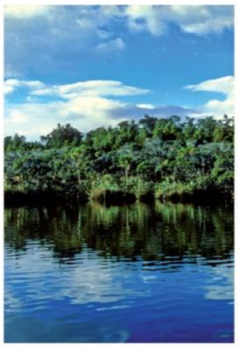

National Weeds Distribution Database scoping study

Landcare Research
Manaaki Whenua

National Weeds Distribution Database scoping study

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Summary

Project and Client

Environment Southland (ES), through Envirolink medium advice project 883-ESRC228, sought advice on the potential establishment of a National Weeds Distribution Database (NWDD) to better support regional decision making and management of weeds. The project was co-funded by the Terrestrial and Freshwater Biodiversity Information System Programme (TFBIS) administered by the Department of Conservation. Landcare Research was contracted to carry out this scoping study. Landcare Research has a strong background in environmental data management and the development of federated data-sharing networks. Landcare Research used the services of Julian Carver of Seradigm Consulting, who has an extensive knowledge of the national environmental data management landscape and issues, together with Michael Browne, former manager of the Global Invasive Species Database, who has detailed knowledge of weed data management and end-user needs. TFBIS is interested in the potential of the NWDD as a template for more general data sharing and data access of biodiversity data generated within councils and the wider sector. The project was also supported by the NWDD Steering Group with membership from AgResearch, Landcare Research, regional council biosecurity managers, MAFBNZ, the Forestry Industry and DOC.

Objectives

The key objectives of the scoping study were to investigate why and how weed data are currently collected, to understand how the data are subsequently managed and utilised, to determine the benefits that could be delivered through the establishment of an NWDD, and to define the way such a system could be developed. The study explores the benefits to the individual councils, but also the broader context of national-level monitoring and reporting, and the utility of an NWDD to the research community developing tools and services to support a range of end-users. Together these interests and issues are the key factors in determining if an NWDD is technically feasible, how it might be constructed and managed, and whether there is a sufficient cost–benefit case to proceed.

If the contributing bodies do see sufficient benefits in proceeding with the establishment of an NWDD then this document serves as the foundation for further funding bids, through Envirolink Tools, TFBIS, and/or national agencies. As such this document serves as part of an ongoing preparative phase.

Methods

The scoping study was carried out by developing a questionnaire with input from the NWDD Steering Group. This questionnaire was sent to targeted individuals within councils and other agencies, and followed up by in-depth interviews. In addition the NWDD was discussed at a number of regional and national workshops on biodiversity data management, as sponsored by TFBIS through the Dataversity network. The scoping study was also informed by the management group of the Beating Weeds II FRST-funded research programme led by Landcare Research.

The scoping study also involved consultation with other relevant biodiversity and biosecurity sector initiatives including the MAF-led ‘Future of pest management’ programme, MoRST’s

Environmental Data Management policy work, DOC's NHMS programme, and initiatives to develop shared biodiversity/biosecurity regional council systems.

Conclusions

The findings of this scoping study indicate there is significant interest in establishing an NWDD. Participants in the study could see a number of benefits that would support their weed management efforts, including:

- Viewing changes in weed distributions in other regions
- Understanding threats on their borders and the factors causing those threats
- Understanding how weeds would spread in different circumstances
- Improved decision making through better predictive models
- Acting as a long-term archival service for weed distribution data
- Helping identify national priorities for coordinated action

The current state of regional council biosecurity data management systems and practices means that, in the short–medium term, data will have to be aggregated manually, rather than dynamically harvested from their systems. This is not a major impediment to progress, however, as the data only need to be aggregated every 6–12 months to be useful, and some checking and 'truthing' of the data will be required regardless. The viability of this approach has already been proven by a weed distribution data gathering exercise conducted by DOC.

The current lack of nationally used data collection protocols and data standards means that not all recorded weed data can usefully be aggregated. Again, this is not an impediment, as a useful system, enabling display of current distributions against predicted distributions (developed using scientific models), can be delivered with the basic data that can be manually 'standardised' (i.e. species name, date and location). Additional data on weed management status, density, and control approaches can be added in future stages as these standards emerge, and will support finer grained models and more precise local/regional decision making. The MAFBNZ-led work on the Pest Management Proposed National Plan of Action 2010–2035 is likely to further the development of such standards, and an NWDD could also help catalyse their development as regional councils see the benefits of sharing these data. Initiatives to develop shared biodiversity/biosecurity regional council systems are also likely to improve standardisation, and the ability to dynamically harvest data.

Once the NWDD is established, it is very likely it could also be enhanced to incorporate animal pests. This would provide a near-complete national view of the status of invasive organisms in New Zealand. In addition, the system could be used as a central hub to aggregate data on native species from local and national sources to provide a complete picture of known data on the location and condition of indigenous biodiversity.

The financial and environmental benefits of an NWDD are not easy to calculate as the potential economic loss from future weed incursions is not known. By way of example, however, the recent modelling of the potential distribution of Chilean needle grass and the economic impact of different control scenarios showed that in Canterbury nearly $1 million could be saved through proactive regional control. By reducing the costs for data aggregation for modelling, and by making such models more visible and accessible, it is possible that an NWDD could help ensure economic losses of a similar scale are avoided for other weeds. It could also increase efficiencies in weed management by facilitating the sharing of best practice between regions.

The project is well aligned with other national initiatives such as the Pest Management Proposed National Plan of Action 2010-2035, DOC's NHMS Programme, the move to shared systems in local government, and the recently released Directions and Priorities for Government ICT.

Recommendations

Given the findings it is recommended that the development of an NWDD proceed using a staged approach. In the initial stage, a 2-year project would be run to construct a system that:

- Deploys layers for predicted distributions for six weed species on an early iteration of the NWDD geospatial infrastructure/web site (within the first six months of the project)
- Allows the manual aggregation of weed distribution data from regional councils (and where possible from other sources such as DOC's weed data)
- Displays these data on interactive maps (allowing selection of species for display, and showing RPMS category by region)
- Allows overlay of maps with predicted/potential distributions from scientific models

This will allow some short-term benefits to be realised, and will also act as a stimulus and catalyst for achieving a longer term vision for the system.

In future stages, over the subsequent 2–3 years, the system could be enhanced to:

- Automatically harvest and integrate data directly from regional council systems, and from all other national sources of weed distribution data
- Allow the aggregation and display of weed spread pathways, density, management status and methods, and change indices over time
- Provide more advanced and granular predictive distribution models, and impact assessment tools
- Provide automated cost–benefit analysis tools for particular management scenarios in particular locations
- Allow the general public to provide information on new infestations

To guide the development and implementation of the NWDD a governance structure should be established. This should include a steering group with members from regional councils, the Biosecurity Managers Group, the Biosecurity Institute, MAF, DOC, and the research organisations.

Costs

For planning purposes the project has been split into four workstreams. Using typical staff rates for appropriate qualified personnel, costs for the initial 2-year project are estimated as follows:

Workstream	Cost
Project Management	$51,750
Governance & Engagement	$60,375
Data	$188,812
Technical	$394,875
Total	**$695,812**

With a travel budget of $5,000 this would bring the estimated establishment cost of the NWDD over the initial 2-year project to $700,000.

Ongoing annual maintenance/support is expected to cost approximately $70,000 per annum.

Further enhancements, delivered in successive stages, over the subsequent 2–3 years would require an estimated budget of $400,000 to $600,000.

Next steps

This scoping study should be considered by the project steering group, and the sector as a whole, and if appropriate, a funding bid for the first stage should be prepared.

1 Introduction

1.1 Background

In 2008 Environment Southland (ES) sought an Envirolink medium advice project (499-ESRC212) in order to provide them with information to assist in weed management decision making. The advice concerned the feasibility of establishing a National Weeds Distribution database (NWDD):

Environment Southland (ES) aims to predict the environmental and economic risks posed by particular species of weeds that are already established in the region or that are currently absent but already naturalised elsewhere in New Zealand. A knowledge of national weed distributions would facilitate national and regional reporting on changes in weed distribution. This information on distribution changes can be used to monitor the success of weed management strategies and to assist in developing models for predicting weed risk. To this end ES contracted scientists at the University of Canterbury and AgResearch Ltd to establish the feasibility of developing a readily accessible, user-friendly, national database, to collate, hold and disseminate data about weed distributions throughout New Zealand.

The conclusion this project drew was that establishing a National Weeds Distribution Database (NWDD) was feasible[1]. The report noted the requirement for standardisation of data collection across organisations and communication between organisations to realise the goal.

A result of this initial work was the establishment of an NWDD Steering Group consisting of representatives from regional councils (RCs) together with other national stakeholder groups in CRIs, government agencies, and the forestry sector. Subsequent discussions among the Steering Group established the need to explore in more detail some of the issues:

- The proposed technical solutions to federated data aggregation and integration do indeed exist, but it became clear that further work was required to establish if these solutions could be implemented within RCs.
- Further work was indicated to better establish the needs and benefits that an NWDD would provide, and to more clearly establish what kinds of data were being collected (or not collected), for what purposes, using what standards, and in what systems.

In addition, some current research programmes within CRIs are developing distribution models and decision support systems and these are recognised as providing potential benefit to RCs. However, it is acknowledged that for these models to be useful they will require the data that would be held in an NWDD. Thus one role of an NWDD would be as an important

[1] Basse B, Bourdôt G, Brown J, Lamoureaux S 2008. New Zealand national weeds distribution database: a feasibility study - Report for Environment Southland. Envirolink medium advice 499-ESRC212. Christchurch, University of Canterbury. Pp. 17.

piece of national information infrastructure that would help close the gap between end-user needs and national research outputs.

The Steering Group also recognised the role that an NWDD could provide in stimulating the development and acceptance of national standards for weed distribution data. It could also act as an exemplar project with potential extension of the technical framework to other sources of surveillance and monitoring data in pest management (e.g. animal pests), and more broadly across biodiversity and biosecurity outcomes.

The work reported here was carried out to provide answers to the questions raised by the Steering Group, and potentially, to provide the baseline information necessary to propose an Envirolink Tools application to establish the NWDD.

The potential of an NWDD as an exemplar project for mobilising biodata is also of interest to the Terrestrial and Freshwater Biodiversity Information System Programme (TFBIS). TFBIS is managed by the Department of Conservation (DOC) and is a programme that can initiate or promote the development of systems that increase awareness of or access to fundamental data and information about terrestrial and freshwater biota and biodiversity. The work on this scoping study was therefore cofunded by Envirolink and TFBIS.

The scoping study was done in consultation with other relevant biodiversity and biosecurity sector initiatives including the MAF-led 'Future of pest management' programme, MoRST's Environmental Data Management policy work, the Landcare Research/DOC led Biodiversity Indicators project, the proposed Auckland Regional Council and Environment Bay of Plenty biodiversity management system integration, the Integrated Regional Council Information System (IRIS), and DOC's NHMS programme.

1.2 Objectives

The objectives of this scoping study were to:

- Establish needs and benefits for operational staff within regional councils (RCs) with respect to data contained within an NWDD
- Explore current working practices around pest management policy/strategy development and subsequent operational implementation, and how that impacts on developing a NWDD
- Define what kinds of data are currently being collected, by whom, for what purposes, and using what methods
- Explore how an NWDD could be utilised in models being developed by national research programmes, and how benefits might be delivered to RCs
- Propose an implementation framework for establishing an NWDD together with a timeline
- Explore potential governance structures for managing and maintaining an NWDD

1.3 Methods

The scoping study was carried out by developing a questionnaire with input from the NWDD Steering Group. This questionnaire was sent to targeted individuals with councils and other agencies, and followed up by in-depth interviews. In addition the NWDD was discussed at a number of regional and national workshops on biodiversity data management, sponsored by TFBIS through the Dataversity network. The scoping study was also informed by the management group of the Beating Weeds II FRST-funded research programme led by Landcare Research.

The questionnaire explored the following issues:

- Regards weeds and weed distributions, what are the real-world problems you're trying to solve?
- What kind of data do you record on weeds?
- Where do you store data on weeds?
- If you're looking for information on weeds/weed distributions that you don't have, where do you go?
- Do you use predictive modelling tools for weed distributions?
- If a National Weeds Distribution Database was developed what value would it be to you?

A copy of the detailed survey questions is included in the Appendix.

1.4 Participants

A national survey of the biosecurity managers at the regional councils (Table 1) was conducted. NB when referring to 'regional councils' or 'RCs' in this document, this should be taken to include the unitary authorities (Gisborne District Council, Tasman District Council, and Marlborough District Council).

Weed control and data management for the West Coast Regional Council are undertaken by DOC Hokitika.

Table 1 Summary of regional authorities, biosecurity managers and other staff interviewed

Abbreviation	Council name	Biosecurity contact and other interviewees
NRC	Northland Regional Council	Don McKenzie
ARC	Auckland Regional Council	Jonathan Boow
WRC	Environment Waikato / Waikato Regional Council	Wendy Mead
EBOP	Bay of Plenty Regional Council / Environment Bay of Plenty	John Mather
GDC	Gisborne District Council	Phil Karaitiana
TRC	Taranaki Regional Council	Rob Phillips, Bruce Pope, Catherine Law, Erin Zydervelt
HBRC	Hawke's Bay Regional Council	Darin Underhill
Horizons	Horizons Regional Council / Manawatu-Wanganui Regional Council	Craig Davey
GW	Greater Wellington / Wellington Regional Council	Pedro Jensen, Tim Park
TDC	Tasman District Council	Lindsay Vaughan
MDC	Marlborough District Council	Ben Minehan
WCRC	West Coast Regional Council / DOC Hokitika	Tom Belton
ECAN	Environment Canterbury / Canterbury Regional Council	Graham Sullivan
ORC	Otago Regional Council	Richard Lord
ES	Environment Southland / Southland Regional Council	Richard Bowman

In addition, the following people at government agencies and research organisations were consulted.

DOC:

- Ann Thompson, Senior Technical Support Officer, Threats Management, Research and Development
- Clayson Howell, Scientific Officer, Threats Science, Research and Development
- Jon Terry, Weed Researcher, Threats Science, Research and Development
- Benno Kappers, Data Analyst, Ecosystems Management, Research and Development

- Mike Edginton, Business Systems Analyst, Natural Heritage Management System, Research and Development

MAF:

- Brendan Gould, Team Manager, Plants Environment and Marine, Biosecurity Surveillance Group
- George Gill, Acting Team Manager Plant Response (Response Group)
- John Randall, Team Manager, Pests and Pathways (Pest Management Group)
- Mike Harre, Senior Advisor, National Coordination (Pest Management Group)

Research Organisations:

- Chris Jones, Landcare Research
- Lynley Hayes, Landcare Research
- Jake Overton, Landcare Research
- Graeme Bourdôt, AgResearch
- Shona Lamoureaux, AgResearch
- Mike Dodd, AgResearch
- Michael Watt, Scion
- Darren Kriticos, CSIRO

2 Current situation

2.1 Real-world problems that regional councils are trying to solve

Regional councils are responsible for preventing new weed problems from occurring, eliminating low-incidence known weeds before they get worse, and enforcing boundary control rules for widespread weeds so that neighbours aren't affected. They control weeds to protect the natural character of the region, native biodiversity and economic values. Their surveillance and control activities are driven by the Biosecurity Act 1993, which requires each council to have a regional pest management strategy (RPMS) which must be reviewed at 5-year intervals. In the RPMS, weed species are classified in terms of their management regime and rules are formulated for their control.

Most RCs use the Harris Cost Benefit Analysis[2] to classify weeds, then there is a requirement for public consultation in which the classifications may change, perhaps because of public interest or historical management effort. Many RCs describe this process as lacking objectivity and would like classification to be more evidence-based because their resources are limited and they can only control a small subset of serious weed problems.

Many RCs have teams of three or four biosecurity officers responsible for implementing the RPMS. Some have twice that number. RCs efforts are on both of species-led biosecurity programmes targeting particular weeds and site-led biodiversity programmes focused on protecting areas of high natural heritage value where they often control weeds that are not in their RPMS.

2.2 Weed classification

Weeds are classified in the RPMS according to their management regime. Classifications used by the different RCs are given in Table 3 in the Appendix. Classification schemes have some variation but commonalities between them can be derived from the definitions they use. They fall into two general classes:

- **Low-incidence weeds and new weeds** (Terms used include Total Control, Progressive Control or Eradication pest plants and Surveillance/Exclusion/Potential/Restricted pest plants)
- **Widespread weeds** (Terms used include Containment, Boundary Control or Suppression pest plants)

With new weed problems and low-incidence weeds, the goal is usually detection and eradication. Widespread weeds are usually the subject of boundary control rules that require landowners to control them so they do not spread further. Control operations for widespread

[2] Harris S 1999. Regional implementation of the Biosecurity Act 1993. MAF Policy Technical Paper 99/4, Wellington.

weeds often result from complaints by neighbours who are controlling their own Boundary Control or Containment pest plants. Weeds in other categories used by RCs can usually be assigned to one of these two groups (e.g. Northland's Quarry Control and Roadside Control weeds are also Boundary Control weeds and their Community Control weeds are Total Control within a designated Community Pest Control Area).

