to contribute to pest control in the area in which they reside. It is these smaller groups or 'community groups' that are of relevance to M20, and thus we recognise that the terms 'community', 'community groups', and 'care groups' can be used interchangeably.

   Single volunteers were recognised as a 'community' by some authorities; however, more generally a community was defined as two or more people (rarely groups of private landowners), working to protect and enhance native biodiversity or sites of environmental importance to local communities. Council preference was often for community groups with some formal governance, preferably a Trust or Incorporated Society, or formal registration with the council as a recognised community or care group. Most authorities stated that formal/legal status was not mandatory.

Definition of 'community' – a community is two or more people (i.e. a group) undertaking weed and/or animal pest control to protect and enhance native biodiversity values or sites of environmental importance. A single private landowner conducting control on their own land is not a 'community' (i.e. is not the purview of M20) unless they are part of a community group of two or more people doing control focused on sustaining terrestrial indigenous biodiversity. Communities must be formally registered with their respective regional council, but need not necessarily have legal status.

2. *Contribution* – the term 'contribution' similarly lacked a clear and unified response from experts, and tended to be used to encompass all parts played by the community in bringing about a result, that is the effort or participation by the community group, input (time, resources, money or in-kind support) from all parties involved, and the contribution of the pest control by the community group to the site that they manage, and its benefits to native biodiversity and environmental values at a regional scale. Expert responses indicated that a contribution to M20 should not be driven by non-native biodiversity outcomes, such as control of rabbits or brushtail possums for production purposes. There was further recognition that council experts needed to exercise judgement in what was considered a contribution.

   Definition of 'contribution' – the term 'contribution' should be tightened to explicitly cover three aspects: (1) volunteer effort (i.e. time); (2) funding and in-kind expert time supplied by councils to community groups (we exclude all other in-kind support, because other components are more subjective and difficult to report consistently across regions); and (3) the site managed by a community group to enhance the region's native biodiversity (i.e. the site itself is the contribution made by a community group to the total area of conservation in the region). Provided these contributions are made to enhance native biodiversity values, there should be no threshold in terms of the size of the site that is managed, the number (must be >1) of participants within the community group managing that site, or whether the work is 'community driven' or 'community assisted'.

3. *Control* and *Reduction* – because 'control' and subsequent 'reductions' is what communities do and measure, having clear definitions of these terms will help to make the statistics reported more comparable between regions. Council experts varied in their views as to what constituted control of a pest species. Whilst there was a general recognition that control should be a committed, long-term strategy, experts recognised that some community groups could not sustain committed pest control in all seasons or longer-term, for various reasons. Often, however, these contributions were deemed to have important outcomes for native biodiversity. Similarly, 'one-off control' of a pest species was funded by some regions; however, often for different reasons, such as to encourage community participation, and not necessarily predicated on achieving short-term benefits for native biodiversity.

   The terms control and reduction imply that a monitoring programme is in place to assess whether control has reduced or prevented the spread of the target weed or animal population. In principle, council experts agreed that monitoring the outputs of control undertaken by community groups was a necessary component of M20, and council staff often conducted monitoring as a 'council contribution' to the community group effort. However, a lack of available funding was cited as a major reason for a lack of output monitoring, particularly for small, community driven or assisted projects.

Requirement – community involvement and long-term, committed strategies to pest control and reductions are both important considerations for M20. Where possible, however, communities should participate in projects that have committed, long-term objectives to pest control, and that have output monitoring for reporting control and reduction as a project requirement. Council staff should, if necessary, assist community groups in designing simple output monitoring programmes aimed at quantifying reductions in target pest populations. Alternatively, monitoring could be done by council staff or their sub-contractors. Both of these options are often already provided to assist some community groups with monitoring outputs. It should be noted that community outputs must work towards linking into regional outcomes that relate to enhancing or sustaining terrestrial indigenous biodiversity.

Because there might be inadequate resources to assist all community groups interested in contributing to pest control, councils should prioritise projects based on (1) the potential benefits to protecting and enhancing native biodiversity and environmental values (i.e. regional outcomes), and (2) the quality of the work-plan provided by the community group to council, describing long-term objectives for proposed pest control and monitoring outputs. Where insufficient funding exists for all proposed projects, individuals or groups should be encouraged to contribute to established projects.

