Taranaki Regional Council

AGENDA
Policy & Planning

Tuesday 7 June 2022, 10.30am

Policy and Planning Committee

07 June 2022 10:30 AM

Agenda Topic — Page

Taranaki Regional Council

MEMORANDUM
Policy & Planning

Date 7 June 2022

Subject: Confirmation of Minutes - 26 April 2022

Approved by: A D McLay, Director - Resource Management

S J Ruru, Chief Executive

Document: 3073990

Recommendations

That the Policy and Planning Committee of the Taranaki Regional Council:

a) takes as read and confirms the minutes and resolutions of the Policy and Planning Committee of the Taranaki Regional Council held in the Taranaki Regional Council Boardroom, 47 Cloten Road, Stratford on Tuesday 26 April 2022 at 10.30am

b) notes the recommendations therein were adopted by the Taranaki Regional Council on Tuesday 17 May 2022.

Matters arsing

Appendices/Attachments

Document 3045984: Minutes Policy and Planning Committee 26 April 2022

Taranaki Regional Council

MINUTES
Policy & Planning

Date 26 April 2022, 10.30am

Venue: Taranaki Regional Council Boardroom, 47 Cloten Road, Stratford

Document: 3045984

Members	Councillor	C L Littlewood	Committee Chairperson
	Councillor	M G Davey	
	Councillor	M J McDonald	
	Councillor	D H McIntyre	
	Councillor	C S Williamson	*zoom*
	Councillor	E D Van Der Leden	
	Councillor	M P Joyce	ex officio
Representative Members	Councillor	S Hitchcock	New Plymouth District Council *zoom first 15 minutes*
	Councillor	C Young	South Taranaki District Council
	Ms	B Bigham	Iwi Representative *zoom*
	Ms	L Tester	Iwi Representative
Attending	Mr	S J Ruru	Chief Executive
	Mr	A D McLay	Director - Resource Management
	Ms	A J Matthews	Director – Environment Quality
	Mr	D R Harrison	Director – Operations
	Mr	C Spurdle	Planning Manager
	Mr	N Bradley-Archer	Policy Analyst
	Mr	S Tamarapa	Iwi Communications Advisor
	Miss	J Mack	Governance Administrator
	Ms	V McKay	Science Manager *zoom*
	Mr	R Phipps	Science Manager *zoom*
	Mr	C Wadsworth	Strategy Lead *zoom*
	Mr	J Robinson	Science Advisor
	Ms	G Marcroft	Policy Analyst *(Item 7 & 8)*
	Ms	A Campbell	Planning Officer *(Item 7 & 8)*
	Ms	K Holland	Communications Adviser
	Ms	L Davidson	Executive Assistant
	Ms	C Robb	Happen Consulting *zoom*
	Mr	D Luke	Te Korowai o Ngāruahine Trust
	Ms	F Davey	Nga hapū o Orimupiko Marae
	Mr	J Davey	Nga hapū o Orimupiko Marae
	Four members of the public		
	Two members of the media on zoom		

Apologies Apologies were received and sustained from Councillor D N MacLeod , Councillor N W Walker, Councillor G Boyde (Stratford District Council) and Mr P Moeahu (Iwi Representative – due to technical issues).

McIntyre/Van Der Leden

Notification Of Late Items There were no late items

1. Confirmation of Minutes – 15 March 2022

Resolved

That the Policy and Planning Committee of the Taranaki Regional Council:

a) takes as read and confirms the minutes and resolutions of the Policy and Planning Committee of the Taranaki Regional Council held in the Taranaki Regional Council Boardroom, 47 Cloten Road, Stratford on Tuesday 15 March 2022 at 10.30am

b) notes the recommendations therein were adopted by the Taranaki Regional Council on Tuesday 5 April 2022.

McDonald/Young

Matters arising

1.1 Councillor C L Littlewood noted in the minutes (agenda item 3 – long term vision on FW), that there was detailed discussion on the struggles with community engagement and requested an action for officers to think how better engagement going forward could be achieved and reported back to the Committee

2. Freshwater Implementation Programme Update

2.1 Mr C Wadsworth, Strategy Lead - Resource Management, spoke to the memorandum to provide the Committee with a Freshwater implementation programme update.

2.2 Councillor D H McIntyre commented the E.coli component of the report noted that significant reduction is needed, and questioned whether this is achievable. Ms A Matthews, Director – Environment Quality, responded that this is currently being investigated.

2.3 Ms L Tester, Iwi Representative, sought clarification regarding ongoing work to set draft rules and whether this was taking place in partnership with iwi representatives? Mr C Wadsworth noted it was internal drafting given the tight timeframes. There will be collaboration with the new positions being recruited by iwi and funded by Council.

2.4 Councillor C L Littlewood referred to the social, culture and economic cost benefit analysis referred to within the update and asked when it would be completed. Mr C Wadsworth responded there will be background work required in that context which will determine when the work will be commissioned.

Recommended

That the Taranaki Regional Council:

a) receives the update on the Freshwater implementation programme

Van Der Leden/Joyce

3. Essential Freshwater Implementation Review

3.1 Mr C Wadsworth, Strategy Lead - Resource Management, spoke to the memorandum to inform the Committee of the recent changes to the Essential Freshwater implementation and the review of that process by external consultants.

3.2 Ms Christina Robb, Happen Consulting, introduced herself and the review team and spoke to the circulated presentation.

3.3 Ms L Tester, Iwi Representative, asked what level of iwi engagement had occurred during the review given iwi are equal partners in this process. Ms Robb responded that to date it has been Taranaki Regional Council present at the review workshop as iwi had Covid response pressures that limited their availability.

3.4 Councillor C L Littlewood commented that the timeline to notify the plan had shifted out six months, and what the balance was between allocating more resources at this versus timeline challenges? Ms C Robb responded that there are only so many resources available, and everyone is up against the same resourcing pressures. She noted the Taranaki Regional Council has a good team and arrangements in place and suggested concentrating on getting the issues we know addressed and this review completed by 2024.

3.5 Ms B Bigham, Iwi Representative, asked if the plan will be presented to commissioners for adjudication and what capacity do we have to influence the makeup of that panel? Is there capacity for Taranaki iwi to reflect preference for panel members? Ms C Robb responded – yes, it is set out in the RMA, and one of the panel members is nominated by tangata whenua of the region.

3.6 Councillor C L Littlewood thanked Ms Robb for the presentation and attendance.

Recommended

That the Taranaki Regional Council:

a) receives the Memorandum titled *Essential Freshwater Implementation Review.*

Joyce/Van Der Leden

4. Regional sector submission in response to proposed changes to the Environmental Reporting Act 2015

4.1 Ms A Matthews, Director - Environmental Quality, spoke to the memorandum to update Committee members on a recent submission by Te Uru Kahika – Regional and Unitary Councils Aotearoa in response to the Ministry for the Environment's proposed amendments to the Environmental Reporting Act 2015: *Te whakawhanake i te pūnaha rīpoata taiao o Aotearoa – Improving Aotearoa New Zealand's Environmental Reporting System*.

4.2 Ms A J Matthews, Director – Environment Quality advised the timeframes for the Ministry for the Environment (MfE) consultation and that an update would be provided to the Committee when MfE has received all submissions.

4.3 Councillor C L Littlewood, commented on the need to keep this Committee engaged in the process of sector and individual submissions and reporting those submissions back to this Committee. In response, Mr A D McLay noted the timeline for submissions was often very tight and where there were important local views the Council would compile its own submission or ensure these views were presented.

Recommended
That the Taranaki Regional Council:

a) receives this memorandum *'Regional sector submission in response to proposed changes to the Environmental Reporting System'*
b) notes the recommendations raised in the submission of Te Uru Kahika, a full copy of which is provided in Appendix C.

Young/McDonald

5. Regional sector submission on Te Ara Paerangi – Future Pathways Green Paper

5.1 Ms A Matthews, Director - Environmental Quality, spoke to the memorandum to update Committee members on a recent submission by Te Uru Kahika – Regional and Unitary Councils Aotearoa, in response to the Ministry of Business, Innovation and Employment (MBIE) *Te Ara Paerangi - Future Pathways Green Paper*.

Recommended
That the Taranaki Regional Council:

a) receives the memorandum '*Regional sector submission in response to proposed changes to the Environmental Reporting System*'
b) notes the submission and recommendations of Te Uru Kahika - Regional and Unitary Councils Aotearoa in regard to the Te Ara Paerangi - Future Pathways Green Paper, a copy of which is provided in Appendix B.

McDonald/Van Der Leden

6. State of Environment 2022 report

6.1 Ms A Matthews, Director - Environmental Quality, spoke to the memorandum to advise the Committee of the up-coming launch of the State of Environment 2022 report.

Recommended
That the Taranaki Regional Council:

a) receives the memorandum and endorses the proposed workshop with Councillors and Committee members on 7 June 2022
b) notes the up-coming public release of the State of Environment 2022 report via the 28 June 2022 Ordinary Council meeting.

McDonald/Young

7. Responsibilities for kaimoana management and cultural practices

7.1 Mr A McLay, Director – Resource Management, spoke to the memorandum outlining which agencies manage kaimoana, the current state of the resource, and options for improved management. This item arises from Members' interest at the committee meeting of 15 March 2022 asking officers to investigate the state of the resource and look at options going forward.

7.2 Mr S Tamarapa, Iwi Communications Advisor, gave a mihi to guests Fran Davey, Dion Luke, and other hapū members from Taranaki Iwi.

7.3 Ms F Davey spoke to the Committee, acknowledging the agenda memorandum. She outlined the reasons for the rāhui and the marked increase in visitors from out of region, and their excessive and unethical harvesting practices. Rāhui protects, preserves and allows for regeneration so they placed a rāhui as part of their customary fishing rights. A brochure was handed to Members for information. The delegation is planning a section 186a Fisheries Act application, to protect the resource. They intend to present this to the Minister of Fisheries in June. If the application is successful it would last for two years and could be extended, if the resource had not recovered. The group also requested support from the Council when the public submission period on their application opens.

7.4 Councillor Davey congratulated those present and supports the proposed application.

7.5 Councillor D H McIntyre asked if closing this area of coastline will move the problem to other areas. Ms F Davey responded that neighbouring hapū have aligned with them leaving a small section of coastline – but there could be an all of Taranaki coast rāhui.

7.6 Councillor E Van Der Leden queried whether there was use of any citizen science where kaitiaki are undertaking monitoring and data collection over the rāhui? Ms F Davey responded that it is planned during the two year closure to develop a management plan and undertake surveys. Schools have also been engaged in the area to complete surveys and monitoring.

7.7 Ms B Bigham, Iwi Representative noted in the report (page 220) a comment that there was no clear business case on pursuing the change to the Coastal Plan option and what moral responsibilities do we have? Mr A D McLay responded it was about the cost of the process and the most appropriate and effective legislation was the Fisheries Act.

7.8 Ms B Bigham, Iwi Representative requested the Council send a representative with the delegation presenting the Fisheries Act application. Councillor C L Littlewood agreed and asked officers to action.

7.9 Ms B Bigham, Iwi Representative, referred to page 223 of the report where surveys had been undertaken at six sites twice a year, and asked if this could be extended to include more data around kaimoana. Mr A D McLay referred to paragraph 30 of the agenda memorandum noting that the Council has monitoring expertise and will offer to continue discussion with iwi/hapū on monitoring methods and options.

7.10 Councillor S Hitchcock made comment that rāhui cannot be enforced by the Fisheries Officers and the officers don't have a high community profile. Ms F Davey replied, a conversation is needed with MPI fisheries because often the public don't understand the difference between law and the Treaty – which is also confusing to visitors. This is a new area for all to understand, requiring things like signage and communication between iwi and the community.

7.11 Councillor M P Joyce queried the likely timeframe for an application. Ms F Davey responded that there is communication happening with the Minister, but other coastal areas in NZ were also under pressure and others potentially making applications. The length of coast included in a Taranaki application was being discussed by mana whenua.

7.12 Councillor D H McIntyre asked whether the rāhui and delegation facilitate the ability for taking of kaimoana for local people, or is it total prohibition? Ms F Davey responded that public submissions will determine any restrictions, noting that beaches can be impacted differently.

7.13 Mr Dion Luke – Environmental Lead for Te Korowai Trust then spoke to benefits of the temporary closure through the rāhui and noted fisheries officers numbers and effort needed to be increased to regulate kaimoana harvesting.

7.14 Councillor M J McDonald asked whether two years was long enough to allow regeneration of stocks? Any application should be based on scientific research.

7.15 Councillor S Hitchcock asked whether there was sufficient funding to enable effective monitoring to be undertaken? Mr Luke commented the Trust are looking at options now.

7.16 The Committee thanked the delegation.

Recommended
That the Taranaki Regional Council:

a) receives this memo entitled *Responsibilities for kaimoana management and cultural practices*

b) notes the rāhui by the hapū to protect, preserve and allow for the kaimoana resource to recover

c) notes the Fisheries Act is the most appropriate statute to apply to kaimoana management

d) notes that once an application is made for a temporary closure, under the Fisheries Act, the Council will consider making a submission;

e) determines that this decision be recognised as not significant in terms of section 76 of the *Local Government Act 2002*

f) determines that it has complied with the decision-making provisions of the *Local Government Act 2002* to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determines that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Van Der Leden/Davey

8. New policy directions and the Treaty of Waitangi

8.1 Mr C Spurdle, Planning Manager, spoke to the memorandum to update Members on the adoption of a Heads of Agreement between the Taranaki Regional Council and Iwi Authorities on facilitating iwi engagement on the development of a *Natural Resources Plan for Taranaki* (NRP), and summarising recent work undertaken in exploring the principles of the Treaty of Waitangi and its application to the NRP development process.

8.2 Ms L Tester, Iwi Representative, congratulated the Council on the report and asked if the appointments were fixed term or permanent? Mr C Spurdle responded it was a 3 year agreement, noting this is a starting point to build upon.

8.3 Ms B Bigham, Iwi Representative also offered congratulations on implementing this initiative, noting that the language around iwi authorities and clarification could be confusing. Mr C Spurdle responded that the language is from the Resource Management Act but the new relationship will be more in the spirit rather than legal side of things.

Recommended
That the Taranaki Regional Council:

a) receives the memorandum titled *New Policy Directions and the Treaty of Waitangi*

b) notes the adoption of the Heads of Agreement

c) notes Resource Management reforms propose to require councils to give effect to the Treaty of Waitangi

d) notes that, as part of the development of a proposed NRP, Council will be discussing with tangata whenua opportunities for giving effect to the Treaty of Waitangi

e) determines that this decision be recognised as not significant in terms of section 76 of the *Local Government Act 2002*

f) determines that it has complied with the decision-making provisions of the *Local Government Act 2002* to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determines that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Joyce/McDonald

9. General Business

There being no further business the Committee Chairperson, Councillor C L Littlewood, declared the meeting of the Policy and Planning Committee closed at 11.50am. The meeting closed with a karakia.

Confirmed

Policy and Planning
Chairperson: ______________________________

C L Littlewood
7 June 2022

Taranaki Regional Council

MEMORANDUM

Policy & Planning

Date 7 June 2022

Subject: Climate change projections and impacts for Taranaki

Approved by: AJ Matthews, Director - Environment Quality

S J Ruru, Chief Executive

Document: 3066461

Purpose

1. The purpose of this memorandum is to update the Committee on a the findings and recommendations of a recent report *Climate change projections and impacts for Taranaki*, commissioned by Council and undertaken by the National Institute of Water and Atmospheric Research (NIWA).

Executive summary

2. Climate change is widely recognised as one of the most significant and complex global issues we face. In coming years, the effects of a changing climate will continue to impact our environment, economy and way of life. New Zealand's response is two-fold: adapt to changes in climate, and contribute to a coordinated international response to reduce greenhouse gas emissions to the atmosphere.
3. Taranaki Regional Council (the Council) has a leadership role in the community in responding to climate change challenges and opportunities. This includes working together in partnership with iwi/hapū, district councils, relevant agencies and organisations, stakeholders and the community to inform decision-making, guide policy development, and support communities to respond and adapt to the impacts of a changing climate.
4. Council's *Climate Change Strategy 2020: A strategy to guide Taranaki Regional Council's climate change response* (DM: 2385229) and accompanying Action Plan sets out a range of initiatives and actions for the Council in relation to climate change. This report relates to Policy 2 which requires that Council "Ensure robust climate change information and science is available to support decisions." An update on progress in regard to other initiatives will be presented to this Committee in an up-and-coming Policy and Planning Committee meeting.
5. This memorandum provides an overview of the findings of a recent report *Climate change projections and impacts for Taranaki*. This report was commissioned by the Council, and produced by NIWA. It sets out expected changes for a range of climate variables, which are likely to occur over the 21st century, and draws heavily on climate model

simulations from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report.

6. Key findings include:
   - The global climate system is warming and many of the recently observed climate changes are unprecedented. Climate change is already affecting New Zealand and the Taranaki region. In coming decades, climate change is highly likely to pose challenges to our way of life.
   - In Taranaki, we can expect to see an increase in hot days and decrease in frost days, with annual average temperatures expected to increase by 0.5-1.5°C by 2040 and 1.0-3.5°C by 2090.
   - Rainfall is projected to increase for most of the region, with increasing seasonal variation. Extreme rainfall events are projected to become more severe, while drought potential is expected to increase across Taranaki.
   - Annual average discharge from the region’s rivers is projected to remain stable or slightly increase, while mean annual low flow (MALF) magnitudes are expected to decrease, with a potential 50% reduction in MALF by the end of this century.
   - Global mean sea level has risen over the past century at a rate of about 1.7 mm/year and has very likely accelerated to 3.2 mm/year since 1993. Rising sea level is already observed in Taranaki, with an average increase of 4.0 mm/year, just slightly below the national average of 4.4 mm/year. By 2090, sea level rise of 0.5 – 0.7 m is projected (relative to 1986-2005 baseline).
7. The report provides commentary on climate change impacts and implications for a range of different environments and sectors of Taranaki. Challenges include an increase in flood events and coastal erosion, with increasing damage to inland and coastal infrastructure, and an increase in erosion and landslides. Opportunities could include warmer winter and spring temperatures leading to increased seasonal pasture growth rates, as well as increasing agricultural and horticultural productivity where water availability is not a limitation.

Recommendations

That the Taranaki Regional Council:

a) receives the memorandum

b) notes the findings and conclusions of the *Climate change projections and impacts for Taranaki report*, as outlined in the memorandum

c) notes the report will be made available to the public.

Background

8. Climate change is already affecting New Zealand and the Taranaki region, with downstream effects on our natural environment, the economy and communities. In coming decades, climate change is highly likely to pose challenges to our livelihood and way of life.
9. It is internationally accepted that human greenhouse gas emissions are the dominant cause of recent global climate change, and that further changes will result from increasing concentrations of greenhouse gases in the atmosphere. Human activities (and associated greenhouse gas emissions) are estimated to have caused about 1.0°C of

warming above pre-industrial levels. Estimated human induced global warming is currently increasing at 0.2 °C per decade due to past and ongoing emissions.

10. The rate of future climate change depends on how fast atmospheric greenhouse gas concentrations continue to increase. It is anticipated that continued increases in greenhouse gas emissions will cause further warming and impacts on all parts of the global climate system.
11. Council's *Climate Change Strategy 2020: A strategy to guide Taranaki Regional Council's climate change response* (DM: 2385229) and accompanying Action Plan sets out a range of initiatives and actions for the Council in relation to climate change. Policy 2 requires that Council "Ensure robust climate change information and science is available to support decisions".
12. As a first step, Council recently commissioned NIWA to undertake a review of climate change projections and impacts for the Taranaki region. The scope of this technical report included an analysis of climate projections for the Taranaki region and outlining key impacts that the region is likely to experience as a result of a changing climate. This also included the provision of regional-scale climate projection maps for 16 different climate and hydrological variables and indices.
13. This work draws on information set out in the IPCC Fifth Assessment Report in 2013 and 2014, and the New Zealand climate change projections report published by the Ministry for the Environment in 2018.