Unsurprisingly individual weed species have different RPMS classifications in different parts of New Zealand, but it is also the case that a weed may have different classifications in different parts of a region. In Southland, for example, gorse and broom are Total Control weeds in urban areas but they are Boundary Control weeds in rural areas where they are too widespread to be controlled successfully.

In spite of these variations, weed classifications provide a good insight into an RC's operational priorities. Sharing this information nationally will help weed managers understand the relative importance of different weeds in other RCs. While it is not conceivable for RCs to change the regulatory classifications used in their existing RPMS (for the purposes of national standardisation), it would be possible to include RPMS classifications with site data, and map the RPMS classification to one of two standard classes: Total Control/Surveillance (low incidence), and Containment (widespread).

Weeds are often classified as either environmental or agricultural weeds. The primary negative impact of environmental weeds is on natural areas, processes and values, whereas the primary negative impact of agricultural weeds is on production. Many weeds have both environmental and agricultural impacts. Environmental weeds are beginning to dominate the compliance weeds listed in RPMS. RCs report that this is a relatively new development and that the trend is growing. However, Hawke's Bay, Tasman and Southland still focus at least half their efforts on agricultural weeds that negatively impact productive land and Gisborne (70% of effort), Taranaki (70% of effort) and Marlborough (80% of RPMS weeds) have an even greater focus on agricultural/economic weeds.

Environmental weeds are tackled on council land such as regional parks, but most effort goes into designated sites with high conservation values. There are various designations including QEII covenant sites, 'Protection Management Areas' (PMA), 'Key Native Ecosystems' (KNE) and 'Significant Natural Areas' (SNA). Many RCs also support private landowners in protecting natural areas on their properties. In all of these cases, any weed is a target species, not just weeds named in the RPMS.

2.3 Weed monitoring and surveillance

Most RCs feel they have a fairly good picture of where Total Control and Eradication weeds occur in their regions, due to targeted surveillance and, in some cases, annual surveys. However, some bigger RCs and a number of smaller RCs feel that further survey for these low-incidence weeds is required. For Containment weeds, some RCs with large rural areas feel they have a reasonable distribution picture, but other RCs are less confident. They report a lack of knowledge especially for outliers and new populations, because observations of Containment weeds are often driven by complaints and records are often kept only when these weeds are found in places where they are not common.

RCs feel that it is hard to know where Surveillance weeds occur, except for sites where they have been controlled and monitoring has revealed regrowth. Biosecurity officers monitor plant nurseries and identify and manage sources of Surveillance weed incursions, such as the movement of commodities and transport vectors, garden escapes and unmanaged seed sources, but their knowledge of dispersal mechanisms is rarely recorded.

RCs use a variety of methods to monitor the distribution of weeds, including roadside surveys for target weed species, delimiting surveys around known infestations, and systematic property inspections. They rely on their relationships with landowners, not just to comply with RPMS rules, but also to report weeds when they appear in new places. This work is supported in some cases by aerial surveys and region-wide surveillance programmes that target particular weeds. RCs also cooperate with national agencies on implementation of the National Pest Plant Accord[3] (NPPA), undertaking surveillance to prevent the commercial sale and/ or distribution of an agreed list of pest plants.

Some examples of surveillance activities are outlined below:

- Greater Wellington RC did an aerial survey to spot weeds along Wellington's south coast, recorded GPS locations and controlled the weeds. They also committed significant staff time to conducting delimiting surveys around known Total Control species infestations, but did not have the resources to comprehensively survey every square centimetre of the region. Nor do they currently have predictive modelling tools to allow them to use the data gathered to estimate the potential spread of these species. This kind of evidence, however, is needed for the cost–benefit analysis required to justify allocation of resources for their species-led programmes.
- In Canterbury, they use remote sensing to measure the outcome of keeping land clear of gorse and broom. They do targeted surveillance for Total Control weeds like nassella tussock.
- In Southland there is a regional programme for the pasture weeds ragwort and nodding thistle in which all infested properties are identified and Boundary Control rules are implemented.
- In Otago the region is divided into four parts and each part is surveyed by helicopter for gorse and broom once every 4 years. GPS points are taken for each individual or small cluster, and notes are taken where large infestations occur. This is followed up by a visit or a notification letter requiring control, and an inspection further down the track establishes if the landowners have complied or not.
- Auckland RC conducted GPS surveys of weeds in its parks but the data could only be used to produce a report and GIS shape files. Data were not able to be integrated into their database, so they will hold off surveying extensively until a better database system is in place.

Survey frequency depends on resources, as well as the risk associated with each weed and when it is most practical to survey. For example, Chilean needle grass is only visible for survey purposes 2 months of the year.

Most RCs use GPS and paper records to record data in the field. Typically biosecurity officers complete diaries, standard forms or inspection sheets in the field and subsequently transfer the data to a computer. A minority of RCs use personal digital assistants (PDAs) with

[3] The NPPA is a cooperative agreement between the Nursery and Garden Industry Association, regional councils and government departments with biosecurity responsibilities.

GPS (Global Positioning System), iPAQs (Pocket Personal Computers), laptops and tablets, often only in specific circumstances. Many say they are comfortable with the methods they use and express concern about putting more demands for data capture on their field staff.

Biosecurity officers are responsible for monitoring large areas and feel they need more staff with the right skills. For example, it is hard to identify low-incidence weeds and to detect vine species like old man's beard, which might take 4 or 5 years to appear above the canopy. Officers are generally aware of the distribution of weeds that have been established for a long time but are concerned about their knowledge of the whereabouts of new weeds. Hawke's Bay RC, for example, expects to find a new infestation every 2 years and a brand new weed every 3–4 years, doing targeted surveillance.

With RCs focusing increasingly on targeted risk management for widespread weeds and on detecting new incursions before they get out of the lag phase and start to ramp up, it is very important to have a good understanding of how potential weed threats may manifest themselves. Better resources for weed monitoring and surveillance and standard approaches that facilitate data aggregation will help RCs identify future trends in distribution that can be used to redefine policy.

2.4 Comparison between RPMS

An analysis of a number of RPMS was conducted in addition to the survey and interviews with RCs to get an indication of the degree of overlap between RPMS weeds in different regions. This is helpful in determining how useful an NWDD could be to RCs, and to scientists interested in using the data for national distribution modelling.

Four North Island and four South Island RCs (half of the total) were selected to ensure a representative sample (abbreviations follow Table 1).

North Island:

- NRC: a medium-sized region with 90% of effort on environmental weeds
- ARC: a small-sized region with 80% of effort on environmental weeds
- GDC: a small-sized region with 70% of effort on agricultural/horticultural weeds
- TRC: a medium-sized region with 70% of effort on agricultural weeds

South Island:

- TDC: a small-sized region with 80% of effort on environmental weeds
- MDC: a small- to medium-sized region with 80% of effort on agricultural weeds
- ORC: a large-sized region with 70% of effort on environmental weeds
- ES: a large-sized region with 50% of effort on environmental weeds and 50% on agricultural)

Table 2 Overlap between RPMS weeds in a sample of North and South Island regions

Regional Council or Unitary Authority	% of RPMS weeds unique to this region	% of RPMS Total Control weeds unique to this region	% of RPMS weeds that are aquatic	% of RPMS Total Control weeds that are aquatic
NRC	13	20	40	45
ARC	14	23	19	32
GDC	27	31	4	0
TRC	21	0	11	13
TDC	8	8	18	31
MDC	8	0	16	29
ORC	10	13	15	19
ES*	49	45	5	0

It seems therefore (Table 2), that in spite of there being some differences, there is a large degree of overlap between weeds lists from different regions, with the exception of Environment Southland, whose weed list was twice as long as most other lists and included 'Risk assessment' weeds, which others did not. There are many weeds that appear on multiple lists and some 'usual suspects' like ragwort, old man's beard, nodding thistle, gorse and broom that appear on nearly every list.

Aquatic weeds make up a quarter of all weeds at the top end of both islands, but less so elsewhere. Aquatic weeds have a greater representation when looking only at Total Control weeds.

2.5 Weed control

Regional council efforts are focused on detection and control of low-incidence weeds to achieve the greatest cost–benefit outcome, and preventing further spread of widespread weeds by enforcing boundary control or containment rules. Across the country, more than 80% of control efforts occur in the rural environment.

While RCs do a significant amount of control work themselves, they usually require landowners to do the work or to hire approved contractors under the rationale that exacerbators and beneficiaries should cover the costs. RCs also support community groups to do weed control, for example in ecosystem restoration projects.

Examples of RC activities include: control of wild ginger in Northland where it is established under the canopy of plantation forestry and threatening adjacent native forests; control of privet in urban parts of the Hawke's Bay to mitigate its impact on human health; and biological control of gorse, ragwort, Scotch thistle and nodding thistle in Taranaki. Taranaki RC also has a marine scientist working on monitoring and controlling *Undaria* along the coast.

Gorse is being controlled by helicopter over large areas of the West Coast; biocontrol is being used for California thistle in Southland, and in Canterbury, a customer satisfaction survey showed that 94% of landowners were happy to manage nassella tussock themselves rather than have their rates rise.

2.6 Sources of information on weeds

Regional councils use a variety of sources to access information about control techniques, but it is fragmented and hard to find. They would like to have better access to standard operating procedures for different weeds in different contexts. For example, if there has been a recent history of forestry or grazing, it is important to hit the weeds hard and early so they don't get a chance to take off. Interviewees report that critical information such as the costs and benefits of control operations is not easily available from other councils. In addition, sources of expertise or advice, such as herbicide companies or councils' own trials, are hard to find. The widespread use of common names rather than botanical names often adds to the difficulty of accessing information.

Most interviewees said they get a lot of information on weeds through talking informally to their counterparts in other RCs and to scientists in research organisations. Many rely heavily on relationships with particular scientists at DOC, AgResearch, Landcare Research, NIWA, and MAF. Many RC staff employ the strategy of finding a good contact for advice and information and then returning to those contacts as needed. These informal networks are reinforced at annual gathering such as the NETS conferences organised by the New Zealand Biosecurity Institute.

One RC described neighbouring RCs as the first port of call and another said that if they have a question about a weed that they currently do not control, they would contact the RC that has had the most experience dealing with it. However, they also point out that a Total Control weed in one region may not even be in the RPMS in an adjacent region, so they can't always expect to find distribution data or other information on the weed they are interested in.

RCs organise site visits when they feel the need to discuss a particular weed problem with their counterparts in other regions. For example, officers from the Bay of Plenty have travelled to Northland to get a feel for what might be coming to their region and officers from the GDC met their counterparts from EBOP on-site and shared distribution and control information about a new weed that is a potential risk to maize.

Many interviewees cited information about control approaches and performance outcomes as a high priority. Currently they get this information from control contractors, representatives from the suppliers of pesticides and herbicides, and from officers' observations (e.g. the timing and performance of control methods). They also use EBOP and ARC websites, which both have useful weed indexes with generic and control information about a variety of weeds. Almost all RCs mentioned DOC as a primary source of weed control information, but they also commented that few resources contain reports about performance outcomes (except DOC's BioWeb, which does so for a handful of species). Other comments about DOC include praise for their publications, particularly the weed reports that DOC commissions from experts, the advice they provide to councils, and the research done by their national coordinator. One RC invites DOC staff to be deeply involved in development of their RPMS but to date this collaboration has been more about joint discussions than about directly accessing DOC's data.

Many RCs use Google when initially researching a weed and others regularly use websites such as Weedbusters, the NZ Plant Conservation website and ISSG's Global Invasive Species Database. With specific reference to priorities and risk ratings for particular weeds, one RC said that MAF's weed rating system is too convoluted and DOC's weed rating system does not apply well to a biosecurity-focused application.

Interviewees reported examples of instances where data were sought and obtained from other RCs or national agencies. NRC sourced distribution data for Royal Fern from DOC and they regularly use the website that MAF set up for RCs that lists all RPMS species. Horizons have used information from HBRC for Chilean needle grass. GW said that DOC weed data are not easily accessible and they usually contact Clayson Howell for specific weed distribution information. EBOP regularly uses some of the DOC information systems, and WCRC uses a DOC officer who relies on DOC systems and DOC weed forms for all work on environmental weeds. RCs use MAFBNZ information on NPPA weeds to visit nurseries to ensure those plants are not being sold.

2.7 Modelling

Most RCs haven't used predictive modelling but many are aware of some of the tools that are available. For example TDC is aware of a model for wilding pines but hasn't used it and the ARC intends to look into CLIMEX and other tools. Other RCs commented that they don't have the capacity, staff resources or knowledge within their small groups to use models. Some felt that they are well aware of imminent threats or, if necessary, they can discuss the issues with scientists, and haven't really needed to use modelling.

Greater Wellington has recently engaged with Graeme Bourdôt and Mike Dodd at AgResearch to use its weed distribution data for predictive spatial modelling. In EBOP, Dr Gavin Kenny has undertaken some climate-change-effect modelling for pests such as woolly nightshade. This work shows woolly nightshade is expected to spread further inland and modelling is now being done for new kiwifruit species, which are expected to be able to spread further south.

Some RCs believe that models could help with operational decision making, for example to model what would happen if they don't control a weed to assess the impacts over time of delaying control. Models might help RCs decide whether or not they should hit a weed hard under the RPMS process, or deprioritise it.

2.8 Data collection

Apart from basic data on weed names, location and dates there is significant variation in the way data are collected and stored. Some recommendations for RCs to consider regarding ongoing standardisation of data collection and storage are included in the Appendix in section 13.1.

2.8.1 Recording weed data

Biosecurity officers feel like they've got a good idea of where weeds are, but some of that knowledge is not captured in databases. For example an officer might visit a site, identify weeds and provide advice on appropriate responses without recording any data or uploading diary data to a database. They may control the weed while on site if the infestation is small, but this information may not be recorded. It is common for no data to be collected when landowners or contractors do control work. Data are collected most consistently for Total Control/Eradication weeds.

A summary of data captured by the different RCs is given in Table 4 in the Appendix.

2.8.2 Location data

Weed distribution data collected by regional councils may only represent partial coverage of a region for particular classes of weeds. For many RCs, the main rationale for recording the location of weeds is so that someone can go back and find where the infestation is. Weed infestations are most commonly marked by recording GPS coordinates. Sometimes the whole property, the street address or the farm gate is marked rather than the actual location of the weed.

Multiple points are used in some cases to describe the extent of a location but increasingly RCs are able to draw polygons to delimit infestations. In many cases polygons are only visual estimates of the extent of the infestation and they might be based on a GPS fix and drawn back in the office on a satellite or aerial surveillance map. In some cases the size of the polygon can be used to reflect trend over time, but most RCs consider these unreliable for this purpose because they are not drawn robustly and not always updated over time.

Interviewees mentioned few cases in which absence is recorded explicitly: ECAN's Total Control species at 98 sites, Southland's inspections for old man's beard and their Generalised Random Tessellation Sampling weed survey, EW's survey of city properties for alligator weed, and TRC's recording of individual properties that have no pest plants). Absence is inferred when control operations have been completed and follow-up monitoring over an appropriate time period (up to 9 years for some weeds) confirms that no weeds are present. MDC records all property inspections and any Total Control weeds found, so they can identify inspected properties where Total Control weeds do not occur.

2.8.3 Weed density data

Weed density information is vital for monitoring and for control, but there are not yet any truly nationally adopted standards or standard operating procedures.

There is currently significant variation in the way RCs record the density of weed infestations and subjectivity is a major issue when trying to report the density of, for example, weeds scattered on a hillside, aquatic weeds in a river or ginger plants in a pine plantation understorey. In the past, RCs favoured qualitative measures of density such as Low/Medium/High to encourage staff and contractors to log data in the field, but they are too subjective. The ARC used to record density and condition using Better/Worse/Same, but an expert looking at the data could find no consistent trend in density and condition. GW used to record % Groundcover (visual approximation), % Middle Story Cover (visual approximation), % Canopy Cover and Aquatic Cover (visual approximation), but they too have ceased using this approach because these observations are too subjective.

Regional councils are increasingly recording quantitative data such as counts of seedlings, juveniles and mature plants, counts of plants per square metre or the area of the infestation. The ARC now uses whatever metric is appropriate, including quantity of material removed (for grass). Some RCs use quantitative measures only when recording data on Total Control weeds, and do not use measures of density for other weeds.

New ways of recording density over large areas are being developed. For example, GW is looking at using spray diaries from contractors to approximate how many square metres of weed was killed during a contract based on the amount of spray used and how many square metres each litre of spray covers on the ground.

Standardised monitoring protocols for weed density are a part of DOC's NHMS programme, and significant progress has been made by DOC in this area. DOC also has standard operating procedures for weed surveillance, weed control programme planning, and programming reporting/review. These will soon be made available on the DOC website.

2.8.4 Weed control data

Two key types of weed control data are the methods used and the outcome. The amount and quality of weed control data varies from good for large-scale control programmes, to reasonable for Total Control weeds, to poor when landowners and community groups do the control work. Agencies such as MAF are involved in large-scale programmes such as control of Manchurian wild rice around Dargaville where the infestation stretches 55 km up the Northern Wairoa River. Landcare Research is involved in many biocontrol programmes and aquatic weeds like *Lagarosiphon* in Lakes Dunstan and Clutha are monitored and controlled with funding from LINZ and Contact Energy. Robust data collection is a standard part of the design of these projects, but the data are not usually available via RC databases.

