Space invaders:
A review of how New Zealand manages weeds that threaten native ecosystems

November 2021

Parliamentary Commissioner for the Environment
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Contents

Lamium galeobdolon

A personal introduction

I have been at war with weeds my entire life. I was born on a small Waikato farm with the full suite of early settler weeds – gorse (*Ulex europaeus*), barberry (*Berberis vulgaris*), hawthorn (*Crataegus monogyna*), blackberry (*Rubus fruticosus*). I still live there. Native flora had been pushed to the margins of the landscape at the end of the nineteenth century. For that reason, I grew up with little awareness of the threats that exotic plants posed to native ecosystems. The land was – and largely remains – a northwest European temperate pastoral ecology superimposed on a southwest Pacific temperate ecology.

I also grew up in a household of keen gardeners. The gardens – vegetable and ornamental – were purely exotic. On the farm and in the garden the weed war was all about trying to suppress unwanted exotics in favour of wanted ones. One learns early on that nature abhors a vacuum. Soil exposed by the weight of a heavy beast on a steep gully bank provides an ideal opening for gorse seedlings. Soil, carefully tilled and awaiting the emergence of sown beans or carrots, is ideal for docks, clover, sorrel – whatever lies dormant.

Without realising it, my gardening endeavours were marked by a propensity to create "weed-shaped holes". This brilliant metaphor was the brainchild of Irish ecologist, Yvonne Buckley, who grasped the essence of what so many land uses lead to.[1] By seeking to create highly artificial plant communities – whether to feed ourselves or to provide aesthetic pleasure – we create highly unstable associations that offer gaps for uninvited plants.

And of course, the difference between an invited and an uninvited plant – a prized specimen and a weed – is entirely circumstantial. One person's treasure is another person's weed. It's not even a distinction that is stable over time. Thirty years ago, I happily planted artillery plant (*Lamium galeobdolon*) as one way of covering weed-shaped holes. With its light green and white variegated leaves and cool yellow flowers, it provided an attractive carpet in those corners which otherwise gathered docks and grasses. Three decades on and after endless campaigns through shrubberies and hedges, I am close to (local garden level) elimination. I could name a list of similar friends turned enemies – agapanthus (*Agapanthus praecox*), giant gunnera (*Gunnera manicata*), bear's breeches (*Acanthus mollis*)…

[1] See Buckley et al. (2007).

I first became aware of the exotic–native tensions when I set out as a teenager to establish my first native plot, designed to house my collection of New Zealand ferns. In a gully head surrounded by pasture and filled with grey willow (*Salix cinerea*) I tried to establish native trees to shelter my fern collection only to discover that when grazing mouths were removed, barberry and blackberry were more eager to take over the site.

Living and working overseas for several years meant stepping back from the front line. The war turned almost instantly in favour of the weeds. But not just familiar ones. I was about to learn first-hand about something called *the invasion curve* – the process whereby, over time, introduced plants first naturalise then commence their spread. I returned to find my native garden filled not with familiar weeds but some that had never been on the property before, most notably Chinese privet (*Ligustrum sinense*) and woolly nightshade (*Solanum mauritianum*). A carefully landscaped pond had become almost entirely covered by water primrose (*Ludwigia peploide*s). Days in waders and a boat were needed to physically drag it out.

Most conspicuous of all were the invaders that had taken up residence in a century-old barberry hedge on a road boundary. Road margins are a pathway for plants. I found Chinese privet busily replacing the barberry, accompanied by several other allied battalions led by Japanese honeysuckle (*Lonicera japonica*). Four years on, the battle to subdue the invaders in favour of the old invader, barberry, continues.

Winning it is essential for me because, like most rural New Zealanders, I am trying to undo more than a century's work in excluding stock from gullies and seeking to restore the native vegetation that was once in control. A hedgerow full of new invaders only a short bird flight from the gullies and wetlands is a never-ending source of seed that can so easily upset the best planting plans.

As I plant mānuka (*Leptospermum scoparium*), kānuka (*Kunzea ericoides*) and karamū (*Coprosma robusta*), a hail of privet, barberry and hawthorn seeds are arriving from the air. And down in the boggy areas under the willows, all manner of unwelcome guests threaten to take up their quarters. As I have discovered, native forest restoration is a race against time to beat the weeds. Weeds take no prisoners. Provide them with a weed-shaped hole and they will fill it. Obviously some are worse than others. In my case Japanese honeysuckle's capacity to smother represents a mortal threat to the transition.

To accompany this report, I decided to conduct an inventory of weeds on my property. The results are in the table below. It is by no means comprehensive – for a start it leaves aside all conifers and grasses. But it is an indication of what attempts at native protection or restoration must contend with in just one corner of the country. It is followed by a table of 16 serious weed threats to native ecosystems that aren't on the property but have been identified within a radius of 20 kilometres. There are plenty of invaders looking for a new weed-shaped hole right on my doorstep.

Like so many others, I have come to the realisation that we face a burgeoning problem and one that never pauses. It is a dynamic process that is an ongoing echo of the ecological upheaval that the arrival of humans – particularly Europeans – unleashed on Aotearoa's ecology. And it is likely to intensify as we contemplate some of the land use changes either being compelled by climate change or undertaken to mitigate it (like tree planting).

If I have a battle on my hands on less than 100 hectares, what do the balance of forces look like in the native ecosystems dotted across New Zealand's 268,000 square kilometres? Reflecting on that question has led me to ask what the state of play is and how well prepared we are to confront those exotic plants in the early stages of occupying our landscapes.

Table 0.1: Weeds on the Commissioner's Waikato property identified as posing risks or potential risks to native ecosystems and native ecosystem restoration.

Common name	Scientific name	Year naturalised[2]
Agapanthus	*Agapanthus praecox*	1952
Aristea	*Aristea ecklonii*	1975
Arrow bamboo	*Pseudosasa japonica*	1968
Artillery plant	*Lamium galeobdolon*	1988
Bear's breeches	*Acanthus mollis*	1958
Blackberry	*Rubus fruticosus*	1867
Box elder	*Acer negundo* var. *negundo*	1983
Chinese privet	*Ligustrum sinense*	1950
Climbing dock	*Rumex sagittatus*	1935
Cotoneaster	*Cotoneaster glaucophyllus*	1982
Crack willow	*Salix* × *fragilis*	1880
European barberry	*Berberis vulgaris*	1875
Gorse	*Ulex europaeus*	1867
Great bindweed*	*Calystegia silvatica*	1904
Green goddess	*Zantedeschia aethiopica*	1870
Grey willow	*Salix cinerea*	1925
Hawthorn	*Crataegus monogyna*	1899
Holly	*Ilex aquifolium*	1901
Inkweed	*Phytolacca octandra*	1867
Italian lily	*Arum italicum*	1945
Ivy	*Hedera helix*	1873
Japanese honeysuckle	*Lonicera japonica*	1926
Japanese spindle tree	*Euonymus japonicus*	1980
Jasmine	*Jasminum polyanthum*	1980
Jerusalem berry	*Solanum pseudocapsicum*	1935
Marsh marigold	*Caltha palustris*	1999†
Montbretia	*Crocosmia* × *crocosmiiflora*	1935
Onion weed	*Allium triquetrum*	1899
Pampas	*Cortaderia selloana*	1925
Periwinkle	*Vinca major*	1870
Ragwort*	*Jacobaea vulgaris*	1894
Royal fern	*Osmunda regalis*	1890
Scotch broom	*Cytisus scoparius*	1872
Snow poppy	*Eomecon chionantha*	1997†
Tree privet	*Ligustrum lucidum*	1958
Velvety nightshade*	*Solanum chenopodioides*	1958
Wandering willie	*Tradescantia fluminensis*	1916
Water plantain	*Alisma plantago-aquatica*	1929
Woolly nightshade	*Solanum mauritianum*	1883

* These species have likely not escaped from cultivation as they were accidentally, rather than deliberately, introduced to New Zealand.

† These species have not yet naturalised in New Zealand. This is the year they were first documented growing in the wild.

[2] https://www.nzpcn.org.nz/flora/; Gatehouse, 2008.

Table 0.2: Weeds in the Waikato Regional Council Regional Pest Management Plan 2014–2024 not present on the Commissioner's property but present within 20 kilometres.

Common name	Species name	Year naturalised[3]	Management programme
Alligator weed*	*Alternanthera philoxeroides*	1906	Eradication
Banana passionfruit	*Passiflora* sp.	1958, 1970, 1988†	Progressive containment
Chocolate vine	*Akebia quinata*	1940	Eradication
Evergreen buckthorn	*Rhamnus alaternus*	1940	Eradication
Giant gunnera	*Gunnera manicata*	2003	Eradication
Giant knotweed	*Fallopia sachalinensis*	1935	Eradication
Japanese knotweed	*Fallopia japonica*	1935	Eradication
Kahili ginger	*Hedychium gardnerianum*	1940	Progressive containment
Madeira vine	*Anredera cordifolia*	1940	Progressive containment
Mile-a-minute	*Dipogon lignosus*	1871	Eradication
Moth plant	*Araujia hortorum*	1888	Progressive containment
Old man's beard	*Clematis vitalba*	1940	Eradication
Senegal tea	*Gymnocoronis spilanthoides*	1991	Eradication
Tutsan	*Hypericum androsaemum*	1870	Progressive containment
Yellow flag iris	*Iris pseudacorus*	1978	Eradication
Yellow ginger	*Hedychium flavescens*	1898	Progressive containment

* It is unlikely alligator weed escaped from cultivation as it was accidentally, rather than deliberately, introduced to New Zealand.

† There are four species of banana passionfruit – *Passiflora tripartita* var. *mollissima* naturalised in 1958, *P. mixta* and *P. tarminiana* in 1970, and *P.* × *rosea* in 1988.

[3] https://www.nzpcn.org.nz/flora/


Hedychium gardnerianum

Overview

This report asks whether we are doing the best job we can to manage the risks exotic plants pose to our native ecosystems. At its core, the report reviews the way in which central and regional government agencies go about the business of tackling native ecosystem weeds under the Biosecurity Act 1993.

But a dry review of process doesn't do justice to the complexity of what we are up against. So I have accompanied that review with an extended discussion of the history, science and cultural significance of the process that has seen thousands of introduced plants naturalise in our landscape and, in some cases, take it over. It is full of specific examples to help illustrate what is happening, often unseen, in our own backyards. As a result, it is a longer report than is strictly necessary to address the question of how our regulatory system works. Readers familiar with the science can happily proceed directly to chapter four.

The state of play and what the future may hold

The first three chapters try to define this investigation's scope and provide a summary of what we know about native ecosystem weeds in New Zealand today and how the picture may evolve in the future.

Chapter one spells out the questions that this investigation seeks to answer. Its focus is on weeds that pose risks to native ecosystems (but not marine weeds). Do we adequately understand the risks we face; can we make sensible choices about what to manage; are we making the best use of the limited human and financial resources we have? It is *not* about the effectiveness of different tools and methods for controlling these weeds or assembling a list of the worst ones.

It also discusses why the word 'weed' is such a slippery customer. Anyone who ventures into the world of weed ecology is rapidly confronted by a jungle of specialised terms. To use them all the time would make for some very long sentences. That is why I have stuck to the word 'weed' – but given the focus of this report, it is generally a reference to **weeds that impact on native ecosystems**. In general use, weeds are of course unwanted plants and the same plant can be both wanted and unwanted in different settings. Conifers and Russell lupins (*Lupinus polyphyllus*) provide two interesting examples.

More interesting still is the way Māori view weeds. A special report commissioned to provide a Māori perspective on exotic plants underlined a refreshing distance from the native–good/exotic–bad dichotomy that is sometimes echoed. The report suggests that:

> "a weed is a plant that upsets the balance that Papatūānuku needs to be well. That suggests that a weed is a plant that dominates an ecosystem to the extent that it is no longer able to function in a way that enables it to sustain the life that belongs there. A weed is a plant that disrupts that natural balance."[1]

There is no shortage of candidate plants available to disrupt that balance. New Zealand is one of the weediest island nations in the world. The North Island and South Island each have more naturalised plant species than almost any other island in the world. Māori brought a dozen or so plants with them. Europeans brought more than 25,000. Over two centuries, 1,800 have naturalised, meaning they have escaped cultivation and can sustain wild populations. Since the 1950s, ornamental plants have supplied the bulk of these.

Chapter two describes a process that ecologists term an *invasion curve* – the trajectory an introduced plant follows as it moves from arriving to surviving and then thriving. It also outlines some of what we know about the extent to which we can predict what plants will take off and the types of harm they can cause to native ecosystems. How a plant will behave depends on the context, which makes forecasting the future even more difficult. A survey undertaken twenty years ago found that of 181 exotic plant species on land administered by the Department of Conservation (DOC), around ten per cent were not known to be weeds overseas.[2] Something about local conditions enabled them to gain a foothold.

But of course, local conditions aren't static – they are continually changing as we change land uses, and are likely to change even more as climate change intensifies. With such a large source of potential invaders already growing in parks and gardens, **chapter three examines how it is only a matter of time before new garden escapees respond to the opportunities that land disturbance and a warming and changing climate provide.**

How well does the current biosecurity system deal with native ecosystem weeds

The balance of the report deals with whether we are match fit for the challenge that this silent vegetative army poses. **Chapter four asks whether we even know enough about what is out there to make sensible decisions**. There is no shortage of raw information. But its curation, management and accessibility leave much to be desired. The problems identified include the following:

- The many databases we have don't connect so valuable information is not shared.
- Much information is either not accessible or not easily accessible.
- There is no comprehensive, up-to-date, authoritative database that pulls together all the information on exotic plant species in New Zealand, if and how they are managed, and by whom.
- Taxonomic issues, including a vast variety of exotic plant names (with all the opportunities for miscommunication that invites), hamper information flow.

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[1] McGowan, 2021, p.9.

[2] Williams et al., 2000, p.27, Table 11.

- Surveillance of the weed battleground is patchy. Reports from the front line often depend as much on luck as systematic surveillance.

The chapter finishes with a sketch of what a good information system for weeds might look like. Importantly, any such system should seek to include information on *all* exotic plant species growing wild in New Zealand – not just those already known to harm the integrity of native ecosystems.

We need to know what is happening so we can tackle new invaders early. Early intervention offers the best chance of eradicating them or, if that is impossible, controlling them cost-effectively. Eradication is no easy thing. Somewhat chillingly, there is no record in New Zealand of any terrestrial plant having been successfully eradicated from the country when the extent of its spread has been greater than one hectare at a given site. We need an information system that can assist us to better detect and respond to newly naturalised species or those just beginning to spread. An uncertain or slow-moving response will see weeds get beyond the point where eradication is a realistic outcome.

High quality information would put us in a position to make better use of the scarce human and financial resources available to us. But it won't avoid the need to make choices. **Chapter five is about prioritisation that can guide how we mobilise the scarce human and financial resources that are available**. Decisions need to be made about *which* plants to manage, *where* and *how* they are to be managed and by *whom*.

The key questions that pose themselves include: which exotic plants are most demanding of attention now? Are today's choices being taken with sufficient regard for future challenges? Obviously, any prioritisation system needs to be based on the best evidence we can muster and be sufficiently flexible and adaptive to respond to new information. But even more importantly, it has to be able to communicate a clear idea of the outcome that is being sought over the long term.

Weed management programmes need to be achievable and sustainable over time – potentially a very long time. There is no point in creating an expensive weed-shaped hole waiting to be reinvaded. Knowing what comes next is critical. If the aim is eradication, there needs to be a good chance of success and it must be backed with the resources needed to make it a success. Otherwise, there is a risk that failure gives way to ongoing control after a considerable waste of time and effort. On the other hand, deciding to live with a weed comes at the cost of 'constant gardening'. Weighing up current harm against future risks and making the necessary trade-offs is an exacting task that is at the core of any biosecurity system.

That brings us to the heart of this investigation. How well does New Zealand's biosecurity system manage native ecosystem weeds? **Chapter six describes the statutory and regulatory framework that governs that system. Chapter seven then considers the roles of the different actors and how in practice they exercise their responsibilities**.

The first thing that needs to be said about the biosecurity system is that it is immensely complex. The Biosecurity Act of 1993 establishes the legal basis for defending the border from unwanted intrusions by harmful organisms ranging from four-legged animals to invisible pathogens. The Ministry for Primary Industries (MPI) is on the front line. It looks and acts far beyond the border, as well as dealing with those organisms that have managed to penetrate the border. The biosecurity system straddles central and local government and relies on the engagement and cooperation of industries and communities.

It must be incredibly challenging to explain the system to a new Minister or newly elected councillors. While the Biosecurity Act may tie many threads together from a statutory point of view, understanding how the many agencies that deal with native ecosystem weeds are supposed to work together is anything but straightforward. And, in any case, some weed control activities are carried out under other Acts.

The second thing that must be said about the biosecurity system is that it is overwhelmingly focused on border and pre-border measures. We appear to have done a lot of thinking about what we *don't* want crossing our border and, appropriately, expend very considerable effort defending it. But when it comes to exotic species that have already made Aotearoa their home and are causing harm in some situations, legislation has little to say about where attention should be focused.

Part 5 of the Biosecurity Act deals with the management of harmful organisms (which can be any living thing, including native ecosystem weeds) that are *already* in New Zealand. The stated purpose of this part of the Act – the eradication or effective management of harmful organisms – is premised on preventing, reducing or eliminating the adverse effects of these organisms to a wide range of outcomes, including economic wellbeing, the environment and enjoyment of it.

Importantly, however, the purpose clause of Part 5 provides no direction on how these outcomes, that can often be in conflict, are prioritised. Significantly, the stated purpose focuses as much on instruments and measures – in other words delivery – as it does on the outcomes.

The Biosecurity Act has nothing to say about the priorities that are to be accorded to any harmful organism or group of organisms. Neither do the other two main Acts dedicated to environmental protection and conservation – the Resource Management Act 1991 and Conservation Act 1987.[3]

Without clear priorities on the face of any statutes, weeds that pose risks to our native ecosystems end up being managed on the basis of day-to-day, case-by-case trade-offs. As there is no direction given on the priority to be accorded to native ecosystem weeds, this often means that unless their control sparks political concern, they may be quietly left to spread.

Widespread community concern about the risks that animal pests pose to the environment, including native ecosystems, has managed to mobilise national political concern and many millions of dollars, both public and private, to control four-legged predators. There are 31 exotic mammals at loose, with a strategy in place to free New Zealand of a handful of them – mustelids, rats and possums – by 2050. *The Predator Free 2050 Strategy* states that these species were chosen "because, collectively, they inflict the worst damage of all the introduced predators on New Zealand's wildlife. We also know more about their biology and control than any other predators."[4]

No such focused call to arms exists on the weeds front. Of the tens of thousands of exotic plants that have been introduced to New Zealand, thousands are already surviving in the wild. At least 380 are troublesome for native ecosystems and the potential for them to be joined by others currently biding their time is high – particularly garden escapees. But even the most triffid-like stranglers, such as wild ginger (*Hedychium* sp.) or climbing asparagus (*Asparagus scandens*), are unable to arouse a sense of outrage the way that a stoat filmed eating a kiwi chick can.

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[3] It wasn't always that way. For almost a century, harmful exotic plants had their own statute. A Noxious Weeds Act was enacted in 1900 containing a list of troublesome plants. It survived, with many amendments, until it was replaced in 1978 by a Noxious Plants Act. But the focus remained squarely on plants considered harmful by farmers and landowners. That Act was swept away with the passage of the Biosecurity Act.

[4] New Zealand Government, 2020, p.14.

The stoat does its business in seconds. The loss of habitat and other impacts on ecosystems that some weeds can inflict may unfold over many years. But what is at stake is just as serious. New Zealand needs better national oversight of how this slow-motion botanical conquest is unfolding and a similarly clear list of priorities based on robust risk assessments. There needs to be clarity about who is responsible for taking action, and shared tools and information available to all levels of government and the wider community.

That is difficult to achieve under the current legislation. While the Biosecurity Act states that the Minister provides leadership through national policy direction and requires him to deliver it, the Act only allows for one such direction to be prepared. This means it has to cover everything – which makes its preparation both exhaustive and exhausting.

Remarkably, there is no legislated minimum content for the national policy direction the Minister is required to make. There is no requirement to make certain weeds a priority or spell out priority weeds – or for that matter *any* other pests – that need to be managed nationally. Instead, the National Policy Direction for Pest Management 2015 is an instrument directed at managing resources rather than making transparent the trade-offs that arise in the context of the entire pest management system.

The Biosecurity Act and the National Policy Direction for Pest Management provide a framework under which national pest management plans and national pathway management plans can be prepared. But neither kind of plan has ever been prepared for a terrestrial exotic plant. The absence of such plans suggests that there are barriers to their use. It also suggests that the risks that weeds pose to our native ecosystems are simply not regarded as a priority. All the while the weeds are growing through the gaps.

New Zealand needs better coordination and national direction that can be specifically targeted to managing weeds that are currently harming, or could harm, native ecosystems. If there were such national policy direction, it would require a much clearer focus on *who* should be responsible for providing the leadership needed to manage these weeds.

That leadership is currently fragmented. While the Biosecurity Act states that the Director-General of **MPI** provides "overall leadership in activities that prevent, reduce, or eliminate adverse effects from harmful organisms that are present in New Zealand",[5] there is little visibility of this leadership being exercised with respect to the management of native ecosystem weeds. MPI's focus is squarely on pre-border and border measures. While MPI responds to plant incursions that are new to New Zealand, when it comes to plants that are present in the country, the ministry largely leaves their management to others, including DOC, regional councils and landowners, providing only limited oversight. As such, MPI depends on local communities and councils for surveillance and does not typically get involved if the detection of a plant is simply its first detection in a new region.

This emphasis aligns with a longstanding tradition in New Zealand that weeds pose costs that are in the first place a matter for landowners to attend to. While this may be a reasonable strategy for production weeds where land managers have economic incentives to control them, those incentives are weaker or non-existent when it is native ecosystems that are at stake. If national resources need to be called upon, it is much harder to mount an economic case. This is reflected in the exotic plant initiatives that MPI has taken coordinating responsibility for at the national level.

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[5] Biosecurity Act 1993 s 12A(1).

These include the National Wilding Conifer Control Programme, the National Pest Plant Accord and the Freshwater Biosecurity partnership, as well as some targeted support for velvetleaf (*Abutilon theophrasti*), Chilean needle grass (*Nassella neesiana*) and sea spurge (*Euphorbia paralias*) management. While some of these initiatives clearly offer benefits to native ecosystems, only sea spurge qualifies as a plant species for which MPI is providing some coordination where the benefits are largely confined to native ecosystems.

One consequence of the modest priority accorded to post-border weed management by MPI may be having to intervene late and massively if the combined effect of regional and landowner efforts falls short. The current $100 million wilding conifer programme led by MPI is a case of belated national coordination and intervention for a problem that had been gathering for decades.

That said, MPI does lead something called the National Interest Pest Responses programme, which aims to eradicate eight plant species nationally, and locally eradicate and contain a ninth. Curiously, this list of plants has remained unchanged for years.

While **DOC** has no leadership role for biosecurity, it does have a leadership role in protecting native biodiversity. It has developed several weed-related initiatives and lists in the past, including a strategic plan for weeds in 1998 and a list of environmental weeds in 2008. But it is not clear how many weeds, if any, are still managed under these initiatives. Its focus appears to be elsewhere, currently spending three times more on controlling animal pests than weeds.

In any case, DOC cannot manage weeds beyond the land it administers and lacks the resources to adequately manage even that. While DOC retains a handful of expert staff who understand the risks weeds pose to native ecosystems, a significant fraction of its weed expertise was lost in restructuring a decade ago.

Regional councils also have valuable expertise in dealing with exotic plants and supply significant local leadership. But they are largely left to manage as best they can and perhaps inevitably end up dealing with the same weeds in different ways. While promoting coordination of pest management between regions is one way councils provide leadership under the Biosecurity Act, in practice the coordination and alignment of regional pest management plans appears to be minimal.

While regional councils collectively aim to manage 334 plant taxa through their pest management plans, these plants are managed for a variety of reasons, not just because of their impacts on native ecosystems. Further, the lists of plants included in the final regional pest management plans that emerge reflect public and local political pressures to varying degrees, rather than the weeds that pose the greatest risks or cause the greatest harm. A repeated concern expressed by regional council staff is the sheer time and cost involved in developing pest management plans under the Biosecurity Act.

Trying to provide a focus for a more joined-up nationwide approach to tackling native ecosystem weeds does not fall naturally out of the current legislative framework. The best way forward would be for the Ministers of Biosecurity and Conservation to jointly provide clearer direction on the priority to be accorded to tackling the weeds already in the country that pose the most serious threats to our native ecosystems.

Working closely with regional councils, MPI and DOC should develop national policy direction on native ecosystem weeds. This could be achieved through writing something into the existing National Policy Direction for Pest Management. But it might be achieved more effectively and efficiently if the Biosecurity Act were amended to enable a plurality of national policy directions to be developed to address discrete classes of pests, as insects, plants, mammals and pathogens all present different challenges and need to be managed differently.

Whatever solution is preferred, national policy direction *must* substantively address native ecosystem weeds. At a minimum, that national policy direction should:

- provide clear direction on national priority weeds by:
    - requiring a group of experts to identify national priority weeds using a robust and transparent prioritisation process by a certain date
    - requiring coordinated management of national priority weeds, once they have been determined
    - providing clear direction on management when conflicting values arise
    - requiring regular, proactive and coordinated surveillance and monitoring of the national priority weeds.
- provide clear direction on the management of emerging weeds, including a requirement for regular, coordinated scanning and surveillance
- specify roles to define what is to be done nationally, including any financial contributions by central government, and what is to be done regionally.

Clearly, not every weed is a national priority and resources will limit the number of weeds threatening our native ecosystems that can qualify for this treatment. But some of the rapidly spreading, shade-tolerant plants like wild ginger and climbing asparagus can be so destructively transformative that unless there is a concerted, joined-up effort we risk seeing significant areas of our native forests succumbing to these plants and whatever might follow in their wake.

Time and money being consumed in regions across New Zealand arguing over what goes into regional pest management plans or how any weeds should be managed, could in some cases be saved if clear national priorities were communicated, roles specified and resources prioritised.

Beyond this, improved tools are needed to support a more coordinated effort even where management choices are being made regionally. New Zealand needs a single authoritative and publicly accessible database of all exotic plants present in the country. It needs to use an agreed taxonomy and be constantly updated so that confusion about what is and isn't present can be minimised. It should also, where possible, link to spatial data that describes where plants of concern are currently located, their rate and methods of spread and current management status.

Information of this nature needs to be constantly updated. The pool of native ecosystem weeds does not remain static. Land use change will continue to bring more invasions. Climate change is likely to help some weeds progress along the invasion curve and permit more of them to survive, thrive and spread in parts of New Zealand where they are not found today.

This is not good news given the current patchy and limited nature of a largely passive surveillance system that is too often dependent on serendipitous sightings. New populations of weeds are often only spotted and reported once they are beyond the point where they might have been easily eradicated. This hampers management efforts.

For this reason, MPI and DOC, working in collaboration with regional councils, should set up an emerging risks team to scan for and coordinate the management of newly emergent weeds. Such a team should seek to bring together the best in-house skills hosted by these organisations with experts from the science sector, including the Crown Research Institutes and universities.

Grounds for optimism from the weed roots

Finally, while native ecosystem weeds pose daunting challenges, there is some good news. **Chapter eight details four grassroots – or more appropriately 'weed-roots' – initiatives that are making serious inroads in combatting highly invasive native ecosystem weeds**. The Stewart Island/Rakiura Community & Environment Trust, Project De-Vine Environmental Trust in Golden Bay, the Weed Action Native Habitat Restoration Trust at Whangārei Heads and Te Toa Whenua in the rohe of Te Roroa are community-based initiatives dealing to weed problems that would make many blanch.

All of them have a clear idea about the sustainability of the outcome they are seeking. They are not simply creating weed-shaped holes. They are highly focused and organised. All of them have a very long-term perspective – they know that this is not a problem that can be concluded and walked away from. The chapter also details the approach some rongoā practitioners take to managing plants that upset the balance of Papatūānuku.

The addition of chapter eight is not an afterthought to raise people's spirits. It is included to avoid what could otherwise be an unfortunate conclusion of this report: that native ecosystem weeds can be combatted top-down from the centre. They can't. Weeds grow in places, often on private land, and the people best placed to understand them will often live nearby.

There *is* a need for better tools, information and coordination. Central government has a vital role to play here. There is also a need for a degree of prioritisation at the national level. We shouldn't have to wait until a serious native ecosystem weed is decades along a destructive invasion pathway before any government funds are allocated to backup local and regional efforts.

But nothing should be prioritised or spent without listening very carefully to groups like these. It is these weed-roots organisations that have adopted contemporary technologies to pioneer new approaches to old problems. We need widespread experimentation and information sharing. Any national level response needs to underpin this both through excellent tools and security for whatever ongoing funding is offered.

Managing native ecosystem weeds is with us forever. We need to act in a way that recognises the commitment that implies. If we do, we have a better chance of engaging the long-term commitment of communities to initiatives such as these.

A list of recommendations

Recommendation 1: The Minister for Biosecurity and the Minister of Conservation should provide clearer direction on the priority to be accorded to managing native ecosystem weeds that are already present in New Zealand.

Recommendation 2: The Director-General of the Ministry for Primary Industries (Biosecurity New Zealand) and the Director-General of the Department of Conservation should jointly provide leadership for managing native ecosystem weeds that are already present in New Zealand.

Recommendation 3: In exercising that leadership, the two Director-Generals should require MPI and DOC officials to jointly develop (in collaboration with representatives from regional councils) national policy direction on native ecosystem weeds.

Recommendation 4: National policy direction specifically directed to native ecosystem weeds should be provided *either*:

- (a) by rewriting the existing National Policy Direction for Pest Management 2015 to include several targeted sections on the management of different pests already present in New Zealand – predators, browsers, invertebrates, pathogens, plants – including one specifically devoted to the management of native ecosystem weeds; ***or*:**
- (b) by amending section 56 of the Biosecurity Act 1993 to allow for multiple targeted national policy directions.

Recommendation 5: Any national policy direction that includes policy on native ecosystem weeds should require engagement with iwi and hapū and contain the following minimum content:

- provide clear direction on national priority weeds by:
    - requiring a group of experts to identify national priority weeds using a robust and transparent prioritisation process by a certain date;
    - requiring coordinated management of national priority weeds, once they have been determined;
    - providing clear direction on management when conflicting values arise;
    - requiring regular, proactive and coordinated surveillance and monitoring of the national priority weeds;
- provide clear direction on the management of emerging weeds, including a requirement for regular, coordinated scanning and surveillance; and
- specify roles to define what is to be done nationally, including any financial contributions by central government, and what is to be done regionally.

Recommendation 6: The Ministry for Primary Industries should work with the Department of Conservation, Ministry of Business, Innovation and Employment, regional councils and relevant Crown Research Institutes to develop, administer and maintain a single authoritative and publicly accessible database of all exotic plants in New Zealand.

- As a minimum, this database should:
  - use an agreed taxonomy (established by experts) and be able to cope with inevitable species name changes and multiple names (i.e. synonyms);
  - be maintained so it can provide an up-to-date, authoritative list of plant species present in New Zealand; and
  - include as much available information as feasible (including spatial data that is maintained and improved over time) on plant status, distribution, rate of spread, impacts, methods of spread, and management and control around the country (how, where and by whom).

Recommendation 7: The Ministry for Primary Industries, Department of Conservation and regional councils, working with iwi and hapū and other relevant organisations, should set up an 'emerging risks team' to scan for and coordinate management of newly emerging native ecosystem weeds.

Simon Upton

Parliamentary Commissioner for the Environment

Ipomoea indica

Tirohanga whānui

Ka pātai tēnei pūrongo mēnā he pai rawa tā mātou mahi ki te whakahaere i ngā tūraru a ngā tipu nō tāwāhi ki ō mātou pūnaha hauropi taketake. Kei tōna iho, e arotake ana te pūrongo i te āhuatanga o te mahi a ngā tari kāwanatanga ā-motu, ā-rohe hoki i te whakahaere i ngā otaota pūnaha hauropi taketake i raro i te Ture Biosecurity 1993.

Engari kāore te arotake noa i te hātepe e whakatutuki pai ana i te whīwhiwhi o te kaupapa kei mua i a tātou. Nā reira, kua tāpirihia e au te kōrerorero whānui o te hiranga ā-hītori, ā-pūtaiao, ā-ahurea hoki o te hātepe i whakanoho tūturu nei i ngā tipu nō tāwāhi ki tō tātou horanuku, ā, i ētahi wā, i whakawhārikihia. Kei roto te huhua o ngā tauira hei whakaahua i ngā mahi, tē kitea i te nuinga o te wā, i roto i ō mātou ake iāri. Nā reira, he pūrongo roa ake i tō te mea e tino hiahiatia ana ki te urupare i te pātai he pēhea te whakahaere o tā mātou pūnaha waeture. Mēnā e mōhio ana te kaipānui ki te pūtaiao, haere tōtika ki te upoko tuawhā.

Te āhuatanga nāianei, ā, ka ahatia ā muri ake

Ka whakamātau ngā upoko e toru tuatahi ki te whakamārama i te whānui o tēnei whakatewhatewha me te whakarato i te whakarāpopototanga o ngā mea e mōhio ana mātou mō ngā otaota pūnaha hauropi i Aotearoa nāianei, ā, he pēhea te kukuwha ā muri ake.

Ka whakatakoto te upoko tuatahi i ngā pātai me whakautu tēnei whakatewhatewha. Ko te arotahi ki ngā otaota e tū ana hei tūraru ki ngā pūnaha hauropi taketake (engari, kaua ko ngā otaota moana). E tino mārama ana mātou ki ngā tūraru kei mua i a mātou; ka āhei mātou te kōwhiri tika mo ngā mea hei whakahaeretanga; e tika ana tā mātou whakahaere i te iti o ngā rauemi tangata, ahumoni hoki kei a mātou? Ehara te kaupapa i te painga o ngā taputapu me ngā tukanga hei whakahaere i ēnei otaota, te whakarārangi rānei i ngā mea kino rawa.

Ka kōrero hoki mō te take he mea mania te kupu 'otaota'. Ki te uru te tangata ki te ao o te hauropi otaota, ka tere kite i te huhua o ngā kupu motuhake. Ki te whakamahi i ēnei kupu i ngā wā katoa, ka kitea ngā rerenga roa rawa atu. Koinā te take kua whakamahi au i te kupu "otaota' – engari nā te arotahi o tēnei pūrongo, he kōrero i te nuinga o te wā mō **ngā otaota e pā kino ana ki ngā pūrongo taketake**. I te tino whakamahinga o te kupu otaota, he tipu kāore i te hiahiatia, ā, he tipu e hiahiatia ana, kāore i te hiahiatia ana i roto i ngā wāhi rerekē. He tauira hira ngā Conifer me ngā Russell lupin (*Lupinus polyphyllus*).

He hira ake te tirohanga o te Māori ki ngā otaota. Kei roto i te pūrongo motuhake i whakahaua ki te whakarato i te tirohanga Māori ki ngā tipu nō tāwāhi i kitea te tirohanga rerekē i te mea taketake–pai/nō tāwāhi–kino e rangona ana i ētahi wā. Ka kī te pūrongo:

> "ko te otaota te tipu e whakahē ana i te hangarite e hiahiatia ana e Papatūānuku kia ora ai. E whakapae ana tēnā ko te otaota he tipu e whakatuanui ana i te pūnaha hauropi kia kore ai e āhei te mahi kia whakaora i te koiora me noho i reira. Ko te otaota te tipu e whakahē ana i te whārite māori."[1]

He nui rawa ngā momo tipu e wātea ana ki te whakahē i taua whārite. Ko Aotearoa tētahi o ngā whenua motu nui rawa te otaota puta noa i te ao. He nui ake ngā tūmomo tipu kua noho taketake ki Te Ika-a-Māui me te Waka-a-Māui i tō te nuinga o ngā motu puta noa i te ao. He āhua tekau mā rua ngā tipu i haria mai e ngāi Māori. E 25,000 ngā tipu i haria mai e te Pākehā. I roto i ngā tau rua rau, ka noho taketake ngā mea 1,800, arā, kua wehe i te tiritiri, ā, ka toitū ngā taupori pāwhara. Mai i ngā 1950, kua whakaratoa ēnei e ngā tipu whakarākei.

Ka tautuhi te upoko tuarua i te hātepe e kīia nei e ngā kaimātai hauropi he *kōpiko urutomo* - te ara whiu e whāia ana e te tipu nō tāwāhi ina neke ana mai i te tae mai ki te whakarauora, ā, ki te matomato. Ka whakahua hoki i ētahi o ngā mea e mōhio ana mātou mō tā mātou āheinga ki te matapae ko ēhea ngā tipu ka kaha haere me ngā tūmomo whakakino ki ngā pūnaha hauropi taketake. Ka whakawhirinaki te whanonga o te tipu ki te horopaki, nā reira, e uaua ai te matapae te wā e whai ake ana. I roto i te rangahau i mahia i te rua tekau tau i mua i kitea o te 181 momo tipu nō tāwāhi i runga i te whenua e whakahaeretia ana e te Tari Taiao (DOC), tekau ōrau kāore i whakaarohia he otaota i tāwāhi. Nā te āhuatanga o konei i tautokohia kia pūmai ai ki konei.[2]

Kāore e kore, ka neke ngā āhuatanga o konei – e panoni ana i ngā wā katoa ina panoni ai mātou i te whakamahinga o te whenua, ā, he nui te tūponotanga ka kaha ake te panoni ina kaha ake te panoni āhuarangi. Nā te puna nui o ngā mea urutomo pea e tipu ana i roto i ngā papa rēhia me ngā māra, **e mātai ana te upoko tuatoru i te tūponotanga ka urupare ngā mea hou e puta ana i ngā māra ki ngā kōwhiringa mai i te whakahē i te whenua me te whakamahana e whakarato ana te panoni āhuarangi.**

He pēhea te pūnaha whakahaumaru koiora onāianei e whakarite ai i ngā otaota pūnaha hauropi taketake

E aro atu ana te toenga o te pūrongo mēnā e reri ana tātou mō te wero a tēnei taua otaota ngū. **E pātai ana te upoko tuawhā mēnā e mōhio ana mātou he aha ngā mea hei tautoko i a mātou kia tika ngā whakataunga**. Kāore i te ngaro ngā mōhiohio mata. Engari, he nui te mahi kia tika te whakarite, whakahaere, me te whakatapoko. Kei roto i ngā raruraru kua tautuhia:

- Kāore e tūhono ana ā mātou pātengi raraunga huhua, nā reira, kāore i te tuaritia ngā mōhiohio hira.
- He nui ngā mōhiohio kāore e taea te whakapā atu, kāore e tino ngāwari ana te whakapā atu rānei.

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[1] McGowan, 2021, p.9.

[2] Williams mā., 2000, wh.27, Ripanga 11.

- Kāore he pātengi raraunga hōhohu, hou rawa, whaimana e kume mai ana i ngā mōhiohio katoa e pā ana ki ngā momo tipu nō tāwāhi i Aotearoa, ā, mēnā e whakahaeretia ana, ā, he pēhea, ā, mā wai.
- Ko ngā take pūnaha whakarōpū, tae atu ki te huhua o ngā momo ingoa tipu (me ngā kōwhiringa mō te pōhēhētanga kei roto), e whakapōturi ana i te rere o ngā mōhiohio.
- He pūreirei te tūtei i te mura o te ahi e pā ana ki ngā otaota. Ka whakawhirinaki ngā pūrongo i te pakanga ki te waimārie me te tūtei pūnahanaha hoki.

Ka oti te upoko i te tuhinga o te āhua o te pūnaha mōhiohio pai mō ngā otaota. Ko te mea hira, me āta whakauru tētahi pūnaha pēnā i ngā mōhiohio mō ngā momo tipu nō tāwāhi katoa e tipu pāwhara ana ki Aotearoa – kaua ko ngā mea anake e mōhiotia ana ka whakakino i te pai o ngā pūnaha hauropi taketake.

Me mōhio mātou he aha ngā nekeneke kia āhei te whawhai moata ki ngā kaiurutomo hou. Ka tāpae te wawao moata i te tūponotanga pai rawa o te whakakore i aua mea, ki te kore, te whakahaere me te iti o te utu. Ehara te whakakore i te mea ngāwari. Ko te mea kino, kāore anō kia angitu te whakakore i tētahi tipu whenua i te motu mēnā kua whānui ake tana māhorahora i te heketea kotahi i te wāhi kotahi. Me whai mātou i te pūnaha mōhiohio e āhei ana te tautoko i a mātou ki te kite me te urupare ki ngā momo kua whakamāorihia inākuanei, ngā mea rānei kātahi anō ka tīmata te māhorahora. Mēnā he urupare pōkaikaha, pōturi rānei, ka tae atu ngā otaota ki te wāhi kāore e taea te whakakore.

Mā ngā mōhiohio tino kounga e āhei mātou te whakamahi i te iti rawa o ngā rauemi tangata, ahumoni hoki e wātea ana ki a mātou. Engari kāore e karo atu i te hiahia kia kōwhiri. **Ko te tikanga o te upoko tuarima he pēhea te kawatau e ārahi i tā mātou whakatū i ngā rauemi tangata, ahumoni iti hoki e wātea ana**. Me whakatau ko *ēhea* ngā tipu hei whakahaere, *ki hea*, ā, he *pēhea* e whakahaere, ā, *mā wai*.

Ko ētahi o ngā pātai matua: ko ēhea ngā tipu nō tāwāhi me aro atu ināianei? E tika ana te whakatau i ngā kōwhiringa ināianei e pā ana ki ngā wero ā muri ake? Kāore e kore, me noho te pūnaha kawatau ki te taunakitanga pai rawa kei a mātou, ā, me tāwariwari me urutau hoki ki te urupare ki ngā mōhiohio hou. Engari he hira ake kia āhei te whakakakau i te whakaaro mārama o te putanga e rapuahia ana i te wā roa.

Me āhei, me toitū ngā hōtaka whakahaere otaota i te wā roa – tērā pea he wā roa rawa. Kāore he take ki te auaha i te kōwhaowhao utu nui ki te āhua o te otaota e tatari ana kia urutomohia anōtia. He mea waiwai te mōhio he aha te mea e whai ake ana. Mēnā ko te whāinga te whakakorenga, me noho te tūponotanga pai , ā, me tautoko e ngā rauemi e hiahiatia ana kia angitu ai. Ki te kore, he tūraru ka puta mai te mūhore i te whakahaere pūmau i te paunga o te wā nui me te mahi nui. Engari, mēnā ka whakaae ki te noho me te otaota ko te utu he "mahi māra mutunga kore" pea. Mā te ine i te whakakino onāianei ki ngā tūraru ā muri ake, me te whakarite i ngā whakawhitinga he mahi uaua kei te iho tētahi pūnaha whakahaumaru koiora.

Kua tae mātou ki te iho o tēnei whakatewhatewha. He pēhea te pai o te whakahaere a te pūnaha whakahaumaru koiora i ngā otaota pūnaha hauropi taketake? **Ka tautuhi te upoko tuaono i te anga ā-ture, ā-waeture hoki e whaimana ana i roto i te pūnaha. Kātahi ka whaiwhakaaro te upoko tuawhitu ki ngā mahi a ngā kaimahi rerekē, ā, he pēhea tā rātou whakatinana i ā rātou haepapa.**

Ko te kōrero tuatahi mō te pūnaha whakahaumaru koiora he whīwhiwhi rawa. Ka whakatū te Ture Biosecurity o 1993 i te pūtake ā-ture mō te wawao i te rohenga i ngā urunga mai kāore i te hiahiatia a ngā rauropi whakakino mai i ngā kararehe waewae whā ki ngā tukumate tē taea te kite. Kei te mura o te ahi te Manatū Ahu Matua (MPI). Ka tiro, ka mahi ki tua atu i te rohenga, tae atu ki te whakarite i ngā rauropi kua whakawhiti mai i te rohenga. Ka kapi te pūnaha whakahaumaru koiora i te kāwanatanga ā-motu, ā-rohe hoki, ā, ka whakawhirinaki ki te whakapāpā me te mahi tahi a ngā ahumahi me ngā hapori.

Te āhua nei he tino wero te whakamārama i te pūnaha ki te Minita hou, ki ngā kaikaunihera pōtitanga hou. Ahakoa ka tākai te Ture Biosecurity i ngā aho huahua mai i te tirohanga ture, kāore i te ngāwari te mārama he aha te ara tika kia mahi tahi ai ngā tari huhua. Ā, i tua atu i tēnā, ka whakamahia ētahi mahi whakahaere otaota i raro i ētahi atu Ture.

Ko te kōrero tuarua mō te pūnaha whakahaumaru koiora ko te tino arotahi ki te rohenga me ngā tikanga i mua i te rohenga. Kua āta whakaaro mātou mō ngā mea kāore i te hiahiatia ki te whakawhiti i tō mātou rohenga, ā, e tika ana, ka whakapau kaha nui ki te wawao. Engari e pā ana ki ngā momo nō tāwāhi kua tau kē ki Aotearoa, ā, e whakakino ana i ētahi āhuatanga, he iti rawa te kōrero a te ture me aro ki hea.

Ko te kaupapa o te wāhanga 5 o te Ture Biosecurity ko te whakahaere i ngā rauropi whakakino (he mea koiora, tae atu ki ngā otaota pūnaha hauropi taketake) kei Aotearoa kē. Ka kīia ko te kaupapa o tēnei wāhanga – te whakakorenga, te whakahaere whaihua o ngā rauropi whakakino – ko te ārai, te whakaiti, te whakakore rānei i ngā putanga kino o ēnei rauropi ki te whānuitanga o ngā putanga, tae atu ki te oranga ohaoha, te taiao me te ngahau i te taiao.

Heoi anō, ko te mea hira, kāore te whiti kaupapa o Wāhanga 5 e whakarato ai i te whakamāramatanga mō te kawatau i ēnei putanga, he mea taupatupatu i ēnei wā. Ko te mea hira, ka ōrite te arotahi o te kaupapa i kōrerohia ki ngā taputapu me ngā inenga – arā te whakarato – ki ngā putanga.

Kāore he kōrero i roto i te Ture Biosecurity mō ngā kawatau me tuku ki te rauropi whakakino, te rōpū rauropi rānei. Kāore hoki he kōrero i roto i ngā Ture matua e rua e whakaritea ana mō te whakahaumaru taiao me te whāomoomo – te Ture mō te Resource Management 1991 me te Ture Conservation 1987.[3]

Nā te mea kāore he kawatau mārama i te āhua o ngā ture, ka whakahaeretia ngā otaota ka noho whakamōrea ki ō mātou pūnaha hauropi taketake i runga i te mahi o ia rā, me ngā whakawhitinga kaupapa-ki-te-kaupapa. Nā te mea kāore he ahunga e pā ana ki te kawatau o ngā otaota pūnaha hauropi taketake, ko te tikanga, ki te kore he āwangawanga tōrangapū, ka waiho ki te māhorahora haere.

[3] Kāore i pērā i ngā wā katoa. E tata ana ki te rautau, he ture ake mō ngā tipu kino nō tāwāhi. Ka whakaturea te Ture Noxious Weeds i te tau 1900 me te rārangi tipu whakararu i roto. Ka haere tonu, me ngā menemana huahua, tae ki te wā i kapia e te Ture Noxious Plants i te tau 1978. Engari ko te tino arotahi tonu ko ngā tipu e whakaarohia ana he whakakino e ngā kaipāmu me te hunga whiwhi whenua. Ka tahia atu taua Ture i te pāhitanga o te Ture Biosecurity.

Nā te āwangawanga hapori whānui ki ngā tūraru a ngā riha kararehe ki te taiao, tae atu ki ngā pūnaha hauropi taketake, i whakaputa i te āwangawanga tōrangapū me ngā tāra miriona, ā-tūmatanui, ā-tūmataiti hoki, ki te whakahaere i ngā konihi waewae whā. E 31 ngā kararehe nō tāwāhi e hāereere ana, me te rautaki ki te whakawātea i a Aotearoa i ētahi noa iho o aua mea – te whānau tori uaroa, kiore nui me ngā paihamu – hei te 2050. Ka kī te Predator Free 2050 Strategy i kōwhiria ēnei momo "nā te mea, hui katoa, ka tuku i te whakakino nui rawa ki ngā kararehe o Aotearoa o ngā konihi katoa i whakaurua mai. He nui ake hoki ō mātou mōhiotanga ki tō rātou mātai koiora, whakahaere hoki i tō ētahi atu konihi."[4]

Kāore tētahi whakatairangatanga i te mura o te ahi e pā ana ki ngā otaota. He mano ngā tipu nō tāwāhi e ora ana i te ngahere o ngā tipu tekau mano i whakaurua mai ki Aotearoa. Kāore e iti iho i te 380 ngā mea e whakahōhā ana i ngā pūnaha hauropi taketake, ā, he nui te tūponotanga ka haere mai ētahi atu ki ō rātou taha – otirā ngā mea e puta mai ana i ngā māra. Engari kāore e taea e ngā mea whakanoti pērā i ngā triffid, arā te ginger mohoao (*Hedychium* sp.) te apareka whakapiki rānei (*Asparagus scandens*), te whakarewa i te pukuriri pērā i te taute i hopukia ki te ataata e kai ana i te pipi kiwi.

Ka pau ngā hēkona i te taute te mahi. Ko te ngarohanga o te nōhanga me ētahi atu pānga ki ngā pūnaha hauropi a ētahi otaota ka puta mai i roto i ngā tau huhua. Engari he pērā te taumaha o tēnei kaupapa. E hiahiatia ana e Aotearoa te tirohanga whānui pai ake ā-motu o te tuwheratanga o tēnei raupatu tipu haere pōturi me te rārangi mārama o ngā kawatau e puta mai ana i ngā aromatawai tūraru kaha. Me tino mārama ko wai ka noho haepapa ki te mahi, me ngā taputapu tuari me ngā mōhiohio e wātea ana ki ngā taumata katoa o te kāwanatanga me te hapori whānui.

He uaua ki te whakatutuki i raro i te ture onāianei. Ahakoa ka kī te Ture Biosecurity ka ārahi te Minita mā te ahunga kaupapahere ā-motu, ā, e herea ana ia ki te whakarato, kotahi anake te ahunga e whakaaetia ana kia whakaritea i raro i te Ture. Nā reira, me kapi i ngā mea katoa – nā reira he whānui he whakaruha hoki ana whakaritenga.

Ko te mea rerekē, kāore he ihirangi iti rawa i whakaturea mō te ahunga kaupapahere ā-motu me mahi e te Minita. Kāore he herenga kia whakaritea ētahi tūmomo otaota, te kī rānei he aha ngā otaota kawatau – otirā ētahi atu riha rānei – me whakahaere ā-motu. Engari, ko te National Policy Direction for Pest Management 2015 he taputapu e arotahi ana ki te whakahaere i ngā rauemi, kaua ko te whakaatu i ngā whakawhitinga e puta mai ai i te horopaki o te pūnaha whakahaere riha katoa.

E whakarato ana te Biosecurity Act me te National Policy Direction for Pest Management i te pou tarāwaho hei whakarite i ngā mahere whakahaere riha ā-motu me ngā mahere whakahaere ara ā-motu. Engari kore rawa tētahi o ēnei mahaere i whakaritea mō te tipu whenua nō tāwāhi. E marohi ana te korenga o aua tūmomo mahere, he ārai kia whakamahia aua mahere. Ka marohi hoki ehara ngā tūraru a ngā otaota ki ā mātou pūnaha hauropi taketake i te kawatau. I te hipatanga o te wā, e tipu ake ana ngā otaota i ngā ango.

E hiahiatia ana e Aotearoa te ruruku me te ahunga ā-motu pai ake, ka taea te whai te whakahaere i ngā otaota e whakakino ana, ka whakakino pea rānei, i ngā pūnaha hauropi taketake. Mēnā tērā tētahi ahunga kaupapahere ā-motu, ka hiahia i te arotahi mārama ake mā wai e noho haepapa ki te whakarato i te hautūtanga e hiahiatia ana ki te whakahaere i ngā otaota.

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[4] Te Kāwanatanga o Aotearoa, 2020, wh.14.

Kei te marara taua hautūtanga ināianei. Ahakoa ka kī te Ture Biosecurity ka whakarato te Tumuaki-Matua o **MPI** i te "tino hautūtanga i roto i ngā mahi e ārai, whakaheke, whakakore rānei i ngā putanga kino e puta mai ana i ngā rauropi whakakino i Aotearoa",[5] he iti rawa te kitea o tēnei hautūtanga e whakamahia ana e pā ana ki te whakahaere i ngā otaota pūnaha hauropi taketake. Ko te tino arotahi a MPI ko ngā tikanga i mua i te rohenga, me te rohenga anō hoki. I a MPI e urupare ana ki ngā urunga tipu hou ki Aotearoa, e pā ana ki ngā tipu kei roto i te motu ināianei, ka waiho te Manatū mā ētahi atu e whakahaere, tae atu ki DOC, ngā kaunihera ā-rohe me ngā kaipupuri whenua, e whakarato ai i te tirohanga whānui iti. Nā reira, e whakawhirinaki ana a MPI ki ngā hapori ā-rohe me ngā kaunihera hei tūtei, ā, kāore e whai wāhi mēnā ko te kitenga i te tipu, ko te kitenga tuatahi noa iho ki tēnei takiwā hou.

Ka tīaroaro tēnei mahi whakanui ki te whakaaro pūmau i Aotearoa ko ngā utu e puta mai ana i ngā otaota, he mea mā ngā kaipupuri whenua. Ahakoa he rautaki pai tēnei mō ngā otaota whakaputanga, arā, he whakapoapoa ohaoha mā te hunga whakahaere whenua ki te whakahaere, he iti iho aua whakapoapoa, kāore he whakapoapoa rānei mēnā kei te mura o te ahi ngā pūnaha hauropi taketake. Mēnā me rapu i ngā rauemi ā-motu, he uaua ake te whakatakoto i te take ohaoha. E kitea ana tēnei ki ngā hinonga tipu nō tāwāhi e noho haepapa ana a MPI ki te ruruku i te taumata ā-motu.

Kei roto i ēnei ko te National Wilding Conifer Control Programme, te National Pest Plant Accord me te rangapū Freshwater Biosecurity, tae atu ki te tautoko heipū hoki mō whakahaere o te velvetleaf (*Abutilon theophrasti*), Chilean needle grass (*Nassella neesiana*) me te sea spurge (*Euphorbia paralias*). Ahakoa he hua nō ētahi o ēnei hinonga ki ngā pūnaha hauropi taketake, ko te sea spurge anake te momo tipu e whakarato ana a MPI i te ruruku e noho ana ngā painga ki ngā pūnaha hauropi taketake.

Ko tētahi putanga o te kawatau iti a MPI ki te whakahaere otaota i muri i te rohenga ko te wawao takamuri i runga i te whakapau kaha nunui mēnā kāore e eke ngā mahi a te takiwā me ngā kaipupuri whenua. Ko te hōtaka wilding conifer $100 miriona onāianei e ārahina ana e MPI he tauira o te ruruku ā-motu me te wawao tōmuri mō te raruraru i te whakaemi mai mō ngā tekau tau.

Ahakoa tērā, ka ārahi a MPI i tētahi mea e kīia ana he hōtaka National Interest Pest Responses, e whai ana ki te whakakore i ngā momo tipu e waru ā-motu, me te whakakore ā-rohe me te karapoti i te tuaiwa. Ko te mea ohorere, kāore i panoni tēnei rārangi tipu i ngā tau huhua.

Ahakoa kāore he tūnga hautūtanga tā **DOC** mō te whakahaumaru koiora, he tūnga hautūtanga ki te whakahaumaru i te kanorau koiora taketake. Kua whakawhanake i ngā hinonga e pā ana ki te otaota me ngā rārangi i mua, tae atu ki te mahere rautaki mō ngā otaota i te tau 1998 me te rārangi o ngā otaota taiao i te tau 2008. Engari kāore i te mārama e hia ēnei otaota, mēnā ētahi, e whakahaeretia tonutia ana i raro i ēnei hinonga. Kei wāhi kē te arotahi, he whakarea toru te utu ki te whakahaere i ngā riha kararehe i tō ngā otaota.

Heoi anō, kāore e taea e DOC te whakahaere i ngā otaota i tua atu i te whenua e whakahaeretia ana e ia, ā, he iti rawa ngā rauemi ki te whakahaere i tērā. Ahakoa e pupuri tonu ana a DOC i ngā kaimahi mātanga torutoru e mārama ana ki ngā tūraru o ngā otaota ki ngā pūnaha hauropi taketake, he wāhanga nui nō te mātanga otaota i ngaro i te waihangatanga anō i te tekau tau i mua.

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[5] Biosecurity Act 1993 s 12A(1).

He mātanga kounga tō ngā **kaunihera ā-rohe** ki te whakarite i ngā tipu nō tāwāhi, ā, ka whakarato i te hautūtanga ā-rohe hira. Engari ka waihotia rātou ki te whakahaere ki te kounga e āhei ana rātou, ā, kāore e kore ka whakahaere anō i ngā otaota ki ngā ara rerekē. Ahakoa te whakatairanga i te ruruku o te whakahaere riha i waenganui i ngā takiwā tētahi ara e whakarato ana ngā kaunihera i te hautūtanga i raro i te Ture Biosecurity, i te whakatinanatanga he iti rawa te ruruku me te tīaroaro o ngā mahere whakahaere riha ā-motu.

Ahakoa e whai ana ngā kaunihera ā-rohe ki te whakahaere i ngā rōpū tipu 334 mā ā rātou mahere whakahaere riha, e whakahaeretia ana ēnei tipu mō te huhua o ngā take, kaua ko te pānga anake ki ngā pūnaha hauropi taketake. Waihoki, e whakaata ana te rārangi tipu i roto i ngā mahere whakahaere riha whakamutunga i ngā pēhanga tōrangapū tūmatanui, ā-rohe hoki, kaua ko ngā otaota tūraru nui, whakakino nui rānei. Ko tētahi āwangawanga kaha te kōrerotia e ngā kaimahi kaunihera ā-rohe ko te nui o te wā me te utu ki te whakawhanake i ngā mahere whakahaere riha i raro i te Ture Biosecurity.

Kāore e puta māori mai ana te arotahi mō te ahunga whakakotahi ā-motu ki te whakarite i ngā otaota pūnaha hauropi taketake i te pou tarāwaho ture onāianei. Ko te ahunga whakamua pai rawa kia tuku ngātahi ngā Minita o te Whakahaumaru Koiora me te Whāomoomo i te ahunga mārama ake ki te kawatau o te whakarite i ngā otaota i roto i te motu ka tino tūraru i ō mātou pūnaha hauropi taketake.

Me whakawhanake a MPI me DOC i te ahunga kaupapahere ā-motu mō ngā otaota pūnaha hauropi taketake, me te mahi tahi me ngā kaunihera ā-rohe. Ka whakatutukihia tēnei mā te tuhi i tētahi mea ki te National Policy Direction for Pest Management onāianei. Engari he whaihua, he pai hoki te whakatutuki mēnā i whakarerekēngia te Ture Biosecurity kia taea ai te whakawhanake i te huhua o ngā ahunga kaupapahere ā-motu kia urupare i ngā momo motuhake hei riha, hei pepeke, hei tipu, hei kararehe, hei tukumate. He rerekē ngā wero o ēnei mea katoa, ā, me rerekē te whakahaere.

Ahakoa he aha te whakataunga e hiahiatia ana, *me* āta urupare te ahunga kaupapahere ā-motu i ngā otaota pūnaha hauropi taketake. Me pēnei te ahunga kaupapahere ā-motu i te itinga:

- whakarato i te ahunga mārama mō te kawatau ā-motu o ngā otaota mā te:
    - whakahau i te rōpū mātanga ki te tautuhi i ngā otaota kawatau ā-motu mā te hātepe kawatau mārama ā tētahi wā e whakaritea ai
    - whakahau i te whakahaere ruruku o ngā otaota kawatau ā-motu, i te wā kua tautuhia
    - whakarato i te ahunga mārama mō te whakahaere mēnā e puta mai ana ngā uara taupatupatu
    - whakahau i te tūtei me te aroturuki riterite, whakapau kaha me te ruruku o ngā otaota kawatau ā-motu.
- whakarato i te ahunga mārama mō te whakahaere o ngā otaota e puta mai ana, tae atu ki te karapa me te tūtei riterite, ruruku hoki
- tautuhi i ngā tūnga ki te whakamārama me aha ā-motu, tae atu ki ngā tāpaetanga ahumoni a te kāwanatanga ā-motu, ā, me aha ā-rohe.

Kāore e kore, ehara ngā otaota katoa i te kawatau ā-motu, ā, ka tepea e ngā rauemi te nama o ngā otaota e whakawehi ana i ō mātou pūnaha hauropi taketake e taea ana te uru ki tēnei mahi. Engari nā te panonitanga whakamōtī a ētahi o ngā tipu māhorahora tere, e rata ana ki te whakamarumaru pērā i te tinita mohoao me te apareka whakapiki, ki te kore e āta mahi tahi ai, ko te tūraru ka kapia ngā takiwā hira o ā mātou ngahere taketake ki ēnei tipu me ngā mea e whai ake ana i aua tipu.

Ka taea te whakakore i paunga o te wā me te moni i roto i ngā takiwā puta noa i Aotearoa ki te taupatupatu me tuku i te aha ki ngā mahere whakahaere, me pēhea rānei te whakahaere i ngā otaota, mēnā i whakakakauhia ngā kawatau mārama ā-motu, ka tautuhia ngā tūnga, ā, ka kawatau i ngā rauemi.

I tua atu i tēnei, e hiahiatia ana ngā taputapu pai ake ki te tautoko i te mahi ruruku ake ahakoa kei ngā takiwā e whakataua ana ngā kōwhiringa. E hiahia ana a Aotearoa i te pātengi raraunga kotahi e whaimana ana, e taea te uru e te hunga tūmatanui o ngā tipu nō tāwāhi katoa i roto i te motu. Me whakamahi i te pūnaha whakarōpū e whakaaetia ai kia whakaiti i te pōhēhētanga mō ngā mea i konei, kāore i konei rānei. Me tūhono hoki, mēnā e āhei ana, ki te raraunga takiwā e tautuhi ana i te wāhi o ngā tipu e āwangawangahia ana ināianei, te pāpātanga me te tukanga o te māhorahora me te āhua whakahaere ināianei.