Discussion

14. The technical report describes changes, which are likely to occur over the 21st century to the climate of the Taranaki region. Consideration of future change incorporates knowledge of both natural variations in the climate and changes that may result from increasing global concentrations of greenhouse gases that are contributed to by human activities.
15. Future changes in our climate will depend upon the pathway taken by the global community. The global climate system will respond differently if greenhouse gas emissions are reduced or if they continue on their high emissions trajectory. This report represents two representative concentration pathways (RCP's) to reflect two greenhouse gas emission scenarios. RCP8.5 is a high-end scenario predicting what would happen if atmospheric greenhouse gas concentrations continue to rise at their current high rate. RCP4.5 is a mid-range scenario representing moderate global action taken towards mitigating greenhouse gas emissions.
16. Historic climate conditions are provided to give context for future changes. The future changes discussed in the report consider differences between the historical period 1986 and two future time-slices: mid-century (2031-2050) and late century (2081-2100).
17. NIWA reports that changes to the future climate of Taranaki are likely to be considerable. Some of the main impacts projected include an increase in hot days, a reduction in frost days, a shift to larger extreme rainfall events and increased potential for drought. The following list summarises the projections of different climate variables in the region:

Temperature

18. The projected temperature changes increase with time and greenhouse gas concentration pathway. Future annual average warming spans a wide range: 0.50-1.00°C by 2040, and 1.00-1.50°C (medium greenhouse gas concentration pathway: RCP4.5) or 2.50-3.00°C (high greenhouse gas concentration pathway: RCP8.5) by 2090.
19. Annual average maximum temperatures are expected to increase by 0.75-1.00°C by 2040 (RCP4.5). By 2090, maximum temperatures are projected to increase by 1.25-2.00°C (RCP4.5) or 2.50-3.50°C (RCP8.5).
20. The average number of hot days is expected to increase with time and increasing greenhouse gas concentrations. Up to 15 more hot days are projected by 2040 (RCP4.5 and RCP8.5), and up to 63 more days are projected by 2090 (RCP8.5).
21. Annual average minimum temperatures are expected to increase by up 0.50-0.75°C by 2040 (RCP4.5). By 2090, minimum temperatures are projected to increase by 1.00-1.25°C (RCP4.5) or 2.00-3.00°C (RCP8.5).
22. The average number of frost days is expected to decrease with time and greenhouse gas concentrations. The largest decreases are projected for high elevation and inland locations, with up to 15 fewer frost days projected by 2040 (RCP8.5), and up to 15 (RCP4.5) or 23 (RCP8.5) fewer days by 2090.

Rainfall and drought

23. Projected changes in rainfall show variability across Taranaki. Annually, rainfall is projected to increase for most of the region under both RCP4.5 and RCP8.5. By 2090, larger and more extensive changes to rainfall are projected at the seasonal scale. For some parts, winter increases of 8-22% (RCP8.5) and spring decreases of up to 6% (RCP4.5) are projected.
24. Extreme, rare rainfall events are projected to become more severe in the future. Short duration extreme rainfall events (e.g. thunderstorms) have the largest relative increases compared with longer duration extreme rainfall events (e.g. ex-tropical low pressure systems).
25. Drought potential is projected to increase across Taranaki, with annual accumulated Potential Evapotranspiration Deficit (PED) totals increasing with time and increasing greenhouse gas concentrations. By 2040, PED totals are projected to increase by 25-90 mm. By 2090, PED totals are projected to increase by 25-90 mm (RCP4.5) or 30-110 mm (RCP8.5).

River flows

26. The effects of climate change on hydrological characteristics were examined by driving NIWA's national hydrological model with downscaled Global Climate Model outputs from 1971-2099 under different greenhouse gas concentration pathways. Annual average discharge is projected to remain stable or slightly increase across both greenhouse gas concentration pathways and future time periods.
27. Mean annual low flow (MALF) magnitudes are expected to decrease across both greenhouse gas concentration pathways and future time periods for most catchments. A decrease in MALF of up to 50% is expected for most of the river systems in the region with increased greenhouse gas concentration and time.

Sea level

28. One of the most certain consequences of increasing concentrations of atmospheric greenhouse gases and associated warming is the rising sea level. Rising sea level in past decades has already affected human activities and infrastructure in coastal areas is New Zealand, with a higher base mean sea level contributing to increased vulnerability to storms and tsunami.

29. Rising sea level has already been observed in Taranaki. Absolute sea-level rise (SLR), calculated from satellite altimetry, shows the region is trending at an increase of around 4 mm/year (trend for 1993-present), which is close to the New Zealand-wide average of 4.4 mm/year (calculated up to the end of 2015). By 2090, sea-level rise of 0.5 m (RCP4.5) or 0.7 m (RCP8.5) is projected (relative to 1986-2005 baseline).

Impacts on the region

30. NIWA reports a range of ongoing and potential future impacts of a changing climate on different sectors and environments in Taranaki including:

    - A warmer atmosphere in the future is expected to result in increases to rainfall intensity. Increased rainfall intensity can cause soil saturation issues for the agricultural sector. It also increases the risk of flooding events which have associated adverse impacts such as damage to infrastructure
    - Increased risk of land degradation resulting from landslides and soil erosion
    - Warmer winter and spring periods will allow increased seasonal pasture growth rates
    - Increased concentrations of atmospheric carbon dioxide should increase forest, pasture, crop, and horticulture productivity, if not limited by water availability
    - Climate change-induced hazards are likely to expose the people of Taranaki to a range of direct and indirect health impacts. Examples include an increasing prevalence of hot conditions and heatwaves, and through the impacts of flooding, fires and infrastructure damage. Direct impacts could include injury, impacts on mental health and wellbeing, disruption to healthcare and critical services, and damage to people's homes. Indirect impacts could include secondary health issues, microbial contamination of drinking water supply, food security, air quality and the introduction of new diseases
    - Ongoing sea-level rise is likely to increase exposure of infrastructure to extreme coastal flooding, as well as cause habitat loss at the coastal margins where ecosystems are not able to move further inland (coastal squeeze). Exposure is likely to increase over time in response to higher sea levels.

Recommendations and next steps

31. The report outlines a number of recommendations and next steps to extend and develop our knowledge of climate change projections and impacts for the region including:

    - Investigation into how large floods may change in the future. This is the subject of an ongoing 5-year research programme led by NIWA and data will likely become available for use by councils in due course
    - Further work to understand climate change impacts on surface water low flows, groundwater recharge, lake levels, and wetlands, is now needed to inform policy development

- Additional work to understand the impacts of climate change on soil erosion and suspended sediment loads in Taranaki
- Investigation into the potential changes to heat stress in the agricultural sector (e.g. projected change in occurrence of heat stress conditions for dairy cows)
- Analyse and map future areas of high fire risk by combining projected climate data such as temperature, precipitation, and wind with relevant fire risk factors such as vegetation type and flammability
- Modelling potential changes to crop suitability with climate change specific to Taranaki for a range of crop types.

32. These recommendations are being considered as we look to develop our operational work programme for 2022-2023.
33. Responding to climate change requires collective effort. Over the past few months Council officers have been working alongside our region's district councils to share learnings and co-ordinate our efforts. An update on the group's progress, along with other climate change initiatives, will be provided to an up-and-coming Policy and Planning Committee meeting.

Financial considerations—LTP/Annual Plan

34. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

35. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

36. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.
37. It is noted that climate change and the role that human activities have on greenhouse gas emissions is identified in the majority of our regions iwi management plans.

Community considerations

38. This memorandum and the associated recommendations have considered the views of the community, interested and affected the preparation of this memorandum.
39. The contents of the climate change projections and impacts for Taranaki technical report include analysis of climate projections for the Taranaki region. Details specific to Taranaki are based on scenarios for New Zealand that were generated by NIWA from downscaling of global climate change simulations.

40. The climate change information presented in this report is consistent with national-scale climate change guidance produced for the Ministry for the Environment (2018), and sea-level rise information is consistent with the coastal hazards guidance manual published by the Ministry for the Environment (2017).

Legal considerations

41. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices/Attachments

Document 3068330: Climate change projections and impacts for Taranaki

Climate change projections and impacts for Taranaki

Prepared for Taranaki Regional Council

April 2022

Climate, Freshwater & Ocean Science

Prepared by:
Gregor Macara, John-Mark Woolley, Abha Sood (Regional Climate Modelling), Stephen Stuart (Regional Climate Modelling), Chris Eager, Christian Zammit, Sanjay Wadhwa

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NIWA CLIENT REPORT No: 2022068WN
Report date: April 2022
NIWA Project: TRC22301

Quality Assurance Statement		
	Reviewed by:	Petra Pearce Manager – Climate, Atmosphere and Hazards NIWA Auckland
	Formatting checked by:	Jess Moffat
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Cover image: *Mount Taranaki. [Gregor Macara, NIWA]*

This report may be cited as:
Macara, G., Woolley, J.-M., Sood, A., Stuart, S., Eager, C., Zammit, C., Wadhwa, S. (2022) *Climate change projections and impacts for Taranaki*. NIWA Client Report 2022068WN.

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Executive summary

The climate of Taranaki is changing, and these changes will continue for the foreseeable future. It is internationally accepted that human greenhouse gas emissions are the dominant cause of recent global climate change, and that further changes will result from increasing concentrations of greenhouse gases in the atmosphere. The rate of future climate change depends on how fast atmospheric greenhouse gas concentrations continue to increase.

Taranaki Regional Council commissioned NIWA to undertake a review of climate change projections and impacts for the Taranaki region. This report addresses expected changes for a range of climate variables out to 2100 and draws heavily on climate model simulations from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report. The following bullet points outline some key findings of this report:

- The projected temperature changes increase with time and greenhouse gas concentration pathway. Future annual average warming spans a wide range: 0.50-1.00°C by 2040, and 1.00-1.50°C (medium greenhouse gas concentration pathway: RCP4.5) or 2.50-3.00°C (high greenhouse gas concentration pathway: RCP8.5) by 2090.
- Annual average maximum temperatures are expected to increase by 0.75-1.00°C by 2040 (RCP4.5). By 2090, maximum temperatures are projected to increase by 1.25-2.00°C (RCP4.5) or 2.50-3.50°C (RCP8.5).
- The average number of hot days is expected to increase with time and increasing greenhouse gas concentrations. Up to 15 more hot days are projected by 2040 (RCP4.5 and RCP8.5), and up to 63 more days are projected by 2090 (RCP8.5).
- Annual average minimum temperatures are expected to increase by up 0.50-0.75°C by 2040 (RCP4.5). By 2090, minimum temperatures are projected to increase by 1.00-1.25°C (RCP4.5) or 2.00-3.00°C (RCP8.5).
- The average number of frost days is expected to decrease with time and greenhouse gas concentrations. The largest decreases are projected for high elevation and inland locations, with up to 15 fewer frost days projected by 2040 (RCP8.5), and up to 15 (RCP4.5) or 23 (RCP8.5) fewer days by 2090.
- Projected changes in rainfall show variability across Taranaki. Annually, rainfall is projected to increase for most of the region under both RCP4.5 and RCP8.5. By 2090, larger and more extensive changes to rainfall are projected at the seasonal scale. For some parts, winter increases of 8-22% (RCP8.5) and spring decreases of up to 6% (RCP4.5) are projected.
- Extreme, rare rainfall events are projected to become more severe in the future. Short duration extreme rainfall events (e.g. thunderstorms) have the largest relative increases compared with longer duration extreme rainfall events (e.g. ex-tropical low pressure systems).
- Drought potential is projected to increase across Taranaki, with annual accumulated Potential Evapotranspiration Deficit (PED) totals increasing with time and increasing greenhouse gas concentrations. By 2040, PED totals are projected to increase by 25-90

mm. By 2090, PED totals are projected to increase by 25-90 mm (RCP4.5) or 30-110 mm (RCP8.5).

The effects of climate change on hydrological characteristics were examined by driving NIWA's national hydrological model with downscaled Global Climate Model outputs from 1971-2099 under different greenhouse gas concentration pathways:

- Annual average discharge is projected to remain stable or slightly increase across both greenhouse gas concentration pathways and future time periods.
- Mean annual low flow (MALF) magnitudes are expected to decrease across both greenhouse gas concentration pathways and future time periods for most catchments. A decrease in MALF of up to 50% is expected for most of the river systems in the region with increased greenhouse gas concentration and time.

One of the most certain consequences of increasing concentrations of atmospheric greenhouse gases and associated warming is the rising sea level. Rising sea level in past decades has already affected human activities and infrastructure in coastal areas is New Zealand, with a higher base mean sea level contributing to increased vulnerability to storms and tsunami.

- Rising sea level has already been observed in Taranaki. Absolute sea-level rise (SLR), calculated from satellite altimetry, shows the region is trending at an increase of around 4 mm/year (trend for 1993-present), which is close to the New Zealand-wide average of 4.4 mm/year (calculated up to the end of 2015).
- By 2090, sea-level rise of 0.5 m (RCP4.5) or 0.7 m (RCP8.5) is projected (relative to 1986-2005 baseline).

The following points summarise ongoing and potential future impacts of a changing climate on different sectors and environments in Taranaki:

- A warmer atmosphere in the future is expected to result in increases to rainfall intensity. Increased rainfall intensity can cause soil saturation issues for the agricultural sector. It also increases the risk of flooding events which have associated adverse impacts such as damage to infrastructure.
- Increased risk of land degradation resulting from landslides and soil erosion.
- Warmer winter and spring periods will allow increased seasonal pasture growth rates.
- Increased concentrations of atmospheric carbon dioxide should increase forest, pasture, crop, and horticulture productivity, if not limited by water availability.
- Human health will also be affected by a changing climate, for example due to the increasing prevalence of hot conditions and heatwaves.
- Ongoing sea-level rise is likely to increase exposure of infrastructure to extreme coastal flooding, as well as cause habitat loss at the coastal margins where ecosystems are not able to move further inland (coastal squeeze). Exposure is likely to increase over time in response to higher sea levels.

1 Introduction

Climate change is already affecting New Zealand and the Taranaki region with downstream effects on our natural environment, the economy, and communities. In the coming decades, climate change is highly likely to increasingly pose challenges to New Zealanders' way of life.

Taranaki Regional Council (TRC) commissioned the National Institute of Water and Atmospheric Research (NIWA) to undertake a review of climate change projections and impacts for the Taranaki region (regional extent shown in Figure 1-1). This work follows the publication of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report in 2013 and 2014, and the New Zealand climate change projections report published by the Ministry for the Environment (Ministry for the Environment, 2018). The contents of this technical report include analysis of climate projections for the Taranaki region in greater detail than the national-scale analysis. Regional-scale climate projection maps have been provided for 16 different climate and hydrological variables and indices.

This technical report describes changes which are likely to occur over the 21st century to the climate of the Taranaki region. Consideration about future change incorporates knowledge of both natural variations in the climate and changes that may result from increasing global concentrations of greenhouse gases that are contributed to by human activities. Climatic variables discussed in this report include temperature, rainfall, and potential evapotranspiration deficit (a measure of drought potential). Projections for sea-level rise and river flows are also discussed. Commentary on climate change impacts and implications for some of the different environments and sectors of Taranaki are provided, including erosion and landslides, human and ecosystem health, and pasture growth.

Some of the information that underpins portions of this report resulted from academic studies based on the latest assessments of the Intergovernmental Panel on Climate Change (IPCC, 2013; 2014a; 2014b; 2014c). Details specific to Taranaki were based on scenarios for New Zealand that were generated by NIWA from downscaling of global climate model simulations. This effort utilised several IPCC representative concentration pathways for the future and this was achieved through NIWA's core-funded Regional Modelling Programme. The climate change information presented in this report is consistent with national-scale climate change guidance produced for the Ministry for the Environment (2018), and sea-level rise information is consistent with the coastal hazards guidance manual published by the Ministry for the Environment (2017).

A brief introduction to global and New Zealand climate change, based on the IPCC Fifth Assessment Report, is provided in Appendix A. Components of interannual climate variability are described in Appendix B.

Figure 1-1: Regional and district boundaries for Taranaki. The green border about Mt Taranaki indicates the extent of the Egmont National Park.

2 Condensed methodology and limitations

A detailed methodology explaining the modelling approach for the climate change projections presented for Taranaki is provided in Appendix C. This section provides a brief introduction to representative concentration pathways (RCPs) (Section 2.1), how the maps and tabulated climate projections are derived (Section 2.2), and limitations on the results and use of data presented in this report (Section 2.3).

2.1 Representative concentration pathways

In this report, the downscaled results of the selected global climate models based on two RCP scenarios (RCP4.5 and RCP8.5) are presented. The RCPs are scenarios of how greenhouse gas concentrations and other atmosphere pollutants might change during the course of the 21st Century. The rationale for choosing these two scenarios was to present a 'high end' scenario if atmospheric greenhouse gas concentrations continue to rise at high rates (RCP8.5) and a scenario which could be realistic if moderate global action is taken towards mitigating greenhouse gas emissions (RCP4.5). Including all four RCP scenarios within the body of this report would make it unwieldy, but GIS datasets for climate projections of the four RCPs were provided to the Council. For sea-level rise, projections for all four scenarios from the Ministry for the Environment (2017) coastal guidance, comprising RCP2.6, RCP4.5 and RCP8.5 (with a second high-end H^+ scenario to cover the potential for runaway polar ice sheet instabilities), are presented in the sea-level rise and coastal impacts assessment (Section 4).

RCP8.5 is described as a high-risk scenario, with greenhouse gas concentrations continuing to increase at the current or an accelerated rate. Whilst global emissions are unlikely to continue increasing at current rates to the end of the 21st century (Hausfather & Peters, 2020), the RCP8.5 projections serve the purpose of defining the upper envelope of likely futures required for high-risk impacts. Additional unaccounted risks resulting from other mechanisms (e.g. positive feedback loops) may result in impacts similar to those projected in the RCP8.5 scenario, even if the emissions scenario doesn't play out as projected. Examples of positive feedback loops include the melting of permafrost in Arctic regions, melting ice (e.g. Arctic sea ice) and clouds. Notably, RCP8.5 most closely resembles the total cumulative carbon dioxide emissions from 2005-2020, thus remaining RCPs assume a level of mitigation during the 2005-2020 period that did not occur (Schwalm *et al.*, 2020).

The RCPs inform projections which provide plausible futures under climate change. However, climate change over the remainder of the 21st century and beyond is uncertain. This is because:

- It is unknown how greenhouse gas concentrations will actually change over this period. Emissions may be significantly reduced, or they may continue to increase, or they may plateau. The two RCPs selected represent two representative choices among a wide range of possible options.
- Limitations in understanding of climate processes and how they are represented in the climate models used to predict how the climate will change. There is considerable complexity and inherent uncertainty in climate modelling (e.g. the response of the Antarctic ice sheet to increasing temperatures resulting in increased sea level rise).
- Uncertainty in natural climate variability.

This inherent uncertainty is the basis for why projected climate changes (for the globe and for New Zealand) are modelled based on a suite of RCPs. For risk assessments, it is best practice (e.g. as was done for the National Climate Change Risk Assessment; Ministry for the Environment, 2020) to consider climate change projections based on a range of RCPs, including a high concentration pathway. The RCP8.5 projections serve the purpose of defining the upper envelope of likely futures required for high-risk impacts.

2.2 Maps and tabulated climate projections

Downscaled climate projection data is presented as 5 km x 5 km square pixels over New Zealand. Data were downscaled only where low-resolution cells in the climate model consisted of land coverage and where they overlapped high-resolution cells on land. For display purposes, NIWA has undertaken interpolation to continue the climate projections to the coast for the climate change and historic climate maps presented in Section 3. The nearest neighbour interpolation method was used to do this, where the value of the empty coastal cell was estimated using the value of the nearest neighbouring cells. Because the values at these locations are estimates generated simply for presentation purposes (i.e. not a direct output of the climate change model), mapped climate change values at these coastal locations may go unmentioned in this report.

Climate projections are presented as a 20-year average for two future periods: 2031-2050 (termed '2040') and 2081-2100 (termed '2090'). All maps show changes relative to the baseline climate of 1986-2005 (termed '1995'). At the start of each subsection in Section 3.1 to Section 3.4, summary tables present an overview of the projected changes, relative to the 1995 baseline, across Taranaki. These span the entire range of projections illustrated in the associated maps. As such, only isolated portions of the area may observe projected changes at the lower and upper limits of the range presented in the summary tables. The reader is referred to the maps for detailed projections, and also referred to the limitations (Section 2.3) associated with the interpretation of these maps.

Note, the legend increments for many of the maps presented in this report are not linear. This is necessary to encapsulate the observed spatial variability across Taranaki. Historic maps are not provided for mean wind speed, strong wind, surface solar radiation and relative humidity as these have not been bias-corrected, and therefore do not provide a reliable representation of the observed magnitude of these variables.

GIS datasets for climate projections of all four RCPs were provided to TRC.

2.3 Limitations

As with any modelling exercise, there are limitations on the results and use of the data. This section outlines some of these limitations and caveats that should be considered when using the results in this report.

- Though only a small number of model simulations (six) were possible due to the large computing resources required for running climate model simulations, they were very carefully selected to cover a wide range of climate model projections.
- The average of six models is used in this report, however data from individual models is available for further assessment if required in the future. The six models chosen represented historic climate conditions in New Zealand well, and span a range of future outcomes. The climate signal is better represented by ensemble averages since the uncertainty due to climate models and internal variability is much reduced.