4. *Habitat* – fine- and even broad-scale habitat characteristics will differ between many regions. Experts suggested that for national reporting purposes, ‘basic’ or ‘broad’ habitat categories are most appropriate. In addition, broad-scale habitat characteristics for M20 should align with those identified from other relevant indicators (i.e. M20 should use LCDB classes and units). Regional councils can further stratify habitat classes in sites where community contributions occur for intra-regional purposes if deemed necessary. This could include reporting within naturally uncommon ecosystems and wetlands (M12).

17.2.2 Statistics to report

1. The number of communities (that are registered with councils), and the mean number of volunteers per community group that are contributing to weed and animal pest control and reductions. If a community group contributes to pest control on more than one site, then details on the number of ‘site’ contributions made per group.

2. Summary information should be divided further into the total number of contributions to weed pest control and animal pest control.

3. The total amount of time (plus mean and range) in person hours that community groups contribute to pest control.

4. The total amount of money (plus mean and range) and the total amount of in-kind time (plus mean and range) in person hours that councils provide to community groups that contribute to pest control.

5. The total area (hectares; plus mean and range) within a region in which community groups are conducting pest control and reductions. Information on this statistic needs to be available in a digital format. Some community groups are unlikely to have the technical skills with GPS or GIS they need to delineate the sites where they conduct pest control. In these instances, council staff should assist with the delineation of boundaries using GPS units, or alternatively identifying the sites where control is conducted within cadastral maps, if these are available and boundaries match pre-existing delineated land parcels.

National reporting for M20 should move towards routinely including habitat and information about where specific weed and/or animal pest species are being controlled, rather than simply reporting the number of contributions and area.

17.2.3 Reporting frequency

Regional councils should update statistics relating to M20 annually, and these should be made available to the public in regional reports. These reports can then be aggregated nationally, combining information across council reports.

17.2.4 Hierarchies

Reporting for M20 should be at the level of pest plant or pest animal species. However, where pest control includes multiple species that are difficult to identify to the level of species (e.g. some groups of invasive weeds), and assistance from expert taxonomists is unavailable, reporting may need to be at a higher level.

17.2.5 Spatial and temporal analyses

The time-series of the number of community contributions to weed and animal pest control should be presented by habitat type. Similarly, time-series of spatial data delineating the extent of community contributions to weed and animal pest control should be colour-coded to showcase different habitat types where the control occurs.

17.2.6 Relationships with present patterns and other measures

It would be useful to compare GIS overlay of sites with community contributions to weed and animal pest control with sites where control is being undertaken by regional councils, DOC or other agencies. This would show the full spatial extent of the area within each region where pest control is being undertaken to sustain and enhance terrestrial indigenous biodiversity, albeit with possible differences in methodology, intensity, and rigour. In addition, overlaying GIS layers derived from M20 with other indicators (e.g. M7 and M15), would be useful to assess the spatial pattern of community contributions with respect to pest distribution and abundance. This type of analysis might help elucidate how community contributions align with regional outcomes.

17.3 Assessment of existing methodologies

Based on the questionnaire that was sent to participating regional councils, we collated information on how regional councils determine which community groups are funded and supported towards weed and animal pest control projects. We found that there were considerable differences in the definitions and approaches that regional councils have adopted so far. For the purpose of providing a national, standardised method of reporting M20, we provide standard definitions for the main components of M20 (see section 17.1.1). These definitions could be applied to historical data relevant to M20 and held by councils to determine the progress of community projects contributing to pest control.

17.4 Development of a sampling scheme

There is no sampling scheme associated with M20.

We acknowledge that the statistics that will be reported (e.g. total area in which community groups are conducting pest control) may have been derived from data collected by untrained community members, and therefore prone to error. However, because the rationale behind M20 is to provide a measure of community engagement, we believe the lack of accuracy is not of concern and will not affect the overall utility and importance of this indicator.