Me riterite te whakahou i ngā mōhiohio pēnei. Kāore e noho ōrite ana te mātāpuna o ngā otaota pūnaha hauropi taketake. Mā te panoni o te whakamahi whenua e tō mai ai i ētahi atu urutomo. He nui te tūponotanga ka āwhina te panoni āhuarangi kia ahu whakamua ētahi otaota i runga i te kōpiko urutomo me te tautoko i ētahi atu o aua mea kia ora, kia matomato, kia māhorahora hoki ki ngā wāhanga o Aotearoa kāore i te kitea ināianei.

Ehara tēnei i te rongo pai nā te āhuatanga pūreirei me te tepenga o te pūnaha tūtei hāngū e whakawhirinaki ana i te nuinga o te wā ki ngā kitenga waimārie. Ka kitea, ka pūrongohia hoki ngā taupori otaota i te wā kua oti te wā he ngāwari te whakakore. Ka whakauaua tēnei i ngā whakapau kaha whakahaere.

Nā reira, me whakatū a MPI me DOC, e mahi tahi ana me ngā kaunihera ā-rohe, i te tīma mō ngā tūraru e puta mai ana ki te karapa, me te ruruku i te whakahaere o ngā otaota e puta hou mai ana. Me rapu te tīma pērā ki te whakaemi i ngā pūkenga pai rawa rō-whare e tiakina ana e ēnei rōpū whakahaere me ngā mātanga nō te rāngai pūtaiao, tae atu ki ngā Hinonga Rangahau Karauna me ngā whare wānanga.

He take kia ngākau rorotu mai i ngā pakiaka otaota

Ka mutu, ahakoa he tino wero tō ngā otaota pūnaha hauropi taketake, tērā te rongo pai. **Ka whakaatu te upoko tuawaru i ngā hinonga pakiaka karaehe – e tika ana pea te 'pakiaka-otaota' – e āta pakanga ana ki ngā otaota pūnaha hauropi taketake tino urutomo nei**. Ko te Stewart Island/Rakiura Community & Environment Trust, te Project De-Vine Environmental Trust i Te Tai Tapu, te Weed Action Native Habitat Restoration Trust i ngā Mātārae o Whangārei me Te Toa Whenua i roto i te rohe o Te Roroa ētahi o ngā hinonga ā-hapori e whakatika ana i ngā raruraru otaota ka whakaohorere i te tini me te mano.

E tino mārama ana rātou ki te toitū o te putanga e rapu ana rātou. Kāore rātou i te auaha noa i ngā pūare āhua otaota. He arotahi nui, he whakaritenga nui hoki. He tirohanga wā roa tā rātou katoa – e mōhio ana rātou ehara tēnei i te raruraru ka taea te whakaoti me te wehe atu. Ka whakatakoto hoki tēnei upoko i te ahunga a ētahi kaimahi rongoā ki te whakahaere i ngā tipu e whakahē ana i te whārite o Papatūānuku.

Ehara te tāpiritanga o te upoko tuawaru i te whakaaro nō muri mai ki te hiki i te wairua. E tāpirihia ana kei pōhēhētia e tika ana tētahi whakataunga i roto i tēnei pūrongo: ka taea te whawhai ki ngā otaota pūnaha hauropi mai i runga ki te pū. Kāore e taea. Ka tipu ngā otaota ki ngā wāhi, i te whenua tūmataiti i te nuinga o te wā, ā, ka noho tata te hunga e tino mōhio ana me pēhea.

He hiahia ki ngā taputapu, ngā mōhiohio me te ruruku pai ake. He mahi hira tā te kāwanatanga ā-motu i konei. E hiahiatia ana hoki te kawatu i te taumata ā-motu. Me kaua mātou e tatari kia pau ngā tekau tau o te ara urutomo whakakino o tētahi otaota pūnaha hauropi taketake i mua i te wā ka tukunga ngā pūtea kāwanatanga ki te tautoko i ngā mahi ā-rohe, ā-takiwā hoki.

Engari me kaua e kawatau, e utu moni rānei ki te kore e āta whakarongo ki ngā rōpū pēnei. Kua ū ngā rōpū pūtake-otaota nei i ngā hangarau hou ki te waihanga i ngā ahunga hou ki ngā raruraru tawhito. E hiahia ana mātou ki te whakamātautau whānui me te tuari mōhiohio. Me noho hei pūtake te urupare taumatau ā-motu i tēnei mā ngā taputapu pai rawa me te whakahaumaru mō te pūtea haere tonu e tāpaetia ana.

Ka noho te mahi whakahaere otaota pūnaha hauropi taketake ki a mātou mō ake tonu atu. Me mahi tātou kia whakaatu i te haepapa e puta mai ana i tēnā. Ki te pēnei, he pai ake te tūponotanga ka noho haepapa ngā hapori ki ngā kaupapa pēnei mō te wā roa.

He rārangi tūtohunga

Tūtohunga 1: Me whakarato te Minita mō te Whakahaumaru Koiora me te Minita mō Te Papa Atawhai i te ahunga mārama ake ki te kawatau mō te whakahaere i ngā otaota pūnaha hauropi taketake kei Aotearoa ināianei.

Tūtohunga 2: Me tuku ngātahi te Kaiwhakahaere-Matua o te Manatū Ahu Matua (Whakahaumaru Koiora Aotearoa) me te Kaiwhakahaere-Matua o te Papa Atawhai i te hautūtanga ki te whakahaere i ngā otaota pūnaha hauropi taketake kei roto i Aotearoa ināianei.

Tūtohunga 3: Ina whakahaere ana i taua hautūtanga, me whakahau ngā Kaiwhakahaere-Matua i ngā āpiha nō MPI me DOC ki te whakawhanake ngātahi (me te mahi tahi ki ngā māngai nō ngā kaunihera ā-rohe) i te ahunga kaupapahere ā-motu mō ngā otaota pūnaha hauropi taketake.

Tūtohunga 4: Me kōwhiri i *tētahi* o ngā kōwhiringa e rua e whai ake nei ki te whakarato i te ahunga kaupapahere ā-motu mō ngā otaota pūnaha hauropi taketake:

- (a) te tuhi anō i te National Policy Direction for Pest Management 2015 onāianei ki te whakauru i ngā wāhanga heipū mō te whakahaere i ngā riha rerekē i Aotearoa i nāianei – ngā konihi, ngā kaitirotiro, ngā kararehe kore tuarā, ngā tukumate, ngā tipu – tae atu ki te mea e āta arotahi ana ki te whakahaere i ngā otaota pūnaha hauropi taketake; ***tēnei rānei***:
- (b) mā te whakarerekē i te wāhanga 56 o te Ture Biosecurity 1993 kia whakaaetia ngā ahunga kaupapahere ā-motu heipū huhua.

Tūtohunga 5: Mēnā he kaupapahere mō ngā otaota pūnaha hauropi taketake i roto i te ahunga kaupapahere ā-motu me whakahau te whakapāpā ki ngā iwi me ngā hapū, ā, me kaua e iti iho te whakauru i te ihirangi e whai ake nei:

- te whakarato i te ahunga mārama mō ngā otaota kawatau ā-motu mā te:
  - whakahau i te rōpū mātanga ki te tautuhi i ngā otaota kawatau ā-motu mā te hātepe kawatau mārama hei tētahi wā motuhake;
  - whakahau i te whakahaere ruruku o ngā otaota kawatau ā-motu, ina whakataua ai;
  - whakarato i te ahunga mārama mō te whakahaere mēnā e puta mai ai he uara taupatupatu;
  - whakahau i te tūtei me te aroturuki auau, whakapau kaha me te ruruku o ngā otaota kawatau ā-motu;
- whakarato i te ahunga mārama ki te whakahaere i ngā otaota e puta mai ana, tae atu ki te herenga mō te karapa me te tūtei riterite me te ruruku; me te
- tautuhi i ngā tūnga kia whakatau me aha ā-motu, tae atu ki ngā tāpaetanga ahumoni a te kāwanatanga ā-motu, ā, me aha ā-rohe.

Tūtohunga 6: Me mahi tahi te Manatū Ahu Mahi me te Papa Atawhai, Hīkinia Whakatutuki, ngā kaunihera ā-rohe me ngā Hinonga Rangahau Karauna hāngai ki te whakawhanake, whakahaere me te whakapūmau i te pātengi raraunga kotahi e whaimana ana, e taea ana te uru te hunga tūmatanui, o ngā tipu nō tāwāhi katoa i Aotearoa.

- Me kaua e iti iho ngā mea e whakaurua ai ki tēnei pātengi raraunga i ērā e whai ake nei:
  - whakamahi i te pūnaha whakarōpū e whakaaetia ana (he mea whakatū e ngā mātanga), ā, me āhei te whakamahi ki ngā panoni ingoa me ngā ingoa huhua (arā, ngā kupu taurite);
  - kia whakahaeretia kia āhei te whakarato i te rārangi whaimana, hou rawa o ngā momo tipu i Aotearoa i tēnei wā; me te
  - tāpiri i te nuinga o ngā mōhiohio e āhei ana (tae atu ki te raraunga takiwā e whakahaeretia ana, e whakapaitia ake ā tōna wā) mō te tūnga o te tipu, te māhorahora, te pāpātanga o te māhorahora, ngā pānga, ngā tukanga māhorahora, me te whakahaere me te whakarite puta noa i te motu (he pēhea, ki hea, mā wai).

Tūtohunga 7: Me whakatū te Manatū Ahu Mahi, te Papa Atawhai me ngā kaunihera ā-rohe, e mahi tahi ana me ngā iwi me ngā hapū me ētahi atu rōpū whakahaere hāngai, i te 'tīma tūraru e puta mai ana' ki te karapa me te ruruku i te whakahaere o ngā otaota pūnaha hauropi taketake e puta mai ana.

Simon Upton

Te Kaitiaki Taiao a te Whare Pāremata

1

Chrysanthemoides monilifera subsp. *monilifera*

Why this report?

For an island nation, New Zealand has a very high number of naturalised exotic plant species – it stands out globally in this regard. Over the years, humans have introduced more than 25,000 exotic vascular plant species to these islands, and nearly 3,000 of them have been found growing in the wild.[1] Some do more than merely survive. Almost 1,800 exotic plant species are now considered naturalised.[2] In other words, they have escaped cultivation and are successfully maintaining populations in the wild without human help.[3] To put this botanical invasion in perspective, a recent study found that both the North Island and South Island have more naturalised plant species than almost any other island in the world.[4]

On the other side of the botanical ledger, there are about 2,300 native vascular plant species growing in New Zealand.[5] This means that for every four native plant species growing here, there are roughly three naturalised ones also growing in the wild. There are plenty of potential places for these naturalised plants to thrive. Widespread clearance of native forests has created a porous front that opens the remaining native ecosystems to invasion from naturalised plants.

These botanical incursions come not just from plants associated with production systems but also from urban development and sprawl. Many thousands of ornamental and horticultural plants have been brought here to look at and admire or eat. Problems arise when they escape their fields and gardens to spread across the landscape with unintended impacts in new settings.

This wave of leafy exotic invasion has not yet peaked. It is estimated that 20 new exotic plant naturalisations occur each year.[6] Many of these are garden escapees. Without intervention, harm to native ecosystems will increase, not only as the existing naturalised invaders we know about continue their spread but as they are joined by these new 'escapees' that start to move away from where they have been deliberately planted.

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1 An estimated 25,049 plants have been introduced to New Zealand (Diez et al., 2009). As of 2020, 2,841 exotic plants were listed as growing in the wild (Brandt et al., 2021). 'Vascular' plants include all seed plants and ferns but do not include algae, mosses, and lichens.

2 As of 2020, 1,798 naturalised plant species occurred in New Zealand (Brandt et al., 2021).

3 Richardson et al., 2000b.

4 Hulme, 2020, p.1541, Figure 1. The only other islands that come close in terms of weediness are those in the Hawaiian archipelago, which have 1,488 naturalised species (Pyšek et al., 2017).

5 As of 2020, 2,299 native plant species occurred in New Zealand (Brandt et al., 2021).

6 Howell, 2008, p.17.

New Zealanders have a responsibility to protect the native plants, animals and other life forms that are unique to Aotearoa. Nearly 80 per cent of the native plants found here are found nowhere else (Figure 1.1).[7] If we do not care for them, no one else will. There is no doubt that some of the exotic plant species that have naturalised here pose a serious risk to some of our unique species and ecosystems – they are **native ecosystem weeds**. The message is that we need to protect our native ecosystems from invasion by weeds.

Box 1.1: Key terms used in this report

- **Native –** a species naturally occurring in New Zealand (synonymous with 'indigenous')
- **Exotic –** a species originating from a country other than New Zealand (synonymous with 'alien')
- **Ecosystem –** a system of organisms interacting with their physical environment and with each other; *native ecosystems* are those that are dominated by native species
- **Ecosystem integrity –** the ability of an ecosystem to support and maintain its structure, its functions and its resilience to the adverse impacts of natural or human disturbance, including those caused by exotic plants[8]
- **Biodiversity –** the variability among living organisms, and the ecosystems of which they are a part, including diversity within species, between species and of ecosystems
- **Harm –** a negative impact on some aspect of a native ecosystem
- **Risk –** the chance that exotic plants will cause some harm to native ecosystems
- **Native ecosystem weed –** an exotic plant species that poses considerable risk to the integrity of native ecosystems
- **Naturalised –** an exotic plant species that is able to maintain a population in the wild without direct human assistance

[7] Brandt et al., 2020.

[8] McGlone et al. (2020) provide a discussion of the concept of ecological integrity.

Source: harrylurling, iNaturalist

Figure 1.1: A high proportion of New Zealand's plants are endemic; species such as the tētē kura or Prince of Wales fern (*Leptopteris superba*) are found nowhere else on Earth.

The challenges of ensuring the biosecurity of our native ecosystems are different from the challenges of protecting our production systems. The comparatively simple production systems we employ are much easier to describe. These production systems – with an almost exclusive reliance on selected exotic plant species – constitute relatively simple ecologies that are subject to ongoing land use change. Pasture, arable, horticultural and forestry crops change constantly in response to market demands. These production systems are certainly vulnerable to invasion by many other exotic plant species, but the businesses that rely on these production systems have clear economic incentives to manage the plants that threaten them.

By contrast, native ecosystems tend to be much more complex and varied than those put together by humans. Preserving native ecosystem integrity and the dominance of native species within them in the face of a constant stream of invading weeds – some of which are the very species we grow in our production systems – poses a much more demanding challenge for biosecurity management. The incentives to act are often less clear: the challenge is not just about *how* to manage them but even *what* to manage and what success looks like. It can be hard to find consensus that a particular exotic plant is a problem. These difficulties have led to native ecosystems receiving much less attention and investment in biosecurity than farm and forestry systems.

The impact of weeds on native ecosystems does not occur in isolation. At any given site, a multitude of issues such as climate change, habitat loss, pollution and predation are likely to be combining in ways that make management decisions hard to make and outcomes less certain.

The ongoing wave of exotic botanical arrivals contrasts markedly with that of animal arrivals. Very few species with feathers or fur have naturalised in New Zealand. Only 37 bird and 31 terrestrial mammal species are considered naturalised, and most of these species have been here for many decades, if not more than a century.[9]

The dangers posed to native species by many of these exotic animals, particularly the predatory mammals, have been widely recognised. The war we are waging on predators has taken on the proportions of a national crusade. New Zealand spends large sums on predator control. For example, the Department of Conservation (DOC) has in recent years spent around $36 million per year on animal control efforts.[10] That is three times more than it has spent on plant control.[11]

Such spending is unsurprising – globally, the economic cost of managing biological invasions (of any kind) is significant and increasing.[12] Worse still, the global cost of damage is even higher and is continuing to rise.[13] But economically quantifiable costs account for only some of the impacts of invasions. When it comes to harm being caused to native ecosystems, indirect costs are even harder to quantify.

That has not stopped the fight against predators mobilising a great deal of attention and funding. For some reason, the aspirational call of 'Predator-Free 2050' has no plant-based equivalent. But some exotic plant species already in the country also pose significant risks to native ecosystems, even if their impacts accrue more slowly and they lack the charisma of their four-legged, twin-eyed counterparts (Figure 1.2).

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[9] Robertson et al., 2017; King and Forsyth, 2021. The number of mammal species excludes moose (*Alces alces*), which may be extinct.

[10] Based on the average budgeted spend over the last five years – 2015/16 to 2020/21 (DOC staff, pers. comm., 12 August 2021).

[11] DOC staff, pers. comm., 16 April 2021.

[12] Diagne et al., 2021.

[13] Diagne et al., 2020, 2021.

Source: Rod Morris

Figure 1.2: When it comes to battling unwanted exotic species, animals such as the stoat pictured here with a dead kiwi chick, capture more attention than plants.

Nevertheless, increasing amounts are being spent by various organisations on controlling exotic plants in New Zealand even if a large proportion of this increase has been on one notable programme – the National Wilding Conifer Control Programme. This programme will be discussed later in this report, but it is worth noting here that protecting native ecosystems is only one of its objectives.

The focus of this report is on how well we currently manage the thousands of exotic plant species that are already here and mitigate the risks that some of them pose to the integrity of native ecosystems.[14]

Specifically, it seeks to answer the following questions:

- Are the ecological risks posed by exotic plants to the integrity of New Zealand's native ecosystems adequately known?
- Are these ecological risks then adequately understood by the organisations and individuals charged with managing exotic plants in native ecosystems?
- Do the organisations and individuals charged with management have the information, skills and resources necessary to do a good job?
- Are they making sensible strategic choices about where resources get spent given the nature of emerging and future challenges?

[14] Note that the exotic plant species we try to manage can be hiding behind a variety of often confusing and poorly defined terms, including weeds, pest plants, noxious plants, unwanted organisms and invasive species.

- Is the regulatory system fit for purpose in light of the above?
- Are all organisations, groups and individuals coordinated (and incentivised) in their efforts to manage the right exotic plants?

This report does not:

- provide a list of the most important exotic weeds or native ecosystems
- assess the efficacy and effectiveness of tools and methods for controlling exotic plants
- explore the management of marine weeds.

Not everyone thinks about exotic plants in the same way

While more funding and community effort is being devoted to managing exotic plants, agreeing on which plants to manage, where and how is not always straightforward. How people view exotic plants often depends on where they grow and the various social, economic and environmental benefits or risks they pose.

For Māori, the distinction between native and exotic origin may be less relevant than what particular plants mean for the health or mauri of a place. The creation story in te ao Māori connects Māori with the environment and ultimately guides how they interact with it.[15] When Tāne-mahuta separated his parents, he immediately clothed Papatūānuku with his descendants – the plants, trees and animals of the forest. Māori also connect to the environment through whakapapa (genealogy, lineage, descent) and see humankind as teina or pōtiki (junior) to ngā atua (ancestors with continuing influence, gods, guardians of an environmental domain), where Papatūānuku is the supreme earth mother. This creates a relationship between humankind and the environment where the junior party is responsible for caring for its elder. When this is done, Papatūānuku will provide the resources needed to sustain life. Therefore, a te ao Māori lens views the relationship of people with the environment as being not about domination or manipulation but a balancing between resource use and care.

This balance can be found in the interconnection of all things. The mauri or life force exists in that web of interconnections, and if the mauri is diminished, this affects everything that is connected to it. For example, old trees would not survive without support from the subcanopy all the way down to the microbes in the soil and beyond.

All exotic species (not just plants) have an impact on Māori connectedness to a place by outcompeting or destroying taonga. This has in turn impacted on the identity of Māori, who see their relationship with taonga as a source and an expression of identity. When a taonga is no longer available or out of reach, for whatever reason, the identity of Māori is affected. This makes loss of taonga species not just an ecological or physical issue but a more profound issue involving the loss of mauri.

There is a difference between looking through anthropocentric eyes and earth-centred eyes. In the latter's eyes, the central concern is that Papatūānuku is protected and clothed. Exotic plants may be a minor problem if the alternative is that the earth is laid bare by extreme events like floods and fires.

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[15] This section draws on a report commissioned for this investigation to provide Māori perspectives on exotic plants in Aotearoa (McGowan, 2021). This report, produced by Robert McGowan, is available on the Parliamentary Commissioner for the Environment (PCE) website.

Similarly, whether a plant is exotic or not is a secondary issue as all plants will require management for one reason or another. Even native plants can be problematic outside their natural range and can upset the balance. Māori were the first humans to introduce plants to Aotearoa, bringing about a dozen species from their homeland.[16] The concern is less with the fact that species are imported and more about their potential impact on the mauri of places and what that means for their management.

Robert McGowan, one of the foremost authorities on rongoā Māori (traditional Māori medicine), has proposed that:

> "a weed is a plant that upsets the balance that Papatūānuku needs to be well. That suggests that a weed is a plant that dominates an ecosystem to the extent that it is no longer able to function in a way that enables it to sustain the life that belongs there. A weed is a plant that disrupts that natural balance."[17]

From this, it follows that the way a plant relates to other species becomes the key issue. If an exotic plant species interferes with another species in a major way, this weakens the mauri, and the integrity of the whole ecosystem suffers.

More generally, different people's perspectives on how to manage various plant species invading a given place can often be in conflict. The trade-offs between using land for different purposes such as agriculture, urban development or biodiversity conservation will favour different plant species and different values. Some economically or culturally valuable exotic plant species are spreading and having unwanted impacts elsewhere in the country – including on our remaining native ecosystems. Wilding conifers, Russell lupins and gorse illustrate some of the tensions.

Wilding conifers – a burning issue

A high-profile example, seared into our collective memory from recent wildfires, is wilding conifers (also known as wilding pines).[18] Exotic trees, such as Monterey pine (*Pinus radiata*) and Douglas fir (*Pseudotsuga menziesii*), are widely grown in plantations in New Zealand for their timber. Many other exotic conifer species have been the subject of widespread planting over the years, notably during the large-scale revegetation efforts of the 1960s and 70s. The governments of that era even attempted to manage high-country erosion through the mass aerial spreading of conifer seeds.[19] This well-meaning operation was unfortunate because not only was the problem misunderstood, but the solution was ineffective and has been harmful to both productive and native ecosystems in ways those involved at the time never imagined.

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[16] Research suggests that six cultivated plants (aute (*Broussonetia papyrifera*, paper mulberry), taro (*Colocasia esculenta*), tī pore (*Cordyline fruticosa*, Pacific Island cabbage tree), kūmara (*Ipomoea batatas*), uwhi (*Dioscorea alata*, yam), and hue (*Lagenaria siceraria*, bottle gourd) (Horrocks, 2004)) and five unintentionally transported plants (beggar's tick (*Bidens pilosa*), yellow wood sorrel (*Oxalis corniculata*), punawaru (*Sigesbeckia orientalis*), remuroa (*Solanum americanum*, glossy nightshade), and pūhā (*Sonchus asper,* sow thistle)) likely arrived with Polynesians to Aotearoa (Leach, 2005). Mātauranga Māori also states that some karaka (*Corynocarpus laevigatus*), an important food staple, was brought here by early Polynesian explorers (Best, 1977, p.45).

[17] McGowan, 2021, p.9.

[18] 'Wilding' is used here in the context of an exotic conifer species that was cultivated (e.g. planted on purpose) but now grows wild.

[19] A recent *New Zealand Geographic* article on wilding conifers provides an example – in Marlborough, the Forest Service flew aeroplanes across the hills in Branch River, "tipping sacks of seeds out the door – more than two tonnes of them, here and in the neighbouring Leatham River valley" (Hansford, 2021).

In parts of the country, some of these exotic conifer species have spread rapidly beyond the boundaries of erosion control efforts or commercial plantations and are causing problems for the surrounding landscapes.[20,21] In some cases, whole valleys have become covered in wilding conifers in less than a decade.

Commercial conifer plantations currently cover more than 1.5 million hectares in New Zealand, but wilding conifers have spread to cover an even larger area – over 2 million hectares (as of 2016).[22] While the value of forestry exports was $5.7 billion in 2020 and predicted to increase in 2021, some neighbouring landowners are experiencing considerable economic losses.[23]

The losses due to wildings over the next 50 years if they were not managed have been estimated to be in excess of $5 billion.[24] Farmers are losing grazing land to wilding conifers, homeowners are losing houses (following conifer-fuelled wildfires), conservators are losing habitat, and water yield in some catchments is being reduced.[25] Wildfires, such as those at Lake Ōhau and Twizel, made headlines around the country in 2020. The Twizel fire burnt through around 3,500 hectares of mostly wilding pines and scrubland.[26] The Lake Ōhau fire destroyed up to 50 homes and burnt around 1,600 hectares of mostly DOC land.[27]

In 2020 the Government set aside $100 million to spend over four years to control wildings. But this is only the second phase of at least five phases planned, so the total cost of bringing the problem under control is going to be much higher.[28]

Wilding conifers are clearly harmful to some of our native ecosystems. For tussock grasslands, herb fields and shrublands, the wildings' ability to invade, outgrow and smother is of major concern. Many of the existing native species are simply lost from sites where this happens.[29]

Several wilding conifer species, particularly lodgepole pine (*Pinus contorta*), are able to grow at higher elevations than native trees, especially in eastern areas of the South Island where mountain beech forms the native treeline (Figure 1.3).[30] This poses a threat to New Zealand's diverse alpine ecosystems. Douglas fir can even grow up through native forests.[31] Given a chance, these weeds can form dense, monospecific stands, leading to considerable biodiversity losses.

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[20] Douglas fir has particularly spread in elevated parts in the south of the South Island where it is well suited to the conditions (Ledgard et al., 2005).

[21] See Kelly (2020).

[22] Pine cover from NZFOA (2019). Wildings cover from New Zealand Wilding Conifer Group (no date).

[23] Forest Owners Association, 2021.

[24] Wyatt, 2018.

[25] Fires are a concern for any forest owner, and considerable effort is made to limit and control fires in commercial plantations. This includes maintaining fire breaks and stocking water reservoirs for fire-fighting purposes.

[26] Holden, 2020.

[27] RNZ, 2020.

[28] Wyatt, 2018.

[29] Froude, 2011, p.64.

[30] The elevational limit of many pines in New Zealand is approximately 150 m higher than mountain beech (*Fuscospora cliffortioides*) (Cieraad et al., 2014), with lodgepole pine seen to spread 250 m above the natural treeline from planted stands at the mountain beech treeline (Tomiolo et al., 2016). Several wilding conifer species have been documented growing above the natural treeline; lodgepole pine, mountain pine (*Pinus uncinata*) and dwarf mountain pine (*Pinus mugo*) are also known to produce cones at these high elevations (Froude, 2011; Tomiolo et al., 2016).

[31] Douglas fir can grow in canopy gaps in beech forest and, where the forest canopy is sparse, can grow faster than the beech trees (Froude, 2011, p.65).

Source: Jonathan Underwood, iNaturalist

Figure 1.3: Lodgepole pine (*Pinus contorta*) pushing up through native vegetation in the Wairau Valley.

On the other hand, conifers can on occasions provide habitat for some threatened native species when no alternative exists. For example, the Zealandia sanctuary in Wellington, which mostly contains native plants, has left some tall, old-growth pine trees because they provide roosting and nesting places for native bird species such as kākā (*Nestor meridionalis*) until suitable native habitat can develop.[32]

Most of Aotearoa was shrouded in forest prior to human arrival, and a touted benefit of planting pine trees in steep, deforested, erosion-prone land is that the roots can support the soil, minimising slips and soil losses. A pertinent question then becomes – is *any* new forest better than no forest?

The question is particularly topical today because current policies that allow fossil greenhouse gas emissions to be offset by establishing new forests are creating considerable interest in planting more conifers. Some of these efforts include initiatives to plant exotic conifers on lower value farmland because they can rapidly capture carbon. In some cases, there are plans to then manage these exotic forests in a way that can facilitate a transition to permanent native forests. In the long term, this approach could provide both native biodiversity and carbon sequestration benefits – *if* it is successful.[33]

[32] Zealandia Ecosanctuary, 2016.

[33] The success will depend on many factors, including strength of native revegetation, which often depends on climate characteristics, including temperature and rainfall, seed source proximity, slope, soil properties and level of active management. Evidence that management of exotic forests to facilitate a transition to permanent native forests can be successful is limited.

While, from a climate perspective, allowing wilding conifers to continue to spread over high-country tussock could be seen to provide a similar service to having native trees – in terms of rapid carbon storage – the economic and ecological impacts of wildings outweigh the climate benefit. In addition, while mature native forests rarely burn, pine forests clearly do. So without careful management, even the carbon storage benefits of wilding conifers could easily be lost if fire releases the carbon back into the atmosphere. Unsurprisingly, it is no longer possible to register and gain carbon credits for wilding trees.

Russell lupins – a beautiful threat to native ecosystems

Another species that highlights conflicting perspectives on exotic plants is the Russell lupin (*Lupinus polyphyllus*).[34] With its colourful flowers, this plant is valued by many for its picture-postcard qualities in the landscape. But others consider the same plants in the same landscape to be harmful and unwelcome. Lupins are legumes – plants naturally able to fix nitrogen from the atmosphere. Legumes provide nourishment to the soil and other pasture plants without the need to apply manufactured fertiliser. Some landowners find the plant useful for providing forage in areas with lacklustre soil.

Russell lupins in the South Island high country provide a striking note of spring and summer colour in an otherwise muted visual palette. They are popular, as is attested by the number of people who photograph them, many being unaware that they are an exotic species. Russell lupins have been called a 'social media star' in the Mackenzie Basin. They adorn calendars, websites and advertising, and regularly feature in wedding photos from the region. So striking are the flowers that people even notice when they are absent for a season (Figure 1.4).[35]

[34] For example, see MacDuff (2021).

[35] For example, see Sabin (2020).

Source: Nicole Janowski, iNaturalist

Figure 1.4: Russell lupins (*Lupinus polyphyllus*) near Lake Tekapo. In flower, these exotic weeds have a striking visual impact, adding a riot of colour to an otherwise muted high-country palette. Their ecological impact is less benign.

Many people plant lupins in their gardens, and one prominent seed company even promoted the plant as native.[36] But they do not 'belong' in the ecosystems they have invaded and are dramatically changing them. Russell lupins spread rapidly, forming dense stands in the gravel beds of braided riverbeds, creating problems for the native species that live there.[37] The plants provide increased cover for predators, smother open nesting sites on the boulder banks and fundamentally alter river processes, such as the way the braids and islands form as their roots stabilise riverbanks.

Unmodified braided river ecosystems are few and far between as a result of hydro-electric development, irrigation and flood control measures. As a result, many of the species found in them are rare. Lupins add a further pressure to these already endangered ecosystems.[38]

[36] McGregor's was until recently selling Russell lupin seeds as part of their New Zealand Native Seeds collection (Anthony, 2021).

[37] Hejda, 2013.

[38] O'Donnell et al., 2016.

Gorse – a thorny matter

Where some exotic plants began life in New Zealand as welcome additions to the landscape, they have since become major problems in many people's eyes.

A striking example comes from the contrasting views that rapidly developed towards one of the earliest plants brought to New Zealand by European settlers – gorse (*Ulex europaeus*). This species was introduced as a 'living fence' to stop stock from wandering (Figure 1.5).

By the 1850s provincial laws were being passed requiring owners of living fences to keep them trimmed and controlled along road, rail and waterway margins. Some provinces, such as Wellington, began to require timber or stone fences as early as 1854 because living fences were coming to be regarded as problematic.[39]

A letter to the editor of the *Evening Post* in 1913, penned by someone with the sardonic epithet of 'Grubber', lamented the spread of gorse around Wellington.[40] The writer argued that, in addition to limiting grazing on production land, gorse fires were also leading to a reduction in native bush. This was viewed as a matter of national security because native bush was "our only safe fort" should war break out, this being 1913.

Source: James Newman

Figure 1.5: Having been a problem here for over 150 years, gorse (*Ulex europaeus*) is still a prominent part of the landscape in many parts of the country.

[39] Examples of such legislation include the Fencing Ordinance 1854 (Wellington), the Furze Ordinance 1859 (Taranaki) and the Gorse Hedges Act 1861 (Nelson).

[40] Grubber, 1913.

Today, gorse is still disliked by many landowners because of both the way it encroaches on pasture and the fire risk it poses in drier climates.[41] Nevertheless, in some conditions it may serve as a nursery for native seedlings where native forest or scrub is sparse but a native seed source is nearby.[42] Gorse can even serve as suitable habitat for threatened native species, such as the Mahoenui giant wētā (*Deinacrida mahoenui*),[43] but it cannot substitute for the habitat provided by native woody species.[44] In addition, as with lupins, gorse can have unwanted impacts in other native ecosystems such as braided rivers.

Protecting native ecosystems from weed invasions is clearly necessary. With the thousands of exotic plant species already in New Zealand, and the multitude of views about them, how do we choose which ones to target for removal? How can we determine what ecological risks exotic plant species present? Are we already targeting the most harmful and pressing ones? The next chapter outlines the ecology of plant invasions and the harm they can cause to native ecosystems.

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[41] For example, dead gorse was considered to help fuel the fires on the Christchurch Port Hills in 2017. Further, Christchurch City Council has produced guidance to reduce the fire risk, which includes planting other green fire break plants to suppress gorse (Christchurch City Council, no date; Johnston, 2017).

[42] Native forest can regenerate under gorse that has invaded pastures once livestock are removed (Norton, 2009).

[43] Mahoenui giant wētā use gorse for food and shelter (Ewers, 2008).

[44] Stanley and Bassett, 2014, pp.139–142, Table 7.2.

2


Clematis vitalba

Ecology of exotic plant invasion – the current state of play

"From the extraordinary manner in which European productions have recently spread over New Zealand, and have seized on places which must have been previously occupied, we may believe, if all the animals and plants of Great Britain were set free in New Zealand, that in the course of time a multitude of British forms would become thoroughly naturalized there, and would exterminate many of the natives." (Darwin, 1859, p.337.)

New Zealand's native ecosystems – dynamic and unique

The history of Aotearoa's flora and fauna is one of constant change, with the species and ecosystems we see around us today being points on a long evolutionary timescale. Today's ecosystems would look different to those 800 years ago, even if humans had not arrived, settled, and introduced tens of thousands of new plants and animals. But the rate of change over this period has been vastly accelerated by human activities. The risks posed by these pressures to New Zealand's native ecosystems are even more serious given the uniqueness of the native biota – 83 per cent of reptiles, 99 per cent of the arthropod group containing millipedes and centipedes, 100 per cent of conifers, and 85 per cent of flowering plants are found nowhere else.[1] Protecting the integrity of native ecosystems requires an understanding of the harm that some exotic plants can cause and how human activities across the landscape can increase the risk of invasion by these plants into native ecosystems.

[1] Lee and Lee, 2015.

New species introductions and land use change

The most celebrated elements of Aotearoa's flora and fauna are those with Gondwanan lineage, having evolved on a landmass that began its separation from Gondwana approximately 82 million years ago. However, they represent only a small portion – maybe just ten per cent – of our native species.[2] Most are believed to have evolved from ancestors that arrived from around the Pacific through long-distance dispersal.[3] Being remote and isolated, relatively large, and topographically complex, New Zealand has become host to a collection of varied ecosystems that operate within an island context. This history has made our native flora and fauna truly distinct from other temperate regions around the world.[4]

Humans effectively removed these natural biogeographic filters by introducing organisms from other parts of the globe to New Zealand. Though plants have arrived throughout New Zealand's geological history, human-facilitated movement of species dramatically increased their rates of arrival. As an example, the 392 native plant species of the Chatham Islands are assessed to have arrived over a period of more than 2 million years, while the 396 exotic plant species growing wild there arrived over a period of just 500 years, most of them since European settlement about 230 years ago.[5]

Māori brought approximately a dozen new plants with them to Aotearoa, but more than 25,000 plant species have been introduced since European colonisation.[6] Of these, nearly 3,000 exotic plant species currently grow in the wild, and approximately 1,800 of these wild-growing species are considered **naturalised** because their wild populations can sustain themselves without direct human assistance.[7] Naturalised plant species therefore make up 44 per cent of New Zealand's vascular flora today.[8]

At the same time as introducing new species, humans fundamentally changed the landscape. Polynesian settlement was followed by forest clearance to facilitate hunting, travel and the cultivation of food plants. Following European arrival, native forests were cleared on a far more systematic and destructive basis to make way for pastoral systems and new urban communities. Native grasslands were stocked with sheep, forests with deer, and rivers with trout. Coupled with changes in land use, introduced species have led to elements of predominantly western European ecosystems being superimposed over New Zealand's native ecosystems to create hybrid ecosystems.[9] Today, exotic plants growing wild in New Zealand come from all over the world.[10]

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2 Wallis and Trewick, 2009.

3 Available molecular phylogenies combined with other evidence, including close links with overseas species and the continuing unassisted arrival of species from Australia, suggest the vast majority of native plant and animal groups in New Zealand are derived from long-distance dispersal (Wallis and Trewick, 2009; Kelly and Sullivan, 2010).

4 Kelly and Sullivan, 2010.

5 Kelly and Sullivan, 2010.

6 Best, 1977; Horrocks, 2004; Leach, 2005; Diez et al., 2009. Details in chapter one.

7 Brandt et al., 2021.

8 Brandt et al., 2021.

9 Hobbs et al., 2009.

10 Fridley and Sax, 2014.

Consequences of these changes for native ecosystems

Even without the influence of humans, New Zealand's native plant species have had to adapt constantly to environmental change, including natural disturbances. Human settlement changed the way disturbances happened across the landscape, largely to the benefit of exotic plant species that were typically well-adapted to the new land uses and often able to take advantage of natural disturbances to grow quickly and displace native plant species.

A disturbance is anything that triggers enduring change to an ecosystem by damaging or killing the organisms living there. It may involve geological or climatic events, or outbreaks of disease. It may wipe the slate clean or remove only some organisms. Some ecosystems rely on such events to maintain their distinguishing characteristics. For example, braided rivers are defined by frequent flooding, and coastal sand dunes by wind disturbance.[11]

Natural disturbances occur at multiple scales and over multiple time frames. They can affect large parts of the country over a long time period – like the recovery from glaciation over the past 12,000 years[12] – or be highly localised. Natural disturbances such as volcanism and earthquakes can reset the stage over very large areas. Ash deposits from major volcanic eruptions can smother thousands of square kilometres of vegetation, with fires and lahars potentially continuing to disturb recovering ecosystems on a smaller scale for decades.[13] At the other end of the scale, native plants are subjected to much smaller, localised perturbations, such as flooding of ephemeral wetlands, landslides during extreme weather events, or wind damage causing treefall in forests.[14]

The arrival of humans in New Zealand added another layer of challenges for native plants to overcome. Changing land use both added new disturbances (such as livestock grazing) and altered some of the existing natural disturbances – most notably fire. Though fire occurred in many parts of New Zealand prior to human settlement, the timescale for returning fires was probably in the order of centuries to millennia for many native ecosystems.[15] Ignition sources, such as lightning strikes and volcanic eruptions, were rare. And when fires did start, most long-established vegetation was not highly flammable.[16]

Probably on account of its rarity, only a few native plant species in New Zealand have developed adaptations to fire, such as thick bark that increases survival, resprouting ability, post-fire seed release to aid post-fire colonisation, or highly flammable foliage.[17] A notable example is mānuka (*Leptospermum scoparium*), but others include wineberry (makomako, *Aristotelia serrata*), māhoe (*Melicytus ramiflorus*) and kāmahi (*Weinmannia racemosa*). Many of these native plants could be classified as 'fire tolerant' rather than 'fire adapted' because their traits may represent adaptations to other types of disturbance.[18] The introduction of 'fire-loving' exotic plants to New Zealand and their invasion into burned areas have promoted a recurrence of fire, due at least in part to their highly flammable foliage. This, in combination with wider-scale invasion of many of these plants, has contributed to further increases in the frequency and intensity of fires across New Zealand's landscapes.[19]

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[11] Singers and Rogers, 2014.
[12] Wallis and Trewick, 2009.
[13] Wyse et al., 2018.
[14] Singers and Rogers, 2014; Wyse et al., 2018.
[15] Perry et al., 2014; Wyse et al., 2018.
[16] Perry et al., 2014.
[17] Perry et al., 2014, p.165, Table 2.
[18] Perry et al., 2014.
[19] Beaglehole, 2012.

By bringing new animals to New Zealand, humans introduced another avenue of disruption for native plants and ecosystems. Native plants evolved with browsing birds, so they are poorly adapted to contend with browsing deer and possums, or grazing livestock. Mammalian herbivores have different modes of feeding and forage preferences than browsing birds.

Many woody native plants and tussock grasses in New Zealand are poorly defended from mammalian browsing and grazing, especially in comparison with exotic plants that evolved with such animals.[20] Exotic birds introduced to New Zealand by humans cannot fully replace the roles of native browsing birds that have become extinct, like moa.[21]

Beyond changing the natural disturbances New Zealand's ecosystems face, introduced animals feed on the fruit and seeds of exotic plants, helping them to spread. Eurasian blackbirds (*Turdus merula*), common starlings (*Sturnus vulgaris*), song thrushes (*Turdus philomelos*), common mynas (Acridotheres tristis), brushtail possums (*Trichosurus vulpecula*) and feral pigs (*Sus scrofa*) are among the main documented dispersers of fleshy-fruited exotic plant seeds in New Zealand.[22] The impacts of these introduced animals are felt in every corner of the country, including places with otherwise-intact native ecosystems. This both helps exotic plants to invade places still dominated by native vegetation and alters the composition of plant species in those ecosystems.[23]

Vulnerability of ecosystems to plant invasion and its impacts

All of New Zealand's ecosystems are vulnerable to plant invasion and its harmful effects, but some ecosystems are much more vulnerable than others to **native ecosystem weeds**. This is due to the characteristics of both the weeds and the ecosystems being invaded. The exotic plant species introduced to New Zealand are generally distinct from the native flora, containing many novel plant groups and a higher proportion of annuals and herbaceous species.[24] Many weeds with distinct traits can therefore invade areas lacking native species of similar growth form, such as wilding conifers growing above the native treeline.

In addition to open habitats, disturbed areas are particularly vulnerable to invasion. Few native plants can compete with weeds adapted to fire or mammalian grazers and browsers, along with generally higher levels of anthropogenic disturbance.[25] For example, in grasslands across Banks Peninsula, herbaceous native plants tend to be found in areas of low disturbance, while herbaceous exotic plants occur mainly in disturbed areas.[26]

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[20] Lee et al., 2010.

[21] Although one counterexample might be exotic waterfowl, such as Canada geese (*Branta canadensis*), which seem to maintain low-growing turf vegetation in a similar manner to how we think moa and native waterfowl might have done (Craine et al., 2006; Lee et al., 2010).

[22] Wotton and McAlpine, 2015.

[23] Kelly and Sullivan, 2010; Lee et al., 2010; Perry et al., 2014.

[24] The naturalised exotic flora includes 67 plant families and 649 genera not naturally occurring in New Zealand (Brandt et al., 2021).

[25] Kelly and Sullivan, 2010; Lee et al., 2010; Perry et al., 2014.

[26] Pouteau et al., 2015.

The modified landscapes we maintain in New Zealand today thus provide ample habitat for native ecosystem weeds to thrive. Ecosystems characterised by natural disturbance, such as braided riverbeds, are also vulnerable because weeds often respond more strongly to the disturbances rather than other conditions that help native species establish.[27] Every scar on the landscape – whether caused by fire, flood or human action – thus becomes another opportunity for a fast-growing weed to take hold. This has led to the open habitat of braided riverbeds becoming covered in exotic herbs and shrubs, the replacement of native vegetation with fire-adapted weeds following fire, and the encroachment of vines or ground cover into forests along tracks and roads or into gaps created by treefall.

Even native forest that remains intact may not be fully resilient to this onslaught of potential invaders. As of 2006, 41 exotic plant species had been recorded in native forest vegetation research plots, though the degree of harm they could cause to the ecosystem is thought to be low.[28] Once established, however, these types of exotic plants will not require ongoing disturbance to maintain their hold.[29]

Many exotic plants already present in New Zealand have not reached the full extent of their potential distribution or are yet to 'jump the fence' and escape cultivation, including from our gardens. The presence of this persistent pool of exotic plant species in New Zealand makes it essential to understand how they might invade and harm ecosystems so that we can better manage them to protect the integrity of native ecosystems.

The process of plant invasion into native ecosystems

The risk exotic plant species pose to native ecosystems depends in part on how likely they are to invade those ecosystems. For an invasion to occur, an exotic plant species must arrive at a place, put down roots and survive to reproductive age, reproduce successfully and spread to new places. In other words, the species must *arrive*, *survive* and *thrive* without the direct assistance of humans. This includes finding a space among the ecological communities that already occupy these sites.

Only a small proportion of plants introduced to a new country can overcome all these hurdles. Globally, research shows that about 25 per cent of exotic plant species make it through each successive stage of invasion, meaning that about 15 of every 1,000 plants introduced to a new country will reach the point of spreading widely.[30] Similarly, in New Zealand, a few thousand of the tens of thousands of exotic plant species introduced currently survive or thrive in the wild, and a few hundred spread widely into native ecosystems.[31] Understanding what can enable or inhibit these transitions through the stages of invasion at the national scale, as well as at the scale of ecosystems or local sites, is essential to assessing the risk an exotic plant species poses to native ecosystems. In other words, determining whether it could be a native ecosystem weed. This understanding is also important for designing effective management approaches – in particular, when human activities are enabling invasion.

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[27] Brummer et al., 2016.

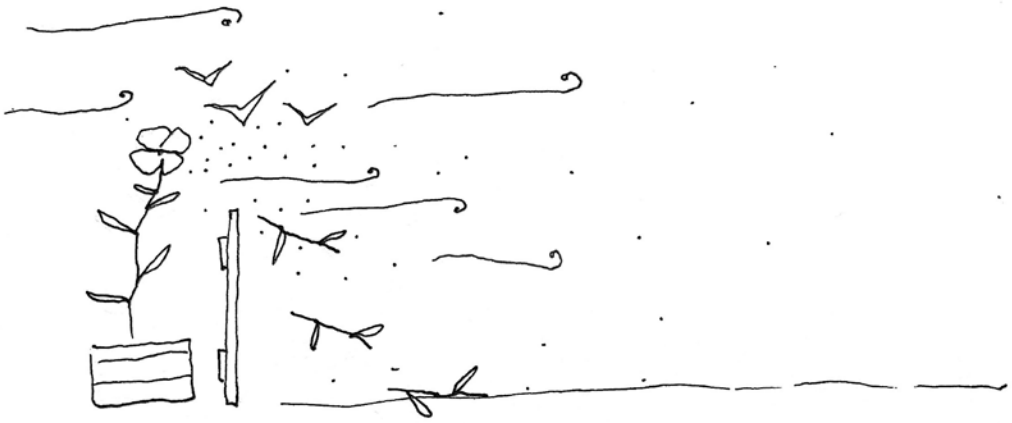
[28] Wiser and Allen, 2006, p.197, Table 13.1.

[29] Wiser and Allen, 2006; Kelly and Sullivan, 2010.

[30] See chapter 13 in Jeschke and Pyšek (2018).

[31] For example, as of 2020, 380 exotic plant species are managed as conservation weeds by DOC (DOC staff, pers. comm., 22 September 2021).

Arriving



Source: PCE

Figure 2.1: The arrival of an exotic plant via wind or animal-mediated dispersal.

Exotic plant species already present in New Zealand can reach native ecosystems from source populations that are growing in cultivation, such as gardens or plantations (Figure 2.1), or in the wild. The **arrival** of an exotic plant species to a new site is more likely if a large number of **propagules** (i.e. seeds, pieces of stem, or any other part of a plant that can grow into a new plant) have many chances to get to the site.[32]

Some exotic plant species are particularly good at reproducing. Old man's beard (*Clematis vitalba*) can produce over 35,000 seeds per square metre.[33] A single population covering more than 50 square metres might therefore produce millions of propagules in any one year. Similarly, a few gardens or a small plantation of such prolifically seeding plants can send enormous quantities of seed into the landscape.

A greater **dispersal ability** increases a plant's chances of arriving at new sites. Dispersal is aided by (1) the characteristics of the plant's propagules, and (2) the **vectors** that carry propagules to a new site, such as wind, water or animals. Lightweight seeds or seeds with wings are carried further by the wind than heavier seeds or seeds without appendages – Scots pine (*Pinus sylvestris*) seeds have been recorded travelling up to two kilometres.[34] The seeds of fruit-bearing species can also be carried far from the parent plant by birds – on average travelling more than 40 metres, but sometimes over one kilometre.[35] Propagules are more likely to arrive from source populations close to a site, but exotic plant species with good dispersal ability can spread further afield.

[32] Theoharides and Dukes, 2007; Catford et al., 2009. This is known as propagule pressure.

[33] van Gardingen, 1986, p.33, Table 3.2.

[34] Tamme et al., 2014, Supplement 1. Wind-dispersed seeds with appendages disperse further on average than those without appendages (Bullock et al., 2017), and lighter wind-dispersed seeds disperse further on average than heavier seeds, once plant height is taken into account (Thomson et al., 2011).

[35] Bullock et al., 2017, p.11, Table 3. On average, though, seeds dispersed by birds will travel further than those dispersed by wind (Thomson et al., 2011; Bullock et al., 2017).

Both native and introduced birds spread the seeds of exotic plants – it rarely matters whether the birds evolved in the same place as the plant.[36] Hundreds of exotic plants in New Zealand may be spread by birds, including plants with attractive fruits like boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*), Chilean flame creeper (*Tropaeolum speciosum*), Chilean mayten (*Maytenus boaria*), climbing asparagus (*Asparagus scandens*) and Kahili ginger (*Hedychium gardnerianum*) (Figure 2.2).[37]

Source: Northland Regional Council

Figure 2.2 Seeds from exotic plants with attractive fruits can be spread by birds. These kererū are gorging on the fruit of the exotic bangalow palm (*Archontophoenix cunninghamiana*).

[36] New associations with birds often emerge for an exotic plant growing in a new region, either with exotic bird species (e.g. the Eurasian blackbird (*Turdus merula*) dispersing boneseed and bitou bush (two subspecies of *Chrysanthemoides monilifera* in Victoria, Australia), or with natives (e.g. cockatoo in Australia dispersing seeds of *Pinus* spp., which are normally wind-dispersed) (Richardson et al., 2000a).

[37] Wotton and McAlpine, 2015; Dawson, 2017.

The advantages to an exotic plant species of dispersal by animals, such as birds and humans, include moving its propagules large distances, and often depositing them directly into a site with suitable habitat.[38] For example, birds will land on perches, such as branches in a bush patch, and excrete seeds; humans might transport a boat from a lake infested with exotic aquatic plants like hornwort (*Ceratophyllum demersum*) directly to a new lake. Dispersal vectors also travel along landscape corridors, such as walking tracks, rivers, or linked bush patches and shelterbelts (discussed further in the section on thriving, below).

In addition to dispersal over space, plant species can ensure their continued dispersal over time – and many exotic plants are impressive time travellers. For example, the seeds of gorse (*Ulex europaeus*) are estimated to be able to germinate more than 90 years after burial in the soil.[39] This dormancy allows the plants to build up a seedbank – the plant population will then be able to regenerate, likely after a disturbance, even if some years are not good for flowering or seedling survival.

Surviving

Source: PCE

Figure 2.3: The survival of an exotic plant at a new site without human assistance.

Surviving at a new site without direct human assistance is the next step an exotic plant species must take for invasion to occur (Figure 2.3). Successfully surviving and growing at a new site depends mostly on its environmental conditions.[40] The right climate and enough space, light, water and nutrients are needed, as well as low pressure from herbivores and diseases, and sometimes the presence of essential symbionts like mycorrhizae (soil fungi that interact with plant roots to help the plant acquire nutrients and water in exchange for sugars the plant makes during photosynthesis).[41]

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[38] Richardson et al., 2000a.

[39] Gorse seeds were shown to be viable after 10 years buried in soil at three sites across New Zealand, and seed viability remained so high at one site that a statistical model predicted that 10% of seed buried there could be viable for over 90 years. However, the authors note that this estimate extrapolated far beyond the data used to construct the model (Hill et al., 2001).

[40] Theoharides and Dukes, 2007; Richardson and Pyšek, 2012.

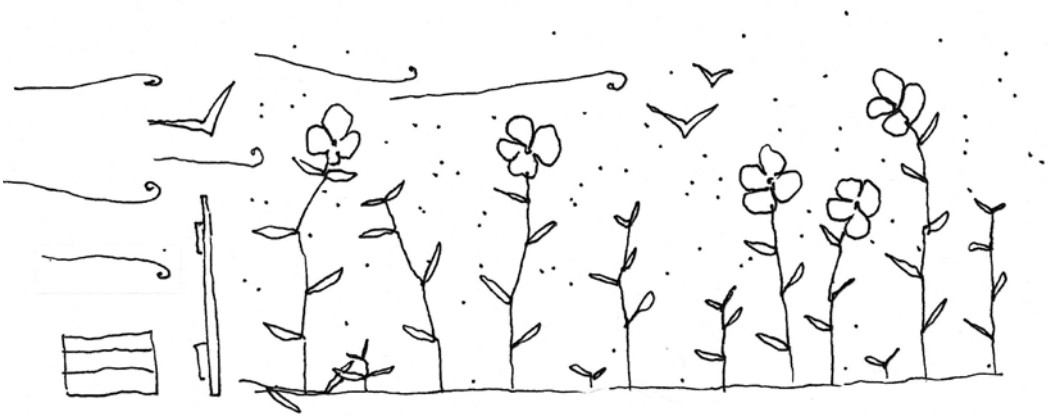
[41] Richardson et al., 2000a; Theoharides and Dukes, 2007.

Certain traits enable plants to grow in habitats that would otherwise be unsuitable. For example, plants that fix atmospheric nitrogen can grow in habitats with low soil nitrogen availability where others might not be able to grow due to nutrient limitation.[42] Legumes like Scotch broom (*Cytisus scoparius*), Russell lupin (*Lupinus polyphyllus*) and gorse are nitrogen-fixers, which may partly explain why they often occur in braided riverbeds and other sites with nutrient-poor soils.

External factors can also increase the availability of resources a plant needs at a site. Disturbance creates gaps in the vegetation, which increases the space and light available to a newly arrived exotic plant. Many invading plants – like Chilean flame creeper and gorse – tend to grow only in treefall gaps or along tracks in New Zealand forests for this reason.[43] Fertilisation of soils can help exotic plants grow where nutrients are limited – especially plants without traits like nitrogen-fixation or that lack relationships with mycorrhizae. And, as previously described, many exotic plants are better able to outcompete native plants when nutrient levels are elevated.[44] Fire not only creates gaps and increases nutrients but can also stimulate germination of 'fire-loving' plants by heating their seeds.[45]

Other organisms at the site can also inhibit survival or growth of an exotic plant species, either by their presence or absence. For example, wilding conifers are less likely to survive in sites where herbivores, such as livestock or hares, are present and might crop their seedlings, or where the mycorrhizae on which they depend are missing. Introduced pines did not grow well outside cultivation in much of the southern hemisphere until their particular mycorrhizal partners were also introduced.[46]

Thriving



Source: PCE

Figure 2.4: Exotic plants thriving in the wild, successfully reproducing and spreading.

[42] Richardson et al., 2000a.
[43] Sullivan et al., 2006; Wiser and Allen, 2006.
[44] Craine et al., 2006.
[45] Perry et al., 2014.
[46] Richardson et al., 2000a; Froude, 2011.

A **thriving** exotic plant species is able to reproduce in the wild and begin spreading to new sites (Figure 2.4). Exotic plant species that have naturalised in New Zealand have managed to successfully reproduce in the wild somewhere within the country. The likelihood that they might do so elsewhere is therefore greater than those species currently only surviving alongside cultivated populations.

Successful reproduction is influenced by the same environmental conditions as survival, but also depends on the species' **mode of reproduction**. Some plants can reproduce vegetatively – from fragments of stem or pieces of roots – and might therefore progress through the stages of invasion more easily than plants needing to reproduce via seed.[47] For example, all of the crack willow (*Salix* × *fragilis*) trees in New Zealand are male, so no seeds are produced.[48] Instead, the species has spread entirely through fragments of stem that spread by water and grow into new trees. A branch broken off one of these willows and dug into the ground will quickly develop roots. At least 330 of New Zealand's naturalised plants can reproduce through vegetative means.[49]

A flowering plant species might need the right pollinator to produce seeds, unless it can self-pollinate or is wind pollinated.[50] If the right pollinator is not already present in New Zealand, it might arrive via its own natural dispersal mechanisms – such as when Australian fig wasps (*Pleistodontes* sp.) seemingly blew into New Zealand on the wind in the latter half of the twentieth century. Moreton Bay figs (*Ficus macrophylla*) have been present in New Zealand since the mid-1800s but were not known to set seed before 1994.[51] A species that had been something of a curiosity in the landscape for nearly 150 years suddenly developed the potential to spread into native ecosystems.

Human actions can also enable successful reproduction where it was previously inhibited. A potent example is Chilean mayten, of which only male plants were sold in New Zealand until the mid-1980s when seed-grown plants appeared on the market, some of which were female. This enabled planted individuals to reproduce via seed as well as suckers.[52] Bringing in pollinators can also enable many flowering exotic plants to naturalise – as was the case for red clover (*Trifolium pratense*), which did not set seed here until bumblebees were introduced in the late 1800s.[53]

Some naturalised plant species can reproduce both vegetatively *and* sexually (i.e. via seeds), such as Chilean mayten, climbing asparagus and Kahili ginger.[54] This gives them more opportunities to begin to **spread** to new sites across the landscape and restart the process of arriving, surviving and thriving in entire new regions. Whether a naturalised species can successfully reproduce following its arrival and survival in a new local site will still often depend on particular conditions at that site, including having the right climate, sufficient nutrients and more than one individual plant present if it cannot self-pollinate.

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[47] Theoharides and Dukes, 2007.

[48] The species is dioecious, with male and female flowers occurring on separate individuals. Plants that are monoecious, with both male and female parts in the same flower, can sometimes self-pollinate, in which case a single individual could produce seeds.

[49] Gatehouse, 2008, p.33, Table 8.

[50] Richardson et al., 2000a; Theoharides and Dukes, 2007; Richardson and Pyšek, 2012.

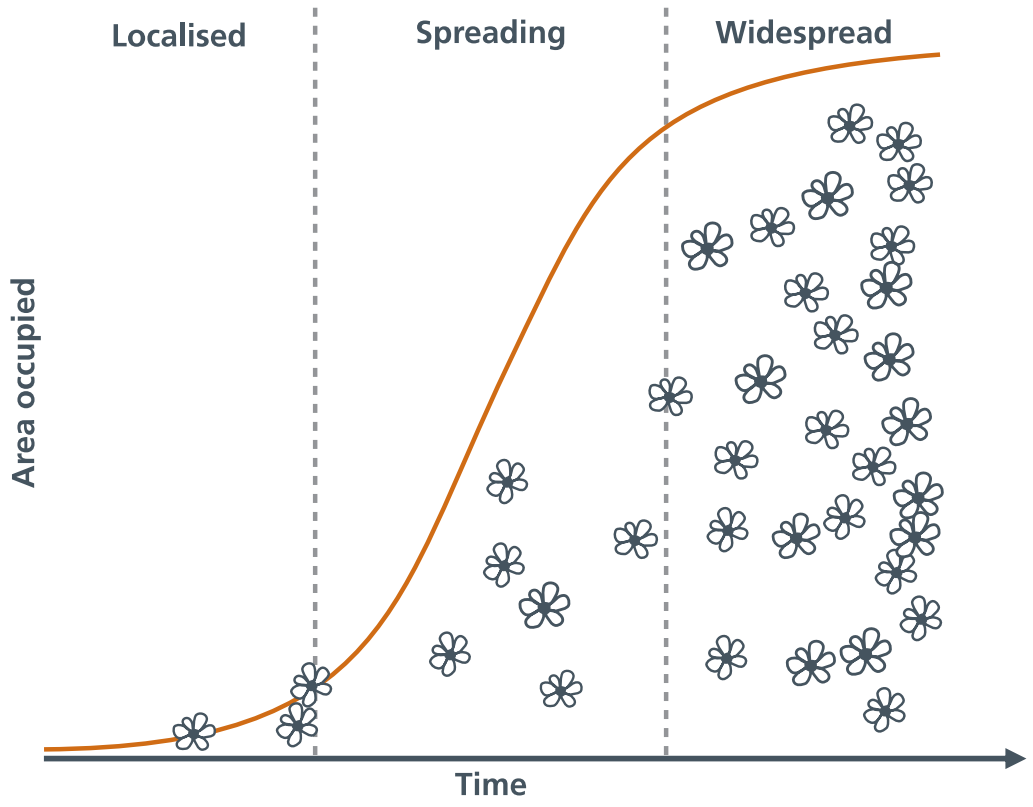
[51] Gardner and Early, 1996. Moreton bay fig trees planted in Auckland in about 1850 feature in The New Zealand Tree Register (e.g. https://register.notabletrees.org.nz/tree/view/783).

[52] Dawson, 2017.

[53] Richardson et al., 2000a.

[54] Gatehouse, 2008; Dawson, 2017.

The area occupied by a naturalised plant species invading a new region can be quite small at first, with the species only occurring in localised populations (Figure 2.5). The species might then begin spreading quite rapidly into suitable habitats throughout the region. A naturalised species becomes widespread once it is common and abundant across most suitable habitats.



Source: PCE

Figure 2.5: The area occupied by a naturalised plant species invading a new region can be small at first but then grows quickly as the species begins to spread.

The rate of spread of a naturalised plant species depends on both its ability to disperse and the characteristics of the landscape through which its propagules move.[55] Spread is partly about how far a plant's propagules travel – known as the species' dispersal distance. Most propagules, such as seeds, fall close to the parent plant – within several metres – so spreading to suitable sites nearby tends to be faster than to sites very far away.

[55] Theoharides and Dukes, 2007.

How a naturalised plant species' populations are distributed across the landscape is therefore an important part of spread. As long as each plant population can produce propagules, many small populations may enable a naturalised plant species to spread faster across a landscape than a single large population. The occasional long-distance dispersal event that carries an exotic plant's propagules very far away might therefore greatly increase the rate of spread across a region if the plant establishes a new population.[56] A study of herbarium records for 100 native ecosystem weeds in New Zealand found that species with higher rates of spread occupied a greater area.[57] This is one reason why management strategies, such as for wilding conifers, often concentrate first on controlling newly invaded sites farthest from the stand of trees producing seeds.[58]

But spread can also be facilitated by the characteristics and arrangement of different suitable habitat patches across the landscape.[59] Naturalised plants might jump from patch to patch, either by birds full of fruit and seeds flying between patches of trees, or by wind depositing seeds in a newly cleared space of land. Or plants might spread along a corridor that connects patches of habitat or provides habitat along its edges – crack willow spreading along rivers is a good example.