- The time periods chosen for historic and future projection span 20-year periods. This is seen as a relatively short timeframe to understand average conditions in the historic period and in the future, as there is likely an influence of underlying low frequency climate variability (e.g. decadal signals from climate drivers like the Interdecadal Pacific Oscillation etc.). However, as climate data is subject to significant trends, a short period is more homogenous and representative. Moreover, the IPCC uses 20-year periods, so we have followed that approach for consistency.
- Care needs to be taken when interpreting grid-point-scale projections such as those available in the GIS layers provided to TRC. The data have been bias-corrected, downscaled and interpolated from the 30 km regional climate model grid to the 5 km grid across New Zealand using physically based models and interpolation. The regional climate model and bias correction may not accurately reproduce the role of Mt Taranaki in blocking rainfall from the Tasman Sea, or the maritime influence of the sea on temperature indices, for example. Therefore, the data from these grid points does not correspond to on-the-ground observations. It is more appropriate to consider relative patterns rather than absolute values, e.g. the magnitude of change at different time periods and scenarios.
- The distinctive topography of Mount Taranaki (i.e. volcanic cone, where the land area decreases rapidly as elevation increases) is not well accounted for by the climate model grids. Therefore, the modelled historic data (and resultantly, the projected changes) over the mountain’s upper slopes is not an accurate representation of what would be recorded in those parts. For example, the models will underestimate rainfall and frost days for Mount Taranaki’s highest elevations, and modelled temperatures will be higher than observed. Again, the reader is encouraged to consider relative patterns of projected change, rather than absolute values.

Although there are some limitations and caveats in the approach used here, considerable effort has been made to generate physically consistent climate change projections for Taranaki at unprecedented temporal and spatial resolutions. A considerable research effort has also been dedicated to validating simulated climate variables, and thus the projections provide a good basis for risk assessments and adaptation plans.

3 Current and future climate of Taranaki

3.1 Temperature

3.1.1 Mean temperature

Projected mean temperature changes (°C) across Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	+0.50-1.00	+0.75-1.00
2090	+1.00-1.50	+2.50-3.00

Seasonal:

	RCP4.5		RCP8.5	
	2040	2090	2040	2090
Summer	+0.50-1.00	+1.00-1.50	+0.75-1.00	+2.00-3.50
Autumn	+0.75-1.00	+1.25-1.50	+0.75-1.25	+2.50-3.50
Winter	+0.50-0.75	+1.00-1.25	+0.50-1.00	+2.00-3.00
Spring	+0.50-1.00	+1.00-1.50	+0.50-1.00	+2.00-3.00

Historic (average over 1986-2005) and future (average over 2031-2050 and 2081-2100) maps for mean temperature are shown in this section. The historic maps show annual and seasonal mean temperature in units of degrees Celsius (°C) and the future projection maps show the change in mean temperature compared with the present day, in units of °C. Note that the historic maps are on a different colour scale to the future projection maps.

For the modelled historic period, coastal and low elevation portions of Taranaki have the highest annual and seasonal mean temperatures whereas some areas further inland have lower mean temperatures, particularly the higher elevations of Mount Taranaki (Figure 3-1 and Figure 3-2).

Representative concentration pathway (RCP) 4.5

By 2040, annual and seasonal mean temperatures are projected to increase by 0.50-1.00°C under RCP4.5 (Figure 3-3 to Figure 3-4).

By 2090, annual mean temperatures are projected to increase by 1.00-1.50°C (Figure 3-3). At the seasonal scale, projected increases to mean temperature also range from 1.00-1.50°C (Figure 3-5). The highest projected increases by 2090 under RCP4.5 are in the range of 1.25-1.50°C, and occur throughout Taranaki in autumn.

Representative concentration pathway (RCP) 8.5

By 2040, annual mean temperatures are projected to increase by 0.75-1.00°C (Figure 3-3). This is also the case for majority of the region during summer and winter, while mean temperatures for most the region are projected to increase by 1.00-1.25°C during autumn (Figure 3-6).

By 2090, annual mean temperatures under RCP8.5 are projected to be around 2.50-3.00°C higher for Taranaki (Figure 3-3). At the seasonal scale, projected increases to mean temperatures are generally higher for summer and autumn (up to 3.00-3.50°C in northern areas), with the majority of the region projected to increase by 2.50-3.00°C in winter (Figure 3-7).

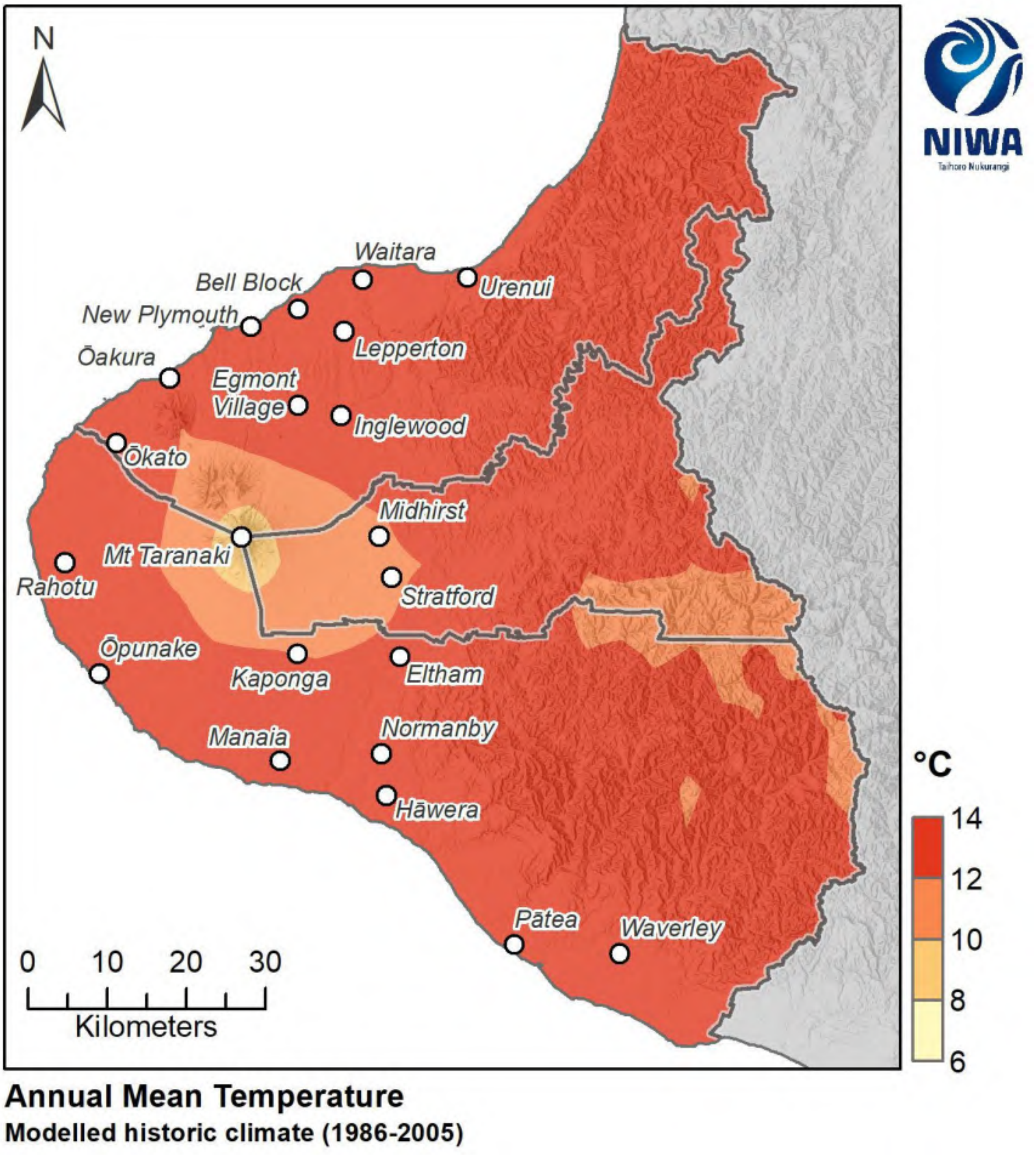


Figure 3-1: Modelled annual mean temperature, average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

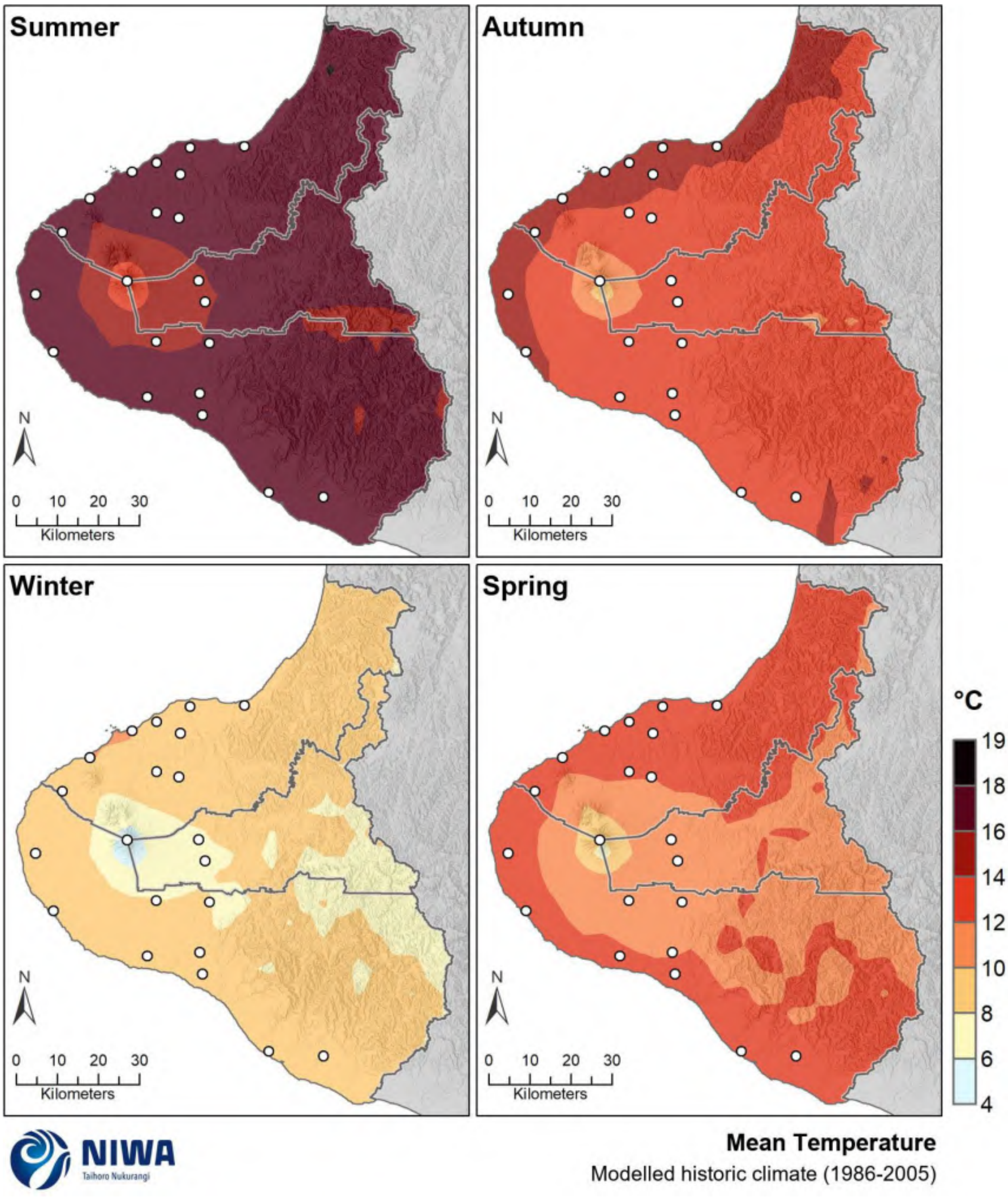


Figure 3-2: Modelled seasonal mean temperature, average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

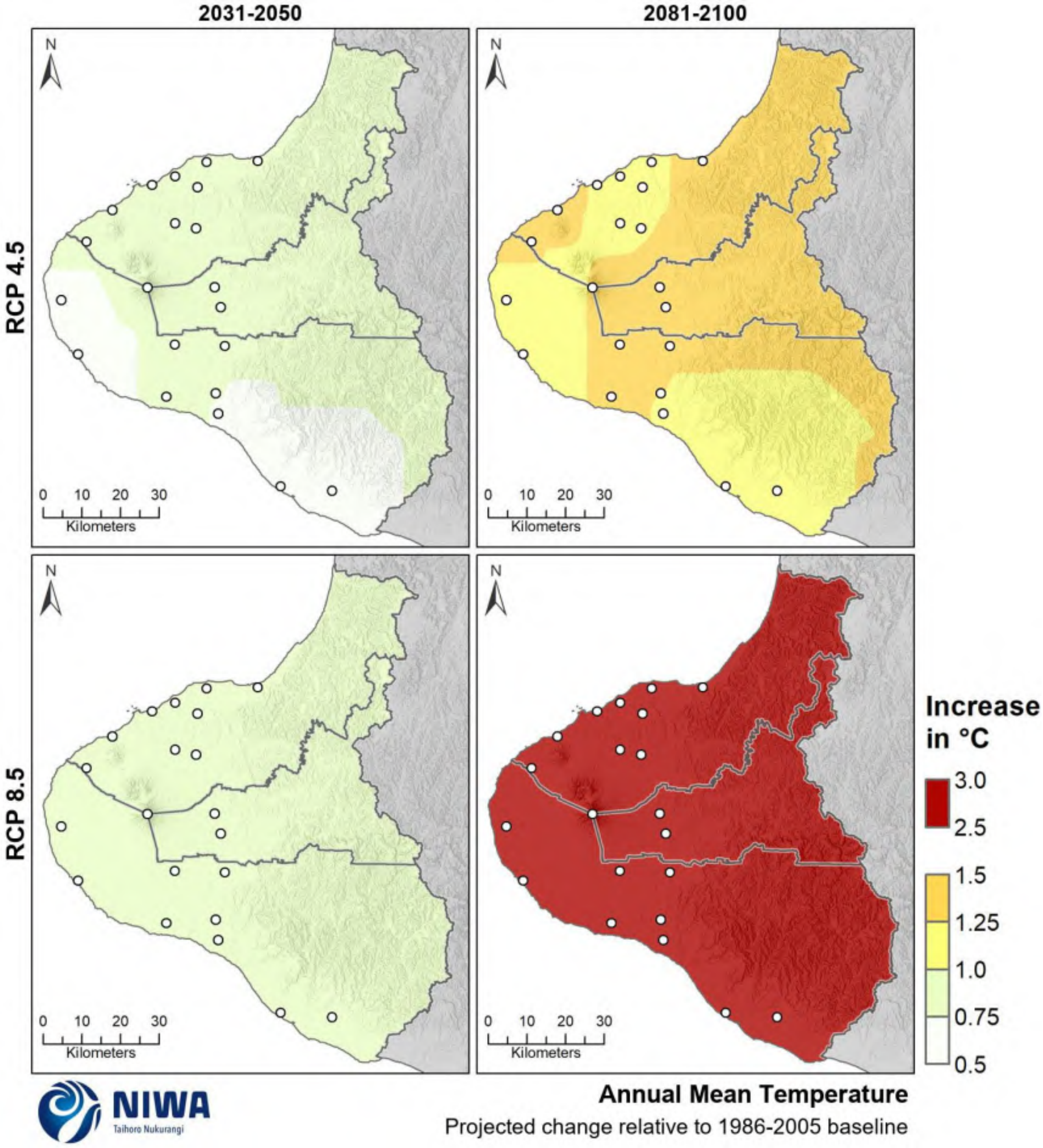


Figure 3-3: Projected annual mean temperature changes by 2040 and 2090 under RCP4.5 and RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

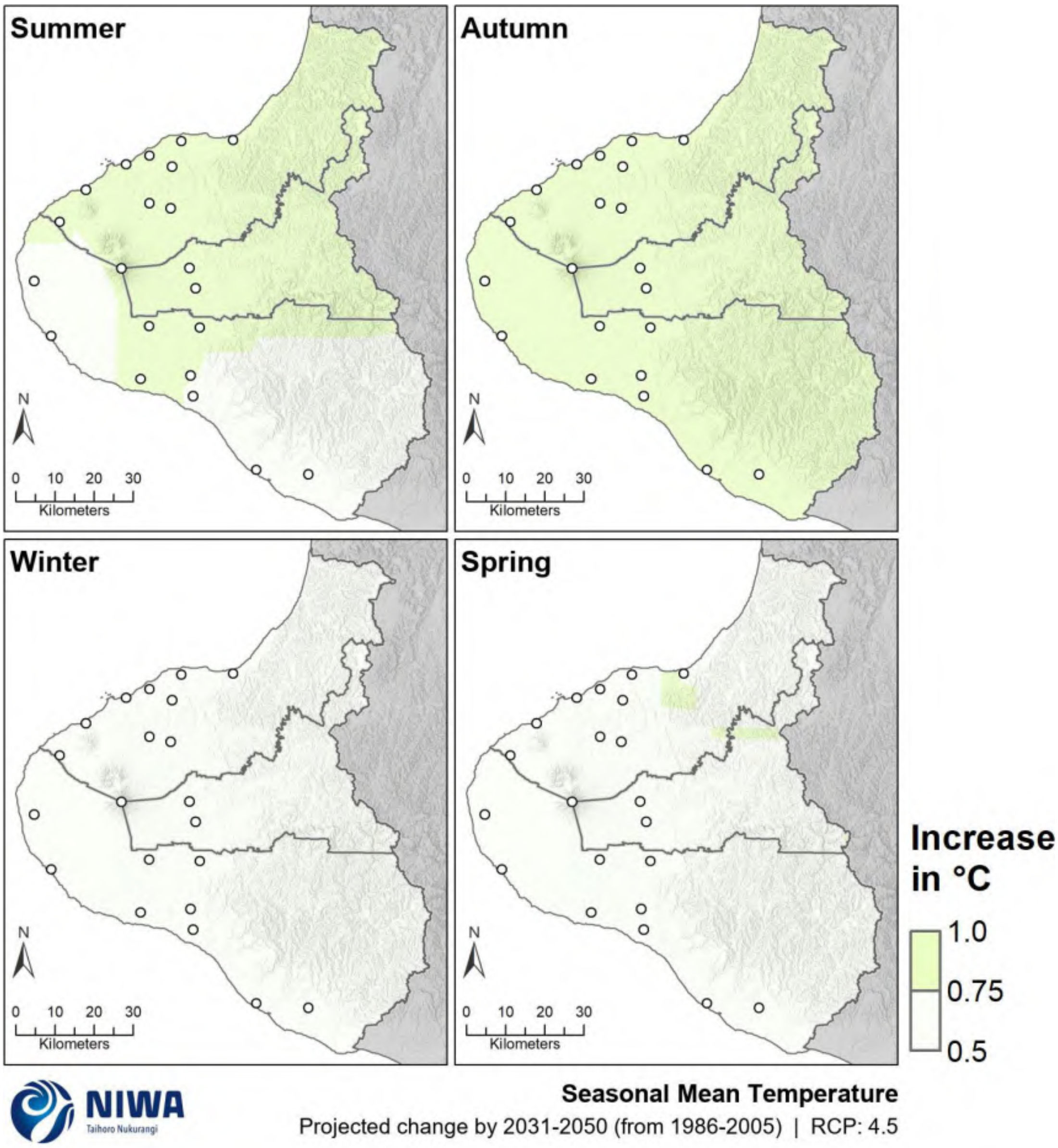


Figure 3-4: Projected seasonal mean temperature changes by 2040 under RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

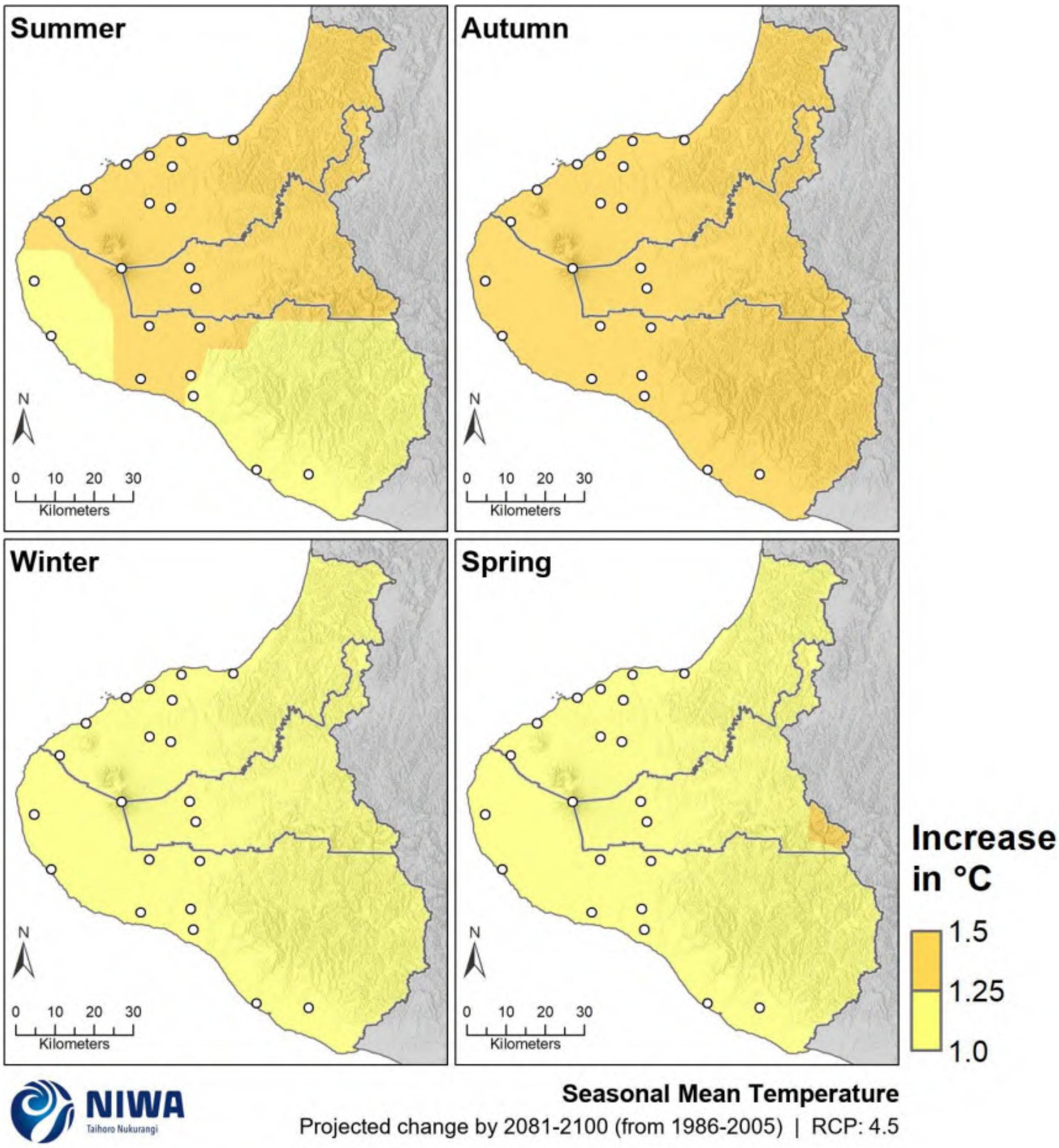


Figure 3-5: Projected seasonal mean temperature changes by 2090 under RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