As a general rule, RCs take responsibility for control of Total Control weeds and weeds in KNEs or council-owned land, often using contractors. Treatment details such as control effort (e.g. amount of herbicide) and contractor hours are recorded but these data are not always readily available in RC databases. Outcomes are tracked more consistently, but there is some variation in how they are reported. Many RCs track outcomes of control operations by classifying sites as New, Active, Monitoring or Historical. The MDC uses 'before and after' photos for measuring post-control outcomes in an effort to keep data capture simple for those doing the control. Other RCs use the quantitative measures of weed density described above to track outcomes.

Most Boundary Control or Containment weeds are controlled by landowners and very little data are available in RC databases. For these weeds RCs either assist landowners with control in a shared basis, or enforce RPMS rules that require an occupier to control the weed.

The key data source for control work performed by landowners is the RC's Inspection Notice or Notice of Direction. Most RCs have extensive inspection programmes. New sites for Total Control weeds are inspected as frequently as every 6–8 weeks and infestations are often controlled at the time of inspection. Inspections for Boundary Control weeds are less frequent and are often driven by complaints from neighbours.

Inspection Notices may include weed name, date, property owner's name, recommended action, action taken, amount of herbicide, and any follow-up required, but this information is not always available in RC databases. In some cases Inspection Notices are removed from active files once the landowner has fully complied. However, as control operations take place, and the site is reinspected based on rules that define the return period for inspections for different plants, the site classification is updated.

2.8.5 Site classification

Regional councils consistently use site and property classifications to monitor compliance or control outcome. The ORC classifies sites as:

- Compliant (assume zero density, but regrowth is likely)
- Non-compliant minor (a few plants left)
- Non-compliant major (landowner did not control)

The TRC classifies sites as:

- Property with no pest plants (inspected as time permits)
- Property has had pest plants, but they are under control (inspected once a year)
- Pest plants are flourishing (these properties are targeted as a priority, inspected three times a year)

The most common site or property classification scheme is:

- New site (discovery and initial knockdown)
- Active site (regular ongoing control)
- Monitoring site (frequent reinspections)
- Historical site (infrequent inspections)

Properties with weeds and infested sites are reinspected and treated as often as five times a year, depending on the species and the site. Weed inspections and actions that are agreed upon with landowners are usually recorded in diaries and follow-up visits scheduled, but this information is often not uploaded to a database. The property or the infestation site is reclassified if the weed problem is addressed satisfactorily and the new classification may be updated in a database. If a standard approach can be developed, property classification is a potential source of weed distribution and control outcome data.

2.9 Information Management Systems

Perhaps not surprisingly nearly every RC has a unique approach to weed data management. At the national level there is convergence around the policy framework of the regional pest management strategies (RPMS) but the information support systems for implementing RPMS vary greatly. The numerous factors driving these different approaches include the availability of human, technical and physical resources, coordinated strategic goals and prioritisation, and the intra-council policy frameworks. These factors vary considerably between RCs, and naturally lead to heterogeneity of solutions for information capture, management and reporting.

A significant and universal issue was the lack of available national standards for monitoring, surveillance and performance reporting protocols, or the standard data-elements that should be incorporated into those protocols. This is a common theme reinforced by the findings of other recent surveys[4, 5]. There is thus little current basis on which to develop standardised information management systems. Other main constraints we noted were the availability of capital expenditure for back-office and field data capture systems, coupled to the limited human resource available for data management, and IT expertise for developing and maintaining systems.

Our observations also indicate that data management policy is often focused on satisfying the immediate needs of individual operational teams within RCs, and only when there are regulatory factors is a 'whole of council' approach adopted. In the majority of RCs animal pests are managed by different teams to plant pests, with different information management systems.

We encountered the entire spectrum of information management systems, from those that are nearly entirely paper-based, with some use of spreadsheets, through to in-field GIS-based data-capture, transferred to dedicated data management modules within an RC integrated data management suite. Among the RCs with the most sophisticated data management systems are ARC and EBOP. However, generally the most common arrangement consisted of a structured spreadsheet or desktop database management system (generally using Microsoft Access), managed by individuals at the team-level, loosely coupled to spatial data components managed within an RC-wide GIS system. Some interviewees expressed concern over the ability to adequately report from these systems, while others said that data extraction was simple. In many cases local development of systems is on hold with the intention of adopting a future IRIS system, or the system being proposed by the ARC/EBOP alliance. There will undoubtedly be challenges in integrating these externally developed systems into local existing infrastructure, at the team-level, while continuing to maintain and support them as national systems.

Many RCs noted the increased prioritisation of biodiversity reporting in a broader context than has historically been the remit of weed management teams. This is yet another significant factor that will impact on future weed management and the necessary supporting information systems.

Some RCs reported very close information-sharing relationships with DOC, including in one instance of the use of DOC's information systems to satisfy internal needs for data management.

One question we asked concerned the privacy of data associated with weed management, and how that might impact on the ability to share data between councils, with national agencies, with research scientists, and with the general public. Again we received a range of responses with the most common one being that the issue had not been considered in detail. One RC reported that legal advice had been sought and all data would be publicly available. Many others felt it inappropriate to make data publicly available that would allow the linking of

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[4] Clayton RI, Cowan PE 2009. Best practice operational and outcome monitoring for pest management – a review of existing council approaches and activity. Landcare Research Contract Report LC0809/085.

[5] Clayton R, Cowan P 2010. Management of animal and plant pests in New Zealand – patterns of control and monitoring by regional agencies. Wildlife Research 27: 360–371.

enforcement/regulatory issues to individuals and land parcels. In this respect the trust relationship between RC teams and landowners was seen as paramount to successful outcomes. One RC suggested that inter-council data sharing would require formal data-sharing arrangements.

In summary, existing information systems within RCs are generally not currently sufficiently grounded in common data standards, protocols, or technical implementation to enable the use of existing solutions for automated distributed data-harvesting and integration into an NWDD. However, it is clear that harmonisation is seen as desirable by many parties and there are many initiatives, including the NWDD, which can support progress.

3 National and international context

3.1 Related New Zealand strategies, programmes and projects

3.1.1 The Biosecurity Surveillance Strategy 2020

The Biosecurity Surveillance Strategy 2020 was published by MAF in November 2009. It addresses the surveillance requirements for New Zealand's total biosecurity system including the activities conducted directly by MAF Biosecurity New Zealand, and those of other participants.

Along with goals, outcomes and actions for each of 'leading biosecurity surveillance' and 'delivery quality surveillance' the strategy has a focus on 'working together' and 'sharing information' that are particularly relevant to the establishment of an NWDD. The relevant goals under those two headings are as follows:

Working Together

- Significant biosecurity surveillance decisions are transparent and made using consistent criteria.
- Biosecurity surveillance resources are targeted to deliver the greatest benefit to New Zealand.
- Stakeholders with a role, or interest, in delivering biosecurity surveillance work together using formal and informal mechanisms.

Sharing Information

- Biosecurity surveillance activities are supported by adequate processes and systems for managing and storing data.
- There is increased awareness of, and appropriate access to, surveillance data and other information that supports biosecurity activities.
- Biosecurity data are converted to information of known quality and used to support decision making.
- The communications and information needs of stakeholders in biosecurity surveillance are appropriately met.

The surveillance strategy has a number of expected outcomes related to information management including:

- Harmonised or compatible data formats and systems are widely used among organisations collecting or holding surveillance data.
- The collection and collation of surveillance data is supported by appropriate IT infrastructure.

- Biosecurity surveillance participants are aware of relevant activities undertaken by other parties, including data collection, maintenance, distribution and reporting functions.
- Biosecurity surveillance data and information are widely available, thereby increasing their use.
- Increased data sharing will reduce duplication of effort and foster close working relationships between surveillance participants.
- Robust biosecurity decisions are made because of improved data analysis, combined with timely reporting.
- Participants in biosecurity surveillance provide complete and accurate data and/or information to each other in a timely manner.
- Participants in biosecurity surveillance receive the available information and/or data that meet their needs.

The inclusion of these outcomes in the surveillance strategy supports the case for the establishment of an NWDD. In addition, MAF staff interviewed saw an NWDD as contributing positively to achieving these outcomes.

The surveillance strategy includes a number of data/information management related actions including:

1. Conducting a gap analysis to identify information needs not currently being met and opportunities for improving the use of existing data
2. Developing a repository that provides details of surveillance datasets and information sources of relevance to the biosecurity system
3. Exploring and negotiating agreements between biosecurity surveillance participants governing the appropriate exchange of data of mutual interest
4. Exploring and developing data quality standards and metadata specifications applicable for use with biosecurity surveillance data

These actions are scheduled to be initiated in late 2011. As such they could support the improvement of an NWDD though standards development and data-sharing agreements, along with a policy environment for biosecurity surveillance that encourages collective action.

3.1.2 Pest Management Proposed National Plan of Action 2010–2035

MAF Biosecurity is leading the development of a whole-of-sector plan of action to improve pest management in New Zealand. This plan has a particular focus on making it easier for everyone involved to act collectively in the country's best interests.

Reports on the future of pest management in New Zealand[6], commissioned by MAFBNZ and regional councils, identified five key areas for improvement:

1. There is a lack of clarity in pest management roles and accountabilities.
2. Crown obligations as a 'good neighbour' landowner do not match those of other parties.
3. The legislation underpinning pest management activities is outdated.
4. Physical control and pest management monitoring tools are insufficient for future needs.
5. Collective action and participation in pest management is insufficient.

The proposed plan of action suggests a set of changes, grouped into four themes:

1. Clear roles and accountabilities
2. Improved and simplified processes
3. Better and more accessible tools
4. Acting collectively

Although much more broadly focused than just weeds, the plan does have a number of implications for a national weeds distribution database. These include changes that would improve the usefulness of an NWDD, and those that would be supported by an NWDD, and are as follows.

In providing for **clear roles and accountabilities** the plan proposes, among other things:

- Amending the Biosecurity Act to extend the focus to include pathways and vectors by which harmful organisms can spread, and to ensure the costs associated with pests and pest management programmes are fairly distributed
- That the Crown be bound to good-neighbour rules in regional pest management strategies under the Biosecurity Act, once the strategies have been aligned with the national policy direction
- That MAF oversees New Zealand's pest management system, including measuring overall system performance against outcomes

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[6] 'Think piece on the future of Pest Management in New Zealand', LECG and John Hellstrom, 3 October 2008, and 'The future of pest management in New Zealand: a think piece', Enfocus, August 2008.

- That regional councils ensure their regional pest management strategies are aligned with the national policy direction

These changes will require increased coordination and information sharing between regional councils, MAF, DOC, and other landowners, something that an NWDD is likely to help facilitate.

In providing for **improved and simplified processes** the plan includes:

- Simplifying pest management strategy development and review processes and making strategies more flexible by, among other things, enabling parts of RPMS to be changed without reviewing the whole strategy
- Introducing a new legislative tool to allow the movement of risk goods and craft to be regulated within New Zealand where these pose a risk of spreading harmful organisms, by establishing ‘pathway management plans’
- Creating a binding national policy direction that will set out processes to improve the rigour and consistency of pest management strategies, including establishing national priorities for pest management, and a process for determining what should reasonably be included in national and regional pest management strategies
- Establishing a unified performance measurement framework for pest management for New Zealand as a whole, and developing indicators and measures that can align and link pest management systems and agencies’ own frameworks, so information can be provided without unreasonable difficulty or expense

Changes to RPMS processes may mean an NWDD can be more useful than otherwise, as councils could choose to more regularly monitor weeds likely to enter their region, and amend their RPMS accordingly (rather than only doing so every 5 years). Introducing ‘pathway management plans’ may require a better understanding of pathways for weed spread, and modelling tools to show the impact of managing (or not managing) particular pathways at a national level. The move to alignment of national and regional strategies, and a unified performance measurement framework, would mean information in an NWDD could be used to support these processes. It could also encourage or require increased standardisation of data collection and recording. Landcare Research staff involved in work on the performance measurement framework have been consulted as a part of this scoping study.

The third major theme for action is providing **better and more accessible tools**. The plan advocates for integrated toolbox management including, of particular relevance to an NWDD:

- Developing best practice guidelines for core pest management activities, regional and national pest management strategy processes, and for pest management tools and practices for agencies engaging with the wider community
- Providing accessible, authoritative information, including on tikanga and mātauranga Māori practices, for agencies, industry and members of the public engaged in pest management

The action plan says:

> *Developing and sustaining all the tools needed for effective pest management is a growing job and one that can no longer be left to ad hoc and disjointed approaches. Tools include physical control tools, like traps and poisons, monitoring tools, technical information and best practice approaches and standards.*

This drive towards sharing of best practice is likely to be another factor in encouraging the development of the standards for data collection and recording that would improve the value of an NWDD. If control data were included in an NWDD this could be one source of identifying emerging, good and best practices and including them in the toolbox.

The action plan also sees the integrated toolbox as forming a critical link with the Biosecurity Science Strategy, and facilitating the transfer of knowledge from the science system to application in the pest management system, and in helping articulate priorities for pest management research. This focus on knowledge transfer supports the concept of increasing data available to scientists for distribution modelling, and for the use of the outputs of models in planning by regional councils.

The action plan seeks improvements in tools to ensure less time and money is spent in identifying the information required to design, undertake and evaluate pest management control and monitoring, and on updating organisations' internal information systems to accommodate new pest management regulations and techniques. These objectives are complementary to those of an NWDD.

The plan also seeks to encourage two-way capability building for effective tāngata whenua involvement in pest management, and skill development in tikanga for agencies. This involves, among other things, developing capacity to predict biosecurity risks to taonga and other culturally significant resources, something which an NWDD may help facilitate by making it easier to visualise weed distributions nationally.

Finally, the plan provides for **acting collectively**, and proposes:

- Promoting leadership for engagement and co-operation through, among other things, appropriate national, regional and issue-based forums
- Promoting partnerships that encourage inclusive participation in the development of pest management strategies and policies, favour investment in joint pest management programmes, co-ordinate pest management operations with others, and invest in shared systems and capability while leveraging existing capability
- Improving support for collective action through, among other things, reducing duplication in reporting processes and making it easier to fund large projects from multiple sources of funds
- Using a more collective approach for national pest management programmes through improved joint decision-making and cost-sharing approaches

This drive for more coordinated and collective action is likely to support, and be supported by, an NWDD.

Submissions to the draft plan of action closed on 23 July 2010, and a revised plan is being prepared. The final plan of action, once completed, should be taken into account in any further work on the National Weeds Distribution Database.

3.1.3 Department of Conservation

The Department of Conservation has a number of projects and initiatives underway that need to be considered in the context of an NWDD. These are:

- Baseline data derived from a national 10 ×10 km grid snapshot of weed presence/absence (Clayson Howell and Jon Terry)
- The Natural Heritage Management System (NHMS) programme of work

National 10 x 10 km grid snapshot of weed presence/absence

The Department recently ran a project to collate weed presence/absence data nationally. They took the list of weed species from the NPPA and added 30 species that appear on two or more RPMS. This gave a total of 182 weeds, for which they then collated all the available electronic point data from six herbaria[7], and from NVS[8], FBIS[9], two DOC datasets, and from the eight regional councils[10] that were able to provide data to the project. These data were used to mark known presence within a 10 × 10 km grid. They then visited all of the regional councils (with the exception of ARC), and 'office-truthed' the data by meeting with RC biosecurity staff, and getting them to mark additional squares where they knew the weed to be.

They found that, overall, the mapped distributions from the aggregated data under-represented the weed distributions known by RC staff by about 50%. They also found that, for the more widespread weeds, there are very good records in some regions, but where infestations are extensive in other areas, staff do not record data on those weeds. Clayson Howell, the manager of this project, is therefore concerned that the available weed distribution data may not be accurate enough to support useful distribution modelling in all cases.

It is understood that similar projects are underway in the United Kingdom (BSBI) and Southern Africa (SAPIA), at higher spatial resolutions, e.g. the UK is going for 2 × 2 km scales.

While this project is only a snapshot in time, it is the most comprehensive picture of weed distribution data nationally, and shows the value of a human-mediated approach. It also demonstrates the risks and challenges of relying on digitised/databased information only.

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[7] AK, WELT, CHR, NZFRI, WAIK, OTA

[8] The National Vegetation Survey Databank, managed by Landcare Research

[9] The Freshwater Biodiversity Information System, managed by NIWA

[10] NRC, EBOP, Horizons, TRC, GW, MDC, ECAN, ES

The Department believes the project could be run on a decadal basis. With 3000 cells for 182 species it required a day or two of time on-site in each region. The time commitment would, of course, be higher at greater degrees of spatial resolution.

The Natural Heritage Management System (NHMS) programme

The Department of Conservation has a large programme of work underway to create a comprehensive Natural Heritage Management System. To date, significant work has gone into creating standard inventory and monitoring protocols including data collection standards. Specifically, the Biodiversity Monitoring and Reporting System will provide a national grid-based monitoring system for natural heritage data capture. This will include monitoring the distribution and abundance of weeds considered a threat.