Human activities that fragment the landscape contribute to naturalised plant spread by altering the habitat mosaic across that landscape. Many naturalised plant species that invade native ecosystems also invade production land. Because of this, small fragments of native ecosystems within a production landscape often face a constant high level of invasion pressure. Urban areas, gardens and cultivated populations of exotic plants are also potential source populations for the invasion of native ecosystems. As a Ministry of Agriculture and Forestry report summarised in 2010, "Most new naturalisations of plants are associated with deliberate cultivation."[60]

The first sighting of an exotic plant species growing in the wild is usually close to urban areas, and coastal forests near human settlements contain more exotic plant species than forests that are more isolated.[61] The dumping of garden waste combined with spread along roads can provide a significant pathway for new exotic plant species to invade native ecosystems (Figure 2.6).[62]

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[56] Whether the rate of spread in a real landscape will be greater from a large source population or several small outlier populations depends on many factors, including population growth rates and fecundity, propagule dispersal distances, and how frequently far-dispersing propagules find suitable habitat. Models for invasive species spread are reviewed in Epanchin-Niell and Hastings (2010).

[57] Aikio et al., 2010a.

[58] Caplat et al., 2014.

[59] Theoharides and Dukes, 2007.

[60] Biodiverse Limited, 2010, p.16.

[61] Sullivan et al., 2005; Aikio et al., 2012.

[62] For example, in 2010, establishment of at least 13 environmental weeds under native forest along a stretch of the Akatarawa Saddle road, Wellington, was attributed to dumping of garden waste, with spread likely promoted by roadside mowing (Biodiverse Limited, 2010, p.59).

Source: Jon Sullivan, Flickr

Figure 2.6: Dumped garden waste, as seen here in Governors Bay, Christchurch, is one pathway for exotic plants to escape cultivation and go on to survive and spread in the wild.

Once a naturalised plant species begins to spread, it has completed the process of invasion. In each case, the recipe for a successful invasion is the matching of exotic plant attributes to the environmental conditions, often reinforced by disturbances and facilitated spread caused by human activity.[63]

[63] Theoharides and Dukes, 2007; Pyšek et al., 2020.

Can we predict which exotic plant species will successfully invade?

Several factors in combination drive the process of invasion – the attributes of the exotic plant species, the environmental context of the new region it is invading and the context of its introduction, including human activities that can facilitate its spread.[64] At a national scale, we can make fairly accurate predictions about which exotic plant species are likely to naturalise using weed risk assessments that incorporate all three types of factors, such as the Australian Weed Risk Assessment protocol.[65] For example, an assessment of exotic conifers introduced to New Zealand correctly identified all the species that had naturalised.[66] The matching of climate between New Zealand and the species' native range, and whether a species was able to naturalise elsewhere in the world, were important elements in being able to accurately predict which of these species with similar traits would successfully naturalise.[67]

There may be a greater challenge, however, to predicting which naturalised plant species will spread widely. Plant species that have naturalised in many regions across the world have spread widely in only a few of them.[68] In addition to traits that contribute to spread, planting and spread of exotic plant species by humans tends to be a major determinant of naturalised species' distributions in new regions.[69] This helps explain why garden plants are overrepresented as successful invaders – they are often selected to be hardy, fast growers and destined to be planted widely, creating well-tended source populations of potential invaders around the entire country.[70]

It is not just widespread exotic plants that pose risks to native ecosystems, however. At a local scale, successful invasion into a vulnerable site may require only that it be within dispersal distance of a thriving exotic plant species. This is in part why weed risk assessment cannot replace the need for surveillance that can identify supposedly low-risk exotic plant species that begin to spread.[71] We do not know enough to rely purely on predictive tools.

While there are traits which are common among exotic plants that spread widely – such as vigorous seedlings, fast vegetative growth, high reproductive rates, high dispersal ability and high stress tolerances – having all of these attributes does not necessarily mean a plant will successfully invade.[72]

To further complicate things, a plant's traits in exotic settings are sometimes expressed differently than in its native setting. For example, lodgepole pine (*Pinus contorta*) reproduces at a younger age in New Zealand than it does in its native range in North America or in exotic populations in South America.[73] This speeds up the invasion process for lodgepole pine in New Zealand compared with elsewhere in the world.

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[64] Richardson and Pyšek, 2012; Pyšek et al., 2020.

[65] Pheloung et al., 1999; DAWE, 2019. The criteria for evaluating exotic plant species for the National Pest Plant Accord provide another example (Champion, 2005).

[66] McGregor et al., 2012.

[67] McGregor et al., 2012.

[68] See Figure 2 in Richardson and Pyšek (2012, p.386).

[69] McGregor et al., 2012; Pyšek et al., 2020.

[70] "Compared to their general representation in the naturalised flora (48.4%), plant species introduced through the ornamental plant pathway are overrepresented (58.4%) among plants listed as environmental weeds" (Hulme, 2020, p.1545).

[71] Hulme, 2012.

[72] Whitney and Gabler, 2008; Richardson and Pyšek, 2012; Kuester et al., 2014.

[73] Taylor et al., 2016, p.101, Figure 4.

There are several reasons why plant species might behave differently in a new region, largely because they are interacting with a different suite of species than those in their native range. For example, they might leave behind the insects that eat their leaves or seeds and keep their native populations in check.[74] Or the exotic plant species might be distinct from any native plant species in the new region, and thus able to find its own space in the native ecosystem or competitively suppress the native species.[75] These mechanisms can all contribute to the successful invasion of an exotic plant species. They can also suggest which measures are most likely to be effective at controlling the species. For example, insects or fungal diseases that the exotic plant left behind in its native range can be introduced to New Zealand as biological control agents to reduce the growth and spread of its populations.[76]

Most exotic plant species introduced to New Zealand will not become widespread. But the question is not just *which* of the hundreds of early-stage invaders will be the next one to take off, but also *when*. The length of time between an exotic plant species' introduction to a new country and its beginning to spread can last anywhere from a few years to centuries.[77] This is known as the 'lag phase'.[78] Some exotic plant species may merely survive or remain localised in the wild for decades, but when the right trigger comes along, they can shift seemingly quickly to the spread stage. In a study of 105 spreading exotic plants in New Zealand, most showed a lag of 20 to 30 years between first being documented in the wild and spread being observed.[79] The lag phases for four widespread exotic plant species – Scotch broom, common elder (*Sambucus nigra*), perennial ryegrass (*Lolium perenne*) and Yorkshire fog (*Holcus lanatus*) – were more than 90 years.

In this way, low initial reproductive rates and less vigorous growth or spread can give some exotic plant species a benign appearance at the outset. The length of time a species has been present in its new region is therefore another important element to consider when predicting whether it will spread widely.[80]

Importantly, the absence of an exotic plant species from a site should not be interpreted as the site's (or ecosystem's) ability to resist invasion. Ecosystems are dynamic. If a new source population of exotic plants establishes nearby or environmental conditions at the site change, the species could overcome whatever barriers are currently preventing its invasion. All it takes is propagules from an exotic plant species with the right traits, such as shade-tolerant vines like old man's beard or rhizomatous herbs like wild ginger,[81] to find their way into a forest gap and they could be well on their way to invading and harming the ecosystem (Figure 2.7).

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[74] This mechanism of invasion is known as the enemy release hypothesis (Catford et al., 2009).

[75] Several mechanisms of invasion relate to distinctness from and interactions with the native plant community, such as the empty niche and novel weapons hypotheses (Catford et al., 2009).

[76] New Zealand is a world leader in research and implementation of biological control of exotic plant species (Schwarzländer et al., 2018).

[77] Aikio et al., 2010b.

[78] Theoharides and Dukes, 2007.

[79] Calculation of these lag phases used herbarium records, so these time periods are underestimates of the time between when the exotic plants first arrived in Aotearoa and when they started spreading (Aikio et al., 2010b).

[80] Pyšek et al., 2020.

[81] Baars and Kelly, 1996; Harris et al., 1996.

Source: Anna Hooper

Figure 2.7: Once the foliage has been cut, the extent of the dense rhizomes of wild ginger (*Hedychium* sp.) is revealed. These roots help the plant to spread vegetatively, ensuring little else can grow and making control much harder.

How exotic plants can harm native ecosystems

New Zealanders are familiar with widespread exotic plants dominating corners of the landscape – native forest smothered by old man's beard, hillsides covered in wilding conifers or gorse, wandering willie (*Tradescantia fluminensis*) or wild ginger (*Hedychium* sp.) carpeting the forest floor, willows and poplars (*Populus* sp.) lining riverbanks, and agapanthus (*Agapanthus praecox*) along roadsides and coastal habitats. In addition to their likelihood of invading, the risk each of these exotic plant species pose to the integrity of native ecosystems depends on the harm they can do – in other words, the negative impact they could have on some aspect of that native ecosystem. Many exotic plant species will have little impact on most native ecosystems, and from an aesthetic or cultural point of view, some impacts may even be judged positive by some people.[82] It is essential to know how each exotic plant species could impact on different native ecosystems to help evaluate which invaders pose the greatest risk – in other words, which species are native ecosystem weeds.

[82] This report focuses on negative environmental impacts of exotic plant species, but some of their effects on native ecosystems can be positive. For example, the exotic plant species may have taken on the role of missing native plants in providing resources to wildlife, such as food, nesting sites and shelter (summarised in Table 7.3 in Stanley and Bassett, 2014).

Weeds can cause many types of harm

The breadth of impacts weeds can have on ecosystems ranges from competing or hybridising with native plant species to promoting fire, altering hydrology, and causing over-enrichment of nutrients.[83] These impacts harm native ecosystems by threatening particular native species, reducing native species diversity or changing how the ecosystem functions – its physical and chemical dynamics. The risk posed by exotic plant invasion to New Zealand's unique native ecosystems is especially high because so many native species are found nowhere else.

Weeds can harm native species in various ways. They may outcompete them for resources, such as light; hybridise with them, diluting the native gene pool; or basically poison them, releasing chemicals into the soil that inhibit other plants' growth.[84] Weeds can also transmit new diseases to native plants. This is called 'pathogen spillover'.[85] These harms can reduce native species diversity in ecosystems they invade, and are why weeds pose the main threat to one third of New Zealand's nationally critical native plant species.[86]

A different suite of native plants – often with lower diversity – tend to grow under woody weeds compared with native bush. For example, even when native plants do grow up through gorse, the development of those plant communities is different than under kānuka (*Kunzea ericoides*).[87] Sites dominated by certain species of woody weeds – such as buddleia (*Buddleja davidii*) – have very few native plants underneath them, while sites dominated by other species – such as Douglas fir (*Pseudotsuga menziesii*) – have considerably more. Still, only up to 75 per cent, on average, of the understory plant cover is native.[88]

Invasion by weeds distinct from the native plant community can completely change the vegetation structure of an ecosystem. Aquatic plant invaders like hornwort can clog up otherwise-clear lakes.[89] Wilding conifers can convert grasslands or alpine habitats into forest. And old man's beard can overtop and smother trees in native bush, in the worst cases causing the canopy to collapse, as observed in a survey of Taihape reserves in the North Island in 1998.[90]

Weeds can also affect how ecosystems function by altering the pattern of disturbances across the landscape or over-enriching the ecosystem with nutrients. Fire promoters – such as gorse and wilding conifers – have highly flammable foliage and wood, and dramatically increase fuel loads.[91] When they have invaded an ecosystem, fires happen more frequently and burn more intensely.[92]

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[83] Blackburn et al., 2014.

[84] How impact mechanisms of competition, hybridisation and poisoning/toxicity can reduce native species diversity are described further in Blackburn et al. (2014).

[85] Bufford et al., 2016.

[86] See Table 1 in Hulme (2020, p.1541).

[87] Sullivan et al., 2007.

[88] Stands of 11 of 41 woody weeds surveyed had less than 10% native cover in the understory on average (McAlpine et al., 2018).

[89] Matheson et al., 2004.

[90] Ogle et al., 2000.

[91] Perry et al., 2014.

[92] Richardson et al., 2000b; Blackburn et al., 2014.

Some weeds promote erosion, while others stabilise soils – often with knock-on effects on water quality and flows.[93] Riparian invaders, such as Asiatic knotweed (*Fallopia japonica*), can increase erosion of streambanks if they die back in winter or have shallow-rooted rhizomes that do not hold the soil as well as diversely vegetated banks.[94] In highly dynamic dune systems, stabilisation and accumulation of sand by marram grass (*Ammophila arenaria*) can remove essential habitat for both native plants and animals.[95]

Nitrogen-fixing legumes increase soil nitrogen levels wherever they invade. Nitrogen leaching from extensive infestations of gorse can contribute significantly to a catchment's total nitrogen load.[96] Wilding conifer invasion can increase the levels of nutrients like nitrogen and phosphorus in the soil because their mycorrhizae mobilise these nutrients – usually to the greater benefit of other plant invaders like sward grasses or hawkweeds (*Hieracium* and *Pilosella* spp.) than to native plants.[97]

Known harms to New Zealand's native ecosystems

Measuring the impact of an exotic plant species is often difficult and expensive and can only be done after it has successfully invaded an ecosystem. The potential harm most exotic and even naturalised plants could cause to New Zealand's native ecosystems must often be inferred from their traits (e.g. flammability), the ecosystems they might invade and, if available, their impacts elsewhere in the world. For example, based on their measured impacts overseas, more than one third of exotic plant species banned from commercial sale in New Zealand would be expected to reduce native plant diversity, and several species would be expected to affect water quality and flows, cause changes to ecosystems, alter fire frequency or hybridise with native plants.[98]

Even among exotic plant species already widespread in New Zealand, harm to native ecosystems has only been measured in respect of a few species. As of 2014, published data on impacts were available for only 6.7 per cent of the exotic plants listed as environmental weeds by DOC.[99]

However, certain weeds might be overlooked because they do not dominate the native ecosystems they invade, though they can still cause harm to these ecosystems – sometimes greater harm than the larger, dominant invader. For example, exotic herbaceous species have been found to change soil characteristics and suppress native plant establishment on braided river floodplains to a greater degree than the shrub buddleia.[100]

Other weeds might be overlooked because they have become so common, such as browntop (*Agrostis capillaris*), a turf grass that is widespread and often abundant in montane grasslands. Browntop forms dense swards when establishing after fire, inhibiting germination of native shrubs and providing habitat for the exotic slug *Deroceras reticulatum*, which can decimate populations of the native fern *Botrychium australe*.[101]

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[93] Richardson et al., 2000b; Blackburn et al., 2014.

[94] Arnold and Toran, 2018; GISD, 2021c.

[95] Hilton et al., 2005.

[96] In a worst-case scenario of gorse infesting more than 5,000 ha in the Ruamāhanga River catchment, nitrogen leaching from the infestation was estimated to represent 12–25% of the catchment total – the equivalent to leaching from 9,000–14,000 ha of pasture (Mason et al., 2016).

[97] Froude, 2011.

[98] Hulme, 2020, p.1546, Figure 3.

[99] Impacts summarised in Table 7.2 in Stanley and Bassett (2014) of 22 species included in DOC's list of environmental weeds in Howell (2008).

[100] Peltzer et al., 2009; Fukami et al., 2013.

[101] Sessions and Kelly, 2000, 2002.

The harms weeds cause overseas are likely to happen here as well. But given New Zealand's unique native ecosystems, the harms caused here are often worse. It is in New Zealand that some exotic plant species, such as climbing asparagus, have first been noted as native ecosystem weeds (Figure 2.8).[102] As of 2000, approximately ten per cent of 181 exotic plant species that had been found on conservation land were not known to be weeds overseas.[103]

Source: Anna Hooper

Figure 2.8: Climbing asparagus (*Asparagus scandens*) can grow throughout the understory of native forest, halting regeneration of native plants and scrambling up the trunks of trees and shrubs. When it has overwhelmed the canopy, it completely transforms the forest.

Which harms matter most?

The harms that will matter most depend on which ecosystems we are trying to protect. Some impacts of weeds are immediately clear, such as wilding conifer invasion converting diverse grasslands and shrublands into a monoculture of trees (Figure 2.9). Other impacts are more subtle, taking longer to become evident, such as changing the movement of riverbed gravels and altering the habitat for nesting birds, increasing the frequency of fires or altering an ecosystem's food web. The danger of focusing too narrowly on a specific set of harms as the 'most important' is that other valuable components of native ecosystems will be lost.

[102] Climbing asparagus is not listed in the Global Invasive Species Database (http://www.iucngisd.org/gisd/) and is listed with minimal information in the Invasive Species Compendium (https://www.cabi.org/isc/datasheet/112477). Though naturalised in Australia, it is not classified as a Weed of National Significance, nor is it among the 398 weeds profiled by Weeds Australia (https://profiles.ala.org.au/opus/weeds-australia/profile/Asparagus%20aethiopicus).

[103] Williams et al., 2000, p.27, Table 11.

2014

2017

Source: Sherman Smith

Figure 2.9: The speed with which wilding conifers can spread and grow can be seen in these two photos of the upper Waiau Toa/Clarence River taken from the same point just three years apart.

The degree of harm any particular weed can do depends on the native ecosystem that it invades. This means, for example, that weeds that are functionally distinctive from the native plant community will pose a greater risk in certain ecosystems – where they change the vegetation structure or increase fire frequency – while weeds that are closely related to a native plant species pose the greatest risk of hybridising with that species. Weeds that are widespread might therefore be considered low risk at a nationwide scale but cause significant harm where they threaten nationally critical native species. For example, cocksfoot (*Dactylis glomerata*) threatens the native grass *Poa spania*, and creeping bent grass (*Agrostis stolonifera*) threatens the native forget-me-not *Myosotis stolonifera*.[104]

Weeds do not have to become widespread or reach high abundances to cause harm. Certain effects of wilding conifer invasion occur when the first trees establish, such as changes to soil nutrients, while others strengthen as the density of conifers increases, such as the build-up of fuel loads for wildfires.[105] Eight weeds growing in the grasslands of Banks Peninsula, including cocksfoot and white clover (*Trifolium repens*), reduce native plant diversity at low to intermediate abundance, and this impact is compounded when scaling up to the landscape level.[106]

Furthermore, some exotic plant and animal species interact with each other in ways that promote invasion by other species or increase harm to ecosystems. For example, mycorrhizal spores spread by European red deer (*Cervus elaphus*) and Australian brushtail possums can aid the spread of lodgepole pine and Douglas fir into new habitats.[107] And, by promoting fire, fire-adapted weeds increase the speed of their own spread across the landscape.[108]

Altogether, this means we have to think about both the exotic plant species and the ecosystem it is invading – including the native and exotic species already there – if we are to adequately assess the potential harm it may cause.

As discussed at the beginning of this chapter, New Zealand's ecosystems are dynamic – always changing. The global context around them is also always changing, and this has implications for the risks weeds pose to native ecosystems. The next chapter explores how these risks are likely to grow in future, given the exotic plant species already growing in the wild and expected changes in their numbers and distribution around the country.

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[104] Hulme, 2020, p.1541, Table 1.

[105] Sapsford et al., 2020.

[106] Bernard-Verdier and Hulme, 2019.

[107] Wood et al., 2015.

[108] "*Ulex, Hakea, Banksia, Pinus, Erica, Cytisus, Chrysanthemoides* – all classed 'environmental weeds' by Howell (2008) – are more strongly fire-adapted than any indigenous species other than possibly mānuka. These exotic taxa are all pyrophyllic and depend upon fire for their persistence in the landscape" (Perry et al., 2014, p.168).

3

Lomatia fraseri

What might the future hold?

This chapter looks to the future, scanning the horizon for likely shifts in ecology that could influence the risk that weed invasion poses to the integrity of native ecosystems.

The already considerable impacts of weeds on Aotearoa's native ecosystems could be amplified in the future. More exotic plant species are expected to escape into the wild and spread further. Land use change and climate change will supercharge these ecological shifts.

More new exotic plant species escaping and spreading further each year

While new exotic plant species arrive on New Zealand's shores every year,[1] the greatest source of potential new invaders to native ecosystems lies within our borders. Since the 1950s, ornamental plants have been the main source of new naturalisations in New Zealand.[2] A 2020 checklist documenting new plant invasions found that at least 66 of the 88 exotic plants that were newly sighted growing in the wild since 2010 were garden escapees.[3] This is a conservative assessment, however, because most of the remaining 22 species are likely to have come from a more distant cultivated source and spread to the observed location by natural or human vectors, including the dumping of garden waste.

Between 2006 and 2020, at least 70 more exotic plant species, ranging from ferns and grasses to trees, shifted from being recorded as surviving in the wild to being naturalised.[4] Some were first spotted in the wild in New Zealand in the late 1800s, others over a hundred years later, in the 2000s (Figure 3.1).[5] For example, saltgrass (*Distichlis spicata*) was first observed in the wild in New Zealand in 1870, but was not considered naturalised until 2017.[6]

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1 For example, sea spurge (*Euphorbia paralias*) has recently drifted across the Tasman Sea from Australia, where it is also a native ecosystem weed (Biosecurity New Zealand, 2020).

2 Hulme, 2020, p.1542, Figure 2.

3 At least one source of these 66 species was classed as a cultivation escape because the wild individuals were seen near the putative parent plant. Of the other 22 species, six were classed as garden discard, 16 as spontaneous occurrence and two as unknown. One of these spontaneous occurrences is sea spurge, which is known not to be from a cultivated source within New Zealand. Ogle et al., 2020.

4 Seventy exotic plants classed as casual by Howell and Sawyer (2006) were classed as naturalised by 2020. For more, see Brandt et al. (2021).

5 Gatehouse, 2008.

6 Saltgrass was first documented in the wild in an herbarium collection from 1870 (Gatehouse, 2008, p.180). It was classed as casual (i.e. surviving in the wild but not naturalised) in checklists from 2000 and 2006) (Howell and Sawyer, 2006; Gatehouse, 2008). It was classed as naturalised in a checklist from 2017 (Schönberger et al., 2017).

Source: barnesyard, iNaturalist

Figure 3.1: Marsh mallow (*Althaea officinalis*) was first documented growing in the wild in New Zealand in 2019.

Of the roughly 25,000 exotic plant species that have been introduced to New Zealand by humans, fewer than ten per cent have to date naturalised. But it is only a matter of time before they are joined by others. So which will be the next? The short answer is that we do not know, but we can use a combination of risk assessment and targeted surveillance approaches to identify those exotic plant species that need to be managed now, before they become a problem in the future.

A sharper focus could be given to exotic species that have yet to naturalise and those that have naturalised only in the past 50 years to understand what factors might be currently limiting their survival and spread.[7] Combining this with regular surveillance of places where new escapees are most likely to turn up, such as the fringe of urban areas or roadsides, would facilitate early detection and rapid response to a species beginning to spread.[8]

[7] Hulme, 2020.

[8] Aikio et al., 2012; Hulme, 2012.

Land use change will continue to bring more invasions

Changes in how land is being used continues to be a major driver of exotic plant invasions today. Clearing land, whether for planting or harvesting exotic plants or expanding built environments, provides ample opportunities for weeds to invade and spread. The disturbances that land use change bring create a never-ending supply of 'weed-shaped holes'.[9] The fragmentation of land use is an exotic plant's friend (Figure 3.2).

Source: Peter Scott

Figure 3.2: Heavy rainfall can lead to mass landslides on exposed hills. As well as being a costly loss of productive soil, landslides increase the amount of disturbance to the land, providing ample opportunities for weeds to invade and spread.

Land use change also creates more opportunities for native ecosystem weeds to spread by strengthening pathways for propagules to travel along (e.g. more people and machinery moving along roads, more development and planting of ornamental exotic plants in rural areas). Certain pathways can be expected to pose a greater risk than others. For example, cultivation was identified over ten years ago by the Ministry of Agriculture and Forestry as a major source of risk for new plant naturalisations in New Zealand, with waste disposal seen as a key pathway for spread.[10] This source of new invaders is expected to become more problematic in future, as plants that used to be considered a low invasion risk – such as subtropical or tropical garden ornamentals that struggle to grow here without help – are released from their climatic constraints (discussed below) and propagules are transported around in green waste.

[9] Buckley et al., 2007.

[10] Biodiverse Limited, 2010.

He Pou a Rangi – Climate Change Commission's final advice to Government in May 2021 includes projections that contemplate a cumulative net change of over 1 million hectares of land converted to forest by 2050 in all the modelled scenarios.[11] Some years are projected to see over 40,000 hectares of net change, with most of this change predicted to come from the destocking and conversion of less productive sheep and beef pasture (see Figure 3.3).

Source: adapted from Climate Change Commission, 2021

Figure 3.3: The historical and projected annual net change in forest area (exotic and native combined) under different scenarios modelled by He Pou a Rangi – Climate Change Commission. Tailwinds and headwinds represent optimistic and pessimistic future scenarios in terms of barriers to technology and behaviour changes.

The Climate Change Commission sees particular value in native afforestation, indicating that by 2050 at least 40 per cent, and as much as 80 per cent, of the new forests being established should be native.[12] What this might mean for the risk of weed invasion into native ecosystems will depend critically on the type of new forests being created and how they are established and managed.

Simply removing livestock from marginal pastoral land in the hope that it will revert to permanent native forest will bring its own weed management challenges – but so too will planting new exotic plantation forests. Other types of forest already being attempted include permanent 'carbon' forests that begin as exotic but are managed to transition to native over time, and native plantation forests using species such as tōtara (*Podocarpus* sp.). There is also the question of what new species might be planted as part of any new afforestation efforts.[13]

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[11] The Climate Change Commission (2021) estimated 1.19 million hectares under its most pessimistic headwinds scenario and 1.23 million hectares under its most optimistic tailwinds scenario.

[12] Climate Change Commission, 2021.

[13] "Certain policies aiming to mitigate climate change may result in negative outcomes for weed management, such as by planting biofuels and forestry trees that have a high potential to become invasive" (Sheppard et al., 2016, p.401). See also Pyke et al. (2008) and Gibson (2021).

Rapidly planting forests was seen as a key part of the transition to a low-emissions economy by the Productivity Commission.[14] The One Billion Trees Programme, which started in 2018 and is run by Te Uru Rākau – New Zealand Forest Service within the Ministry for Primary Industries (MPI), was introduced in part to help achieve this.[15] As the name suggests, the programme aims to increase existing, business-as-usual planting rates to see 1 billion trees planted across New Zealand over the next decade. A large proportion of this 1 billion tree tally was actually projected to be radiata pine (*Pinus radiata*) tree seedlings planted as part of ongoing commercial forestry operations.[16] But the programme has directly funded 42.6 million new trees to be planted by 2028, of which 69 per cent are native species, the balance being exotic species.[17]

A strong message of the One Billion Trees Programme is the encouragement given to 'planting the right tree in the right place'. While the criteria for funding were not prescriptive of the species that should be planted, MPI provided a provisional list that met its criteria. Alarmingly, the list initially contained eight exotic tree species that are on the Weedbusters list, including one species – Japanese spindle tree (*Euonymus europaeus*) – that is on MPI's own list of unwanted organisms.[18] The provisional list has subsequently been amended to exclude these species (although it still contains some wilding conifer species) and to remind applicants to take care when choosing tree species.[19] Nevertheless, this slip-up highlighted a concern raised by some that this widespread disturbance and planting may exacerbate weed invasion problems in some areas. A recently developed set of guidelines aimed at helping to select exotic tree species in a way that minimises and mitigates unwanted impacts may be of value in this context.[20]

Afforestation is not the only land use change that is occurring. Urban expansion is expected to continue to bring fresh opportunities for weed invasions as construction interrupts land management, disturbs the ground and provides easy new pathways for plants to move along. An increasing number of lifestyle blocks, gardens, and parks with associated tracks and roads will increasingly bring weeds into closer proximity with native ecosystems whose isolation has to date largely spared them from invasion.

Other societal needs and demands will continue to change land uses too. Changes to farming practices, for example, could have significant implications for the spread of weeds and the risks they pose to native ecosystems.

Recent analysis of global development scenarios has highlighted that the threat of biological invasions to both biodiversity and the economy has been neglected. One study highlighted that "socioeconomic developments and technological innovation have the potential to shape biological invasions, in addition to well-known drivers, such as climate and human land use change and global trade."[21]

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[14] NZPC, 2018.

[15] Office of the Minister of Forestry, 2018.

[16] A 2018 Cabinet paper that laid out possible pathways towards the 1 billion trees target suggested that between 570 and 770 million trees could be from replanting by commercial foresters (Office of the Minister of Forestry, 2018).

[17] According to MPI, the One Billion Trees fund is now closed for new applications. The number of new trees directly funded was summarised by MPI in January 2021 (Te Uru Rākau – New Zealand Forest Service, 2021b).

[18] According to a Forest and Bird press release (Forest and Bird, 2018). Weedbusters is an online tool providing information to help those managing plants. It is discussed in chapter four.

[19] New Zealand Farm Forestry Association, 2018.

[20] Brundu et al., 2020.

[21] Roura-Pascual et al., 2021, p.1637.

Climate change will aid the invasion process

Many aspects of climate change are poised to help exotic plant species progress through the invasion process and permit more of them to survive, thrive and spread in parts of New Zealand where they are not found today.[22]

Climate change is leading to an overall warming across the globe, but the effects of this warming will not be felt in the same way everywhere.[23] The mid-point for projected warming in New Zealand by 2040 is 0.8 degrees Celsius, with 30–50 per cent fewer frosts each year.[24] But different regions will be affected by climatic changes in different ways, as is shown in the two maps in Figure 3.4 on pages 70 and 71. Frosts, for example, will be progressively limited to higher altitudes and latitudes.

The water cycle is also being changed in uneven ways around the globe. Some places are becoming drier, others wetter, and many may experience more extreme events too. The most recent Intergovernmental Panel on Climate Change (IPCC) report points out, for example, that globally more and more land area will be affected by droughts of increasing severity and frequency.[25] Here, the east coasts of the North and South Islands are expected to be hotter and drier, increasing the likelihood of drought conditions. In the southwest of New Zealand, more rain is expected annually and with it a greater likelihood of flooding.[26] Extreme events such as these increase the potential for disturbance to the land, favouring those plants that are better adapted to respond quickly to upheavals.

Warming temperatures will change where in New Zealand many naturalised plants grow best, and will enable some of them to ripen fruit or spread their seeds more prolifically. Several pine species are serotinous – meaning that resins keep their cones closed until heated sufficiently for their bonds to break, releasing the seeds inside. Wildfires are usually the trigger to open cones in the countries where these pines are native, but hot summer temperatures and radiation from the sun can break the resin bonds too.

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[22] McGlone and Walker, 2011.

[23] The latest Intergovernmental Panel on Climate Change (IPCC) assessment report (AR6) has an interactive tool that allows users to view how regional impacts vary. See their interactive website (https://interactive-atlas.ipcc.ch/).

[24] Projections for warming in New Zealand range from 0.2–1.7 °C by 2040, relative to the 1986–2005 period. Decreases in the number of frosts (i.e. nights ≤ 0 °C) are expected to be most pronounced in the coldest regions (MfE, 2018).

[25] IPCC, 2021, p.49.

[26] IPCC, 2021.

Cones of radiata pine in New Zealand open at 45 degrees Celsius on average – a temperature that cones hanging in the sun can currently reach on summer days with an ambient high of 33 degrees Celsius, leading to about half of the cones opening.[27] The wilding potential of pines could therefore increase with warmer summer temperatures in New Zealand, leading some plantations to release seeds that have to date been held in check by their resin-bonded cones.

Climate warming will also enable some potential native ecosystem weeds that struggle to grow at all in the wild to survive and successfully reproduce. For example, fewer frost days could release a plant from the pampered constraints of sheltered gardens by enabling it to survive the winter in the wild. The seedlings of three subtropical to tropical woody ornamentals – bangalow palm (*Archontophoenix cunninghamiana*), common guava (*Psidium guajava*) and Queensland umbrella tree (*Schefflera actinophylla*) – cannot currently survive the winter in Lincoln, Canterbury, and some will die in an Auckland winter as well, if there are frosts. But an increase of just one degree Celsius in the average minimum temperature over winter in Auckland can mean the difference between all Queensland umbrella tree seedlings dying or all of them surviving.[28]

The main driver of climate change itself, increased carbon dioxide in the atmosphere, can also have a direct effect on plant growth. On its own, an increase in carbon dioxide should ordinarily provide a benefit to most plants' growth – what is often called the carbon dioxide fertilisation effect.[29] But this benefit could easily be cancelled by other climate change impacts such as changes to the water cycle, including increasing droughts.[30] While it remains a considerable challenge to reliably predict exactly what changes in climate will occur at any given location, let alone which species of plants will outcompete others at those sites, best estimates suggest that globally the risks from weed invasion will typically increase. A recent meta-analysis of 111 published studies investigating the responses of 129 exotic plant species to climatic changes found that exotic plant growth increased with higher carbon dioxide, warmer temperatures and higher rainfall.[31] If changing conditions provide an advantage to even a few weeds, that could greatly increase the risk they pose to native ecosystems.

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[27] The temperature at which radiata pine cones opened in laboratory tests ranged from 35 to 53 °C. The ambient temperature at which cones kept outdoors opened ranged from 27.7 to 32.7 °C; cones in the sun reached temperatures up to 15 °C higher than ambient (Wyse et al., 2019).

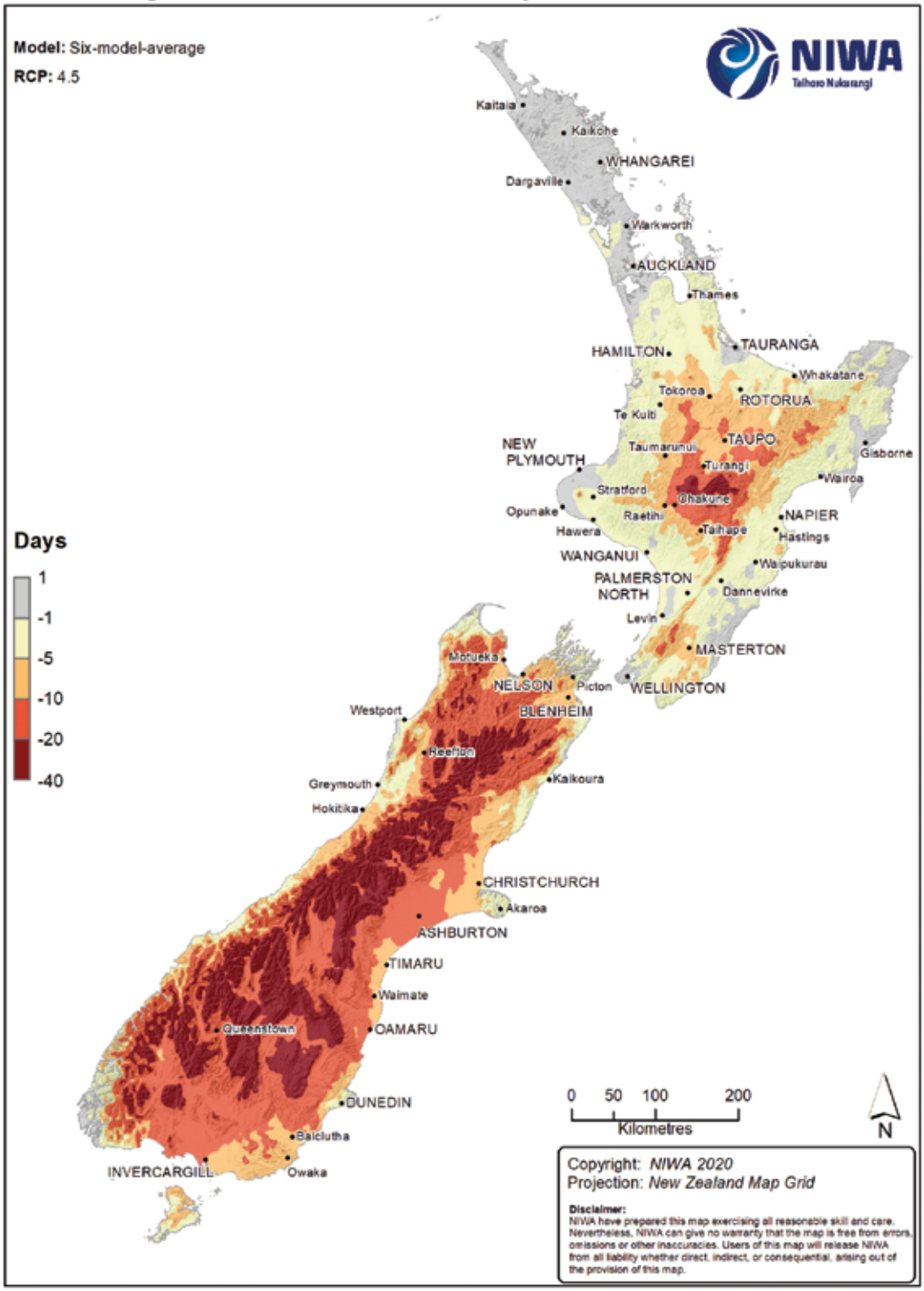
[28] Sheppard et al., 2014, 2016.

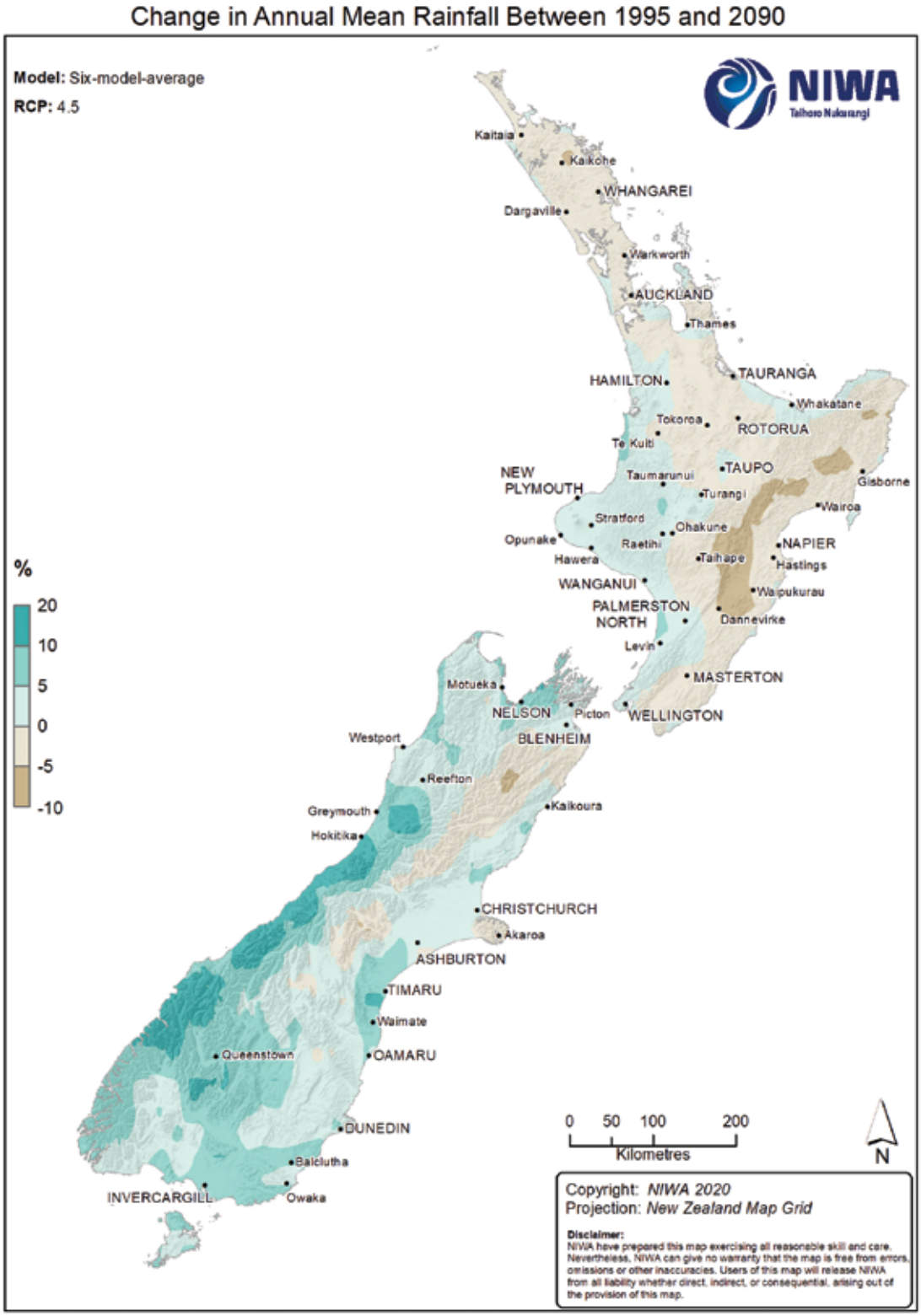
[29] Almost all plants, including most trees and shrubs, are in a group known as C3 plants. These plants are considered to benefit, at least to some degree, from increasing levels of atmospheric CO_2. A smaller group known as C4 plants, which includes plants such as maize and sugarcane, are better adapted to growing under low atmospheric CO_2 levels.

[30] C4 plants are also better adapted than C3 plants to growing where water is scarce.

[31] Jia et al., 2016.

Change in Number of Annual Frost Days Between 1995 and 2090





Source: NIWA, no date

Figure 3.4: National Institute of Water and Atmospheric Research maps showing the projected change in annual frost days (facing page) and precipitation (above) by 2090 under the IPCC emissions scenario – RCP4.5.

Until now, the more than 3,000 tropical plant species introduced to New Zealand were less likely to naturalise than if they had been introduced to Australia.[32] But as the climate warms, that could change. As of 2006, 358 exotic plant species from tropical regions were growing in the wild in New Zealand and 225 of these had naturalised.[33] A warming climate could therefore enable a further 2,000 subtropical exotic plant species already here to escape cultivation and facilitate naturalisation and spread of the hundreds already growing in the wild.

In general terms, a warmer climate is expected to enable many exotic plant species that are already naturalised in the north of New Zealand to extend their southern limit. As of 2020, there were 265 naturalised plant species that had only ever been recorded in the North Island, and 12 of these only in Northland.[34] Few rigorous projections have yet been made of how climate change could affect the amount of suitable habitat available to naturalised plant species that may currently be locally distributed largely due to climatic constraints.

Models predict that current climatic conditions provide some suitable habitat in the South Island for bangalow palm and common guava, though this is restricted to areas very near the coast (Figure 3.5). But only under predicted climate change scenarios does any habitat south of Auckland become suitable for the Queensland umbrella tree, according to these models.[35] Conversely, climate change may also reduce the suitability of some parts of New Zealand for the growth of certain weeds. For example, lower rainfall in the northernmost tip of New Zealand may reduce the suitability of habitat there for bangalow palm by 2090.[36]

But for all exotic plant species modelled to date, whether recently naturalised like the three described above or already widespread, such as buddleia (*Buddleja davidii*) and Scotch broom (*Cytisus scoparius*), climate change is expected to substantially expand their potential range in New Zealand.[37] For example, pinwheel succulents (*Aeonium haworthii*) appear to have reached their current elevation limit on Banks Peninsula due largely to winter mortality, but fewer frost days may relax this constraint and allow them to spread further.[38]

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[32] An estimated 3,156 tropical plant species have been introduced to New Zealand (Diez et al., 2009, p.1178, Table 3).

[33] Adapted from Fridley and Sax (2014). This does not include an additional 98 exotic plant species surviving in the wild and 273 naturalised plant species whose native range includes both temperate and tropical regions.

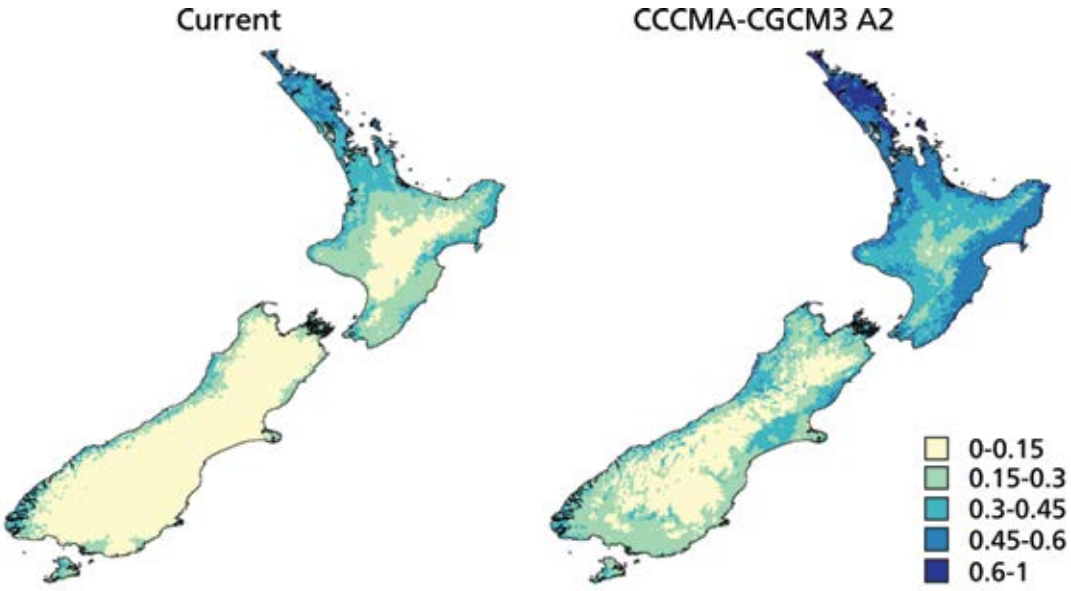
[34] This is out of 1,730 naturalised plant species for which the Global Biodiversity Information Facility (GBIF) had records (Etherington and Brandt, 2020).

[35] Sheppard, 2013.

[36] Sheppard, 2013.

[37] Potter et al., 2009; Kriticos et al., 2011.

[38] Pannell et al., 2019.



Source: adapted from Sheppard, 2013

Figure 3.5: The potential distribution of common guava in New Zealand increases under all modelled climate change scenarios. Shown here, as an example, is the plant's probability of being able to grow around New Zealand in the current climate (left) and its potential future distribution in 2090 (right).[39]

But it is not only through warming that climate change will promote the further spread of exotic plant species already growing wild. With a changing climate will come stronger and more frequent storms, and worsening fire risk.[40] As discussed in chapter two, the likely increase in disturbance events across the landscape will provide more opportunities for disturbance-adapted weeds to grow and spread because they can usually take advantage of cleared spaces faster than native plants. For example, climate change will increase the variability of hydrological flows in rivers, including high and erosive flows, and this will increase their vulnerability to invasion by weeds.[41] These events can also directly help to spread exotic plant propagules such as seeds or fragments of stem and root. Stronger winds and more frequent flooding could lead weeds that rely on wind and water as dispersal vectors to be spread over greater distances (Figure 3.6).

[39] As predicted by one global circulation model (CCCMA-CGCM3) using the A2 emissions scenario from the IPCC's Fourth Assessment Report. The A2 emissions scenario was projected to lead to a best estimate of 3.4 °C of further warming over the twenty-first century (IPCC, no date a).

[40] Perry et al., 2014; Macinnis-Ng et al., 2021.

[41] Brummer et al., 2016.

Source: Peter de Lange, iNaturalist

Figure 3.6: *Hygrophila ringens* is an aquatic plant commonly grown horticulturally and first seen growing in the wild in New Zealand in 2007. It can spread vegetatively along waterways when bits of stem or rooted pieces are carried downstream during flooding.

These future trends will not only increase weed invasion in New Zealand – they will exacerbate weed impacts in a wider range of native ecosystems.[42] For example, the climate of Fiordland and Mount Aspiring national parks might become suitable for buddleia to invade, bringing its effects on soil nutrients and changes to the native plant community around it.[43] Further, as discussed in chapter two, the presence of many weeds can affect the intensity and frequency of disturbances, such as fire. The harm to native ecosystems caused by weeds like wilding conifers is only expected to worsen as climate and land use change combine.

[42] Macinnis-Ng et al., 2021.

[43] Kriticos et al., 2011; Stanley and Bassett, 2014.

Box 3.1: Climate change and biological control

Climate change might also affect how well we are able to control some weeds using some of our current methods. Biological control agents are organisms, such as insects or fungal diseases, that have been released to control a weed. Their continued success will depend on how climatic changes affect the weed, the control agent and the interactions between them.

Biological control could become less effective if the control agents do not shift their ranges along with any shifting range of the weed, if the changed climate offsets the timing of their seasonal life stages or behaviours from that of the weed, or if their survival decreases under changed conditions (e.g. changes in the plant's chemistry under increased carbon dioxide making it less nutritious for leaf-feeding insects).[44]

An increase in extreme weather events and a lack of ability to adapt to changing conditions due to low genetic diversity are additional potential challenges to effective biological control under future climate change scenarios.[45] Moreover, the risk of some biological control agents having harmful effects – directly or indirectly – on native ecosystems could change with increasing temperature or changes in the distribution of the agent that bring it into contact with native species that were previously isolated.[46]

Alternatively, climate change could increase the effectiveness of biological control if it expands the range of control agents currently restricted by their climate tolerance. For instance, one of the beetles that feeds on alligator weed (*Alternanthera philoxeroides*) cannot currently survive the winter outside of Northland. Warmer winters outside of Northland could be expected to facilitate its spread.[47]

An alternative mechanism for improved biological control would be changes in plant chemistry stimulating control agents to do more damage (e.g. leaf-feeding insects consuming more plant tissue to make up for it being less nutritious).[48]

To illustrate how complicated this can be, the ragwort flea beetle (*Longitarsus jacobaeae*) is limited by soils being too wet during its immature stages, so it is predicted to become more effective at controlling ragwort (*Jacobaea vulgaris*) in the northern North Island (where rainfall will decrease) and be able to follow expanding ragwort populations only where rainfall does not exceed its tolerance threshold.[49]

[44] Kriticos et al., 2011; Gerard et al., 2013.
[45] Gerard et al., 2013.
[46] Gerard et al., 2013.
[47] Stewart et al., 1999.
[48] Kriticos et al., 2011.
[49] Gerard et al., 2013.

Native ecosystems will also be grappling with change

The combined effects of climate change and land use change are essentially re-dealing the hand for both weeds and native biota at the same time.[50] New Zealand's native species have had to adapt to changes in climate and land use here in the past, but the current rate of warming is probably much faster than anything the planet has experienced for millennia.[51] Weeds are likely to have the best chance of responding to these changes.

In very simple terms, for a species to survive it needs to either cope with the changing conditions where it currently lives, or move to a new location were conditions are suitable. With warming, this will generally be southward and upward in elevation.[52] This upward shift will reduce the area available to New Zealand's alpine species, most of which are found nowhere else in the world.[53] The pressure of finding suitable habitat may be compounded by competition from weeds also moving into these habitats. For example, under warmer conditions, the flowering of exotic heather (*Calluna vulgaris*) overlaps more with flowering of the endemic shrub monoao (*Dracophyllum subulatum*). This leads to lower seed production in monoao when surrounded by flowering heather, possibly on account of increased competition for pollinators.[54]

The need to shift to new locations with a more suitable climate can be challenging enough on its own, especially for long-lived plants that take years to produce seeds, or plants that need essential partners like pollinators or mycorrhizae to move with them. But human modification of New Zealand's ecosystems has amplified this challenge. Many suitable habitats have been lost, and the remaining ones are fragmented and becoming more so. Many native species face the combined challenge of greatly reduced populations and fragmentation of any remaining suitable habitat. They therefore have much less wiggle room to absorb the further pressures of climate change.[55]

The combined effects of these pressures are likely to be particularly strongly felt in northern parts of the North Island as fragmented native ecosystems come under increasing invasion pressure with a reduction in frost days. Fragmentation of native ecosystems will also exacerbate the effects of worsening droughts and fires on native ecosystems in eastern parts of both the North Island and South Island, with 'fire-loving' weeds helping to fuel the flames.[56]

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[50] According to the IPCC's *Climate Change 2014: Synthesis Report*, "Many plant and animal species will be unable to adapt locally or move fast enough during the 21st century to track suitable climates under mid- and high range rates of climate change (RCP4.5, RCP6.0 and RCP8.5) (medium confidence)" (IPCC, no date b).

[51] IPCC, 2021.

[52] McGlone and Walker, 2011.

[53] Dennis, 2017.

[54] Giejsztowt et al., 2020.

[55] Macinnis-Ng et al., 2021.

[56] McGlone and Walker, 2011.

4

Epilobium hirsutum

Assessing the state of what is known about exotic plants in New Zealand

At its outset, this report posed a series of questions about how well New Zealand is managing the impact of weeds on the integrity of native ecosystems. A fundamental component of this analysis is assessing our information systems.

Up-to-date, appropriate and accessible information is essential if we are going to make well-judged assessments of the risks weeds pose, support those on the front line tackling them, make credible assessments about whether we are succeeding or not, and change course as new challenges and new information emerge.

This chapter focuses on the state, utility and accessibility of the information base we possess about exotic plants. The essential question is this: Do those who are managing exotic plants have access to the information, skills and resources necessary to do a good job? The chapter focuses on the scope and state of the various databases and lists related to exotic plants and how accessible the information they contain is. The information relating to the risks weeds pose to native ecosystems has already been discussed in chapter two.

The chapter concludes by considering what a good information system might look like and how the information might best be managed.

Do we have the information we need to manage exotic plants?

Unclear exactly which exotic plant species are in New Zealand

While it is estimated that more than 25,000 exotic plant species have been introduced to New Zealand, there is no up-to-date and authoritative list of plant species growing in New Zealand. In its absence there are a number of different technical databases and lists maintained by the Ministry for Primary Industries (MPI) and Manaaki Whenua – Landcare Research (MWLR). Details of these lists are provided below, together with a discussion of their accessibility.

Information on the whereabouts of exotic plants is lacking

Authoritative information on the whereabouts of exotic plants in the New Zealand landscape is similarly lacking. Most exotic plant species, including those that have been the focus of control efforts for decades, suffer from an absence of comprehensive information on their distribution and rate of spread.[1]

Documenting the current distribution of exotic plants and how this is changing over time is a key piece of information required to assess the risks they pose to native ecosystems – and effectively prioritise the management of the thousands of exotic species that are growing here.[2] The absence of this information has been identified as a major barrier by many, including regional councils, researchers and government agencies.[3]

Some valuable information about the distribution and abundance of exotic plant species and their rate of spread comes from nationwide but limited monitoring that evolved out of the carbon monitoring system, developed for international reporting requirements under the United Nations Framework Convention on Climate Change. In 2002 the Ministry for the Environment (MfE) created an 8 × 8 kilometre sampling grid covering all native forest areas in the country and established 1,257 permanent plots on the grid.[4] MfE's focus was on the amount of carbon sequestered in these forests and how it is changing over time. The plots were initially remeasured by MfE in a five-year cycle but transitioned to a ten-year cycle in 2014. These plots are used to help inform the Land Use Carbon Accounting System (LUCAS), but monitoring also gathers some details of the plant species present at the sites.

The Department of Conservation (DOC) has developed a terrestrial Biodiversity Monitoring and Reporting System that is designed to report on national biodiversity outcomes by measuring key indicators on public conservation land.[5] One of the eight objectives of this monitoring was to reduce the "spread and dominance" of exotic species by documenting the "presence, dominance and rate of increase of exotic species in the natural environment".[6]

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[1] For example, Tomiolo et al. (2016) conducted the first study to quantify the rate of spread of the wilding lodgepole pine (*Pinus contorta*) into New Zealand's alpine habitats from planted stands.

[2] As identified in a recent report on the state of plant biosecurity science in New Zealand, "There are also many data gaps for biosecurity organisms already established in NZ that, if filled, would help to model outbreaks and opportunities for control" (Dyck and Hickling, 2021, p.19).

[3] As part of this investigation, a report was commissioned to review how regional councils manage exotic plant species in New Zealand. This report, prepared by Wildland Consultants, is available on the Parliamentary Commissioner for the Environment (PCE) website. Regional council staff surveyed by the report authors reported that a major data gap was knowing distributions of exotic plant species, especially in their own and neighbouring regions (see Hutchison et al., 2021). There was also an MWLR scoping report on this in 2010 (Cooper et al., 2010).

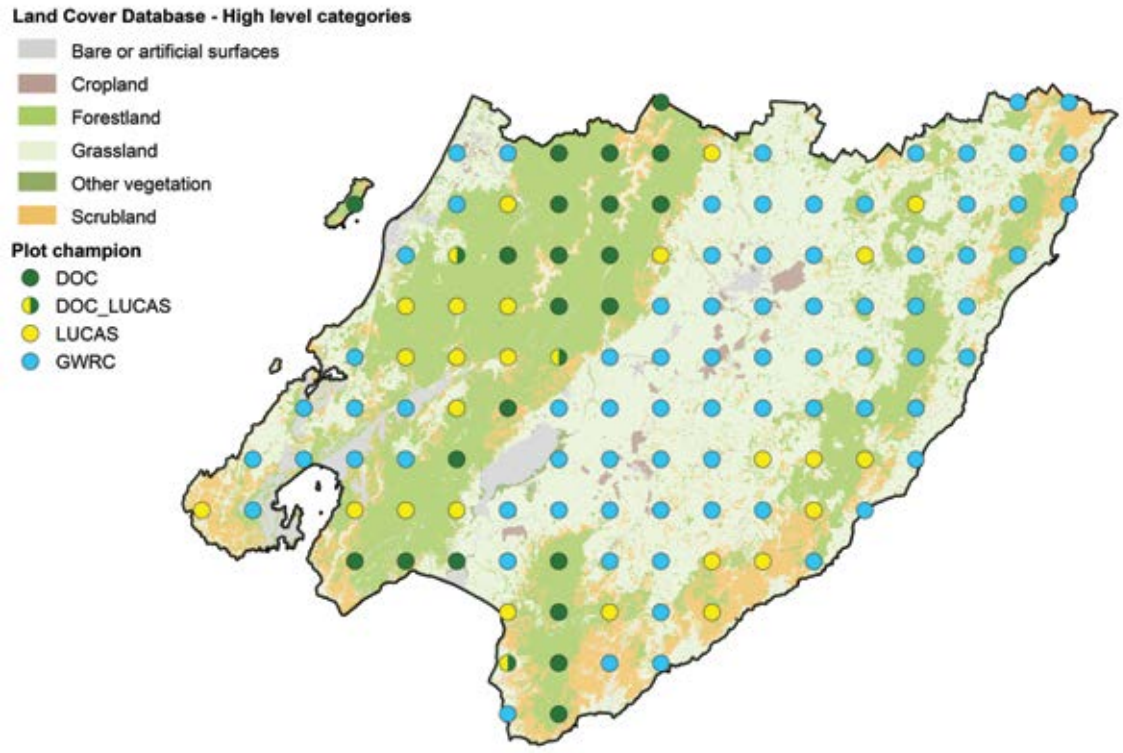
[4] In addition, approximately 700 LUCAS plots were established in exotic forests around the country. For details see MfE (2010), Searles (2018) and Paul et al. (2021).

[5] Wright et al., 2020.

[6] Wright et al., 2020, p.69.

DOC began its monitoring on the LUCAS plots that were located within DOC-administered forests in 2011, but has since expanded coverage to include plots on non-forested area and cover all DOC-administered land, mostly following the same 8 × 8 kilometre grid started by MfE (this is known as Tier 1 monitoring by DOC).[7] There are now approximately 1,400 such permanent plots on DOC land and they are resampled approximately every five years (about 280 each year). This monitoring is now in its third cycle of measurement. A range of biodiversity variables are measured at each plot and certain weeds are recorded as part of this monitoring effort.[8]

Further, regional councils also undertake some biodiversity monitoring on selected sites in their regions, most commonly reporting on some of the biodiversity indicators developed by MWLR.[9] For example, Greater Wellington Regional Council has extrapolated the same 8 × 8 kilometre grid of permanent plots that is used by MfE and DOC (for their LUCAS and Tier 1 monitoring) so that it covers all land in the region (see Figure 4.1). This means that combined, all plots in the region create a comprehensive broadscale monitoring grid that should be capable of showing changes in widespread weed distributions over time.



Source: Uys and Crisp, 2017

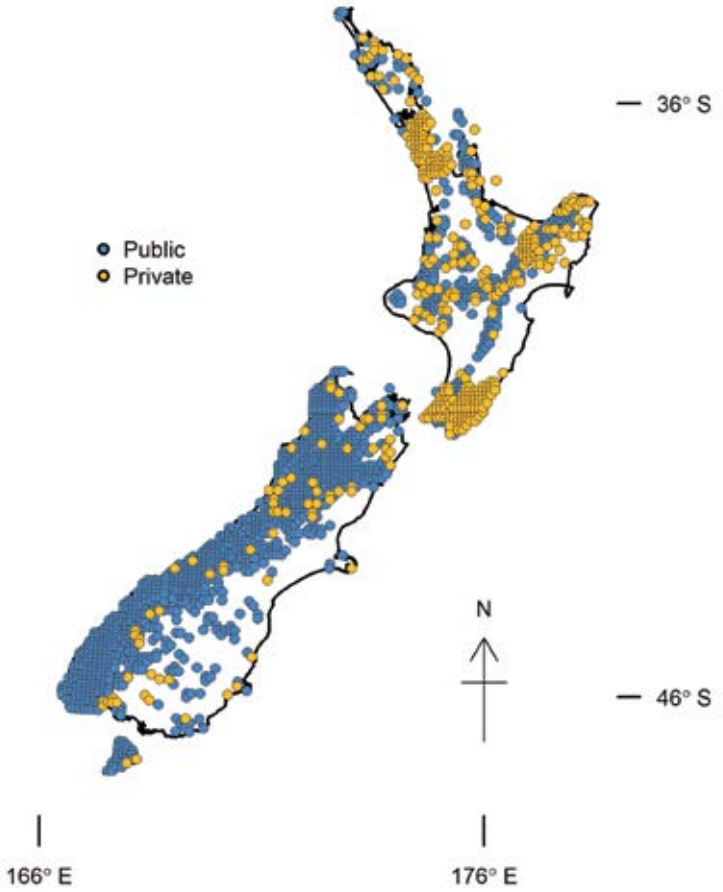
Figure 4.1: Comprehensive broadscale monitoring grid in the Greater Wellington region.

[7] There are three tiers to DOC's reporting system. For more, see DOC's monitoring and reporting website (https://www.doc.govt.nz/our-work/monitoring-and-reporting-system/ [accessed 24 September 2021]).

[8] More information about these biodiversity variables can be found in Bellingham et al. (2020). DOC measures relative abundance of 47 'species of concern' (Bellingham et al., 2016).