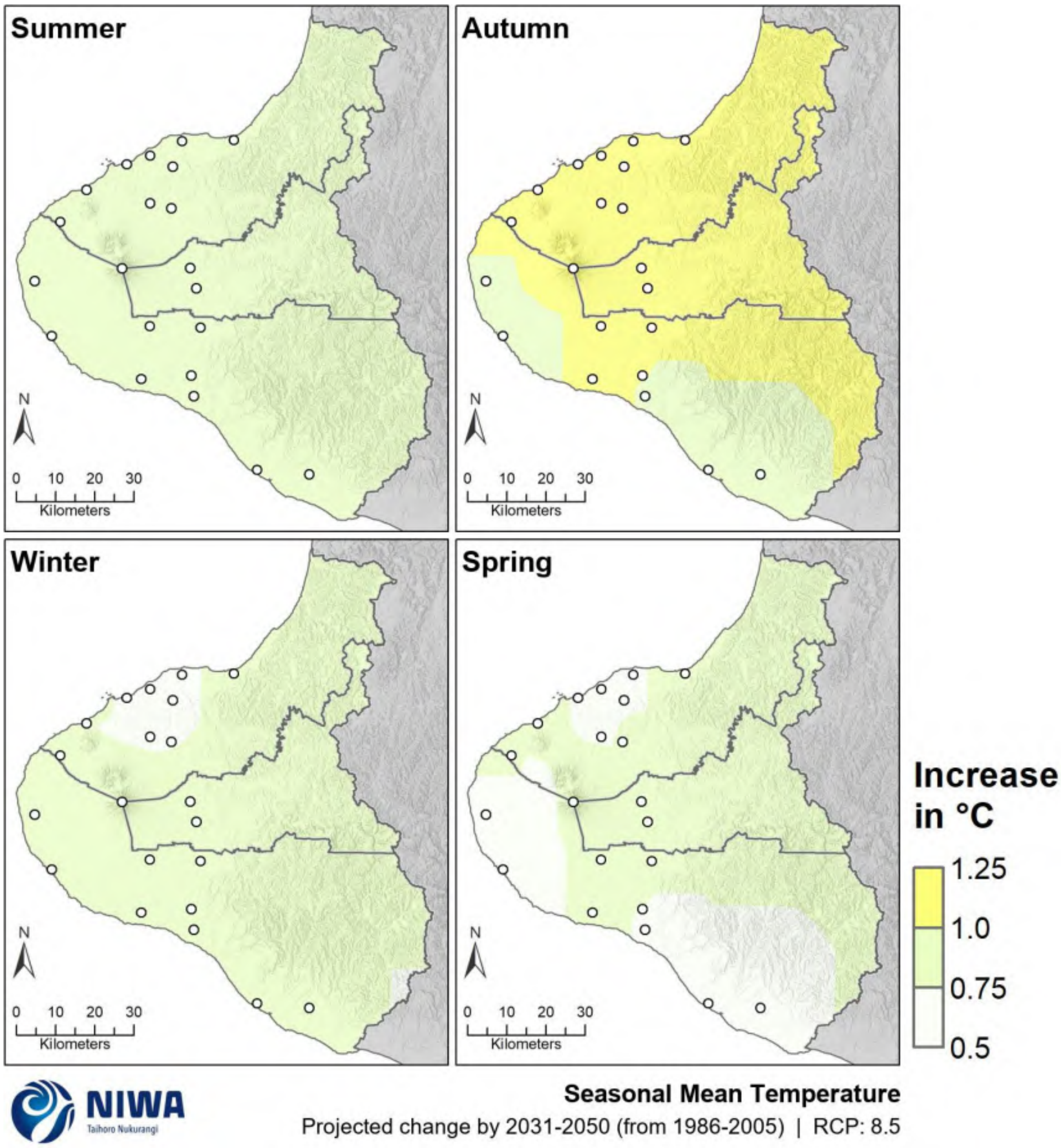


Figure 3-6: Projected seasonal mean temperature changes by 2040 under RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

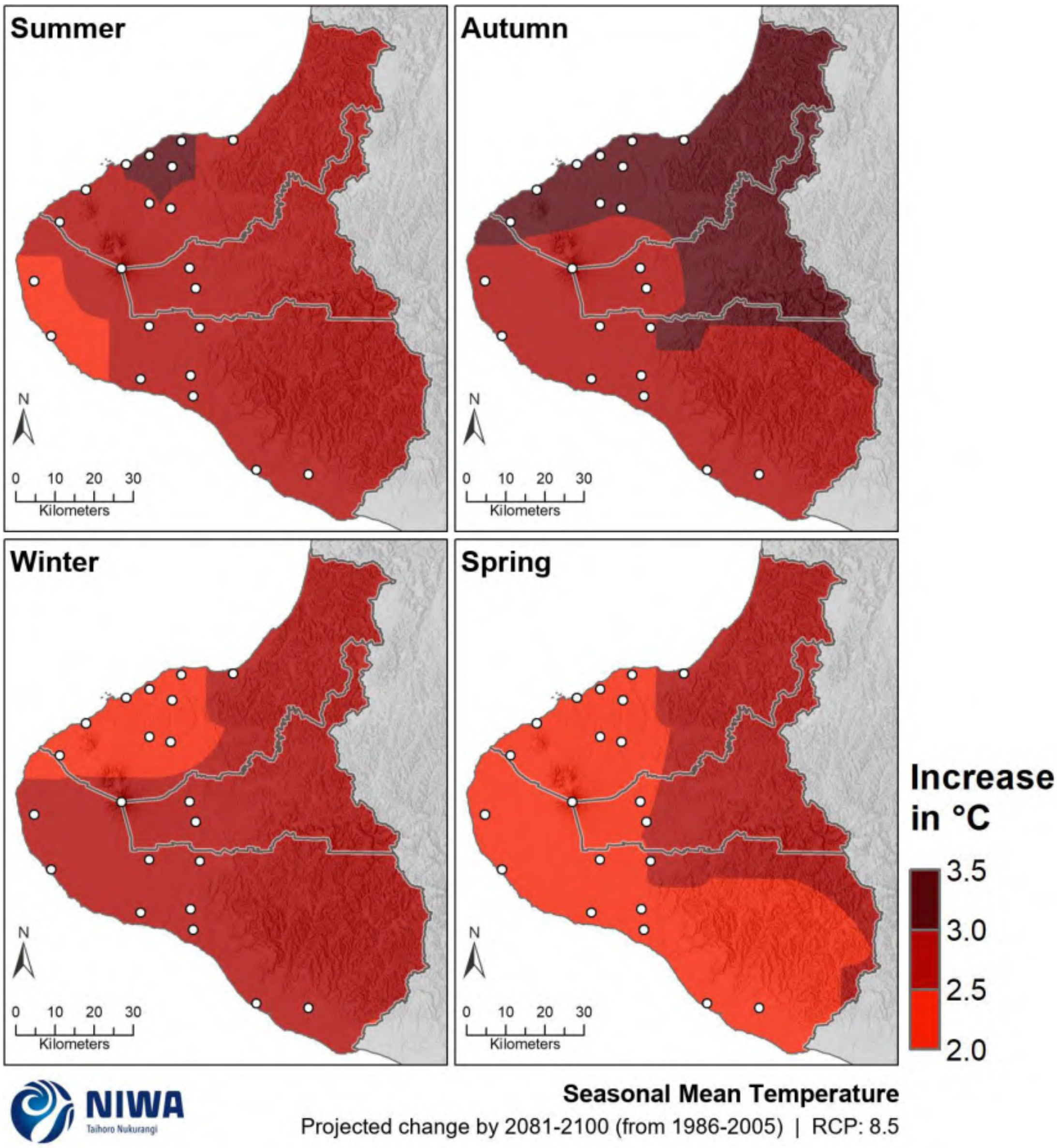


Figure 3-7: Projected seasonal mean temperature changes by 2090 under RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.1.2 Maximum temperature

Projected maximum temperature changes (°C) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	+0.75-1.00	+0.75-1.25
2090	+1.25-2.00	+2.50-3.50

Seasonal:

	RCP4.5		RCP8.5	
	2040	2090	2040	2090
Summer	+0.75-1.25	+1.25-2.00	+0.75-1.25	+2.50-3.50
Autumn	+0.75-1.25	+1.25-2.00	+1.00-1.50	+2.50-4.00
Winter	+0.50-1.00	+1.00-1.50	+0.50-1.25	+2.00-3.50
Spring	+0.50-1.00	+1.00-2.00	+0.75-1.25	+2.00-3.50

Maximum temperatures are generally recorded in the afternoon hours of the day, and therefore are known as day-time temperatures. Historic (average over 1986-2005) and future (average over 2031-2050 and 2081-2100) maps for mean maximum temperature are shown in this section. The historic maps show annual and seasonal mean maximum temperature in units of degrees Celsius (°C) and the future projection maps show the change in mean maximum temperature compared with the historic period, in units of °C. Note that the historic maps are on a different colour scale to the future projection maps.

For the historic period, annual mean maximum temperatures of 16-18°C are common in Taranaki (Figure 3-8). Summer mean maximum temperatures of 20-23°C are typical in the region, while autumn mean maximum temperatures are approximately 2°C higher than in spring.

Representative concentration pathway (RCP) 4.5

By 2040, annual mean maximum temperatures are projected to increase by 0.75-1.00°C under RCP4.5 (Figure 3-10). At the seasonal scale, winter and spring maximum temperatures are projected to increase by 0.50-1.00°C, while increases for summer and autumn range from 0.75-1.25°C (Figure 3-11).

By 2090, projected changes to annual mean maximum temperatures are higher than 2040, with increases of 1.25-2.00°C for the region (Figure 3-10). Summer and autumn maximum temperatures are projected to increase by 1.25-2.00°C, while winter is projected to have maximum temperature increases ranging from 1.00-1.50°C.

Representative concentration pathway (RCP) 8.5

By 2040, annual mean maximum temperatures are projected to increase by 0.75-1.25°C under RCP8.5 (Figure 3-10). At the seasonal scale, autumn maximum temperatures are projected to increase by 1.00-1.50°C with projected increases of 0.75-1.25°C in summer and spring (Figure 3-13).

By 2090, projected increases to maximum temperatures are considerable, and much greater than under RCP4.5, with annual increases of 2.50-3.50°C projected for Taranaki (Figure 3-10). At the seasonal scale, autumn maximum temperatures are projected to increase by the most across the region, with increases of 2.50-4.00°C (Figure 3-14). The smallest increases (although still considerable) are projected around New Plymouth in winter, and southern parts of the region in spring, with projected increases of 2.00-2.50°C.

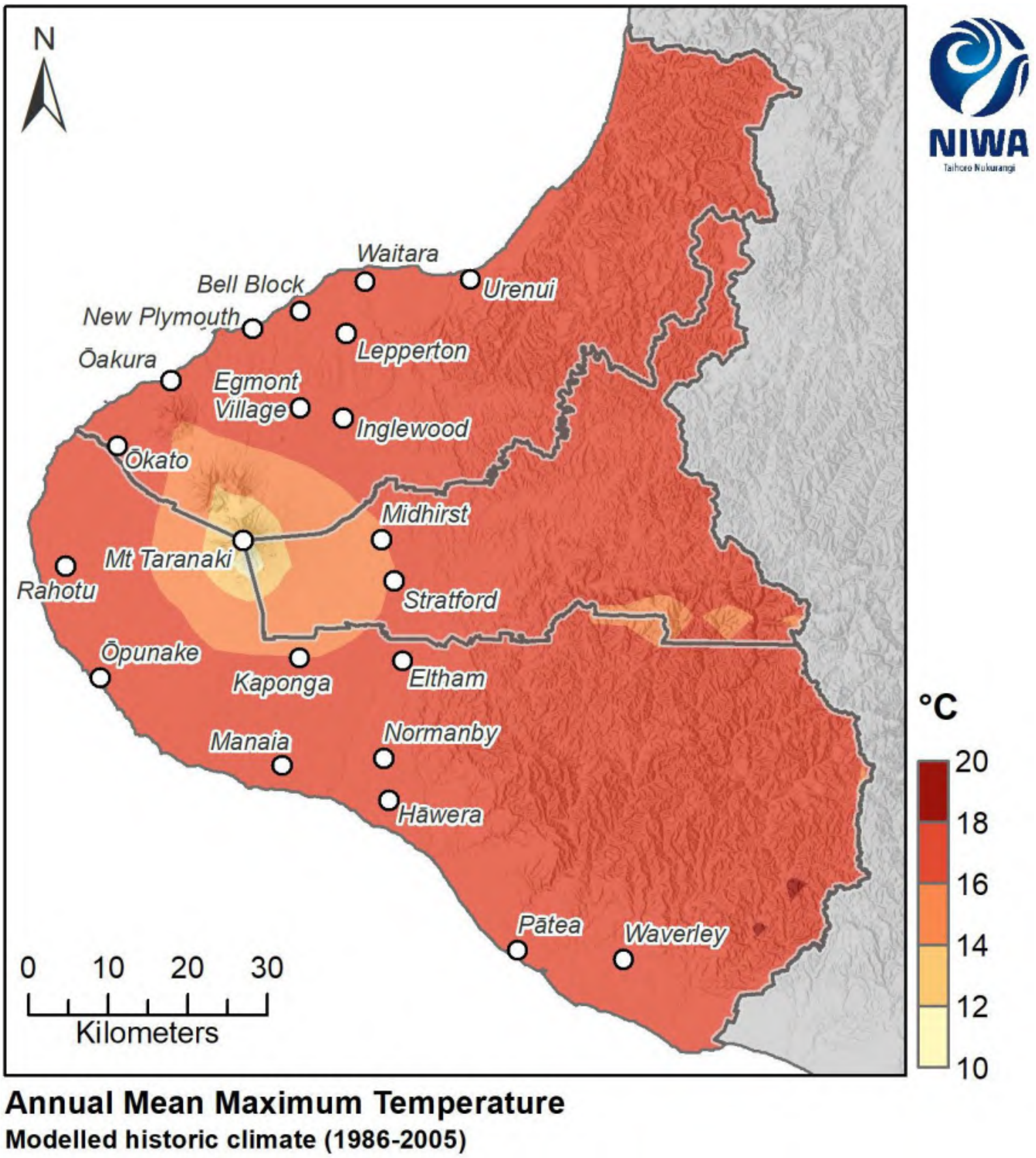


Figure 3-8: Modelled annual mean maximum temperature, average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

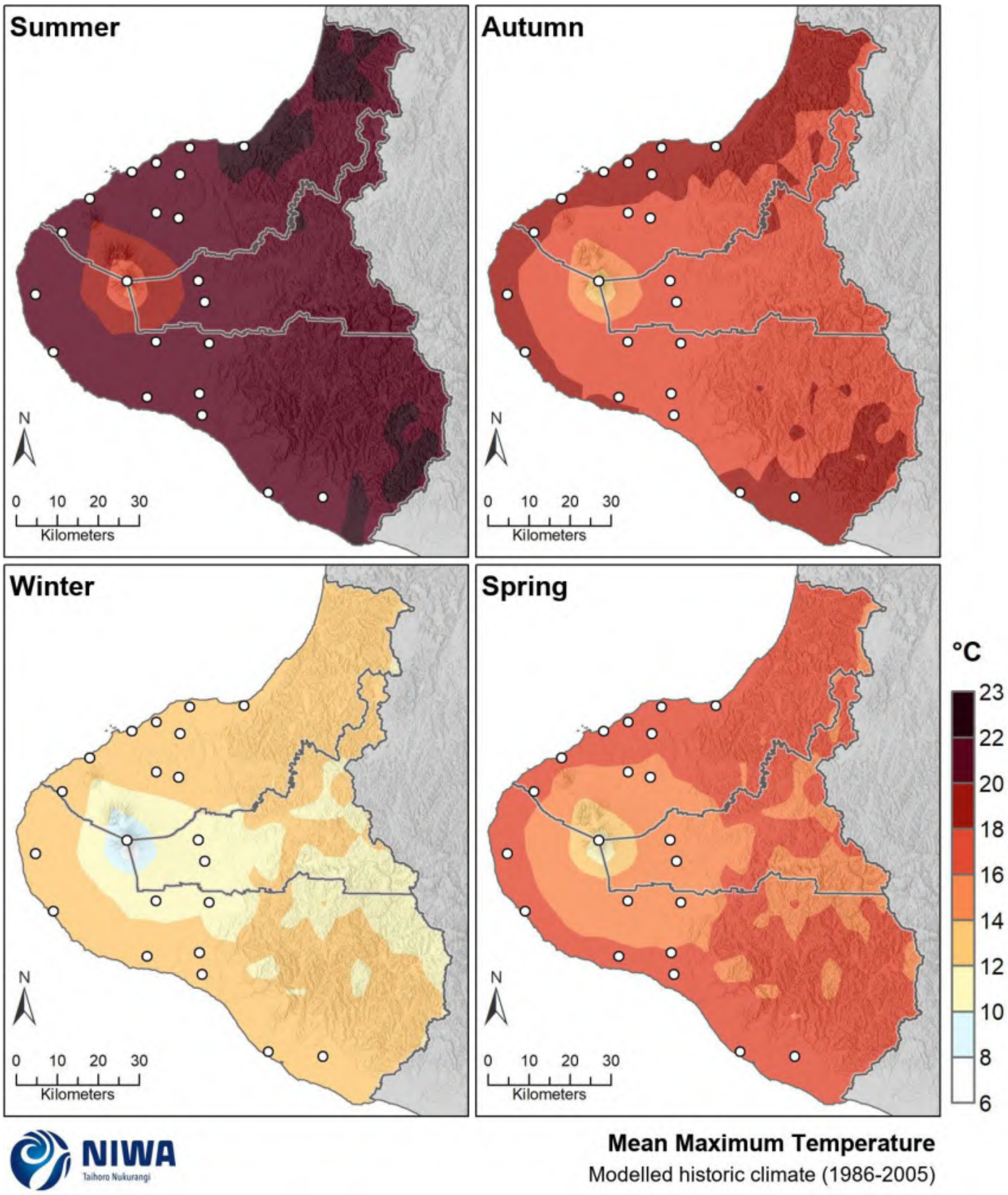


Figure 3-9: Modelled seasonal mean maximum temperature, average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

