LANDCARE RESEARCH
MANAAKI WHENUA

Indicator M6: Number of new naturalisations

Indicator M6: Number of new naturalisations

Fiona Thomson

Landcare Research

Excerpt from:

Bellingham PJ, Overton JM, Thomson FJ, MacLeod CJ, Holdaway RJ, Wiser SK, Brown M, Gormley AM, Collins D, Latham DM, Bishop C, Rutledge D, Innes J, Warburton B 2016. Standardised terrestrial biodiversity indicators for use by regional councils. Landcare Research Contract Report LC2109.

Prepared for:

Regional Councils' Biodiversity Monitoring Working Group

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

August 2016

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:	Lynley Hayes, Landcare Research Kevin Collins, Waikato Regional Council
Approved for release by:	Fiona Carswell Portfolio Leader – Enhancing Biodiversity Landcare Research

Cite this report as:

Bellingham PJ, Overton JM, Thomson FJ, MacLeod CJ, Holdaway RJ, Wiser SK, Brown M, Gormley AM, Collins D, Latham DM, Bishop C, Rutledge D, Innes J, Warburton B 2016. Standardised terrestrial biodiversity indicators for use by regional councils. Landcare Research Contract Report LC2109 for the Regional Councils' Biodiversity Monitoring Working Group.

Contents

Overview

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

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

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

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

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

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

---

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

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

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

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

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

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

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

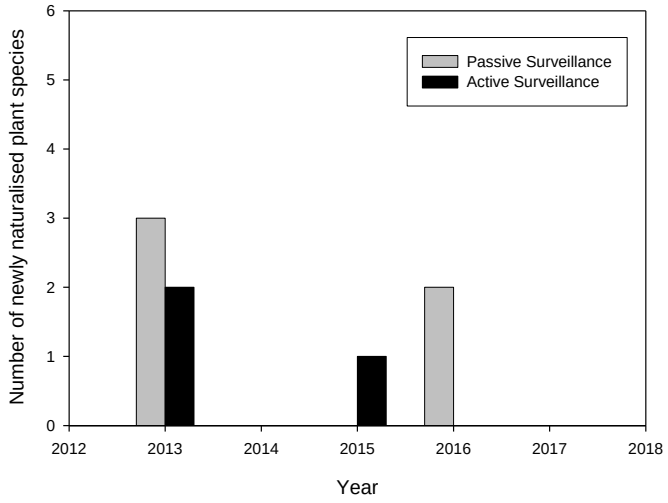
5.6.1 Reporting indices and formats

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).

5.8 References

Aikio S, Duncan RP, Hulme PE 2010. Herbarium records identify the role of long-distance spread in the spatial distribution of alien plants in New Zealand. Journal of Biogeography 37: 1740–1751.

Atkinson IAE, Cameron EK 1993. Human influence on the terrestrial biota and biotic communities of New Zealand. Trends in Ecology and Evolution 8: 447–451.

Basse B, Bourdôt G, Brown J, Lamoureaux S 2008. New Zealand National Weeds Distribution Database: a feasibility study. Report for Environment Southland. University of Canterbury Research Report UCDMS2008/8. University of Canterbury, Christchurch.

Bellingham PJ, Peltzer DA, Walker LR 2005. Contrasting impacts of a native and an invasive exotic shrub on flood-plain succession. Journal of Vegetation Science 16: 135–142

Bourdôt G, Basse B, Kriticos D, Modd M 2015. A cost–benefit analysis blueprint for regional weed management: *Nassella neesiana* (Chilean needle grass) as a case study. New Zealand Journal of Agricultural Research 58: 325–338.

Brotons L, Thuiller W, Araújo MB, Hirzel AH 2004. Presence-absence versus presence-only modelling methods for predicting bird habitat suitability. Ecography 27: 437–448.

Browne M, Pagad S, De Poorter M 2009.The crucial role of information exchange and research for effective responses to biological invasions. Weed Research 49: 6–18.

Clarkson BR, Sorrell BK, Reeves PN, Champion PD, Partridge TR, Clarkson BD 2004. Handbook for monitoring wetland condition. doi: 10.7931/J2Z60KZ3. https://datastore.landcareresearch.co.nz/dataset/handbook-for-monitoring-wetland-condition (accessed 14 April 2016).

Cooper J, Carver J, Browne M 2010. National Weeds Distribution Database scoping study. Landcare Research Report prepared for Envirolink: 883-ESRC228.

Costall JA, Carter RJ, Shimada Y, Anthony D, Rapson GL 2006. The endemic tree *Corynocarpus laevigatus* (karaka) as a weedy invader in forest remnants of southern North Island, New Zealand. New Zealand Journal of Botany 44: 5–22.

Gormley AM, Forsyth DM, Griffioen P, Lindeman M, Ramsey DSL, Scroggie MP, Woodford L 2011. Using presence-only and presence–absence data to estimate the current and potential distributions of established invasive species. Journal of Applied Ecology 48: 25–34.

Greene T, McNutt K (eds) 2012. Biodiversity Inventory and Monitoring Toolbox. Wellington, New Zealand Department of Conservation. http://www.doc.govt.nz/biodiversitymonitoring/

Howell C 2008.Consolidated list of environmental weeds in New Zealand. DOC Research and Development Series 292. Wellington, New Zealand Department of Conservation.

Hurst JM, Allen RB 2007. A permanent plot method for monitoring indigenous forests – field protocols. Manaaki Whenua – Landcare Research, Lincoln. (See http://nvs.landcareresearch.co.nz/).

Milne R, Williams M 2008. Getting to grips with GRTS. In: Froud KJ, Popay IA, Zydenbos SM eds. Surveillance for biosecurity: pre-border to pest management. The New Zealand Plant Protection Society (Incorporated). Pp. 193–200.

Morton J, Harris W 2008. Weed spotters' guide. A guide for regional bodies to deliver a weed spotters network in their regions. Adelaide, CRC for Australian Weed Management.

Richardson DM, Pyšek P, Rejmánek M, Barbour MG, Panetta FD, West CJ 2000. Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distributions 6: 93–107.

Ringvall A, Petersson H, Ståhl G, Lämås T 2005. Surveyor consistency in presence/absence sampling for monitoring vegetation in a boreal forest. Forest and Ecology Management 212: 109–117.

Smith HA, Johnson WS, Shonkwiler JS, Swanson SR 1999. The implications of variable or constant expansion rates in invasive weed infestations. Weed Science 47: 62–66.

Sullivan JJ, Timmins SM, Williams PA 2005. Movement of exotic plants into coastal native forests from gardens in northern New Zealand. New Zealand Journal of Ecology 29: 1–10.

Sullivan J, Williams PA, Timmins SM 2006. Effects of *Pinus radiata* plantations on environmental weed invasion into adjacent native forest reserves. DOC Research & Development Series 239: 1–25.

Sullivan JJ, Williams PA, Timmins SM, Smale MC 2009. Distribution and spread of environmental weeds along New Zealand roadsides. New Zealand Journal of Ecology 33: 190–204.

Williams PA, Cameron EK 2006. Creating gardens: the diversity and progression of European plant introductions. In: Allen RB, Lee WG (eds) Biological invasions in New Zealand. Heidelberg, Springer. Pp. 33–47.

Williams PA, Wiser S 2004. Determinants of regional and local patterns in the floras of braided riverbeds in New Zealand. Journal of Biogeography 31: 1355–1372.

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).