[9] In 2016 MWLR advised regional councils to adopt the Tier 1 approach to biodiversity monitoring in their regions and developed 18 standardised terrestrial biodiversity indicators for use by regional councils. Two of the 18 are most relevant to exotic plant invasions (Bellingham et al., 2016).

However, having such a comprehensive grid of permanent monitoring plots in a region is currently an exception, not the rule (see Figure 4.2).



Source: Bellingham et al., 2020

Figure 4.2: The permanent broadscale monitoring grid does not cover the entire country.

This grid of permanent plots covering the land is valuable for many reasons, including helping to better understand the spread and impact of native ecosystem weeds. For example, data collected from this monitoring has been used by DOC to report on the areas of DOC-managed land that are under the greatest pressure from exotic species, including woody weeds.[10,11] MWLR was able to ascertain if the proportion of exotic plant species in native forest had changed over time by looking at monitoring data from LUCAS/Tier 1 plots on public conservation land.[12] Greater Wellington Regional Council has also reported on the proportion of exotic plant species growing in each plot in its state of the environment monitoring data reports.[13]

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[10] See https://www.doc.govt.nz/contentassets/ebf6dc3ecb554b7a8b8cd3d223501a5f/factual/invasive-species-pressure.pdf [accessed 24 September 2021].

[11] See https://www.doc.govt.nz/contentassets/ebf6dc3ecb554b7a8b8cd3d223501a5f/factual/woody-weeds.pdf [accessed 24 September 2021].

[12] Overall, these native forest plots had a low and relatively constant proportion of exotic plants present (just 3% on average) but some changes in individual species were able to be detected in the ten years of monitoring (Bellingham et al., 2014).

[13] Uys and Crisp, 2017.

MWLR is also actively carrying out further research in this area to better understand weed invasions into forests.

Despite this effort, issues remain. The existing Tier 1 monitoring sites do not always overlap with key sites where exotic plant species thrive or where there is a high risk of invasion. The five-year (or ten-year) interval between resampling each plot and the large scale of the grid also mean that the early invasion of many exotic plants will likely be missed, or their spread only detected when early-stage eradication is no longer a viable management option for a given area. In addition, biodiversity monitoring undertaken by regional councils around the country is patchy. Only three councils (Auckland, Greater Wellington and Southland) collect data and report (at least partially) on the two most relevant indicators for weed invasions – the number of new naturalisations, and the distribution and abundance of plant and animal pests.[14]

It is clear that Tier 1 monitoring, while valuable, does not replace the need for well-designed and cost-effective weed surveillance and monitoring systems. Indeed, while Tier 1 monitoring has contributed to the evidence underpinning the National Wilding Conifer Control Programme, more investment and tailored design was needed to detect low-level infestations and support implementation and reporting, leading to the development of the Wilding Conifer Information System that is administered by Land Information New Zealand.[15]

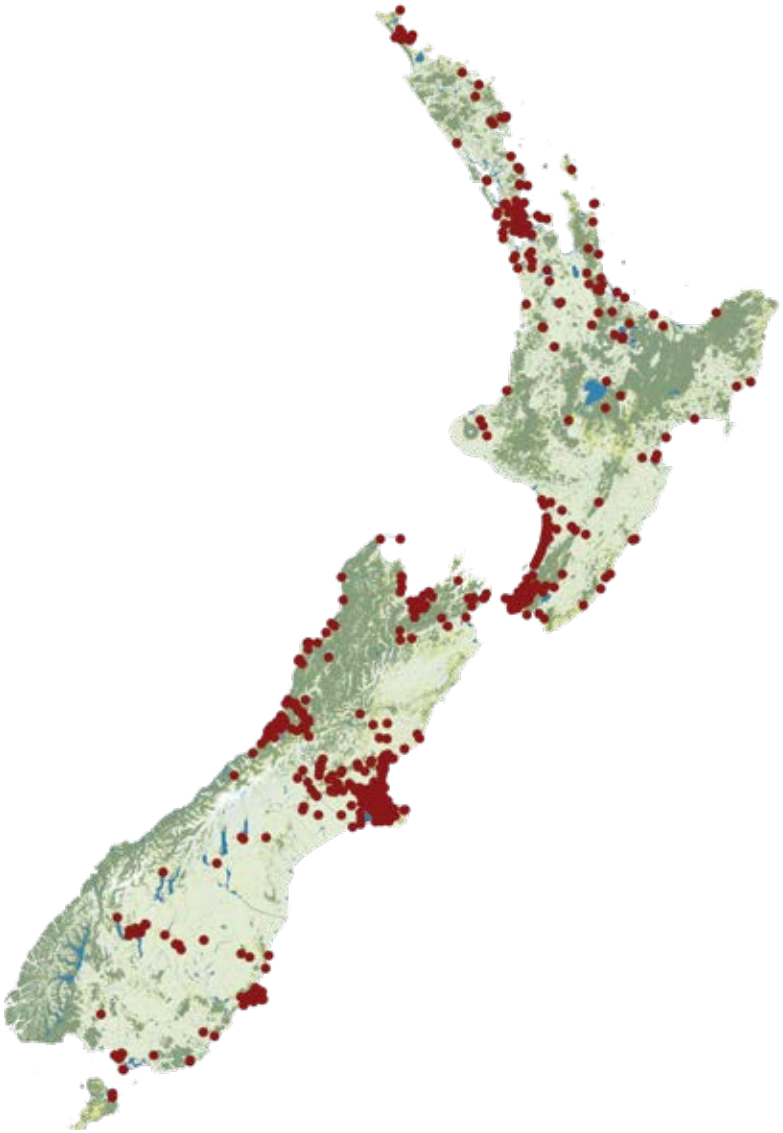
In addition to any monitoring by government agencies, some useful information on where exotic plant species are growing is provided by interactive databases that provide a place to marshal observations by members of the public as well as professionals. The website iNaturalist is the most widely used platform of this type, with the recently launched Find-A-Pest app linked directly to it.[16] These databases can play an important role in helping with surveillance and advocacy, but they are not designed to provide authoritative information on all species present in New Zealand.

Relying on public observations to make up for the limitations of officially collected data is an inadequate strategy. Firstly, most people rarely venture far from the beaten track, so geographic coverage is patchy and would appear to be biased toward urban centres. This can be seen by looking at the existing 900+ records of radiata pine (*Pinus radiata*) sightings in the country (see Figure 4.3).

[14] This is based on a survey of biodiversity monitoring undertaken by regional councils and unitary authorities. The survey was conducted by PCE staff for this investigation.

[15] DOC staff, pers. comm., 24 September 2021.

[16] See the iNaturalist NZ website (https://inaturalist.nz/) and the Find-A-Pest website (http://www.findapest.nz/).

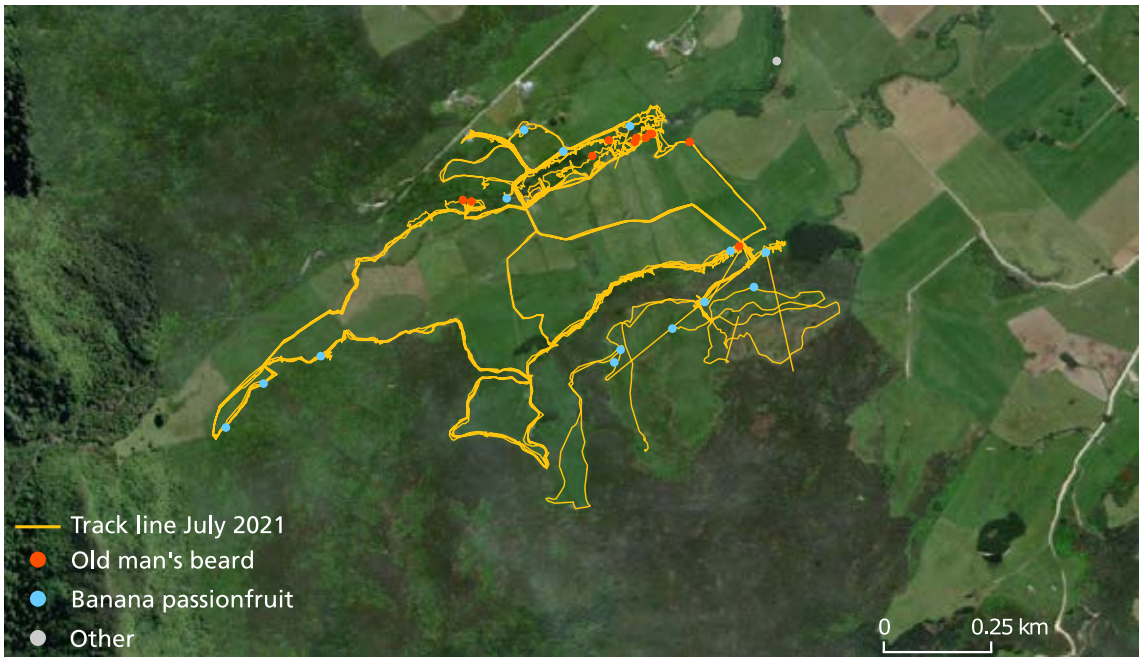


Source: adapted from iNaturalist

Figure 4.3: Map showing the location of over 900 iNaturalist records for radiata pine in New Zealand as of June 2021.

Secondly, the information recorded on iNaturalist reflects the particular focus of the individuals choosing to upload them – many species are simply not recorded very often. This may be because they are common or because they are inconspicuous. Finally, iNaturalist does not record useful pieces of information such as search effort, density or where species were looked for but not found. This citizen science surveillance is valuable but can only ever be a component of a robust monitoring system.

Another source of information comes from community groups that are dotted around the country. For example, the Project De-Vine Environmental Trust in Golden Bay and the Stewart Island/Rakiura Community & Environment Trust have publicly accessible geospatial databases on their websites that show some of the data relating to their efforts searching and destroying weeds (see Figure 4.4 and chapter eight).



Source: PDVET

Figure 4.4: An example of the sort of information publicly available on the weed control efforts undertaken by community groups. This screen grab shows the actual paths of workers searching for weeds in Golden Bay, including where individual plants of each species were found.[17]

Information on how to control exotic plants could be improved

Information, including which control methods work for a given weed (and just as importantly, which methods do not work), along with the pros and cons of their use, is vital to make sensible and defensible decisions on which species to manage, where and how. Ideally, this information needs to be backed up by evidence. For example, the decision to use a given herbicide or biological control agent to control a weed may be contentious due to other possible effects of the control method. Citing, and providing access to, the information any such action is based on helps everyone better assess the trade-off between risks being taken and those being mitigated. Clearly communicating the methods being employed is also important because some control methods preclude the use of, or can have impacts on, other methods. Access to evidence rather than anecdotes will help reduce confusion and misinformation.

Sources of public information on control methods include some regional councils, pest control contractors, research institutions and community groups. Many of these refer to each other, and often to the well-known Weedbusters website, which details some of the methods used to control over 400 weeds, including herbicide formulation advice. This website is a useful resource for many as it describes many of the weeds people are likely to encounter, but it does not cover all exotic plants present in New Zealand, and technical information on plant species is not regularly updated.[18]

[17] See https://pdvet.org.nz/https-projectde-vine-maps-arcgis-com-apps-dashboards-aefd53e90541489aa66eb56657053231/ [accessed 24 September 2021].

[18] See https://www.weedbusters.org.nz/. The Weedbusters website drew on a DOC weeds database for this information when it was created (DOC staff, pers. comm., 23 September 2021).

Access to up-to-date information is critical as new species invade and novel methods of control continue to be developed.

What role for mātauranga Māori?

In chapter one the connection and relationship that exists between people and ecosystems was explained using a te ao Māori lens. The knowledge that is generated and understood within this lens is defined as mātauranga Māori.[19] Mātauranga Māori is the body of knowledge that has been generated and transmitted orally over many generations since the first Polynesians arrived in Aotearoa. Mātauranga Māori is not just information; it also holds tikanga, processes and ways of knowing. The accumulated knowledge represents sustained and often extremely subtle observations. In the same way that Māori regard themselves as connected to and a part of the land, the knowledge that has been accumulated is often strongly related to place. It is the knowledge base that enabled Māori to manage their areas and sustainably use resources. That knowledge would have been hard-won from the experience of settling and having to learn to live in a previously uninhabited land.[20]

Te ao Māori can provide a different lens through which to manage exotic plant species where a holistic approach can complement a more traditional scientific framework. Mātauranga Māori can provide us with important information on managing our unique ecosystems – for example, having a better understanding of species distributions by collating mātauranga Māori from the time before colonisation. The use of mauri could be utilised to understand the impacts of other species in the ecosystem. Additionally, use of an exotic plant species could be further explored as a management tool. As Māori see themselves as part of the ecosystem, use of weeds as a resource is a way to balance the impacts of people and plants, especially when eradication of the weed is not achievable. For example, pūhā (sowthistles, *Sonchus* spp.) will grow in places that have been disturbed and proliferate if left to grow.[21] Pūhā is a favoured vegetable for Māori, who will pick young shoots before it goes to seed, but it cannot be harvested if herbicide has been used in the area. Using herbicide therefore limits the opportunity to use harvesting as a control method for pūhā and other edible weeds.

Unfortunately, mātauranga Māori is relatively invisible in the management of weeds and their impacts on native ecosystems. If mātauranga Māori is to be used as a source of information to help with weed management, appropriate partnerships with Māori need first to be developed.[22]

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[19] Hikuroa, 2017.

[20] PCE, 2019, p.69.

[21] Several species of pūhā grow in New Zealand and can be eaten, including both native and exotic species. Exotic pūhā may still displace native pūhā where they co-occur, even with harvesting.

[22] McAllister et al., 2019.

How accessible is information on exotic plants?

While a large amount of information relevant to exotic plant management in New Zealand exists, it is often scattered and not always easily accessible.[23] This information is collected by staff in local government (regional councils) and central government (primarily DOC and MPI) as well as researchers in universities, Crown Research Institutes and consultancies, and community groups. It is stored in numerous databases and other resources.

Key types of resources include:

- **technical databases** (often developed within Crown Research Institutes, central government agencies and regional councils and also by some community groups) – sometimes publicly accessible, sometimes not
- **field guides, booklets and exotic plant websites** (often developed by regional councils and keen volunteer groups)
- **citizen science resources**, including apps and websites like iNaturalist (a public-focused interactive website allowing citizen scientists to upload their observations).

In terms of public-facing technical databases, five key national ones are managed and maintained by MWLR.[24] A brief description of each is given below:

- **New Zealand Organisms Register** – a dynamic catalogue of taxonomic names of plants, fungi, vertebrates and invertebrates present in New Zealand[25]
- **Ngā Tipu o Aotearoa – New Zealand Plants** – a plant names database delivering referenced, scientific and common names of New Zealand flora[26]
- **Systematics Collections Data** – specimen and culture data from nationally significant collections, including the Allan Herbarium specimen data for plants[27]
- **New Zealand National Vegetation Survey Databank** – New Zealand's repository for ecological data on vegetation structure and composition[28]
- DataStore group database of **New Zealand Non-native Flora Traits and Distributions** – designed to provide data for exotic plant species to support research and decision making.[29]

MPI also manages several relevant public-facing technical databases:

- The **Plants Biosecurity Index (PBI)** lists import requirements for species approved for importation into New Zealand. It also lists many, but not all, other exotic plant species known to be in New Zealand.[30]

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[23] This section draws on a report commissioned for this investigation to provide a stocktake of the available resources and databases about exotic plant species in New Zealand (Dawson, 2020). This report, produced by Murray Dawson (MWLR), is available on the PCE website.

[24] For more details see Dawson (2020).

[25] See https://www.nzor.org.nz/.

[26] See https://nzflora.landcareresearch.co.nz/.

[27] See https://scd.landcareresearch.co.nz/.

[28] See https://nvs.landcareresearch.co.nz/.

[29] See https://datastore.landcareresearch.co.nz/group/nz-non-native-flora-traits.

[30] See https://www1.maf.govt.nz/cgi-bin/bioindex/bioindex.pl.

- The **Official New Zealand Pest Register** lists information about terrestrial pests, aquatic pests and disease-causing organisms. The information provided includes their official regulatory status, such as 'unwanted organism'. Regulatory status used to be recorded in the Unwanted Organisms Register, which, up until 2020, listed all formally identified 'unwanted organisms', including exotic plant species. That database is no longer active – having been subsumed by the Official New Zealand Pest Register.[31]
- MPI also maintains a public-facing web-based '**Search for a pest or disease**' database that includes the ability to search for exotic plants, both terrestrial and aquatic, and provides some information on the plants, including their regulatory status.[32]

In addition, MPI maintains a list of plants in the **National Pest Plant Accord (NPPA)**. The NPPA is a cooperative agreement between MPI, DOC, regional councils and New Zealand Plant Producers Incorporated. All NPPA plants are also unwanted organisms. Currently 135 taxa are listed in the NPPA.[33]

Other public-facing databases that relate to exotic plants are listed below.

- The **New Zealand Plant Conservation Network flora database** details the biology, ecology, distribution, history of introduction and naturalisation, and effective control methods for some weeds.[34]
- The aforementioned **Weedbusters website** was started in 2003 as an interagency initiative led by DOC and supported by MPI and regional councils. It was intended to raise awareness of the impact of weeds by providing information about selected exotic plant species, including how to identify and control them. The website is now unfunded and has had reduced maintenance in recent years. However, this website still provides useful and accessible information about weeds and their management.[35]
- The **AgPest database**, maintained by AgResearch, details the biology, impacts, control methods and identification features of exotic plant species that are of primary concern to agriculture.[36]
- Geographic Information Systems (GIS) containing weed-related data are sometimes provided by community-led conservation groups, such as **Stewart Island/Rakiura Community & Environment Trust** and **Project De-Vine Environmental Trust** in Golden Bay.[37]
- Some regional councils host websites with plant databases, such Auckland Council's **Pest Search** and Northland Regional Council's **Pest Control Hub**.[38]

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[31] See https://pierpestregister.mpi.govt.nz/.

[32] See https://www.mpi.govt.nz/biosecurity/how-to-find-report-and-prevent-pests-and-diseases/search-for-a-pest-or-disease/.

[33] See https://www.mpi.govt.nz/biosecurity/how-to-find-report-and-prevent-pests-and-diseases/partnerships-programmes-and-accords/national-pest-plant-accord-for-preventing-the-sale-of-invasive-weeds-in-nz/.

[34] See https://www.nzpcn.org.nz/.

[35] See https://www.weedbusters.org.nz/.

[36] See https://agpest.co.nz/.

[37] See https://experience.arcgis.com/experience/e30ddfaf989b475eb3c9d55d98ed3f27 and https://pdvet.org.nz/https-projectde-vine-maps-arcgis-com-apps-dashboards-aefd53e90541489aa66eb56657053231/.

[38] See https://www.tiakitamakimakaurau.nz/protect-and-restore-our-environment/pests-in-auckland/pest-search and https://www.nrc.govt.nz/Environment/Weed-and-pest-control/pest-control-hub/?pwsystem=true&pwid=5&sort=alpha.

Behind the scenes there are other internal databases.

- Regional council databases typically document details of known exotic plant distributions and current control programmes being undertaken as part of regional pest management plans (RPMPs). These databases may be robust, but it is hard to be certain since they are not publicly available. Other organisations, such as DOC and MPI, sometimes rely on these sources of information.[39]
- DOC also has several internal weed-related databases. One is a geographic information system (GIS) Weed Data System that was established in 2014 and is primarily focused on the recording and reporting of data to assist in the management of weed infestations on DOC-managed lands. The system contains information about DOC weed management actions but is variable in quality and of limited value for analysis and assessment. It relies on staff entering information manually in the office rather than real-time Global Positioning System (GPS) tracks. There is also an older Weeds Database called Bioweb – designed to contain comprehensive information on many exotic plant species, including their attributes, distribution and methods of control – which was used to inform the Weedbusters website.[40] Bioweb is no longer current, and the technology is no longer supported within DOC. However, it remains a useful reference for staff.
- MPI maintains an internal database for incursion investigation teams to log incursion investigations and a separate one for documenting management responses (if initiated), but these are not available to the public.

In addition to the databases described above, other relevant resources include floras (these are scientific descriptions of the taxonomic features of plants that help with identifying species), exotic plant keys (used to help identify plant species), illustrated guidebooks that include common exotic plant species, and the global citizen science web platform iNaturalist, which was described above.

Many international public-facing databases also exist, including a key one for understanding species distributions – the Global Biodiversity Information Facility (GBIF). The facility was created by a network of countries and organisations and is coordinated by a secretariat in Denmark that focuses on making scientific data on biodiversity (including distribution) available via the internet.[41] GBIF aggregates a large number of datasets from many countries. New Zealand has contributed 100 datasets so far, including digitised herbarium specimens and vegetation survey data, totalling over 7.5 million records.[42] The facility is currently being developed as a tool for government agencies to use here in New Zealand.[43]

Other relevant international databases include the Global Compendium of Weeds, the Global Invasive Species Database, the International Plant Names Index and Plants of the World Online.[44]

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[39] For example, approximately half of the regional councils record phenology data in the field, while the other half do not. Further, not everyone uses tablets and GPS units to record information – many council staff use handwritten data sheets and store hard copies. Sharing of information with the other councils is also ad hoc. See Tables 27–29 and 32 in Hutchison et al. (2021).

[40] Edkins, 2003; DOC staff, pers. comm., 21 September 2021.

[41] https://www.gbif.org/what-is-gbif [accessed 24 September 2021].

[42] GBIF continues to receive data from herbaria, the National Vegetation Survey databank, iNaturalist and other sources from New Zealand.

[43] In 2021, MBIE has invested in the development of the New Zealand 'node' for GBIF. See also https://www.gbif.oIn 2021, MBIE has invested in the development of the New Zealand 'node' for GBIF. See also https://www.gbif.org/the-gbif-network.

[44] See http://www.hear.org/gcw/, http://www.iucngisd.org/gisd/, https://www.ipni.org/ and http://www.plantsoftheworldonline.org/.

Problems with existing information systems

A number of issues are apparent from assessing these sources of information, a key one being that **many of New Zealand's databases are not as connected as they could be**.

A key connection that is missing is one between technical taxonomic databases and regulatory ones. Indeed, this need has been recognised by MPI staff. For example, the New Zealand Organisms Register, developed and maintained by MWLR, is not currently linked with any MPI-developed and maintained databases, including the PBI or the Official New Zealand Pest Register.[45] Old infrastructure and database architecture is also, in some cases, hampering connectivity.[46] The Official New Zealand Pest Register is envisaged to enable data sharing between relevant databases.[47]

Individual institutions and councils often manage their own datasets in a way that is invisible or inaccessible to others, including the public. Regional council staff collect valuable field data about distribution, abundance, phenology and control of exotic plant species,[48] but that information is usually stored in internal spreadsheets and databases and is not publicly available. Useful information may even be confined to obscurity in a notebook in a desk as some regional council staff store exotic plant information as hard copies.[49] If these records are not digitised, they risk disappearing into obscurity. Data sharing with other councils and agencies remains ad hoc, on request, and is not consistent across all councils and programmes.[50]

For example, the common reed species *Phragmites karka* is closely related and very similar in appearance to the aggressive wetland invader *Phragmites australis*, one of eight plants on MPI's National Interest Pest Responses list for eradication from New Zealand.[51] There is little information globally about the impacts of *P. karka* as it may not be distinguished from *P. australis* either taxonomically or operationally, but it is considered likely to cause similar harm to native ecosystems.[52]

MPI was notified of a *Phragmites* sighting in Feilding in late 2020 and confirmed it as *P. karka*, which had come to the attention of a keen weed officer in 2006.[53] From looking at iNaturalist, one might assume that *P. karka* still has a limited distribution – just four or so observations at essentially two sites in the Manawatū-Whanganui region. No other spatial distribution information for this species is publicly accessible. However, a conversation with Horizons Regional Council staff revealed that the species may be much more widespread within the region since a 2015 survey found it infesting several kilometres of two streams, as well as being noted at over 20 other sites in the region.[54]

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[45] MPI staff plan to expand the Official New Zealand Pest Register by incorporating the PBI and the New Zealand Organisms Register (including consistent naming conventions) and providing links to other websites and databases such as GBIF (MPI staff, pers. comm., 28 September 2021).

[46] As MPI databases have been built on older database architecture and do not follow international biodiversity information standards, technical upgrades would be required to achieve smooth data and information sharing across these databases. This includes improving naming conventions for species. For more details, see Dawson (2020).

[47] MPI staff, pers. comm., 22 September 2021.

[48] See Table 27 in Hutchison et al. (2021, p.42).

[49] See Table 29 in Hutchison et al. (2021, p.43).

[50] Northland Regional Council and Gisborne District Council reported that they did not share exotic plant species data with other councils and agencies (Hutchison et al., 2021, p.45, Table 32).

[51] MPI, 2021c.

[52] *Phragmites karka* is listed as a synonym for P. australis on the Global Invasive Species Database (GISD, 2021b). The two species have similar biology, and they are described in the same datasheet in the Invasive Species Compendium (CABI, 2021).

[53] Bleach, 2021, p.44; Horizons Regional Council staff, pers. comm., 16 July 2021.

[54] Horizons Regional Council staff, pers. comm., 16 July 2021.

Lack of accessibility to information is a related issue. Some data relating to exotic plants is publicly accessible online, such as observations from iNaturalist, Tier 1 monitoring data held in MWLR's National Vegetation Survey Databank, and New Zealand records located in GBIF. However, this public accessibility is not routinely the case.[55] Some organisations restrict access to their databases and information on exotic plants in general. For example, information from DOC's internal Weed Data System is not shared with others in the absence of a formal request. This database contains information about DOC control efforts but is variable in quality and of limited value for analysis and assessment purposes since it does not typically record effort and area. It relies on staff entering information manually in the office rather than real-time GPS tracks.

Only some information generated as a result of MPI incursion investigations and management responses is published on MPI's website. For example, while the sea spurge (*Euphorbia paralias*) risk assessment was posted on MPI's website, assessments for other exotic plant species were not. Further, even basic information collated about new species incursions is not consistently uploaded to MPI's 'Search for a pest or disease' database. For example, at the time of writing, this database contained no great willowherb (*Epilobium hirsutum*) entry, despite MPI confirming discovery of this exotic plant species in Canterbury in 2018, and a management response being underway to suppress it to a low level.[56]

Regardless of which agency performs an assessment, it seems beneficial to make it publicly available, even if the conclusion is to take no action on a particular plant. Doing so will provide clarity and transparency of the process and outcome as well as to help inform subsequent assessments.

There may be legitimate reasons why some information is not made publicly available, such as confidentiality. But any such privacy concerns, if they exist, need to be critically assessed alongside the value of sharing such information for the benefit of the wider community. It is hard to imagine that biosecurity is best served by keeping the knowledge of unwanted exotic plants in specific locations under wraps. In any case, there are often simple ways to address these concerns, such as anonymising public data and setting up permissions processes for full access.[57]

Combined, the issues described above lead to confusing information. See Box 4.2 for an example.

[55] Interestingly, MPI does not use iNaturalist to inform its investigations; iNaturalist users are expected to call MPI's hotline if they want to report a suspected exotic plant (MPI staff, pers. comm., 22 September 2021).

[56] MPI, 2018b; MPI staff, pers. comm., 24 March 2021.

[57] For example, locations of species on iNaturalist and GBIF can be obscured, and databases like MWLR's National Vegetation Survey Databank have permissions requirements and explicit terms of use for certain datasets.

Box 4.2: An example of confusing and muddled information

MPI's quarterly *Surveillance* magazine for March 2021 describes how the recent discovery of water lettuce (*Pistia stratiotes*) in Whangārei is being managed.[58] The article states that the species has apparently been eradicated from New Zealand twice already.[59]

But finding out more about water lettuce from the MPI website, including its management status and where it has been known to occur, is an exercise in frustration. It can be found in the 'Search for a pest or disease' database, but the information is minimal and was last updated in 2009.[60] The entry states that it is present and established in New Zealand, but there is no mention of where it is or what has been done to manage it. For example, the *Surveillance* article mentions that water lettuce is on the NPPA list (limiting the sale of the plant), but this status and a link to the NPPA are not included on this information page.

Searching on the newly created Official New Zealand Pest Register under 'imports' produces an even briefer record for this species – it says little more than that water lettuce is a regulated pest and provides links to the 'Search for a pest and disease' information page for the species.[61] The Official New Zealand Pest Register provides links to other web pages about the species, but the only New Zealand-based page is for the New Zealand Organisms Register.

A wider search of other New Zealand databases listed earlier in this chapter reveals a little more detail. The New Zealand Plant Conservation Network states that the species has been "nationally eradicated, previously known from Tauranga and Hokianga, Northland."[62] Ngā Tipu o Aotearoa, the New Zealand Plant Names Database, lists the plant as "Casual" (i.e. growing in the wild but not naturalised), with the note "*Pistia stratiotes* was found from two known sites, but now eradicated" (Figure 4.5).[63]

[58] Bleach, 2021, p.39.

[59] Water lettuce is one of eleven exotic plant species believed to be eradicated from New Zealand. This is discussed further in chapter five.

[60] MPI, 2009.

[61] See https://pierpestregister.mpi.govt.nz/PestsRegister/ImportCommodity/ [accessed 1 July 2021].

[62] See https://www.nzpcn.org.nz/flora/species/pistia-stratiotes/ [accessed 20 September 2021].

[63] See https://nzflora.landcareresearch.co.nz/default.aspx?selected=NameDetails&TabNum=0&NameId=51234455-D20A-4323-838F-6E52FADBABD1 [accessed 20 September 2021]. NIWA staff, pers. comm., 19 April 2021.

Source: Mackay Region Natural Environment, Flickr

Figure 4.5: Water lettuce (*Pistia stratiotes*) covering water in Australia shows just why it was worth eradicating from New Zealand before it could spread widely.

Beyond issues with connectivity and access, there is a **lack of clarity of purpose and usability** of existing databases. Databases are developed to support the developer's needs, not necessarily for informing the public. In many cases the stated purpose versus perceived purpose differs markedly, and their implementation, documentation and functionality are poor. For example, the PBI, which lists the import requirements for plant species, is maintained on a very rudimentary web page that provides no information about its purpose or how to use it. Furthermore, there is no link on the PBI web page to the two import health standards that rely on the PBI. Both documents are available elsewhere on MPI's website and refer the reader to the PBI (although one fails to provide the web link).[64]

There is also a lack of clarity about what the PBI does or does not do. This is particularly troubling given that the Environmental Protection Authority refers applicants to the PBI to check if a species they wish to import is already in New Zealand when MPI does not consider that the Environmental Protection Authority should do so.[65] The PBI contains over 29,000 native and exotic species that are in New Zealand, so it extends far beyond those with import requirements (Figure 4.6). But this is not a list of all plants in New Zealand. In other words, a plant may not be on the PBI but still be in New Zealand. This confusion might be cleared up with accompanying information on the PBI website.[66]

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[64] MPI, 2021a, b.

[65] See https://www.epa.govt.nz/everyday-environment/gardening-products/importing-plants-and-seeds/ [accessed 20 September 2021]. The Environmental Protection Authority assesses the ability to import any species that is *new* to New Zealand under the Hazardous Substances and New Organisms Act 1996 (MPI staff, pers. comm., 22 September 2021).

[66] MPI recently announced that the PBI is planned to be decommissioned in the last quarter of 2021 and replaced with the Product Import and Export Requirements integrated search tool (Biosecurity New Zealand, 2021). Further, it looks like the PBI might be subsumed by the Official New Zealand Pest Register, as indicated at https://pierpestregister.mpi.govt.nz/.

Source: Peter de Lange, iNaturalist

Figure 4.6: Listed on the Plants Biosecurity Index (PBI), ipil-ipil (*Leucaena leucocephala*) was first documented growing in the wild in New Zealand in 2015 and is listed as one of the 'world's worst invasive alien species' in the Global Invasive Species Database.[67]

Likewise, MPI's recently launched Official New Zealand Pest Register was touted as a "one-stop-shop for all pests and diseases regulated in the biosecurity system … creating a concise and clear resource for use by importers, exporters, researchers, councils and educational institutions."[68] Providing this information for about 23,600 species and maintaining it will be a significant ongoing task. However, as it is now, the current web page appears to be tailored for importers and exporters and it is unclear how useful it is for those managing native ecosystem weeds.[69] For example, there is currently no single website that can give a list of all species that are legally declared pests by regional councils across the country. This means that interested stakeholders, such as researchers and those in the nursery industry, have to consult the MPI website plus search through pest management plans in each region to get a national view.

MPI used to maintain an online database (called 'Biosecurity activity and performance data'), where users could find which pest plants and animals were managed across all regional pest management strategies. However, this database was decommissioned several years ago due to it using an outdated platform that was expensive to maintain and difficult to update.[70] Given that RPMPs are in place for at least ten years, it does not seem too onerous to maintain such a database at a national level as part of MPI's overall leadership. Further consideration needs to be given to reinstating something similar that details all relevant plant work that regional councils are doing.

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[67] http://www.iucngisd.org/gisd/100_worst.php

[68] MPI, 2020b.

[69] See https://pierpestregister.mpi.govt.nz/. MPI staff plan to expand this register by incorporating the PBI and New Zealand Organisms Register (including consistent naming conventions) and providing links to other websites and databases such as GBIF (MPI staff, pers. comm., 28 September 2021).

[70] Dawson, 2020.

As might be expected from the issues identified above, **duplication of effort** is also occurring. For example, MWLR and the New Zealand Plant Conservation Network maintain separate flora databases.[71]

Many of the existing databases are **poorly funded and maintained**. Beyond the initial development, the ongoing curation of databases is often under-resourced or ad hoc, left to passionate individuals rather than formally supported and adequately funded.[72] Essential databases need better support to guarantee ongoing maintenance, coordination and accessibility of data without undue replication.

Currently, **no comprehensive, constantly updated database of information to manage exotic plants exists**. Several attempts have been made to create a dedicated database for exotic plants. In 2010, MWLR undertook a scoping study for a National Weeds Distribution Database; however, this initiative did not proceed due to a lack of coordination and funding.[73]

Exotic plant research and management in New Zealand would be improved by aggregating the data from various councils and agencies, such as DOC and MPI into an appropriate database that is regularly maintained and updated. This includes data on where each species occurs, what impacts they are having or could have, and how they are being controlled. Better connectivity would provide a step-change in accurately informing policymakers and land managers about where plants of concern are and how fast they are spreading around the country.[74] It would also allow for better national oversight and assessment of how well regional pest managements are aligned and coordinated.

Naming issues hinder information flow

Central to any coordination of information about exotic plants in New Zealand is an authoritative and definitive up-to-date list of species. This will ensure that everyone involved – whether they are collecting information, maintaining various datasets, or making risk assessments and management decisions – is clear which plant species they are talking about. This naming authority is a cornerstone of any biological information system and vital for regulatory clarity.

Pulling together information held in existing databases and resources about exotic plants in New Zealand is difficult because many plant species are not consistently named.[75] To extract as much information as possible it is essential that people are clear about what plant is being discussed. Common names such as blackberry or banana passionfruit can refer to multiple species. In addition, as any grower will attest, there can be many varieties or subspecies of any single species of plant (Figure 4.7).

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[71] Dawson, 2020.

[72] For example, Dawson states that ongoing resourcing for support, maintenance and enhancement of the New Zealand Organisms Register is challenging (see Dawson, 2020, p.38). Weedbusters is an example of a database established but now not maintained.

[73] MWLR staff, pers. comm., 27 July 2020. Cooper et al.'s (2010) scoping study indicates there is significant interest in establishing a National Weeds Distribution Database. Participants in the study could see several 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; and helping identify national priorities for coordinated action.

[74] See Hutchison et al. (2021, pp.49–50).

[75] Dawson, 2020.

Source: Clockwise from top: jessica, iNaturalist; Ron Brasher, iNaturalist; Ainafarhanah, iNaturalist

Figure 4.7: Copperleaf (*Acalypha wilkesiana*) was first documented growing in the wild in New Zealand in 2009 and illustrates the wide variety of plant forms, even within a single species.

Even Latin binomial names are prone to change as the understanding of taxonomic relationships improves. For example, Asiatic knotweed has been referred to by three different scientific names. Taxonomists working from specimens in the eighteenth and nineteenth centuries independently named it *Reynoutria japonica* and *Polygonum cuspidatum*, respectively, but these were later found to be the same species.[76] Early descriptions of Asiatic knotweed in New Zealand used these names but further research led to the plant being renamed *Fallopia japonica*, which is the currently accepted name for the species in the New Zealand Organisms Register.[77] Most New Zealand databases and current RPMPs list the species as *Fallopia japonica*. However, it is listed as *Reynoutria japonica* in the *Greater Wellington Regional Pest Management Plan 2019–2039*, demonstrating the potential for confusion when comparing which species are managed across different parts of the biosecurity system.[78]

Name changes as a result of research are not uncommon. When that happens, there needs to be an authoritative source of guidance on which name is being used in order to clearly communicate what is known, or needs to be known, about the plant's characteristics. Any database of exotic plants needs to be able to cope with name changes and synonyms – including multiple common names in English and Māori – so it can reliably link to other sources of information.[79] International databases regularly update their lists of accepted species names.[80]

There is a clear and pressing need for an authoritative list of names for exotic plant species present in New Zealand. This list needs to be regularly updated and informed by the various other plant databases, checklists and herbaria records. It can then be used by planners, researchers and regulators alike to ensure consistency and minimise confusion.

Patchy surveillance hampers efforts to manage exotic plants

Considerable efforts are made to stop new species arriving in New Zealand. New Zealanders and overseas visitors cannot help but be aware of the essential role border biosecurity plays. To help keep various organisms, including new exotic plant species, out of New Zealand, MPI focuses on pre-border and border measures. In addition, MPI operates a surveillance programme for a broad range of organisms. It is focused on high-risk areas and designed to quickly spot any new organisms that arrive in the country and prevent them from becoming self-sustaining in the wild.

However, for the tens of thousands of exotic plant species already here, surveillance is typically less systematic. MPI's involvement is limited, with surveillance left to other organisations such as DOC and regional councils.

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[76] Beerling et al., 1994.

[77] Beerling et al., 1994. See also http://www.nzor.org.nz/names/1dbf3b45-1b22-4283-b963-fb4a32c5ba8b [accessed 19 September 2021]. *Fallopia japonica* is also the currently accepted name in the Integrated Taxonomic Information System (https://www.itis.gov/ [accessed 19 September 2021]).

[78] Greater Wellington Regional Council, 2019. Fallopia japonica is listed as the accepted name by Ngā Tipu o Aotearoa – the New Zealand Plant Names Database, New Zealand Plant Conservation Network and Weedbusters and is used in Auckland, Bay of Plenty, Canterbury, Horizons, Northland, Otago, Southland, Tasman-Nelson, Waikato and West Coast RPMPs.

[79] See Heenan et al. (2021) for the importance of having te reo Māori and botanical nomenclature as complementary naming systems for New Zealand's flora.

[80] For example, GBIF continually updates its list of accepted species names; it currently considers *Reynoutria japonica* to be the accepted name for Asiatic knotweed but will link any search for *Fallopia japonica* to these records (https://www.gbif.org/ [accessed 11 May 2021]).

Overall, New Zealand's surveillance for exotic plants already present in the country is best described as fragmented, relying on passive surveillance and the investigation of chance discoveries rather than coordinated and systematic surveillance. As a result, it is likely that discovery of any new risks to native ecosystems will depend to a large measure on luck.[81]

As described earlier in this chapter, DOC's Tier 1 monitoring sites do not always overlap with key sites where exotic plant species thrive or where there is a high risk of invasion. The five-year (or ten-year) interval between resampling each plot and the large scale of the grid also means that the early invasion of many exotic plants will likely be missed, or their spread only detected when early-stage eradication from an area is no longer a viable management option for a given area.

Monitoring undertaken by regional councils around the country is also patchy. A few examples illustrate the point. A report concerning a range extension of pink ragwort (*Senecio glastifolius*) in the winter 2020 issue of New Zealand Biosecurity Institute magazine *Protect* illustrates just how serendipitous surveillance can be.[82] Pink ragwort has been spreading widely throughout the lower North Island but was thought to be currently restricted to just a few locations in the South Island.[83] The report noted that a Tasman District Council biosecurity officer noticed, by chance, some flowering plants in pots as he drove past a house in Golden Bay and investigated, since he knew the plant was all but absent from the region.[84] It turned out that pot plants, along with unwanted hitchhiking weeds, had been moved from Wellington along with the other possessions of the new occupiers of the house.

Another recent example is the detection of alligator weed (*Alternanthera philoxeroides*) in Manawatū. The plant has been in Northland for over a century, carried here from South America in the ballast of tall ships, and has slowly been spreading southwards. In late March 2020, it was discovered by chance in an entirely new place, far from any other known population, by a pest control officer from Taranaki Regional Council who happened to be walking past the Mangaone Stream in Palmerston North.[85] This newly discovered population is upstream of an internationally significant wetland – one of seven Ramsar sites in New Zealand.[86] The population was already well established, and considerable resources are now being diverted to try to eradicate it – including the dramatic approach of digging up a large part of the streambed.[87] It is unclear how successful this will be. Searches since the excavation have found significant new sites of alligator weed.[88]

Himalayan wineberry (*Rubus ellipticus*), described as one of the 'world's worst invasive alien species',[89] provides another example of what the absence of systematic monitoring to detect the spread of weeds to new sites means in practice. Himalayan wineberry was recently discovered in New Zealand, again by chance, in an Auckland reserve by two botanists (Figure 4.8).[90] They contacted MPI about the incursion in August 2019, after they had formally identified the plant.

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[81] A recent review of plant biosecurity science in New Zealand noted: "There is no active [plant] biosecurity surveillance or even condition-monitoring surveillance of our natural estate, so we rely on general surveillance to provide alerts to new problems" (Dyck and Hickling, 2021, p.16).

[82] Wright, 2020, p.9.

[83] Kriticos et al., 2018.

[84] This species is not in the Tasman-Nelson RPMP, but it is on the 2008 DOC environmental weeds list (Howell, 2008).

[85] Martin, 2020.

[86] The Convention on Wetlands of International Importance was signed in 1971 in Ramsar, Iran (https://www.ramsar.org/). As of early 2020, 171 countries had become signatories to the convention.

[87] Norman, 2021.

[88] Horizons Regional Council, 2021.

[89] GISD, 2021a.

[90] de Lange et al., 2019.

Almost exactly a year earlier, a contractor carrying out a vegetation survey had found the plant at the site and uploaded the finding to the iNaturalist website.[91] At the time of this first sighting there was some debate as to the correct identification of the plant, but the matter was not pursued. As a result, a year passed before MPI became aware of the incursion. Given the impact the species could have, as has been shown overseas, and the chances of eradication being crucially linked to early intervention, the loss of a year could be the difference between success and failure.

Source: Peter de Lange, iNaturalist

Figure 4.8: A close-up of one of the Himalayan wineberry (*Rubus ellipticus*) plants discovered growing in New Zealand for the first time in 2019. The plants were found by chance in an Auckland reserve. The thorns on mature vines are ferocious.

Even monitoring for high-profile species (e.g. wilding conifers) is patchy.[92] For example, an approximately 200-hectare plantation of Douglas fir (*Pseudotsuga menziesii*) on Maungatua near Dunedin airport was spotted by chance in 2014 by a retired botany professor from a nearby road.[93] It turned out that the plantation had been planted without a consent. After the issue was notified, work to remove them took several years.

While the detection of the new weed invasions in each of these examples is good news, the sightings were all essentially serendipitous. Someone with the right skills to notice the plant was in the right place at the right time and knew who to notify – but the person's presence was entirely coincidental. While it makes sense to use as many eyes as we can to detect new exotic plants, the general public needs support from formal systems that can digest and interpret reported sightings. If there is to be minimal delay between new detections and notification of or action by the agency responsible, there must be a comprehensive surveillance programme that employs both passive

[91] See https://inaturalist.nz/observations/15185681 [accessed 24 September 2021].

[92] Greene et al., 2020; Leonardo et al., 2020.

[93] Porteous, 2014b, a.

(serendipitous) and active (systematic) surveillance, with a process to rapidly respond to detections. For example, there should be regular scanning by MPI of iNaturalist for new possible incursions.[94] This is not currently undertaken. Remote sensing techniques could also be better integrated into surveillance and response programmes (see Box 4.3).

As it is now, new populations are often only spotted and reported once they are beyond the point where they might have been easily eradicated.[95] Recent incursion investigations by MPI have concluded that two 'new' exotic plant species – great willowherb and Himalayan wineberry – had in fact been in the country for several years.[96] While the outcome for each species' management is still unclear, what is certain is that earlier detection would have provided better odds of success at a lower cost.

Box 4.3: Remote sensing – a surveillance tool to detect plants from afar

Research has been undertaken on methods for detecting all kinds of plants – herbs, trees, shrubs, ferns and succulents – in many habitat types – forest, shrubland, grassland, agricultural land and wetlands – using remote sensing and computer-based processing of images.[97] Remote sensing employs some form of technology to capture images from a distance and computers can 'learn' to classify parts of those images as certain types of plants.

Being able to detect all kinds of plants in all habitat types remotely remains a work in progress. It is challenging to distinguish specific plants in more complex habitats, and certain types of plants are more difficult to detect, such as understory and small or young plants. But there have been recent successes with tackling these challenges – for example, the successful detection of understory trees in forests and pre-coning wilding conifers in New Zealand grasslands.[98]

A new tool for surveillance

In terms of weed invasions, remote sensing has mostly been used to detect dominant or spreading invaders (i.e. plants at later stages of the invasion process), but research over the last decade has looked into how remote sensing could be used to detect exotic plant species at earlier stages of invasion.[99]

Being able to distinguish a particular exotic plant depends on how distinct its spectral signature is from surrounding vegetation and from other plants that could be present in the area.[100] Any plant species with distinctive flowers, such as red-flowered pōhutukawa (*Metrosideros excelsa*) or yellow-flowered gorse (*Ulex europaeus*), is often easier to distinguish from the background vegetation – just as it would be for our eyes.[101] Plant species that look similar are harder to distinguish. For example, recent work by DOC found

[94] This task should be relatively simple. The website currently has a dedicated list of 'New Zealand discoveries' (https://www.inaturalist.org/projects/new-zealand-discoveries) that attempts to "draw together observations that are first wild records for New Zealand nationally, or regionally, or first wild records in a decade or more, nationally or regionally." Getting alerts from this list would appear to be a good first step.

[95] Watching out for the spread of high-profile weeds like wilding conifers is an exception, at least in some locations.

[96] MPI, 2018a, 2019.

[97] Vaz et al., 2018; Dash et al., 2019a.

[98] Perroy et al., 2017; Dash et al., 2019b; Greene et al., 2020.

[99] Vaz et al., 2018.

[100] Dash et al., 2019a.

[101] Kattenborn et al., 2020; Scion, 2020.

that wilding conifers as a group could be detected in the Mackenzie Basin, but there were not enough individuals of the different species to confirm that the approach could successfully distinguish between lodgepole pines (*Pinus contorta*) and other conifers.[102]

Careful planning is needed to implement remote sensing as a reliable surveillance tool. Different types of spectral imagery and spatial resolution will be useful in different contexts, depending on target plants and habitats and detection requirements. For example, detecting an understory exotic tree species with red-blue-green composite imagery from a drone requires at least ten per cent canopy openness, and detecting trees less than a metre tall requires flying at the minimum altitude just above the forest canopy.[103]

New Zealand researchers have put together a practical guide highlighting the best combination of platform, sensor, resolution and timing to achieve different detection objectives for wilding conifers.[104] This type of approach could be useful for many of the other weeds New Zealand confronts.

Positioning New Zealand to take advantage of growing improvements

New Zealand should be poised to take advantage of the technological improvements in the pipeline to use remote sensing for surveillance. Ongoing developments in sensors and airborne products will keep expanding possibilities and lowering costs, such as lighter-weight sensors of all spectral types and longer-lasting drone batteries.[105] Processing techniques for the vast quantities of data generated by remote sensing devices continues to improve, both in hardware capability and approaches to interpreting the data. Specific programming developments are also underway, including within the New Zealand research community.[106]

More could be done to employ available technologies to address some of our weed surveillance needs and to investigate how best to use and improve these technologies to support the New Zealand biosecurity system. There are several remote sensing data providers in New Zealand that provide a range of capability and services, and there is a research base that can be built on.[107]

This is particularly so in respect of wilding conifers and more general land cover across the country.[108] New Zealand should look to expand the use of remote sensing and automated processing to detect other weeds that pose risks to the integrity of native ecosystems.

There is also a need to explore how remote sensing can be most effectively integrated into weed surveillance programmes and into any mapping of weed distributions or land cover.[109] For example, remote sensing for wilding conifers is most cost effective for the control of scattered or sparse trees rather than dense stands.[110] Coordination of the many threads of current research in this area and close partnerships between researchers and practitioners would help make best use of these technologies.

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[102] Greene et al., 2020.

[103] Perroy et al., 2017.

[104] Leonardo et al., 2020, p.3, Table 1.

[105] Dash et al., 2019a.

[106] For example, a cloud-clearing method for satellite imagery (MWLR, 2020), employing 'deep learning' to interpret low-cost aerial imagery (Scion, 2020, 2021) and automated surveillance of aquatic weeds (NIWA, 2021).

[107] Leonardo et al., 2020, p.4, Table 2.

[108] Several land-cover classes within the Land Cover Database indicate certain groups of exotic plant species based on the dominant vegetation within the pixel (e.g. "Gorse and/or Broom", "Deciduous Hardwoods"). See https://lris.scinfo.org.nz/document/22464-lcdb-v2-classes-illustratedpdf/.

[109] For example, Sheffield and Dugdale (2020) propose a framework for incorporating automated detection processes with remote sensing into biosecurity programmes.

[110] Greene et al., 2020.

A lack of appropriate expertise to gather and coordinate information

The need to collect better information about exotic plants and manage that information appropriately requires specific skills, but the necessary expertise is limited. There are not enough skilled taxonomists and botanists to collect, collate and manage information about exotic plants. The 'taxonomic impediment' has been recognised as one of four priority areas for pest management:

> "The ability to detect and evaluate invasion risks is compromised by a growing deficit in taxonomic expertise, which cannot be adequately compensated by new molecular technologies alone. Management of biosecurity risks will become increasingly challenging unless academia, industry, and governments train and employ new personnel in taxonomy and systematics."[111]

Surveillance and monitoring generate critical information needed to manage weeds. At its core this work requires an adequate number of skilled field staff who can correctly identify exotic and native plant species and assess the risks that exotic plants pose – "while citizen science initiatives such as iNaturalist can provide useful support, they cannot substitute for this core professional expertise".[112] Many regional councils have a small number of biosecurity and biodiversity staff.[113] These skill sets need constant updating as new exotic plants escape and spread around the country (Figure 4.9).

Source: Alan Melville, iNaturalist

Figure 4.9: Alpine daisy bush (*Olearia phlogopappa*) was first documented growing in the wild in New Zealand in 2007. Given there are 41 native species of *Olearia* in New Zealand including some that look similar, this exotic plant may be harder to detect if it naturalises and begins to spread to new locations.

[111] Ricciardi et al., 2021, p.119.

[112] Wright et al., 2020, p.75. See also McKinley et al. (2017).

[113] For example, Chatham Islands, West Coast, Gisborne, Tasman, Nelson, Marlborough, Hawke's Bay and Otago have fewer than ten biosecurity and biodiversity staff. By comparison, Auckland Council has 86 staff in its natural environment (biodiversity and biosecurity) teams. The survey was undertaken as part of the report prepared by Hutchison et al. (2021).

DOC has several specialist experts working on exotic plants – but many fewer than it had ten years ago. There are currently three dedicated weed scientists and five specialist weed technical advisors.[114] A major, department-wide restructure that began in 2012 has had significant implications for the way DOC operates, including how weeds are managed. Prior to 2012 there were 12 weed technical advisors, spread around conservancies, rather than the five employed today.[115]

The restructure also resulted in the loss of around 100 full-time equivalent staff in DOC's service and support functions (including some science and technical roles). With such large-scale changes, it is difficult to assess if the new structure is materially better than the old. Recent increases in DOC funding are encouraging, but increased funding does not immediately – or even necessarily – replace lost expertise.

Scientific capacity is also needed to help gather more information and better understand things like the ecological impacts of exotic plant species. This information is vital to better inform modelling of risk and prioritise which exotic plant species to actively manage, and where. Information management also requires expertise to design, implement and maintain databases, websites and associated material.

The 2021 *Plant Biosecurity Science in New Zealand* report examined the issues raised here, in a related though different biosecurity context, and concluded:

> "Does New Zealand have the right biosecurity science capability and infrastructure to avoid or mitigate the next serious biological incursion that would threaten New Zealand plants, either productive or natural? … the answer is a qualified 'No'."[116]

The report noted an attrition of exotic plant experts in the research community as they age and retire. A related issue of declining taxonomic expertise was noted as part of the stocktake of existing databases made for this investigation.[117] This is a concern, given the increasing pressure weeds are applying to Aotearoa's native ecosystems.

What might a good information system look like?

What information is needed?

Ideally the biological and ecological characteristics of each exotic plant species need to be understood – these are some of the key factors that will influence its potential to harm native ecosystems.

In addition, there needs to be an understanding of how far and fast each exotic plant species is spreading across New Zealand. This information needs to be regularly updated as spread will entail different management responses in different places. For example, an exotic plant species that is widespread in the North Island should trigger very different management responses in the South Island if a population is found for the first time.

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[114] Many other staff also work on exotic plants to some degree, as part of their wider roles.

[115] DOC staff, pers. comm., 21 September 2021.

[116] Dyck and Hickling, 2021, p.11.

[117] Dawson, 2020.

Other information that supports management decisions is also needed, such as information that helps assess the threat the exotic plant species poses to our native ecosystems and the feasibility of controlling it.

For any exotic plant species, the following questions should be answered.[118]

- **Exactly what species is it?**

  What is its taxonomy? How is it related to other plant species both native and exotic to New Zealand?

- **How does it grow?**

  Is it a tree or a grass? Can it tolerate shade? Does it fix atmospheric nitrogen? Does it associate with mycorrhizae in the soil? How does it respond to fire?

- **How does it reproduce?**

  Does it reproduce vegetatively, sexually or both? Is it reproducing in New Zealand? How often and how many viable seeds can it produce?

- **How does it disperse?**

  Does it disperse by wind, water, birds or humans, and how far?

- **What are, or could be, its impacts in New Zealand?**

  How do the plant's attributes (like flammability) affect the ecosystems it invades? What are its observed impacts in New Zealand and overseas? What are the impacts of plants that are closely related (or have similar traits)?

- **Where is it located? What is its stage of invasion?**

  Is it growing in the wild or naturalised? Is it localised or widespread? Where was it looked for (including where it was looked for but not found)? Where is the species cultivated and in what quantities? Having this information at national and sub-national levels – including political regions or areas with defensible geography, like islands – and at a series of points in time would provide the most useful picture of the plant's invasion progress.

- **How can it be controlled?**

  What methods of control work now or could be on the horizon? What are their costs, pros and cons?

- **Where has it been managed before? Where is it being managed now?**

  What records are available of the current and past management actions taken for the species, where and by whom (e.g. which agencies in the biosecurity system or which community groups or trusts)? Documenting the purpose of management, including the intended outcome for the integrity of native ecosystems, is also important.

[118] This list is based on the kinds of information provided by the Global Invasive Species Database and the CABI Invasive Species Compendium and used in the Australian Weed Risk Assessment protocol (Pheloung et al., 1999; DAWE, 2019).

Who should pay to collect and coordinate this information?

Diversification of funding sources could enhance the security of funding arrangements and make the system more resilient. This could be achieved through greater use of the 'beneficiary pays' principle, which would ensure those organisations that benefit from a particular dataset contribute to the cost of provision (e.g. the establishment and maintenance of monitoring networks). While such an arrangement could be considered more equitable from a distributional perspective, it may also act to strengthen funding arrangements by reducing the burden placed on any single data provider. Co-funding arrangements would allow multiple providers to derive benefits from a dataset while contributing towards a commensurate share of the cost.

Since information on exotic plants and native ecosystems has both local, regional and national benefits, one suggestion could be that central and local government as well as individual landowners and industry should contribute to the cost of information-gathering initiatives and the cost of standardising data collection practices to ensure consistency. While the exact split of contributions should be determined on a case-by-case basis, effort needs to be made to diversify funding sources and reduce the burden on any single funder.

How should this information be managed?

Ideally, such information about exotic plant species would be housed in a robust system that is appropriately designed, adequately resourced, accessible and coordinated. This information system is needed to enable managers to interrogate and cross-reference all relevant sources in order to respond swiftly when managing weeds.

An accessible information system along these lines would improve transparency and accountability for decisions about managing, or not managing, exotic plant species.[119] Stakeholders will be able to better understand the evidential basis on which various decisions have been made. It will also highlight where knowledge has increased or where gaps in our knowledge remain.

National oversight and coordination are essential for two fundamental reasons:

1. Most information about exotic plant species – including their ecology, impacts, rate of spread and successful methods of control – is of value to anyone in New Zealand who is seeking to manage these plants.
2. Exotic plants do not recognise administrative boundaries, so actions taken by one agency, region or individual often have implications for others and can benefit the entire country.

Ideally, New Zealand's information system for exotic plant species needs to be able to link with major global online resources such as GBIF, the Centre for Agriculture and Biosciences International (CABI) Invasive Species Compendium and the Global Invasive Species Database.[120] But it is also important that it is appropriately tailored to suit New Zealand's needs. A model for this could come from the Atlas of Living Australia, which is a "collaborative, digital, open infrastructure that pulls together Australian biodiversity data from multiple sources, making it accessible and reusable." It helps to "create a more detailed picture of Australia's biodiversity for scientists, policy makers, environmental planners and land managers, industry and the general public, and enables them to work more efficiently."[121]

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[119] This data for exotic plant species may well be best placed within a wider pest or threat data management system, possibly linked to other biophysical data such as information about native biodiversity.

[120] See https://www.cabi.org/isc/ and http://www.iucngisd.org/gisd/.

[121] See https://www.ala.org.au/about-ala/ [accessed 24 September 2021].

Importantly, any such system should seek to include information on *all* exotic plant species growing wild in New Zealand – not just those already known to harm the integrity of native ecosystems.

Tackling invaders early is not only cost effective, it also offers the best chance of eradicating them or even cost-effectively controlling them. **It is a somewhat chilling fact that there is no record in New Zealand of any terrestrial plant having been successfully eradicated when the extent of spread has been greater than one hectare**.[122] We need an information system that can assist us to better detect and respond to newly naturalised species or those just beginning to spread. An uncertain or slow-moving response will see weeds get beyond the point where eradication is a realistic outcome.

The same need for high-quality information applies even to the most common and widespread exotic plant species. Being clear about the risks being taken can provide a good basis for evaluating the outcomes of current management decisions and adapting and improving on them going forward. That includes being in a position to know when to walk away – or change tack – so that efforts are not locked into trying to manage things inappropriately. High-quality information management extends to keeping track of past assessments and management actions and outcomes so they can be built on rather than forgotten. Most importantly, New Zealand needs the expertise and interdisciplinary skills to assemble and interpret the information needed to manage exotic plants well.

[122] This is discussed further in chapter five.

5

Pistia stratiotes

Prioritisation to guide management of native ecosystem weeds

That many exotic plant species pose significant risks to many native ecosystems is beyond dispute. Even the most widespread and long-established of these native ecosystem weeds still have the potential to spread further and cause more harm. They are being joined by newcomers each year as more exotic plants escape cultivation to join the fray. A biosecurity system needs to stop new species arriving on our shores *and* minimise the harm from those that are already here. A key question is whether our resources are allocated in a way that will do a good job of both tasks.

It is clearly not possible to remove every individual exotic plant growing in the wild today or to immediately stop their spread to new areas. There are neither the resources nor the technical capacity to do so.[1] In any case, as far as we know, many exotic plant species have only minor impacts on some native ecosystems. So the key questions that pose themselves are:

- Which exotic plants are most demanding of our attention now?
- Are sensible strategic choices being made about how resources are spent?
- Are today's choices being taken with sufficient regard for future challenges?

Essentially, decisions need to be made about *which* exotic plants to manage first, *where* they are to be managed and *how* they are to be managed, including by *whom*. To do so strategically, a robust and transparent prioritisation process is required – elements of which are discussed below.

[1] Even if there were adequate resources, some sort of process will still be required to manage conflicts as some of the very same exotic plant species that invade native ecosystems are also highly valued in other contexts.

What are the features of a robust prioritisation process?

Clarity of purpose

Any prioritisation process needs to be able to support those working towards a set of overarching goals for native ecosystems. While prescribing any such goal is beyond the scope of this report, in general terms it could be something along the lines of managing exotic plant species in a way that keeps the level of risk they collectively pose to the integrity of Aotearoa's native ecosystems below an acceptable level.[2]

There will likely never be unanimous agreement about exactly what such a goal should be or what the priority actions would be to move towards it.[3] But whatever the choices that are made, they need to have a clear purpose as to what they are trying to achieve, as well as what levels of risk are deemed acceptable. Ideally, these will be ecologically sound and clearly linked to specific measures of both risk and ecosystem integrity.

At its simplest, prioritisation needs to be based on the risk that exotic plants pose, which is a function of the invasion process and their potential harm to native ecosystems. Most importantly, prioritisation needs to be informed by available evidence and acknowledge, but not be hamstrung by, uncertainty.

Transparent

The prioritisation process needs to be transparent in terms of the rationale (why the process was structured this way), the process followed, and the reporting of the resulting decisions, including what information was relied upon. Decisions, and the basis for them, need to be documented and clearly communicated. This applies as much to decisions *not* to intervene as it does decisions to act. In the context of any regulations, high standards of transparency are important for a number of reasons. Those affected by regulations have a right to understand the basis on which the regulations were made. If landowners are required to control certain plants, they need to know why.

Further, a transparent prioritisation process is one that people can learn from. Given that the process of prioritising native ecosystem weeds is an iterative process that needs to be repeated as new risks emerge and control efforts are reviewed, transparency ensures that the process itself adds to the understanding of everyone involved in controlling these weeds.[4]

Flexible and adaptive

Any management strategy for exotic plants needs to remain flexible and adaptive. Regular monitoring and review are important components of the system so that past actions can be evaluated, new information can be incorporated, and progress towards stated goals can be assessed.

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[2] There would need to be recognition that this risk is not zero and never will be.

[3] As described in chapter one, not everyone thinks about exotic plants in the same way, so agreeing on which plants to manage, where and how is not always straightforward.

[4] Results of a robust prioritisation process are repeatable, and making that process transparent enables other decision makers to use that information in their own processes (McGeoch et al., 2016).