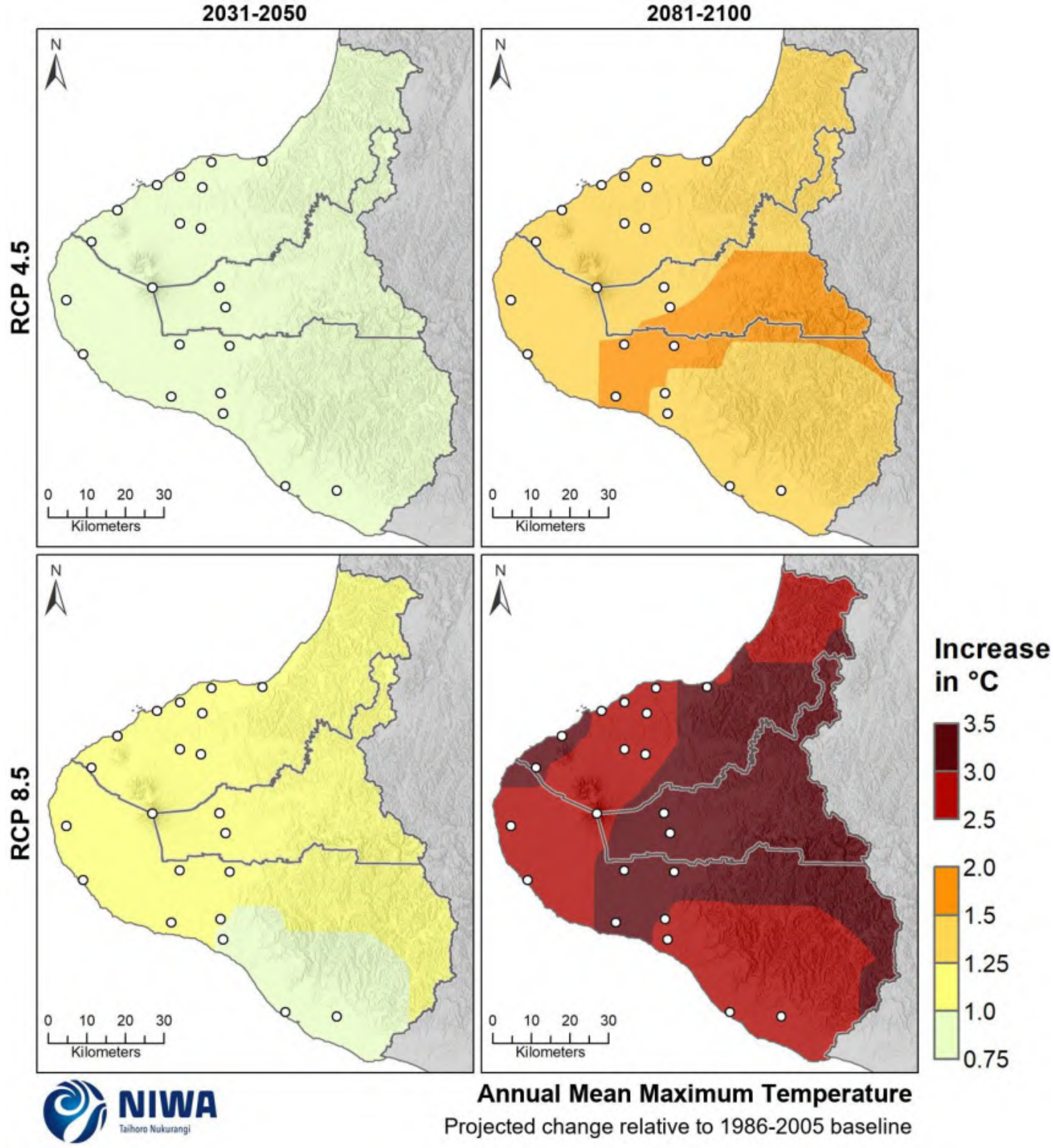


Figure 3-10: Projected annual mean maximum temperature changes by 2040 and 2090 under RCP4.5 and RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

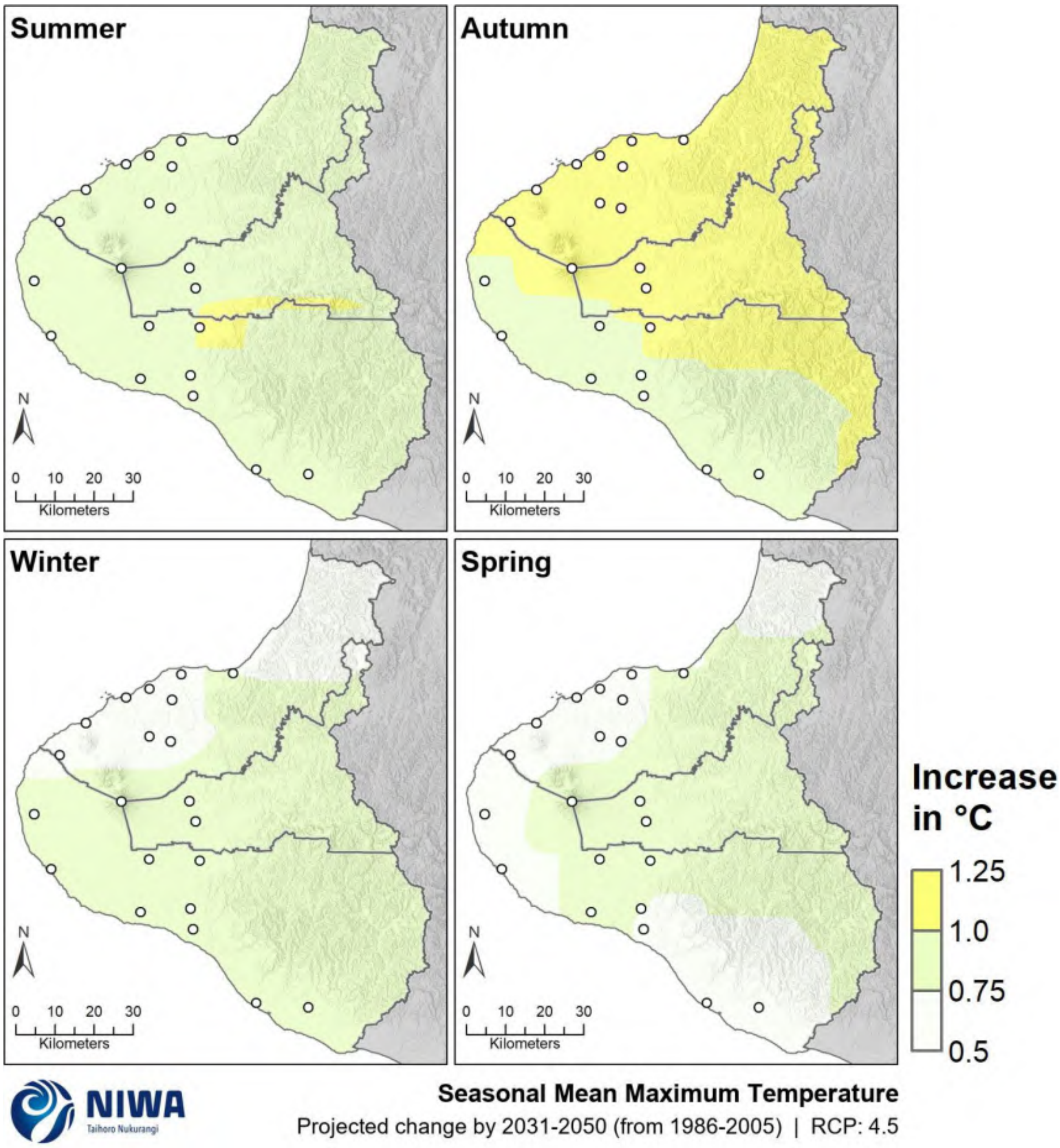


Figure 3-11: Projected seasonal mean maximum temperature changes by 2040 under RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

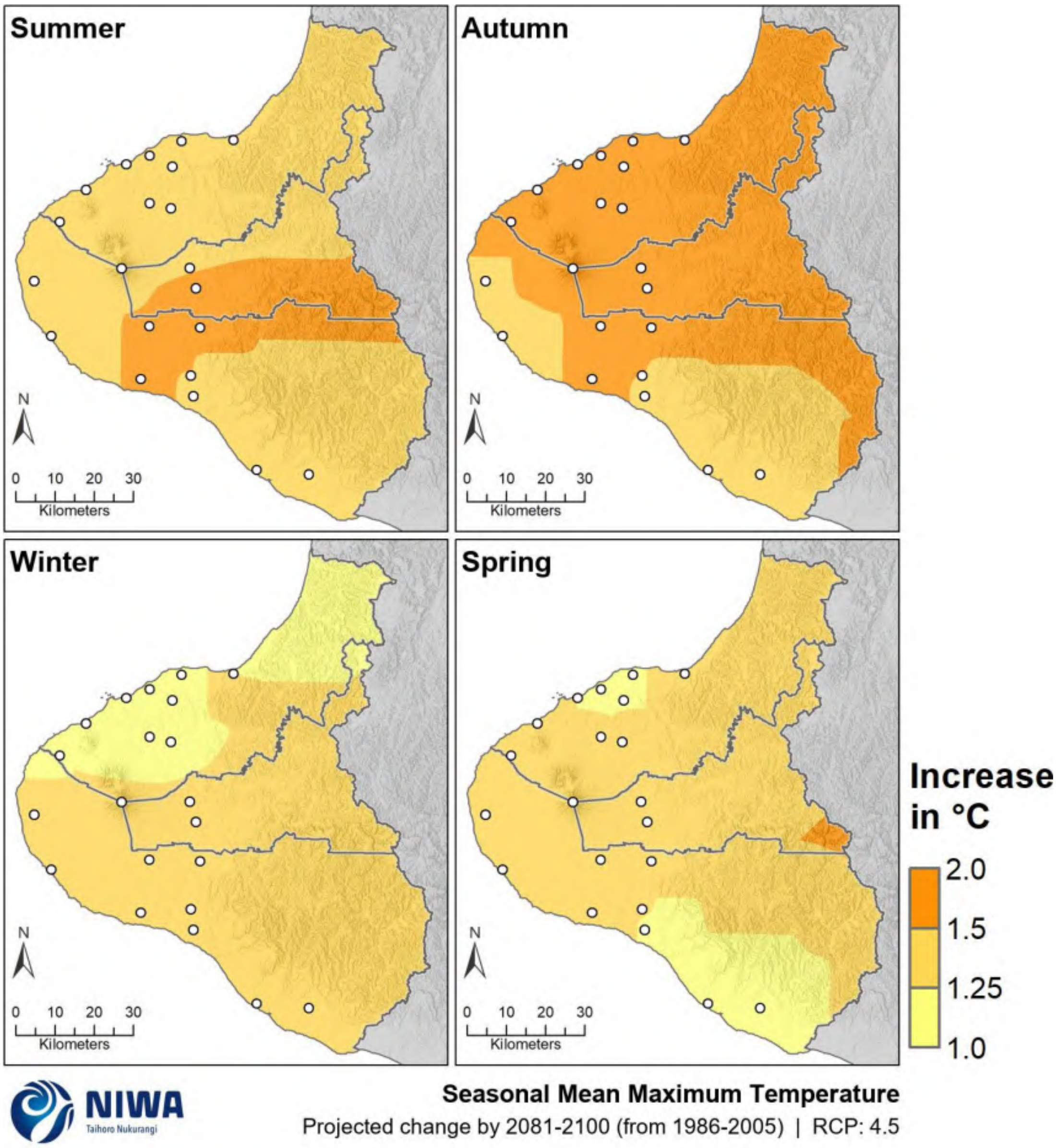


Figure 3-12: Projected seasonal mean maximum temperature changes by 2090 under RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

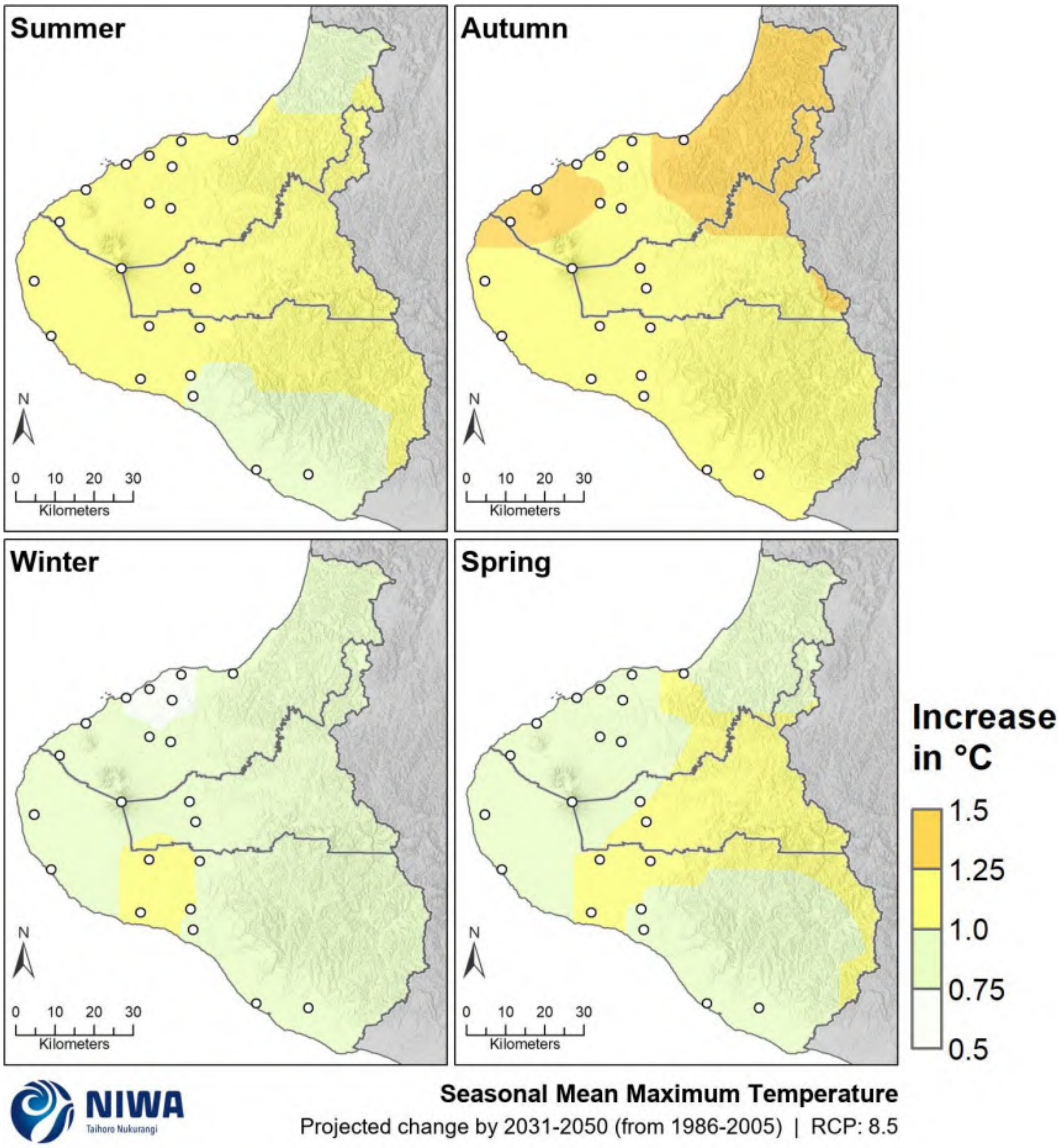


Figure 3-13: Projected seasonal mean maximum temperature changes by 2040 under RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

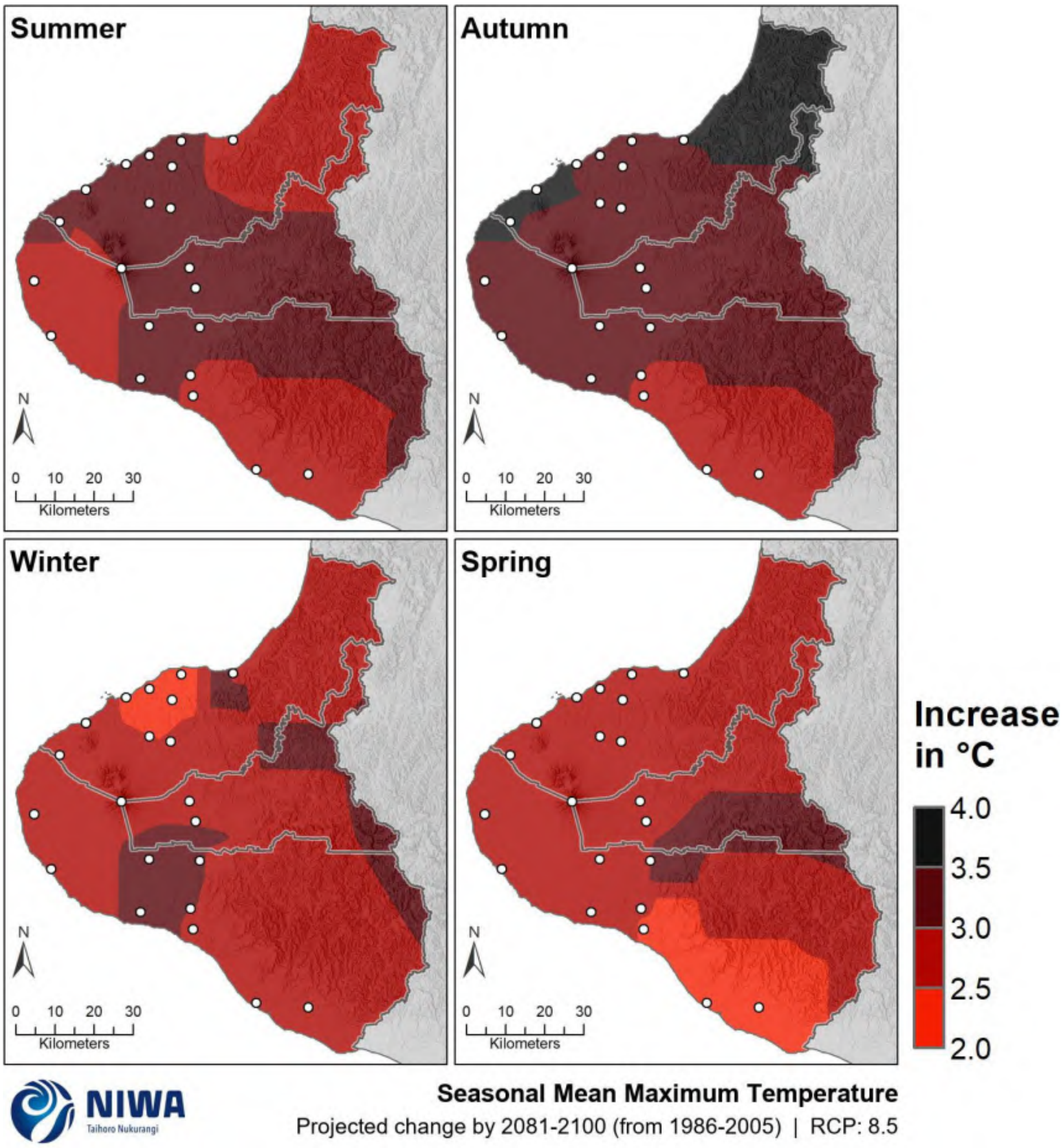


Figure 3-14: Projected seasonal mean maximum temperature changes by 2090 under RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.1.3 Minimum temperature

Projected minimum temperature changes (°C) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	+0.50-0.75	+0.50-1.00
2090	+1.00-1.25	+2.00-3.00

Seasonal:

	RCP4.5		RCP8.5	
	2040	2090	2040	2090
Summer	+0.50-1.00	+0.75-1.50	+0.50-1.00	+2.00-3.50
Autumn	+0.50-1.00	+1.00-1.25	+0.75-1.00	+2.00-3.00
Winter	+0.50-0.75	+0.75-1.25	+0.50-1.00	+2.00-2.50
Spring	+0.50-0.75	+0.75-1.25	+0.50-0.75	+1.50-2.50

Minimum temperatures are generally recorded in the early hours of the morning, and therefore are known as night-time temperatures. Historic (average over 1986-2005) and future (average over 2031-2050 and 2081-2100) maps for mean minimum temperature are shown in this section. The historic maps show annual and seasonal mean minimum temperature in units of degrees Celsius (°C) and the future projection maps show the change in mean minimum temperature compared with the historic period, in units of °C. Note that the historic maps are on a different colour scale to the future projection maps.

For the historic period, coastal portions of Taranaki have the highest annual and seasonal mean minimum temperatures (8-10°C at the annual scale; Figure 3-15).Winter mean minimum temperatures between 1-4°C are observed for some inland and high elevation parts of Taranaki (Figure 3-16).

Representative concentration pathway (RCP) 4.5

By 2040, annual mean minimum temperatures are projected to increase by 0.50-0.75°C under RCP4.5 (Figure 3-17). Mean minimum temperatures are projected to increase by 0.50-1.00°C in summer and autumn, and 0.50-0.75°C in winter and spring (Figure 3-18).

By 2090, increases to annual mean minimum temperatures of 1.00-1.25°C are projected for Taranaki (Figure 3-17). Winter and spring minimum temperatures are projected to increase by 0.75-1.25°C, while summer is projected to have minimum temperature increases ranging from 0.75-1.50°C (Figure 3-19).

Representative concentration pathway (RCP) 8.5

By 2040, annual mean minimum temperatures are projected to increase by 0.50-1.00°C under RCP8.5 in Taranaki (Figure 3-17). At the seasonal scale, projected increases are similar to RCP4.5 by 2040, with summer and winter minimum temperatures projected to increase by 0.50-1.00°C for the region (Figure 3-20).

By 2090, projected increases to minimum temperatures are greater than under RCP4.5, with annual increases of 2.00-3.00°C projected for Taranaki (Figure 3-17). At the seasonal scale, summer and autumn minimum temperatures are projected to increase the most compared with the other seasons, with increases of 3.00-3.50°C projected for northernmost parts of Taranaki (Figure 3-21). Increases of 1.50-2.50°C are projected for spring.