Requirements for an information system have been developed, and it is likely that construction of the system will soon commence. The system will bring together information on DOC's operational activities (what conservation work is planned, what is being done, what the results were), and existing databases/geospatial layers of known distributions and conditions for flora and fauna (including weeds).

This system is likely to be designed to integrate with other national systems such as the New Zealand Organisms Register (NZOR), National Vegetation Survey Databank (NVS) and others, where appropriate. It could eventually become an important data contributor to, and user of, data from an NWDD.

Contribution of DOC data to an NWDD

The Department's weed distribution data from BioWeb will be migrated into the NHMS. There are some gaps in DOC data which means they don't represent a comprehensive national view of weed distributions, on public conservation land, but these gaps are being filled through ongoing inventory and monitoring work.

Staff at DOC record weed data from public conservation land, and also undertake some weed management work on iwi land, and have distribution data from those activities. While many weed inventories that have been recorded were drawn from sites where weeds impacted on the biodiversity values in those places, DOC does also have some distribution records of important individual weed species.

Currently, operational activity data (on weed management operations) is managed in a separate system from BioWeb (which contains recorded weed distributions). Once these are combined within NHMS it will be much easier to incorporate DOC operational activity data into an NWDD (i.e. in addition to DOC's inventory and monitoring data).

Having DOC's weed distribution data in an NWDD could be extremely useful, both to scientists and technical staff, for weed distribution modelling and management, and to regional councils for increased awareness of weeds and control operations on public conservation land near their boundaries.

Some aspects of DOC's weeds data may not be especially useful for RCs, for example the DOC 'weediness scores', as these only take into account environmental impact rather than including agricultural impact. By and large, however, DOC data will be valuable, and the work DOC has done on standard operating procedures for weed surveillance, monitoring, weed control programme planning, and programming reporting/review may well contribute to truly national standards and help inform standardisation of data collection by RCs. DOC's work on protocols for results and outcome monitoring may help extend RC weed control practices to become more outcomes focused.

3.1.4 Indicators and Performance Management Frameworks

There is work being carried out by Landcare Research and DOC to develop a set of biodiversity indicators suitable for adoption by councils and linked to the NHMS to enable nationally consistent reporting of biodiversity values and change. Ideally, this work will also be linked to the proposed Pest Management Performance Measurement Framework[11].

3.1.5 Shared systems developments

Several proposed and current projects exist to develop shared information systems between RCs. These include the IRIS project, and proposals to TFBIS for scoping studies for a biodiversity system and a biosecurity security system to be shared by a number of RCs.

The Integrated Regional Information System, or IRIS, is being built for EW, NRC, Horizons, WCRC, ES and TRC. It has a range of functions including rating and consents, but biodiversity and biosecurity modules are also planned.

The scoping study for a joint biodiversity management system was proposed by ARC and EBOP to look at merging their systems and making them available to other RCs. The scoping study would investigate that merged system becoming the biodiversity module for IRIS. Similar proposals for the investigation of a joint biosecurity system have been discussed by the Regional Council Biosecurity Managers Group.

These systems, if adopted by a number of RCs, are likely to help drive standardised recording/capture of weed distribution/control data that would help increase an NWDD's value of an NWDD.

3.1.6 Directions and Priorities for Government Information and Communication Technologies (ICT)

The new *Directions and Priorities for Government ICT*[12] were announced by the Internal Affairs Minister the Hon Nathan Guy on 7 October 2010. This includes five directions:

1. Provide clear leadership and direction
2. Support open and transparent government

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[11] Jones C 2009. Performance measurement in New Zealand pest management: a review of national and international processes and requirements for a national performance management framework. Landcare Research Contract Report LC0909/015.

3. Improve integrated service delivery
4. Strengthen cross-government business capability
5. Improve operational ICT management

Within these directions there are a number of priorities that are relevant to the implementation of an NWDD. These include:

2.1 Improve public access to government data and information

2.2 Support the public, communities and business to contribute to policy development and performance improvement

2.3 Create market opportunities and services through the re-use of government data and information

3.1 Prioritise investment in shared solutions for integrated, multi-channel, service delivery across government

4.2 Reduce duplication by standardising and consolidating common business processes across government

The document also makes the following statements:

> *"Open and active release of government data will create opportunities for innovation, and encourage the public and government organisations to engage in joint efforts to improve service delivery."*
>
> *"Government data effectively belongs to the New Zealand public, and its release and re-use has the potential to:*
>
> - *allow greater participation in government policy development by offering insight and expert knowledge on released data (e.g. using geospatial data to analyse patterns of crime in communities)*
> - *enable educational, research, and scientific communities to build on existing data to gain knowledge and expertise and use it for new purposes"*

These directions, priorities and statements indicate that there is top level support in government for the kind of approach that the implementation of an NWDD would take, and the kind of biosecurity system changes it would facilitate.

3.2 International context

There is the opportunity to share New Zealand weed data internationally and to access international data (e.g. for modelling and management practices) via the Global Biodiversity Information Facility (GBIF) and the Global Invasive Species Information Network (GISIN) by employing international standards with New Zealand weed data where possible. GBIF-mediated data for home-range and equivalent niche presence are already used extensively by modellers. GISIN has worked closely with GBIF in developing a platform and data exchange standards for sharing invasive species information at a global level via the Internet, and there are plans to integrate data from the two networks.

4 Benefits

4.1 Benefits to regional councils

Regional council/unitary authority staff interviewed could see a number of benefits in an NWDD. These included:

- Viewing changes in weed distributions in other regions
- Understanding threats on their borders and the factors causing those threats
- Understanding how weeds would spread in different circumstances
- Improved decision making through better predictive models
- Acting as a long-term archival service for weed distribution data
- Helping identify national priorities for coordinated action

All councils interviewed saw value in being able to view changes in weed distributions over time in other regions. This was true both specifically for neighbouring regions, and for other parts of the country. Level of interest varied from just being of curiosity value, to being of very high value, partly perhaps due to the difference in size of regions and their level of geographical isolation.

For neighbouring regions there are already established processes for information sharing including informal conversations, a biosecurity email list, conferences, field trips to adjacent regions, meetings to discuss cross-boundary priorities, and formal submissions on each other's RPMS. Being able to see weed distributions in neighbouring regions would therefore be a complement to, rather than a replacement for, these other communication methods. A number saw having the data visible and able to be displayed geospatially as useful in early warning of what might come into their region, understanding where the pressure on their boundaries was coming, and what the pathway pressures were, and in justifying to their council and regional stakeholders the reasons for including particular weeds in their RPMS. This was true for the surveillance context if a particular weed was coming their way, and for total control if, for example, there was a chance through working together with neighbouring regions they could eradicate a weed or keep it isolated.

Almost all councils saw significant value in having access to better knowledge of how weeds would spread in different circumstances. They were interested in seeing trends over time in other regions in aspects such as how drought affects different weeds, how long it takes weeds to come out of their lag phase, and the effectiveness of particular control approaches. This was particularly true for weeds that were not yet, or only just, invading their regions. This kind of information was seen as being very useful in providing evidence to support the development of RPMS.

Most councils could see some benefit in an NWDD facilitating improved weed distribution modelling. In general, however, they had relatively limited knowledge about what models could do, and what benefits they might provide. Those already working with scientists to use predictive distribution models tended to be more enthusiastic about their potential benefits.

Apart from NRC, those interviewed were relatively ambivalent about the value of an NWDD in helping understand how climate change would impact on weed distributions as they saw this as involving timescales that were too long to be practically useful.

Almost all councils saw value in an NWDD acting as an archival service, ensuring that there was a standardised and stable long-term home for their data. A number cited changes in staff and changes in their biosecurity information systems as having resulted in loss of historical data in the past.

Other benefits councils could see included:

- Identifying national priorities for whole-of-country containment boundaries and eradication efforts, and coordinating the work of DOC and MAF with local government
- Improving effectiveness of control operations through sharing information at a national level on control operation approaches, history and successes/failures
- Having one place that provides a reliable source of references to other information on the characteristics of particular weeds

4.2 Benefits for research

A number of researchers from the Beating Weeds II FRST-funded research programme were interviewed as a part of this scoping study. One of the catalysts for the NWDD project was the participation of Graeme Bourdôt in past NPPA reviews. Graeme is a researcher in Beating Weeds II, and an NWDD steering group member. It became apparent to him that the distributions of weeds at a national level often just weren't known, and this made objectively prioritising weeds for inclusion or exclusion on the NPPA a difficult process.

One major use for nationally aggregated weed distribution data is for the preparation and display of actual weed distributions against predicted potential distributions. In this context models are developed using data from a weed's native habitat to determine the environmental factors (climate, altitude, temperature, landscape type) that govern the range in which it could spread. These are then mapped onto New Zealand land environments data and climate data to create models showing the weed's potential range in New Zealand. The end result is a map showing where a particular species of weed is, and where it is likely to spread to (without intervention). The extent (size) of the land area at risk is readily calculated from these maps and thus potential economic losses can be estimated for cost–benefit analyses. This can help biosecurity managers make informed decisions, taking into account the national picture, on where to direct their eradication, boundary containment, and surveillance efforts at a broad, regional-level scale. To generate these kinds of maps, researchers require only basic distribution data (species name, spatial location, and date). While precise spatial locations are helpful, especially at mapping at the regional scale, they are not essential and 10 × 10 km grid presence/absence data may be sufficient. More detailed data will be useful in developing finer grained tactical models, and this is explored at the end of this section.

Researchers saw having relatively coarse grained data, with some degree of 'office-truthing' as being very useful in creating national-scale maps of known distributions vs potential distributions. Even if the data were somewhat patchy due to different councils focusing their surveillance and data-recording efforts on different weeds, they saw this approach as being useful in targeting further survey and data collection efforts to improve coverage and accuracy over time. With appropriate quality controls (such as viewing photos, and on-site checks by RC biosecurity staff) they also saw the potential for citizen entry of weed observations as useful in filling in gaps in known presence data.

For researchers the modelling work is not especially time consuming. However, gathering the known weed distribution data is an onerous task. An NWDD could significantly reduce the cost of gathering/aggregating data for models, and therefore allow greater numbers of weeds to be modelled for a particular level of funding. For the purpose of creating national-scale maps of known distributions vs potential distributions, the lack of standardisation on recording of abundance, control methods, etc., was not seen as an issue.

For researchers, being able to monitor change in distributions over time would be very useful. In Britain, for example, over two census periods of weed distributions they were able to establish a change index. This helped to show pathway of spread, and to discern whether infestations were spreading geographically, infilling significantly, or both. This then helped to inform both strategic and tactical weed management efforts. Monitoring change in distributions over time on a national scale in New Zealand would help to correlate spread rates in this country with predicted rate of spread based on that in their native range, or in other countries where they are invasive weeds. This could help increase the precision of the predictive capabilities of New Zealand spread models.

While more detailed data on density, control methods, and success of control are not necessary for national-level models of potential distribution, those data are very useful for models enabling finer grained tactical planning at local and regional scales. These models take into account additional environmental factors such as land cover, soil type, land use, and the location of pathways of spread such as rivers, tracks, and roads. They also use data collected by RCs such as known absence, density, whether control is occurring/has occurred, whether an observation is a planted weed or a truly naturalised occurrence. These models help analyse patterns of spread and can be used to more effectively design regional- or local-level surveillance and control activities, including selecting the optimum management strategy for a particular weed. If biodiversity values and agricultural/horticultural economic values are incorporated they can also be used in impact assessment. This can facilitate planning to rank weeds in terms of their impact, and to get optimal value for money for particular control approaches. It can also be used to assess the benefits of RC staff measuring and recording additional parameters, and collecting more or less data.

While these approaches are most useful at a local/regional level, patterns of impact can be aggregated up into a national picture, and support national-scale decision making, coordination and evaluation. These finer grained models are already beginning to be used in one or two RCs, and this could continue unaided by a NWDD. For increased value they will require standardisation of measures of abundance, and recording of control approaches and control history. As such they could be incorporated into an NWDD at a later stage, once data standards have emerged and stabilised.

Researchers also saw the possibility of developing semi-automated cost–benefit analysis tools for control approaches to particular weeds in particular locations. These would take into account current land use, sites of high biodiversity values, risk analysis, future behaviour of weeds and potential management actions. This could help RCs determine changes to their RPMS, to plan which weeds to prioritise action on so as to get the best value for money spent, and to coordinate tactical actions such as cooperating with DOC and neighbouring RCs on eradication or containment efforts. In addition, building an economic model to be run in a GIS for cost–benefit analysis could save real costs for each council's analysis and decision-making process. This could also facilitate national-level cost–benefit analysis for cases where a national strategy may be required, or to justify the benefits of undertaking biological control.

4.3 Benefits perceived by DOC

While some DOC staff saw inherent challenges with the variability and patchiness of regional council weed data, there were a number of perceived benefits of an NWDD, both for DOC, and for the country as a whole.

Staff at DOC saw value in being able to overlay DOC weed data with RC data for particular weeds over particular time periods. This could support DOC and RC staff working together to 'office-truth' or 'ground-truth' data on a rolling basis, to improve overall data quality.

Staff could also see benefits of an NWDD in facilitating the planning of coordinated weed control management across public conservation land and RC/private land. This is particularly true with regard to changes proposed to the Biosecurity Act (suggested in the Pest Management Proposed National Plan of Action 2010–2035). In particular, the Government has made the decision that, in the future, the Crown will be required to meet good neighbour obligations under RPMS once they are aligned with the National Policy Direction. Increased engagement between DOC and RCs, and adequate data to support robust, strategic decision making, will however be necessary to ensure DOC's resources for biodiversity management are not arbitrarily diverted from achieving national outcomes to local programmes. An NWDD could help avoid these risks.

Some DOC Research & Development staff undertake weed modelling to understand potential impacts on biodiversity values of controlling or not controlling weeds. Having more available and accurate data could benefit this work, and give DOC staff better access to models developed by other scientists.

4.4 Benefits perceived by MAF

As discussed in the sections on related strategies and programmes above, there are a number of ways an NWDD could contribute to projects and outcomes defined by MAF.

For surveillance the NWDD could support increased whole-of-sector information sharing, and the development of standards for weed distribution data.

For the work under the Pest Management Proposed National Plan of Action, an NWDD could support the alignment of national and regional pest management strategies, and make a unified performance measurement framework and national reporting easier to achieve.

An NWDD is also likely to support the development of the 'integrated pest management toolbox' that MAF would like to see, by increasing the flow of knowledge from the science system to application in the pest management system through more data being available to scientists for distribution modelling.

The action plan seeks improvements in tools to ensure less time and money is spent in identifying the information required to design, undertake and evaluate pest management control and monitoring, and on updating organisations' internal information systems to accommodate new pest management regulations and techniques. These objectives are complementary to those of an NWDD.

From a MAFBNZ response perspective they see themselves as potential users of an NWDD. Having access to predictive modelling, and combining this with data on pests and pathogens associated with weeds could help plan incursion responses.

There may be an opportunity to integrate the NPPA database and data on weed control undertaken by MAF into an NWDD, and make information from the NWDD available to internal MAF systems.

The recent draft internal MAF Information Management Strategy advocates making more use of external systems, and the NWDD could be one of these.

4.5 Future benefits to biosecurity and biodiversity

Once the NWDD is established, it is very likely it can be enhanced to incorporate animal pests. This could in a similar way aggregate vertebrate pest management data from RC biodiversity and biosecurity systems, and from VectorNet, PestLink, and NHMS. It could also incorporate invasive invertebrate data from regional and national sources. This would provide a near-complete national view of the status of invasive organisms in New Zealand.

In addition, the system could be used to aggregate data on native species from local and national sources to provide a complete picture of known data on the condition of indigenous biodiversity.

These expansions of an NWDD into a national pest distribution database, or a national biosecurity/biodiversity distribution information system, will very likely take some years to realise, but they are almost certainly achievable given enough interest, will and resourcing.

4.6 Financial benefits

The financial benefits of establishing an NWDD are not easy to quantify, and a detailed cost–benefit analysis has not been conducted as a part of this scoping study.

By way of example, however, the recent modelling of the potential distribution of Chilean needle grass[13], and the economic impact modelling of different control scenarios for that weed[14], demonstrate the approximate quantum of savings that could be achieved by an NWDD.

The potential distribution of Chilean needle grass in Canterbury was determined in a research project led by Graeme Bourdôt. This involved using a CLIMEX model to determine its potential habitats, and assessment of the current land uses of those areas (e.g. high producing pasture). In order to estimate the costs of Chilean needle grass spreading from current infestations, a model of plant population growth and regional spread was then used to determine the outcome of no regional intervention, versus regional control through adding the weed to ECAN's RPMS. This showed a net present value cost of $0.4 to $1.2m including lost production and costs of control by landholders for no regional control, versus a net present value cost of $290,000 for regional control.

It is likely that an NWDD could help avoid similar levels of potential economic loss and/or loss of biodiversity, by making the right information accessible for decision making to ensure other weeds emerging from their lag phase can be proactively controlled on a regional or national basis. It would do this by reducing the costs for data aggregation for such models, and by making such models more visible and accessible to regional and national decision makers.

Weeds occurring currently in New Zealand's pastures have an aggregate cost to the economy of $1.2 billion/annum and ongoing naturalisations from a pool of 25,000 exotic plant species are steadily creating new weeds, the impacts of which could be precluded by early recognition and appropriate action[15].