An evidence-based process

Prioritising weed control actions specifically to benefit native ecosystems is not easy. The process requires consideration of many factors, including:

- The risks that a given weed poses to a given native ecosystem, including its impact on mauri. At its simplest, this risk includes how likely it is that the weed can invade a given location and harm the ecosystems that are there. The following factors need to be considered:
    - the stage in the invasion process and potential for spread, including the speed at which it does so
    - the biophysical attributes of the site of focus and its surrounding landscape or region and how these are changing over time
    - the harm that the weed is causing or will cause to these ecosystems.
- Any other threats the ecosystem faces, how they are being managed and what implications these other factors might have for weed management. For example, removing weeds at a site may not improve the condition of an ecosystem if herbivores are still present as they may eat any new native plant seedlings that do emerge.
- The feasibility and sustainability of control, including the available options for control of any given weed species, how long they will take and, crucially, what will happen once the plants are removed. Removing certain plants can often create what's known as a 'weed-shaped hole', leaving space for other plants to move in.

The prioritisation process will therefore combine an assessment of the risk an exotic plant species poses to native ecosystems (i.e. which species to manage and where) with an assessment of the ability for available management options to minimise that risk (i.e. an assessment of feasibility).[5] It should draw on available evidence and clearly cite the evidence considered – particularly where different sources may be conflicting or the information may be anecdotal. It should also explicitly define the spatial scale or area of interest – national and local-scale priorities could reasonably differ. Existing formalised weed risk assessment tools could be adopted and refined to apply to the scope of the decisions being made, such as nationwide assessment or assessment of harm to specific ecosystems. Several such tools have been developed overseas and within New Zealand, though not all have been tested to evaluate how well they perform.[6]

Importantly, consideration must extend to both the weed species and the native ecosystems at risk. For example, a weed that poses a risk to high-value and threatened ecosystems should be considered higher priority in these ecosystems than a plant with the same characteristics that does not grow in a threatened ecosystem. More than 63 per cent of naturally uncommon ecosystems in New Zealand are threatened, including wetlands, alpine areas and coastal habitats.[7] It would therefore make sense to prioritise control of even widespread and largely overlooked exotic plant species, such as browntop (*Agrostis capillaris*), in some areas, specifically to protect these ecosystems when the species is not usually controlled anywhere else.

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[5] McGeoch et al., 2016.

[6] For example, the Australian Weed Risk Assessment protocol has been tested for exotic conifers introduced to New Zealand (Pheloung et al., 1999; McGregor et al., 2012; DAWE, 2019). Some of the prioritisation approaches used in New Zealand are discussed further in chapter seven.

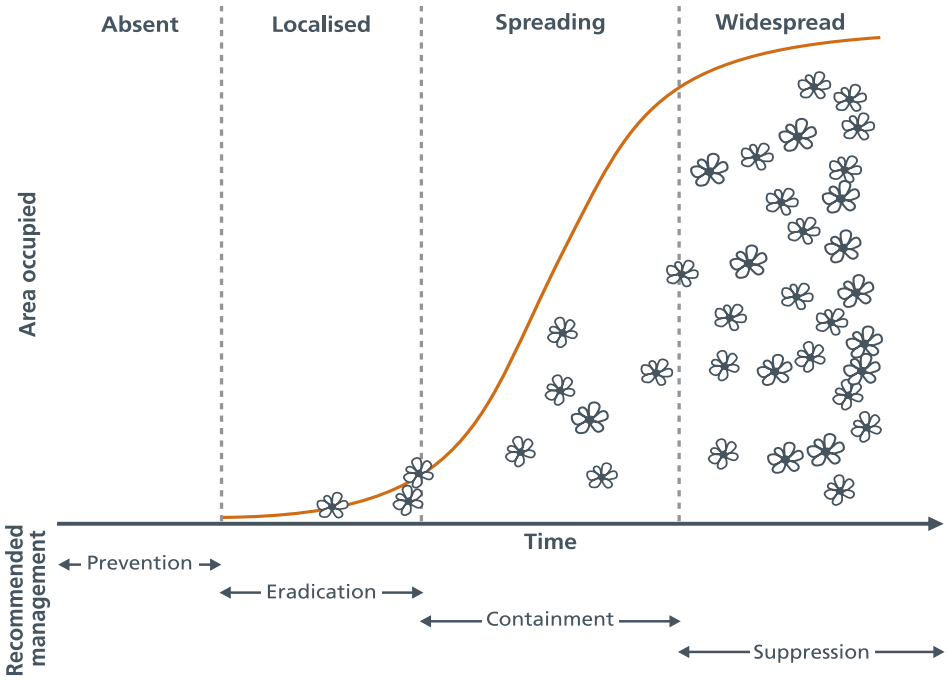
[7] Naturally uncommon ecosystems are those with an extent less than 0.5% of New Zealand's total land area. Forty-five of 71 naturally uncommon ecosystems are considered Vulnerable, Endangered or Critically Endangered (DOC, 2020c).

A complementary approach to selecting high-priority sites for management could also be used. In addition to protecting ecosystems vulnerable to the impact of plant invasion, sites that are most likely to be invaded because they are highly disturbed or near human settlement, such as roadsides, might be prioritised for surveillance and early intervention.[8]

Which management approach to take?

Deciding which management approach to take for high-priority weeds (i.e. where and how to manage) depends both on what is needed to reduce the risk they pose – for example, removing a weed from the ecosystem completely or just reducing its density – and on the effort that would be required to control it to that degree.[9] Both of these factors are influenced by where in the invasion process the weed is – is it still absent from the places at risk, or is it already widespread?

Directly tying the management approach to where in the invasion process the weed has progressed to (i.e. to its position along an invasion curve) could be a simple initial guideline (Figure 5.1).[10] This will be most useful when applying the weed's position along the invasion curve for the specific area of interest for management. A national-level management decision would rely on the nationwide status of the weed, while a decision on how to manage a weed in a particular ecosystem would in the first instance rely on the weed's absence or presence in that ecosystem as well as its occurrence in the wider landscape.



Source: PCE

Figure 5.1: A guideline that links management approaches to an exotic plant species' position along the invasion curve.

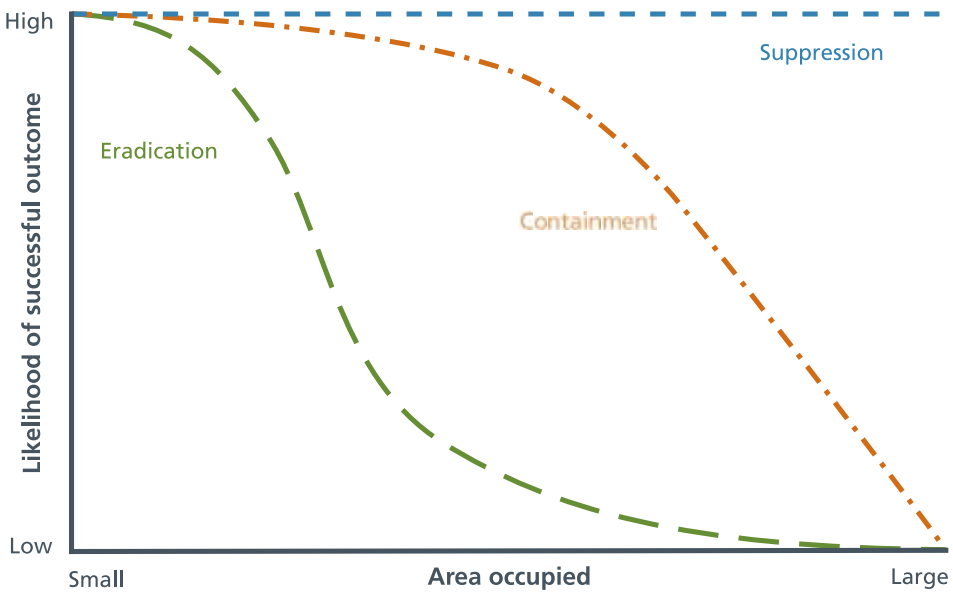
[8] Sites both 'sensitive' and 'susceptible' to exotic plant invasion should be prioritised to mitigate risk (McGeoch et al., 2016). Roadsides in New Zealand tend to accumulate exotic plants from other habitats so could be a useful target for surveillance (Aikio et al., 2012).

[9] Robertson et al., 2020.

[10] A variety of terms are used to refer to management approaches for exotic plants at different stages of invasion. Some examples are listed in Robertson et al. (2020, p.2636, Table 1).

For example, **eradication** – removing the entire population from the area of interest – is often feasible only when the infestation is represented by a small number of plants within a clearly defined and limited area.[11] Box 5.1 provides more details on what it takes to eradicate an exotic plant. Once the species has begun spreading or is widespread, **containment** or **suppression** is more likely to be the selected management option. Containment involves limiting the spread of a reproducing population; suppression reduces the distribution or abundance of a population within the area of interest.[12]

However, a more nuanced approach is called for (Figure 5.2). Long-established, abundant weeds that cause serious harm to ecosystems can still demand high priority and merit the concerted and persistent effort required to achieve eradication, at least in high-value sites. Conversely, the suppression of weeds that are still spreading but cause harm to few ecosystems could be sufficient to limit their likelihood of invading the ecosystems they threaten.



Source: PCE

Figure 5.2: Area occupied by a weed has a major bearing on the choice of management options. For instance, successful eradication is more likely for weeds only occupying small areas but may still be justified for a more widespread weed if it is known to be causing considerable harm.

[11] Definition of eradication from Robertson et al. (2020, p.2638, Figure 1).

[12] Definitions from Robertson et al. (2020, p.2638, Figure 1).

In general terms, the approach taken to managing an exotic plant species will tend to be based on how widespread it is or could become.

- For any species absent from an area, preventing its entry will be the most effective management strategy, centred on surveillance and restricting pathways for invasion. High-priority weeds might include those with high potential to spread to the area, such as those growing in adjacent ecosystems or regions. Weeds that are especially difficult to control – or lack any effective control method that can be used in New Zealand – might also be high priority for prevention.
- Eradication is more likely for localised exotic plants, especially as a precautionary approach to early-stage invaders with unknown impacts. However, eradication may be considered for weeds with larger populations, especially if their harm to high-value sites is considered unacceptable.
- Containment, which includes slowing spread and restricting populations to areas where the weed has low impact, is more likely for weeds that are spreading. Containment may also be considered for more localised weeds that, for example, cannot be eradicated due to being present in the surrounding landscape, or for widespread weeds that pose large risks to particular native ecosystems.
- Suppression is most likely for widespread weeds but may be considered for spreading weeds with low potential to invade or harm native ecosystems if, for example, they are kept below certain densities or prevented from reproducing.

Geographic barriers can play a key role when determining a more nuanced management approach, especially with regard to its feasibility. For example, Cook Strait is a natural barrier between the North Island and South Island, and thus a justifiable boundary for sub-national eradication programmes, as was the case with hornwort (*Ceratophyllum demersum*; see Box 5.1). Using such barriers may require greater coordination among organisations tasked with exotic plant management – for example, across multiple political regions or between the Department of Conservation (DOC) and a regional council – because these barriers may not align with political boundaries.

Box 5.1: What does it take to eradicate an exotic plant species?

Ingredients for successful eradication

Eradicating exotic plants once they are naturalised is often incredibly difficult. It involves preventing new pathways of incursion and any reinvasion by removing new populations of weeds faster than they can spread. Preventing reinvasion requires sustained effort over time to ensure complete removal of seeds from the seedbank or other methods of reproduction.

In practice, eradication successes are so rare that it is difficult to identify any recurring pattern that provides clues about what it takes to succeed. Biological aspects of the exotic plant species, such as how long its seeds remain viable in the ground, and characteristics of the invasion, such as its extent and duration, are important but may not play as much of a role in eradication as coordinated and sustained efforts.[13] For example, though successful eradications to date have been limited to those instances where the target plant has only occupied a small area (most likely less than a hectare), even very localised infestations pose enormous challenges.[14] A single missed plant or seed can cause a setback. Studies have reported examples where follow-up monitoring was skipped for a year or two and weed populations re-asserted themselves.[15] Sustained support for long-term management programmes – including being prepared to sustain resourcing over decades, having engaged stakeholder communities, and planning to deal with possible reinvasion – is essential for eradication to be successful.[16] Eradication does not mean walking away and forgetting once the initial operation is complete.

How many exotic plants have we eradicated from New Zealand?

To date, 11 exotic plant species are believed to have been eradicated from the whole of New Zealand.[17] Efforts to eradicate these plants were led by different organisations, including the Ministry of Agriculture and Fisheries, the National Institute of Water and Atmospheric Research and regional councils.

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[13] Howell, 2012; Hulme, 2020.

[14] The four successful eradications from DOC management areas were less than 1 ha in extent, but several infestations of similar size were not cleared (Howell, 2012). Aquatic weeds that have been successfully eradicated from the whole of New Zealand were much less than 1 ha in extent, except annual wild rice (*Zizania palustris*), which was estimated to have been 1 ha (NIWA staff, pers. comm., 19 April 2021).

[15] Twenty-five of 111 DOC eradication programmes from 1998/1999 to 2007/2008 found reinvasion of exotic plant infestations that had been declared cleared; 97% of these happened within the first three years after clearing an infestation. At the same time, progress of the eradication programme (i.e. proportion of infestations cleared each year) increased with the visitation rate of infestations (Howell, 2012).

[16] Hulme, 2020.

[17] Howell and Sawyer, 2006; Champion, 2018; Hulme, 2020. They are creeping knapweed (*Acroptilon repens*), flowering rush (*Butomus umbellatus*), skeleton weed (*Chondrilla juncea*), Brazilian water hyacinth (*Eichhornia paniculata*), bogbean (*Menyanthes trifoliata*), fringed water lily (*Nymphoides peltata*), Taurean thistle (*Onopordum tauricum*), water lettuce (*Pistia stratiotes*), clasped pondweed (*Potamogeton perfoliatus*), great reedmace (*Typha latifolia*) and annual wild rice (Hulme, 2020).

Some weeds have also been successfully eradicated from a part of New Zealand, most notably hornwort, which was eradicated from the South Island under the Ministry for Primary Industries' (MPI's) National Interest Pest Response (NIPR) programme.[18] On a smaller spatial scale, four weeds were successfully cleared from specific areas managed by DOC during their eradication programmes that ran from 1998 to 2008.[19]

This very limited success has not stopped MPI naming a further eight exotic plant species for nationwide eradication in its NIPR programme (described in more detail in chapter seven) and regional councils listing 102 exotic plants for eradication.[20]

How do we know these plants have been eradicated?

Because the seeds of many plants can remain viable for years (decades in the case of gorse (*Ulex europaeus*)), follow-up surveillance is needed to control any re-emergence from the plant's seedbank. The 11 plant species cited were only declared eradicated from the whole of New Zealand after five years of annual inspections found no new plants.[21]

Most NIPR programme plants undergo a ten-year monitoring phase before being declared eradicated from New Zealand. When eradication is attempted for only a part of New Zealand (e.g. an island or a natural reserve), surveillance for reinvasion needs to be ongoing and, where possible, pathways of spread actively managed to prevent reinvasion. Cleaning aquatic gear is essential to stopping the spread of hornwort from the North Island back to the South Island.[22] Reinvasions of weeds cleared during DOC's eradication programmes from 1998 to 2008 usually occurred within three years. Four eradication programmes were discontinued when reinvasion from neighbouring uncontrolled areas could not be avoided.[23]

Even when no new exotic plants have been seen in the wild for many years, source populations of the plants may still be present in cultivation (i.e. in gardens or ornamental ponds). For example, as described in chapter four, water lettuce (*Pistia stratiotes*) was found in pots on a Northland property in late 2020 and cleared by MPI.[24] The species had twice been considered eradicated before this, showing just how necessary ongoing vigilance is.

[18] Champion, 2018; Hulme, 2020.

[19] The four successfully cleared infestations were hornwort from Motueka, climbing spindle berry (*Celastrus orbiculatus*) in the Ruapehu district, common cordgrass (*Spartina anglica*) in South Marlborough and old man's beard (*Clematis vitalba*) in the Waikato. At the end of the study period, the Waikato area had just been declared clear of old man's beard and the other three areas had remained clear of infestation for at least three years (Howell, 2012).

[20] Hutchison et al., 2021, p.11, Table 6.

[21] Howell and Sawyer, 2006; NIWA staff, pers. comm., 19 April 2021.

[22] NIWA, no date a.

[23] Howell, 2012.

[24] Bleach, 2021, p.39.

How to balance current harm with future risks?

Any prioritisation process needs to weigh up the case for tackling weeds that have not yet invaded native ecosystems but pose a risk to them versus dealing with those that are already present and known to be causing harm. It may not always be possible to do both, so having a process that clarifies what is being done and why will help.

From a precautionary point of view, there is good sense in preventing further invasions and eradicating localised invaders where possible. Early action to eradicate is much more cost effective than the 'constant gardening' that comes with weeds that become widespread.[25] But making the decision to attempt eradication, rather than containment or suppression of a weed, is not one to be taken lightly. There needs to be a good chance of success and it must be backed with the resources needed to make it a success. Otherwise, there is a risk that a failure to eradicate gives way to ongoing control after a considerable waste of time and effort.

Knowing how much effort to put into the numerous exotic plant species that are at different stages of invasion in different ecosystems around the country is always going to be difficult. A prioritisation process using risk assessment approaches could better inform trade-offs between managing weeds early versus later in the invasion process. One approach to assess future risk could be to target exotic plant species that are growing in the wild but have not yet naturalised on account of the current climate, especially species that are known to be native ecosystem weeds overseas. Few studies to date, however, have projected the potential distribution of currently localised exotic plants under future climate scenarios.[26] Another approach could be to target recently naturalised plants currently found in only one region. A first step might be to evaluate species naturalised within the past 50 years that have already undergone some type of risk assessment.[27]

Trade-offs are inevitable

As outlined above, trade-offs are inevitable given the many threats facing native ecosystems now and in the future. For example, if eradicating all weeds from a particular site was necessary to protect the site's ecosystem integrity, but the cost of doing so would consume the entire regional budget for pest control, weed control at that site might be considered unfeasible. The trade-off might be considered too high if all other exotic plant risks in the region would be left unaddressed.

But if a high risk to native ecosystems from weed invasion is being accepted because it is not considered feasible to address that risk, the decision to do so must be transparent. Deciding to leave an exotic plant alone because it poses a low risk to native ecosystems is one thing – but failing to control it because managers do not have the tools or resources needed to do so is another.

This distinction will enable appropriate trade-offs to be made with current decisions. If weed control at a particular site is considered unfeasible, region-wide planning could endeavour to protect the same ecosystem type in a different location. Using a clear, transparent and evidence-based process to decide *which* weeds to manage *where* and *how*, enables decision makers to identify what obstacles limit addressing the highest-priority risks to native ecosystems, and to then try to overcome those obstacles before the next regular reassessment of priorities.

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[25] Harris and Timmins, 2009.

[26] Hulme, 2020.

[27] Hulme, 2020.

Part of this process should include asking: Which exotic plant species or native ecosystem risks from invasion might benefit from *national* coordination of management? In other words, is the spatial scale of focus appropriate for the weed or ecosystem risk being considered? If everyone in New Zealand benefits from the eradication of a new exotic plant incursion, then it makes sense for these types of responses to be coordinated centrally and avoid the financial burden of control being placed on a single regional or local organisation. Similarly, strategies to keep a weed in the North Island from spreading to the South Island is of wider benefit than to a single region.

The following two chapters consider what current laws have to say about the way weed management is prioritised and what actually occurs in practice.

6

Archontophoenix cunninghamiana

How are exotic plants regulated?

The management of exotic plants in New Zealand is a reflection of the biosecurity rules we have created. These rules require several (sometimes competing) interests to be considered when undertaking control activities in relation to exotic plants – including production, human health and enjoyment, and the environment.

However, there is little guidance on how to weigh these competing interests or what weight if any should be given to the protection of native ecosystems. Neither is there clarity about how the biosecurity and biodiversity policy frameworks are supposed to relate to one another. But clarity is essential if we are to make effective interventions against troublesome plants.

This chapter explores the current regulatory context and the extent to which it can secure wider ecological goals as they relate to exotic plants. Chapter seven then focuses on roles and accountabilities to ascertain what does and does not work in practice.

A historical detour - how exotic plants came to be managed

European settlers saw some of the plants they brought with them becoming problems almost from the outset. This included plants that were accidentally introduced in contaminated seed, such as Scotch thistle (*Cirsium vulgare*), and those that were deliberately introduced for a purpose, such as gorse (*Ulex europaeus*) and Scotch broom (*Cytisus scoparius*) for hedging to contain livestock.[1] Exotic plants arguably prompted New Zealand's first environmental legislation, with provincial statutes passed as early as 1854 to combat exotic plants in various regions.[2]

[1] Missionary settlers in the Bay of Islands from 1815 were planting sweetbriar and barberry in their gardens, and then using furze (gorse) to form some living fences. The fencing was initially in part to prevent their animals straying into Māori plantations, an offence that attracted utu or rebalancing. These exotic plants became early garden escapees and then problematic weeds in Northland (Druett, 1983, p.64; Ballantyne, 2015, pp.66, 92–94).

[2] Provincial legislation included the Thistle Act 1854 (Wellington), the Scotch Thistle Ordinance 1856 (Taranaki), the Thistle Act 1857 (Auckland), the Furze Ordinance 1859 (Taranaki), the Thistle Act 1859 (Nelson), the Thistle Ordinance 1862 (Canterbury), the Thistle Act 1862 (Marlborough), the Thistle Prevention Ordinance 1862 (Otago) and the Thistle Ordinance 1862 (Southland).

Rather than encouraging any concerted action to control or eradicate exotic plants, these early legislative measures seem to have really been about providing landowners with a way to take action and recover costs from adjoining landowners whose exotic plants were imposing costs on them. In reality, action was likely to be limited to situations where exotic plants were a fire risk, blocked easy and safe passage along road or rail, or blocked waterways, causing flooding and erosions.[3] The economic burden of exotic plants was largely regarded as being incentive enough for landowners to keep them under control.[4]

By the late 19th century, the scale of the problem that had been unleashed was becoming apparent. Whole paddocks in Raglan County were observed in 1881 to be covered in gorse.[5] In *New Zealand Farmer*, June 1889, a South Canterbury correspondent described gorse as "a good servant but a tyrannous master", for gorse thrived in many parts of New Zealand and quickly got out of control.[6]

During the late 1880s there were unsuccessful attempts to introduce a national law to exterminate or control Californian thistle (*Cirsium arvense*). In 1891 the Minister of Agriculture sought a comprehensive approach to problem plants around the country.[7]

After eight years of repeated bill submissions and much debate, the New Zealand Government enacted the Noxious Weeds Act 1900, a national-level law relating to problem plants.[8] The Act's purpose was to "prevent the Spread of Noxious Weeds and enforce the Trimming of Hedges". While 'noxious' was not defined in the Act, some clue was provided by the plants listed within the schedules of the Act.[9] Three species were on the first schedule, listing noxious plants to be controlled nationwide: blackberry (*Rubus fruticosus*), Californian thistle (also called Canada thistle) and sweetbriar. A further six were listed on the second schedule, listing plants that a local authority could choose to declare noxious in their jurisdiction: Bathurst burr (*Xanthium spinosum*), Scotch broom, giant burdock (*Arctium majus*), gorse, hakea (*Hakea acicularis*) and ragwort or rag weed (*Jacobaea vulgaris*).[10] In each case it was the threat to agricultural production that caused a plant to find its way onto a schedule.[11]

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[3] See for example, the Public Works Act 1876, the Municipal Corporations Amendment Act 1880 and the Fencing Act 1881.

[4] Hulme, 2020.

[5] Hargreaves, 1965.

[6] Isern, 2007, p.179.

[7] A committee of 10 MPs canvassed landowner attitudes about exotic plants and reported back to the House that the problem had already reached drastic proportions, with thistle, gorse and briar (*Rosa rubiginosa*) overrunning the country and decreasing land values (Bagge, 2014).

[8] According to Hulme (2020), the Noxious Weed Act 1900 was the first legislation anywhere in the world to address the management of exotic plants. This Act was watered down from the original bill. The first eight versions of the bill were unsuccessful. Reasons for failure included some plants being viewed as problematic in some regions but not in others, the cost of eradication being seen as unnecessary in regions where the plants were not yet problematic, and the cost of eradication being seen as exorbitant in regions where exotic plants were already well-established. The final version listed only a few plants to be controlled nationwide, also using the word 'clear' instead of 'eradicate' or 'control'.

[9] Seed import advertisements from the late 1840s used the term noxious in relation to sorrel (dock (*Rumex* sp.)) seed. In 1893 the Department of Agriculture's annual report stated that "the spread of many weeds of a noxious character is becoming alarming, and the necessity for legislation at the earliest possible moment cannot be overestimated" (House of Representatives, 1893, p.3). The Noxious Weeds Bill 1893 through to the Noxious Weeds Act 1900 simply identify 'noxious' as meaning those plants or seeds seen as so problematic that the Governor has added them to the statutory schedules of exotic plants needing clearance or control.

[10] There was also a longer third schedule, listing the varieties of seeds or spores that were to no longer be sold or planted.

[11] That said, some of these exotic plants – including blackberry, sweetbriar, Scotch broom, gorse and hakea – also impact on native ecosystems even if that was not the reason for their inclusion.

The Noxious Weeds Act was consolidated three times and amended eight times between 1900 and 1978. The Act was then replaced by the Noxious Plants Act 1978, which was subsequently amended three times before being replaced by the much broader-in-scope Biosecurity Act 1993.

At the same time as exotic species were becoming unmanageable, Māori were also becoming more and more disconnected from taonga species like pōhutukawa (*Metrosideros excelsa*) and koromiko (*Hebe*, *Veronica* sp.). This is in part due to the alienation of Māori from their land but to a lesser extent from land clearance. As the Waitangi Tribunal has noted, restricted access to places and taonga resulted in Māori being unable to practice kaitiakitanga and overall rangatiratanga of flora and fauna.[12] On the other hand, Māori were not passive in the proliferation of exotic species. For example, when potatoes and other exotic crops were brought to Aotearoa, Māori were quick to plant them in their māra kai.[13] However, almost all environmental or natural resource legislation from 1840 onwards has directly affected the ability of Māori to effectively manage their flora taonga, including the management of exotic plant species.[14] There has been some attempt to rectify this, as noted in Box 6.1 below, but there is still room for improvement.

The current legislative framework

The primary Act establishing New Zealand's current biosecurity framework is the Biosecurity Act 1993. While its focus is obviously on biosecurity, this Act has an important role in managing the risks that weeds pose to the integrity of native ecosystems. Two other Acts also have fundamental relevance to the protection of our native ecosystems and plant biodiversity: the Conservation Act 1987 and the Resource Management Act 1991 (RMA).[15]

All three Acts play varying roles in the way New Zealand currently manages exotic plants.

Biosecurity Act 1993

The central piece of legislation governing the management of exotic plants is the Biosecurity Act 1993.

The Biosecurity Act is an umbrella Act designed to provide the statutory basis for a single overarching biosecurity system.[16] New Zealand's biosecurity system has to manage both an *external border* (to prevent any organisms from arriving) and pests *within the border* to prevent harmful spread. As a result, the Act is a complex, lengthy statute comprising (after amendments) 12 parts, with detailed provisions governing all manner of rights and obligations covering public agencies and private businesses.

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[12] Waitangi Tribunal, 2011.

[13] Waitangi Tribunal, 2011.

[14] Waitangi Tribunal, 2011.

[15] While there are other Acts, like the Land Act 1948, the Forests Act 1949, the Reserves Act 1977, the Queen Elizabeth the Second National Trust Act 1977, the National Parks Act 1980 and the Waitakere Ranges Heritage Area Act 2008, they are of secondary importance and often limited to specific locations.

[16] The relationship between the Biosecurity Act 1993 and the RMA 1991 is generally governed by ss 7 and 7A of the Biosecurity Act, which set out that, except where the responsible Minister exempts an attempt to eradicate an organism in accordance with Part 6 of the Biosecurity Act from the application of the duties and restrictions under Part 3 of the RMA, nothing in the Biosecurity Act can be read "so as to affect or derogate in any way" from the RMA (Biosecurity Act 1993, s 7(2)).

Surprisingly given its complexity, the Biosecurity Act lacks an overall purpose clause. However, as with any statute, a clear articulation of the purpose is important because the purpose statement is used to interpret the Act, and all powers and functions that exist under the Act must be exercised in accordance with their statutory purpose. Instead, no fewer than five separate parts of the Act have their own purpose statements.[17]

The most relevant for the purposes of this report is Part 5, which deals with pest management. Section 54 reads:

> "The purpose of this Part is to provide for the eradication or effective management of harmful organisms that are present in New Zealand by providing for—
>
> (a) the development of effective and efficient instruments and measures that prevent, reduce, or eliminate the adverse effects of harmful organisms on economic wellbeing, the environment, human health, enjoyment of the natural environment, and the relationship between Māori, their culture, and their traditions and their ancestral lands, waters, sites, wāhi tapu, and taonga; and
>
> (b) the appropriate distribution of costs associated with the instruments and measures."[18]

The stated purpose of Part 5 – the eradication or effective management of harmful organisms – is premised on avoiding harm to a wide range of outcomes, including the environment and enjoyment of the natural environment. Importantly, however, the purpose clause provides no direction on how these outcomes, which can often be in conflict, are prioritised.

Further, the purpose statement makes no explicit reference to native ecosystems or biodiversity, although this was recommended in a submission on the Biosecurity Law Reform Bill 2010.[19] The production-focused laws that preceded the 1993 Act appear to have cast a long shadow.

Significantly, the stated purpose focuses as much on instruments and measures – in other words, delivery – as it does on the goals.

Part 5 of the Biosecurity Act requires the responsible Minister to make a national policy direction in relation to pest management and allows for several types of plans to be prepared at different levels, both national and regional.[20]

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[17] See s 16 on the purpose of Part 3, which deals with the importation of risk goods; s 42 on the purpose of Part 4, which deals with surveillance and prevention; s 54 on the purpose of Part 5, which deals with pest management; s 100X on the purpose of Part 5A, which deals with government–industry agreement for readiness or response; and s 143 on the purpose of Part 7, which deals with exigency actions.

[18] Biosecurity Act 1993, s 54.

[19] Prior to 2012, the Part 5 purpose clause read: "The purpose of this Part of this Act is to provide for the effective management or eradication of pests." See Biosecurity Act 1993, s 54, as enacted (http://www.nzlii.org/nz/legis/hist_act/ba19931993n95183/). In a 2011 submission, the Environment and Conservation Organisations of Aotearoa New Zealand (ECO) proposed that the purpose statement should include the protection of native biodiversity, pointing out that the Act's definition of environment was broad and "does not include specific reference to biodiversity" (ECO, 2011, p.2). In response, Ministry of Agriculture and Fisheries (MAF) officials noted in their Departmental Report on the Bill that they "consider that the term environment adequately captures the protection of indigenous biodiversity" (MAF, 2011a, p.33).

[20] The Biosecurity Act *provides* for all of these plans and appears to assume that these plans will be prepared, although the Act does not explicitly *require* them. While ministers *may* approve the preparation of a national pest or pathway management plan, the Act provides that regional councils provide leadership in pest management (see Biosecurity Act 1993, ss 10, 12A, 12B and 13). This includes "facilitating the development and alignment of regional pest management plans and regional pathway management plans" (s 12B(2)(b)), with the regional councils having the "power" to prepare proposals for, make and implement regional pest or pathway management plans (s 13(1)(c)).

These plans are:

- national pest management plans
- national pathway management plans
- regional pest management plans (RPMPs)
- regional pathway management plans
- small-scale management programmes.

For each of the types of plans, the Act provides a framework for the plan's development and specifies several requirements.[21] Among other things, the responsible Minister (in the case of national plans) or the council (in the case of regional plans) needs to be satisfied that each pest proposed for inclusion in a plan "is capable of causing at some time an adverse effect on 1 or more" from a list of 11 disparate items (s 62(d)). This list includes "the survival and distribution of indigenous plants or animals" and "the sustainability of natural and developed ecosystems, ecological processes, and biological diversity", alongside "economic wellbeing" and "social and cultural wellbeing", to name just a few.[22]

No priority is given to any of these items. As a result, and without clear direction in the purpose clause, it is not clear, on the face of this statute, how New Zealand's broader biosecurity system ranks the protection of New Zealand's native ecosystems alongside other, potentially conflicting outcomes. In practice, those organisations responsible for implementing the Act are left to make trade-offs on a day-to-day, case-by-case basis. As a result, there is a very real risk that weeds harming native ecosystems may be overlooked unless their control aligns with a range of other specified values – but as to which ones, the Act is silent.

Pest management under the Biosecurity Act was explicitly based on the assumption that those with an interest to act will do so.[23] While arguable, such an expectation is at least plausible in respect of economically costly pests. But it is less clear that this expectation holds where the integrity of the country's native ecosystems is at stake. The Act needs clearer direction about the considerations and trade-offs that are involved in managing various exotic plants in the same landscape (Figure 6.1).

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[21] See Biosecurity Act 1993, ss 59–98.

[22] See Biosecurity Act 1993, ss 62, 71, 82 and 91.

[23] A 2010 Cabinet paper confirmed that legal instruments in Part 5 of the Biosecurity Act are "based on the concept that those with an interest to act will do so. Where potential benefits of pest management are broader than the individual, those who benefit will band together and pool their resources based on how much they are willing to pay to avoid the costs of pests" (Carter, 2010b, p.3).

Source: Peter de Lange, iNaturalist

Figure 6.1: Green honey-myrtle (*Melaleuca diosmifolia*) was first seen growing in the wild in New Zealand in 2016. While this plant species is not widely known as a native ecosystem weed elsewhere in the world, it is one in Victoria, Australia. There it displaces native plants and increases fire risk. Current legislation in New Zealand provides little guidance on the trade-offs involved in managing emerging versus widespread weeds.

Resource Management Act 1991

The cornerstone of New Zealand's environmental legislation – the Resource Management Act 1991 (RMA) – is another relevant piece of legislation. It applies to almost all New Zealand land except most conservation land and land managed by the New Zealand Defence Force.[24]

The RMA recognises in its purpose that "safeguarding the life-supporting capacity of … ecosystems" is an important part of the sustainable management of natural and physical resources.[25] In achieving the purpose of the RMA, matters of national importance must be recognised and provided for. These include "the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna" and "the relationship of Māori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga".[26] Among other things, the RMA tasks regional councils and territorial authorities with maintaining native biodiversity in their regions.[27]

The Government is currently in the process of reforming New Zealand's resource management legislation. It is too soon to say how this will influence the protection of native ecosystems.

Conservation Act 1987

The oldest of these three umbrella Acts, the Conservation Act applies to public conservation land administered by the Department of Conservation (DOC). This land is to be managed for conservation purposes and in doing so shall give effect to the principles of the Treaty of Waitangi.[28] 'Conservation' is defined in the Act as the "preservation and protection of natural and historic resources for the purpose of maintaining their intrinsic values, providing for their appreciation and recreational enjoyment by the public, and safeguarding the options of future generations". Not all of the conservation estate is held for the same purposes, however. DOC-administered land and waters includes national parks (managed under the National Parks Act 1980), wildlife areas (managed under the Wildlife Act 1953), reserves (managed under the Reserves Act 1977), conservation areas and stewardship land (both managed under the Conservation Act).

Both the Conservation Act and the RMA are broad in their scopes. While exotic plant management is not mentioned explicitly, the protection of native ecosystems is clearly a core element of both statutes. Furthermore, they allow for a broad range of instruments to be prepared, including national direction and associated plans, which are discussed later in this chapter.

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[24] Other exceptions include, for example, court cell blocks. Also note that the RMA can apply to the use of conservation land if an activity on conservation land has cross-boundary effects (see RMA 1991, s 4).

[25] RMA 1991, s 5(2)(b).

[26] RMA 1991, s 6.

[27] RMA 1991, ss 30, 31 and 62.

[28] Conservation Act 1987, ss 4 and 6.

Box 6.1: Recognising Māori rights to manage flora and fauna – Wai 262 and exotic plants[29]

In late 1991, a Waitangi Tribunal claim (Wai 262) was lodged by a group of Māori from across Aotearoa stating that the Crown had denied Māori the full exercise of their tino rangatiratanga, or absolute authority, over many aspects of life, but particularly those relating to natural resources, including native flora and fauna. This also included the right to protect mātauranga Māori related to flora and fauna.

Although the claim is far broader than just weeds and their impacts on Māori relationships with taonga and significant places, it does explore the impact that exotic plant species have had on taonga, mātauranga Māori and other cultural values. Wai 262 further explains that the impacts of exotic plant species (and the way they are controlled) on Māori extends beyond everyday practical issues to encompass tino rangatiratanga, kaitiakitanga and mauri.

The Tribunal made several relevant recommendations, including Māori participation in the development of National Policy Statements, more control of kaitiaki in environmental decision-making and establishing appropriate partnerships between Māori and the Crown in the protection of mātauranga Māori.[30]

It took 20 years for the claim to be heard, culminating in the 2011 Waitangi Tribunal report. A further six years passed before some of the recommendations were enacted through the Resource Legislation Amendment Act 2017. However, in 2020 a more concerted effort was taken to look at a whole-of-government response to Wai 262.

The Government identified multiple workstreams across different agencies that were affected by the claim. Those that touched on exotic plant management included:

- developing the National Policy Statement for Indigenous Biodiversity and *Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy 2020*
- reforming the resource management system
- reviewing the Biosecurity Act 1993 and the Plant Variety Rights Act 1987
- improving access to cultural materials
- using mātauranga Māori in decision-making contexts.[31]

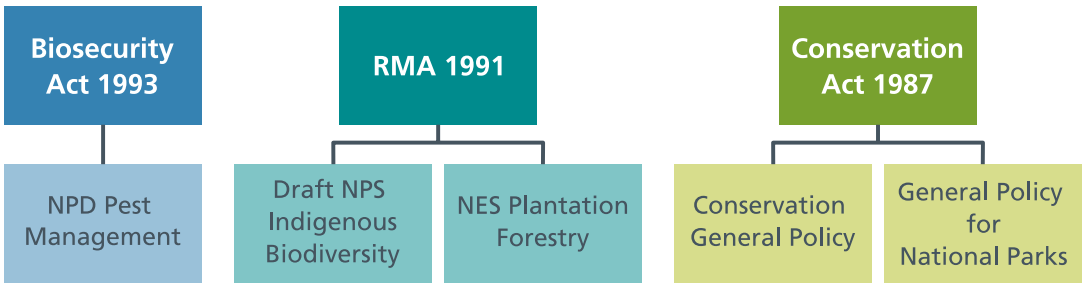
[29] Waitangi Tribunal, 2011.

[30] Waitangi Tribunal, 2011; TPK, 2018.

[31] TPK, 2019.

National direction instruments - secondary legislation

In addition to the primary legislation discussed above, there is a secondary tier of policy instruments that set out additional rules and requirements in line with the relevant Acts. These generally take the form of statements or directions on national policy. The relationship between the different pieces of legislation and the secondary instruments is reflected in Figure 6.2.



Source: PCE

Figure 6.2: Three acts with associated national direction instruments are most relevant to the management of exotic plants in New Zealand. Numerous plans and strategies have been prepared under each of these.

The national direction instruments under the three statutes do not provide a clear link between managing exotic plants and protecting native ecosystems. The three most relevant directions are:

- the **National Policy Direction for Pest Management 2015 (NPD)**, developed under the Biosecurity Act
- the **National Environmental Standards for Plantation Forestry (NES-PF)**, developed under the RMA
- the draft **National Policy Statement for Indigenous Biodiversity (NPS-IB)**, developed under the RMA.[32]

In addition, the **Conservation General Policy**, developed by DOC, provides general policy under a range of statutes, including the Conservation Act.[33]

National Policy Direction for Pest Management

The Biosecurity Act states that the responsible Minister has responsibility for:

- providing for the coordinated implementation of the Biosecurity Act
- recording and coordinating reports of suspected new organisms
- managing appropriate responses to such reports.[34]

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[32] The NPD and, in the case of the national policy statements under the RMA, the Order in Council approving the statements are disallowable instruments for the purposes of the Legislation Act 2012 and must be presented to the House of Representatives under s 41 of that Act. They are not legislative instruments for the purposes of the Legislation Act (see Biosecurity Act 1993, s 57(9), and RMA 1991, s 52(4)). For definitions, see Legislation Act 2012, ss 4 and 38.

[33] Functionally, the Conservation General Policy made under the Conservation Act plays a similar role to national directions under the Biosecurity Act and the RMA. They are all carried out under their constituent legislation and are used to set out general goals and methods for creating subsidiary documents like regional plans, with these subsidiary documents being subordinate to the national direction documents. The Conservation General Policy is simply approved by the relevant Minister.

[34] See Biosecurity Act 1993, s 8.

In addition, the Act states that the responsible Minister provides leadership through national policy direction and requires such direction in relation to pest management to be prepared.[35] However, the Act allows for only one such direction to be prepared, so it has to cover everything – which makes its preparation both exhaustive and exhausting.[36]

A national policy direction for pest management was developed in 2015. The NPD is the national-level direction most directly related to the management of exotic plants outside of the conservation estate.

The NPD elaborates on the Biosecurity Act requirements and sets out the procedural framework and legal requirements for pest management across the country with the purpose of ensuring that pest management activities "provide the best use of available resources for New Zealand's best interests and align with one another, when necessary, to contribute to the achievement" of the pest management part of the Biosecurity Act.[37] In short, it is an instrument directed at managing resources rather than making transparent the trade-offs that arise in the context of pest management. Beyond requiring that resources be directed to "New Zealand's best interests", the NPD has nothing to say about the relative importance of native ecosystems, compared with activities such as production, health and housing.[38] Since all these areas compete for any resources allocated under the Biosecurity Act, the absence of any specific guidance leaves open any priority that may be accorded to native ecosystems or biodiversity outcomes.

While section 56 of the Biosecurity Act includes examples of the matters on which direction may be given, there is no legislated minimum content for a national policy direction – for example, there is no requirement to include priority pests that need to be nationally managed. The Biosecurity Act appears to be similar to the RMA in being enabling and permissive but not prescriptive with regard to a minimum set of things that must be the subject of direction.[39] It differs, in providing no priorities such as those reflected in sections 6 and 7 of the RMA.

At the time of its development, the NPD was envisaged to include national priorities for pest management. In 2010, the Ministry of Agriculture and Fisheries (MAF) wrote:

> "The Government has decided to create binding national policy direction that will set out processes to improve the rigour and consistency of pest management strategies and establish national priorities for pest management."[40]

However, the final NPD issued in 2015 failed to identify any. The exact reasons why this should have been the case remain opaque. One possible reason could stem from the Biosecurity Act's requirement that the responsible Minister must have regard to the extent that a national policy direction is likely to affect the accountability of decision makers, including the accountability of local decision makers to their communities of interest.[41] Taking into account the autonomy of local decision makers may have had a bearing on the decision for the final NPD to focus on *consistency* of pest management plans rather than setting national *priorities*.[42]

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[35] See Biosecurity Act 1993, s 56.

[36] See Biosecurity Act 1993, s 56(1).

[37] See Biosecurity Act 1993, s 56(2). This is also repeated on page 3 of the NPD (New Zealand Government, 2015).

[38] New Zealand Government, 2015, p.3.

[39] Section 57 of the RMA does require national direction in respect of coastal policy through the preparation of a National Policy Statement.

[40] MAF, 2010, p.26.

[41] Biosecurity Act 1993, s 56(7)(e).

[42] MPI staff, pers. comm., 9 August 2021.

The NPD expands on the requirements for national and regional plans set out in the Biosecurity Act. It covers:

- setting objectives for each pest included in national or regional pest or pathway management plans or small-scale management programmes
- using standardised 'intermediate outcomes' and 'management programmes' for each pest in national or regional pest or pathway management plans or small-scale management programmes
- analysing the benefits and costs of the plan for each pest, and allocating costs for national and regional pest and pathway management plans
- developing good neighbour rules in RPMPs
- outlining a time frame within which the responsible Minister or regional council (respectively) must determine whether a national or regional pest management plan or a pathway management plan is inconsistent with the NPD.[43]

At the time of its development, the NPD was seen as a way of improving the rigour and consistency of pest management.

In 2010 MAF acknowledged that:

> "In the absence of any national policy direction, regional councils have developed regional pest management strategies using individual approaches, resulting in some inconsistencies between regions and tensions between the strategies and the national priorities of Crown agencies. Conversely, few national pest management strategies have been prepared at all, hampering national consistency in the treatment of some pests."[44]

Further, over 40 different terms were used by regional councils to describe pest management programmes.[45] Many terms had variable meanings and were poorly aligned across plans, often being used to incorporate a mix of outcomes, activities, measures and rules.[46] This variety and inconsistency in terminology made it hard to understand what different programmes were aiming to achieve. Ministry for Primary Industries (MPI) officials at the time stated that:

> "Nationally it is then difficult to determine the relationship between programme names, objectives, performance measures or rules in the programmes. This, in turn, reduces opportunities for national monitoring and reporting on programmes."[47]

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[43] This latter requirement is spelled out in cl 9 of the NPD (New Zealand Government, 2015) and refers to the requirement in s 100E(3) of the Biosecurity Act that the Minister or council must determine whether a plan is inconsistent with the NPD within the time frame set out in the direction (18 months from the making, revocation or replacement of the NPD). If a plan is inconsistent, it must be amended or reviewed under s 100D or s 100G of the Act. For example, in March 2017, Greater Wellington Regional Council found that the Wellington Regional Pest Management Strategy 2002–2022 was inconsistent with the NPD and commenced a review (Bejakovich, 2017a, b).

[44] MAF, 2010, p.26.

[45] An internal MPI paper prepared in 2011 stated that "regional councils have adopted a plethora of pest management classifications to describe their programmes" – "18 major pest categories and 28 minor categories". "Sometimes this variation is derived from internally derived logic, and on other occasions it is to accommodate the full scope of their plans, which address not only pest species for which rules apply, but other species which are still of interest to the agency" (MPI, 2011, p.2).

[46] For example, the term "total control pests" was commonly applied to pest species that existed at a low level in a region and were controlled by the council everywhere and anywhere the pest was found within the region. However, other councils applied the same term to describe a pest that was widespread and that land occupiers, rather than the council, were required to control (MPI, 2013, p.16).

[47] Further, MPI officials noted the failure of previous efforts to address variations in terminology through advice and guidance, disseminated in 1994, 2000, 2005 and 2009, with "variable uptake" (MPI, 2011, p.3).

To facilitate improved consistency of terms, the NPD has produced a set of five management outcomes to indicate what any management actions seek to achieve. The NPD introduced a requirement that for each pest listed in a plan, the objectives of the plan must state the intermediate outcomes the plan is seeking to achieve. These intermediate outcomes are:

- exclusion, which means preventing the establishment of the pest that is present in New Zealand but not yet established in an area
- eradication, which means reducing the pest infestation level to zero levels in an area in the short to medium term
- progressive containment, which means to contain or reduce the geographic distribution of the pest to an area over time
- sustained control, which means providing for ongoing control of the pest to reduce its impacts and spread to other properties
- protecting values in places, which means that the pest that is capable of causing damage to a place is excluded or eradicated from that place, or is contained, reduced, or controlled within the place to an extent that protects the values of that place.[48]

Further, the NPD requires specification of the geographic area to which the outcome applies, the extent to which the outcome will be achieved (if applicable), and the period within which the outcome is expected to be achieved. If the pest management intermediate outcome is expected to take longer than ten years to achieve, the NPD requires stating what is intended to be achieved in the first ten years of the plan, or during the current term of the plan prior to next review.[49]

To detail how these outcomes will be achieved, each pest in the plan must be assigned to one or more of the standardised management programmes. These programmes, which mirror the intermediate outcomes, are:

- exclusion programme
- eradication programme
- progressive containment programme
- sustained control programme
- site-led pest programme, in which the intermediate outcome for the programme is that a pest that is capable of causing damage to a place is excluded or eradicated from that place, or is contained, reduced, or controlled within the place to an extent that protects the values of that place.[50]

These requirements are examined in more detail later in this chapter, with a particular focus on assessing how the NPD has been picked up in RPMPs.

From the analysis in this section though, it is evident that the NPD missed a chance to set national priorities for pest management and require national coordination.

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[48] See sub-cl 4(1) of the NPD (New Zealand Government, 2015). For ease of reading, "subject" has been replaced with "pest" in this report.

[49] See sub-cl 4(1)(f) of the NPD (New Zealand Government, 2015).

[50] See sub-cl 5(1) of the NPD (New Zealand Government, 2015). For ease of reading, "the subject, or an organism being spread by the subject" has been replaced with "a pest" in this report.

Draft National Policy Statement for Indigenous Biodiversity

The draft NPS-IB has been developed under the RMA to provide national direction and guidance to local government on how to improve biodiversity management across the country. While the draft NPS-IB touches on the impacts to biodiversity from native ecosystem weeds, as it currently stands it provides no direction on exotic plant management.

The statement of fundamental concepts, which prefaces the NPS-IB, identifies "pest vegetation or fauna incursions and changes that result in increased risk of incursions" as an adverse effect on native biodiversity that the NPS-IB is seeking to limit.[51] However, there is no direct reference to weeds or pest vegetation in either the objectives or policies laid out in other sections of the NPS-IB. While subdivision and plantation forestry activities receive detailed treatment, the risks posed by weeds are nowhere to be found. Further, there are no links with the Biosecurity Act or the NPD.

At the time of writing, the proposed NPS-IB remains a draft. It has been in the making for over a decade, the extended delays reflecting the complex nature of the challenges at stake.

National Environmental Standards for Plantation Forestry

The NES-PF, also developed under the RMA, has some bearing on the management of wilding conifers. Among other things, the NES-PF includes measures to control the spread of wilding conifers, which can cause harm to a range of valued ecosystems, including productive landscapes and native ecosystems. These rules apply to wilding spread from any forest larger than one hectare that has been planted specifically for commercial purposes and will be harvested.[52]

Landowners and forest operators are required to apply a Wilding Tree Risk Calculator to a site when they are considering establishing a new plantation forest or replanting a different type of conifer that has a higher risk score than the previous species. If the risk of wilding spread is high, a resource consent will be required as a way to manage the risk. It is worth noting here that existing tools for estimating and managing the risk are crude. The Wilding Risk Calculator spread scores have been found to underestimate long-distance spread.[53] The one-year review of the NES-PF also concluded that "changes to the calculator are needed to adjust some of the settings in the calculator, align how afforestation and replanting are treated, and strengthen the requirements about who is qualified to use it."[54]

Further, the NES-PF requires that wildings in wetlands and significant natural areas that can be attributed to the afforestation or replanting must be eradicated at least every five years.[55] This requirement provides a link between the management of one group of exotic plant species and native ecosystem protection. We will have to wait for the full implementation of the NPS-IB to see how this works in practice.

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[51] See cl 4(g) of the draft NPS-IB (New Zealand Government, 2019).

[52] New Zealand Government, 2017a, p.2.

[53] Wyse and Hulme, 2021.

[54] Te Uru Rākau – New Zealand Forest Service, 2021a, p.66.

[55] See cls 11(5) and 79(6) of the NES-PF (New Zealand Government, 2017b). However, attribution of where a particular wilding has come from is very contentious.

Conservation General Policy

The Conservation General Policy provides clearer guidance on the management of weeds for the benefit of native ecosystems. However, the policy only applies to DOC and its management of the conservation estate.

The Conservation General Policy was developed by DOC in 2005 and last revised in 2019. It provides general policy on how conservation legislation is applied in practice for several pieces of conservation legislation, including the Conservation Act, the Wildlife Act and the Reserves Act. A separate General Policy for National Parks covers national parks established under the National Parks Act.

The Conservation General Policy states that biosecurity and pest management programmes (which include the management of weeds) should give priority to:

- preventing pests becoming established, including illegal and inadvertent transfers
- eradicating newly naturalised pests at places, where practicable
- eradicating, containing or reducing the range of pests that are established but not widespread, where practicable
- controlling widespread pests where this is required to protect indigenous species, habitats and ecosystems, where eradication or containment of them is not practicable.[56]

Further, the policy states that biosecurity and pest management programmes should:

- seek to maximise outcomes for the benefit of indigenous species, habitats and ecosystems
- provide for either single or multiple species measures to protect specified places
- take account of statutory pest management strategies
- be developed in collaboration with other relevant management agencies.[57]

In addition to two general policies, DOC has developed a hierarchy of management strategies and plans (statutory planning documents), each of which cannot derogate from its parent. These include conservation management strategies, national park management plans and conservation management plans.[58] There are 17 conservation management strategies, 13 national park management plans and 11 conservation management plans that are current, under review, or in development.[59] These are required to be reviewed every ten years and in theory cover 100 per cent of public conservation lands and waters.

The Conservation General Policy instructs conservation management strategies and plans to identify and, where possible, prioritise the threats posed by pests to native species, habitats and ecosystems. For example, the Wellington Conservation Management Strategy lists numerous weeds as threats for the identified priority ecosystems on public conservation lands and waters in the region.[60]

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[56] DOC, 2019a, policy 4.2(b).

[57] DOC, 2019a, policy 4.2(c).

[58] These are place-specific documents that are developed by DOC through engagement with Treaty partners and in close consultation with the conservation board responsible for the region involved. Other interested stakeholders are also involved. The strategy or plan that ultimately emerges from this process is then subject to final approval by the relevant conservation board or – having had regard to the views of the Minister of Conservation – by the New Zealand Conservation Authority.

[59] DOC, 2020d.

[60] See DOC, 2019c.

National-scale exotic plant management plans and strategies

National pest and pathway management plans

While the Biosecurity Act allows the preparation of (and the NPD provides the framework for) **national pest management plans** and **national pathway management plans**, neither has ever been prepared for an exotic plant.[61]

National pest management plans would present an opportunity for strategic oversight and coordination of efforts to contain or eradicate a plant. However, to date, only three national pest management plans have been prepared and none of them address the management of exotic plants.[62]

National pathway management plans would facilitate a focus on stopping the movement of propagules – the seeds or other parts of a plant that can grow to produce a new plant. High-risk pathways include those used by many plants, such as birds dispersing seeds, or those by which types of plants with large impacts could spread, such as aquatic plants attached to boats or dumping of garden waste. Invasion pathways created through human activity, such as the movement of contaminated machinery with propagules attached, can be higher priorities for management since we can control these more easily than natural dispersal pathways.

Pathway management options were explored by MAF officials in 2010.[63] One of the series of Cabinet papers that led to the Biosecurity Law Reform Act 2012 briefly mentioned the "potential creation of 'internal borders' for specified activities in New Zealand" with the intention of using this instrument to target specific high-risk pathways.[64] Further, it proposed to expand the purpose of the pest management part of the Biosecurity Act to include pathways and vectors by which harmful organisms could spread.[65] However, while pathways and vectors might be implied in the current purpose statement, they are not mentioned explicitly.

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[61] While national and regional pest management plans and small-scale programmes have been in the Biosecurity Act since enactment in 1993, national and regional pathway management plans were added in 2012. At a high level, pathway management plans are intended to prevent or manage the spread of harmful organisms, whereas pest management plans are aimed at the eradication or effective management of particular pests.

[62] The three national pest management plans that have been prepared are the Biosecurity (National Bovine Tuberculosis Pest Management Plan) Order 1998, the Biosecurity (National American Foulbrood Pest Management Plan) Order 1998, and the Biosecurity (National Psa-V Pest Management Plan) Order 2013. A draft national pest management plan has been developed for kauri dieback. While much public consultation and expert input has gone into the draft plan, the plan has not been signed off by the Minister yet (Keep Kauri Standing, no date). Note that, if a national pest management plan for kauri dieback is promulgated, it will be for the management of a pathogen (*Phytophthora agathidicida*), not a plant. Further, Budget 2021 set aside $28 million to manage the threat of kauri dieback and "buy time while seeking a cure by containing the disease. It will finalise and implement a Kauri Protection National Pest Management Plan under the Biosecurity Act 1993, which will build on, and enhance, the work of existing kauri programmes and provide a national, prioritised and managed response to kauri dieback, while there is still an opportunity to contain the disease" (New Zealand Government, 2021).

[63] High-risk human-mediated pathways of invasion in terrestrial, freshwater and marine environments within New Zealand were identified and evaluated by MAF officials, while natural modes of pest spread were out of scope for this technical paper (Biodiverse Limited, 2010).

[64] Carter, 2010a, pp.10–11.

[65] Carter, 2010a, p.15.

Despite all that activity, there has never been a national pathway management plan developed to address pathways of spread of terrestrial exotic plants.[66] This is even though it is cheaper and more effective to prevent plants from arriving and establishing at any site than to eradicate and control them once they are established.[67]

Relevant national non-statutory strategies

Several national non-statutory strategies have relevance to the management of exotic plants. However, neither of the most relevant national strategies (described below) is focused solely on the management of weeds that are harming native ecosystems.

Tiakina Aotearoa – Protect New Zealand was the first biosecurity strategy for New Zealand, published in 2003. It had a broad vision of "New Zealanders, our unique natural resources, our plants and animals are all kept safe and secure from damaging pests and diseases" and listed five outcomes: environmental, commercial, cultural, human health and social. It also included a section on pest management.[68]

The 2011 *Pest Management National Plan of Action* released by MAF described one of the overall pest management outcomes being sought as preventing or reducing "unwanted damage caused by harmful organisms that have established in New Zealand". It also listed similar outcomes – economic strength, healthy environment, healthy New Zealanders and cultural identity – as whole-of-New Zealand outcomes to which biosecurity contributes, without elaborating on what happens when these outcomes clash.[69]

The key national biosecurity strategy – *Biosecurity 2025: Direction Statement for New Zealand's biosecurity system* – also lacks explicit direction for how to protect New Zealand's native ecosystems.[70] The direction statement, which was published by MPI in November 2016, incorporates the following in its "mission for the biosecurity system": "The biosecurity system protects New Zealanders, our way of life, our natural and productive resources and our biodiversity from the harmful effects of pests and diseases."[71]

As an aspiration, such a mission is commendable if unremarkable. But realising any such goal requires trade-offs, and as noted above, there is no sense of any priorities to guide them and no particular priority accorded to the protection of native ecosystems.

The most relevant strategy document for setting national-level outcomes for native ecosystems is *Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy 2020*, published by DOC in August 2020. This strategy attempts to capture the biodiversity goals and aspirations of all New Zealanders, and so, by design, exotic plant management only gets a brief mention.[72]

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[66] To date, only two pathway management plans have been developed. They are the Fiordland Marine Regional Pathway Management Plan and the Northland Regional Pest and Marine Pathway Management Plan. In addition, two multi-regional partnerships have been established: Top of the North Marine Biosecurity Partnership and Top of the South Marine Biosecurity Partnership. These partnerships are in discussions around the development of inter-regional marine pest pathway management plans. Environment Canterbury is also currently in discussions with the neighbouring regional councils, aiming to ultimately develop a South Island pathway management programme for terrestrial exotic plants (Environment Canterbury staff, pers. comm., 26 May 2020).

[67] Biodiverse Limited, 2010, p.8, Figure 2.

[68] MAF, 2003, p.8.

[69] MAF, 2011b, p.10.

[70] Note that Biosecurity 2025 is referred to as a "partnership between people, organisations, Māori, and central, local and regional government." As such, the Biosecurity 2025 Direction Statement is stated to belong to all New Zealanders (MPI, 2016).

[71] MPI, 2016, p.4.

[72] The term 'weed' is mentioned only four times, and out of almost a hundred goals, only three mention weeds. See goals 11.1.1, 11.1.3, 11.3.1 and 11.3.3 (DOC, 2020e, p.53).

In short, New Zealand currently lacks a national-level unambiguous plan or strategy for managing weeds harming native ecosystems (Figure 6.3).

Source: moira_parker, iNaturalist

Figure 6.3: Compounding problems. Here, gorse (*Ulex europaeus*), which naturalised in 1867, is seen growing with Chilean flame creeper (*Tropaeolum speciosum*), which naturalised in 1958, among native kānuka (*Kunzea ericoides*). New Zealand lacks an unambiguous national-level plan or strategy for managing weeds harming native ecosystems.

Perhaps the closest attempt at creating one was the *DOC Strategic Plan for Managing Invasive Weeds*. It was published over 20 years ago (1998) and described the long-term goal, objectives, general principles and means for DOC to follow. However, this document was never intended to be a national strategy – the strategic plan clearly stated that it was "not intended to be a plan for controlling any or all invasive weeds throughout New Zealand or within whole regions including on private land".[73] This plan was primarily intended as an internal document for DOC's management of weeds on the land it administers and DOC's other statutory roles and responsibilities (e.g. under the Biosecurity Act).[74]

By contrast, Australia has had an Australian Weeds Strategy since 1997 that is now in its third iteration (see Box 6.2)

[73] Owen, 1998, p.1.

[74] Owen, 1998.

Box 6.2: The Australian Weeds Strategy

Australia recognised the need for a nationally coordinated strategy on exotic plants in 1991, but it was not until 1997 that its first National Weeds Strategy was published – an apparent reflection of the complexity of addressing exotic plant related issues across varying governmental departments, including Agriculture, Forestry and the Environment.[75]

The 1997 strategy was subsequently refreshed and rebranded in 2007 as the Australian Weeds Strategy and refreshed again in 2016.[76] The stated purpose of the strategy is to provide national guidance, coordinate effort and inform the plans and actions of all involved. It identifies areas that require national collaboration as well as helping to provide clarity around priorities, roles and responsibilities. The three main goals of the Australian Weeds Strategy are essentially:

- prevention, detection and early intervention of new exotic plants
- minimising the impact of established exotic plants
- enhancing capacity for exotic plant management.

Finally, a relevant consideration for any national-level strategy touching on exotic plants is the Convention on Biological Diversity, which New Zealand signed at the 1992 Rio Earth Summit. Box 6.3 outlines what New Zealand has signed up to and its self-assessed progress to date.

Box 6.3: What about the outcomes New Zealand has signed up to internationally?

New Zealand is a signatory to the 1992 United Nations Convention on Biological Diversity and the Aichi Biodiversity Targets agreed in 2010 for 2011–2020.[77] Among the 20 targets, one is of particular relevance to this report. Target 9 reads:

> "By 2020, invasive alien species and pathways are identified and prioritised, priority species are controlled or eradicated and measures are in place to manage pathways to prevent their introduction and establishment."[78]

This target has to be read alongside wider biodiversity outcomes, such as Target 12:

> "By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained."[79]

[75] Thorp and Lynch, 1999.

[76] Natural Resource Management Ministerial Council, 2016.