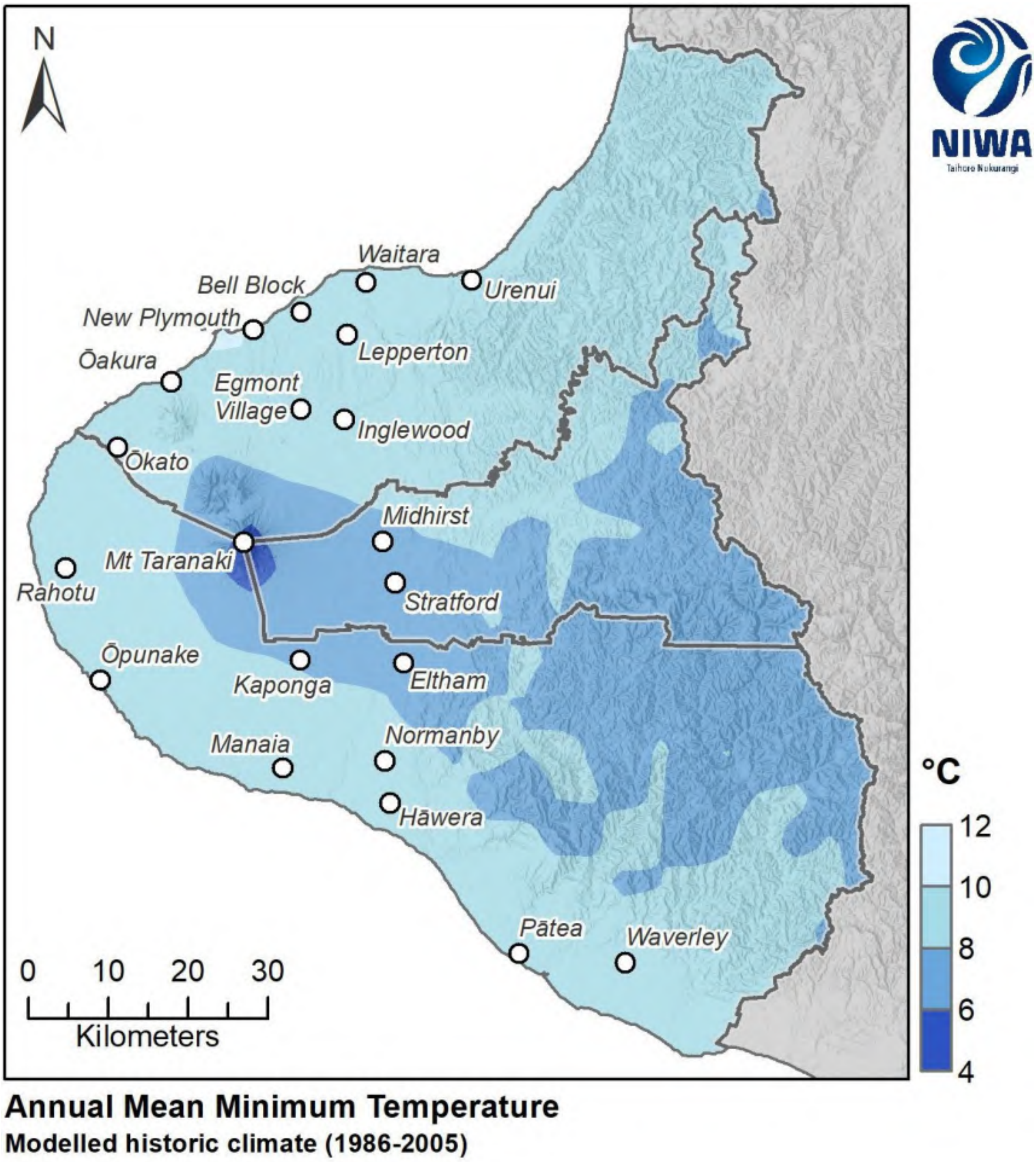


Figure 3-15: Modelled annual mean minimum temperature, average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

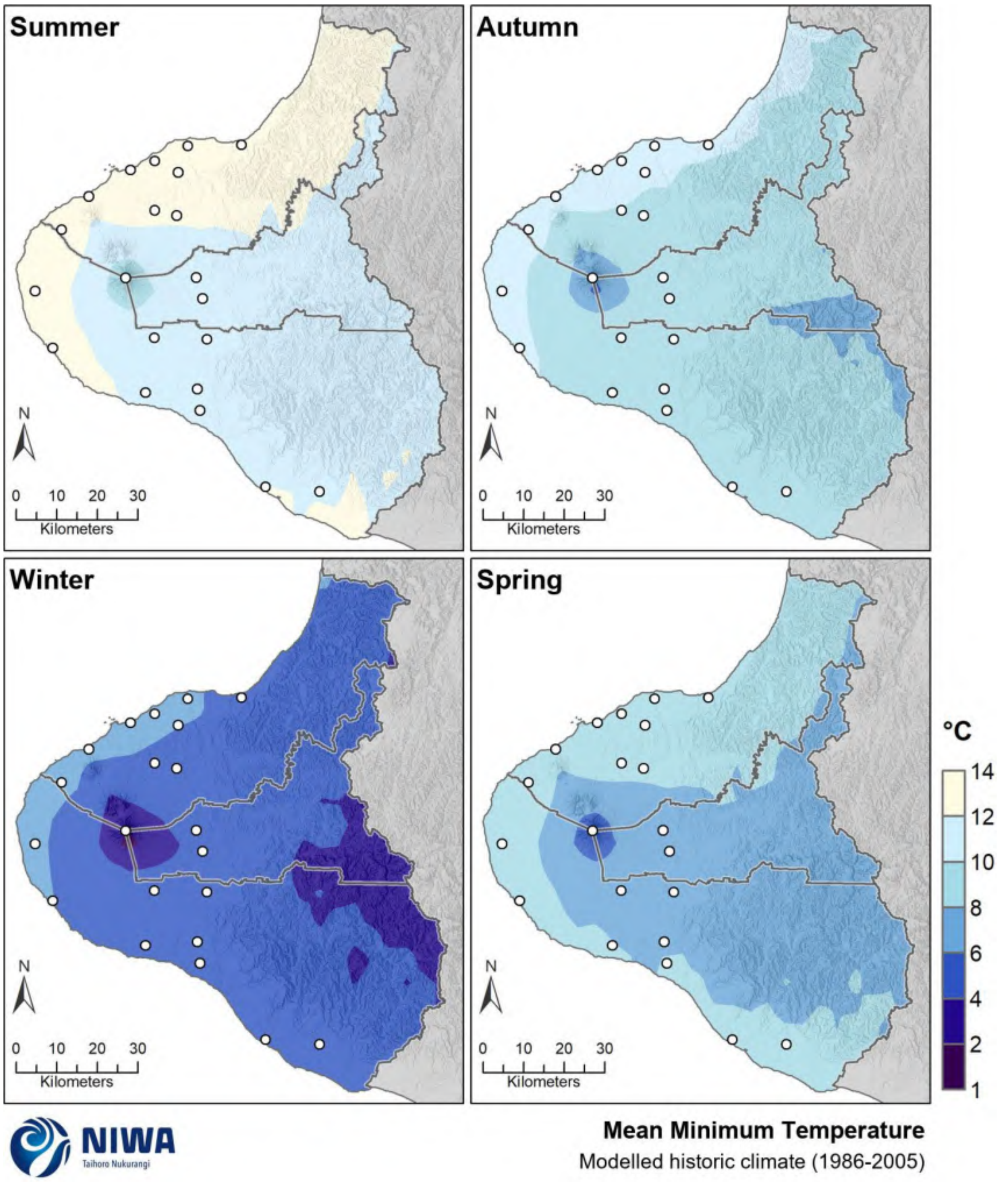


Figure 3-16: Modelled seasonal mean minimum temperature, average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

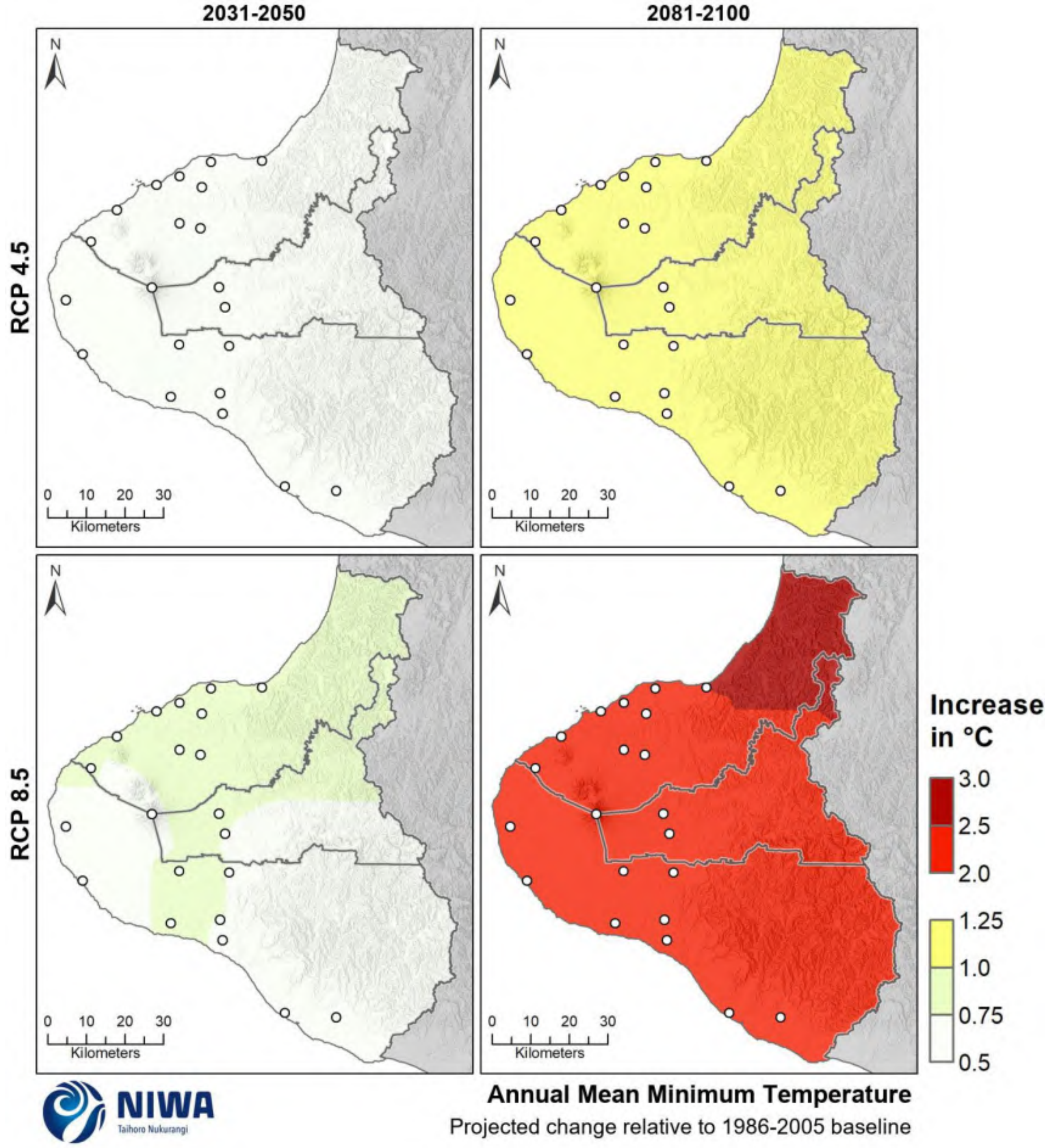


Figure 3-17: Projected annual mean minimum temperature changes by 2040 and 2090 under RCP4.5 and RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

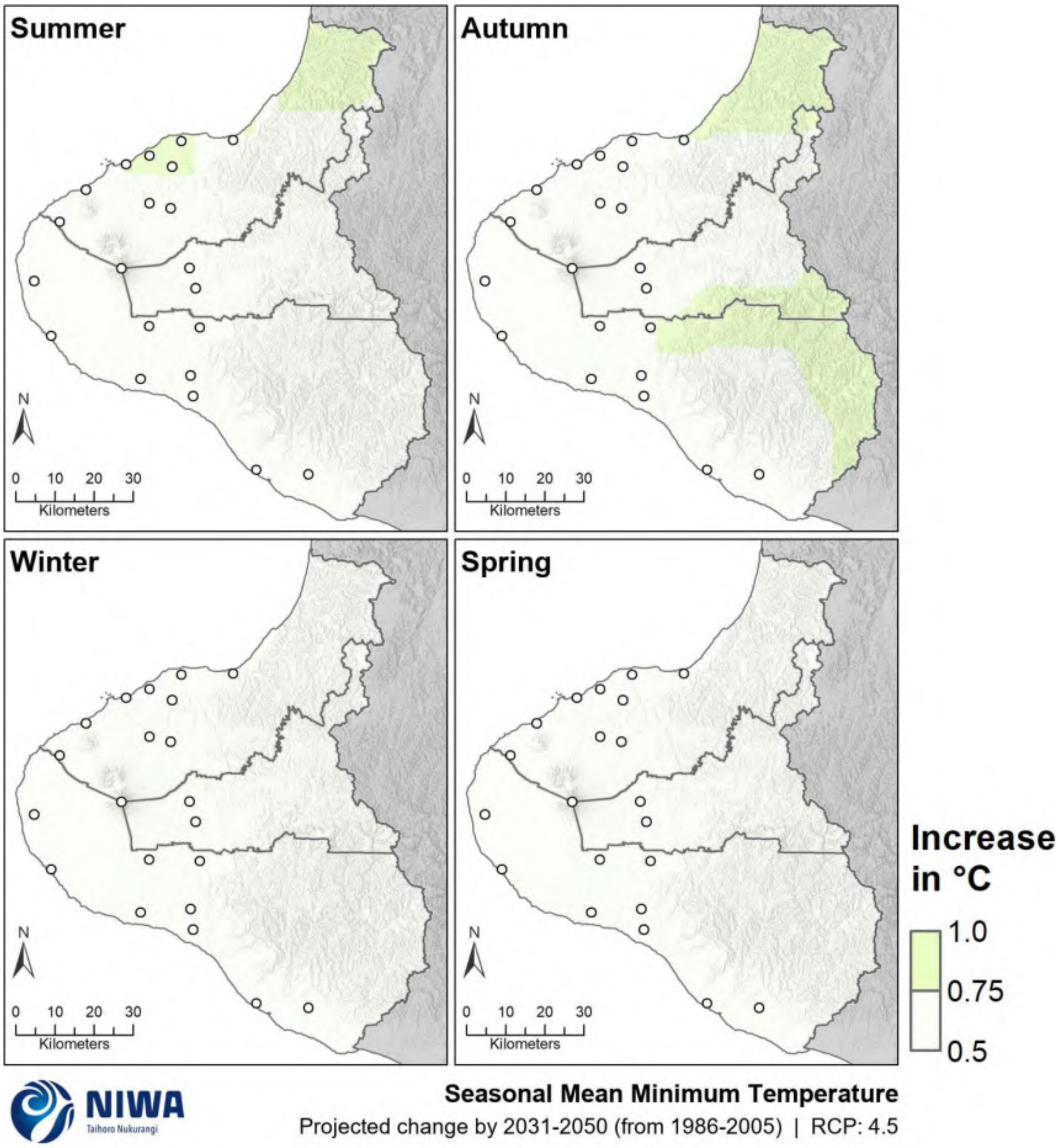


Figure 3-18: Projected seasonal mean minimum temperature changes by 2040 under RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

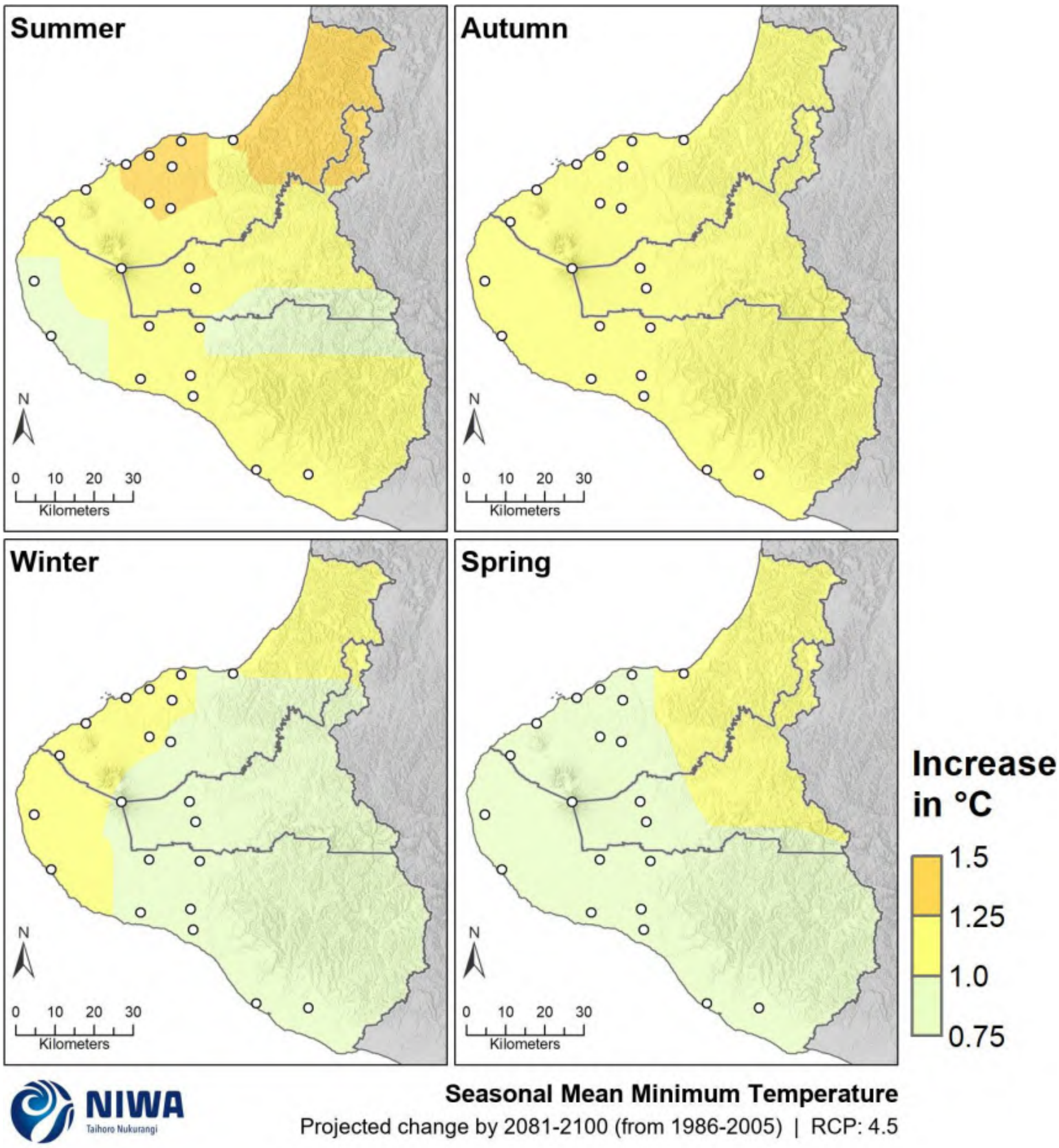


Figure 3-19: Projected seasonal mean minimum temperature changes by 2090 under RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