Of the eight RCs for which a detailed comparison of their RPMSs was done for this scope, there were 74 different weed species in the Total Control category. Of these an average of 17.5% were unique to their region. Only 2 weeds were in five of the eight regions, 2 were in four, and 5 were in three (with none in six, seven, or all eight regions). Given this level of current limitation in range for total control weeds, and given that all total control weeds are likely to be in their lag phase, the economic and/or biodiversity impact from these and other new weeds is likely to be high if optimal classification and control approaches are not used regionally and nationally. If the economic impacts were of a similar order to that of Chilean

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[13] Bourdôt et al. 2009. The potential global distribution of the invasive weed *Nassella neesiana* under current and future climates. Biological Invasions: Special Issue ICBI.

[14] Harris Consulting 2010. Economic evaluation of regional pest management strategy for plant pests. Report prepared for Environment Canterbury.

needle grass this would equate to between $8m and $67m NPV losses that could be avoided by other individual regions instituting timely enough proactive control or containment outside their borders (for just the weeds from these eight RCs, let alone those from the eight others). This is of course an extremely rough estimate, as the cost impacts will be different for different regions, different weeds will have different behaviours and costs associated, and many of the weeds have more of a biodiversity impact than an agricultural one, for which the dollar value of is harder to assess.

That said, it appears likely that having the data, models and information available to ensure the right decisions can be made could lead to some significant cost savings. In fact, the only way to more accurately estimate the magnitude of those savings regionally and nationally is to conduct the kind of study done for Chilean needle grass. These kinds of studies, along with raising awareness of their results, would be made significantly easier and more effective with an NWDD in place.

In addition, Cowan et al[16] estimated an annual $20m expenditure on pest control across RCs, with a further $4.3m on monitoring. The development and adoption of an NWDD and the information management and knowledge application principles it will facilitate (e.g. the sharing of best practice control approaches, and enhancement of outcome monitoring) are also anticipated to promote dramatic changes in strategic and tactical weed management practice. Calculating the exact economic returns of these changes in weed management practice is difficult. Even a 5% improvement in efficiency through use of an NWDD however would come close to justifying the costs for the project, without even taking into account the reduction in potential costs and economic losses through infestation in new regions as described above.

5 Vision

A vision for an ideal information management system for weeds is as follows.

Data Capture and Management:

- All councils are collecting weed management data according to a set of nationally agreed protocols for monitoring, surveillance, regulatory intervention and performance evaluation. These protocols are nested within a broader set of agreed protocols covering the broader range of biodiversity-related data.
- Definitions of data 'fields' within information systems are based on national and international standards.
- Data content is based on standard terminologies and incorporates live data feeds from national 'data dictionaries' (e.g. spatial data, NZOR names, etc.).
- Metadata about data are captured and managed similarly and nest within the broader category of a defined set of national environmental metadata.
- Where appropriate data management is carried out at the national level, and where appropriate it is managed locally, without barriers or even the realisation by end-users that some systems are local, and others national.

Data Aggregation:

- All local council systems provide a set of standard web services by which their data may be remotely interrogated.
- All data can be accessed and integrated nationally with minimal manual communication, intervention, or data manipulation necessary.
- All council systems have an agreed, standardised security model for identity management and data access.
- A national organisation (e.g. a government agency, or the Biosecurity Institute) coordinates the harvesting and integration of data from distributed data-providers, conforming to an agreed exchange standard, and automatically consolidates those data into a central repository for modelling and reporting.

Online Services/Applications:

- A national organisation provides agreed services based on the central data repository.
- Those services would include tools and interfaces for locating, compiling, reporting/downloading and annotating data.
- End-users are able to capture and reuse the workflows they created for locating/reporting on specific weeds or areas.
- Configurable early warnings to specific end-users of defined changes in data (e.g. new high-risk weed detected in adjacent council area close to border, or spread probability model indicates increased surveillance necessary).
- Access to reporting tools for spatial and temporal visualisation of data through GIS systems.

- Access to standard spatial and temporal national data layers (e.g. land environments, climate) for providing context for end-user analyses of data.
- Access to live simulations and models, based on live input data, for potential spread, pathway risk analysis, and the cost–benefit of intervention, at both national and regional scales.
- End-user generated data+model+output sessions captured as workflows and capable of being easily established, modified and reinvoked.

Information Sharing:

- Council information systems are able to communicate and integrate directly with NWDD services as part of the emerging national information infrastructure.
- Access to a maintained catalogue of expertise, and a community of practice with private/open forums for discussion among experts, and the ability to capture, annotate and locate 'soft knowledge'.
- Access to a maintained catalogue of standard monitoring protocols, case studies and evaluations.

This vision for data management is currently unachievable, and is unlikely to be completely achieved until 2015–2020. In planning an NWDD it is necessary to balance such a vision against the current reality and select initial components that provide the clearest cost–benefit, and establish a pathway to achieving such a vision over time.

In this context we identify an initial scope that is achievable and does not compromise the longer term vision.

6 Scope

6.1 Functional scope

The functional scope defines what the system will do, i.e. the ‘functions’ that it provides to users. As with the data scope (section 6.2) and system scope (6.3), a staged approach is proposed, with initial functionality delivered in the first two years of the project, and additional functionality delivered in stages thereafter.

6.1.1 Initial functionality

As a part of the initial system, public users will be able to:

- View national and regional distribution maps for one or more individual weeds
- View national distribution maps for individual weeds colour-coded by RPMS status in each region
- View national and regional distribution maps for individual weeds overlaid with potential distributions based on distribution models (where those models have been developed by researchers)
- View national and regional distribution maps for individual weeds overlaid with national spatial layers from Land Environments of New Zealand (LENZ), the Landcover Database (LCDB) and other publicly accessible environmental layers identified by end-users

NB for the general public, it is suggested that maps will be to some extent ‘zoomable’, but not down to the individual-property level.

Registered users (such as those within RCs, central agencies, and research organisations) will be able to do all of the above, and:

- View national and regional distribution maps for one or more individual weeds:
  - showing comparisons with historical ‘snapshots’ of distributions, to view change over time
  - zoomable down to the level where individual points or polygons (including property boundaries) can be observed
  - for individual infestations, view the date on which that infestation was recorded, and its (non-standardised) management status
  - allowing the overlay or removal of distribution layers from external sources such as NVS, NHMS, NZ Biodiversity Recording Network (NZBRN), NZVH (where those external sources have been integrated with the NWDD)
  - showing annotations provided by registered users against data

- Use NZOR data to resolve ambiguities and differences in scientific and common names
- Extract data from the system for use in offline modelling tools
- Participate in an online forum to discuss use of the system, suggested enhancements, and to share experiences and knowledge about weed management
- Provide feedback to other RCs on data quality issues, and to administrators of the system on issues with data quality and functionality

Administrators of the system will be able to:

- Upload regular 'snapshots' of updated data from RCs
- Upload new predicted distribution models developed by scientists

6.1.2 Additional functionality

As a part of future stages, public users will, in addition, be able to:

- Provide comments and feedback on the status of particular infestations
- Provide information on new infestations, with a subsequent notification sent to the relevant RC
- View information on weed identification (e.g. keys), and best practice control methods

Registered users will be able to, in addition:

- View national and regional distribution maps for one or more individual weeds:
    - showing introduction/spread pathways
    - qualitative and quantitative densities
    - management status (nationally standardised)
    - management methods (nationally standardised, or just free text)
    - view change indices over time
    - showing predicted spread over time given no control activity in their region (based on models)
    - showing predicted spread over time given varying levels of control activity in their region (again based on models)
- View reports showing tables and graphs of weed RPMS category, distribution, and success of control for each region
- Use automated cost–benefit analysis tools for particular management scenarios in particular locations

- Receive and action feedback from citizens on potential new infestations, including verifying new infestations, and/or responding to feedback (as a comment in the system, and an automatic email to the person who provided the feedback)

Administrators of the system will be able to:

- Set up new web service connections to harvest and integrate data directly from RCs' systems
- Set up regular harvesting schedules, and initiate one-off harvests as required
- Upload advanced predicted distribution models developed by scientists
- Upload new cost–benefit models developed by scientists

6.2 Data scope and recommended basic fields

The initial scope of the NWDD should include all those plant pests managed by RCs (including those for both terrestrial/freshwater and marine environments) as part of their RPMS, and those plants listed on the NPPA and managed locally.

One issue this raises is that RPMS species vary between regions, consequently integrating regional data will not result in a complete national picture for some species. It is therefore critical to incorporate metadata for each region that include the list of species they monitor/manage, and their respective status under the respective RPMS, so that the inherent patchiness of integrated regional data may be assessed. It should be noted that this range of species may include plant pests of the marine environment.

The actual scope of data incorporated into a NWDD in the short and longer terms needs to be agreed as part of the project implementation. It is likely it will be valuable to incorporate other data sources such as DOC Weeds, NZBRN, NVS, and the NZVH in subsequent stages. It may also be useful to provide for non-RPMS weeds managed by RCs.

While the data scope is not yet completely agreed, the following defines in general terms the immediate minimum requirements, and longer term desirable elements.

6.2.1 Proposed minimum dataset for short-term implementation

1. RC Team Metadata
    a. metadata concerning the council/team providing the data
    b. the complete list of species managed by the council, their respective management categories, and date of the respective RPMS
2. Weed Observation Data
    a. Identifier for the RC team carrying out the observation
    b. Descriptor for the operation that resulted in the observation
    c. the name of the species (scientific or common name)
    d. spatial location as a point locality (GPS/MAP coordinates), a specified land

parcel, or a defined polygon boundary

e. the date on which the species was observed

f. local RPMS Status at the time of observation (Low-incidence weeds and new weeds, Widespread weeds)

g. Presence (Absent, Sometimes Present, Present)

6.2.2 Desirable data components to be considered in future implementation

1. Introduction/spread pathway data
2. Qualitative Density (Localised and numerically rare, etc. …, widespread and dominant)
3. Quantitative Density Type (defined in a SOP)
4. Quantitative Density Value (classes defined in a SOP or free text?)
5. Management Status (New, Active, Monitoring, Historic*)
6. Management Method (free text)

* The 'Historical' value for Management Status can be used to infer absence at some point, but this approach should be restricted to Total Control weeds because EW, for example, may declare compliance to be 'Complete' for Containment pest plants when they have decided not to re-inspect unless there's another complaint. It would therefore be erroneous for a 'Complete' site to be treated as a 'Historic' site.

6.2.3 GISIN data models and concepts

A consideration for an NWDD is how it may integrate, in the future, with existing national and international data-sharing networks such as the Global Invasive Species Information Network (GISIN). GISIN has deployed six data models that build on the components of Darwin Core[17] biodiversity data standard and the Dublin Core[18] metadata standard, but which define additional concepts that are important to invasive species science. The site classifications used by RCs can be readily mapped to the Status concept in GISIN's ManagementStatus data model. Qualitative density information used by RCs can be mapped to GISIN's Abundance and Distribution concepts in the SpeciesStatus data model, and RC weed classifications can be mapped to GISIN's RegulatoryListing concept.

The full GISIN Protocol[19] incorporates data models for SpeciesStatus, ManagementStatus and Common Concepts. They are detailed in the Appendix to this document.

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[17] Biodiversity Information Standards, TDWG, Darwin Core: http://rs.tdwg.org/dwc/index.htm

[18] Dublin Core Metadata Initiative: http://dublincore.org/

[19] Global Invasive Species Network protocol: http://www.gisin.org/cwis438/websites/GISINDirectory/tech/Protocol_Home.php?WebSiteID=1

6.3 System scope

The vision for the NWDD incorporates an on-demand, technology-mediated data harvesting and national integration portal. The NWDD would thus be a continuously updated and automatically synthesised data-store requiring little human intervention for its maintenance, thus reducing associated ongoing costs.

The current absence of nationally applied standards for data collection protocols, storage and management, requires that a short-term scope for the NWDD must involve a human-mediated process for data acquisition, with centralised integration and management. In the longer term the NWDD would evolve to using agreed national protocols which may emerge from activities supporting the Pest Management Proposed National Plan of Action 2010–2035. In the near term the process of creating an NWDD would utilise only the minimum data standards outlined above. The system would, however, incorporate technology tools to facilitate data harvesting in a variety of formats from data providers, and its repeated transformation into a common standard. The NWDD would consist of a centrally managed integrated dataset, with the component council datasets updated as required. This central repository would have local support tools to identify and resolve issues concerning species names, or point/boundary spatial data. The central repository would have an associated website providing different levels of data access for registered/authorised users, and the public. It would also have a standard set of web-services allowing councils to directly link local data management/reporting systems to the NWDD repository, and to allow the incorporation of NWDD data into predictive modelling tools.

7 Technology

7.1 Architecture

The ideal architecture would be a 'Service Oriented Architecture'[20] enabling an entirely technology-mediated automatic harvesting of data from a distributed network of data providers and its integration into a centralised repository. The repository would have a standard set of website and web-service interfaces to the data and tools. The short-term realistic scope outlined above relies more on a human-mediated network for data acquisition; initially, a semi-automated process for data integration and validation, and a standard set of centralised data interfaces. It is feasible to design the overall systems architecture such that it can transition from the near term to the longer term vision. The necessary modularisation of functional components, linked by standard data and service interfaces, remains largely unchanged by the replacement of an initial human-mediated data-flow pipeline with an automatic process.

[20] Service-oriented Architecture, SOA: http://en.wikipedia.org/wiki/Service-oriented_architecture

7.2 Development options

The initial proposed implementation of an NWDD would have no consequences for the systems currently being employed or developed within RCs. In the initial phase all the technology development is associated with the national repository. In the longer term there would be necessary changes to council systems so they can automatically consume and deliver data from/to the NWDD and its associated services and tools, and these should be taken into account in individual and joint RC systems development projects. The most fundamental long-term change is the adoption of nation-wide standard protocols and data standards.

Further design and analysis will be required to determine the optimal development platform for the NWDD. There are a range of options including reusing parts of systems and tools being developed overseas (e.g. in the Atlas of Living Australia project).

The estimates of costs for development of the NWDD included in this document are based on the existing geospsatial and software infrastructure and capabilities within Landcare Research.

8 Governance

Governance involves decision making on aspects such as priorities for system functionality, assigning responsibilities and authority for system management and maintenance, implementation of particular data standards, and sourcing and ensuring the responsible spending of funds for system development and maintenance. Governance may also involve some ongoing engagement and communication with senior decision makers in agencies in the biosecurity sector.

Governance will be required both during and after the initial establishment project; however, the appropriate governance structures may be different for each of those phases.

There was consensus among stakeholders interviewed that a governance group should be representative, and have members from RCs, the Biosecurity Managers Group, the Biosecurity Institute, MAF, DOC, and the research organisations.

There were differing views about whether in the longer term the governance should be 'hosted' by MAFBNZ, or by the Biosecurity Institute. This should be explored in more depth during the initial establishment project. It should be noted also that in the Pest Management Proposed National Plan of Action 2010–2035 a governance structure for the integrated pest management toolbox is suggested:

> *A group comprising representatives of major stakeholders would oversee and foster the establishment of the pest management toolbox. Capability to undertake projects and programmes of work would be provided by a toolbox manager jointly funded by pest management agencies and situated within MAF.*

This could be an appropriate 'home' for the NWDD governance, and may be able to provide administrative support for NWDD governance functions.

It is suggested that if an NWDD establishment project commences before the above pest management toolbox governance structures are set up, the existing NWDD project steering group be engaged on a more formal basis. The existing Steering Group comprises Graeme Bourdôt, AgResearch (Chair); Matthew Brown, AgResearch; Jerry Cooper and Kevin Richards, Landcare Research; Richard Bowman, ES (regional council representative on behalf of Biosecurity Managers Group); Brendan Gould and Mike Harré, MAFBNZ; Kit Richards, Forestry Industry; Carol West, DOC; Ann Thomson, DOC. It may be desirable to include additional representatives from regional councils, and from the Biosecurity Institute.

9 Implementation

9.1 Technical platform

The scope and architecture outlined here makes no assumptions about the underlying technical platform. Different components, within RCs, and within the centralised NWDD repository could be assembled using any number of platforms. Agreement is necessary only to determine the service-level interfaces between different systems. Here we envisage the adoption of industry standard protocols such as SOAP/REST/XML[21], and the range of OGC[22] spatial interface standards. These communication protocols would wrap the underlying data, in the form of the minimum dataset for data provision and reporting, or standard spatial data-formats.

9.2 Data content

We recommend an initial 2-year pilot project to establish an NWDD platform. In this preliminary phase only the minimal dataset outlined above would be considered for incorporation into the NWDD.

As a way to demonstrate value, and deliver ‘quick wins’ during the first six months of the project, it is proposed that existing map layers of predicted distributions be provided on an early iteration of the geospatial infrastructure and web portal for the project. Predicted distribution layers have already been developed for Nassella tussock, Chilean needle grass, hawthorn, buddleja, and layers for giant buttercup and early yellow bristlegrass will be available early next year. These layers go down to 5x5km square resolution, and show which areas are climatically optimally suitable, suitable, marginally suitable, and unsuitable for each weed. The layer for Chilean needle grass also incorporates land use factors and the layer for Nassella tussock will do so very soon.