[77] A post-2020 framework is still being prepared, with the formal process delayed in part by the Covid-19 global pandemic (see https://www.cbd.int/conferences/post2020). While the new targets are yet to be finalised, a 'zero draft' has been proposed (CBD, 2020c).

[78] CBD, 2020a.

[79] CBD, 2020a.

Global progress towards these targets has been limited: In the words of the 2020 *Global Biodiversity Outlook 5*, "The overall picture from the national reports provided by countries is also one of progress, but again at levels generally insufficient to achieve the Aichi Biodiversity Targets".[80]

New Zealand's progress mirrors these global efforts. Despite some progress, protecting native ecosystems in New Zealand remains challenging, and "more work needs to be done".[81]

Assessing progress towards each individual target is harder.[82] It might appear that New Zealand has met Target 9 since our national report states:

> "There is significant monitoring of unwanted organisms already in New Zealand in an attempt to control and eradicate them, where possible. Surveillance is used to identify any emerging risks. … Within New Zealand, the impacts of pests and diseases that have crossed the border (including those that have already established) have been managed."[83]

It is hard to assess what these words actually mean. This is partly because the target is hard to measure – something that has been recognised internationally. But the vague wording of the report does not help. The range of actual outcomes that potentially lie under the bland claim that the impacts of pests and diseases "have been managed" is very wide. Management could be more forensically defined to make a clear separation between eradication and suppression, and between progressive containment and simply learning to live with a pest.[84]

Regional-scale exotic plant management: A myriad of strategies and plans

At the regional level, the Biosecurity Act allows the preparation of (and the NPD provides the framework for) RPMPs, regional pathway management plans, and small-scale management programmes. However, only the first type of plans is currently being used to manage exotic plants across the country.

There has never been a regional pathway management plan developed to address pathways of spread of terrestrial exotic plants.

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[80] CBD, 2020b, p.10.

[81] See National Report (6NR) submitted in 2019 (DOC, 2019b).

[82] Noting that the online reporting system now seeks to state whether or not each country is moving towards or away from each target. For more, see the Convention on Biodiversity information submission website (https://chm.cbd.int/search/reporting-map?filter=AICHI-TARGET-09).

[83] DOC, 2019b, p.115.

[84] According to Essl et al. (2020), any targets "should explicitly consider the three main components of biological invasions, i.e. (i) pathways, (ii) species, and (iii) sites; the target should also be (iv) quantitative, (v) supplemented by a set of indicators that can be applied to track progress, and (vi) evaluated at medium- (2030) and long-term (2050) time horizons" (pp. 99–100).

Similarly, there are no current small-scale management programmes for any terrestrial exotic plants.[85] One historical programme was identified. In 2009, Environment Canterbury used a small-scale management programme to manage Chilean needle grass (*Nassella neesiana*). Over a decade later, this exotic plant has persisted in the Canterbury region and is listed as a pest in the region-wide sustained control programme in the current Canterbury RPMP 2018–2038.[86]

Small-scale management programmes allow regional councils to eradicate or control unwanted organisms of limited distribution in their regions.[87] These programmes were envisaged as a tool to allow regional councils to respond quickly and effectively to incursions in their regions, before unwanted organisms could spread.[88] To declare such a programme, the council would need to be satisfied that the organism can be eradicated or controlled effectively by small-scale measures within three years of the measures starting because (i) its distribution is limited and (ii) technical means to control it are available.[89] The maximum duration of a small-scale programme is five years, and the maximum amount regional councils can spend on a small-scale programme is $500,000 under the Biosecurity (Small Scale Organism Management) Order 1993.[90] The effort that went into producing these specifications has yielded virtually nothing, suggesting that the specified conditions are unworkable. For a council to be able to satisfy itself that an exotic plant could be eradicated or controlled within three years, the plant would have to have a very short-lived seedbank. No such constraints apply to four-legged taxa.

Interestingly, the Biosecurity Amendment Act 1997 made small-scale management programmes exclusively available to regional councils. Between 1993 and 1997 both ministers and regional councils could undertake small-scale management of unwanted organisms without pest management strategies.[91] The exact reasons for these amendments are unknown, but one can speculate that the Minister for Biosecurity had lost interest in using these programmes and left it up the councils to deal with new plant incursions in the regions.

Instead, all reliance has been placed on RPMPs. At the time of writing, all regional councils and unitary authorities had operative RPMPs. These plans are examined in more detail below.

In addition to the RPMPs prepared under the Biosecurity Act, at the regional scale, current management of the risks that weeds pose to native ecosystems is also covered by regional policy statements, regional biodiversity strategies and regional biosecurity strategies.[92]

Table 6.1 details the extent to which regional councils have developed biosecurity and biodiversity strategies alongside their RPMPs.[93]

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[85] The only current programme that this investigation has come across is a small-scale management programme declared for the Mediterranean fanworm (*Sabella spallanzanii*) by Nelson City Council and Tasman District Council in July 2017. Obviously, a fanworm is not a terrestrial exotic plant. For details, see Russell (2017).

[86] See Biosecurity NZ – MAF (2010, p.3) and Table 14 in Environment Canterbury (2018, p.43).

[87] These regional small-scale management programmes, led by regional councils and essentially aimed at eradicating a new incursion to a region, are different from the MPI-led incursion investigations and incursion responses, which are often aimed at eradicating a new incursion to New Zealand.

[88] See the Biosecurity (Small Scale Organism Management) Amendment Order 2009 and Treasury (2009).

[89] Biosecurity Act 1993, s 100V.

[90] See Biosecurity (Small Scale Organism Management) Order 1993.

[91] See Biosecurity Act 1993, s 100, as enacted.

[92] Note that not all regional councils and unitary authorities have prepared all the documents mentioned.

[93] Hutchison et al., 2021.

Table 6.1: RPMPs, regional biosecurity strategies and regional biodiversity strategies.

Region	RPMP – years operative	Operative regional biosecurity strategy	Operative regional biodiversity strategy
Northland	Yes, 2017–2027	No	No
Auckland	Yes, 2020–2030	No	Yes
Waikato	Yes, 2014–2024 A new proposed plan for 2021–2031 was notified in April 2021	No	No
Bay of Plenty	Yes, 2020–2030	No	No
Gisborne	Yes, 2017–2027	No	No
Hawke's Bay	Yes, 2018–2038	No	Yes
Taranaki	Yes, 2018–2028	Yes	Yes
Manawatū-Whanganui	Yes, 2017–2037	No	No
Wellington	Yes, 2019–2039	No	No
Tasman	Yes, 2019–2029	No	No
Nelson	Yes, 2019–2029	No	Yes
Marlborough	Yes, 2018–2038	Yes	No
Canterbury	Yes, 2018–2038	No	Yes
West Coast	Yes, 2019–2029	No	No
Otago	Yes, 2019–2029	Yes	Yes
Southland	Yes, 2019–2029	Yes	No
Chatham Islands	Yes, 2021–2041	Yes	No

Whether as many as three separate documents – RPMPs, regional biosecurity strategies and regional biodiversity strategies – are needed to guide management of weeds that could or do harm native ecosystems is a moot point (Figure 6.4).

Only two councils – Otago and Taranaki – have prepared all three; others rely on two or just one of the three documents. Further, the perceived relationship between the three documents varies among councils and depends on the number of plans and strategies prepared. Most councils that produced a separate biosecurity strategy in addition to an RPMP considered that the strategy sat "above an RPMP in terms of hierarchy and that it should set out the strategic management of all harmful organisms within a region (not just those in an RPMP) through both regulatory and non-regulatory means".[94]

Source: Murray Dawson, iNaturalist

Figure 6.4: This blaze of yellow flowers on the Port Hills in Christchurch is boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*), a weed listed in Environment Canterbury's RPMP and regional biodiversity strategy.

An example of this is Taranaki's regional biosecurity strategy, which is considered to sit above the RPMP in terms of hierarchy to provide an overview of pest management occurring in the region through regulatory and non-regulatory means.[95] However, other councils that did not develop a separate biosecurity strategy, like Auckland Council, reported including strategic content within the RPMP to provide wider context of the whole biosecurity system.

[94] Palmer, 2020, p.11.

[95] Taranaki Regional Council staff, pers. comm., 29 June 2021.

Further, the councils that have developed regional biodiversity strategies considered them overarching documents, guiding biosecurity and pest management, and more. For example, Taranaki's regional biodiversity strategy outlines, among other things, non-regulatory and regulatory pest management actions and programmes that the council will either lead or participate in to achieve its biodiversity outcomes.[96]

Irrespective of the number of plans and strategies created, effective management of weeds for the purposes of protecting native ecosystems requires clearly stated goals that translate into actions. Ideally, a biodiversity strategy should clearly identify which remaining native ecosystems are most precious, and where they are. A biosecurity strategy that is helping to protect these ecosystems can then help identify, require monitoring, and prioritise management of any weeds that are threatening these native ecosystems. Finally, a pest management plan could then include clear rules for the management of these weeds at the sites.

Current plans and strategies fall short of this ideal.

For example, Taranaki Regional Council's non-statutory biodiversity strategy (2017) mentions pest management as one of the objectives: "promoting biodiversity outcomes through pest management programmes".[97] However, exotic plants, and in particular, the weeds that are impacting on native ecosystems, are not explicitly mentioned.

Taranaki's non-statutory biosecurity strategy for 2018–2038 contains several aspirational outcomes (e.g. that "widespread pests and weeds having regionally significant impacts are being managed to an appropriate level that, at the very least, reduces adverse impacts on neighbours"), but it does not explicitly relate these to native ecosystems or make an attempt to prioritise weeds impacting on native ecosystems.[98]

Finally, Taranaki Regional Council's RPMP, prepared under the Biosecurity Act following requirements outlined in the NPD, sticks with the NPD language as it outlines eradication and sustained control programmes. Given that, it is perhaps unsurprising that the RPMP is silent about any desired outcomes for native ecosystems from weed management.

In summary, the connection between exotic plant management and native ecosystems remains opaque. A lack of measurable goals and actions throughout many strategies and plans contributes to potential challenges of accountability and enforcement. Further, a fragmented regulatory landscape can lead to tensions between rules (see Box 6.4).

[96] See Taranaki Regional Council, 2018.

[97] See Taranaki Regional Council, 2017a, p.25 and p.31.

[98] See Taranaki Regional Council, 2018, p.i.

Box 6.4: Tensions between the rules

A complex and fragmented regulatory landscape leads to tensions between rules. For example, bangalow palm (*Archontophoenix cunninghamiana*) is listed in Auckland Council's RPMP as being managed on a site-led basis within parks, and managed via sustained control over the rest of the region.[99]

Rules under the sustained control programme prohibit anyone from breeding, distributing, planting or selling bangalow palms, and require landowners to destroy bangalow palms that have been planted on their land in breach of the RPMP (if directed to do so by an authorised person).

However, specific old palm trees are scheduled as protected under the Auckland Unitary Plan (prepared under the RMA). Some of the oldest bangalow palms in the region, these protected trees act as a seed source, each potentially producing up to 12,000 seeds per year for birds to spread far and wide (Figure 6.5).[100] Resource consent is required to remove these palms, so in its absence, 'constant gardening' is used to manage ongoing spread into native ecosystems. A plan change is required to remove these palms from the Auckland Unitary Plan.

[99] Auckland Council, 2020, p.59.

[100] This is based on the interpretation that there is one seed per fruit, with each tree having, on average, approximately 3,000 bunches of four fruits when grown in the sun (Mengardo and Pivello, 2012).

Source: Andrew Townsend, iNaturalist

Figure 6.5: Bangalow palm (*Archontophoenix cunninghamiana*) in flower shows how much seed a single tree can produce, facilitating its spread from gardens into native ecosystems.

Regional pest management plans: A world of nuances and inconsistencies

Currently all regional councils and unitary authorities have operative RPMPs, which have been prepared with a 10- to 20-year time frame.[101] All RPMPs (with the exception of Waikato Regional Council's (see Table 6.1)) have been prepared after the publication of the NPD in 2015 and follow the specified requirements.[102]

Collectively, regional councils and unitary authorities manage 334 plant species through their current RPMPs. RPMPs group the plants under five pest management programmes as required and defined by the NPD – exclusion, eradication, progressive containment, sustained control and site-led programmes – and include specific rules for each plant or group of plants. Specific rules often vary between regions.

Long duration – a barrier to quick responses to emerging threats and new information

Current RPMPs have been prepared to last for 10 or even 20 years.[103] It takes time to prepare an RPMP, so regional councils understandably want to avoid the cost of frequent updates and rewrites. Long plan durations may be viewed as evidence of the amount of effort required to satisfy the Biosecurity Act's requirements.[104] On the other hand, these long durations may be viewed as evidence of the long-term nature of pest management programmes, which require time to deliver results.[105]

The process for amending comprehensive, long-term plans is a time-consuming exercise, as it usually requires a set process that includes public consultation. The lack of flexibility was noted in the 2010 Cabinet papers and subsequently led to the Biosecurity Act amendment in 2012 that permitted minor changes to plans as well as whole and partial plan reviews to be carried out.[106]

Despite these amendments to the Biosecurity Act, no currently operative RPMP has ever been amended in respect of an exotic plant. This may be due to the fact that many RPMPs have only recently been made operative or because a full process is still required in respect of the part(s) of the plan subject to partial review.[107]

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[101] This section draws on a report commissioned for this investigation to review how regional councils manage exotic plants. Wildland Consultants was engaged to gather information via a desktop exercise followed by a survey, identify key themes across and within the regions, and compare and contrast exotic plant management approaches across regional councils. This report is available on the PCE website (Hutchison et al., 2021).

[102] Note that the Waikato Regional Council has prepared a new draft RPMP 2021–2031, which the council publicly consulted on in April 2021.

[103] Twenty years for RPMPs in Hawke's Bay, Manawatū-Whanganui, Wellington, Marlborough and Chatham Islands, and ten years for the remaining 11 RPMPs, given that Tasman and Nelson have a joint RPMP (see Table 6.1).

[104] For example, Auckland Council aims to start working towards the next full RPMP in 2022, even though the current RPMP remains operative until 2030 (Auckland Council staff, pers. comm., 22 September 2021).

[105] However, "pest management intermediate outcomes" specified in the NPD are not actually biodiversity outcomes. Also, with regard to the 20-year duration of plans, the NPD states that "if the period within which the pest management intermediate outcome is expected to be achieved is more than 10 years, state what is intended to be achieved in the first 10 years of the plan, or during the current term of the plan prior to next review (as applicable)." See sub-cls 4(1)(f) and 4(2)(h) of the NPD (New Zealand Government, 2015).

[106] See Biosecurity Act 1993, ss 100D (plan reviews) and 100G (minor changes to plans). Note that while partial plan reviews avoid the need to consult on the entire plan, they still require the full process to be run in respect of the part(s) of the plan under review. Minor changes to RPMPs can be progressed if the council is satisfied that the amendment does not have a significant effect on any person's rights and obligations and is not inconsistent with the NPD.

[107] For example, in August 2019, Marlborough District Council notified a 'review proposal' recommending amendments to the RPMP 2018 to include "wilding pest conifers". This proposal has been appealed, and at the time of writing was in front of the Environmental Court (Environment Court of New Zealand, 2020; MDC, 2020).

While long-term planning is important for achieving biodiversity outcomes, it poses a challenge for responding to new information and emerging threats. This could include the need to modify the list of exotic plants and associated programmes included in RPMPs as a result of a programme review, or having to respond to any new exotic plants that appear within the region's borders, such as occurs when MPI hands over responsibility for the management of an exotic plant to the regional level.[108] Misaligned budgetary and plan-making cycles can also pose problems for a rapid response to an emerging issue. Aligning public consultation on an RPMP with consultation on the 10-year Long-term Plan Budget could be beneficial.[109]

While regional councils often undertake internal reviews of their management programmes to inform and adjust management operations, in-depth formal reviews are rare – and the links between such reviews and resulting decisions are rarely transparent or widely communicated. But such reviews provide valuable learnings from successes and failures, such as the need to continue current levels of wild kiwifruit (*Actinidia* sp.) control in the Bay of Plenty to keep their populations from expanding,[110] and to make defensible decisions – especially decisions to walk away or to scale down management of a weed.

For example, the attempted eradication of woolly nightshade (*Solanum mauritianum*) in the Bay of Plenty region during the 1990s was reviewed in 2003.[111] This review identified factors – both ecological and operational – that contributed to the failure to eradicate woolly nightshade and justified a shift to a containment approach while emphasising the importance of trialling new management tools, like biological control.

This case also highlights how exotic plant management decisions have to balance limited resources across multiple risks – including several native ecosystem weeds, such as wild kiwifruit and wild ginger (*Hedychium* sp.), which were emerging as invaders at the time of the 2003 review (Figure 6.6). Transparent decision making using formalised risk assessments coupled with reviews of priorities and management approaches are needed to clearly communicate that the decisions made are justified given the risks weeds pose to native ecosystems and the feasibility of control with limited resources.

[108] For example, the Himalayan wineberry incursion in Auckland.

[109] For example, public consultation on Auckland Council's current RPMP 2020–2030 coincided with the consultation on the 10-year Budget (Long-term Plan) 2018–2028, providing an opportunity to increase the scope of the RPMP. While this coincidence was serendipitous, for the next RPMP, Auckland Council is planning to build in this timing consideration into its project planning (Auckland Council staff, pers. comm., 22 September 2021).

[110] Sullivan, 2014.

[111] Stanley, 2003.

Source: Anna Hooper

Figure 6.6: Wild ginger (*Hedychium* sp.) seed can be spread by birds, but it also spreads vegetatively via rhizomes, invading even intact forest.

How the National Policy Direction for Pest Management has been picked up in regional pest management plans

Management programmes: Attempt at consistency and clarity

One aim of the NPD was to improve consistency of terms used in regional pest management. It achieved that by standardising the names of management programmes (exclusion, eradication, progressive containment, sustained control and site-led programmes) and requiring their use in pest management plans. However, some problems remain.

While the NPD sets out a standardised framework and a process for the preparation of plans, including RPMPs, final RPMPs that emerge reflect public and political pressures to varying degrees. The analysis commissioned for this investigation concluded that "the considerable variation in the number of [exotic plants] managed through RPMPs … [is] … primarily due to political and cultural differences among the regional councils."[112]

[112] Hutchison et al., 2021, p.12.

Variations in approaches can also be seen with the use of site-led programmes. Auckland, Waikato, Gisborne, Wellington, Tasman-Nelson, Canterbury, Otago and Southland councils have site-led programmes in their current RPMPs. The rules for site-led programmes vary with context (as one might expect).

For example, to control banana passionfruit (*Passiflora* sp.), Environment Canterbury has a site-led programme for which it "will take a lead role" with the aim of reducing its extent by 50 per cent at each site within ten years (Figure 6.7).[113] By comparison, Otago Regional Council aims to progressively contain banana passionfruit "to avoid, mitigate or prevent damage to the native ecosystem values" on the Otago Peninsula, one of the areas with a site-led programme.[114] Otago Regional Council aims to achieve this by "supporting community groups and agencies in bringing about the desired levels of environmental protection."[115]

Source: James Newman

Figure 6.7: With tendrils ever on the lookout for something to wrap around, banana passionfruit (*Passiflora* sp.) can quickly cover entire canopies in a carpet of vines. The fruits are also popular with birds, possums and people, adding to the ways the plant can spread.

Otago Regional Council's RPMP does not have any occupier control rules but notes that these may be necessary in the future.[116] By contrast, site-led programmes in Auckland Council's RPMP include rules such as requiring landowners within the buffer zone of parks to destroy specific exotic plants such as wild ginger.[117]

[113] See Table 32 in Environment Canterbury (2018, p.72).
[114] ORC, 2019, p.70.
[115] ORC, 2019, p.70.
[116] See Table 26, ORC (2019, p.70).
[117] See rule 7.5.2.17.1 in Auckland Council (2020).

While the NPD identifies "protecting values in places" as an intermediate outcome of the site-led programmes,[118] Northland, Bay of Plenty, Hawke's Bay, Taranaki, Horizons, Marlborough, West Coast and Chatham Islands councils have decided to use non-regulatory approaches to protecting specific values in specific places. No site-led programmes with site-led rules are included in their RPMPs. Further, some regional councils stated that non-regulatory site-led approaches specifically for protecting biodiversity and native ecosystems are supported through other council initiatives and strategic direction.[119]

The variable use of site-led management programmes in RPMPs suggests a need to further examine the NPD's requirements. Site-led programmes are different from the other four management programmes – exclusion, eradication, progressive containment and sustained control – being focused on sites, not specific pests. But the NPD definition of site-led programmes still talks about pests being "excluded or eradicated from that place, or contained, reduced, or controlled".[120] This creates the potential for site-led programmes to duplicate or overlap with the other programmes focused on exclusion, eradication, progressive containment, or sustained control.

The potential for overlap is further increased by the NPD requiring specification of a geographic area to which outcomes apply for *all* of the management programmes, not just site-led ones. As such, RPMPs include various maps of areas where progressive containment or sustained control applies. These areas can be as small or as big as a council decides.

Furthermore, the definitions of management programmes and intermediate outcomes in the NPD are scarcely expressed in clear, unambiguous language. Sustained control programmes are, for example, defined as providing for ongoing control of the pest to reduce its impacts and its spread to other properties. Importantly, the degree of control is not spelt out.[121]

Organisms of interest: A catch-all category

Under the Biosecurity Act, a pest is defined as "an organism specified as a pest in a pest management plan" (which includes national and regional pest management plans). However, section 70(2)(d) of the Biosecurity Act allows the proposal for a pest management plan to also include "any other organism intended to be controlled".[122] This opens the door for the inclusion of various organisms, including exotic plants, without conferring pest status on them, even though the NPD does not mention 'organisms of interest' as one of its five pest management programmes.

[118] NPD, sub-cl 4(1)(v) for pest management plans and sub-cl 4(2)(v) for pathway management plans (New Zealand Government, 2015).

[119] For example, see Horizons Regional Council (2017).

[120] See NPD sub-cl 5(1)(e) (New Zealand Government, 2015).

[121] Vague definitions and a lack of clarity with regard to requirements leave lots of room for variable interpretation. Regional councils vary in their interpretation of what 'sustained control' means, and what rules are appropriate to be included (Auckland Council staff, pers. comm., 22 September 2021).

[122] Biosecurity Act 1993, s 70(2)(d).

Many RPMPs refer to organisms capable of causing adverse effects, particularly to biodiversity and native ecosystems, that pose a sufficient future risk to warrant being watch-listed. The categorisation of plants (and other pests) as 'organisms of interest', often in an appendix to an RPMP, appears to be a direct attempt to trigger section 70(2)(d). The reasons for this categorisation differ from region to region, ranging from legacy reasons (i.e. carrying over plants from past plans) to promoting education and research and investigating opportunities for ongoing surveillance or future control. In some cases, it may simply be to satisfy public or political pressure.[123] However, not all regional councils include organisms of interest in their RPMPs.[124]

Designating plants as *organisms of interest* instead of *pests* means that the quite extensive powers available to councils and authorised persons under the Biosecurity Act to manage and eradicate pests will not apply unless they are re-categorised as pests. An analysis of exotic plants listed only as organisms of interest in RPMPs revealed that on average these plants have been wild in New Zealand for longer, occur in more regions, and are less likely to be impacting on native ecosystems than exotic plants specified within RPMP programmes.[125] This does not mean, however, that these plants are more or less harmful to native ecosystems than the exotic plants included in RPMPs as pests.

The *organisms of interest* label feels like a catch-all category, without a clear indication of how this identification is supposed to contribute to managing the impacts of exotic plants labelled as organisms of interest on either productive or native ecosystems. In addition, this category implies some form of management, when in reality none may be occurring. It might make more sense to have these plants declared as pests in RPMPs, or not included at all – with the reasons for their omission transparently communicated.

Good neighbour rules: Ineffective rules for managing the spread of weeds into native ecosystems

Simply put, good neighbour rules are rules in RPMPs that direct land occupiers to undertake certain actions to manage the spread of a pest to nearby land beyond their ownership. For example, land occupiers may be required to maintain a certain width of boundary strip clear of a pest.

The Biosecurity Act 1993 defines a good neighbour rule as a rule that:

- applies to an occupier of land and to a pest or pest agent that is present on the land
- seeks to manage the spread of a pest that would cause costs to occupiers of land that is adjacent or nearby
- is identified in an RPMP as a good neighbour rule
- complies with the directions in the national policy direction relating to the setting of good neighbour rules.[126]

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[123] For example, Waikato's proposed Biosecurity Strategic Plan 2021–2031 states: "Only some harmful species are designated as pests in Waikato Regional Council's RPMP, however, many others present a biosecurity risk. The council can provide advice on organisms that are of interest to the Waikato and that may be candidates for pest status in the future, depending on changes to their distribution or degree of impact, as well as the ability for us to successfully control these species" (Palmer and McKenzie, 2021, p.12).

[124] Depending on the RPMP, pest plants listed in an appendix may be called organisms of interest, non-RPMP pests or advisory pests. Currently operative RPMPs for Auckland, Gisborne, Taranaki, Manawatū-Whanganui and Marlborough regions do not include organisms of interest. Bay of Plenty's proposed RPMP included an appendix with 55 plants listed as advisory pests. This appendix was challenged in the Environment Court and, as this report was going to print, the Environment Court released its decision directing Bay of Plenty Regional Council to modify its RPMP by moving 24 plants from the appendix into the sustained control programme, leaving 31 plants in the appendix. (Kirkpatrick et al., 2021).

[125] Hutchison et al., 2021.

[126] Biosecurity Act 1993, s 2.

Further, the Act states that "a good neighbour rule in a plan, or action taken under a plan to enforce a good neighbour rule in the plan, are the only ways in which a plan may cause the Crown to become liable to meet obligations or costs".[127] This means that *all* land occupiers, regardless of tenure, are now required to meet good neighbour rules under RPMPs. The NPD provides legal requirements on the setting of good neighbour rules in RPMPs, in accordance with the Biosecurity Act.[128]

The NPD explicitly states that before a rule can be identified as a good neighbour rule in an RPMP, the regional council must be satisfied that:

- in the absence of the rule, the pest would spread to land that is adjacent or nearby within the life of the plan and would cause unreasonable costs to an occupier of that land
- the occupier of the land that is adjacent or nearby is taking reasonable measures to manage the pest or its impacts
- the rule does not set a requirement on an occupier that is greater than that required to manage the spread of the pest to adjacent or nearby land
- it has considered whether the costs of compliance with the rule are reasonable relative to the costs that such an occupier would incur, from the pest spreading, in the absence of a rule.[129]

Given that the scale of what would need to be managed could be epic (e.g. controlling wind-dispersed plants), the word 'reasonable' seems key here.

So, in MPI's words, good neighbour rules "are not about eradicating a pest or managing its spread throughout a region. Rather, … good neighbour rules focus on managing any costs caused to neighbours by the spread of pests."[130] It explains the rationale for good neighbour rules in these terms:

> "Land occupiers do not have an absolute right to impose impacts on their neighbours; nor do they have an absolute obligation to prevent all pest spread off their land. A reasonable balance of property rights between the two extremes needs to be determined, and good neighbour rules seek to establish this balance."[131]

The introduction of good neighbour rules that apply to all land occupiers regardless of tenure was seen as an attempt to address "escalating tensions" between the Crown and regional councils,[132] as prior to the rules being introduced the Crown was not required to participate in regional pest management.[133] The key risk of the escalating tensions as stated by a 2010 Cabinet paper was the risk of regional councils pulling back on investment:

> "Maintaining the situation, where the Crown is not required to participate in regional pest management, may result in regional councils and communities pulling back on investment in regional pest management and commitment to working with central government in other areas."[134]

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[127] Biosecurity Act 1993, s 69(5).

[128] Biosecurity Act 1993, s 56; NPD, cl 8 (New Zealand Government, 2015).

[129] See NPD, sub-cls 8(1)(a), (c), (d) and (e)(ii) (New Zealand Government, 2015).

[130] MPI, 2013, p.37.

[131] MPI, 2013, p.37.https://www.mpi.govt.nz/dmsdocument/3489/direct

[132] Carter, 2010a, p.6.

[133] Interestingly, according to the 2015 MPI guidance document, binding the Crown was not the primary purpose of good neighbour rules (MPI, 2015b, p.42).

[134] Carter, 2010a, p.6.

This Cabinet paper argued that the NPD and binding the Crown would result in improved engagement between the Crown and regional councils, more efficient and effective activities over time, and continued willing participation of regional councils and communities in the biosecurity system.[135] The Cabinet paper concluded that MAF officials considered "the benefits of more effective and efficient regional pest management outweigh the residual and financial risks to the Crown of being bound, as they are only the same kind of risks that all other landowners face now".[136] At the time, concerns were expressed about binding the Crown to RPMPs.[137]

Because good neighbour rules confine their focus to neighbours and boundaries and are not intended to address the wider spread of exotic plants, they have a very limited ability to curb the spread of weeds into native ecosystems. But even with the focus on the boundaries, several issues stand out.

Firstly, there is considerable variability in the use of good neighbour rules in RPMPs across the country. Not all regional councils and unitary authorities decided to include these rules in their current RPMPs. For example, while Gisborne District Council has 40 good neighbour rules for exotic plants in its RPMP, Bay of Plenty Regional Council and Greater Wellington Regional Council do not have any.

Auckland Council's RPMP contains just one region-wide good neighbour rule that applies throughout rural Auckland, for gorse, and eight good neighbour rules that apply in specific areas, such as proximity to Auckland's highest ecological value parks. Auckland Council considers that region-wide good neighbour rules are not particularly effective from a native ecosystems-protection perspective, especially for widespread weeds. As a result, it considers that managing multiple weeds in high-value native ecosystems and preventing reinvasion into these ecosystems (via buffer zones, which are essentially good neighbour rules) is a better approach.[138]

Secondly, analysis of the exotic plants included in the current RPMPs with good neighbour rules reveals that regional councils use good neighbour rules for exotic plants that have an impact on both native ecosystems and productive landscapes. Interestingly, while most exotic plants that have a good neighbour rule somewhere in the country impact on biodiversity, the good neighbour rules per region become distinctly less biodiversity-focused overall as one moves southwards.[139]

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[135] Carter, 2010a, p.8.

[136] Carter, 2010a, p.9.

[137] In 2011, Forest and Bird said that this arrangement would "effectively make national pest management objectives, often defined or required by statute, subservient to regional pest management objectives, when the reverse should apply". Further, Forest and Bird noted that if this proposal was to proceed, then an increase in Vote Conservation would be required (Forest and Bird, 2011, p.5). ECO shared similar concerns that requiring the Crown to meet good neighbour rules would result in "the Department of Conservation spending money on local pest issues which have little impact on indigenous biodiversity … while spending on important risk species … suffers" (ECO, 2011, p.2). It is not clear that these reservations have in fact been borne out, since DOC still has its own separate system to prioritise exotic plant control on its land. Further, DOC's contribution to regional pest management of $2.7 million in 2019/2020 is a reasonably small sum compared with its spend on natural heritage – $240 million in the same year (DOC, 2020a).

[138] Auckland Council staff, pers. comm., 22 September 2021.

[139] Currently, good neighbour rules are used for a total of approximately 38 exotic plants that affect ecosystems and biodiversity – 11 of which are exotic plants that impact productive landscapes, and 24 impact both. Further, good neighbour rules in Northland, Auckland, Waikato and Gisborne are all (or almost all) for exotic plants with biodiversity impacts (though many of these plants affect production systems, too), while good neighbour rules in the South Island are almost exclusively for plants that have some type of production impact (almost all have both types of impacts, and only lupins are exotic plants with 'biodiversity only' impacts).

Thirdly, the management requirements these rules apply, such as the width of the boundary strips required, are frequently at odds with plant invasion ecology. For example, Otago Regional Council's RPMP specifies the following widths for boundary strips: 20 metres for old man's beard (*Clematis vitalba*); 200 metres for wilding conifers; 10 metres for gorse and Scotch broom; 100 metres for nodding thistle (*Carduus nutans*); 50 metres for ragwort; and 10 metres for wild Russell lupin (*Lupinus polyphyllus*). Auckland's buffer zones are a notable exception. The width of the buffer zone around Auckland's highest ecological value parks has been set at 500 metres following an internal analysis of literature on wind and bird dispersal distances.

The efficacy of any of these boundary strips must be questionable, especially for bird-dispersed and wind-dispersed plants. While ten metres is likely a sufficient boundary strip for gorse because few seeds, if any, are likely to fall more than five metres from the edge of a 1.5-metre-tall gorse bush, some prescribed boundary strips appear much too narrow to prevent spread by exotic plants onto neighbouring properties.[140] For example, studies overseas have measured seeds of Douglas fir (*Pseudotsuga menziesii*) dispersing up to 800 metres and seeds of Scots pine (*Pinus sylvestris*) dispersing up to two kilometres – or eight to ten times the width of their prescribed boundary strip.[141]

About half the seeds of a radiata pine (*Pinus radiata*), a relatively large-seeded pine species, are expected to disperse beyond 200 metres under a moderate wind (Figure 6.8).[142] Similarly, overseas research suggests seeds from old man's beard can travel 100 metres – five times its prescribed boundary strip in Otago Regional Council's RPMP.[143] Of course, not all seeds will be dispersed to the maximum dispersal distance, but the narrow width of the boundary strips leaves their efficacy questionable.

[140] Hill et al., 1996.

[141] Tamme et al., 2014, Supplement 1.

[142] Wyse et al., 2019.

[143] Tamme et al., 2014, Supplement 1.

Source: James Newman

Figure 6.8: Once radiata pine (*Pinus radiata*) cones are split open by heat, winged seeds (not shown) can be blown far and wide by a strong wind.

While setting different widths of boundary strips for different exotic plants makes ecological sense, setting different widths for the same exotic plants across different regions does not. For example, the width of the boundary strips to which good neighbour rules apply for wilding conifers in the Northland region is ten metres. This width increases to 50 metres in the Gisborne region, 100 metres in Waikato and 200 metres in most other regions with good neighbour rules for a group of wilding conifers. Similar variability can be observed for old man's beard, with the width of the boundary strips ranging from 10 metres to 500 metres.

Finally, the enforcement of good neighbour rules in all regions but one is complaint-based: an occupier of neighbouring land (who must themselves be taking reasonable steps to manage a pest along the boundary) needs to complain to the regional council about the neighbour. By comparison, the Auckland RPMP's use of buffer zones relies on council enforcement throughout a buffer zone in a coordinated manner to avoid constant reinvasion from non-compliant neighbours, and to the extent required to maintain the ecological integrity of adjacent Auckland parks and their ecosystems.[144] Further, the NPD and RPMPs are silent about any burden of proof requirements. In some cases, it is almost impossible to demonstrate that exotic plants have indeed come from a specified property.

The Biosecurity Act allows regional council officers to inspect exotic plants on land and, if necessary, advise landowners of the need to undertake control work. If that work is not done, council officers have the power to advise of their intention to carry out the work on the land on the landowner's behalf.[145] Significant difficulties occur when that landowner is the Crown.[146] These are caused by the need to obtain permissions under the Reserves Act, the National Parks Act and the Conservation Act. These Acts make it an offence to carry out particular activities on land held under those Acts without authorisation, some of which might fall under common control practices (e.g. removing plants from a reserve). Authorisation is required for a regional council appointee to undertake these activities on reserve land, national parks or conservation land, and the relevant administrative body (e.g. DOC) could decline access to a person trying to carry out control activities for the regional council under the Biosecurity Act.

In short, good neighbour rules are not an effective means to tackle invasions at a landscape scale and, whatever their benefits, should not provide any comfort that they are preventing the spread of weeds into native ecosystems.

The unclear role and utility of cost–benefit analyses

The Biosecurity Act requires all proposals for national and regional pest management plans and pathway management plans to outline the benefits and costs of the plan, including the extent to which any person or group is likely to benefit from the plan and contribute to the creation, continuance, or exacerbation of the problems proposed to be resolved by the plan, and the rationale for the proposed allocation of costs.[147] This does not necessarily mean that costs and benefits need to be monetised.

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[144] This means that except for the good neighbour rule for gorse to protect rural primary industry, Auckland Council no longer does isolated reactive complaint-based enforcement (Auckland Council staff, pers. comm., 22 September 2021).

[145] Biosecurity Act 1993, ss 122 and 128.

[146] Environment Canterbury staff, pers. comm., 22 June 2021 and Waikato Regional Council staff, pers. comm., 27 July 2021.

[147] Biosecurity Act 1993, ss 61, 70, 81 and 90. These apply in relation to national and regional pest management plans and national and regional pathway management plans.

In addition, the Act specifies that when preparing any of these plans, the Minister for Biosecurity (in the case of national plans) or the council (in the case of regional plans) needs to be satisfied that for each pest, "the benefits of the plan would outweigh the costs, after taking account of the likely consequences of inaction or other courses of action".[148] Further, the NPD outlines legal requirements for analysing benefits and costs for any pest or pathway proposed for inclusion in pest or pathway management plans.[149] It also outlines legal requirements for proposed allocation of costs for pest and pathway management plans.[150]

The Biosecurity Act's almost laser-like focus on costs, benefits, funding and compensation, throughout the pest management part of the Act, emphasises the relative weight placed on these factors in decision making in a way that threatens to trump every other consideration. Forest and Bird raised the concern in 2011 that cost–benefit analysis could become a barrier to precautionary action to protect the environment:

> "The cost and benefits of action or inaction in relation to the natural environment (or other intangible public values) are notoriously difficult to measure, let alone monetarise. Cost-effectiveness must be considered in a [plan], that is a given; however, if it becomes an *absolute criteria* [sic], then the Minister is prevented from taking precautionary action or acting in the public interest where there are benefits but where they are difficult to cost."[151]

In fact, the Biosecurity Act explicitly states that costs and benefits include "costs and benefits of any kind, whether monetary or non-monetary".[152] Further, the NPD does not mandate monetisation of costs and benefits. Rather, it states that quantification of costs and benefits should only occur where it is practical to do so.[153]

However, this poses another challenge. On the one hand, a qualitative identification and description of costs and benefits recognises that many environmental costs and benefits suffer from data deficiencies and subjectivity bias, so they can be difficult to meaningfully quantify. On the other hand, if values that native ecosystems provide are not monetised through a conventional cost–benefit analysis, they are often overlooked in policy decision making.[154] This suggests that additional support for the use of alternative methods could be beneficial.

One of the biggest challenges with environmental cost–benefit analysis is that it is difficult to monetise non-market values, which can be considerable. What value do we place on a tūī or flax, or wilding conifers marching up tussock-covered hill slopes? And do we even feel comfortable attempting this? For many Māori thinking about a tūī (*Prosthemadera novaeseelandiae*) through a whakapapa lens, monetising this relationship is an unthinkable ask, akin to monetising your grandmother. But this is true for many other New Zealanders as well. Monetary values have a place, but they should not be privileged at the expense of cultural and biodiversity values.

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[148] Biosecurity Act 1993, ss 62, 65, 71, 74, 82, 85, 91 and 94. These apply in relation to national and regional pest management plans and national and regional pathway management plans.

[149] See cl 6 of the NPD (New Zealand Government, 2015).

[150] See cl 7 of the NPD (New Zealand Government, 2015).

[151] Forest and Bird, 2011, p.4. To give the Minister for Biosecurity flexibility to take a precautionary approach, Forest and Bird recommended that the phrase "must be satisfied that" be replaced with a more flexible "must have regard to" (Forest and Bird, 2011, p.5).

[152] Biosecurity Act 1993, s 2.

[153] See NPD, sub-cls 6(2)(c) and 6(2)(d) (New Zealand Government, 2015).

[154] For example, Auckland Council's *Proposed Regional Pest Management Plan – Cost Benefit Analyses* states: "There are widely recognised difficulties (both logistical and philosophical) in ascribing monetary values to native ecosystems. Nonetheless, it is acknowledged that native ecosystems do provide functions that benefit humans, but that the human use value of the environment is often overlooked in decision-making if it is not monetised" (Auckland Council, 2018, p.2).

Within the New Zealand context there are relatively few non-market value estimates available for use in environmental cost–benefit analyses. Where estimates do exist, they are often patchy, inconsistent or not directly comparable and not readily generalisable.

Taking into account geospatial effects can also be problematic. Regional councils and unitary authorities use their ratepayer base to fund pest management activities for numerous outcomes – including economic wellbeing, the environment, health and safety. Regional councils are incentivised to fund pest management activities on the basis of the benefits these activities will deliver to their region and the ratepayers who ultimately fund regional pest management programmes. Further complications stem from the fact that neither exotic plants (and other pests) nor ecosystems respect political boundaries. Pest management undertaken in one region may deliver benefits to neighbouring regions or, in the case of a new incursion, to the country as a whole.

The same issue applies to neighbouring properties – actions on one parcel of land can benefit or harm others nearby. This can be problematic when carrying out an environmental cost–benefit analysis because it is unclear how costs and benefits spread across multiple regions should be accounted for (and not double counted).

Finally, the Act's almost singular focus on costs and benefits is at odds with the wealth of other techniques that can be deployed to test the value and effectiveness of proposed interventions. These tools are not mutually exclusive and could be used in complementary ways to gain a more complete picture of a proposed pest management strategy. Some of these tools include:

- cost-effectiveness analysis
- cost–consequence analysis
- multi-criteria analysis
- risk–benefit assessment
- options analysis
- stress testing
- scenario analysis
- extreme event analysis.

Each method varies in its degree of comprehensiveness, the way time is treated and the degree to which costs and benefits are incorporated and quantified.

Among the legal requirements outlined by the NPD is a requirement to identify two or more options for responding to a pest that is spreading (one option must be either taking no action or taking the actions that would be expected in the absence of a plan).[155] While this requirement reads like a requirement for an alternative plan to be considered, by nature, cost–benefit analysis includes a counterfactual for any proposed options to be compared with. While it is essential to recognise taking no action as a baseline scenario, the NPD stops short of requiring a comparison with a baseline scenario or consideration of more than one management programme (e.g. a comparison between sustained control and progressive containment). This means that the NPD does not require a genuine options analysis, but only an analysis of whether a single proposed plan is more cost effective than doing nothing.

[155] See NPD, sub-cl 6(2)(b) (New Zealand Government, 2015).

Despite the NPD's prescriptiveness, practices vary. For example, Bay of Plenty Regional Council used cost–benefit analysis to explore progressive containment and sustained control options for control of woolly nightshade across the region and in defined areas.[156] By contrast, cost–benefit analysis undertaken by Taranaki Regional Council only compared proposed management programmes (e.g. eradication) to no management.[157]

The NPD requires that when plans are prepared, any risks that an option will not achieve its objective need to be taken into account.[158] The NPD also stipulates that following the analysis of costs and benefits and stating the assumptions made, there needs to be a clear identification of the *preferred option*.[159]

These two requirements go beyond what it is reasonable to expect a cost–benefit analysis to be able to achieve on its own for several reasons. Cost–benefit analyses are not risk assessments, and while they may inform one, other approaches are more appropriate to understand risk and uncertainty. An assessment of whether or not an option is preferred should take into account the quality of the assumptions that inform the analysis (including the uncertainty associated with expected costs and benefits), the un-monetised costs and benefits, and the feasibility of the option. It may also be appropriate for an assessment of the preferred option to take into account the inherent value of biodiversity and native ecosystems independent of their impact on social welfare.

The approach taken by the regional councils to analyse benefits and costs as part of the RPMP preparation process has varied. For example, some regional councils have used a qualitative approach, relying on knowledge and expertise of staff, data and scientific papers on pests to tell the story. Others have opted for a quantitative modelling route, while others still have deployed a combination of approaches.[160] Most councils used a mixture of in-house and external resources to undertake cost–benefit analyses.

The NPD requires that the majority of the information used during the process, including any assessments made, must be made publicly available alongside any proposed plan. Critically, however, the actual components of any cost–benefit analysis undertaken are missing from this requirement.[161] As a result, while all regional councils and unitary authorities have published a cost–benefit analysis document alongside their proposed RPMPs, the level of details included varies widely.

While Auckland Council's cost–benefit analysis report ran to 2,626 pages, Taranaki Regional Council's cost–benefit analysis in support was 86 pages long.[162] Commendably, Bay of Plenty Regional Council went to the trouble of publishing an additional spreadsheet capturing the results of cost–benefit analyses for all pests (including all considered options if there were several), irrespective of whether or not these pests ended up in the final RPMP.[163]

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[156] Bay of Plenty Regional Council, 2020.

[157] Taranaki Regional Council, 2017b.

[158] See NPD, sub-cl 6(2)(g) (New Zealand Government, 2015).

[159] See NPD, sub-cl 6(2)(j) (New Zealand Government, 2015).

[160] Three main models were used by regional councils to analyse benefits and costs: (1) a model developed by Wildland Consultants and Lincoln University, (2) a model developed by Land Water People, and (3) a model developed by AgResearch. Some councils (e.g. Bay of Plenty Regional Council) used two of the three models (Palmer, 2020).

[161] Sub-cl 6(5) of the NPD states: "The proposer of a pest management plan or pathway management plan must document the assessments made in sub clauses (1), (3) and (4) and make them publicly available with the proposal for a pest or pathway management plan" (New Zealand Government, 2015).

[162] See Auckland Council (2018) and Taranaki Regional Council (2017b).

[163] Bay of Plenty Regional Council, 2020.

Significantly, a survey of regional council staff conducted in 2020 revealed that the cost–benefit analysis component of the RPMP development process was considered to generate "the most effort for the least value":

> "All respondents understood the CBA [cost–benefit analysis] process to be a justification to ratepayers and Council for proposed expenditure on management programmes for pests in an RPMP, in terms of the net benefit (and avoided costs) derived to economic, social, cultural, recreational and environmental values as a result of management interventions. However, it was raised that it is likely the majority of ratepayers would not understand the process or outputs of a CBA, and therefore the value and transparency of undertaking this process has been questioned – especially when it is so time intensive and costly to produce, and the outputs of the various CBAs did not result in any changes to proposed programmes, nor have any challenges to the CBAs been raised in Environment Court to date."[164]

Furthermore, comments made by some council staff suggested that undertaking a proper cost–benefit analysis for each pest proposed for inclusion in an RPMP would be cost prohibitive, as the budget equivalent needed to undertake a robust cost–benefit analysis for only one or two pests would have to be spread over 30 to 40 pests.[165] In reality, as mentioned earlier, the plants included in RPMPs around the country reflect public and political pressures to varying degrees.[166] Given scarce resources but no scarcity of exotic plants, it is important to ensure that money spent on cost–benefit analyses for a pest management plan does not exceed the budget set aside to actually manage the pests. Pragmatically, a cost–benefit approach to the use of cost–benefit analysis might be revealing.[167]

In summary, it is worth remembering that there are many factors to consider when deciding to undertake a cost–benefit analysis. They include the availability of environmental values, the cost of undertaking the analysis relative to the cost of the programme, and the scope of analysis required. As cost–benefit analysis is just one tool in a toolbox, consideration needs to be given to whether other tools like cost-effectiveness analysis or cost–consequence analysis might be more appropriate.

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[164] Palmer, 2020, pp. 15–16.
[165] Palmer, 2020, p.15.
[166] Hutchison et al., 2021, p.12.
[167] NZIER, 2018.

7


Euphorbia paralias

Roles, responsibilities and what happens in practice

Who is managing exotic plants in New Zealand?

Six central government agencies (Ministry for Primary Industries (MPI), Department of Conservation (DOC), Toitū Te Whenua Land Information New Zealand (LINZ), Waka Kotahi NZ Transport Agency, KiwiRail, and New Zealand Defence Force (NZDF)), along with regional councils, territorial authorities and Queen Elizabeth II (QEII) National Trust, play a role in managing exotic plants across the country.[1] However, the roles of the organisations differ.[2]

MPI and regional councils provide leadership in pest management nationally or in the regions (respectively), and undertake actions to manage pests, including exotic plants, present in New Zealand.[3] DOC has a dual role – being both a land manager and guardian of native biodiversity – tasked under various legislation with taking action to protect that biodiversity from various threats, including native ecosystem weeds. LINZ, Waka Kotahi, KiwiRail and NZDF are essentially Crown land managers, whose exotic plant management has tended to be reactive rather than proactive.[4]

LINZ manages over 2 million hectares of Crown land, including lakebeds and riverbeds. In 2019, LINZ's biosecurity programme received additional funding for the management of aquatic exotic plants in lakes, and in 2020 received funding to manage land-based exotic plants along riverbanks. The aquatic programme aims to protect LINZ-managed lakes from aquatic weeds such as lagarosiphon (*Lagarosiphon major*) and hornwort (*Ceratophyllum demersum*), and focuses on control of these species as well as pathway management to stop further spread.

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1 The focus here is on spending by government agencies and other large organisations, which is not to detract from the considerable effort undertaken by many individual landowners and groups on the ground to control exotic plants.

2 QEII National Trust is an independent charitable trust established by the Queen Elizabeth the Second National Trust Act 1977. Its mission is to inspire private landowners to protect and enhance open spaces of ecological and cultural significance. QEII partners with private landowners to protect sites on their land with covenants, creating protected areas throughout New Zealand. Providing support and advice to landowners on exotic plant control is part of this work. See https://qeiinationaltrust.org.nz/about-us/.

3 Regional councils also have a role under the Resource Management Act 1991 (RMA) to maintain native biodiversity in their regions.

4 Territorial authorities also have a role under the Biosecurity Act and RMA. However, their involvement in exotic plant management varies across the country. For example, while Wellington City Council has a dedicated biodiversity strategy and action plan (*Our natural capital*), this is an exception rather than a rule (Wellington City Council, 2015). See Biosecurity Act 1993, s 14 and RMA 1991, s 31(1)(b)(iii).

Terrestrial efforts are mainly focused on Scotch broom (*Cytisus scoparius*) and gorse (*Ulex europaeus*) on the banks of non-braided rivers, and Scotch broom, gorse, false tamarisk (*Myricaria germanica*) and Russell lupins (*Lupinus polyphyllus*) on the banks and islands along braided rivers. Prior to the recent increase in funding, almost all management efforts had been focused on Scotch broom and gorse. As a Crown land manager, LINZ also must comply with good neighbour rules in regional pest management plans (RPMPs; discussed in chapter six) by managing boundary strips for certain exotic plants.

NZDF is the third biggest land manager in New Zealand – in total managing about 0.5 per cent of the New Zealand land area, split into blocks spread throughout the country, ranging from vast areas of South Island high country to smaller city plots. Relevant exotic plant management work includes the wilding conifer work near Tekapo and Waiōuru as part of the National Wilding Conifer Control Programme.

Waka Kotahi is another Crown land manager. From the perspective of exotic plants, roads act as pathways of human-assisted spread on, in or with the various forms of transport. Exotic plant management along roadsides is often complaints-based, and Waka Kotahi's efforts tend to focus on the plants listed in RPMPs – again, the plants listed differ from region to region.

KiwiRail manages rail corridors, off-track rail reserves and yards. Like road corridors, rail corridors, which are narrow strips of land that run throughout many parts of the country, provide pathways for exotic plants to spread.

The Ministry for the Environment appears to be surprisingly absent from the conversation on exotic plants. Beyond its ongoing involvement in drafting the proposed National Policy Statement on Indigenous Biodiversity (NPS-IB), it remains a spectator of the weed management efforts.

MPI, DOC and regional councils have broader and more substantive roles. These are examined in more detail later in this chapter.[5]

What are they spending to control exotic plants?

It is difficult to provide a clear picture of exactly how much is spent each year in New Zealand on controlling exotic plants and what fraction of that is devoted to native ecosystem weeds. However, it is possible to provide some information. Figure 7.1 tracks much of the expenditure by the organisations mentioned above on managing exotic plants over the last five years.[6] Together, these organisations have spent around $50 million per annum (averaged over the last five years). While considerable, this figure does not include the money spent by numerous landowners and various groups around the country.

[5] While territorial authorities also have a role, their involvement in exotic plant management varies across the country. For example, while Wellington City Council has a dedicated Biodiversity Strategy and Action Plan (*Our natural capital*), this is an exception rather than a rule (Wellington City Council, 2015). See Biosecurity Act 1993, s 14, and RMA 1991, s 31(1)(b)(iii).

[6] Note that in many cases the amounts shown here only provide an approximation of the total amount spent by each organisation on managing exotic plants. Some organisations provided budgeted amounts being spent, whereas others provided actual or estimated spends. Some organisations were not able to cleanly split out spending on exotic plants from other management actions, and some did not include all exotic plant-related costs (such as monitoring or technical support).

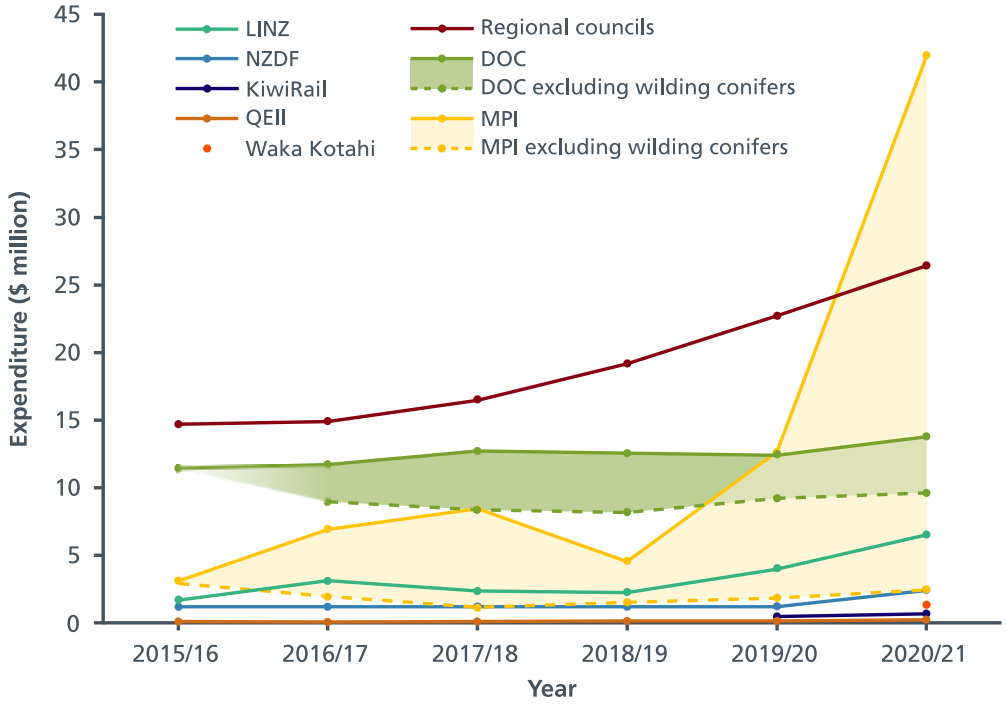
These amounts include money allocated for managing exotic plants for any purpose, so spending focused on native ecosystems is a subset of this. The biggest single item comprises the large National Wilding Conifer Control Programme, which began in 2016. The huge increase in spending by MPI in recent years is essentially due to the extra funding allocated for this programme. Aside from wilding conifers, expenditure by MPI on managing all other exotic plants has fluctuated from year to year due to various responses and pest management efforts but never been more than $3 million per annum.

Combined spending by all regional councils and territorial authorities on plants in their RPMPs has been increasing in recent years, almost doubling from $15 million in 2015/2016 to $26 million in 2020/2021. This total includes council spending on wilding conifers, if wilding conifers were included in RPMPs. In some cases, such work on wilding conifers is detailed in rates allocation. For example, Environment Canterbury allocates some of its general rates for wilding control, and Otago Regional Council has a targeted rate for 'wilding trees'. Not all plant-related spending by councils is captured here – many councils allocate funds to controlling weeds as part of their biodiversity programmes that are outside of RPMPs.

DOC has increased its overall spending on exotic plants to a lesser degree over the same time frame – rising from $11 million in 2015/2016 to $14 million in 2020/2021. Its expenditure on wilding conifers has increased too, rising from $2.7 million in 2016/2017 to $4.1 million in 2020/2021, effectively meaning that spending on all other exotic plants remained relatively steady over the time frame.

LINZ has increased its spending in recent years too – almost four times as much in 2020/2021 as 2015/2016. Much of the increase is going towards work on aquatic and terrestrial exotic plants on river and lake margins. LINZ spent 60 per cent of its budget on exotic plants in lakes in 2020/2021. Very little of its budget is spent on wilding conifers.

NZDF spending has stayed relatively constant in recent years, with the exception of a one-off increase in 2020/21, with the bulk of its work (about 70 per cent) devoted to wilding conifers.



Source: LINZ, NDZF, KiwiRail, QEII, Waka Kotahi, regional councils, DOC, MPI, 2021

Figure 7.1: Expenditure on the management of exotic plants by different organisations from 2015 to 2021. The figure shows the expenditure with and without the expenditure on wilding conifers by MPI and DOC.[7]

Research funding

The Government allocates research funding to support work on controlling exotic plants. Between 2016 and 2019 it announced around $23 million in contestable research funding related to the control of plant-related pests and exotic species. Much of this spending is on two large research programmes for wilding conifers and myrtle rust.[8] Wilding conifers also feature in the latest round of the Endeavour Fund, announced in September 2021. Scion was awarded $13 million over five years to research ways of achieving 'long-term success in managing wilding conifer invasions'. Other ongoing research is funded through the Strategic Science Investment Fund and National Science Challenges – around $2 million annually.[9] Additional funding is sometimes directed towards researching methods for controlling exotic plants. For example, in August 2021 MPI announced a three-year, $3.2 million national research project aimed at finding ways to control six exotic plant species using biological control agents.[10]

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[7] Note that in many cases the amounts shown here only provide an approximation of the total amount spent by each organisation on managing exotic plants.

[8] Calculated based on data supplied by the Ministry of Business, Innovation and Employment (MBIE). Contestable programmes include Endeavour Programmes, Smart Ideas, and The Partnerships Scheme. Most funding went to a wilding conifer research project, with the remainder split across agricultural, freshwater and marine plant pests. Due to the classification, some plant pathogen research is also included in this figure. For more on environmental research funding in Aotearoa, see PCE (2020).

[9] Reported figure is for the financial year 2018/19. The majority of research in the Strategic Science Investment Fund is related to exotic plants in production systems (own calculations based on data supplied by MBIE). See also PCE (2020).

[10] The project is backed by MPI's Sustainable Food and Fibre Futures fund, Manaaki Whenua – Landcare Research, and the National Biocontrol Collective – a consortium of regional councils, unitary authorities and DOC (https://www.mpi.govt.nz/news/media-releases/nationwide-project-offers-hope-in-war-against-weeds/ [23 September 2021]).

MPI's role - what the Act says

Under section 12A of the Biosecurity Act 1993, the Director-General of MPI "provides overall leadership in activities that prevent, reduce, or eliminate adverse effects from harmful organisms that are present in New Zealand". This curiously passive legal drafting does not require the Director-General to provide leadership – it simply states that he is doing it.

Interestingly, this function, added in 2012, only relates to managing harmful organisms (including exotic plants) that are *already* in New Zealand.[11] The Biosecurity Act does not expressly assign the Director-General the same *leadership* role with respect to pre-border or border management, despite the Director-General and MPI's heavy involvement in management at the border.

According to the Biosecurity Act, the ways the Director-General provides leadership include:

- promoting the alignment of pest management within the whole biosecurity system
- overseeing New Zealand's systems for pest management and measuring overall system performance
- facilitating the development and alignment of national pest management plans and national pathway management plans[12]
- promoting public support for pest management
- facilitating communication, cooperation, and coordination among those involved in pest management to enhance effectiveness, efficiency, and equity of programmes.

In addition to the leadership role, the Director-General can appoint chief technical officers and authorised persons.[13] Chief technical officers have the powers to designate **unwanted organisms** they believe to be "capable or potentially capable of causing unwanted harm to any natural and physical resources or human health".[14] The officer must then notify the Director-General, and the Director-General must keep a publicly available register of all unwanted organisms.[15] Currently, the Official New Zealand Pest Register lists 262 unwanted plant taxa.[16]

The designation as an unwanted organism is used to prohibit the deliberate spread of the organism, as the Biosecurity Act states that "no person shall knowingly communicate, cause to be communicated, release, or cause to be released, or otherwise spread any pest or unwanted organism".[17]

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[11] The Ministry of Agriculture and Fisheries (MAF) was the Government's lead agency with respect to biosecurity for New Zealand until 2011, when it was amalgamated into MPI.

[12] Interestingly, back in 2010, the *Managing pests in New Zealand* Cabinet paper envisaged greater focus on public interest, as it stated that "overseeing or providing national pest and pathway management programmes to protect the public interest" was one of the specific functions that MAF was envisaged to be responsible for (Carter, 2010a, p.13).

[13] Chief technical officers are appointed by the Director-General under s 101 of the Biosecurity Act. They must be a person with appropriate experience, technical competence and qualifications relevant to the area of responsibilities allocated to them by the Director-General. Further, chief technical officers have a range of powers (see Biosecurity Act 1993, ss 48 and 49).

[14] Biosecurity Act 1993, s 2.

[15] Biosecurity Act 1993, s 164C.

[16] See Official New Zealand Pest Register (Imports page, https://pierpestregister.mpi.govt.nz/PestsRegister/ImportCommodity/). Calculated by searching for Organism Type = "Plant" and Unwanted = "Yes", which returned 262 records on 8 September 2021.

[17] Several situations are exempt from this rule, including when done in accordance with a pest management plan, or an emergency regulation, or for a scientific purpose carried out with the authority of the Minister for Biosecurity, or as permitted either generally or specifically by a chief technical officer. See Biosecurity Act 1993, s 52.

In addition, authorised persons can be granted the power to:

- compel the provision of information
- inspect and give directions to destroy any pests or unwanted organisms
- take direct measures to eradicate or control harmful organisms
- exercise search and seizure powers.[18]

MPI's role - what happens in practice

While the Biosecurity Act states that the "Director-General provides overall leadership in activities that prevent, reduce, or eliminate adverse effects from **harmful organisms that are present** in New Zealand (pest management)", in practice the overall leadership being provided is limited.[19]

Successive governments have chosen to focus on keeping unwanted species out of the country through pre-border and border work. As a result, MPI's focus is overwhelmingly on pre-border and border measures. Given the history of biosecurity in New Zealand, which has been driven largely by the desire to promote and defend land-based industries, this is not surprising.[20]

By comparison, MPI's focus on the management of harmful organisms (including exotic plants) already present in the country has been and remains limited. The Director-General's leadership role was only added to the Biosecurity Act in 2012, and MPI's focus remains overwhelmingly on pre-border and border measures. MPI has largely left the management of exotic plants already in the country to others, including DOC, regional councils and landowners.

