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Indicator M2: Vegetation structure and composition

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Fiona Thomson

Landcare Research

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Prepared for:

Regional Councils’ Biodiversity Monitoring Working Group

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

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

Reviewed by:	Sarah Richardson, Landcare Research Philippa Crisp, Greater Wellington Regional Council
Approved for release by:	Fiona Carswell Portfolio Leader – Enhancing Biodiversity Landcare Research

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1 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.

2 Indicator M2: Vegetation structure and composition

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 2-1). 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

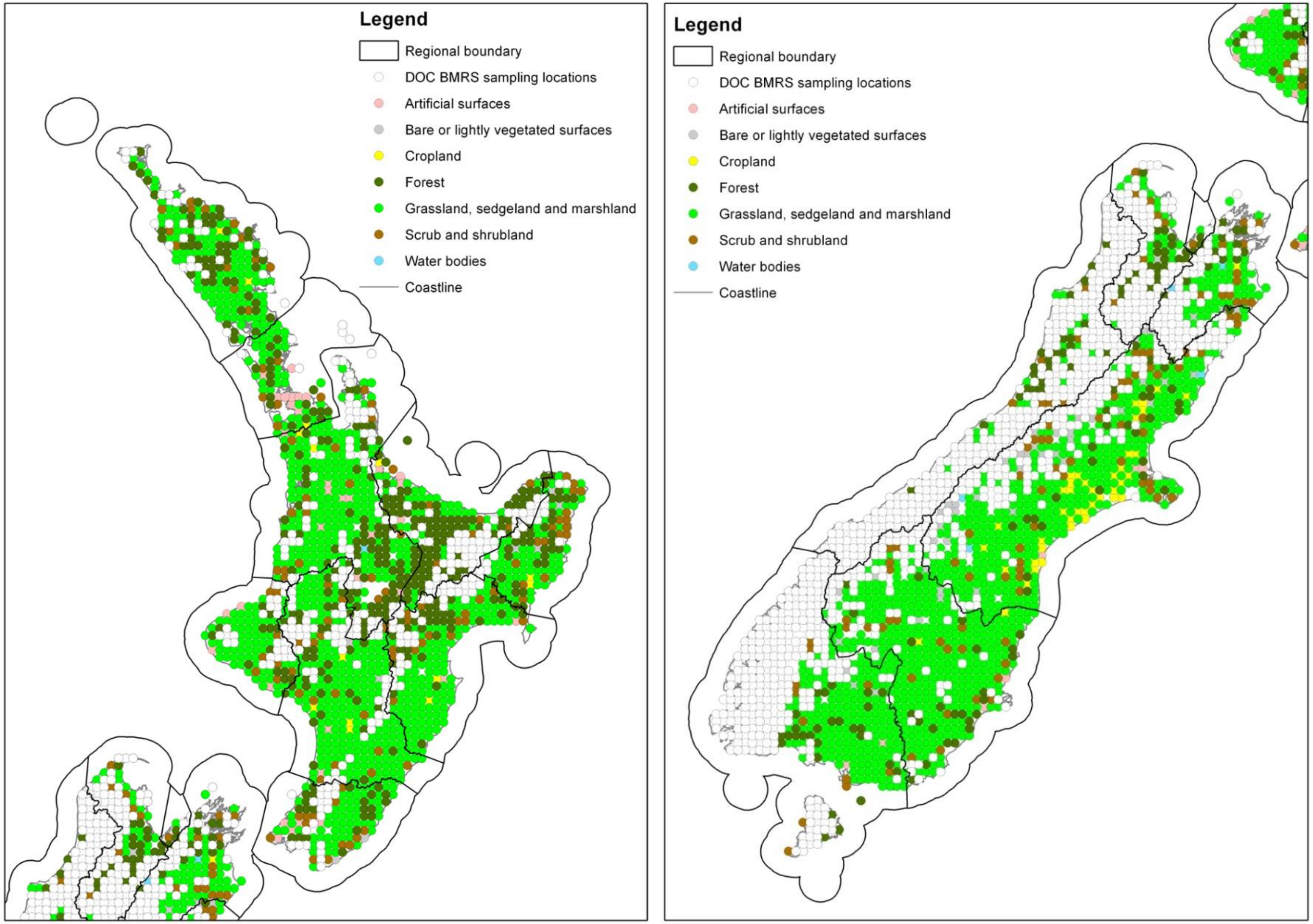
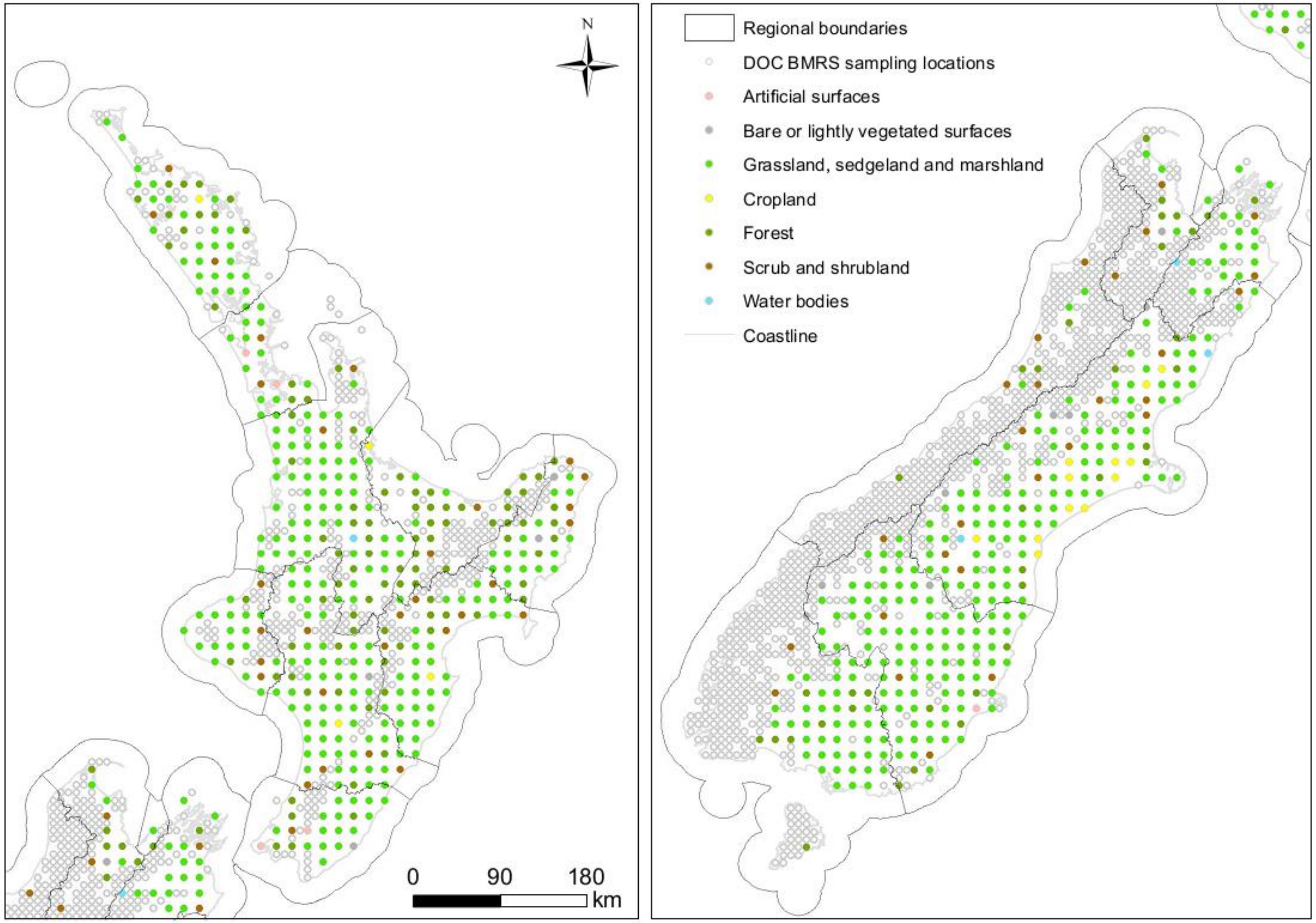


Figure 2-1 Sampling locations on the 8 × 8 km grid in relation to the regional council boundaries and land cover classification of sampling locations (see **Table 2-2**).

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 2-3). Standardised field sampling protocols are used for both the vegetation and animal surveys (DOC 2012).