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[21] SOAP – Simple Object Access Protocol: http://en.wikipedia.org/wiki/SOAP
REST - Representational State Transfer: http://en.wikipedia.org/wiki/Representational_State_Transfer

[22] OGC – Open Geospatial Consortium: http://en.wikipedia.org/wiki/Open_Geospatial_Consortium

Alongside this ‘quick win’ deployment of existing predictive distribution layers, the initial phase of the project would establish an agreed minimal dataset, and agreed data-standards. These standards would then be used to design and develop the NWDD central repository during the first year.

Available data would then be manually collated from RCs. NWDD personnel would develop technology-assisted integration and validation processes to incorporate these data into the NWDD. This would be followed by a ‘truthing’ exercise, as was carried out by Clayson Howell in preparing a national grid-based overview of weed distributions for DOC (and could, with permission, use and build on the results of that exercise). At the end of year one the initial NWDD would have sufficient content to allow the design and development of RC, public and researcher/modeller interfaces to the NWDD data. Year two of the project would involve the extension of the data standards to incorporate a broader range of data, but not implemented within this initial project.

Some recommendations for RCs to consider regards ongoing standardisation of data collection and storage are included in the Appendix in section 13.1.

9.3 Implementation process

There are four identified workstreams for the project:

1. Project Management
2. Governance and Engagement
3. Data
4. Technical

9.3.1 Project management

This involves:

1. Initial project planning (month 1)
2. Ongoing project management (months 1–24)
3. Ongoing project communications with stakeholders (months 1–24)

9.3.2 Governance & Engagement workstream

This involves:

1. Establishment of a national body to carry implementation of the NWDD (month 1)
2. Establishing governance structure (months 1–3)
3. Establishing nominated network of data providers/champions (months 1–18)
4. Using national forums (including work defined in the Pest Management Proposed National Plan of Action 2010–2035) to actively promote the development and adoption of national protocols and standards, (months 18 onwards) leading to:
    a. Nationally standardised protocols leading to comparable data
    b. Planning for future technology-based solutions requiring minimal human intervention for data management and integration
    c. Nationally current and archived, evidence-based reporting, including change of state with time
5. Developing long-term support and maintenance plan for the NWDD (months 18–24)

9.3.3 Data workstream

The Data workstream includes the following tasks:

1. Establish network of individual/institutional contacts as data providers (months 1–3)
2. Develop a minimal agreed data standard for data sharing which can be mapped to data already collected by the majority of councils (months 1–6)
3. Carry out manual data harvesting, distribution and RPMS status, and provide feedback to providers (months 3–18)
4. Establish agreed access to national spatial data layers: Cadastral, LENZ, LCDB (months 1–24)
5. Establish access to spatial prediction layers, and publish these layers on an early iteration of the NWDD web site (months 1–24)
6. Establish access to NZOR (months 3–8)
7. Carry out 'office-truthing' of NWDD content (months 12–24)
8. Engage and support regional and national initiatives in standards development.(months 1–24)

9.3.4 Technical workstream

This involves the development and deployment of the following key components:

1. Systems architecture design (months 1–6)
2. Workflows for transforming data from RCs into a form suitable for integration into a national dataset (months 1–3)
3. Core NWDD and GIS cache database systems (months 1–18)
4. Identity management system (months 3–12)
5. Admin tools – upload/replacement process for datasets (months 3–8)
6. Admin tools – upload/replacement process for spatial models (months 12–24)
7. Interface for NZOR taxonomy disambiguation service (months 8–12)
8. Web-services and website (data discovery, access, visualisation and reporting):
    a. Registered users having full access to data content (months 12–24)
    b. Public users with some agreed level of access to data content (months 12–24)
    c. Mapping services (months 3–18)
    d. Linkages with DOC NHMS and Weed Management systems (months 12–24)
    e. OGC services to end-users (months 18–24)
    f. Data download services (months 8–12)
9. Digital forum to encourage a national community of practice of users of the system (months 12–24)

10. Engage and support regional and national initiatives in systems development (months 1–24)
11. Prioritise the development of automated harvesting and integration of relevant data from additional sources, according to resources available (months 12–24). Integration of these data would be straightforward if New Zealand had an operational GBIF node. In the absence of that national coordination, the inclusion of any of these data into an NWDD will be dependent on available resource within this project:
    a. NVS
    b. DOC NHMS
    c. DOC Weeds
    d. NZ Biodiversity Recording Network (NZBRN)
    e. NZ Virtual Herbarium (NZVH)
    f. Global Biodiversity Information Facility (GBIF)

10 Costs

The Project Management and Governance & Engagement workstreams (outlined in 9.3.1, 9.3.2 above) are estimated to consume around 0.2 FTE over the 2-year period.

The Data workstream (9.3.3 above) is estimated to require 0.3 FTE over the 2-year period.

The Technical workstream outlined in 9.3.4 is estimated to consume the most resource, at around 0.75 FTE over the two years.

Using typical staff rates for appropriate qualified personnel, e.g. within Landcare Research, costs for the workstreams would be as follows:

Workstream	Cost
Project Management	$51,750
Governance & Engagement	$60,375
Data	$188,812
Technical	$394,875
Total	**$695,812**

With a travel budget of $5,000 this would bring the estimated establishment cost of the NWDD over the initial 2-year project to $700,000.

Ongoing annual maintenance/support is expected to require 0.25 FTE, with an approximate cost of $70,000 per annum. This is based on expected effort required for ongoing data collection/curation, and maintenance of the system software, and managing support requests from users.

Estimated costs exclude GST.

10.1 Exclusions

It would be possible to minimise infrastructure costs by hosting the NWDD within an organisation already configured to support these kinds of systems and services, such as a national operational agency or a CRI. Hardware and software infrastructure costs have therefore been excluded as they will vary significantly depending on where the NWDD is hosted.

Also excluded is any time/costs accrued by RCs or other agencies in order to become NWDD data providers, the follow-up data quality assessment, or engagement as part of the NWDD governance structure. We have also excluded costs associated with the development and delivery of national spatial models for predicted distributions, as these would be expected to be funded from research programmes.

Not all items under ‘Prioritise the development of automated harvesting and integration of relevant data from additional sources’ (point 11 from the Technical workstream 9.3.4 above) are costed into the project. Some of these may be achievable if there is surplus resource from other project tasks. Actual costs are largely dependent on technical infrastructure currently being separately planned or developed for those systems. If, for example, these systems have GBIF providers installed then the data could simply be harvested directly from those systems, or from GBIF itself. For NVS and NZBRN the required software infrastructure is already in place. For DOC Weeds and/or NHMS, and the NZ Virtual Herbarium it is not.

10.2 Workstream breakdown

The following table provides estimates of the staff resource required for component of the workplan described in section 9.3 above.

Workstream	Task	Estimated **hours**
Project Management	Initial planning	38
	Ongoing project management	150
	Ongoing project communications	38
Governance & Engagement	Establishment	75
	Ongoing governance & engagement duties	113
	NWDD continuance	75
Data	Provider contact network	150
	Standards development	38
	Manual harvesting	300
	Spatial layers	113
	Predicted distributions	150
	Office-truthing	150
	Data standards outreach	94
Technical	Analysis/architectural design	300
	Harvesting workflows	188
	Core systems	450
	Identity management	113
	Tools/data	188
	Tools/models	188
	NZOR integration	113
	Web services/sites	600
	Digital forum	75
	Technical outreach	75

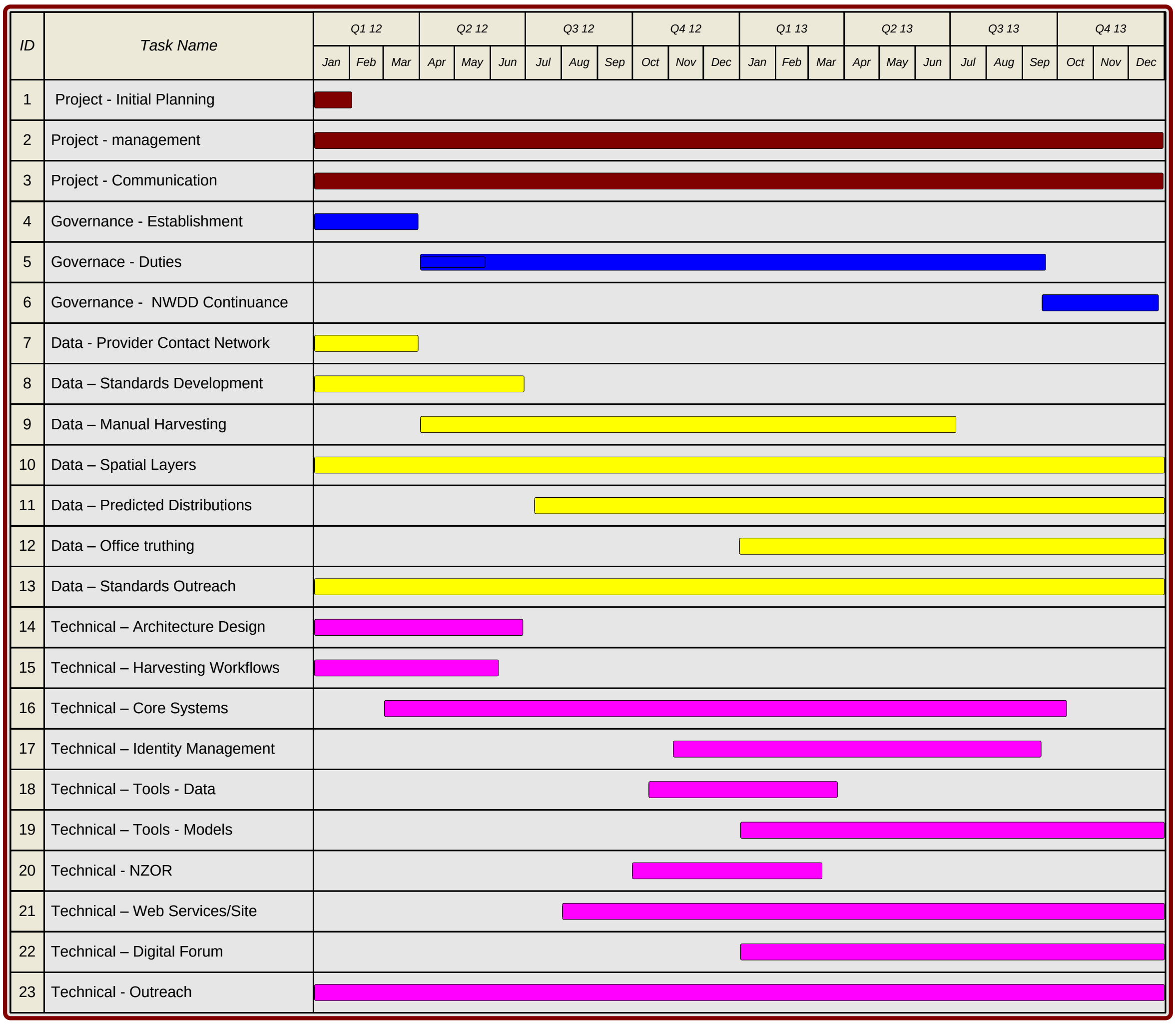
10.3 Future enhancements

Costs for integration of data from additional sources (such as NHMS and the NZVH), as described in point 11 from the Technical workstream 9.3.4 above, are difficult to estimate currently, and are dependent on whether these systems are established as GBIF providers, or whether manual harvesting would be required.

The effort associated with implementing future enhancements to the initial platform, as outlined in section 6.1.2, would require an estimated budget of $400,000 to $600,000.

11 Timeline

Fig. 10.1 Timelines for implementing NWDD stage one



Note, this timeline assumes project commencement at the beginning of 2012, and conclusion of stage one at the end of 2013. Task durations would be similar if the project were begun at an earlier or later date.

12 Recommendations

The findings of this scoping study indicate there is significant interest in establishing an NWDD. Participants in the scoping study could see a number of benefits that would support their weed management efforts, including:

- Viewing changes in weed distributions in other regions
- Understanding threats on their borders and the factors causing those threats
- Understanding how weeds would spread in different circumstances
- Improved decision making through better predictive models
- Acting as a a long term archival service for weed distribution data
- Helping identify national priorities for coordinated action

Many of the recommended items for initial implementation have already occurred as 'static' one-off exercises (e.g. the 10x10 grid weed distribution project, and the predicted distribution models and economic impact analysis for Chilean needle grass).The initial investment in the first stage of an NWDD would contribute significantly to the benefits perceived by stakeholders, and in achieving the financial benefits described in section 4.6 above.

As a relatively modest investment in national biosecurity/biodiversity information infrastructure, an NWDD will support improved decision making, improved monitoring of output performance, and more optimal prioritisation of resources. In addition the development of an NWDD is likely to have a significant role in stimulating engagement, collaboration and cooperation around the adoption of national standards and protocols.

The project is well coordinated and aligned with other national initiatives such as the Pest Management Proposed National Plan of Action 2010-2035, DOC's NHMS Programme, the move to shared systems in local government, and the recently released Directions and Priorities for Government ICT.

It is recommended that a staged approach be taken to the development of an NWDD. The initial stage should focus on realising some short-term benefits, and on catalysing and stimulating the changes in data collection, standards, and RC systems that will be necessary to achieve the longer term vision.

The first stage of the NWDD project will integrate these existing approaches to manual data aggregation and display of predicted distribution layers, and will incorporate a wider range of potential data providers and consumers. It will also include the development of services providing data discovery, reporting and access to modelling and data visualisation tools. Together with an appropriate governance model it is suggested this approach provides the optimal pathway to developing an NWDD with multiple benefits, to encouraging debate and development of national data standards and protocols, and potentially serving as a template for mobilising regional data for subsequent reuse at both the regional and national level.

It is recommended that further stages of development for an NWDD then focus on automated harvesting of data from RCs, incorporation of more data on density, management methods, and change indices over time, and on providing more sophisticated predicted spread models and automated cost/benefit analysis tools for particular management scenarios.

13 Appendix 1

13.1 Some recommendations on data collection arising from this work

These are some observations and suggestions regarding information collection and sharing that are additional to the minimum recommended dataset that would be mobilised in an initial pilot of an NWDD. They are a contribution to necessary debate, which will be promoted within the pilot project, concerning the development of protocols and standards.

1. It would be extremely helpful if RCs shared their experience and developed standard operating procedures for quantitative measures of density for different groups of RPMS weeds, because there is not one metric that suits them all. This would improve data collection, provide a more accurate picture of weed distribution, and a better insight into the results of control treatments. If density information is updated with each inspection, it can be used to infer trend where no control has taken place, or the outcome of control where control has taken place.

   Some candidates for quantifying infestations at monitored sites are:
   a. Numbers of plants
   b. Dominant age class
   c. Numbers of plants in each age class
   d. Area of infestation

   Some additional candidates for quantifying infestations at treatment sites are:
   e. Quantity of material removed
   f. Quantity of spray applied

2. Qualitative measures of infestation density may provide other RCs with a better picture of how severe a weed is in another region and what it is doing over time. The invasion process framework proposed by Colautti and MacIsaac[23] (2004) could be adapted and used to promote standard and consistent qualitative recording of weed density. For any geographical context (a point representing an infestation, a property, a section of a river, a forest, a region) an infestation can be described using one of six classes:
   - Localised and numerically rare
   - Localised and common
   - Localised and dominant
   - Widespread but numerically rare
   - Widespread and common
   - Widespread and dominant

[23] Colautti RI, MacIsaac HJ 2004. A neutral terminology to define 'invasive' species. Diversity and Distributions 10: 135–141.

Classification of infestations will still be subjective, but this simple framework reflects the language that biosecurity officers use and conveys additional information that lies behind location data.

3. It would be helpful to have a national picture of change in status over time for sites where control is occurring, because it shows outcome of control operations. Sites are reclassified over time according to length of time since last visit and what was seen. The following widely used framework could be proposed as a national standard and RCs could be encouraged to record site classification consistently:
    a. New site (discovery and initial knockdown)
    b. Active site (regular ongoing control)
    c. Monitoring site (frequent reinspections)
    d. Historical site (infrequent inspections)

4. There is potentially useful information on control methods and outcomes in the Inspection Notices and Notices of Direction issued by RCs, including date, recommended action, action taken, amount of herbicide, and any follow-up required. Outcome monitoring information was specifically requested by a number of RCs to assist with their control programmes. ECAN is developing outcome monitoring protocols underpinned by science and uses standards developed by CRIs. The Biosecurity Managers Group (BMG) is developing a national approach to outcome monitoring and trying to determine the degree to which RC interventions impact on those outcomes.
5. Recording botanical names and NZOR identifier when available in databases, rather than common names, will make it easier to find and share information.
6. Biosecurity officers are sometimes aware of dispersal mechanisms of weeds but this information is rarely recorded. If it was recorded systematically and shared it would help other RCs identify and manage pathways to prevent new weed incursions. The GISIN standard for dispersal information includes a framework for describing dispersal using three mechanisms and six pathways. Dispersal may occur through three broad mechanisms: the importation of a commodity, the arrival of a transport vector, and/or natural spread from a neighbouring region where the species has been introduced. Five pathways are associated with human activity either as commodities (release and escape), contaminants of commodities, stowaways on modes of transport, and opportunists exploiting corridors resulting from transport infrastructures. The sixth category highlights alien species that may arrive unaided in a region as a result of natural spread (rather than human transport) following a primary human-mediated introduction in a neighbouring region (from Hulme et al. 2008[24]).