This emphasis aligns with a longstanding tradition in New Zealand that exotic plants pose costs that are in the first place a matter for landowners to attend to. While this may be a reasonable strategy for exotic plants that impact on production systems where land managers have economic incentives to control them, those incentives are weaker or non-existent when native ecosystems are at stake.

The consequence of MPI's leadership priorities for post-border exotic plant management may be one of having to intervene late and massively if the combined effect of regional and landowner efforts fall short, as the current wilding conifer programme suggests.

While MPI is best placed to provide national-level leadership, it currently lacks a comprehensive and up-to-date picture of exactly how all exotic plants and animals are being managed around the country. From 2007 to 2018, MPI maintained a website called Biosecurity Performance where the general public could find which exotic plants and animals were managed where across all the regional pest management strategies. This database was decommissioned several years ago due to an outdated IT platform.[21] Neither has MPI progressed work on developing an outcome-based performance measurement framework for the pest management system, covering both plant and animal pests.

These gaps raise questions about the level of overall leadership being provided.

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[18] See Biosecurity Act 1993, ss 43, 109, 111, 112, 114, 118, 120 and 121, amongst others.

[19] Biosecurity Act 1993, s 12A, emphasis added.

[20] See chapter six for a historical detour on how exotic plants came to be managed.

[21] MPI staff, pers. comm., 24 September 2021.

Management of exotic plants present in New Zealand

MPI becomes involved in exotic plant management when:

- the agency has been notified of, and confirmed the arrival of, a new exotic plant in the country;
- exotic plants appear to have limited distribution, and eradication is considered feasible; or
- there is a need for national-scale coordination.

New exotic plants arriving in the country

MPI investigates and responds to new exotic plants spotted in New Zealand for the first time, but it does not typically get involved if the detection of a plant is simply its first detection in a new region.

MPI's primary notification process for new plant incursions is the pest-and-disease hotline (0800 80 99 66) operated by the incursion investigation team. This initiates an investigation, and the information-gathering process begins.

MPI's surveillance team also regularly monitors high-risk sites – areas near ports and airports – for diseases, insects and exotic plants. Sniffer dogs are employed at the international mail centres to sniff out pests. The team also responds to notifications of online selling or trading of suspected illegal plants. Seed imports are a key risk pathway into the country for new exotic plants. However, the dog teams do not run 24/7, and online sales are difficult to capture.

MPI staff expect that the agency will be notified of the presence of new organisms in the country via the hotline. This is a passive approach, which relies on experts and members of the general public around the country spotting interesting or unusual organisms (including plants) and notifying MPI.[22] As noted in chapter four, a lack of regular scanning for relevant information from other platforms, such as observations from citizen scientists on iNaturalist, is another weakness in MPI's approach.[23]

Over the last six years (2015–2020), MPI has received an average of 1,310 notifications of suspected pests or diseases per calendar year, including notifications of plants, invertebrates and diseases.[24] Remarkably, MPI is unable to separate out the number of notifications that involved exotic plants, but it appears they were a minor proportion of all notifications, which were dominated by invertebrates.

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[22] The recent *Plant Biosecurity Science in New Zealand* report examined the issues raised here, in a related though different biosecurity context, and stated: "There is an expectation at MPI that 'if there were emerging pastoral pathogen risks that MPI would be notified'. However, if there are no pastoral pathologists in NZ and no system of pastoral surveillance for emerging pathogens, this could be a risky approach" (Dyck and Hickling, 2021, p.30).

[23] See the discussion of Himalayan wineberry (*Rubus ellipticus*) in chapter four and in this chapter.

[24] MPI received 1,835 notifications in 2015; 1,213 in 2016; 1,040 in 2017; 1,232 in 2018; 1,422 in 2019; and 1,119 in 2020. Of these respective notifications, 580 were investigated in 2015; 462 in 2016; 488 in 2017; 681 in 2018; 934 in 2019; and 723 in 2020 (MPI staff, pers. comm., 21 July 2021).

After a preliminary risk assessment and validation of the notification, MPI's incursion investigation team follows a formal process to determine what action should be taken. If a plant is found to pose a risk that cannot be managed under urgent measures by the incursion investigators, it is contained and handed over to MPI's response team. This team applies a response prioritisation tool for guidance in determining response priority. This will determine whether or not to mount a management response depending on the potential impacts posed by the plant and issues relating to the feasibility of control. If the assessment recommends mounting a response, the response team prepares an options analysis that evaluates at least three potential options:

- full eradication from New Zealand
- no management
- another form of management that can take different forms.

As part of the last option, MPI can hand over responsibility for managing the organism to another organisation. However, this approach carries risks. It is essential that any delegated agency is given clear advice on what management has already been considered, tried, succeeded or failed. Any response will be further delayed if different organisations reassess the same issues. It is not clear whether this currently happens in a consistent fashion.

Since 2015, as part of this process, the MPI response team has assessed 14 exotic vascular plant species or species groups that MPI was notified of. It is likely that most of these plants would have a negative impact on New Zealand's native ecosystems. Eight were discovered as growing plants on private properties or in waterways, five were discovered as seed contamination (i.e. seeds contaminating other seeds or equipment), and velvetleaf (*Abutilon theophrasti*) incursions were detected both as plants and seeds.[25]

The eight exotic species discovered only as growing plants were fo-ti (*Fallopia multiflora*), salvinia (*Salvinia molesta*), fanwort (*Cabomba caroliniana*), great willowherb (*Epilobium hirsutum*), Himalayan wineberry (*Rubus ellipticus*), golden dodder (*Cuscuta campestris*), Chinese knotweed (*Persicaria chinensis*) and sea spurge (*Euphorbia paralias*).[26]

Responses to different notifications reveal divergent thinking. For example, great willowherb was detected at Lake Pegasus, Canterbury, in 2018 by an Environment Canterbury officer who notified MPI. How it arrived in New Zealand is unclear, but MPI believes that the species had been present for a few years given the number of plants present at the site.

The initial risk assessment concluded that the species was expected to have some environmental and socio-cultural impacts, and the recommendation was to eradicate. A further options analysis recommended that MPI lead a response to locally eliminate known infestations, which would "preserve options for the eradication of [great willowherb] in New Zealand, but with realistic consideration that [great willowherb] may not be successfully eradicated."[27] MPI would then hand over long-term management of these sites to Environment Canterbury and local trusts that were managing the wetlands that had been invaded.

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[25] Black grass (*Alopecurus myosuroides*), corn buttercup (*Ranunculus arvensis*), poa grass (Poa sp.), field dodder (*Cuscuta pedicellata*) and other dodder species (*Cuscuta* sp.) were discovered as seeds contaminating other seeds or equipment (MPI staff, pers. comm., 21 July 2021).

[26] MPI received two separate notifications that were confirmed as salvinia, but one of these was notified as a suspected water lettuce (*Pistia stratiotes*) occurrence (MPI staff, pers. comm., 21 July 2021).

[27] MPI, 2018c, p.10

This assessment and recommended course of action were based in part on the conclusion that great willowherb had mostly been spreading vegetatively via rhizomes, despite the fact that it does flower and produce seed here, potentially spreading the plant long distances as well. The viability of this seed was estimated to be low based on the relatively low density of plants at infested sites.[28]

Despite having a risk assessment framework, a degree of subjectivity remains. While MPI staff decided to try to suppress to low levels and potentially eradicate great willowherb, the potential for its long-distance dispersal seemed to be downplayed with sparse evidence to support the conclusion. There was no testing of the viability of wind-blown seed.

By contrast, in the case of Himalayan wineberry, the potential for long-distance dispersal by birds seems to have been a primary reason why eradication was not attempted.[29] This is despite the fact that a paper by South African researchers cited in the risk assessments suggested most seeds fell within 10 metres of the parent plant.[30] Discussions with various experts during this investigation highlighted disagreement with MPI's rationale and decision.

Further, risk assessments concluded that both plant species assessed had been present in New Zealand longer than initially thought – probably years rather than months. It is not clear that this directly influenced the decisions made on how to manage the plants, but once again demonstrates the danger of relying on the assumption that MPI will be lucky enough to be notified of new incursions immediately after they happen and highlights the need for active and regular surveillance.

Finally, lack of transparency remains a concern. On request, this investigation received risk assessments and other documents. But these documents are not readily available to the wider community, which means MPI's decision-making process cannot be understood and critiqued. As mentioned in chapter five, there are real benefits to these decision-making processes being transparent both in the immediate aftermath and as a basis for learning in the future. Decisions, and the basis for them, need to be documented and clearly communicated. This applies as much to decisions not to intervene as it does decisions to act.

Eradicating exotic plants that appear to have limited distribution

In addition to dealing with new incursions, MPI leads a National Interest Pest Response (NIPR) programme. This is a separate programme, with a small, fixed selection of exotic plant species for management.

The original list, assembled in 2006 from a long list ranked by experts, consisted of ten plants, eight of which were already managed nationally either by local or central government agencies.[31] Since then, hornwort (*Ceratophyllum demersum*) was removed from the list, after successful eradication from the South Island.

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[28] MPI, 2018c, p.9.

[29] Himalayan wineberry was first detected near the Gills Scenic Reserve in Auckland in 2018, although MPI was not notified until another observation was made in 2019 (de Lange et al., 2019). After investigation, MPI decided to stand down any response led by MPI and support Auckland Council and any other management authority with technical advice, communications and passive surveillance (via the hotline) (MPI, 2019, p.26).

[30] Lalla et al., 2018.

[31] The original list also included one bird species – rainbow lorikeet (*Trichoglossus haematodus*) – which was later reassessed and removed from this list (MPI staff, pers. comm., 24 September 2021). Wild populations of rainbow lorikeets were declared eradicated from New Zealand in 2014. See https://www.mpi.govt.nz/biosecurity/long-term-biosecurity-management-programmes/national-interest-pest-responses-programme/ [accessed 29 September 2021].

Eight of the nine remaining plants currently managed under this programme have limited distribution around the country and are managed with the aim of nationwide eradication. The eight plants are salvinia, water hyacinth (*Eichhornia crassipes*), Johnson grass (*Sorghum halepense*), Cape tulip (*Moraea flaccida*), pyp grass (*Ehrharta villosa*), phragmites (*Phragmites australis*), hydrilla (*Hydrilla verticillata*) and white bryony (*Bryonia cretica*).

The ninth plant on the list – Manchurian wild rice (*Zizania latifolia*) – is the odd one out, with efforts focused on eradication from the Auckland, Waikato and Wellington regions and containment in Northland.[32]

In the intervening 15 years since 2006, no new plant species have been added to the NIPR programme and no plant-related reassessments have been made. Given that over 25,000 exotic plant species have been introduced to New Zealand, it is unclear why the NIPR list has remained steady with just nine plants following the successful hornwort eradication from the South Island.[33]

Interestingly, the NIPR programme bears some similarity to small-scale management programmes that the Biosecurity Act allowed the Minister for Biosecurity to undertake prior to 1997. The exact reasons for removing the Minister's ability to establish these remain unclear.

As chapter five outlines, there is a clear need for transparent and defensible prioritisation processes that are clearly communicated to help focus and guide actions on the ground. In this vein, the NIPR programme would benefit from regular reviews and updates.

Management of widespread exotic plants in need of national coordination

MPI is also involved in managing some of the more widespread exotic plant species by helping to coordinate actions across regions. While there are numerous exotic plants across the country that could benefit from nationally coordinated efforts, MPI's involvement is limited to a handful of initiatives. These initiatives are the National Pest Plant Accord (NPPA), the National Wilding Conifer Control Programme, and the Freshwater Biosecurity Partnership programme, which aims to prevent the spread of all freshwater pests. In addition, MPI also provides some coordination and support for managing velvetleaf, Chilean needle grass (*Nassella neesiana*) and sea spurge.

While some of these initiatives clearly offer benefits to native ecosystems, only sea spurge qualifies as a plant species for which MPI is providing some coordination where the benefits are largely confined to native ecosystems. In every other case there are economic, cultural and recreational reasons that provide a compelling justification for MPI's oversight. Drawing attention to the co-existence of multiple values underpinning MPI's intervention is neither a criticism nor surprising since native and introduced ecosystems are rarely neatly separated. But it does raise the question of whether a multiplicity of values at risk means that native ecosystem weeds only command attention when they run up against an identifiable economic interest. With this is mind, it is instructive to examine the NPPA and the National Wilding Conifer Control Programme in more detail.

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[32] In Northland, where infestations cover about 500 hectares, the aim is to control infestations in the containment zone on the Northern Wairoa River and eliminate all other populations (https://www.mpi.govt.nz/biosecurity/long-term-biosecurity-management-programmes/national-interest-pest-responses-programme/ [accessed 23 September 2021]).

[33] According to MPI staff this is because of resource allocation issues (MPI staff, pers. comm., 24 September 2021).

The NPPA is a non-statutory cooperative agreement between MPI, DOC, unitary and regional councils, and New Zealand Plant Producers Incorporated (an industry body of plant growers and their industry partners) to manage risks associated with the sale, distribution and propagation of certain plants. The NPPA explicitly relies on the powers granted under the Biosecurity Act to designate and control *unwanted organisms*, which automatically ban any plant listed in the NPPA from propagation, sale or other distribution.[34] All plants on the NPPA are unwanted organisms under the Biosecurity Act. However, not all unwanted organisms make it onto the NPPA list.

The process for establishing and reviewing the NPPA is not prescribed in statute. Rather, it is set up by agreement between the member parties. One of the key functions of this group is to decide on any changes to the list. However, a pre-requisite for inclusion on the NPPA list is that a Chief Technical Officer must first declare the pest plant to be an 'unwanted organism' under the Biosecurity Act.[35]

The NPPA appears to contain an uneven mix of plants, ranging from those rare or absent from New Zealand (e.g. balloon vine (*Cardiospermum halicacabum*)), to those that are already widespread (fully naturalised) in the wild and unlikely to be cultivated (e.g. tussock hawkweed (*Hieracium lepidulum*)). Further, many species listed on the NPPA are common and can be found in public and especially private gardens (Figure 7.2).[36] Currently 135 taxa are listed on the NPPA.[37]

Source: Megan Martin

Figure 7.2: It has been estimated that 20 more exotic plant species from the thousands already bought and grown here escape cultivation and naturalise each year in New Zealand.

[34] See Biosecurity Act 1993, s 2 "Interpretation", and the discussion about unwanted organisms earlier in this chapter.

[35] Biosecurity NZ – MAF, no date.

[36] Dawson, 2020, p.10. All hawkweed species (*Hieracium* and *Pilosella* sp.) are listed in the NPPA.

[37] MPI, 2020a. Note that some taxa are listed in the NPPA as species groups, such as whole genera.

An NPPA review prepared for MPI in 2016 noted that many species were widespread and well past the early invasion stage. By this stage, dispersal occurs predominantly through natural processes rather than deliberate human spread. Although it can still usefully raise awareness in situations such as new subdivisions adjacent to natural areas or on offshore islands, the importance of NPPA's role of preventing spread through plant sales becomes marginal.[38]

Surveillance and inspections of plant nurseries and other outlets where NPPA species are likely to be found is carried out by authorised persons, trained and appointed under the Biosecurity Act. While enforcement is fairly straightforward with well-known plant nurseries, private online groups or individual sellers in online marketplaces tend to fall through the cracks.[39]

Logically, the NPPA would be consistently updated and feature more plants that are at an earlier point on the invasion curve. However, despite the 2016 review, the NPPA list has remained unchanged since 2012 and plans to revise it are currently on hold.[40]

MPI's second major initiative is the well-publicised National Wilding Conifer Control Programme (Figure 7.3), which aims to stop the spread of wilding conifers and "progressively remove them from much of the land already invaded".[41] This programme was established in 2016 and is informed by the *New Zealand Wilding Conifer Management Strategy 2015–2030*.[42] The programme was established decades after wilding conifers were first noticed, resulting in a problem that has grown in size, cost and complexity despite earlier control efforts.

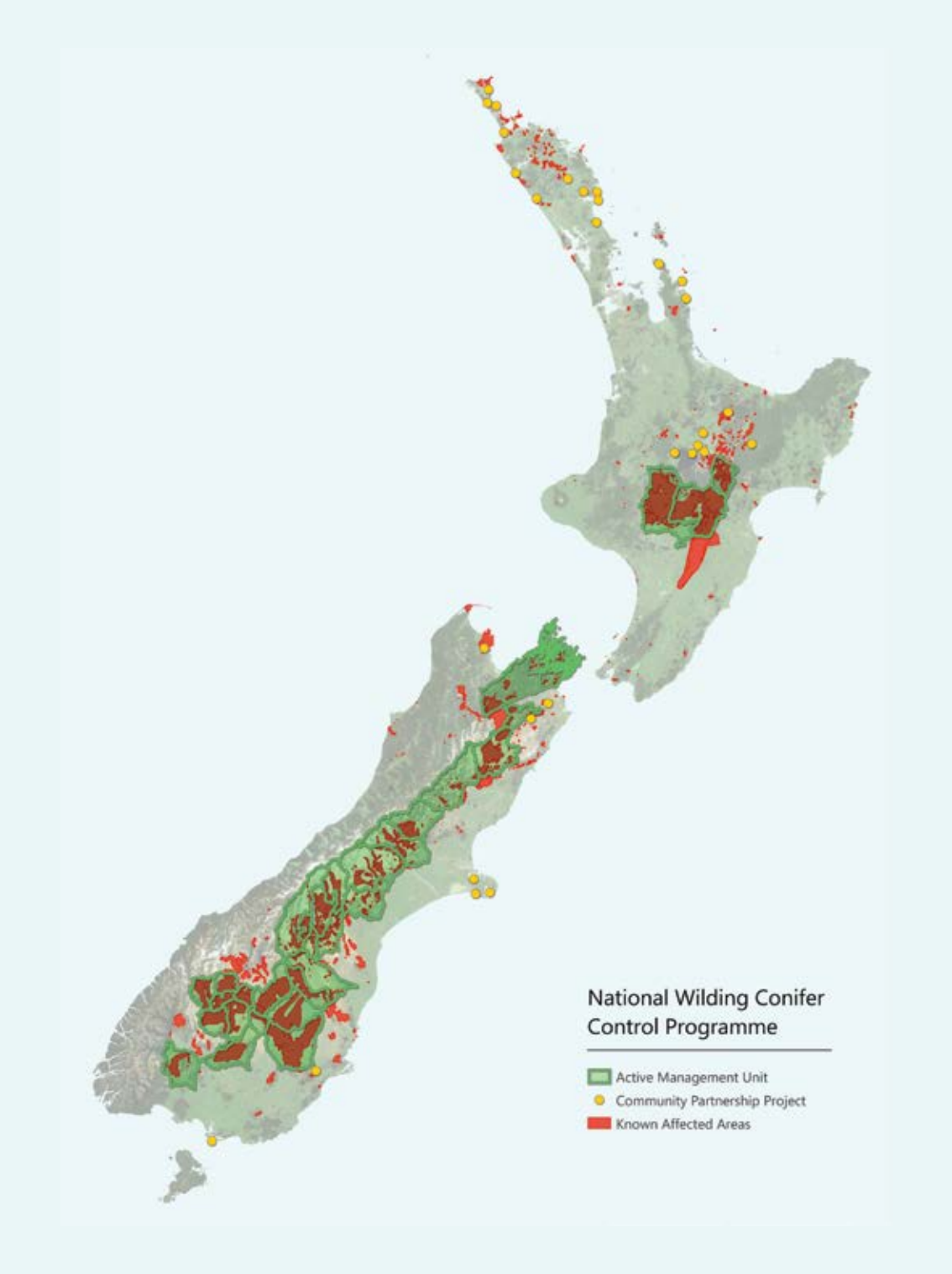
[38] Heenan and Champion, 2016.

[39] At times sale of NPPA plants still occurs, as evidenced by the fact that in 2020, New Zealand Plant Producers Incorporated (NZPPI) created a poster of 12 NPPA plants and sent this poster to various nurseries, retailers and councils, raising awareness, and relying on an "education before enforcement" approach in the first instance (NZPPI, pers. comm., 22 September 2021).

[40] MPI staff have held off reviewing the NPPA list due to other priorities, including dealing with velvetleaf and myrtle rust incursions, and progressing the internal review of the Biosecurity Act (MPI staff, pers. comm., 24 September 2021).

[41] MPI, DOC and LINZ are leading the work, with support from other central and local government agencies. Forestry and farming industries, landowners, researchers and communities are also providing support. See https://www.mpi.govt.nz/biosecurity/long-term-biosecurity-management-programmes/wilding-conifers/ [accessed 29 September 2021].

[42] MPI, 2014.



Source: MPI and LINZ

Figure 7.3: National Wilding Conifer Control Programme.

MPI leadership of this programme has enhanced communication, cooperation and coordination among all those involved and helped promote public support. This has been eased by the funding pool available. Since its inception, over $100 million has been allocated to the programme, most of which was awarded in Budget 2020.[43] Given the scale of the problem, funding will need to continue into the long term if the objective of handing land back to regional councils and landowners to manage is to be safely achieved. Recent modelling has estimated that at least $400 million will be needed to remove all known wilding conifer infestations if action is taken now and costs are not deferred into the future.[44]

While the National Wilding Conifer Control Programme is a welcome acknowledgement that some weed problems are of a scale that requires national coordination, it immediately raises the question of how many other weeds would benefit from nationwide coordination and the extent to which they are being neglected because scarce resources have been diverted to wilding conifers. In the absence of a robust and transparent prioritisation process, we have no way of knowing whether tackling wilding conifers at a national level (a problem many decades in the making) offers greater benefits than seeking to eradicate many more plants that may become the wilding conifers issue of tomorrow. It would be a pity if the case for prioritisation today is pre-determined by the scale of yesterday's neglect.

Overseeing New Zealand's systems for pest management and measuring overall system performance

MPI has not conducted any recent publicly available reviews of exotic plant management in New Zealand.[45] This is despite the Director-General's role in "overseeing New Zealand's systems for pest management and measuring overall system performance", as stated in the Biosecurity Act.[46]

Over a decade ago, Cabinet considered developing an outcome-based performance measurement framework for the pest management system, covering both plant and animal pests. A Cabinet paper on managing pests in New Zealand from 2010 considered it would be:

> "reasonable to require a pest management agency that is responsible for a pest programme under the Biosecurity Act to monitor the programme against its objectives and report this information. The programmes require parties to undertake activities that they otherwise would not, and so the value of these programmes needs to be monitored and assessed. This requirement is also important for managing the Crown's fiscal risk by providing information on the relative value for money gained by pest management strategies, and ensuring money is spent on the right programmes."[47]

[43] Around $140 million has been allocated to date, with $100 million of that from Budget 2020. This amount does not include contributions from regional councils, landowners and others (MPI staff, pers. comm., 24 September 2021).

[44] See Figure 6 in Mason et al. (2021).

[45] Broader pest management was the subject of some work undertaken in 2008 that led to the publication of the Pest Management National Plan of Action in 2011 and the Biosecurity Law Reform Act 2012. In addition, a 2015 paper captured biosecurity system achievements since 2003, in the context of the recommendations from the Biosecurity Strategy 2003. Pest management was one of the categories commented on (MPI, 2015a). MPI staff are currently progressing an internal review of the Biosecurity Act; however, no public consultation has been undertaken to date.

[46] Biosecurity Act 1993, s 12A.

[47] Carter, 2010b, pp.5–6.

Further, the Cabinet paper considered that it was "important that MAF receives information on performance of other aspects of the system, so that it can make informed decisions about system improvements."[48] Despite these good intentions, efforts to develop such a framework came to a halt in 2012 due to a lack of funding and commitment. Even though significant work was done to conceptualise it, the public never got to see the envisaged framework.[49]

Interestingly, the Cabinet paper mentioned above had expressed concerns about the potential costs of gathering and analysing information about performance. In an attempt to meet these concerns, it stated that "any requirement to measure performance and provide information would be limited to what is reasonable … so that information can be provided without unreasonable difficulty or expense."[50] The 2013 Cabinet paper on the Environmental Reporting Bill echoed a similar sentiment when it provided assurance that it would "not impose any requirement … to produce data that does not already exist" and would draw on existing available data.[51] Ambition for good information seemed to ebb during these years.

It was known at the time that it was impossible to assess the performance of any pest management programmes given the paucity of data and information. The situation has not changed. With a few exceptions, it remains difficult to say whether costly efforts to manage exotic plants around the country are having an effect.[52] An opportunity to learn from our actions or lack thereof is being lost.

DOC's role - what the Acts say

While the Biosecurity Act states that the Director-General of MPI provides overall leadership in managing exotic plants that are already in the country, the Act is silent about the role that DOC or its Director-General play in this respect.

However, section 6a of the Conservation Act 1987 requires DOC to manage its land for "conservation purposes", and this can reasonably be expected to include some management of weeds to protect and enhance the integrity of native ecosystems. That said, the Act makes no mention of exotic plants or weeds. In addition, the National Parks Act 1980 and the Reserves Act 1977 establish the principles for how these lands are managed.[53] In theory, 100 per cent of public conservation lands and waters are managed through a complex hierarchy of management policies, strategies and plans (statutory planning documents).

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[48] Carter, 2010b, p.6.

[49] Knox and Carver, 2012.

[50] Carter, 2010b, pp.5–6.

[51] Adams, 2013, p.13.

[52] The Wilding Conifer Information System holds promise in this respect as it is a national system that contains geographic information system (GIS) based information on wilding conifer infestations and all control activities delivered under the National Wilding Conifer Control Programme.

[53] For example, s 4(2)(b) of the National Parks Act states that unless otherwise determined, "the native plants and animals of the parks shall as far as possible be preserved and the introduced plants and animals shall as far as possible be exterminated". Both the National Parks Act and the Reserves Act allow the Minister of Conservation, subject to certain conditions, to authorise the introduction of any biological control organisms to control wild animals or animal pests or plant pests in any national park or reserve (National Parks Act 1980, s 5A, and Reserves Act 1977, s 51A).

Beyond DOC-administered land, DOC has a legislative responsibility to advocate for the conservation of natural and historic resources more broadly, so it could prepare and disseminate guidelines relating to the control of weeds on any land in relation to conservation efforts.[54] However, DOC only has authority to manage weeds on land that is held under the Conservation Act. This contrasts with the Wildlife Act 1953, under which DOC has the power to enter land to protect habitat or protected wildlife from pest animals.[55] The greater attention paid to animal pests has long roots.

DOC's role - what happens in practice

Outcomes and objectives

All of DOC's work, including the management of native ecosystem weeds, is guided by three overarching outcomes: healthy nature, people who care, and thriving communities. The most relevant outcome for the management of weeds is the first – healthy nature – and this is in turn further broken down into two intermediate outcomes: "the diversity of our natural heritage is maintained and restored", and "our history is brought to life and protected".[56]

Six intermediate outcome objectives form the next level down. These have recently been revised, and are now:[57]

1.1 Managing a full range of representative, rare and threatened ecosystems

1.2 Managing for the long-term persistence of threatened species

1.3 Managing the cultural and ecological integrity of landscapes and seascapes

1.4 Restoring the mana of taonga and managing icons

1.5 Managing transformative and local pressures to prevent loss of biodiversity values

1.6 Undertaking obligation type duties as land and biodiversity managers.

These objectives encompass all DOC's biodiversity work but there can be considerable overlap between them. For example, an iconic species requiring management may be living within a landscape that is already being managed as a priority.

Decisions about weed management must be aligned with at least one of these six intermediate outcome objectives; however, it is difficult to summarise how much weed work occurs under each. Weeds are grouped into five categories constituting the possible pressures they pose to a given native species, site, island or landscape, and funding for management is allocated by pressure. The five categories are climbers; ground cover and herbaceous plants; pioneer woody plants; shade-tolerant woody plants; and, more recently, wilding conifers. The decision as to which of these weed groups and the species within them are actively managed at a site rests at the local level with operational staff who are guided by the planning process described below as well as discussions with technical staff. Local resourcing is also a contributing factor.[58]

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[54] Conservation Act 1987, s 6(b). Also see Davis and Cocklin (2001).

[55] Wildlife Act 1953, s 59.

[56] https://www.doc.govt.nz/about-us/our-role/our-purpose-and-outcomes/ [accessed 28 September 2021].

[57] DOC, 2021b. However, to date, the updated intermediate outcome objectives have not been used to prioritise the work, they have only been tested by trying to allocate current work to these objectives. Further, the updated intermediate outcome objectives have not been published on DOC's website yet, as it still lists the intermediate outcome objectives developed in 2010 (https://www.doc.govt.nz/about-us/our-role/managing-conservation/natural-heritage-management/identifying-conservation-priorities/ [accessed 28 September 2021]).

[58] DOC staff, pers. comm., 24 September 2021.

At an operational level, the actions undertaken by staff to manage weeds are recorded in DOC's Weed Data System (mentioned in chapter four). Unfortunately, this database does not align exactly with the intermediate outcome objectives, and inconsistent data entry makes it difficult to assess the information held. A key unknown is the amount of work focused on plants in the initial stages of spread – those in the early invasion stage. The newly named objective that relates to 'transformative and local pressures' does open the door for weeds to be better prioritised and managed, but it remains to be seen what investment in the management of weeds takes place under this objective.[59] As it is now, there is little weed-related work that appears to fit clearly under the transformative pressure objective, although some of DOC's work on wilding conifers does fall under this category.[60]

DOC's management units

It is widely accepted that DOC cannot adequately manage all conservation lands with its current resources.[61] Thus the bulk of DOC's biodiversity work is aimed at managing high-value sites using a spatial prioritisation system that covers the first two intermediate outcome objectives, described above. Broadly speaking, this approach is based on identifying and ranking a set of preselected, high-value sites so that both representative ecosystems and sites containing threatened species are prioritised for management on DOC-managed land.[62] DOC has identified and ranked about 1,400 of these ecosystem-and-species management units and set a stated target to manage 850 of these (see Figure 7.4).[63]

[59] DOC staff, pers. comm., 24 September 2021.

[60] DOC staff, pers. comm., 24 September 2021.

[61] The Auditor-General said this about DOC in 2016: "The job of managing biodiversity on conservation land is greater than the resources available. The Department is able to actively manage only a small proportion of New Zealand's conservation land and threatened species" (Controller and Auditor-General, 2016, p.5).

[62] https://www.doc.govt.nz/about-us/our-role/managing-conservation/natural-heritage-management/identifying-conservation-priorities/setting-priorities/ [accessed 28 September 2021].

[63] Notably there is little detail of what 'managed' means.

Source: DOC, 2021a

Figure 7.4: Map of DOC ecosystem-and-species management units.

Allocation of resources to the top-ranked sites identified by this prioritisation process should, in theory, secure the best outcome for protecting and enhancing the native ecosystems and threatened species that are captured in the first two intermediate outcome objectives described above.[64] This ranking process considers not only the state of the site in question, but also other factors such as the pressures the site faces, including pressures from weeds. Critically, information as to the cost, feasibility and effect of managing each pressure is required for the prioritisation process so that work prescriptions can be made. From a weed perspective, this prioritisation process requires an understanding of which weeds are at each site, their impacts and how they can be controlled, including the cost and impact of any control method being proposed. It is difficult to assess what weed information is used to inform this process or if the assessment of weeds is aligned with prescribed outcomes for each site. However, DOC does try to ensure consistency in making these management prescriptions by developing them via a process that involves biodiversity planners and technical and science advisors, as well as local expertise.

This prioritisation of high-value sites for management is nominally done at a national scale, but it mainly focuses on land within the conservation estate and does not currently consider interactions between these sites and the surrounding land, including private land that may also support at-risk ecosystems and harbour pests, including weeds.[65]

Weeds are also managed by DOC as part of its landscape work and its work on islands, but understanding exactly what weed work is occurring is difficult to summarise. Prominent examples include some of DOC's wilding conifer work (e.g. as part of the National Wilding Conifer Control Programme) and the considerable effort put into managing weeds on Raoul Island (see Box 7.1).

[64] Other intermediate outcome objectives will also contribute to protecting and enhancing native ecosystems.

[65] There are exceptions to this for particular ecosystems not well-represented on public conservation land, but private land is not consistently included in DOC's process to set priorities using the spatial conservation planning software Zonation. While DOC can have management authority for conservation purposes over private land or resources, the property owner needs to agree with the Minister of Conservation that that land or resource should be managed by DOC.

Box 7.1: A history of weed management on Raoul Island

Raoul Island is by far the largest of the Kermadec Islands, which are located about 1,000 kilometres northeast of New Zealand. The island is just over 29 square kilometres (2,900 hectares) in area. It is predominantly covered in subtropical rainforest (Figure 7.5).

Source: David Havell

Figure 7.5: An aerial view of Raoul Island, taken during a weed surveillance flight over the island.

Raoul Island has a long history of human settlement and, with it, numerous exotic species have been introduced. Many animals and plants were introduced for food and, while all exotic mammals (including rats, cats and goats) have now been eradicated, a hangover from some of their impacts remains. There are also still 196 exotic plant species on the island – they actually outnumber native species, of which there are just 118.[66] One of the key natives is an endemic species of pōhutukawa (*Metrosideros kermadecensis*), which is the dominant canopy species on much of the island. A key concern here is that myrtle rust, which could potentially lead to canopy collapse, was recently found on the island (in 2017).[67] If this disease gets a hold and kills this canopy, then what grows up in its place is a major concern.

[66] West and Havell, 2019, p.435.

[67] West and Havell, 2019.

Efforts to manage weeds on the island go back over 45 years, and during this time there have been many successes, with the eradication of no fewer than 11 weed species.[68] Two long-term plot-based monitoring systems are used on Raoul Island, the latest one set up to monitor the effects of myrtle rust in 2017. Both systems include the measurement of exotic plant species.[69] The focus has now turned to nine weeds that are considered critical to eradicate – four species of vines, three types of trees and two shrubs.[70] Removing the vines is considered key because they can trap and kill seabirds returning to breed. These seabirds are important drivers of the island ecosystem that have been slowly returning in numbers since mammalian predators were removed. Weed control to protect threatened plant species in non-forested coastal ecosystems is also considered important.

A recent appraisal of the weed management efforts on the island concluded that eradication is still 'very achievable' for four of the nine species, 'possible' for four more – if more resources are made available – and 'unlikely' for the ninth species, until a control method is developed that can kill tubers on the inaccessible cliffs.[71] Resourcing issues mentioned include:

- inadequate search effort (spatially and temporally)
- insufficient resourcing to properly use existing data to help focus search efforts
- restricted access to the island in some years – due to weather events and volcanic activity
- staff numbers and capacity to work on weeds has dropped in recent years
- health and safety concerns and diversion to other tasks, including the biosecurity surveillance of those visiting the island – visitor numbers have been increasing in recent years (before Covid-19)
- the annual budget for the work was also noted to have been reduced.

Weed management efforts have been reviewed formally twice and are constantly evaluated as the island's ecosystems change. For example, the removal of all goats and rats has dramatically increased the number of seeds and seedlings that now establish for some exotic species. This reassessment is an essential component of good management.

DOC's weed management on Raoul is currently on pause due to Covid-19 restrictions, but the plants are still growing. This could lead to major setbacks. For example, according to West and Havell, "No access to the crater was permitted for two years after the eruption in 2006, resulting in mature plants of purple guava (*Psidium cattleianum*) and Brazilian buttercup (*Senna septemtrionalis*), with dispersal of the former and seed added to the seed bank for the latter."[72]

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[68] The 11 species considered eradicated from Raoul Island are pampas (*Cortaderia selloana*), Moreton Bay fig (*Ficus macrophylla*), fennel (*Foeniculum vulgare*), Mauritius hemp (*Furcraea foetida*), swan plant (*Gomphocarpus fruticosus*), macadamia (*Macadamia tetraphylla*), date (*Phoenix dactylifera*), walking stick bamboo (*Phyllostachys aurea*), Lombardy poplar (*Populus nigra*), ragwort (*Senecio jacobaea*), and pūriri (*Vitex lucens*) (West and Havell, 2019).

[69] DOC staff, pers. comm., 24 September 2021.

[70] African olive (*Olea europaea* subsp. *cuspidata*), yellow guava (*Psidium guajava*), castor oil plant (*Ricinus communis*), grape (*Vitis vinifera*), purple guava (*Psidium cattleianum*), black passionfruit (*Passiflora edulis*), Brazilian buttercup (*Senna septemtrionalis*), Mysore thorn (*Caesalpinia decapetala*), and Madeira vine (*Anredera cordifolia*) (West and Havell, 2019).

[71] West and Havell, 2019.

[72] West and Havell, 2019, p.441.

Historical initiatives

The 1998 strategic plan

More than 20 years ago, DOC developed a Strategic Plan for Managing Invasive Weeds, mentioned in the previous chapter. The plan described the long-term goal, objectives, general principles and means for DOC to follow and included a scoring system to rank the potential risk of invasion and negative impact to native ecosystems by weeds.[73] Two approaches were developed – a 'weed-led' approach, with the focus on priority weed species regardless of where they occurred, and a 'site-led' approach, with the focus on particular conservation sites. The weed-led approach was initially aimed at prioritising the management of weeds at the early stages of invasion, although some widespread species were also included.[74]

While the current Weed Data System still allows staff to record an action as weed-led, rather than site-led, this label no longer relates to the strictly defined weed-led approach envisaged in 1998. Further, it is not clear how many species, if any, are still managed by DOC using the approach described in the 1998 Strategic Plan.[75]

The 2008 list of environmental weeds

In 2008 DOC created a 'consolidated list of environmental weeds'. At the time, many other similar lists existed, so this was an attempt to consolidate and standardise the list of weeds DOC managed.[76] DOC saw its role as pivotal because: "DOC's mandate is national, and it practices active management, and thus is in a good position to maintain a national list of environmental weeds."[77]

The benefits of a single list were mentioned as including helping with research prioritisation and policy advice as well as contributing to international weed work. This list included 328 plant species, 325 of which are exotic. However, it was also pointed out that about 20 new species were naturalising each year, mostly from cultivation, and some of those would also be of conservation concern. It was intended that this list of environmental weeds would be maintained and regularly updated every two years, but this did not eventuate. The list has just been updated for the first time, rebranded as 'conservation weeds'. It now includes 380 exotic species, but this refreshed list has not yet been made public.[78]

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[73] Owen, 1998; Timmins and Owen, 2001.

[74] Examples of 'Weediness' scores from this system can also be seen in Table 1 of Howell (2012, p.253) for weeds that DOC aimed to eradicate from its management areas between 1998 and 2008.

[75] However, prioritisation of weed management within management units is influenced by processes outlined in the Strategic Plan (DOC staff, pers. comm., 24 September 2021).

[76] Howell, 2008.

[77] Howell, 2008.

[78] DOC staff, pers. comm., 22 September 2021.

The 2016 Dirty Dozen

In 2015 the then Minister of Conservation, Maggie Barry, launched a new DOC initiative – a 'war on weeds'.[79] The aim was to raise awareness of the impact of weeds on native plants and ecosystems. This initiative first listed a 'Dirty Dozen' in 2016, and at the time they were described as plants that were considered to be "causing particular problems in different parts of the country" and easily identified and removed.[80] A thirteenth weed – or more correctly, a group of weeds (wilding conifers) – was added to the 2017 version of the Dirty Dozen. Wilding conifers were ranked the number one worst weed on the revised list. While wilding conifers remain a priority for DOC today, the Dirty Dozen does not – there is no current 'dirty dozen', although some of the species on the list were already being managed by DOC and remain part of other work programmes.

The idea of raising public awareness to help direct attention to native ecosystem weeds is certainly a good one, but it does run the risk of people asking: Why these weeds? This risk underlines the need to have a clear prioritisation process (as outlined in chapter five). Choices are unavoidable, but there needs to be clarity of purpose and transparency about *why* and *how* decisions are made.

Working with others

Protecting a valued site or species often requires consideration of what is happening on adjacent land. This includes coordinating the management of weeds at the island or landscape scale, often across land tenure boundaries.

DOC's Conservation General Policy states:

> "Not all conservation goals are achievable on public conservation lands or waters. The Department needs to work cooperatively with other landowners and occupiers and the wider community, including local government, to protect and advocate for natural resources, historical and cultural heritage, and public access. Much of this activity is carried out under the Resource Management Act 1991."[81]

DOC also has obligations under the Biosecurity Act to be a 'good neighbour' to other landowners in managing pests if such a rule is specified in an RPMP (good neighbour rules are discussed in chapter six).[82]

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[79] Barry, 2015.

[80] The 12 species are English ivy (*Hedera helix*), Japanese honeysuckle (*Lonicera japonica*), woolly nightshade (*Solanum mauritianum*), wandering willie (*Tradescantia fluminensis*), buddleia (*Buddleja davidii*), Kahili ginger (*Hedychium gardnerianum*), Darwin's barberry (*Berberis darwinii*), climbing asparagus (*Asparagus scandens*), banana passionfruit (*Passiflora* sp.), moth plant (*Araujia hortorum*), old man's beard (*Clematis vitalba*), and cordgrass (*Spartina alterniflora, S. anglica, S.* × *townsendii*) (DOC, 2017).

[81] DOC, 2019a, p.31.

[82] DOC spent $2.7 million on RPMP work in the 2019/20 financial year compared with over $12 million on managing exotic plants (DOC, 2020a).

DOC has identified for some time that it requires the help of other government and non-governmental agencies and groups to achieve its goals on its own land. An organisational design review in 2011 (leading up to a major restructuring in 2011) stated that the reason for changing operations was to "get others involved in conservation – contributing money and effort to vital conservation work in the field".[83] DOC envisaged at the time a 60/40 split, success occurring when 60 per cent of all conservation work is carried out by local partners on and off conservation land and 40 per cent of all conservation work is carried out by DOC field staff.[84] Almost a decade on, it is unclear how successful this restructuring has been, but it is worth noting that in terms of managing weeds, DOC's expertise has notably shrunk. The pool of technical weed advisors employed by DOC dropped from 12 prior to 2012 to just five today.

Is DOC's work on weeds making a difference to our native ecosystems?

Exactly what work DOC does to manage weeds is hard to pin down, let alone assess. What is apparent is that considerably less money is spent on plant pests than on animal pests, with animal pests cornering $36 million – three times that spent on plants.

In general, it is hard to assess how DOC's weed management fits into DOC's overall objectives given the complexity of DOC's management systems. But it appears that some progress is being made.

In 2012 the Auditor-General identified that in order to better prioritise its management of biodiversity, DOC needed to have "effective long-term monitoring and reporting of the effects of biodiversity management."[85] DOC has now developed a long-term monitoring and reporting system that has three tiers. The first tier (Tier 1), broadscale monitoring, is described in chapter four and includes a grid of plots spaced at eight-kilometre intervals across DOC land. The plots are resampled every five years and include recording the presence or absence of some exotic plants. Tier 1 monitoring may be capable of showing broadscale changes in the distribution of widespread species over time but is not useful for monitoring the arrival and spread of new exotic species at key sites. It is also not clear how the observations from this monitoring programme are used to inform weed management.[86]

The biodiversity benefits of managing weeds need to be framed in terms of ecological outcomes. Goals need to be clear, and interventions need to be reviewed to determine whether those goals are being met. This enables learnings and improvements based on experience. The second tier (Tier 2) of the monitoring system is intended to provide a framework to guide investment by monitoring activities in managed areas.[87] The third tier (Tier 3) relates to monitoring and evaluating research.

In a 2016 follow-up to his 2012 report, the Auditor-General made it clear that there was still work to be done before the second tier (Tier 2) is working properly:

> "We have not seen evidence of a time frame for completing this work. However, we understand that a review of monitoring projects is currently under way, which will help to determine the scale and nature of change needed to bring this work into alignment with the framework."[88]

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[83] DOC, 2011, p.9; Controller and Auditor-General, 2012, p.13.

[84] DOC, 2011.

[85] Controller and Auditor-General, 2012, p.27.

[86] For more, see DOCs monitoring and reporting website (https://www.doc.govt.nz/our-work/monitoring-and-reporting-system/ [accessed 24 September 2021]).

[87] To help inform better weed management, this Tier 2 monitoring needs to be adequately designed to detect weeds.

[88] Controller and Auditor-General, 2016, p.5.

Evidence for monitoring activities guiding investment is still lacking. Specification of desired outcomes at particular spatial scales and over defined time frames is frequently absent. So too is outcome monitoring. Attention, instead, is often focused on outputs (hectares sprayed or treated, hours spent, kilograms of herbicides used, etc).

DOC reports annually on hectares managed and also "hectares of land under sustained pest control".[89] Both the area DOC has under sustained management for weeds and the area treated each year has been declining since 2014.[90]

DOC also reports on the 'ecological integrity' of each site it manages to provide a measure of the 'Difference made for ecosystems'.[91] Such a metric is encouraging but is currently a desktop modelling exercise that is used to report on the difference that funded actions have made. It is based on estimating the assumed effect of taking a prescribed action, rather than actually measuring the outcome on the ground.[92] Given the known ecological complexities and uncertainties involved, this process risks being distanced from reality and appears to be of no help in terms of improving management outcomes based on learning.[93] **There is a clear need for more information based on monitoring *actual* outcomes.**

The role of regional councils - what the Acts say

Regional councils have statutory functions for the management of both native biodiversity and exotic plants in their regions.

Under the Resource Management Act 1991 (RMA), regional councils and territorial authorities are tasked to maintain native (i.e. indigenous) biodiversity in their regions.[94]

Further, the draft NPS-IB (if enacted in its current form) will require local authorities to identify and map significant natural areas. These comprise significant areas of native vegetation and habitat for native fauna, as required under section 6 of the RMA, and are identified using a standardised approach.[95] The identification of significant natural areas extends to both public and private lands.

Regional councils have queried the extent of their responsibilities with respect to biodiversity. A discussion paper commissioned by the regional sector in 2017 raised concerns about the functions of regional councils under section 30 of the RMA regarding biodiversity. It argued that the function of biodiversity maintenance was too ambitious and beyond the capacity of the regional sector given the many players involved in biodiversity management.[96]

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[89] DOC, 2020b.

[90] Hulme, 2020.

[91] DOC, 2020b.

[92] The DOC annual report summarised this monitoring by saying that for terrestrial ecosystems, "An adequate number of sites is managed, but modelled ecosystem condition was estimated to be below targets" (DOC, 2020a, p.25).

[93] Complexities can arise from various management actions interacting and impacts not being properly understood. For example, if a site has prescribed actions that include fencing off herbivores, controlling predators and removing a scrubby weed such as gorse, then very different outcomes might occur depending upon what is actually done when. Excluding herbivores at a site might lead to more weeds establishing and predators flourishing. Similarly, controlling some weeds might open spaces for other weeds, or lead to erosion and species loss. Some of these outcomes might be expected, but the risks of unexpected outcomes justify allocating resources to directly monitor outcomes.

[94] See RMA 1991, ss 30(1)(c)(iiia), 30(1)(ga), 31(b)(iii) and 62(1)(i)(iii).

[95] The standardised criteria are (a) representativeness, (b) diversity and pattern, (c) rarity and distinctiveness, and (d) ecological context. The NPS-IB would also impose constraints on some activities to ensure these significant areas are protected (New Zealand Government, 2019, p.32).

[96] The discussion paper also noted that regional councils had not used land use change controls to protect biodiversity prior to the decision of the High Court in *Property Rights in New Zealand Inc v Manawatu-Wanganui Regional Council* [2012] NZHC 1272 (Willis 2017).

Under the Biosecurity Act, regional councils are tasked with statutory functions with respect to exotic plants in their regions. In section 12B of the Biosecurity Act, regional councils are stated to "provide leadership regionally" with regard to pest management in their regions using the same curiously passive formula of section 12A governing the Director-General of MPI. And, with the omission of having oversight responsibility for New Zealand's pest management system as a whole, the means by which regional councils are supposed to provide leadership are identical with those accorded to the Director-General.[97]

The means are:

- promoting the alignment of pest management in the region
- facilitating the development and alignment of RPMPs and regional pathway management plans in the region
- promoting public support for pest management
- facilitating communication and cooperation among those involved in pest management to enhance the effectiveness, efficiency and equity of programmes.[98]

In addition, section 12B states that "a regional council also provides leadership by promoting coordination of pest management between regions."

Under section 13 of the Biosecurity Act, regional councils are empowered to prepare RPMPs, regional pathway management plans and small-scale management programmes to manage exotic plants and other pests in their regions. They also have the power to carry out monitoring and surveillance of pests and unwanted organisms in their regions.[99] Territorial authorities also have a variety of powers to manage exotic plants.[100]

The regional leadership function for pest management (section 12B of the Biosecurity Act) was added in 2012 as a result of "regional council representatives [requesting] a statement of their roles in law, to provide a clear basis for decisions about what they will fund." Further, the same Cabinet paper revealed that "the many players involved in pest management [had] differing expectations about who is meant to be responsible for what."[101]

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[97] Similar to MAF functions, the 2010 *Managing pests in New Zealand* Cabinet paper envisaged greater focus on public interest, as it stated that "providing pest and pathway management programmes to protect the public interest where best placed to do so" was one of the specific functions that regional councils were envisaged having (Carter, 2010a, p.14).

[98] Biosecurity Act 1993, s 12B.

[99] Biosecurity Act 1993, s 13.

[100] Biosecurity Act 1993, s 14.

[101] Carter, 2010a, p.13.

The role of regional councils - what happens in practice

Managing exotic plants in the regions

Managing exotic plants using regional pest management plans

The management of exotic plants varies between and within regions. All regional councils and unitary authorities currently have operative RPMPs.[102] Collectively, regional councils and unitary authorities manage 334 exotic plant species through their current RPMPs.[103] The lion's share of these plants are found in Auckland Council's RPMP, which lists over 200 species. By contrast, the RPMPs for Taranaki, Wellington and Chatham Islands have fewer than 20 plants listed. The plants are spread across the five pest management programmes, as specified by the National Policy Direction for Pest Management 2015 (NPD): exclusion, eradication, progressive containment, sustained control, and site-led (Figure 7.6).

Source: Gordon Somerville, iNaturalist

Figure 7.6: Old man's beard (*Clematis vitalba*), seen here smothering trees and shrubs in Aro Valley, Wellington, is one of the plant species listed in Greater Wellington Regional Council's RPMP – but only to be managed on a site-led basis in the Hutt City Council area.

Some of the plants listed in RPMPs are not yet present in the region but feature in exclusion programmes. This means that regional councils are managing absent plants by keeping an eye out for them. However, as surveillance efforts appear to be ad hoc, relying on the enthusiasm of council officers and serendipitous detections as described in chapter four, exclusion plants could fall through the cracks of regional monitoring. As a result, it is generally impossible to have confidence that a specific plant is truly absent from a region.

[102] See chapter six for details.

[103] See Hutchison et al. (2021) for details.

Many councils manage the same plants differently in different parts of their regions. There may be good reasons for this. For example, wild ginger (*Hedychium* sp.) is managed with the goal of eradication on Aotea/Great Barrier Island (where eradication may be more achievable). By comparison, it is managed on a site-led basis in Auckland's regional parks and as part of a region-wide sustained control programme. Similarly, in Canterbury, white broom (*Cytisus multiflorus*) is managed throughout the region with a site-led approach and is also part of a sustained control programme in the hill and high-country zone.

Many of the exotic plants listed in RPMPs tend to be ones that have been growing and thriving throughout New Zealand for a long time – most since early last century.[104] By contrast, very few new invaders have found their way into RPMPs. Out of 17 newly naturalised species and 207 new casual species (though a few of these were first observed in the wild prior to 1980), only six have found their way into existing RPMPs.[105]

Most exotic plants listed in RPMPs – between 65 and 100 per cent – overlap with those considered to be 'conservation weeds' by DOC.[106] Unlike DOC, council plans do not divide exotic plants into life form groups that indicate different pressures on ecosystems. But it is possible to identify the variation in how many woody versus herbaceous plants are listed across RPMPs.[107]

Councils use RPMPs to manage both exotic plants impacting on production and plants impacting on native ecosystems. Interestingly, northern and western regions manage proportionally more exotic plants that only impact native ecosystems, while eastern regions manage proportionally more exotic plants that have production impacts (Figure 7.7).[108]

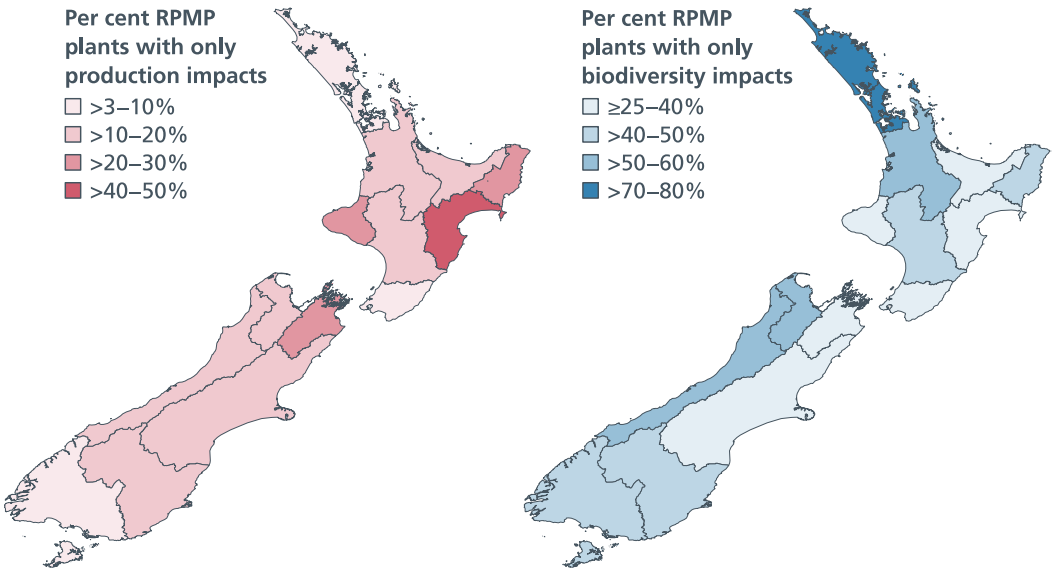
[104] Analysis commissioned for this review revealed that the average date of first discovery of naturalised populations of exotic plants included in RPMPs is 1935, with only 13% of exotic plants on RPMPs across the country being first discovered in the wild on or after 1980 (Hutchison et al., 2021, p.21).

[105] They are camphor laurel (*Cinnamomum camphora*), sea spurge, rosemary grevillea (*Grevillea rosmarinifolia*), giant rhubarb (*Gunnera manicata*), bat-wing passion flower (*Passiflora apetala*) and Chinese knotweed. For details, see Ogle et al. (2020) for newly naturalised species and new casual species, and Hutchison et al. (2021) for the plant species currently included in RPMPs.

[106] Hutchison et al., 2021, p.18, Table 12.

[107] The percentage of woody plants listed in RPMPs ranges from 25.0% to 52.9% and the percentage of herbaceous plants from 35.3% to 68.8% (Hutchison et al., 2021, p.18, Table 13).

[108] Of course, some exotic plants negatively impact on both native ecosystems and production systems.



Source: Hutchison et al., 2021

Figure 7.7: Exotic plants included in RPMPs, with impacts only on production systems (left) and impacts only on native ecosystems (right).

It is worth quickly exploring how management of the same species changes over time. For example, only one of eight exotic plants targeted for eradication by 2003 in Canterbury's 1998 Regional Pest Management Strategy was successfully eradicated from the region (and New Zealand) – Taurean thistle (*Onopordum tauricum*), which was surviving in the wild but not yet naturalised.[109]

The other seven species are listed in Environment Canterbury's current RPMP, published in 2018.[110] One of these is still managed under an eradication programme (marshwort (*Nymphoides geminata*)). The others are managed under progressive containment (African lovegrass (*Eragrostis curvula*) and groundsel bush (*Baccharis halimifolia*)), sustained control (bur daisy (*Calotis lappulacea*), coltsfoot (*Tussilago farfara*), and woolly safflower (*Carthamus lanatus*)), or site-led programmes (white-edged nightshade (*Solanum marginatum*)).[111] This shift in management suggests either unrealistic ambitions or a failure to match ambitions with the means to deliver them.

Further, it is instructive to explore the extent to which, in practice, the assignment of exotic plants in RPMPs to particular management programmes makes ecological sense in terms of their position along an invasion curve, as discussed in chapter five, and also whether the management programmes align with the known area occupied by exotic plants present in the regions.

Generally, management programmes in RPMPs align with the stage of invasion of native ecosystem weeds. However, the assignment by individual councils of particular weeds that impact only on native ecosystems to particular management programmes varies and does not always appear to align with expected best practice, even after factoring in a more nuanced approach, as described in chapter five. Figure 7.8 compares the reliance of the regional councils on the five different pest management programmes.

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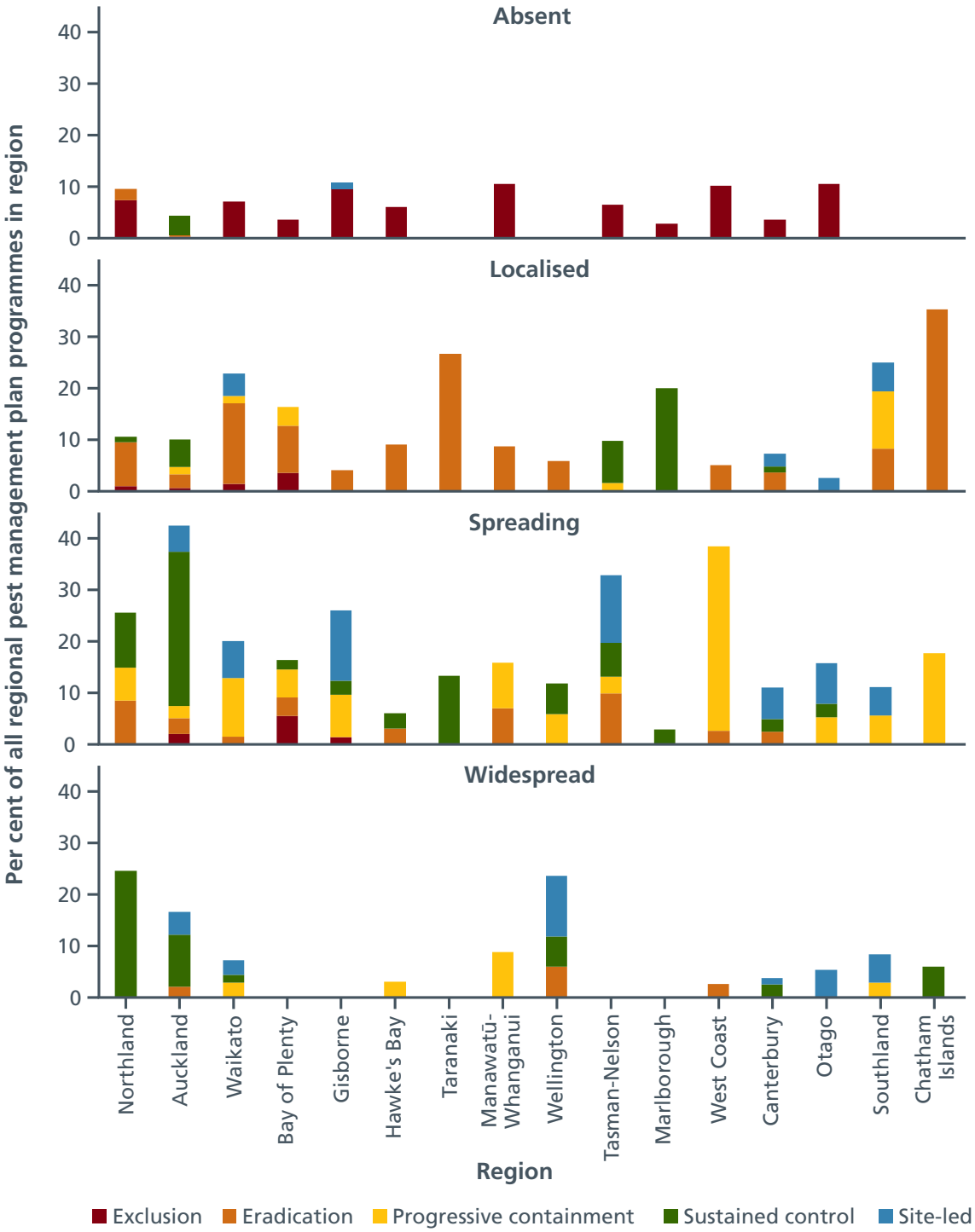
[109] Williams and Braithwaite, 2003.

[110] Environment Canterbury, 2018.

[111] See Hulme, 2020, p.1550. Plants in New Zealand identified as Nymphoides geminata have since been re-identified as *Nymphoides montana*.



Source: Hutchison et al., 2021

Figure 7.8: Regional management programmes versus stages of invasion for exotic plants that impact only on native ecosystems.

For weeds considered **absent** from regions, exclusion programmes are most often employed. However, there are apparent exceptions to this rule. For example, kudzu (*Pueraria montana*) and red sesbania (S*esbania punicea*) are listed in Auckland's region-wide sustained control programme despite being believed to be absent.[112,113]

Most weeds with **localised** populations in regions are managed under eradication programmes. Again, there are exceptions. Puzzlingly, some plants already present in a region with localised populations are being subjected to exclusion programmes, such as houttuynia (*Houttuynia cordata*) in Northland and marshwort in Waikato. In the former case, a new population of houttuynia was discovered just before the Northland RPMP came into effect.[114]

On the other hand, Marlborough District Council appears to be taking a different approach. While Madeira vine, moth plant, cathedral bells (*Cobaea scandens*), purple loosestrife (*Lythrum salicaria*), evergreen buckthorn (*Rhamnus alaternus*), tall wheatgrass (*Thinopyrum ponticum*) and eelgrass (*Vallisneria australis*) are all reported as having localised populations in the region, they are being managed through a region-wide sustained control programme. It is important to note, however, that the actions undertaken within a sustained control programme can lead to a decline in exotic plant populations, such as by removing reproductive parts of all plants each year before they flower or set seed. More than half of Marlborough's sustained control programmes have this aim, as do some programmes for exotic plants in other regions.[115]

Finally, the treatment of **widespread** weeds reveals some remarkable classifications. While most of these plants are managed under sustained control programmes or on a site-led basis, some regions have placed them in eradication programmes. For example, Manawatū-Whanganui has a region-wide eradication programme for woolly nightshade and Wellington has the same for moth plant, even though in each region these species are widespread.[116] As eradications documented to date have only been successful when infestations have been very small (a hectare or less, as discussed in chapter five), region-wide eradication programmes for widespread plants seem ambitious, if not doomed, without further insights into the reasons for these decisions.