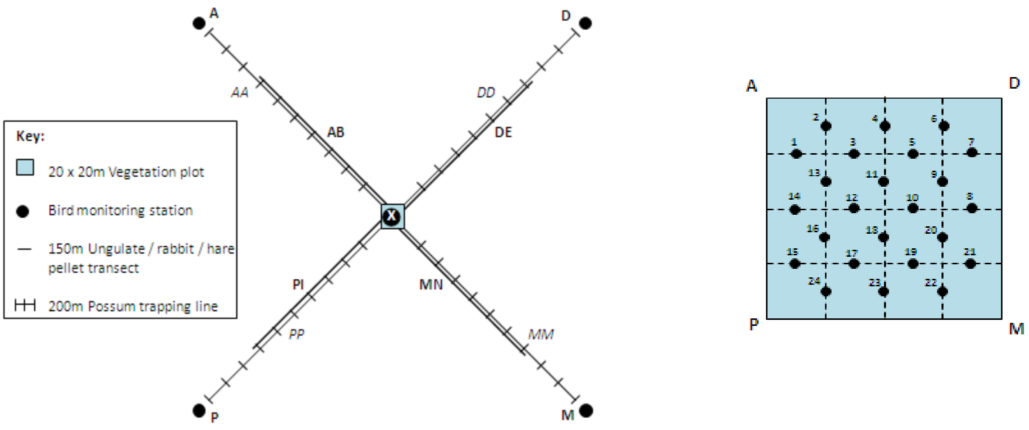


Figure 2-3 Layout of the animal-survey sampling units in relation to the vegetation plot at each sampling location, along with an outline of the 20 × 20 m vegetation plot, subdivided into 16 contiguous 5 × 5 m subplots, and each of the 24 (0.75 m^2) seedling plots within it.

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).

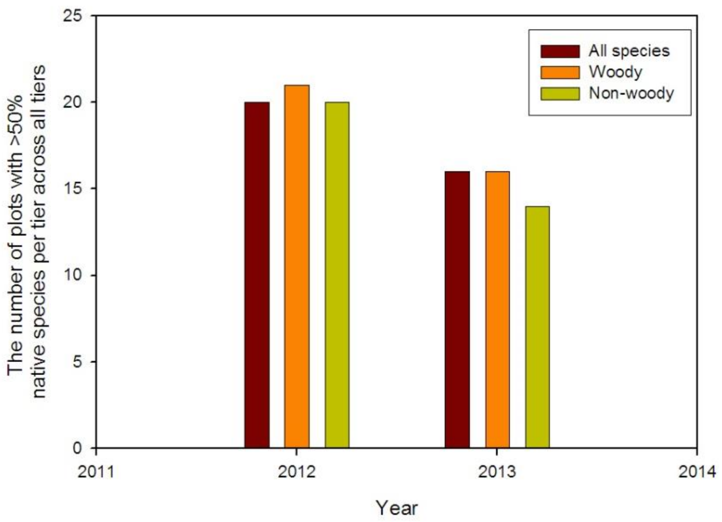


Figure 2-4 The number of plots that have >50% native species in each tier where species occur for all species (woody and non-woody combined), woody species only and non-woody species only.

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.

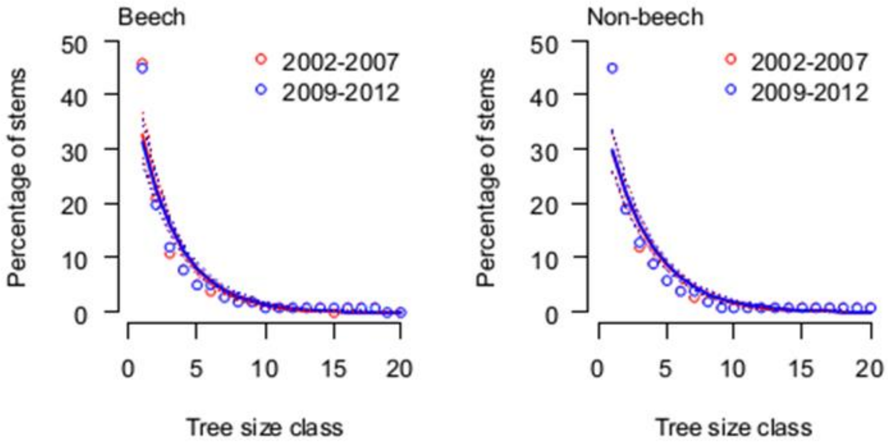


Figure 2-5 Example from MacLeod et al. (2012) showing size-class distribution of kāmahi for two periods in beech forest and non-beech forests. Fitted solid lines are general linear models of stems counts within 20 equal-sized classes. Fitted dashed lines are standard errors around fitted lines.