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[24] Hulme PE, Bacher S, Kenis M, Klotz S, Kuhn I, Minchin D, Nentwig W, Olenin S, Panov V, Pergl J, Pyßek P, Roques A, Sol D, Solarz W, Vila M 2008. Grasping at the routes of biological invasions: a framework for integrating pathways into policy. Journal of Applied Ecology 45: 403–414.

13.2 Survey questionnaire

The following are the questions that were asked during interviews with RC staff:

1. **Regards weeds and weed distributions, what are the real-world problems you're trying to solve?**
    a. In relation to weeds themselves (e.g. biodiversity, significant/valued site management, threatened species management, agricultural/horticultural)
    b. To what extent is information a barrier to dealing with weeds? (e.g. lack of data, inadequate information systems, less than adequate resources to collect data)
2. **What kind of data do you record on weeds?**
    a. E.g. species, location (point/polygon), density, spread over time, control efforts (plans, results)
    b. What survey/monitoring protocols do you use? Does this differ for different types/classifications of weeds?
    c. How do you record data in the field?
        i. Has this changed in the last two years (since Britta Basse’s survey)?
        ii. Are you planning improvements to this?
    d. Do you record absence? Or non-monitored areas?
    e. How often is this data updated? Do you keep time series? Does this vary for different weeds/sites?
    f. How do you categorise weeds?
    g. How do you measure/record eradication? (e.g. a weed was here, and now it’s not)
    h. What standards do you use for your weed data?
3. **Where do you store data on weeds?**
    a. What kind of systems do you have/use?
    b. How easy is the system to use? How useful is it?
    c. Has this changed in the last two years?
    d. What are your plans for developing these further?
    e. Do you use the same/similar systems for animal pests?
    f. What methods do you have for extracting data from those systems?
        i. E.g. printable reports, export to spreadsheet, export to GIS system, web services interface
        ii. How easy/time consuming is it to extract data when requested?
    g. To what extent is data security important? Are there things you won't want viewable by the public, scientists, other local government agencies
    h. What national projects are you aware of/involved in (e.g. IRIS, One-Land, GISD, NZBRN)

4. **If you're looking for information on weeds/weed distributions that you don't have, where do you go?**
    a. Out of the following what do you prioritise/value?
        i. Data from other RCs
        ii. Data from DOC
        iii. Priorities and risk ratings for particular weeds
        iv. Control approaches and performance outcomes
        v. Modelling data from AgResearch/Landcare Research
    b. Who do you work with at these organisations? How helpful were they? How useful has the information been?
5. **Do you use predictive modelling tools for weed distributions? If so:**
    a. Which ones are you aware of?
    b. Which do you use?
    c. What value do you get from them?
    d. What kinds of predictive modelling would you like to be to do that you can’t now? What kind of problems might this help solve?
6. **If a National Weed Distribution Database was developed what value would it be to you?**
    a. What tools and services might it provide that would be helpful?
    b. To what extent would seeing weed distributions in other regions be useful? What could you do if you had access to those data?
    c. To what degree do you think it would be helpful to you if scientists had access to more complete/up to date weed distribution data?
    d. What value would you place on:
        i. knowing what's next door and what they're doing
        ii. better knowledge of how things will spread in particular circumstances
        iii. climate change prediction
        iv. archival services (ensuring there's a standardised long term home for your data)
    e. What system architecture do you think would be most sensible (centralised, federated, mixture)
    f. What type of governance processes do you think would be appropriate for such a system?
    g. What would you see as the options for ongoing funding and maintenance of such a system?

13.3 Classifications used by councils in their RPMS

Table 3 Classifications used by councils in their regional pest management strategies

Council	Classification	Short working definition
NRC	Service Delivery	Refers to pest plants that are of limited distribution or density within the Northland Region, or defined areas of the Region, for which the NRC shall assume responsibility for funding and implementing appropriate management programmes.
NRC	Total Control Pest Plants	Refers to pest plants, in defined areas, which land occupiers are required to treat whenever they appear on their land.
NRC	Boundary Control Pest Plants	Refers to pest plants, in defined areas, which occupiers are required to treat in boundary situations.
NRC	Quarry Control Pest Plants	Refers to those pest plants that the owners or occupiers of quarries and metal stockpile areas are required to control or eradicate from these areas.
NRC	Community Control Pest Plants	These are specified pest plants that have the status of total control pest plants within a designated Community Pest Control Area.
NRC	Roadside Control Pest Plants	Refers to those pest plants which road controlling authorities are required to progressively clear from the Region's road reserves, in accordance with an approved programme.
NRC	Surveillance Pest Plants	Surveillance pest plants have been identified as being of potential high risk to the Northland Region.
NRC	Advice Only	NRC will provide advice only for these pests.
ARC	Total Control	ARC carries out all control work.
ARC	Containment (Removal)	Landowners/occupiers are required to carry out the control work on their property, throughout or in designated parts of the Auckland Region.
ARC	Containment	Landowners/occupiers are required to carry out the control work on their property to a specified distance from any

Council	Classification	Short working definition
	(Boundary Control)	property boundary, throughout the rural parts of the Auckland Region.
ARC	Surveillance Pest	Plants banned from sale, propagation, distribution and display within the Auckland Region.
ARC	National Pest Plant Accord (NPPA)	Pest plants banned from sale, propagation, distribution and display throughout New Zealand (refer Appendix 2).
ARC	Community Initiatives Programme	Community groups may nominate any pest plant in the Strategy on which to carry out control work on. The ARC will provide regulatory back-up for 27 of these.
ARC	Research Organism	Plants that the ARC will carry out research on over the life of the Strategy.
EW	Eradication Pest Plants	High priority
EW	Containment Pest Plants	Landowner responsibility
EW	Potential Pest Plants	Monitoring or surveillance for weeds known to be in other areas or known threats.
EBOP	Agency pests	Pests that we work with MAFBNZ to manage.
EBOP	Exclusion pests	Pests that we wish to keep out of the Bay of Plenty or pests that may be here but are not well established and can be eliminated. EBOP may do the control on our own or with partner agencies such as MAFBNZ or DOC.
EBOP	Control pests	Pests that can be practically and cost-effectively controlled either regionally or within defined subregional areas. The responsibility will rest with the landowner/occupier. Where control cannot be practically delivered by the landowner/occupier, Council may undertake control and may recover costs.
EBOP	Advisory pests	Pests that are not practical and cost effective to control across the region or within a defined subregional area. Landowners/occupiers have responsibility for these pests.

Council	Classification	Short working definition
GDC	Total control	Plant pests of restricted abundance or range, but with a high potential spread and seriousness of effects.
GDC	Containment	Plant pests abundant in suitable habitats in particular areas or across the district unlikely to be eradicated but able to be contained.
GDC	Limited control	Plant pests abundant in suitable habitats but only cause adverse effects in specific areas.
GDC	Regional surveillance	Plant pests currently not known to be in the Gisborne Region but with potential to cause severe adverse effects if introduced.
GDC	NPPA	
TRC	Eradication pest plants.	These management programmes address pest plants not yet established in the region [with the exception of Pampas Grass] and for which the objective is eradication – these are climbing spindleberry, Darwin's barberry, giant reed, mignonette vine, pampas grass [common pampas & purple pampas], Senegal tea, and *Undaria*.
TRC	Containment pest plants.	These management programmes address widespread pest plants in the region and for which land occupier obligations apply to control the spread and 'externality' impacts of these plants – these are Australian sedge, giant buttercup, giant gunnera, gorse, nodding and plumeless thistles, old man's beard, ragwort, pink ragwort, variegated thistle, wild broom, and wild ginger [Kahili ginger & yellow ginger].
TRC	Surveillance pest plants.	These management programmes address other pest plants in the region for which land occupier obligations to control these plants are not considered appropriate – these are brush wattle, *Egeria* oxygen weed, Japanese walnut, *Lagarosiphon* oxygen weed, Spanish heath and woolly nightshade.
HBRC	Total control plant pest	Limited distribution in the region, and the long-term goal is to eradicate it.
HBRC	Containment control plant pest	Abundant in suitable habitats in the region and the long-term goal is to prevent the pest spreading.
HBRC	Regional Surveillance plant	May become a problem over time, or effective methods of control are unknown.

Council	Classification	Short working definition
	pests	
Horizons	Zero-density	All infestations of plants will be controlled to zero-density as and when they are found. Zero-density means the control of the pest plant to the last individual (thus allowing for the reality of reinfestation via the seed-bank or seed-rain). Pest plant species that are limited in distribution will fall under this objective.
Horizons	Containment	Where population levels or difficulty and expense of control prevent achieving a Zero-density objective, high-threat pest plant species will be managed under a Containment objective. For each species managed by Containment, a Control Area is defined (and mapped). Within the Control Area the pest plant species will be controlled wherever it is found. Control Areas are determined by infestation size and are limited by budget. The focus of control is placed where infestations are low or where the pest plant in question poses a high risk.
Horizons	Boundary Control	The Boundary Control objective aims to prevent invasion of pest plant species across property boundaries. An enforceable setback distance of 20 m or 50 m will apply between property boundaries for pest plant species with this objective.
Horizons	Monitoring	Monitoring is a temporary objective for pest plants that are present in the Region but require additional information in order to set control targets. The species will be monitored to assess distribution and abundance.
Horizons	Surveillance	Through active and acknowledging passive surveillance we will search focused on vulnerable areas and valuable natural areas for particular species.
GW	Regional Surveillance	New arrivals or potential threats. Potential pest species not yet known to be in the region and pest species known to be in the region and more research is needed.
GW	Total Control	Pests with a limited distribution within the region, but could potentially have serious adverse effects on significant regional values.
GW	Containment	Pests with a moderate distribution within the region. GW shall be responsible for the control of these species outside designated Containment zones.
	Boundary Control	Pests with a widespread distribution within the region. They comprise some of the most problematic pest species. GW recognises that neither Total Control nor Containment of the pest is achievable.
GW	Suppression and	Suppression pest species are widespread pests that can, and have, spread rapidly over long distances and therefore

Council	Classification	Short working definition
	Site-Led pest species in Key Native Ecosystems (KNEs)	Boundary Control management is not effective. The adverse impacts of Suppression pests are severe, and Total Control or Containment is not achievable. GW has a policy of suppressing pest density throughout the region to minimise impacts. All control work shall be the responsibility of the occupier.
TDC	Total Control Pests	Pests of limited distribution or density in a region, or part of a region, and for which the ultimate goal is eradication.
TDC	Progressive Control Pests	Pests that are unlikely to be eradicated because of their biological characteristics (such as long-term seed viability) but it is still feasible to reduce the density and distribution of the pest.
TDC	Containment Pests	Pests that are abundant in a region, or a part of a region, where the long-term goal is to prevent the pest spreading to new areas or neighbouring properties.
TDC	Boundary Control Pests	Pests of generally widespread distribution and for which the goal is to control the spread of the pest to land that is clear, or being cleared of the pest.
TDC	Regional Surveillance Pests	Pests that may pose a high potential risk but there is limited information on their regional distribution and/or their impact. These pests are banned from sale, propagation, or distribution, but there are no Strategy rules requiring the land occupier to undertake control measures. These pests will be monitored by the Management Agency, which will gather information and keep records on their distribution and impact, provide information and advice to land occupiers, and promote voluntary control.
TDC	Pest Control in Sites of High Public Value	Pests that need to be controlled in order to adequately protect sites of high public value. These sites are where the pests are likely to have the greatest impact and where the greatest benefits can be achieved.
MDC	Surveillance Pests	Pests identified within the Strategy for which the Council will monitor distribution, spread and impacts over the term of the Strategy. However, the Council undertakes monitoring or surveillance work on numerous other plant and animal pests throughout Marlborough.
MDC	Containment Control Pests	Pests that are well established in Marlborough where the long-term aim is to prevent the spread of the pest to new areas and reduce the density of the pest where possible. For the majority of containment control pests, the land occupier is responsible for undertaking control work.
MDC	Total Control Pests	Pests that are of limited distribution and density in Marlborough and for which the long-term aim is to eradicate

Council	Classification	Short working definition
		the pest. Total control pests are those that are dealt with by the 'direct control' method.
WCRC	Total control	Eradicate
WCRC	Boundary control	Control on boundaries to protect landowners who are managing their weeds from their neighbours' weeds.
WCRC	Progressive control	Low density pests managed at selected sites where they were not yet well established but could be a major threat.
ECAN	Containment	Keeping land that is currently clear, clear through the duration of the strategy.
ECAN	Total control	Seven species in very limited areas and density. Every known site is controlled.
ORC	Total control	Total control is the prompt eradication of a species.
ORC	Progressive control	Progressive control allows a period of time for eradication to be achieved.
ORC	Containment control	Containment control allows a pest to be present within defined areas.
ORC	Boundary control	Control within a specified distance of a neighbouring boundary, where the neighbour's land is free of that pest, or is clear of that pest at the boundary.
ES	Exclusion Pest	A potential pest which has not yet been identified as being present in Southland.
ES	Eradication Pest	A pest of limited distribution and density in the Southland Region, which nevertheless has the potential to have serious negative impacts on the community or environment. The goal is to eradicate these pests from Southland.
ES	Containment Pest	A pest that is established in Southland, but is of limited distribution in suitable habitat within the region. The goal is to prevent the Containment pest from spreading outside of its defined Containment Area. A Containment pest is present in the region at a distribution and density that means that eradication is not possible or cost effective.
ES	Suppression Pest	A pest that is widespread in suitable habitat throughout mainland Southland. The goal is to suppress the pest so that impacts on the community and the environment are minimised. The goal will also be to exclude the pest from offshore islands, where it is not present.
ES	Risk Assessment	A pest which is of potential concern to the region, but about which little is known of its distribution or the risk it presents to Southland. The goal is to improve our knowledge about the pest and its distribution through

Council	Classification	Short working definition
	Pest	monitoring, so that it can be classified and appropriately managed when the Strategy is next reviewed.

13.4 Summary of data collected by councils

Table 4 Summary of data collected by councils

Council	Location data	Density Abundance	Control	Comments
NRC	Grid reference locates the site of an infestation, not its extent. Polygons are recorded for contiguous infestations, e.g. wild rice infestation 55 km along the river; 160 sites for Manchurian wild rice are located as points.	Area of infestation is sometimes recorded, but not consistently. Extent of aquatic weeds in lakes, like the submerged freshwater weed hornwort, can be inferred from the area of the lake. Status is now recorded consistently. Status uses a different scale for different species, e.g. for some plants (none, juveniles, seedlings, adults). Use a density rating for others like wild rice (zero is 'no emerging foliage', 1 is '5–10 leaf blades showing', through to 6 which is 'mature stands').	Control effort (e.g. amount of herbicide), contractor hours, results monitoring. Results monitoring can be used to track progress. Reduction in herbicide use over time is used to reduce Status over time (e.g. reduced from Status 6 to Status 2). Do not record outcomes for biodiversity, or 'How it got there'.	Every site is visited at least once per year. Absence not recorded explicitly. Keen to implement improvements such as using change in status over time to give trend information which is very valuable.
ARC	20 × 20 m vegetation plots inspected annually; Property parcels; Point and polygons of infestations. Moved from point to polygon capture with recent launch of 'Biomap 2.0'. Polygons can be part of a property, a number of properties, a hillside or an infestation. Spatial object can change over time since the site is defined by the treatment needed, but polygons can't be used to infer outcome of control.	Density and condition (better, worse, same) used to be recorded, but no longer – too subjective. Numbers recorded flexibly for Total Control plants (# of plants, # of adults, juveniles or seedlings, # of plants per square metre, or even bags of grass).	Control method/product used. Record treatment (knapsack or spray) and herbicide use over time. Total Control sites are reclassified over time according to length of time since last visit and what was seen (Active, Under surveillance, or Historic i.e. eradicated). These data could be used to share information about the outcome of control operations.	Animal pests may be included in new system. Absence can be recorded in the new system, but haven't used it thoroughly yet. Polygons over time can be misleading as an empirical measure of abundance, due to differences in observer consistency in style/way of measuring.