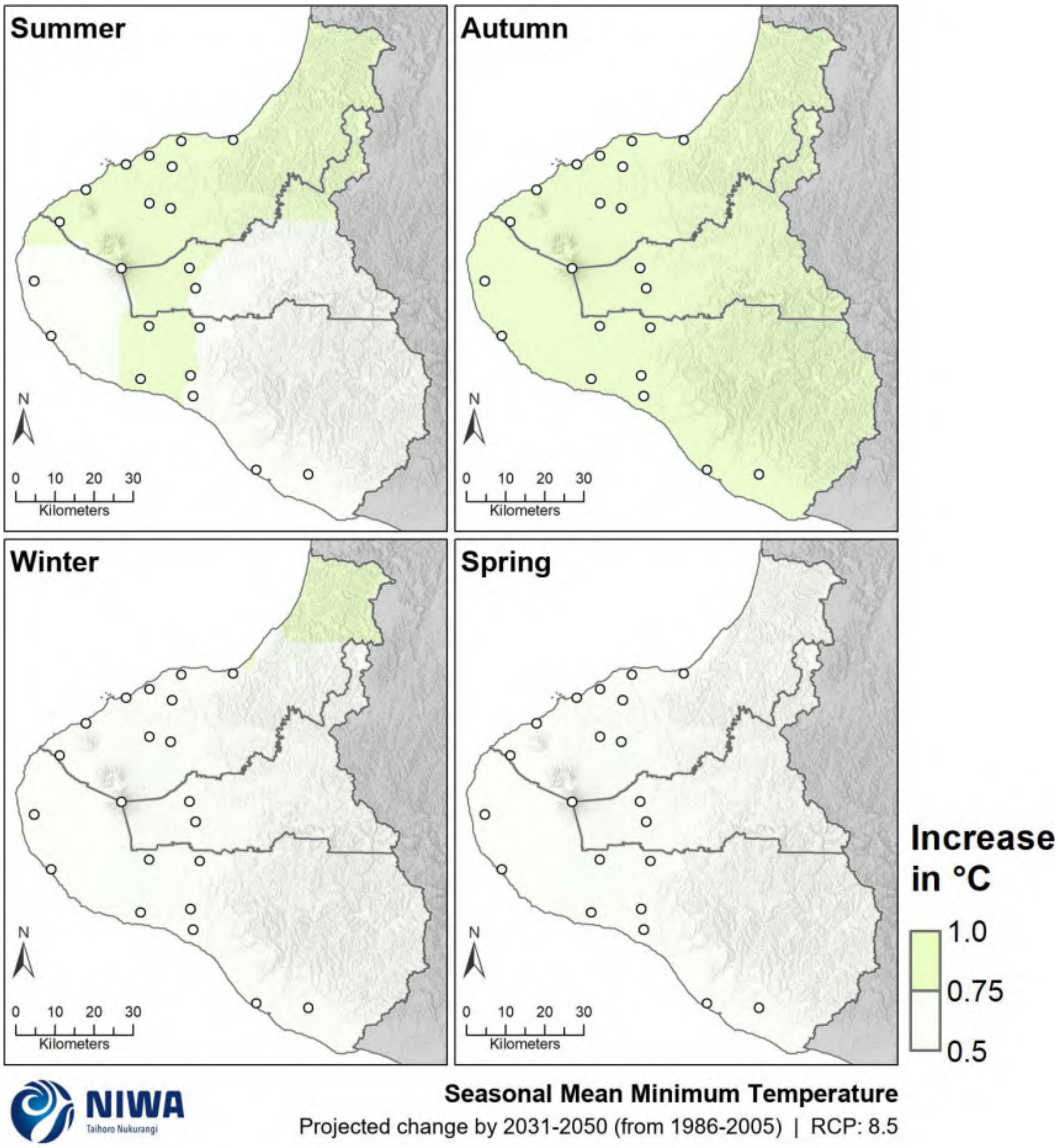


Figure 3-20: Projected seasonal mean minimum temperature changes by 2040 under RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

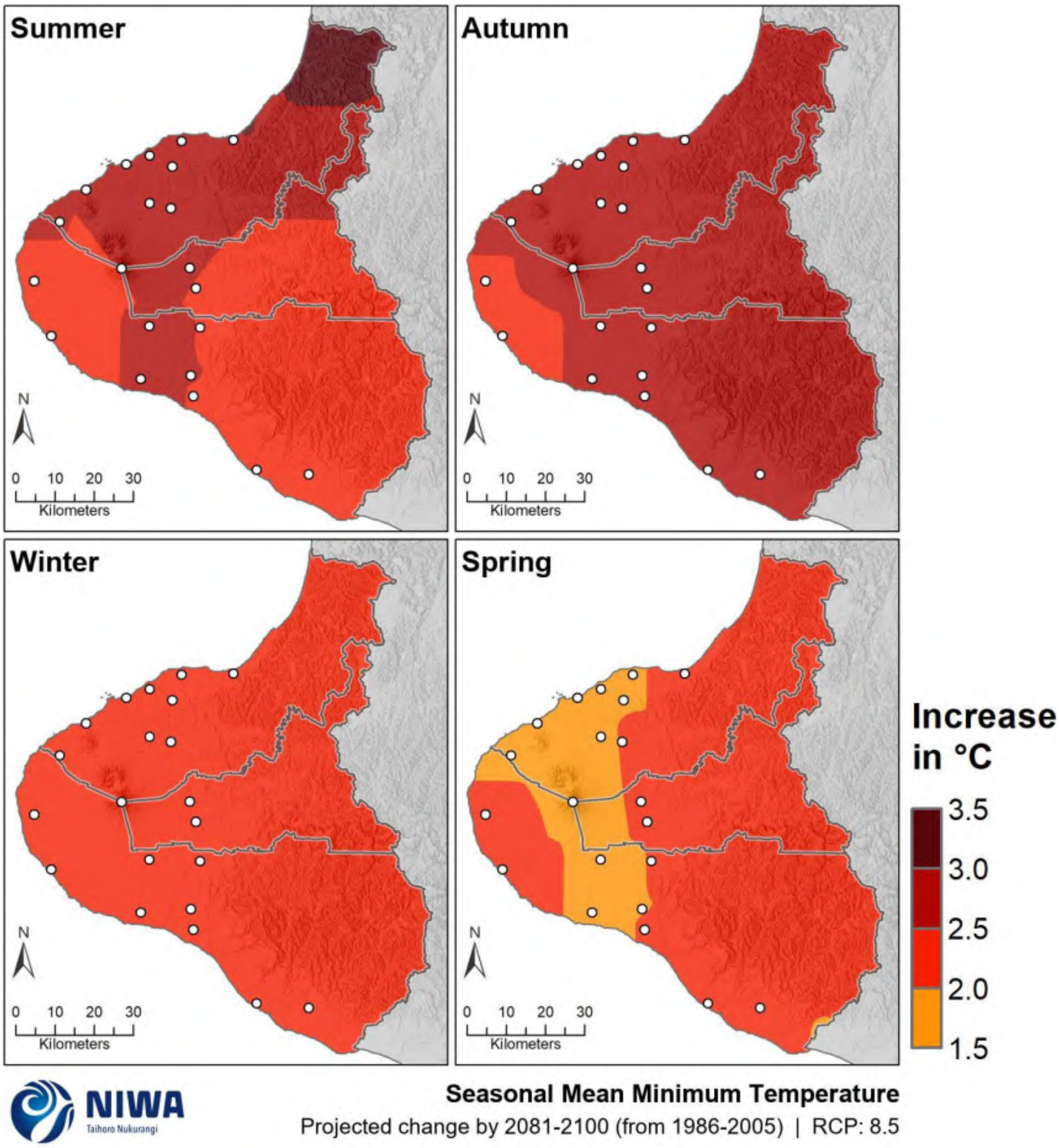


Figure 3-21: Projected seasonal mean minimum temperature changes by 2090 under RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.1.4 Diurnal temperature range

Projected diurnal temperature range changes (°C) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	Up to +0.5	Up to +0.5
2090	Up to +0.5	Up to +1.0

Diurnal temperature range is the difference between the daily maximum temperature and the daily minimum temperature. In New Zealand, diurnal temperature ranges are largest in dry inland areas such as Central Otago, and smallest in humid coastal areas including Wellington and the West Coast. Diurnal temperature range may change over time due to land use change, cloud cover, urban heat effects, and greenhouse gases.

Present-day (average over 1986-2005) and future (average over 2031-2050 and 2081-2100) maps for diurnal temperature range are shown in this section. The present-day maps show annual average diurnal temperature range and the future projection maps show the change in diurnal temperature range compared with present. Note that the present-day maps are on a different colour scale to the future projection maps. Units are degrees Celsius (°C).

The historic diurnal temperature range is highest at southern, eastern and inland locations, and lowest about western and northern areas (Figure 3-22). The annual diurnal temperature range varies from 9-10°C about eastern areas of the Stratford and South Taranaki Districts, to 7-8°C for western-most areas of each District.

Representative concentration pathway (RCP) 4.5

By 2040 and 2090, increases in diurnal temperature range of up to 0.50°C are projected throughout Taranaki (Figure 3-23). Greatest increases of 0.25-0.50°C are projected for the majority of the region by 2090.

Representative concentration pathway (RCP) 8.5

By 2040, increases in diurnal temperature range of up to 0.50°C are projected throughout Taranaki (Figure 3-23). By 2090, diurnal temperature range increases of up to 1.00°C are projected for the region, with largest increases of 0.75-1.00°C for inland areas around and to the east of Stratford and Eltham.

The projected increases in diurnal temperature range (under both RCP4.5 and RCP8.5) are due to higher projected increases in maximum temperatures compared to minimum temperatures. Further research is needed to establish the robustness of these differences in projected maximum and minimum temperatures, and the consequent effect on diurnal temperature range (MFE, 2018).

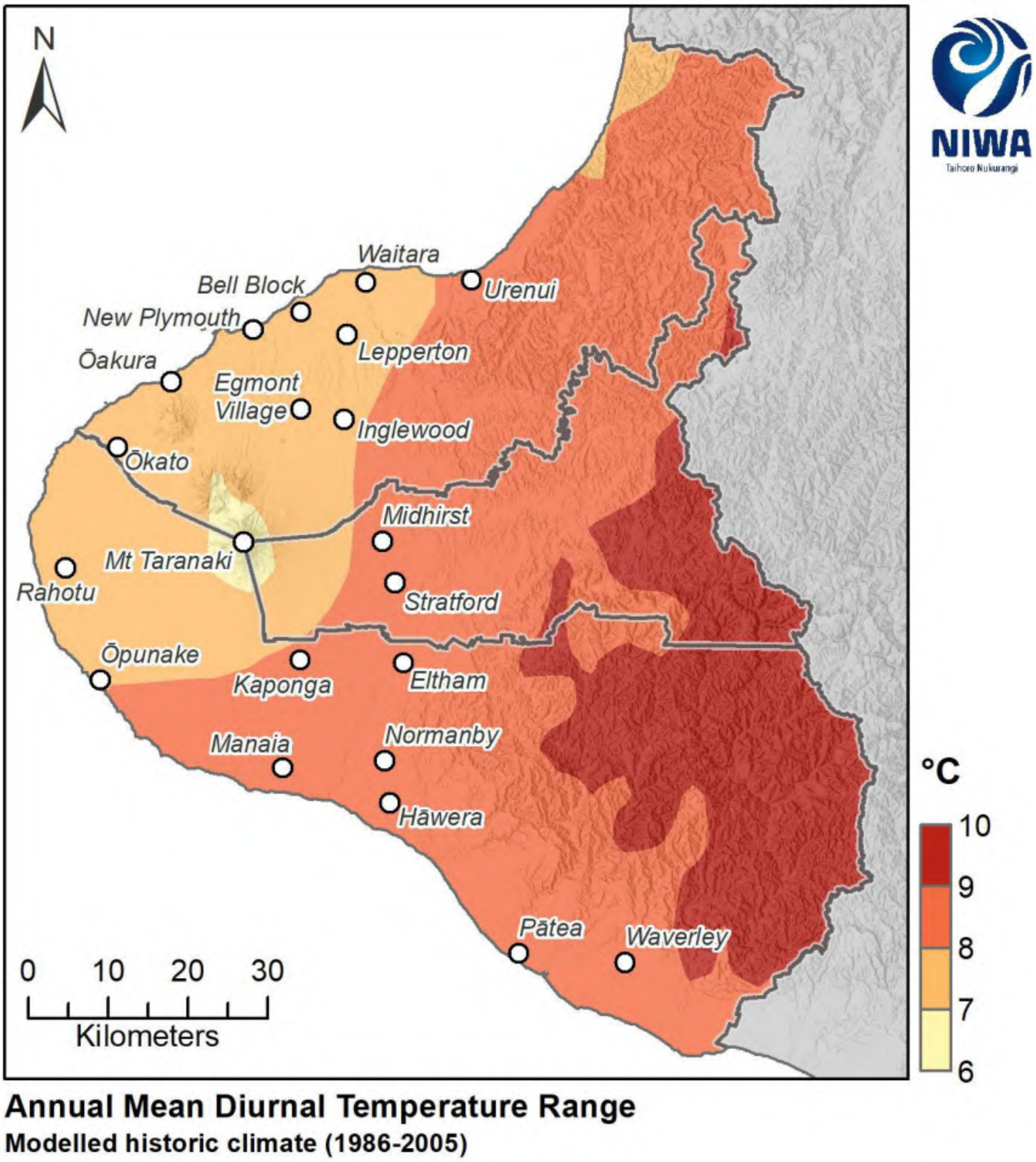


Figure 3-22: Modelled annual diurnal temperature range (Tmax minus Tmin), average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

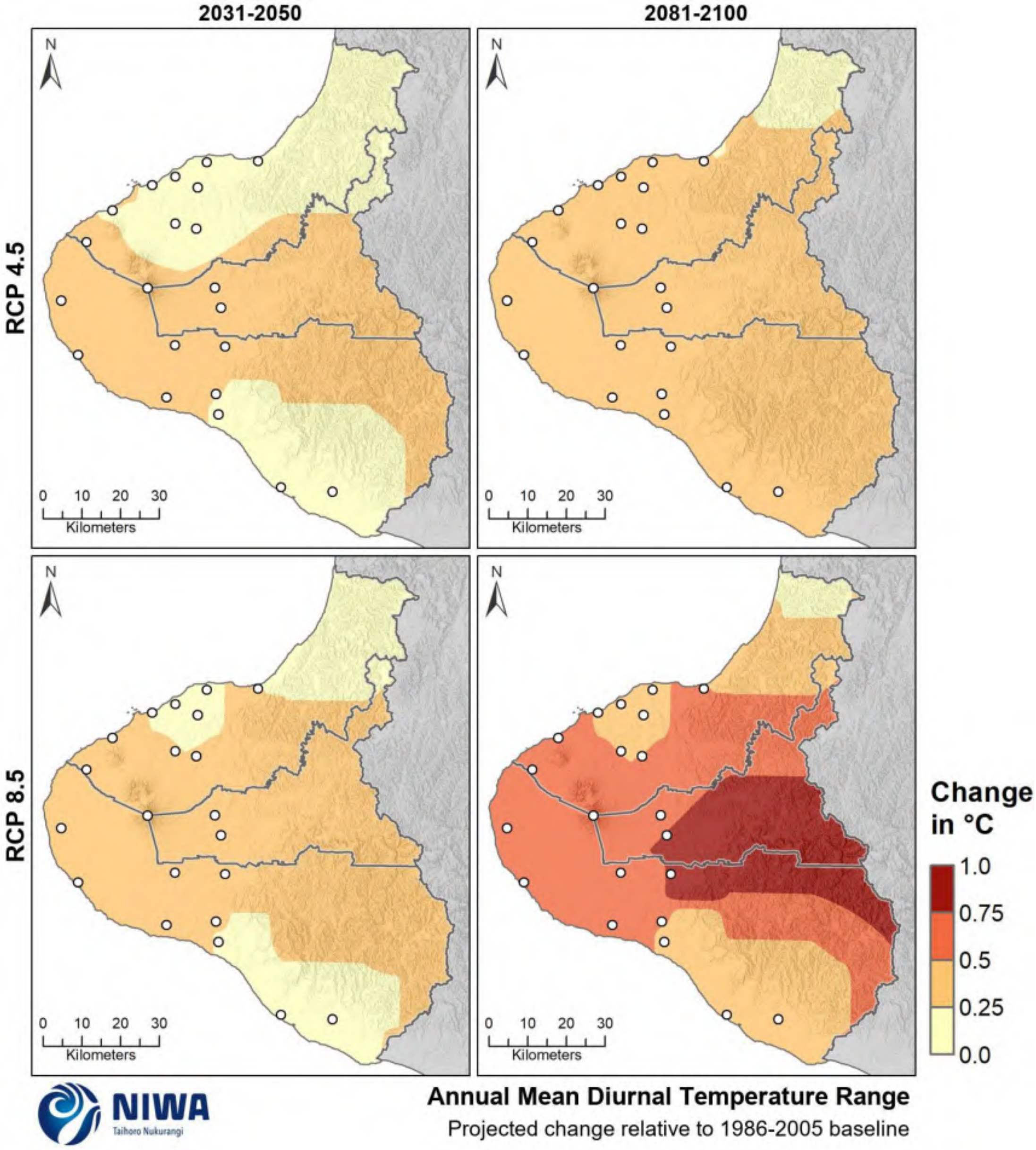


Figure 3-23: Projected annual diurnal temperature range (Tmax minus Tmin) changes at 2040 (2031-2050 average) and 2090 (2081-2100) for RCP4.5 and RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections. Resolution of projection is 5km x 5km.

3.1.5 Frost days

Projected frost day changes (days) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	Up to 10 fewer	Up to 15 fewer
2090	Up to 15 fewer	Up to 23 fewer

A frost day is defined in this report when the modelled daily minimum temperature is equal to or lower than 0°C. This is purely a temperature-derived metric for assessing the potential for frosts over the 5 km x 5 km climate model grid. Frost conditions are influenced at the local scale (i.e. finer scale than 5 km x 5 km) by temperature, topography, wind, and humidity, so the results presented in this section can be considered as the large-scale temperature conditions conducive to frosts. Note also that the topography of Mt Taranaki's highest elevations is not well accounted for by the climate model grid. As a result, the modelled annual number of frost days over the mountain's upper slopes is not an accurate representation of what would be recorded in those parts.

Historic (average over 1986-2005) and future (average over 2031-2050 and 2081-2100) maps for frost days are shown in this section. The historic maps show annual average numbers of frost days and the future projection maps show the change in the annual number of frost days compared with the historic period. Note that the historic maps are on a different colour scale to the future projection maps.

For the modelled historic period, frost days are uncommon for coastal portions of Taranaki from Ōpunake to Waitara (Figure 3-24). Inland and mountainous parts of the region have the highest number of frost days, with 5-20 days per year typical for many central and southern parts of the region.

Representative concentration pathway (RCP) 4.5

By 2040, decreases to frost days are projected throughout Taranaki (Figure 3-25), with highest decreases of 2-10 days projected for inland parts of the region.

By 2090, decreases of up to 15 frost days are projected for the region. Decreases of 2-5 days are common for southern and eastern parts of Taranaki (Figure 3-25).

Representative concentration pathway (RCP) 8.5

By 2040, the projected pattern of change under RCP8.5 is very similar to that projected for the same time period under RCP4.5 (Figure 3-25).

By 2090, decreases of up to 23 frost days are projected for Taranaki (Figure 3-25). This would result in frosts becoming an uncommon occurrence for most areas of Taranaki. Decreases of 5-10 days are common for southern and eastern parts of the region.

