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Indicator M5: Vulnerable ecosystems

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Landcare Research

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Prepared for:

Regional Councils' Biodiversity Monitoring Working Group

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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

[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.

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,

[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
	<u>Geothermal</u>
	Heated ground (dry)
	Hydrothermally altered ground (now cool)
	Acid rain systems
	Fumeroles
	Geothermal streamsides
	<u>Vertebrate induced</u>
	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
Inland/Alpine																
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.

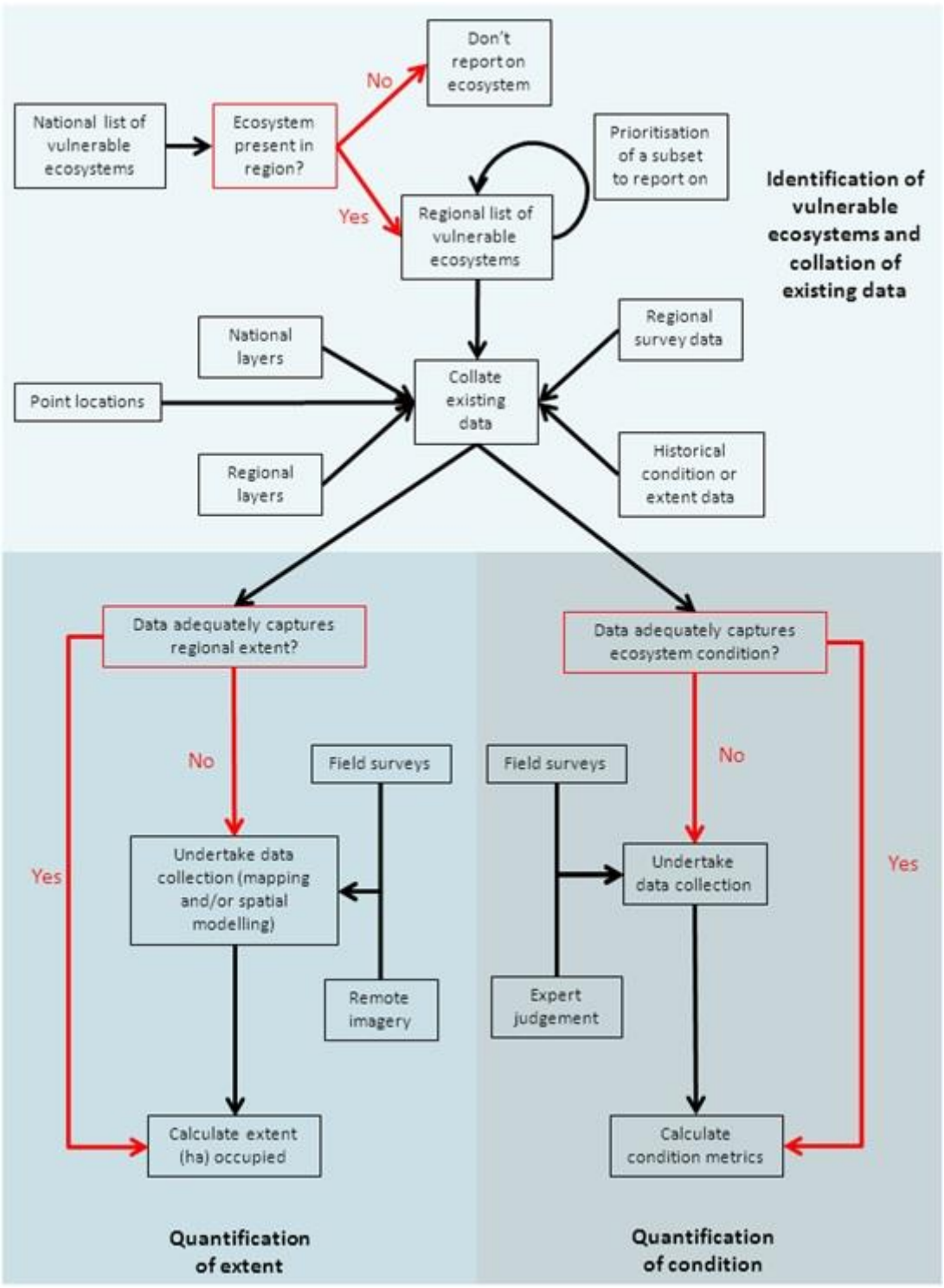

Figure 4-1 Flow diagram illustrating the steps involved in quantifying ecosystem extent and condition.

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

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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]