2.6 References

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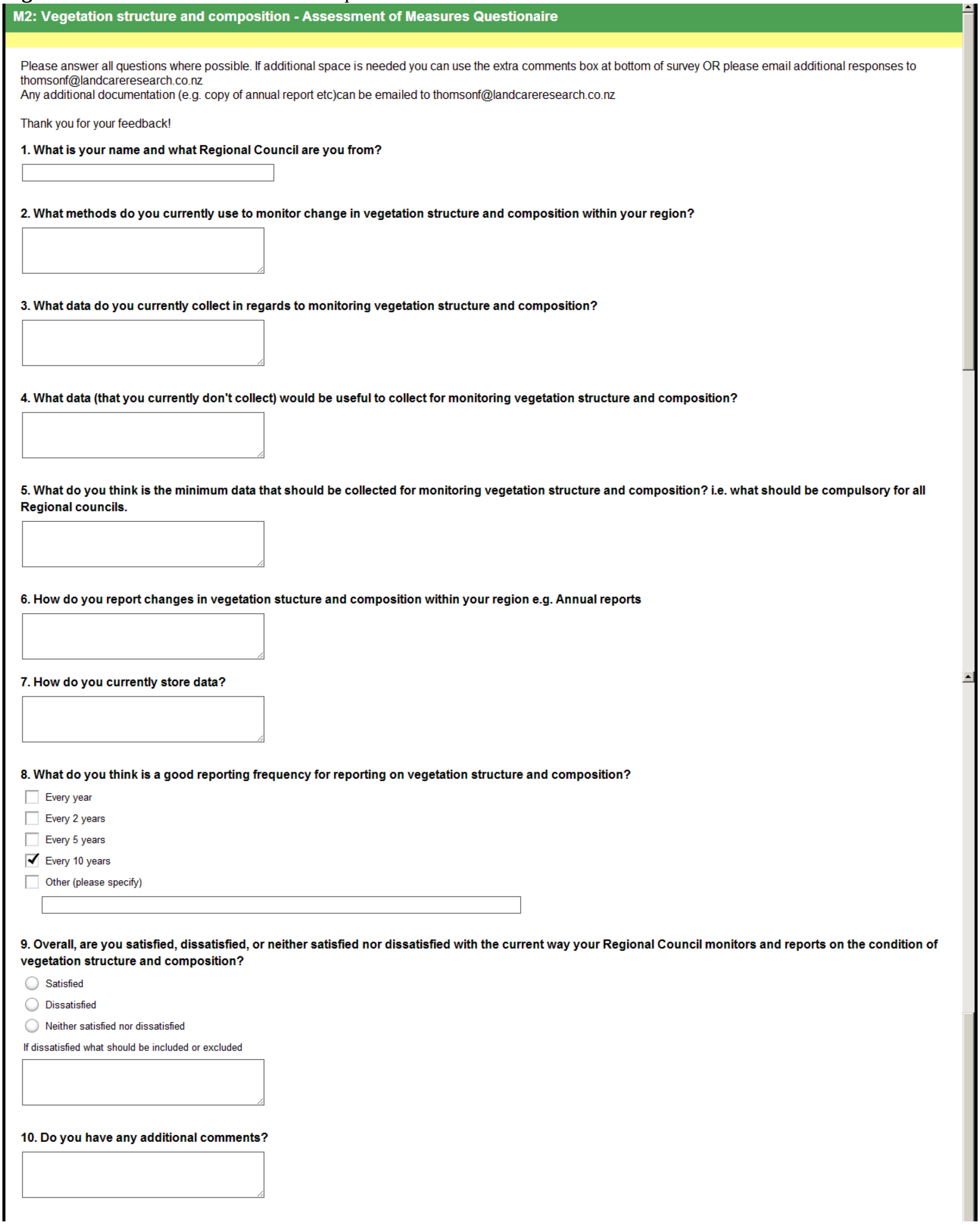
Appendix 2-1 – Assessment of measures questionnaire

Figure A2-1 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?

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	