17.5 Data management and access requirements

Consideration will need to be given to data management and access, and the resulting recommendations will likely need to be aligned with other indicators.

17.5.1 Reporting indices and formats

Collate data in formats as in

Table 17-1and

Table 17-2, and report in example templates (section 17.5.2), updated annually.

Table 17-1 Schematic panel to report on M20

1. Communities contributing to weed and animal pest control and reductions:
    - Total number of community groups –
    - Mean number of volunteers per group –
    - Mean number of 'site' contributions per groups –
2. Total number of contributions to:
    - both weed and animal pest control –
    - weed pest control –
    - animal pest control –
3. Person hours contributed to pest control by community groups:
    - Total (plus mean and range) –
4. Council contributions to community groups involved in pest control:
    - Total cash (plus mean and range) –
    - Total in-kind person hours (plus mean and range) –
5. Total area within a region to which communities are contributing to pest control:
    - Total area (ha) –
6. Mean size of project sites managed by community groups:
    - Mean size (ha) –
7. Range in size of sites managed by community groups:
    - Range (ha) –

Table 17-2 Example table for recording the data needed to report on M20

Group name	Financial year	No. of volunteers[1]	Site name/s	Area of site (ha)	Area covered by group (ha)[2]	Contribution type (pest plant/ pest animal/ both)	Community contribution (person hrs)	Council contribution (financial)[3]	Council contribution (in-kind person hrs)[4]	Species targeted[5]	Spatial information file[6]	Comments/ follow-up

[1] Number of people who have participated at least once in the group's activities during the period of reporting. GIVE NUMBER NOT RANGE.

[2] This should be less thanor equal to the area of the site.

[3] Ideally, this should only include direct financial contribution (in NZ$) from the council to the weed and plant animal control activities at the site. In-kind staff hours, converted to dollars, should **not** be included here.

[4] Ideally, this should only include in-kind council staff hours spent doing activities related to the weed and animal pest control at the site.

[5] This can either be one species (e.g. 'pampas grass') or 'multi-species'. This will not be included for national reporting but might be useful or interesting for regional reporting.

[6] Polygon delineating the area that is being controlled for weeds and animal pests, not the area of the site (which might include areas not being controlled).

Additional points to consider when recording this data:

- Where a community group works across several sites, some information needs to be separated out to the site level.
  - Area of the site and area covered by the group should be reported for each site separately. If they are not, then the reported mean (and range) size of sites managed will be meaningless.
  - Community contributions (person hrs) and council contributions (financial and in-kind person hrs) do not need to be separate to the site level; rather, the community group level is sufficient. In these instances, the statistics reported will be for the community/care group level rather than at the site level.

Site-level reporting of some community groups' work may straddle council borders; reporting will require liaison between councils.

17.5.2 Example template for reporting M20

BAY OF PLENTY REGION

M20 – Community contribution to weed and animal pest control and reductions | **July 2015**

Overview and current status

Within each regional council, volunteer-led community groups contribute to the control of weed and animal pests, in an effort to help conserve local biodiversity. As of July 2015, the Bay of Plenty region has XX hectares distributed across XX sites where community groups are undertaking weed and/or animal pest control (Table 1). These activities involved a total of XX volunteers representing XX community groups. On average, each community group worked for XX hours in weed and animal pest control activities. Further, the BOP RC contributed a total of XX NZ$ and XX person hours to support weed and animal pest control activities conducted by community groups within the region.

Map 1: Sites where community groups conducted weed and animal pest control activities during 2015

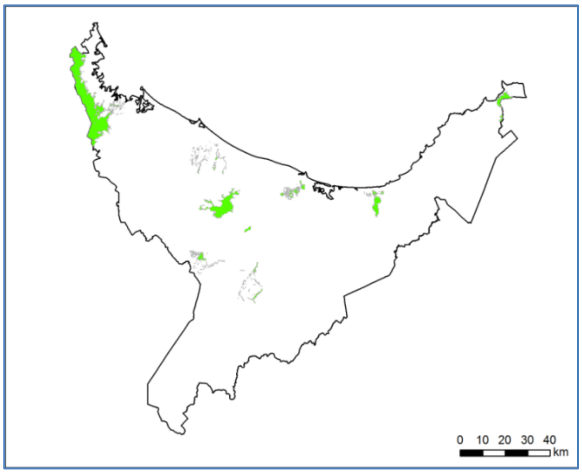

Table 1 Summary of community contributions to weed and animal pest control and reductions in the BOP RC