Often it is hard to evaluate which factors contributed to a particular management decision given the lack of transparency. For example, which of the factors (area occupied, ecosystems at risk, feasibility of management, resourcing provided) determined that a weed with a localised population in the region and known impacts on native ecosystems ended up in a sustained control programme, as opposed to an eradication programme? To what degree has public or political pressure taken a widespread weed from a focused site-led programme to region-wide progressive containment, where few additional gains to native ecosystem protection are expected?

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[112] The accepted scientific name for kudzu is now *Pueraria lobata* (https://nzflora.landcareresearch.co.nz/default.aspx?selected=NameDetails&TabNum=0&NameId=9DBDA06C-95AA-4227-AF89-E0EA4208E95B [accessed 30 September 2021]).

[113] Reluctance to commit to an exclusion pest management programme for kudzu and red sesbania was driven by uncertainty as a result of poor plant distribution data. While these plants are considered absent from the region, council staff were not sure whether the plants were truly absent from the region or they have not been captured by the patchy distribution data. In contrast, Auckland Council committed to an exclusion programme for red sesbania on Aotea/Great Barrier Island because it was confident that the plant was absent and also confident that the values would be worth defending if it did turn up (Auckland Council staff, pers. comm., 21 September 2021).

[114] At the time that Northland Regional Council's RPMP was written, there was one known historical site of *Houttuynia cordata* that was believed to be eradicated. Another site was identified in mid-October 2017; the RPMP was formally published 10 November 2017 (Northland Regional Council staff, pers. comm., 9 August 2021).

[115] See Hutchison et al., 2021, p.16, Table 9.

[116] Data from Hutchison et al. (2021).

Various nuances and difference in interpretation can hide behind a lack of transparency that makes it hard to evaluate whether such management decisions are defensible.

Managing exotic plants outside of regional pest management plans

RPMPs are not the only way that regional councils manage exotic plants. Many councils find the development of RPMPs time-consuming and costly and prefer to undertake some exotic plant management outside of their plans. In some cases, this includes managing new or emerging invaders and in other cases it includes managing widespread plants growing in native ecosystems.[117]

The scale of what occurs outside of RPMPs is highly variable. The amounts spent by councils on management outside of RPMPs range from nothing to $1,605,000.[118] For context, regional councils collectively spent almost $27 million on exotic plant management under their RPMPs in 2020/2021, with Auckland and Canterbury spending over $5 million each.[119]

It appears that regional biodiversity strategies (if they have been prepared) and other non-regulatory council initiatives and programmes guide exotic plant management outside of RPMPs, although it is not always clear whether the risks that these plants pose to native ecosystems are reduced as a result. As non-statutory initiatives they lack regulatory bite, and funding allocated for them is subject to the short-term priorities of locally elected councillors.

Promoting coordination of exotic plant management between regions

Promoting coordination of pest management between regions is one of the ways councils provide the leadership referenced in the Biosecurity Act. In practice, coordination and alignment of RPMPs appears to be minimal. For example, RPMPs do not seem to consistently deal with exotic plants that are under a form of national management by MPI (see Box 7.2).

Box 7.2: National Interest Pest Response (NIPR) plants lack regional coordination

Given that NIPR plants are managed under an MPI-led national programme for the purposes of eradication from New Zealand, one might assume that at least the assignment of these plants to programmes by regional councils would show signs of consistency. This is not the case.[120]

In some regions, certain NIPR plants are not even listed as pest species at all, although they may be listed as 'organisms of interest' – a term that has no regulatory status and hence limits what councils might do to control them.

In some cases, a NIPR plant does not appear in RPMPs because it has not been seen in the few remaining sites for several years, such as pyp grass in Hawke's Bay, whereas other species appear to be listed as pest plants only in regions where they are still present, such as white bryony in Waikato. Other species that are more widespread, such as phragmites, are only in exclusion programmes in Manawatū-Wanganui, Northland and Tasman and in eradication programmes in Canterbury and Hawke's Bay.

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[117] Some of the plants managed outside of RPMPs are widespread exotics (like sycamore (*Acer pseudoplatanus*) and elderberry (*Sambucus nigra*)) often growing in key native ecosystems and other high biodiversity value sites (Hutchison et al., 2021, p.32 and 38–39, Table 23).

[118] For more details, see Table 22 in Hutchison et al. (2021, p.38).

[119] Hutchison et al., 2021, p.35, Table 21.

[120] As described earlier in this chapter, eradication from New Zealand is the goal for eight out of nine NIPR plants.

By contrast, hornwort, which was declared successfully eradicated from the South Island (see discussion of successful eradications in chapter five), is still listed in the management programmes of nine RPMPs (four in the South Island) and as an organism of interest in an additional five (one of which is in the South Island).[121]

In another example, Cape tulip has been successfully eradicated from more than 70 per cent of the sites managed in the NIPR programme, but more than 20 sites remain under active management, including monitoring to confirm eradication, in the North Island and upper South Island. However, it is only listed as a pest plant in Gisborne, Northland and Tasman-Nelson RPMPs, and as an organism of interest for the Chatham Islands, Wellington and West Coast.

It is reasonable to expect that different councils might list the same NIPR species under a different management category – for example, on the exclusion list if the plant is absent from a region. But it seems less defensible to not list these important plants as pests at all. NIPR plants are sometimes in nationally led initiatives that the region supports outside of the RPMP.[122]

While regional sector special interest groups (like the Biosecurity Working Group) facilitate improved communication channels, they are voluntary. Further, these groups are often driven by the enthusiasm of their members and lack formal support.[123] Voluntary special interest groups are not enough to promote serious coordination and alignment of pest management between regions.

After the NPD was gazetted, it "was agreed that neighbouring regions would provide peer review of each other's RPMPs to check for alignment and consistency. In practice, this did not always happen and in some cases, there are inconsistencies in pest management programmes for the same pest between regions."[124]

An analysis of current RPMPs reveals that different management programmes are used to manage the same exotic plants in different regions. When management differences are based on different regional distributions, these differences make biological sense.[125] However, when the area occupied by an exotic plant in several regions is very similar, management differences are harder to justify.

The maps below in Figure 7.10 show the regional extent (i.e. area occupied by) and management of old man's beard (*Clematis vitalba*), boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*), wild ginger (*Hedychium* spp.), lodgepole pine (*Pinus contorta*) and Douglas fir (*Pseudotsuga menziesii*).

[121] Hornwort is listed as an exclusion plant in RPMPs from two North Island and four South Island regions, an eradication plant in one North Island region, a progressive containment plant in three North Island regions, a sustained control plant in one North Island region, a site-led plant in one North Island region, and an organism of interest in three North Island regions, two South Island regions and the Chatham Islands. In three RPMPs, hornwort is listed under multiple management programmes: exclusion, eradication and progressive containment in Bay of Plenty; exclusion, sustained control and site-led in Auckland; and exclusion and organism of interest in West Coast (see Appendix 2 in Hutchison et al., 2021).

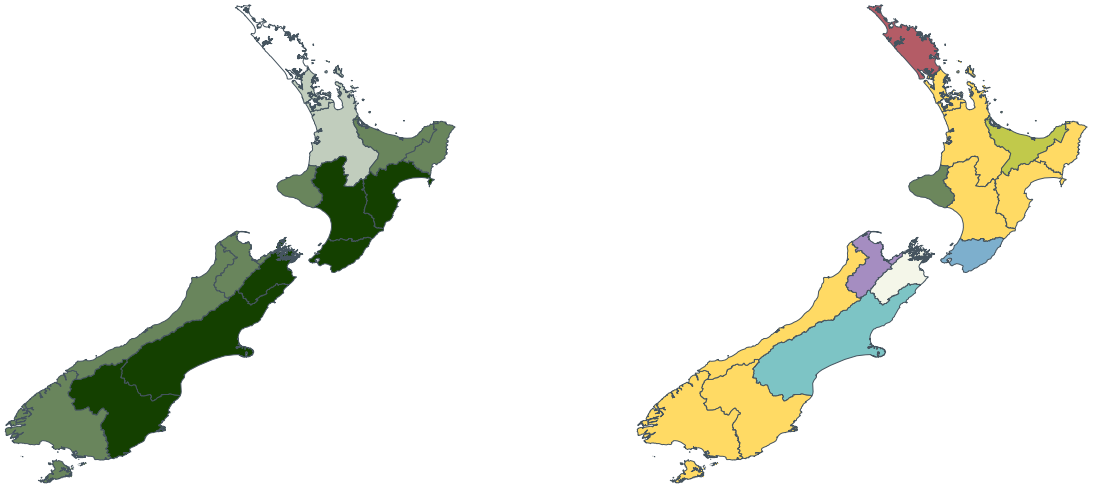
[122] For example, see Table 5 in Auckland Council (2020).

[123] One recommendation from the Plant Biosecurity Science in New Zealand report was that networks needed to be formalised to improve communication and information sharing (Dyck and Hickling, 2021).

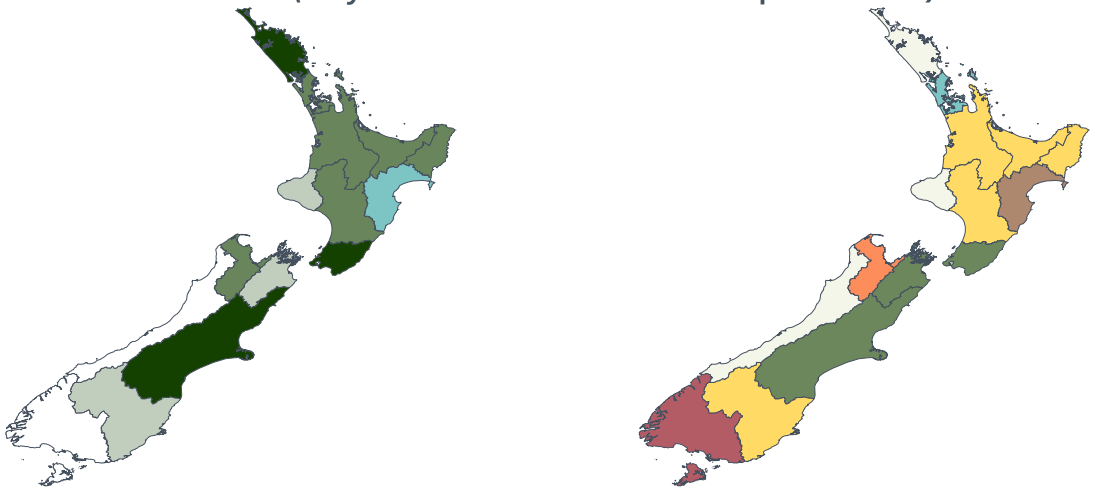
[124] Palmer, 2020, p.11.

[125] For example, it makes sense to assign absent plants to an exclusion programme, early invaders to an eradication programme, and more widespread plants to other programmes.

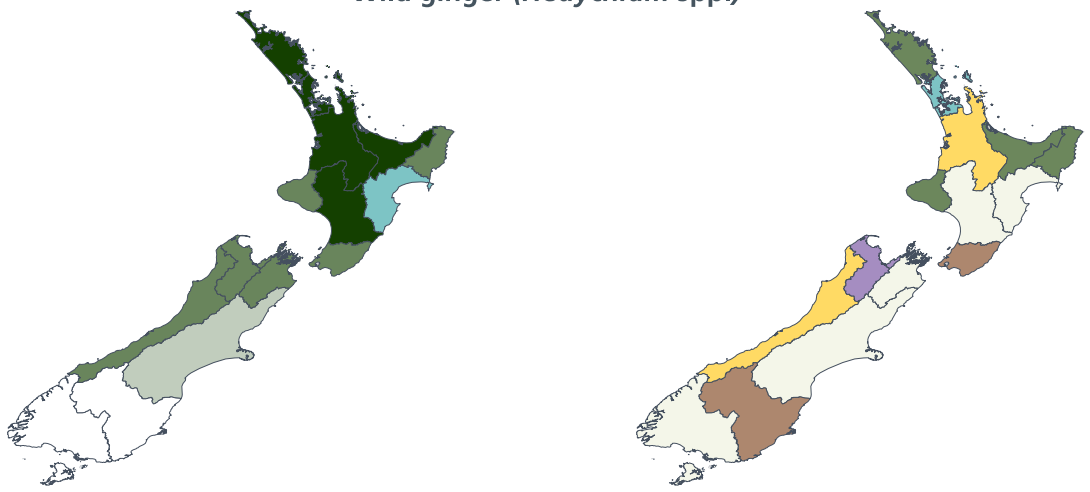
Old man's beard (*Clematis vitalba*)



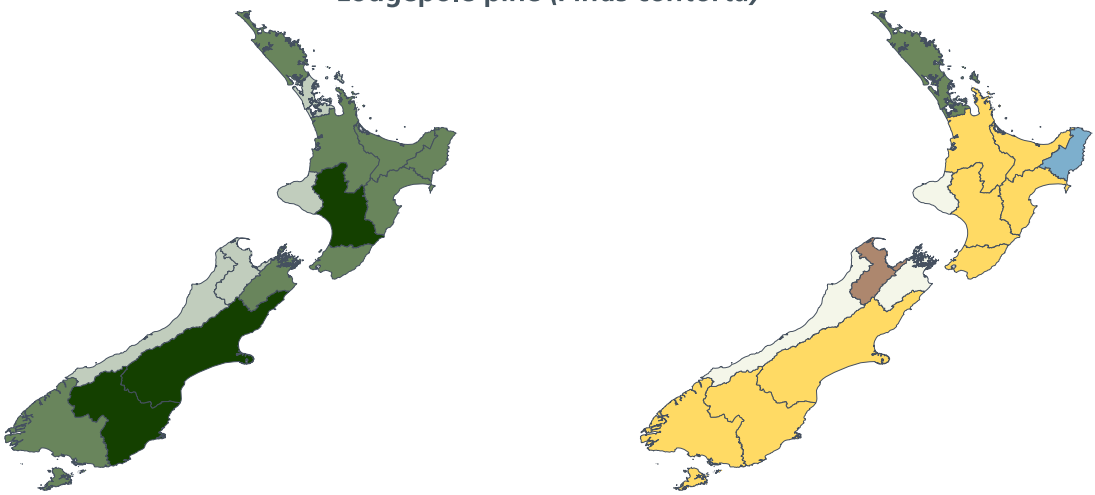
Boneseed *(Chrysanthemoides monilifera* subsp. *monilifera)*



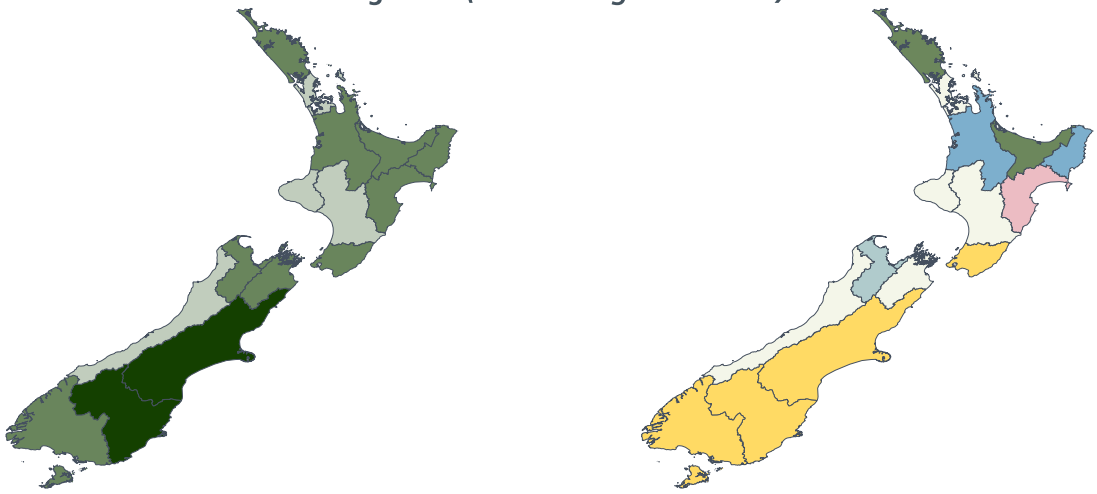
Wild ginger *(Hedychium* spp.*)*



Lodgepole pine *(Pinus contorta)*



Douglas fir *(Pseudotsuga menziesii)*



Area occupied
- Absent
- Localised
- Spreading
- Widespread
- Unknown

RPMP Programmes
- Exclusion
- Eradication + organism of interest
- Progressive containment
- Progressive containment + organism of interest
- Progressive containment + sustained control
- Sustained control
- Sustained control + site–led
- Sustained control + organism of interest
- Organism of interest
- Site–led
- Site–led + organism of interets
- Not listed in RPMP

Source: data supplied by council staff, 2021

Figure 7.10: Regional extent (left side maps) and RPMP management programmes (right side maps) of old man's beard, boneseed, wild ginger, lodgepole pine and Douglas fir.

The maps illustrate inconsistencies between the area occupied by these weeds in the regions and the management approaches adopted. For example, eradication programmes (at least in the statutory sense under the NPD) have not been undertaken where old man's beard and boneseed are at an early stage of infestation (Auckland and Waikato, and Otago, respectively).[126] And there are no exclusion programmes in place for wild ginger where it is currently absent (e.g. Otago), despite the difficulty of controlling it once it has established. As explained in chapter three, many aspects of climate change are poised to help weeds progress through the invasion process and permit more of them to survive, thrive and spread in parts of New Zealand where they are not found today. So wild ginger may expand its range over time.

Even more concerning from the perspective of coordinating pest management nationwide, the RPMP programmes implemented in neighbouring regions do not appear to consistently support each other. For example, the opportunity to exclude old man's beard and boneseed from Northland and Southland, respectively, might conceivably be threatened by a failure to control these plants sufficiently in neighbouring regions where they are under progressive containment (or no RPMP management at all) rather than eradication programmes.

These apparent inconsistencies in management programmes for the same weeds (or groups of plants) in neighbouring regions sends a clear signal that the coordination and alignment called for by the Act needs improvement.

Further, as weeds do not recognise administrative boundaries, managing pathways of spread becomes even more important, as it can be cheaper than trying to manage a widespread plant. However, there are no pathway management plans for terrestrial exotic plants. Regular and adequate surveillance is also an important component of this coordination, as it can help spot plants spreading between regions.

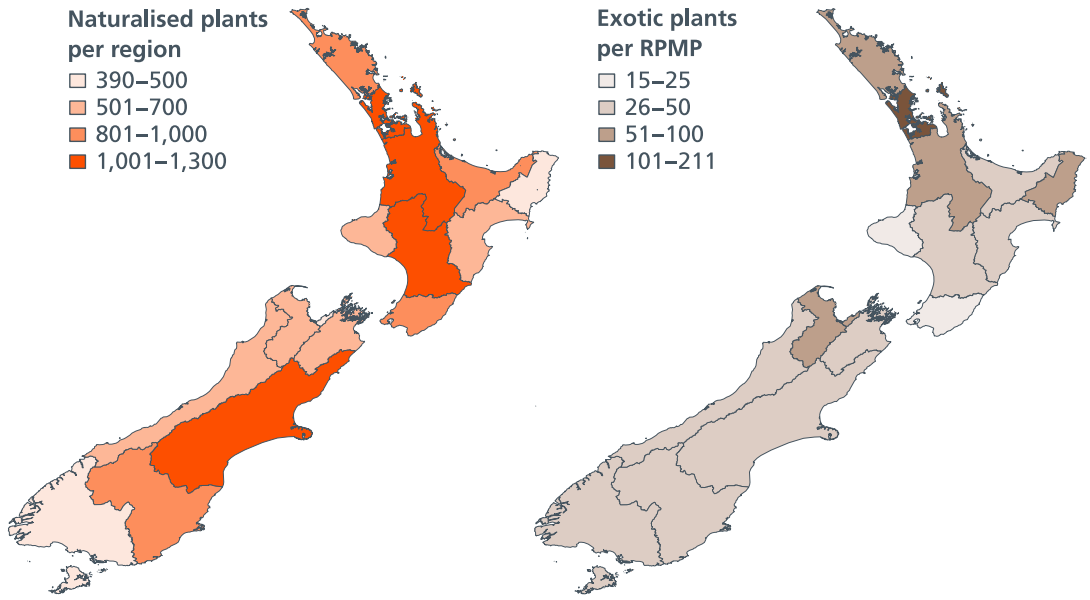
Lack of transparency in decision making remains an issue

As mentioned above, the lack of transparency makes it hard to evaluate whether management decisions are defensible.

To start with, there is an incomplete picture of how exotic plant species in New Zealand are prioritised for management and inclusion in RPMPs.

Given the sheer numbers of exotic plants introduced to New Zealand, not all of them have been assessed by each council when they produce an RPMP. Each RPMP lists only a fraction of the hundreds of naturalised plants in the region (see Figure 7.11).

[126] Note that as the NPD requires stating the intended outcome to be achieved in the first 10 years of the plan, or during the current term of the plan prior to next review, some regional councils are cautious about the assignment of the species to an NPD-defined programme. For example, in the case of old man's beard in Auckland, council staff were cautious that eradication of these species may not be feasible within the 10 years of the RPMP; therefore, they set out to 'progressively contain' old man's beard within that time frame rather than expecting to declare eradication within 10 years. If on track, then old man's beard would likely go into an eradication programme in the subsequent plan (Auckland Council staff, pers. comm., 21 September 2021).



Source: left – Brandt et al., 2021; right – Hutchison et al., 2021

Figure 7.11: Naturalised plant species in the regions (left) and plant taxa in RPMPs (right).

The absence of naturalised plants from an RPMP might be construed as evidence that councils consider that these plants pose relatively little threat to the region's native ecosystems. But it is impossible to know what naturalised plants present in a region have actually been assessed, and whether some species have been assessed but discounted.[127] This is a concern because an unknown number could pose a risk of unknown proportions to our native ecosystems. The reality is that many weeds that pose risks to the integrity of native ecosystems have not been identified as high priorities for management in the sense of being regulated through listing in RPMPs.

Learning to live with some exotic plants is unavoidable given the prevalence of many and their values and uses in certain contexts. Ideally, the exotic plants that are omitted from management programmes would pose minimal risks to native ecosystems. But without systematic assessment, we have no way of knowing if this is the case.

[127] Lack of transparency with the cost–benefit analysis process discussed in the previous chapter is a related point. Bay of Plenty Regional Council has provided a summary of its cost-benefit analysis results, including two plants (agapanthus (*Agapanthus praecox*) and giant reed (*Arundo donax*)) that were considered for its RPMP but left out because the costs of their management outweighed the benefits. Unfortunately, the availability of this information appears to be the exception rather than the rule. See https://www.boprc.govt.nz/your-council/plans-and-policies/plans/regional-plans/regional-pest-management-plan [accessed 5 July 2021].

The RPMPs that finally emerge from consultative processes inevitably reflect public and political pressures to varying degrees. In its analysis of RPMPs conducted for this review, Wildlands Consultants concluded:

> "While the number of weed taxa listed in RPMPs varies considerably among the regions … this variation cannot be explained by biological and geographical differences among regions. Not only did the number of naturalised seed plants and conservation weeds not predict the number of RPMP weeds, when Auckland was excluded as an outlier, but there was also no detectable effect of land area, human population, or area of pastoral, biodiversity, and urban land uses, when Auckland was excluded. The considerable variation in the number of weeds managed through RPMPs must instead be primarily due to political and cultural differences among the regional councils."[128]

As long as a lack of transparency in decision making remains an issue, it will remain hard to assess how final decisions come to be made. It also leaves plenty of room for decisions to be contested. If regional councils lack clear reasons for why they manage exotic plants in particular ways then it becomes difficult to assess outcomes, which is further compounded by a lack of evidence required (see Box 7.3).

Box 7.3: Outcome monitoring – focusing on the wrong thing?

Like DOC, regional councils also appear to focus on actions rather than outcomes when reporting on biodiversity management.

For example, in 2008, Clayton and Cowan surveyed animal and plant pest control and monitoring undertaken by regional agencies.[129] As part of this study, the authors examined two types of monitoring. The first was **result monitoring** (often called operational monitoring), which provides an estimate of the proportional changes in the pest population as a consequence of the control action, or demonstrates whether or not a pre-set target for pest numbers has been achieved by control. The second type was **outcome monitoring**, which measures the state, or change in state, of the managed system in response to management actions, typically measured by changes in native biodiversity or crop yield.

The survey revealed that the use of outcome monitoring was very limited. More than half the local authorities surveyed did no outcome monitoring. Outcome monitoring accounted for just 1.4 per cent of the total spent on council-funded pest control at the time.[130]

The survey highlighted the need for better definition of the desired outcomes of pest management, appropriate indicators of progress towards outcomes, and greater consistency across regions in the collection, analysis and reporting of information about pest management activities and the outcomes of pest management. While the survey findings are over a decade old, there is no indication that the problem has been solved.

[128] Hutchison et al., 2021, p.12.

[129] Clayton and Cowan, 2009, 2010.

[130] The authors found that 82% of the remaining programmes (after exclusion of the programmes focused solely on compliance) had some form of results monitoring, but only 16% had some form of outcome monitoring. Nine programmes (or 11%) had no monitoring at all. All outcome monitoring, except in one programme, had biodiversity protection as its primary goal. Excluding compliance monitoring, about 7% of total funding for pest control was spent on monitoring results and outcomes (Clayton and Cowan, 2010).

8

Asparagus scandens

Down in the weeds...

As detailed in previous chapters, central and local government are required to manage weeds that harm native ecosystems across the country. They do so to varying degrees and with varying levels of success. But they are not the only ones weeding.

Aotearoa is fortunate to have large numbers of passionate individuals, landowners, kaitiaki, hapū, iwi and community groups willing to devote their time and effort to protecting native species and biodiversity. One study estimates there are at least 600 community environmental groups restoring degraded sites.[1] Most of these restoration efforts require some control of weeds and planting of natives.

While some groups are entirely self-sufficient, many depend on external partnerships and grants for survival. Much of this support comes from local and central government. In turn, government agencies like the Department of Conservation (DOC) rely on volunteer effort to achieve its stated biodiversity goals.[2] These partnerships demonstrate that some volunteer work done by community groups is part of New Zealand's pest management system.

From those crusading to eliminate a particularly loathed plant, to community groups working to restore precious sites, these groups are making a substantial dent in the numbers of weeds carpeting and climbing over our land. For Māori, there is often an additional layer of management framed by te ao Māori that emphasises connection to the land, multi-generational thinking and considering the needs of Papatūānuku first and foremost.

These multiple layers of complexity across landscapes, regulatory requirements and opinions can create conflicting management goals for exotic plants, as a valued cultivated plant can also be a native ecosystem weed.

In this chapter we profile a selection of five community groups from Stewart Island/Rakiura to Northland. We will illustrate some of the great work being done on the ground to rid our native ecosystems of weeds, and some of the challenges these groups face.

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[1] Peters et al., 2015.

[2] DOC, 2013, 2016.

Stewart Island/Rakiura Community & Environment Trust

The Stewart Island/Rakiura Community & Environment Trust (SIRCET) is a community-based non-profit organisation that was started in 2003 by motivated locals who wanted to enhance the environment around settled parts of the island. It started with predator control and a native nursery (from which plants were offered to replace potentially weedy exotic plants in locals' gardens) and later moved into weed control and site restoration work.

In 2017, weed control became a priority after SIRCET was awarded a grant from the DOC Community Fund to control Darwin's barberry (*Berberis darwinii*). Darwin's barberry was chosen as the main target plant because it aggressively crowds out native plants and was widespread in the area. The plant is also listed as an unwanted organism by the Ministry for Primary Industries (MPI).

SIRCET has been progressively containing and removing barberry from set geographic areas in accordance with guidance from Environment Southland's RPMP.[3] To a lesser extent, SIRCET also controls other weeds, including bomarea (*Bomarea multiflora*), Spanish heath (*Erica lusitanica*), buddleia (*Buddleja davidii*), pampas (*Cortaderia selloana*) and Chilean rhubarb (*Gunnera tinctoria*).

SIRCET's work on Darwin's barberry has been impressive – to date, over 48,000 individual plants have been killed by grid searching, cutting down and poisoning trees on 538 hectares of private land over four years.[4] The search effort and location of every plant found and removed is made publicly available. This can be viewed via a web-based geographic information system (GIS) on SIRCET's website (Figure 8.1).

The community is surrounded by a robust native ecosystem rich with birdlife, facilitating easy seed dispersal to areas that have been cleared of weeds. This means that when the barberry is removed, the gaps are often recolonised by native plants, rather than by other weeds. However, there is still a risk from browsing by pest animals like deer, so not all natives may flourish after barberry removal.[5]

The majority of the Darwin's barberry control work is done by paid employees because the most effective removal method is arduous. The DOC Community Fund allowed SIRCET to employ three to five people per summer for three years from 2017 to 2020. In 2021, the trust was awarded $2 million over two years from the Jobs for Nature fund, which will allow it to employ 17 people. In practice, this will mean two teams working on weeds full time, and one on predator control. SIRCET can normally count on around 30 to 40 volunteers – which, notably, equates to eight to ten per cent of the population of Stewart Island. Most of these volunteers work in predator control and the nursery.

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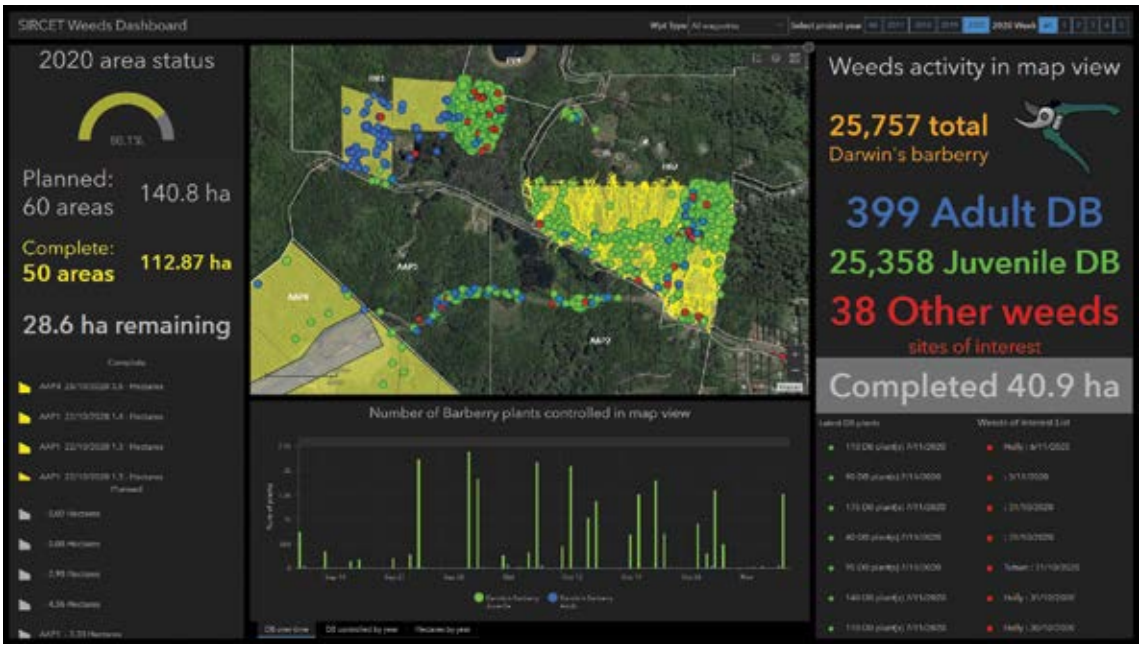
[3] Environment Southland, 2019.

[4] Usually killed by cutting and applying herbicide to the stump.

[5] Forsyth et al., 2003. The group has tried to implement deer control methods in the past, but this has proved challenging due to logistical and social license issues.



Source: SIRCET

Figure 8.1: The SIRCET team carry Global Positioning System (GPS) equipment in the field to track where they walk and mark the location of every Darwin's barberry plant (*Berberis darwinii*) they come across when grid searching. These data are displayed on an interactive map on their website, pictured.[6]

Project De-Vine Environmental Trust

Project De-Vine Environmental Trust (PDVET) emerged out of a couple's frustration with the "overwhelming numbers of weeds" that smothered part of their property in Golden Bay, Tasman Region.[7] From a group of landowners voluntarily removing weedy vines from their adjoining properties from 2006 to 2010, the group has grown to over 20 employees working mostly full time on weed control in the region in 2021 (Figure 8.2).

PDVET's aim is to control and then maintain 'zero-density' of banana passionfruit (*Passiflora tripartita* var. *mollissima* and *P. tarminiana* subgroup), old man's beard (*Clematis vitalba*) and other troublesome weeds in Golden Bay to form a weed-free buffer zone around the Abel Tasman and Kahurangi national parks. It views weed control as the underpinning structure that can then encourage restoration of native ecosystems through planting and managed regeneration.

[6] https://www.sircet.org.nz/current-projects/sircets-war-on-weeds [accessed 25 September 2021].

[7] PDVET, pers. comm., 20 August 2021.

Source: PDVET

Figure 8.2: Fighting weeds is typically hard work requiring fit and strong people to spend many hours in the field. Here a Project De-Vine worker cuts up a large specimen of woolly nightshade (*Solanum mauritianum*).

The two key vines – banana passionfruit and old man's beard – were initially chosen because of their widespread distribution, invasion voracity, capacity to smother and strangle mature native trees and ability to prevent native seedlings from establishing. PDVET's target list has since expanded to include climbing asparagus (*Asparagus scandens*), woolly nightshade (*Solanum mauritianum*), yellow jasmine (*Jasminum humile*) and pampas. They also work to control exotic trees in areas where they threaten native habitats. These are primarily crack willow (*Salix* × *fragilis*), sycamore (*Acer pseudoplatanus*) and wilding conifers.

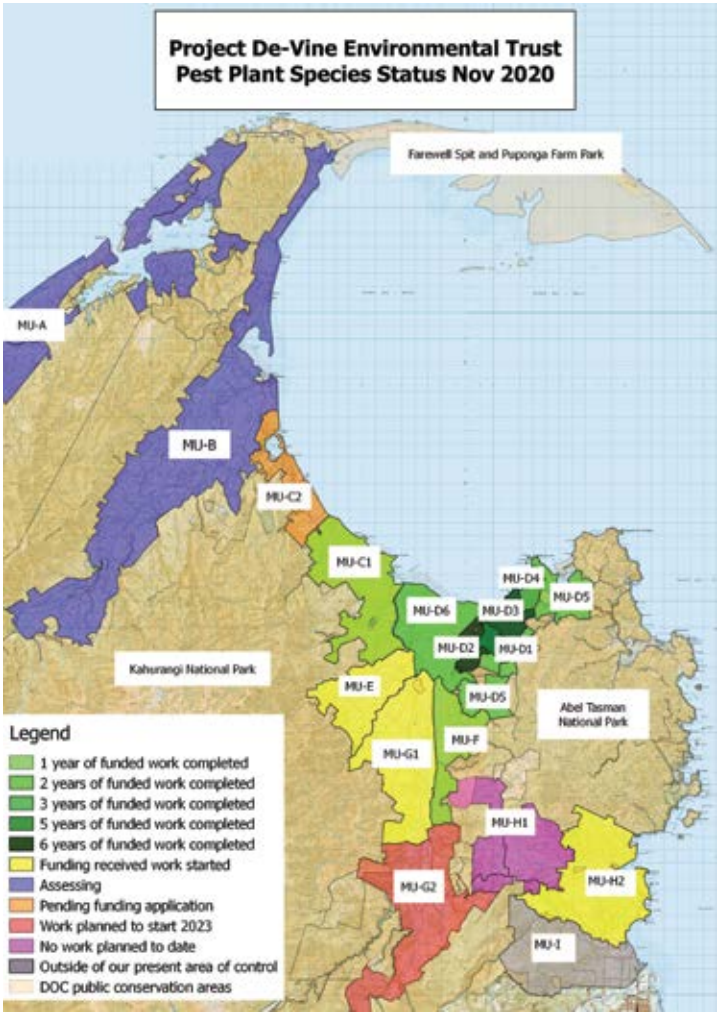
The results are notable. To date, PDVET reports having killed about 1 million weeds.[8] It has assessed over 850 private properties, equating to around 25,000 hectares, and controlled plants on nearly 500 of these properties (11,600 hectares).

A defining feature of PDVET's work is its extensive mapping database built using GIS. Employees using phones in the field can mark weed points, tracks taken through properties and areas for future visits. This reduces potential errors from time-consuming manual data entry and allows the office to easily extract data to report back to landowners and funders.

[8] See https://pdvet.org.nz/pest-plant-numbers [accessed 25 September 2021].

Over the years, PDVET has developed a business model based on a mixture of contract work and charitable funding that allows it to employ a team of field employees, an operations manager and an administrator. This contract work generates a moderate surplus, which is used for operating costs, equipment, ongoing control and scoping new areas. It has divided Golden Bay into management units of set geographic areas constrained by private property boundaries (Figure 8.3), so work and funding applications can be kept to manageable chunks.

Once working within a management unit, PDVET supports as many landowners as possible to control target weeds on their properties. PDVET has found that after it does some initial work, a large number of properties go on to manage their own weed control. The trust encourages this by running community working bees showing the best ways to eliminate target plants and providing free, refillable pesticide gel bottles.[9]



Source: PDVET

Figure 8.3: Like many other groups, Project De-Vine Environmental Trust divides the areas where it plans to work into management units based on private property boundaries. The trust usually applies for funding to assess or control weeds in a specified management unit.

[9] This is sponsored by three branches of the Nelson Building Society across the Tasman District.

Weed Action Native Habitat Restoration Trust

The Weed Action Native Habitat Restoration Trust is working to restore native habitat on the Whangārei Heads peninsula through strategic removal of weeds. The trust works with several weed action groups operating site-led projects on public land (such as reserves owned by DOC or Whangarei District Council).

Overall, the trust aims to control weeds and raise community awareness to prevent new plants getting a foothold and make it easy for every resident to participate. Recently, it has tilted away from solely managing plants at specific sites towards managing weeds across the landscape.

Its multipronged approach involves several elements:

- employing contractors to do heavy-duty work on steep land far from accessways
- facilitating volunteers to work on more accessible public conservation land
- encouraging landowners to engage on their properties
- working with local hapū and assisting them with weed management on whenua Māori.

The trust has chosen to focus on 12 weeds based on their ecological impact. These include:

- those that penetrate intact forest – such as wild ginger (*Hedychium* sp.), tree privet (*Ligustrum lucidum*) and wandering willie (*Tradescantia fluminensis*)
- those that prevent regeneration or displace understorey species in the forest or along forest edges – such as climbing asparagus, woolly nightshade, elaeagnus (*Elaeagnus* × *reflexa*), Taiwan cherry (*Prunus campanulata*), Chinese privet (*Ligustrum sinense*) and cotoneaster (*Cotoneaster glaucophyllus*)
- climbers that can smother and cause canopy collapse in the forest – such as banana passionfruit, jasmine (*Jasminum polyanthum*) and moth plant (*Araujia hortorum*).

Through Northland Regional Council funding, the group has engaged a paid coordinator and receives a portion of a targeted local rate from Whangārei Heads residents earmarked for conservation.[10] The coordinator's main work involves raising awareness, educating the community and landowners, removing barriers to action, providing herbicides and equipment, and providing training and advice on weed control methodologies.

Having access to tools, equipment and the range of herbicides needed to tackle different weeds has proved a real financial and logistical advantage for the community. Volunteers and landowners also have access to advice on the optimal methods to tackle any given plant.

The trust has developed a partnership with tangata whenua Ngātiwai. Through a community funding grant from DOC in 2020, the trust was able to train a team of hapū members to restore native ecosystems through weed control. The funding allowed it to have these participants certified in using herbicides, equipment and first aid. Attempts to attract more funding to employ the trainees as contractors have so far been unsuccessful. Through this partnership, local hapū have begun to develop weed management plans for their whenua and pathways for ecological restoration.

[10] Currently split into two part-time roles – field coordinator and organisational coordinator – totalling 18 hours per week.

The trust is starting to see the fruits of its labours in the form of ecological bounce-back in areas that have been tackled by volunteers in a sustained way (Figure 8.4). Volunteers report native seedlings starting to come back and trees flourishing after being freed from climbers. In the future, the trust would like to expand its geographic range and improve its capability in mapping, monitoring, and reporting.

2015

2021

Source: Weed Action Native Habitat Restoration Trust

Figure 8.4: The Tamaterau Reserve Weed Action group in Whangārei Heads has been removing jasmine (*Jasminum polyanthum*), blue morning glory (*Ipomoea indica*), moth plant (*Araujia hortorum*), wild ginger (*Hedychium* sp.) and Taiwan cherry (*Prunus campanulata*) from the Devonshire reserve since 2015. The group has made huge progress in restoring the Whangarei District Council reserve, which is remnant/regenerating coastal podocarp-broadleaf forest. Now only maintenance work to prevent reinvasion is required.

Te Roroa: Te Toa Whenua

Te Roroa are an iwi whose rohe is on the west coast of Northland, spanning from Hokianga Harbour in the north to Tokatoka in the south, and encompassing the Waipoua Forest and Kai Iwi Lakes. Te Roroa are heavily invested in improving the health of the whenua and ngahere in their rohe. They have several projects focused on regenerating native forest, and the strategy that guides their holistic approach to management of the Waipoua Forest draws heavily from te ao Māori.

Te Roroa started a project called Te Toa Whenua in 2016 to restore 900 hectares of their whenua into high-value native habitat and diverse productive land for current and future generations of their iwi.[11] One of their goals is to create an ecological corridor from the Waipoua Forest to the coastline along the Waipoua River. The iwi say they have a "vested interest in te taiao and in the health of their forest and their whenua".[12] Te Toa Whenua is an intergenerational project that aims to create a mosaic of different sustainable land uses, such as regenerating native forest, developing māra kai, food forests and horticulture, and potentially expanding into native forestry and agriculture. The project also aims to protect wāhi tapu archaeological areas and provide employment.

A large portion of the area of Te Toa Whenua was recently a forestry pine plantation. Now that the pines have been harvested, the exposed land is heavily burdened with wild ginger, pampas, woolly nightshade aristea (*Aristea ecklonii*) and, to a lesser degree, wilding conifers. Te Toa Whenua has been divided into management units, prioritising five active areas mostly along the river, that align with goals to create an ecological corridor and grow food.[13] The management team employs two people full time to remove weeds from these active areas and replace them with native plants.

Te Roroa also have a much larger environment team of around 20 to 25 people (including casual workers) who undertake weed control on the wider whenua. The team contract their skills to Waka Kotahi NZ Transport Agency and Fulton Hogan to manage the State Highway 12 corridor through the Waipoua Forest. They also carry out contract work for DOC along the Waipoua River and in Kai Iwi Lakes, where they form part of the management committee with Northland Regional Council, Kaipara District Council and other local iwi.

In both work streams, Te Roroa take a holistic approach to weed management that is rooted in te ao Māori, where the outcome they want to see – high-value native habitat – influences their preferred removal methods. This includes reducing their heavy reliance on herbicides based on concerns for soil health in areas where they want to grow food, human health from sustained daily use, and unintended damage to species they want to protect. Part of the tension over using herbicides comes from the feeling that it is a short-term fix that keeps Te Roroa locked into a continuous cycle of use. To the iwi, it feels like this keeps them from working towards their actual long-term goal – restoration – because much of their time and effort is spent on these short-term methods.

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[11] McDermott, 2019, p.3.

[12] Te Roroa Environment Manager, pers. comm., 16 September 2021.

[13] McDermott, 2019, p.7.

While they still use herbicides because of their efficiency, they prefer to employ other removal methods such as using diggers to excavate wild ginger, hand pulling of exotic seedlings and seeds, interplanting trees to shade out pampas, and broadcasting native seeds by helicopter or along roadsides. These methods are being trialled in different Te Toa Whenua management units. There are also some units set aside for no management. Monitoring over the last eight to ten years has shown some of these set-aside areas are regenerating well on their own because they are quite close to native seed sources in the Waipoua Forest. However, other areas left to their own devices have become infested with wild ginger.

Te Toa Whenua includes a nursery where hardy succession plants like mānuka (*Leptospermum scoparium*), nīkau (*Rhopalostylis sapida*) and tī kōuka (*Cordyline australis*) are grown for replanting on the forest fringes. A new commercial native plant nursery will boost production once finished. Around the river, Te Toa Whenua has planted dense pockets of natives in fenced areas in the hope these 'seed islands' can help regenerate the surrounding land, reducing the amount of active weed management required.

Rongoā practitioners

Rongoā practitioners work within te ao Māori and are guided by tikanga to care for significant natural areas while also using taonga plants for medicinal purposes.[14] This means that practitioners are strongly connected to the place where they collect their rongoā and feel a deep sense of responsibility for the mauri of the area, including how they impact it while collecting rongoā plants.

For rongoā practitioners, tikanga reminds them that rongoā are there first and foremost to protect Papatūānuku and second to heal people: "Ka ora te whenua, ka ora te tangata. When the Earth is well, people are well."[15] In practice, living by this whakataukī is a fundamentally different way to manage a landscape compared with viewing specific exotic plants as interlopers. It requires a shift to working with the land to enhance the ability for the whenua to heal itself.

Tikanga also requires practitioners to karakia (greet, acknowledge, connect to, respect) the land whenever they arrive, and continuously walk through and connect with the land and be a part of their area. This is not dissimilar to a farmer's connection and understanding of their land. This grounding gives practitioners a broader understanding of how they themselves, exotic plants and other pests impact an area and how to manage that.

The perspective of protecting Papatūānuku foremost can come into conflict with more human-centred views around whether an exotic plant needs to be removed. For rongoā practitioners, having weeds cloak Papatūānuku can be preferable to leaving exposed land bare. This requires considering the broader impacts on an ecosystem over time rather than focusing on an immediate problem, such as a proliferation of weeds. Even when the mauri of a place becomes unbalanced from weeds threatening important rongoā plants, it may not warrant removal of those weeds.

[14] McGowan, 2021.

[15] McGowan, 2021, p.18.

Rongoā practitioner Robert McGowan recounts that after a long-established blackberry bramble (*Rubus* sp.) was removed from a neighbouring property by the landowner, he and his local Waitao Catchment group planted tōtara (*Podocarpus totara, P. cunninghamii*) and kānuka (*Kunzea ericoides*) on the bare land with the aim to return it to its original state. Not long after, an explosion of Scotch broom (*Cytisus scoparius*), gorse (*Ulex europaeus*) and brush wattle (*Paraserianthes lophantha*) overtook the area – all of which had not previously grown there. These weeds suppressed the more aggressive opponent, blackberry, from rebounding.

Since then, McGowan has used the weeds to help natives grow and establish without the blackberry simply by clearing around the planted natives to make sure they have enough light. McGowan's knowledge of place and intention to work with the land has allowed for multiple benefits (keeping Papatūānuku clothed, returning land to its original state, and suppressing difficult-to-tackle blackberry) with limited intervention.

Many rongoā species, such as karamū (*Coprosma lucida, C. macrocarpa* and C. *robusta*), tutu (*Coriaria arborea var. arborea*) and koromiko (*Hebe elliptica*) grow in areas such as forest edges, where exotic plants are often prolific because of consistent disturbance. The dominance of exotic plants in these areas for decades has resulted in many rongoā plants disappearing from the wild, leaving practitioners no longer able to access wild rongoā species. Often the plants they want to collect have been gone so long there are no longer nearby seed sources.

Taking a multi-generational view while also thinking about the health of Papatūānuku, McGowan and others have resorted to planting and growing rongoā plants at home. But this planting is not just for personal use. By planting more than is needed and carefully managing the environment around the plants, McGowan is providing for future generations by harvesting seeds and replanting them in other local areas, and allowing birds and the wind to naturally distribute seeds further still.

Rongoā collection can also be impacted by methods other people use to manage exotic plants, particularly the use of herbicides. Herbicides are a concern to rongoā practitioners because they can kill important plants needed to heal Papatūānuku, and accidentally kill or contaminate rongoā species. This can have cumulative impacts on the overall mauri of an area, including the mauri of the people that utilise it.

Many centralised management regimes do not allow for rongoā practitioners to have a say on what type of method should be used to control exotic plants in a given area. This is a lost opportunity to work with Māori and better understand the potential to implement holistic weed management approaches that have less impact on the land and those that work with it.

Shared experiences across the groups

Coordination helps

There is seemingly endless work removing exotic plants from where they are not wanted. For the work done by kaitiaki, volunteers and community groups to contribute to shared outcomes for native ecosystems, it needs to align with regional and national goals. In practice, this means some coordination must occur with local and central government agencies operating in the area to set realistic aims and choose target plants based on the ecological outcomes being sought across a landscape. Plants do not respect property boundaries, and tackling plants that may not be managed on neighbouring land can lead to frustration as reinvasions set back efforts.

On Stewart Island/Rakiura, SIRCET works closely with DOC and Environment Southland when choosing which weeds to target. DOC has assisted by drawing up a weed control and operational plan (2016–2021), which has now been upgraded to a ten-year plan for 2021–2031.[16] The plan designates weeds into two categories: priority one weeds must be eliminated from the core area, and priority two weeds are to be removed if they are in small numbers. SIRCET has also received assistance from Environment Southland to help with funding, staff effort and landowner permissions.

One of the best examples of coordination between groups comes from Whangārei Heads, where Northland Regional Council has been trialling a programme to achieve sustained control of weeds across the landscape.[17] The council supports community groups and empowers landowners to control weeds by funding a part-time coordinator role and offering in-kind support for landowners tackling particular weeds. The Weed Action Native Habitat Restoration Trust and Backyard Kiwi (a predator-trapping network targeting mustelids and feral cats on the peninsula since 2001) also receive some core funding through this programme.

As part of this programme, a working group composed of landowners and community representatives (including iwi and local land care groups) has been established. The coordinator has assisted the group to develop a project plan to manage and prioritise pest plants and animals in their area based on the sought biodiversity outcomes.

The Weed Action Native Habitat Restoration Trust coordinator performs several functions aimed at reducing barriers for individuals and community groups dealing with weeds. These include facilitating and developing weed action groups, providing free access to tools and herbicides, and running local education campaigns, community workshops, and on-land demonstrations of weed identification and removal. The coordinator also works with agencies and local government on behalf of groups (such as assisting with grant applications) removing some of the administrative burden on volunteers.

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[16] Huggins, 2016; SIRCET, 2020.

[17] Northland Regional Council is trialling this animal and plant pest control programme in five areas with high biodiversity values and community interest: Whangārei Heads, Tutukaka, Kai Iwi Lakes, mid-North/Bay of Islands, and Piroa/Brynderwyn.

The trust expressed the importance of developing a coordinated approach to funding biodiversity efforts that does not silo pest animal management from weed management, and promotes the need for holistic ecological biodiversity management.[18]

Long-term support helps

Managing weeds effectively requires sustained, long-term commitment. The weeding does not stop when all adult plants have been eliminated from an area. Removing seedlings in subsequent years is required until the seedbank is exhausted and careful monitoring is needed to prevent reinvasion. "Once you get into the weed work, you realise that as soon as you stop doing it, you literally see your work starting to go backwards, which gives you a sense that the previous years have been wasted."[19]

Most community groups rely on securing ongoing practical and financial support to maintain volunteer commitment and acquire the equipment and tools required to manage weeds.[20] Community groups that are better at building relationships and procuring support from a range of sources tend to have increased longevity.[21]

Practical assistance may also be required. Removing the largest plants or reaching those on tough terrain can require specialist skills or qualifications to work with mechanised equipment such as chainsaws. Health and safety must remain a priority for any community group, and many we spoke to felt some tasks are beyond what a volunteer should be expected to do. This leaves groups working on public land either waiting for central or local government to assist by prioritising their needs or raising funds to enable the work to be done by skilled contractors.

The groups we spoke to found funding applications time consuming and required totally different skills from those needed for action on the ground. Several groups found that the narrowness of grant requirements does not always align with the long-term nature of weeding work. In particular, the propensity for funding to only apply to specific, short-term projects made it difficult to return to sites and prevent weeds from re-establishing.

To combat this, PDVET uses some creative approaches to allow its members to return to sites for ongoing control work. It carries out four phases of control – initial, follow-up, seedbank and long-term maintenance[22] – using the surplus from its contract work and annual grants from the Rātā Foundation and Tasman District Council.[23] However, this is only possible because PDVET has scaled up its work to become an established business. This level of action may be beyond most groups relying on volunteer effort alone.

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[18] Weed Action Native Habitat Restoration Trust, pers. comm., 25 August 2021.

[19] SIRCET trustee, pers. comm., 4 August 2021.

[20] A survey of 295 community environmental groups found that 93% reported receiving support from project partners. Councils provided 31% of this support and DOC provided 21% (Peters et al., 2015).

[21] Around 100 groups linked to DOC had been running for over a decade (Peters et al., 2015).

[22] Detailed descriptions of the four phases can be found in the trust's strategic plan (PDVET, 2020, p.28).

[23] The Rātā Foundation is one of the few charitable trusts that do allow for follow-up work.

Te Roroa noted that funding design and duration often does not allow for their preferred management methods. Te Roroa believe the available funding has locked them into short cycles of herbicide use that are successful in the short term but not viable as a long-term, multi-generational management option.

Long-term commitment from volunteers can be hard to maintain, particularly as many groups are small and populated by older participants. Weed Action Native Habitat Restoration Trust has a highly motivated and passionate base that works mostly on public land for free.[24] The group wants to do more but is acutely aware of the risk of losing volunteers to burnout, particularly as volunteers report feeling frustrated and disempowered by being "constantly knocked back in funding proposals".[25]

Information, knowledge and skills help

Those leading community groups acknowledged the key role access to information plays in their success. Access allows them to:

- first, acquire the information needed to do the work (i.e. learn how to identify weeds, understand their impact on native ecosystems, and know which herbicides and tools are best suited to removing them)
- second, pass this knowledge and expertise on to volunteers, landowners and the wider community
- third, feed their knowledge about the specifics of their local area back to project partners.

Groups reported using identification websites such as Weedbusters, but access to locally specific advice was not evenly distributed among groups. Some benefitted from expert input to their work from DOC, local government and non-governmental organisations. Others were well equipped in-house with volunteers or employees with environmental management qualifications and experience.

In Northland, Te Roroa have had access to help from ecologists within DOC, Northland Regional Council and local contractors. Te Roroa have also been assisted by a mātauranga Māori team providing input into their Waipoua Forest health strategy. This expertise is focused mostly on limiting kauri dieback.

However, also in Northland, the Weed Action Native Habitat Restoration Trust receives no ecological support from DOC or Whangarei District Council.[26] The trust members have accumulated deep knowledge of local weed control problems and are assisted by a highly qualified coordinator with 20 years of experience in biodiversity management. Local government representatives understand this and follow the trust's recommendations and weed management plans for reserves.

Increasing public awareness of weeds among the wider community is also a key function for some groups. This includes explaining the potential ecological impact of not intervening, what outcomes could be sought, what to do when weeds are sighted, and providing landowners with the knowledge and skills they need to take action on their own properties.

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[24] Most work is done by volunteers, and where funding is available the trust uses contractors in challenging terrain.

[25] Weed Action Native Habitat Restoration Trust, pers. comm., 25 August 2021.

[26] One of the trust's previous coordinators now works for Northland Regional Council. But prior to this, the trust received little advice from that quarter.

The Whangārei Heads area has benefited from Weed Action Native Habitat Restoration Trust engaging with the local primary school, writing articles for the local newsletter and putting up 'weed of the month' handwritten signs around the peninsula, pointing to live problem plants and explaining what damage they can do.[27] The coordinator produces regular Facebook videos showcasing particular weeds and demonstrating the most effective means to kill them. The videos include an invitation to contact the coordinator to borrow the necessary tools to tackle the plant in question. The trust says that since it started in 2014, the community has developed a high level of awareness about weeds, and the number of local weed groups has increased.[28]

Monitoring is not often consistent across groups, or a primary focus at all. For many, visual observations are the key determinant of success. Some groups collect their own GPS data on weed locations and routes taken by members. Two groups we spoke to (PDVET and SIRCET) display these data on public web-based platforms, often using a state-of-the-art GIS (Figure 8.5). With help from ecological contractors, Te Roroa also collect GPS data for internal use. There is potential for these types of data to inform broader work across a region, especially when it comes to surveillance of weeds new to local areas.

Source: SIRCET

Figure 8.5: This screenshot from a GIS database shows the extent of searching (yellow tracks) by SIRCET weed control staff between 2017 and 2020 as they worked around Oban township searching for Darwin's barberry (*Berberis darwinii*) and other weeds.

[27] Weed Action Native Habitat Restoration Trust, 2021, p.2.

[28] It conducted 121 volunteer events, equalling 4,314 volunteer hours. After its core funding from the Northland Regional Council, it fundraised and received an additional $82,160, which was used to purchase equipment and over 500 contractor hours working on public conservation land and public reserves (Weed Action Native Habitat Restoration Trust, 2021, p.3).

Relationships help

Being part of the community they work in can provide groups a real advantage when it comes to encouraging weed control across a landscape. Both SIRCET and PDVET attribute some of their success to the relationships they have built across the small communities they work in. They believe this grants them more access onto private properties than they would otherwise have. SIRCET reports that for its initial work, 134 out of the 146 landowners approached gave permission for SIRCET to access their properties to control Darwin's barberry. Both SIRCET and PDVET tend to start working with the willing and leverage the local network (and local newspapers) to persuade more reluctant landowners to take part.

Both groups usually have funding to undertake the initial removal of adult weeds on private property themselves. PDVET uses this opportunity to inform landowners about target weeds and the best methods to remove them, making it easier for landowners to become involved. PDVET reports that after this initial work, landowners on smaller properties often go on to do the follow-up work themselves.

Persicaria chinensis

Recommendations

Strengthening the system to better manage weeds that threaten native ecosystems

With the aim of promoting leadership, focus and action on native ecosystem weeds, seven recommendations are proposed. They are addressed to Ministers since whatever happens on the ground is shaped by the national framework created under the Biosecurity Act 1993.

That focus should **not** be understood as a conclusion that a better focus for ecosystem weeds is all about top-down direction.

There *is* a need for better tools, information and coordination. Central government has a vital role to play here. There is also a need for a degree of prioritisation at the national level. We should not have to wait until a serious ecosystem weed is decades along a destructive invasion pathway before any government funds are allocated to back up local and regional efforts.

But weeds grow in places, not abstractly or averagely across the country. They grow on both public and private land that is often adjacent. Any improvements in focus, prioritisation and the tools needed to combat these weeds must be developed working very closely with regional councils and drawing on the very significant practical intelligence that has been amassed from community-based initiatives.

With that caveat in mind, I am making seven recommendations as follows:

Recommendation 1: The Minister for Biosecurity and the Minister of Conservation should provide clearer direction on the priority to be accorded to managing native ecosystem weeds that are already present in New Zealand.

Recommendation 2: The Director-General of the Ministry for Primary Industries (Biosecurity New Zealand) and the Director-General of the Department of Conservation should jointly provide leadership for managing native ecosystem weeds that are already present in New Zealand.

Recommendation 3: In exercising that leadership, the two Director-Generals should require MPI and DOC officials to jointly develop (in collaboration with representatives from regional councils) national policy direction on native ecosystem weeds.

Recommendation 4: National policy direction specifically directed to native ecosystem weeds should be provided *either*:

- (a) by rewriting the existing National Policy Direction for Pest Management 2015 to include several targeted sections on the management of different pests already present in New Zealand – predators, browsers, invertebrates, pathogens, plants – including one specifically devoted to the management of native ecosystem weeds; ***or*:**
- (b) by amending section 56 of the Biosecurity Act 1993 to allow for multiple targeted national policy directions.

Recommendation 5: Any national policy direction that includes policy on native ecosystem weeds should require engagement with iwi and hapū and contain the following minimum content:

- provide clear direction on national priority weeds by:
  - requiring a group of experts to identify national priority weeds using a robust and transparent prioritisation process by a certain date;
  - requiring coordinated management of national priority weeds, once they have been determined;
  - providing clear direction on management when conflicting values arise;
  - requiring regular, proactive and coordinated surveillance and monitoring of the national priority weeds;
- provide clear direction on the management of emerging weeds, including a requirement for regular, coordinated scanning and surveillance; and
- specify roles to define what is to be done nationally, including any financial contributions by central government, and what is to be done regionally.

The preceding recommendations are all directed towards improving the leadership needed to tackle national priority weeds that threaten native ecosystems.

In addition, tools focusing on all exotic plants that are already in the country are essential to enable a properly coordinated approach. It is estimated that over 25,000 exotic plants have been introduced to New Zealand. But there is no up-to-date and authoritative list of all plant species growing in New Zealand. Authoritative information on the whereabouts of exotic plants, including native ecosystem weeds, in the New Zealand landscape is similarly limited.

Further, there is no single comprehensive database that contains all the information we currently have on exotic plants. Instead, relevant information is often scattered among numerous databases, lists and other resources. Many plant species are not consistently named in management documents or databases. These taxonomic issues hinder the flow of information needed to inform management decisions.

For this reason, New Zealand needs a single authoritative and publicly accessible database of all exotic plants by merging, updating and improving existing lists.

Recommendation 6: The Ministry for Primary Industries should work with the Department of Conservation, Ministry of Business, Innovation and Employment, regional councils and relevant Crown Research Institutes to develop, administer and maintain a single authoritative and publicly accessible database of all exotic plants in New Zealand.

- As a minimum, this database should:
    - use an agreed taxonomy (established by experts) and be able to cope with inevitable species name changes and multiple names (i.e. synonyms);
    - be maintained so it can provide an up-to-date, authoritative list of plant species present in New Zealand; and
    - include as much available information as feasible (including spatial data that is maintained and improved over time) on plant status, distribution, rate of spread, impacts, methods of spread, and management and control around the country (how, where and by whom).

The pool of native ecosystem weeds does not remain static. Land use change will continue to bring more invasions. Climate change is likely to help some weeds progress along the invasion curve and permit more of them to survive, thrive and spread in parts of New Zealand where they are not found today.

This is not good news given the current patchy and limited nature of a largely passive surveillance system that is too often dependent on serendipitous sightings. New populations of weeds are often only spotted and reported once they are beyond the point where they might have been easily eradicated. This hampers management efforts.

For this reason, the Ministry for Primary Industries and Department of Conservation, working in collaboration with regional councils, should set up an emerging risks team to scan for and coordinate the management of newly emergent weeds.

Recommendation 7: The Ministry for Primary Industries, Department of Conservation and regional councils, working with iwi and hapū and other relevant organisations, should set up an 'emerging risks team' to scan for and coordinate management of newly emerging native ecosystem weeds.

Such a team should seek to bring together the best in-house skills hosted by these organisations together with experts from the science sector, including Crown Research Institutes and universities.

Alternanthera philoxeroides

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