Council	Location data	Density Abundance	Control	Comments
EW	Recording points and polygons. Their Biosecurity Information System is property based. Weed officers enter information as they're doing inspections and surveys. Accuracy depends on what the weed is. If it's a large rural property with woolly nightshade they might draw a large polygon. For eradication weeds, points or small polygons. Once an event is recorded, reinspections are done.	Haven't always captured density information. Polygons represent estimated extent of infestation. Different density categories are used depending on what the weed is (percentage cover, or number of plants per hectare). Can only choose from low/medium/high density (representing defined estimate of numbers per square metre). For some we measure/estimate infestations in square metres.	Once an event is recorded, reinspections are done. WRC classifies a Containment Pest Plant site as 'Complete' when they are satisfied that the weed is eradicated, but also when they decide not to go back there unless there's another complaint (so for Containment Pest Plants, complete doesn't necessarily mean eradicated). Depends on nature of the weed, and on officer preference. For high priority eradication weeds doing plot monitoring to understand how effective control work has been. E.g. for alligator weed 10 x 10 m plots.	Observations for Containment weeds done by looking from the road, targeting particular areas like a town or a highway at particular times. Based on historical knowledge, and try to cover most of their area over several years. No explicit absence information is recorded, except for alligator weed, where the city is being surveyed and actual absence is recorded by property.
EBOP	Points or polygons of the infestation can be plotted straight onto the tablet in the field.	Density. Spread over time for selected species.	Control treatment and results. We are updating management plans for all of the Eradication and Containment pests. EBOP reaches agreement with landowner on control objectives and time frames. EBOP encourages landowners to use preferred contractors (e.g. for woolly nightshade and kiwifruit) by subsidising 50% of the cost. There is a separate cost-recovery database which generates letters for follow-up if required, invoices and contractor worksheets.	Confident of having a very good picture of Total Control weeds across the region. We survey large areas of the BOP through our species-led and biodiversity programmes. We survey other identified risk areas on a case-by-case basis. Officers do road-by-road regional survey, plus some grid-by-grid surveying, plus surveying outward from infestations. Annual surveys target priority pests, e.g. 1000s of wild kiwifruit plants infest gullies. Some weeds surveyed more

Council	Location data	Density Abundance	Control	Comments
			Eradication is defined as zero density. A site remains under surveillance until the seed or reproductive life is exhausted.	frequently. Time series kept for some weeds, e.g. wild kiwifruit. Non-monitored areas show up on the database and we may decide to survey these areas periodically. Absence generally not recorded explicitly.
GDC	They use a single GPS fix as a locator of the infestation and sometimes peg the extent of the infestation to identify it for contractors. They record site visit, date, species, density, distribution, and number of Total Control infestation sites on each property.	Number of Total Control infestation sites on a property recorded. Density is recorded as level I to IV: I = 0–25 plants per hectare II = 26–50 plants per hectare III = 51–100 plants per hectare IV = 100+ plants per hectare Don't record the area of the infestation. Lifecycle stage (e.g. rosette or mature) sometimes noted in weekly reports but not uploaded to system.	'Discretionary control' by council officers may occur when there are few plants and time, but control data not uploaded to system. However, the number of plants in the treatment area or the monitored site at each inspection is recorded, so this can show a reduction in distribution. Eradication is defined as 'zero density' (Level I).	Gisborne District Council has a reasonable regional picture of all Total Control and Containment weeds. They have a Total Control inspection programme: All Total Containment sites are inspected regularly (every 6–8 weeks). Containment sites are inspected as a result of complaint, or when there is spare time. Non-monitored areas are not recorded. Limited Containment: plants on the property are recorded especially on urban boundaries. Regional Surveillance: plant and location recorded.
TRC	System is called Tumbleweed. They used to use points. Now they draw a polygon around the infestation (size reflects trend over time). The Biodiversity Dept will soon be monitoring weed distribution and abundance in	Density classes (heavy, medium or low infestation options)	Control method (biological, chemical, physical options, with further options under each), result of control (free text). This information can be used to generate an Entry Advice Notice or a Notice of Direction. There	The data is updated after each visit – three times a year for known weedy sites, uncontrolled sites etc. They hope to be able to show progress over time in future. Absence is recorded when an RPPMS species previously

Council	Location data	Density Abundance	Control	Comments
	wetlands, forests and sand dunes on 8 x 8 km grids using plots. This will provide for a systematic assessment of 149 Key Native Ecosystems (KNEs).		are three categories of properties: those with weeds where the owner is not good at controlling weeds, and these get inspected at least three times per year; those with weeds where control is being done which get inspected annually. Other properties as time permits. For plants where our goal is eradication we check annually and note when plant has not reappeared after 2–3 years. The category rating (A, B, C) for the property will change. It is hoped that the polygons drawn around infestations can be used to show trend and reduction in area down to zero (e.g. a weed was here, and now it's not).	recorded has been removed. They can see which areas haven't been monitored on their GIS database.
HBRC	Recording points; don't use polygons. Often record multiple points. Record against property in urban areas – not points. Where a weed is not dense but widespread, often do multiple points for clusters. Main rationale is that someone can go back and find where the infestation is. Delays in getting data into database system because officers transfer data from diaries in quiet months.	Record a single GPS point for an infestation of a Boundary Control Plant Pest, plus density or square metres or hectares, and action taken (e.g. clear a boundary). Then do the control. Four density classes: Clear, Low, Medium, High (e.g. Clear is zero, Low is 0–1 plants, Medium is 1–5 plants and High is 5+ plants per square metre). Not recording seedlings, juveniles, adults.	Record control efforts and results. Where its practical they do plant counts while controlling them, and then reinspect after a period of time. Where it's not practical or where the farmer/contractor's doing the work, plant counts won't be done. They then go in and check it's done, and mop up if necessary. Every infestation of Total Control weeds must be visited once a year. With some	Used to grid and survey the region. Now do targeted monitoring at certain times of the year when you're most likely to find the weed (e.g. when they're flowering). With new infestations, will survey to see where it's come from based on how it's spread. Actual absence sometimes recorded (we searched and it wasn't here).

Council	Location data	Density Abundance	Control	Comments
			weeds, sites can be visited up to five times per year. If it's been clear for 8 or 9 years, you'll slow down visiting it annually and just do it every 3 years. Use the 'Clear' option for density when plant is controlled and absent.	
Hori-zons	At present we manually transfer GPS point data into an office based database to record pest plant site locations. We will soon be using GPS-enabled touchscreen tablets to record point and/or polygon site information. This information can be collected at the site or remotely using topo or aerial photography mapping.	Site class: active/clear. Dominant age class: adult/juvenile/seeding (based on majority) Success is the change in age class over time with an ultimate change from Active to Clear. Numbers of plants will be recorded and reported against for certain species and certain sites if that is the best method of measuring change at the site.	Dominant age class is recorded so the change in age class is a measure of outcomes. Have considered measuring the reduction or other of the cost of control operations at each site.	Horizons undertake annual/ biannual/tri-annual monitoring depending on the species and the site. Some sites located through 'passive surveillance', i.e. community observation. Absence of Surveillance plants is recorded at monitored sites, but not from a gridded area. Can infer absence from surveys, but level of certainty varies and partly depends on how long a weed has been in the strategy.
GW	GPS Location (Total Control and Regional Surveillance species only).	Area Infested (m^2), % Groundcover (visual approximation), % Middle Storey Cover (visual approximation), % Canopy Cover and Aquatic Cover (visual approximation), Number of Seedlings Present, Number of Adults Present. NB: In our new pest plant database we are looking to cease recording visual (% Cover) as these observations are too	Record whether infestation was controlled at the time of inspection and control method employed. Eradication: after the last plant was recorded (and destroyed) we conduct five annual inspections (with no plants found) then two biannual inspections (with no plants found) before a site/infestation is considered eradicated (total 9 years with no plants found).	Greater Wellington use result monitoring (simple presence/absence) for our species-led programmes and are starting to use outcome monitoring (tracking native regeneration modified from DOC protocols and merged with FORMAK) for our site-led programmes. Data are updated annually and we maintain and report time-series for Total Control species. We currently

Council	Location data	Density Abundance	Control	Comments
		subjective.		conduct delimiting surveys (in a radius of 200 m) around existing Total Control and Regional Surveillance infestations.
TDC	Just recording point locations for RPMS weeds with limited distribution and other potential pests that might be of concern.	Struggling with recording density or extent. Use generalised comments like 'small clump', 'big clump'.	Date when a new infestation is found is recorded, then the site is reclassified over time based on level of treatment (new site, active site, monitoring, historic). Control undertaken (e.g. 'sprayed small patch with…', 'removed 55 plants') or the requirement for landowner control is recorded. For the worst weeds, annual checks for the first five years, then less frequently depending on seed viability.	
MDC	Mapping all our pest plant infestations as points and polygons for the past 10–12 years. Mapped as per their RPMS classifications. Record inspection on properties and pest plants found.	Fringes (isolated patches), Core (scattered infestation), Nucleus (wide spread infestation).	Class A pest plants aren't on our RPMS as they're managed nationally by MAFBNZ. Landowner is responsible for most control work and it is usually done by contractors, who also find and report new infestations. Eradication is monitored by recording control operations and taking photos, then the site has Surveillance status for 5 years, then Historical if nothing found after 5 years.	Surveillance regime varies weed to weed. Often associated with control operations. Doing surveillance outside of known areas, and recording time spent. Recording where we've been so we can infer where weeds are absent.
WCRC	Site name, grid reference. The vast majority of weed distribution	Infestation size (sometimes area,	Control information recorded using standard DOC form.	DOC has a very good picture of Progressive control weeds

Council	Location data	Density Abundance	Control	Comments
(DOC)	data is weed presence captured as a GPS fix. More rarely, in sites where control operations take place (e.g. a valley floor), a polygon of each infestation is drawn, usually in the office. This is usually based on a GPS fix and an estimate of the extent of the infestation, as opposed to walking around the infestation with a GPS. A habitat assessment is usually made. Different blocks are controlled in different years. Changes in polygon size over time can't be used to infer progress, as the polygons are not usually updated. DOC conducts active surveillance and records every site they find. Historical data seem to have been lost.	but usually # of individuals).	Updating is progressive and annual. We enter new records as they come, plus we do a Weed Surveillance Annual Report which lists important new incursions and action required. Vector information sometimes recorded when the vector is obvious (e.g. gravel/road works).	because they occur at known sites. Boundary control weeds are widespread across the region, so records are usually kept only when weeds such as gorse and broom are found in remote areas, or in places where they are not common. Absence is not recorded explicitly.
ECAN	Locations recorded as points or polygons depending on species. ECAN also keeps a surveillance database (for weeds not in the RPMS) and shares it with DOC, CCC, CRIs and others – 50 and 100 pests. Includes Total Control species and biodiversity pests identified for total eradication from the RPMS. Includes management data too.	Density or extent measured, by number per square metre. With small infestations, will do counts.	Inspection reports go into the regulatory database and a copy goes to the land occupier. If a rule isn't being adhered to, that kicks off the regulatory process. Eradication is recorded as either numbers eradicated or area treated. Number of visits undertaken during the year is determined by the need. No hard and fast rules about declaring a site Historical. Determined on a case-by-case basis. Sometimes	Absence recorded explicitly for Total Control species at 98 sites.

Council	Location data	Density Abundance	Control	Comments
			tricky as with saffron thistle, can go back for 6 or 7 years, not finding anything, then come back an there'll be 30 or 40. ECAN spends a lot on outcome monitoring underpinned by science and using standards developed by CRIs. ECAN's surveillance database (for weeds not in the RPMS) includes management data.	
ORC	In rural areas, GPS fix, plant name, plus field notes recorded in preformatted Inspection Books, then entered into a spreadsheet. In urban areas, street address is used. Most data are updated annually, but, e.g., nasella tussock in open tussock land twice per year.		Eradication is assumed when nothing is found in historical sites. Compliance is recorded during inspections using classifications: Non-compliant minor = a few plants left Non-compliant major = landowner did not control Compliant = satisfactory control (assume zero density, but regrowth is possible). Historical infestation sites continue to be monitored, with visits reducing over the years if nothing found. Helicopter survey for gorse and broom is followed up by a visit or a notification letter requiring control, and an inspection further down the track establishes if they have complied or not. Good regional picture of Total Control	Most activities are species-led, e.g. gorse and broom surveyed by helicopter. GPS point taken for each individual or small cluster, and notes are taken where (rare) large infestations occur. Also programmed inspections, and opportunistic surveillance as officers criss-cross the region. Absence not recorded explicitly.

Council	Location data	Density Abundance	Control	Comments
			weeds but many Boundary Control weed issues get resolved by neighbours without any involvement of the RC. Officers know where they are but they are not recorded on the system.	
ES	Location is recorded as a property parcel polygon for ragwort and nodding thistle. For old man's beard a polygon is drawn. Officers either walk around infestation with GPS or adjust polygon once back in the office. Points are recorded for surveillance observations.	For ragwort and nodding thistle, infestations are categorised as minor, medium or severe. For old man's beard, numbers of adults, juveniles and seedlings are recorded. Surveillance observations use three classes to describe the area infested (>1 square metre, >100 square metre, >1 ha) and two density classes (Scattered or Dense).	Control information includes amount of time spent at site for old man's beard, technique used (e.g. pulling) and amount of herbicide. For RPMS weeds, no control information is recorded except for the Notice Of Inspection which is removed from the Active file once the landowner has fully complied. The recommended action might be recorded. For Eradication plants, a regular census of age classes shows progress. Old man's beard sites attract repeated visits until no plants are present, when the status is changed from Active to Historic. There are rules that define the return period for inspections for different plants.	For the past three summers, grid-based stratified randomised sampling (plus known locations of weeds) aimed at measuring change for all RPMS weeds and 96 DOC species; 4000 RPMS records, plus harvested DOC Bioweb records in Access database with geospatial links. These weed distribution data are enough to categorise plants into RPMS categories. We want tools to predict what will happen in the future and refine the RPMS to address these challenges. Absence data are only recorded for the old man's beard project.

13.5 GISIN

13.5.1 GISIN: Additional concepts for 'SpeciesStatus'

ID	Name	Source	Required	Parameter	Field	Type	Values
5	Abundance	GISIN		Yes	Yes	Enumerated	Dominant, Common, Rare, Zero, Unknown, Monoculture
4	Distribution	GISIN		Yes	Yes	Enumerated	Widespread, Moderate, Localized, Unknown
8	Harmful	GISIN	Yes	Yes	Yes	Enumerated	Yes, No, Potentially, Unknown
1	Origin	GISIN	Yes	Yes	Yes	Enumerated	Indigenous, Exotic, Unknown
3	Persistence	GISIN		Yes	Yes	Enumerated	Persistent, Temporary, Transient, DiedOut, Unknown
2	Presence	GISIN	Yes	Yes	Yes	Enumerated	Absent, SometimesPresent, Present, Unknown, Reported
93	PublicationDate	GISIN		No	Yes	Date	See Protocol Specification on Dates.
7	RateOfSpread	GISIN		Yes	Yes	Enumerated	Rapid, Moderate, Slow, Unknown
9	RegulatoryListing	GISIN		Yes	Yes	Enumerated	Prohibited, Restricted, NotConsidered, Unknown
6	Trend	GISIN		Yes	Yes	Enumerated	Stable, Declining, Unknown, Expanding

13.5.2 GISIN: Additional concepts for 'ManagementStatus'

ID	Name	Source	Required	Parameter	Field	Type	Values
88	Action	GISIN	Yes	Yes	Yes	Enumerated	Prevention, Eradication, Control, Containment, Mitigation, Interception, None
99	Outcome	GISIN		Yes	Yes	Enumerated	Successful, Failed, Unknown, Unconfirmed success, Unconfirmed failure
89	Status	GISIN		Yes	Yes	Enumerated	Proposed, Executing, Completed, Unknown

13.5.3 GISIN: Common concepts

ID	Name	Source	Required	Parameter Field	Type	Values
68	Citation	GISIN	No	Yes	String	
13	CountryCode	GISIN	Yes	Yes	Enumerated	
15	CountyName	GISIN	Yes	Yes	String	See Protocol Specification on Locations
52	DateLastModified	DarwinCore	No	Yes	Date	See Protocol Specification on Dates.
56	DateLastModifiedMax	GISIN	Yes	No	Date	See Protocol Specification on Dates.
55	DateLastModifiedMin	GISIN	Yes	No	Date	See Protocol Specification on Dates.
11	EndValidDate	GISIN	No	Yes	Date	See Protocol Specification on Dates.
107	GlobalUniqueIdentifier	DarwinCore	Yes	Yes	String	
20	Kingdom	DarwinCore Yes	Yes	Yes	Enumerated	Monera, Protista, Fungi, Plantae, Animalia, Other, Unknown
16	LocalityName	GISIN	Yes	Yes	String	See Protocol Specification on Locations
96	LocalityType	GISIN	Yes	Yes	Enumerated	State/Province, County, Postal code, Watershed, Unknown
97	LocationStandard	GISIN	Yes	Yes	Enumerated	USA_FIPS, USA_HUC, AR_PostalCode
98	LocationValue	GISIN	Yes	Yes	String	
92	Memo	GISIN	No	Yes	String	
19	ScientificName	DarwinCore Yes	Yes	Yes	String	Examples of scientific names include: • Tamarix • Tamarix ramossissima • Tamarix ramossissima Ledeb. • Boiga irregularis Merrem, 1802

								• Moerckia hibernica var. wilsoniana Gottsche • Epipenaeon ingens latifrons Bourdon, 1979 • Symphyotrichum lanceolatum ssp. hesperium var. hesperium (Gray) Nesom
13.5.4	10	13.5.5	StartValidDate	GISIN	No	Yes	Date	See Protocol Specification on Dates.
14		StateProvince		DarwinCore	Yes	Yes	String	
58		ValidDateMax		GISIN	Yes	No	Date	See Protocol Specification on Dates.
57		ValidDateMin		GISIN	Yes	No	Date	See Protocol Specification on Dates.