	Total	Mean (per group)	Range
Number of site contributions to:			
– both weed and animal pest control	XX	–	–
– only weed pest control	XX	–	–
– only animal pest control	XX	–	–
Number of community groups	XX	–	–
Site contributions per community group	–	XX	XX – XX
Number of volunteers	XX	XX	XX – XX
Person hours contributed to pest control	XX	XX	XX – XX
Council contributions to community groups (NZ$)	XX	XX	XX – XX
Council contributions to community groups (in-kind)	XX	XX	XX – XX
Area (ha) of sites managed by community groups	XX	XX	XX – XX

BAY OF PLENTY REGION

M20 – Community contribution to weed and animal pest control and reductions | **July 2015**

Recent trends

From 2014 to 2015, the total area in which communities contributed to weed and animal pest control increased from XXX to XXX hectares. Further, the number of community groups conducting these activities increased from XX to XX, and the mean number of individuals involved per community group increased from XX to XX. The mean number of person hours volunteered by each community group increased from XX to XX. The total financial and in-kind contribution by the BOP RC towards weed and animal pest control activities conducted by community groups increased from XX to XX and from XX to XX, respectively.

Map 2: Gains/losses for the period 2014–2015

<Simple map goes here showing gains, no changes, and losses over the most two recent time steps>

Figure 1 Number of community contributions to weed and animal pest control as a function of time

<Simple line graph inserted here to show the temporal trend, which could be separated by habitat type if this information was available>

Figure 2 Area (ha) of community contributions to weed and animal pest control as a function of time

<Simple line graph inserted here to show the temporal trend, which could be separated by habitat type if this information was available>

17.6 Current status of M20 State of knowledge (August 2014)

The regional councils' Biodiversity Working Group requested a spreadsheet that could be used as a template for councils to record data and summarise agreed statistics for national reporting of M20 ('Community contribution to weed and animal pest control and reductions'). This template has been completed by Dave Latham and Cecilia Arienti-Latham (Landcare Research) in collaboration with Nancy Willems (Bay of Plenty Regional Council). During that process, however, it became apparent that there are currently insufficient data to populate the template prepared for M20 and thus, councils were unable to meet a 15 July 2014 deadline for reporting on this measure. The regional councils' Biodiversity Working Group met on 30 June 2014 and accepted this, but they were keen to see councils produce a report for M20 by July 2015.

17.6.1 Requirements for implementing M20

- It is unclear what data councils have available for reporting agreed statistics for M20. **An assessment is needed of the current state of data available** within each council for reporting M20 using the example template. This assessment needs to address the comprehensiveness of data within each council and issues of data quality for each variable reported.
- There has been discussion about using Nature Space (http://www.naturespace.org.nz/) as a repository for data relating to M20. This option requires **critical assessment** by the regional councils' Biodiversity Working Group. If it is a preferred option, then a pathway for implementing data storage and retrieval from Nature Space will be needed.
- It is possible that not all required data will have been collected to report all agreed summary statistics for M20; however, we suggest that councils **begin to collect all necessary data now** for the template (section 17.5.2), recognising that there will be inadequate data for some summary statistics. The aim should be to work towards reporting all summary statistics in future (i.e. implementing reporting for M20 may be incremental, but needs to start now with available data).

17.7 References

Alldredge MW, Pacifici K, Simons TR, Pollock KH 2008. A novel field evaluation of the effectiveness of distance and independent observer sampling to estimate aural avian detection probabilities. Journal of Applied Ecology 45: 1349–1356.

Rosenstock SS, Anderson DR, Giesen KM, Leukering T, Carter MF 2002. Landbird counting techniques: current practices and an alternative. The Auk 119: 46–53.