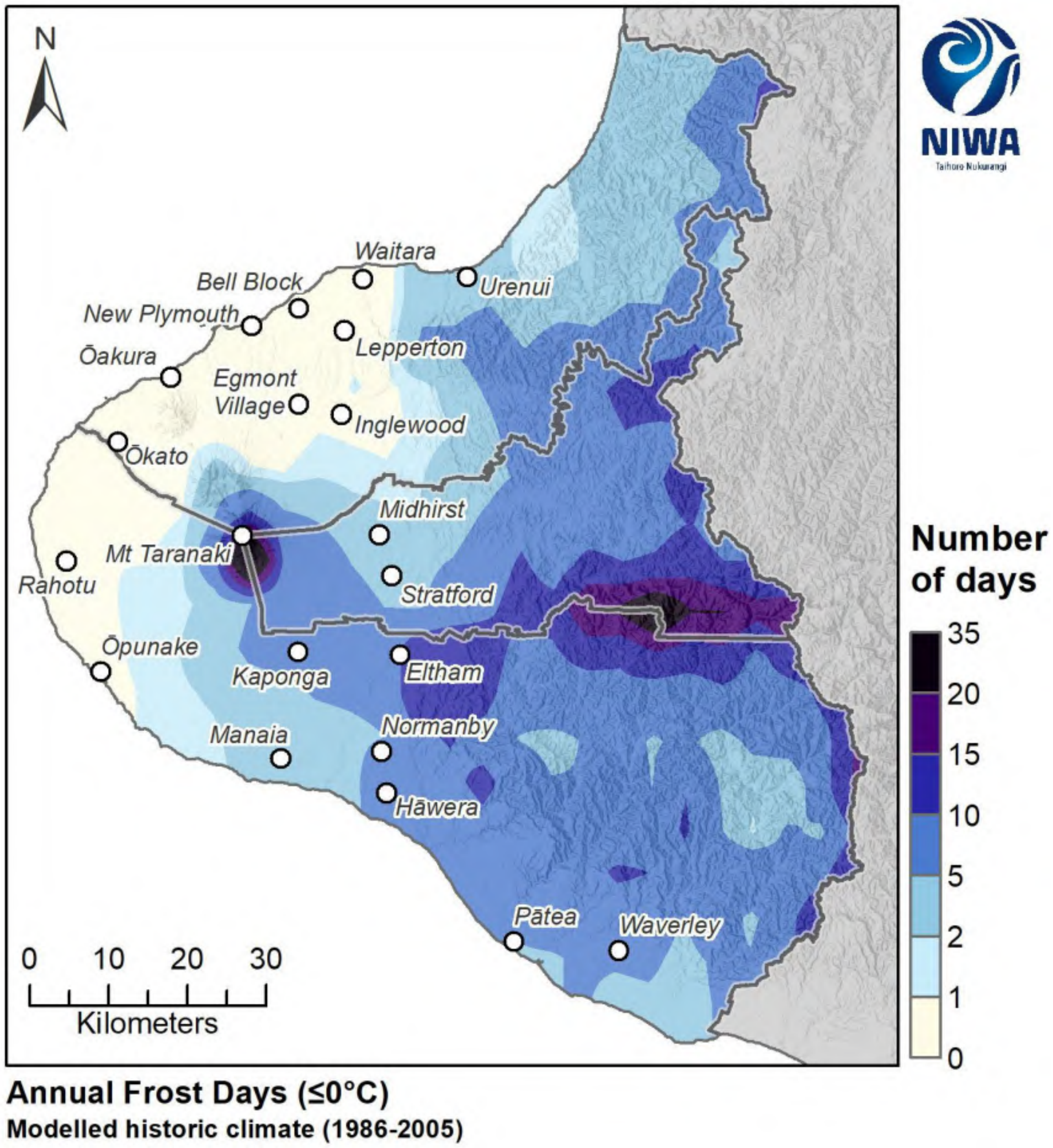


Figure 3-24: Modelled annual number of frost days (daily minimum temperature ≤0°C), average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

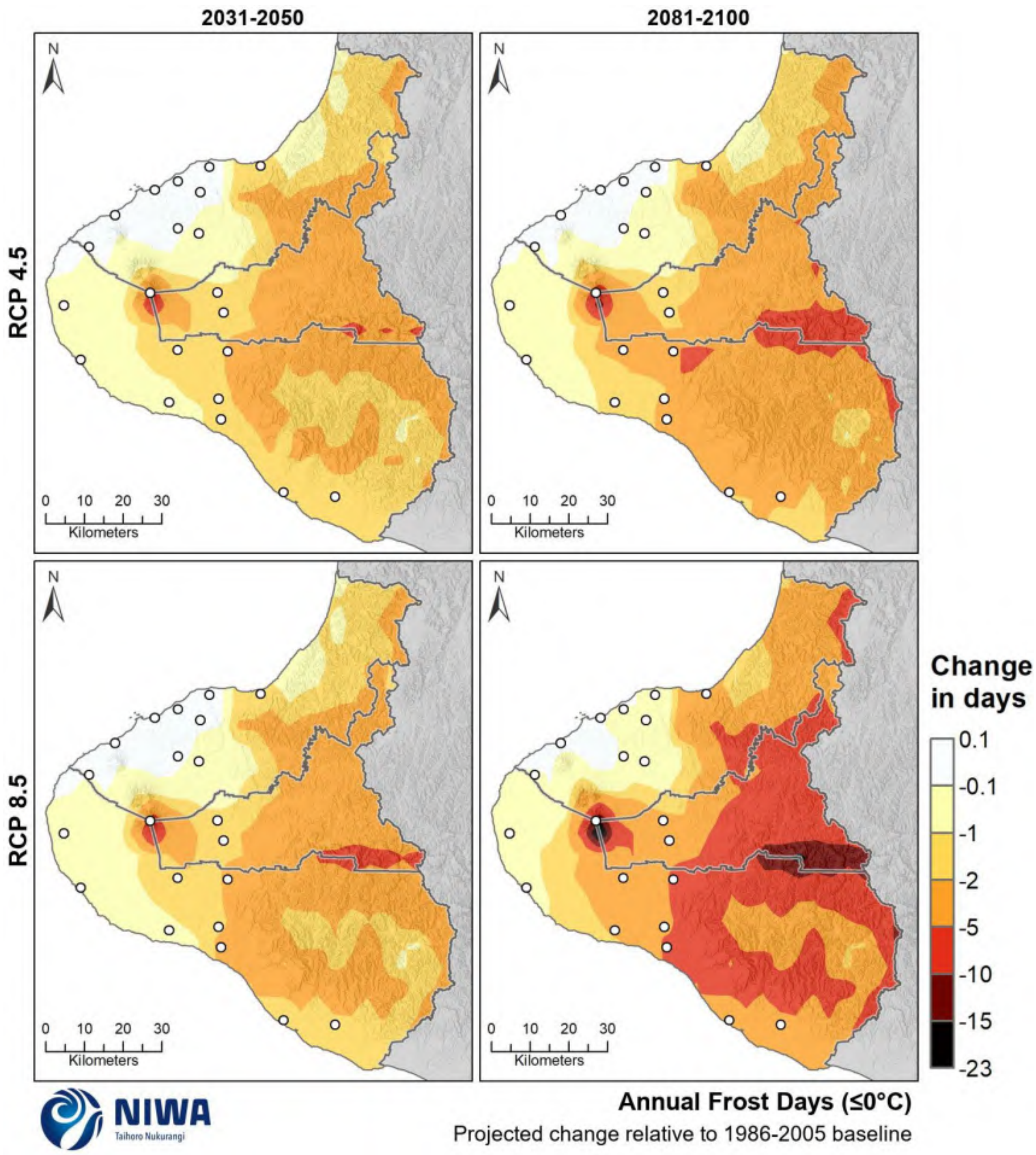


Figure 3-25: Projected annual number of frost days (daily minimum temperature ≤0°C) changes by 2040 and 2090 under RCP4.5 and RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.1.6 Hot days

Projected hot day changes for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	Up to 15 more	Up to 15 more
2090	Up to 30 more	Up to 63 more

In this report, a hot day is considered to occur when the maximum temperature is 25°C or higher. Historic (average over 1986-2005) and future (average over 2031-2050 and 2081-2100) maps for hot days are shown in this section. The historic maps show the annual average number of hot days and the future projection maps show the change in the number of hot days compared with the historic average. Note that the historic maps are on a different colour scale to the future projection maps.

For the historic period, hot days occur most regularly about southern, inland and northern parts of Taranaki. Here, the annual number of hot days averages 10-15 days per year, with isolated areas about Urenui and east of Waverley averaging 15-30 days per year (Figure 3-26). Other coastal and low elevation areas typically observe 5-10 hot days per year. Hot days are uncommon in the elevated terrain around Mount Taranaki.

Representative concentration pathway (RCP) 4.5

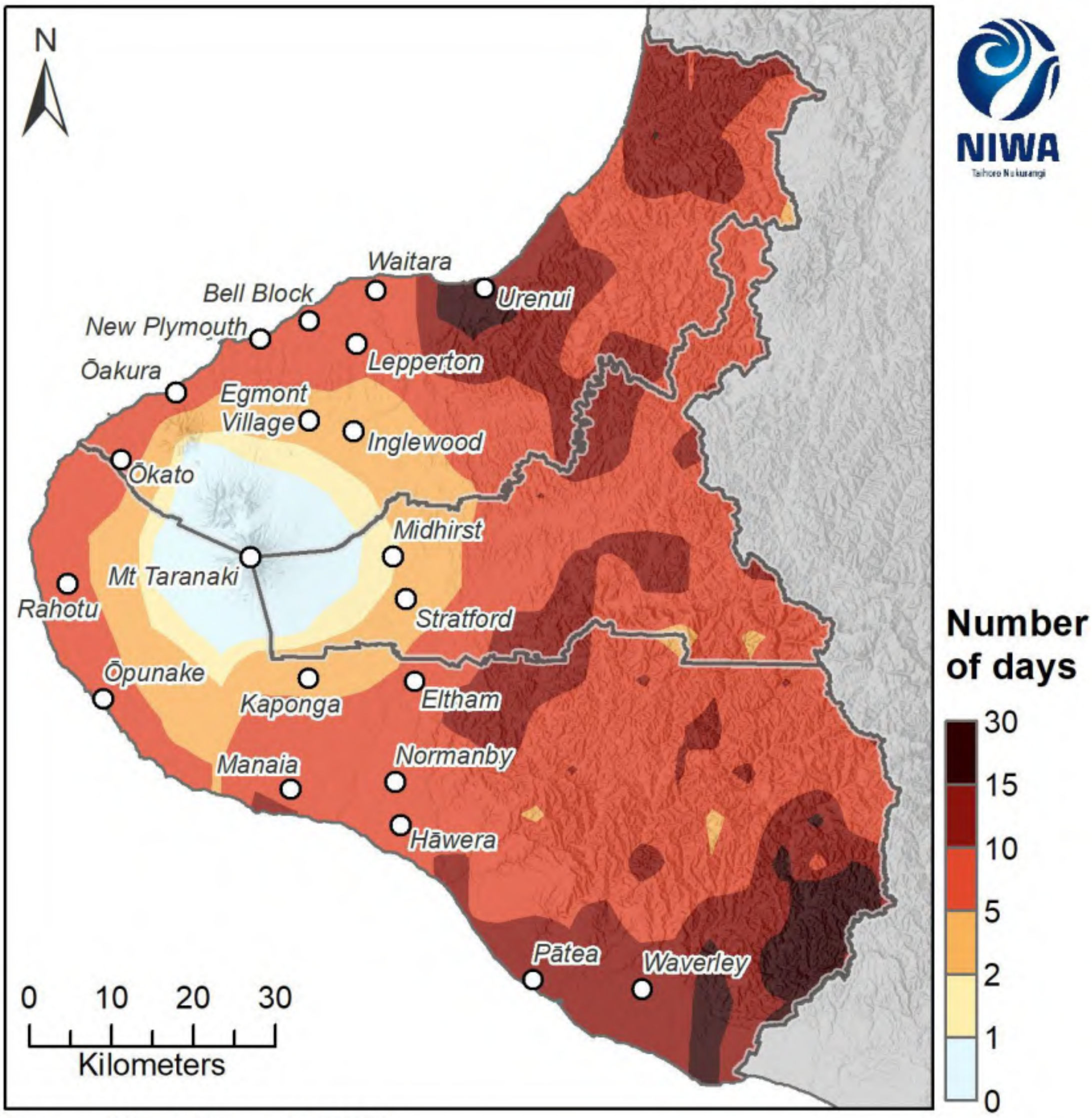
By 2040, increases to hot days are projected throughout Taranaki (Figure 3-27), with increases of 5-10 days projected for most of the region. Highest increases of 10-15 days are projected for isolated inland areas and near Urenui.

By 2090, increases of 10-20 hot days are projected for most of the region. Smaller increases of 5-10 hot days are projected for some inland areas near Mount Taranaki including Kaponga, Stratford and Midhurst (Figure 3-27).

Representative concentration pathway (RCP) 8.5

By 2040, the projected pattern of change under RCP8.5 is similar to that projected for the same time period under RCP4.5. The main difference is a more widespread projected increase of 10-15 hot days, including about New Plymouth, Pātea and Waverley (Figure 3-27).

By 2090, considerable increases of up to 63 hot days are projected for Taranaki (Figure 3-27). Largest increases of 50-63 days are projected for coastal areas of New Plymouth District, and eastern parts of the Stratford and South Taranaki Districts. This is the equivalent of approximately 7-9 additional weeks of hot days compared to the historic climate. For coastal areas about Rahotu and Ōpunaki, an additional 30-40 annual hot days are projected.



Annual Hot Days (≥25°C)
Modelled historic climate (1986-2005)

Figure 3-26: Modelled annual number of hot days (days with maximum temperature ≥25°C), average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

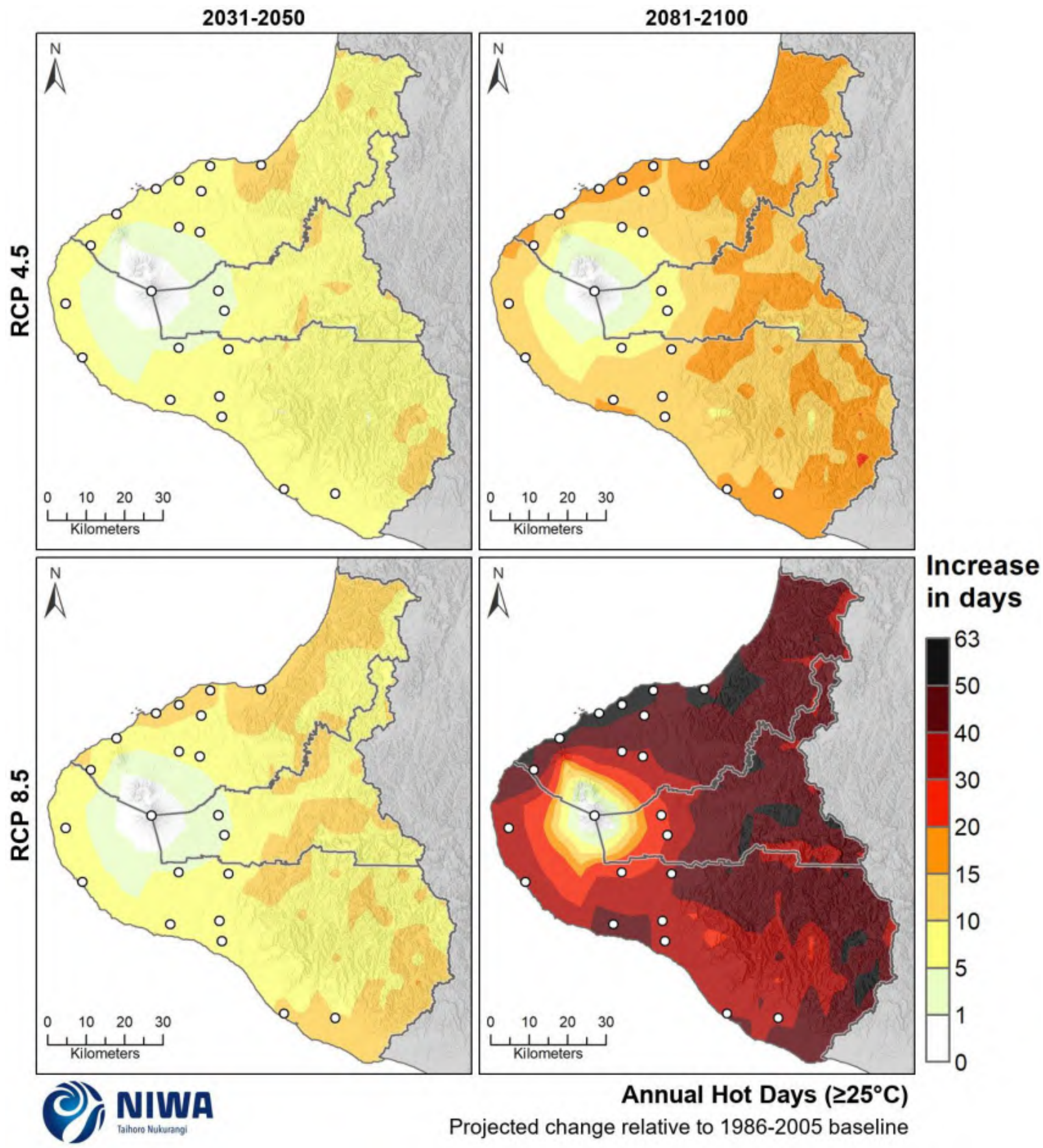


Figure 3-27: Projected annual hot day (days with maximum temperature ≥25°C) changes by 2040 and 2090, under RCP4.5 and RCP8.5. Changes relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.1.7 Growing degree days

Projected growing degree day (base 10°C) changes for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	+90-300	+90-300
2090	+90-450	+450-950

Growing degree-days (GDD) express the sum of daily temperatures above a selected base temperature (e.g. 10˚C) that represent a threshold for plant growth. The average amount of growing degree-days in a location may influence the choice of crops to grow, as different species have different temperature thresholds for survival. The daily GDD total is the amount the daily average temperature exceeds the threshold value (e.g. 10°C) per day. For example, a daily average temperature of 18°C would have a GDD base 10°C value of 8. The daily GDD values are accumulated over the period 1 July to 30 June to calculate an annual GDD value.

Historic (average over 1986-2005) and future (average over 2031-2050 and 2081-2100) maps for GDD are shown in this section. The historic maps show annual average GDD and the future projection maps show the change in GDD compared with the historic average. Note that the historic maps are on a different colour scale to the future projection maps.

The number of historic growing degree-days follows a similar spatial pattern to mean temperature, with the highest number along the coastal and low elevation areas (1100-1550 GDD), and the lowest number of 190-800 GDD about Mount Taranaki (Figure 3-28). GDD about Kaponga, Stratford and Midhurst (800-1000 GDD) are relatively low compared to much of Taranaki.

Representative concentration pathway (RCP) 4.5

By 2040, increases to GDD are projected throughout Taranaki (Figure 3-29), with increases of 200-250 GDD projected for most of the region.

By 2090, increases of 90-450 GDD are projected for Taranaki. Largest increases of 350-450 GDD are projected for most of New Plymouth District, Stratford District east of Stratford, and coastal areas west of Hāwera (Figure 3-29).

Representative concentration pathway (RCP) 8.5

By 2040, increases of 90-300 GDD are projected for Taranaki. Largest increases of 250-300 GDD are projected for most of New Plymouth District, and coastal areas west of Hāwera (Figure 3-29).

By 2090, considerable increases of 450-900 GDD are projected for Taranaki (Figure 3-29). The largest increases of 900-950 GDD are projected for coastal areas north of Mount Taranaki. The increase in GDD will likely influence the types of crops that can be grown at a location, and harvesting times for crops into the future – one would expect to see crops only suitable for warmer northern climates at present move further south as the climate warms, and harvesting times for crops presently grown in Taranaki may shift to an earlier time in the season.

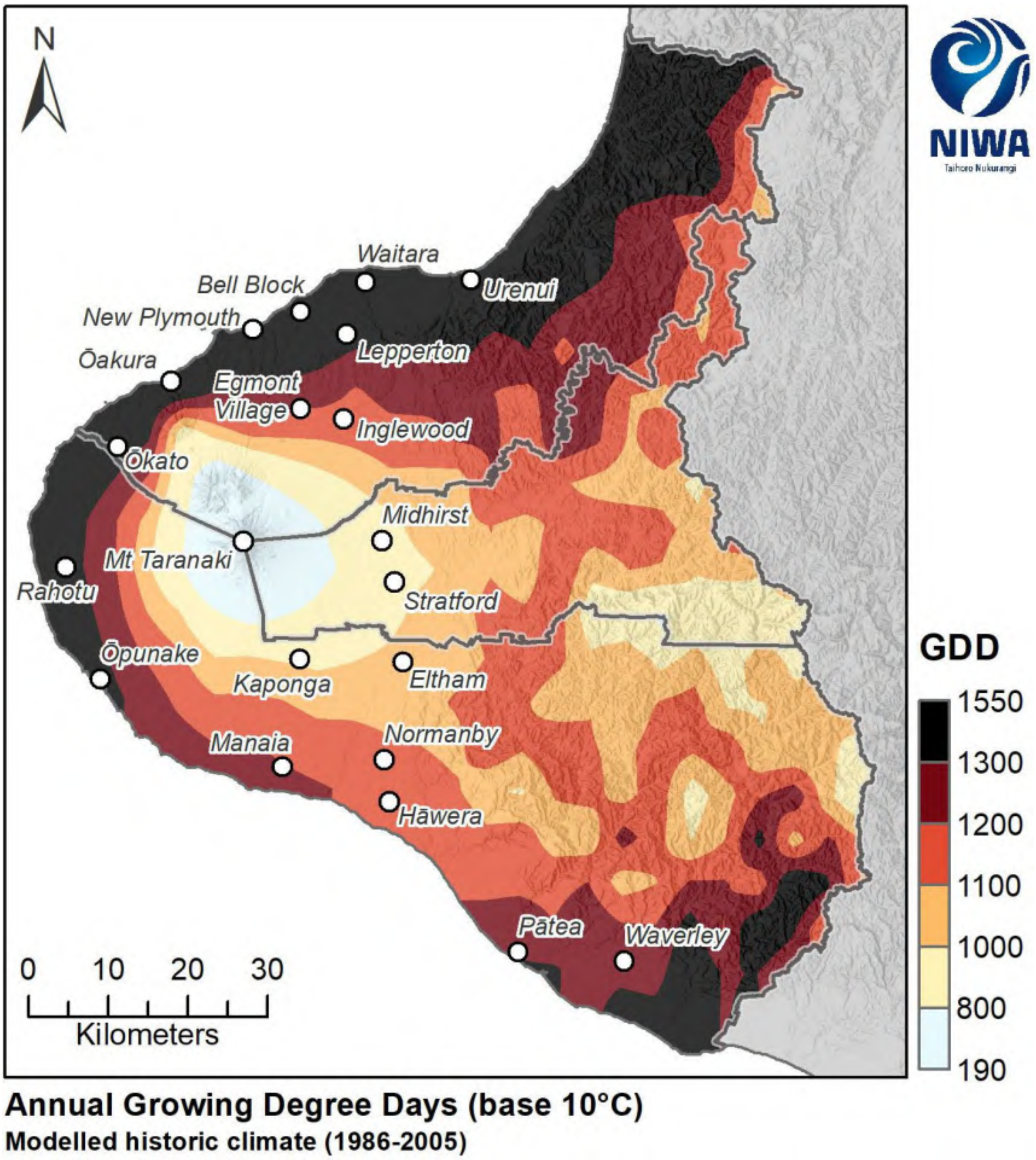


Figure 3-28: Median annual Growing Degree-Days (GDD) base 10°C. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

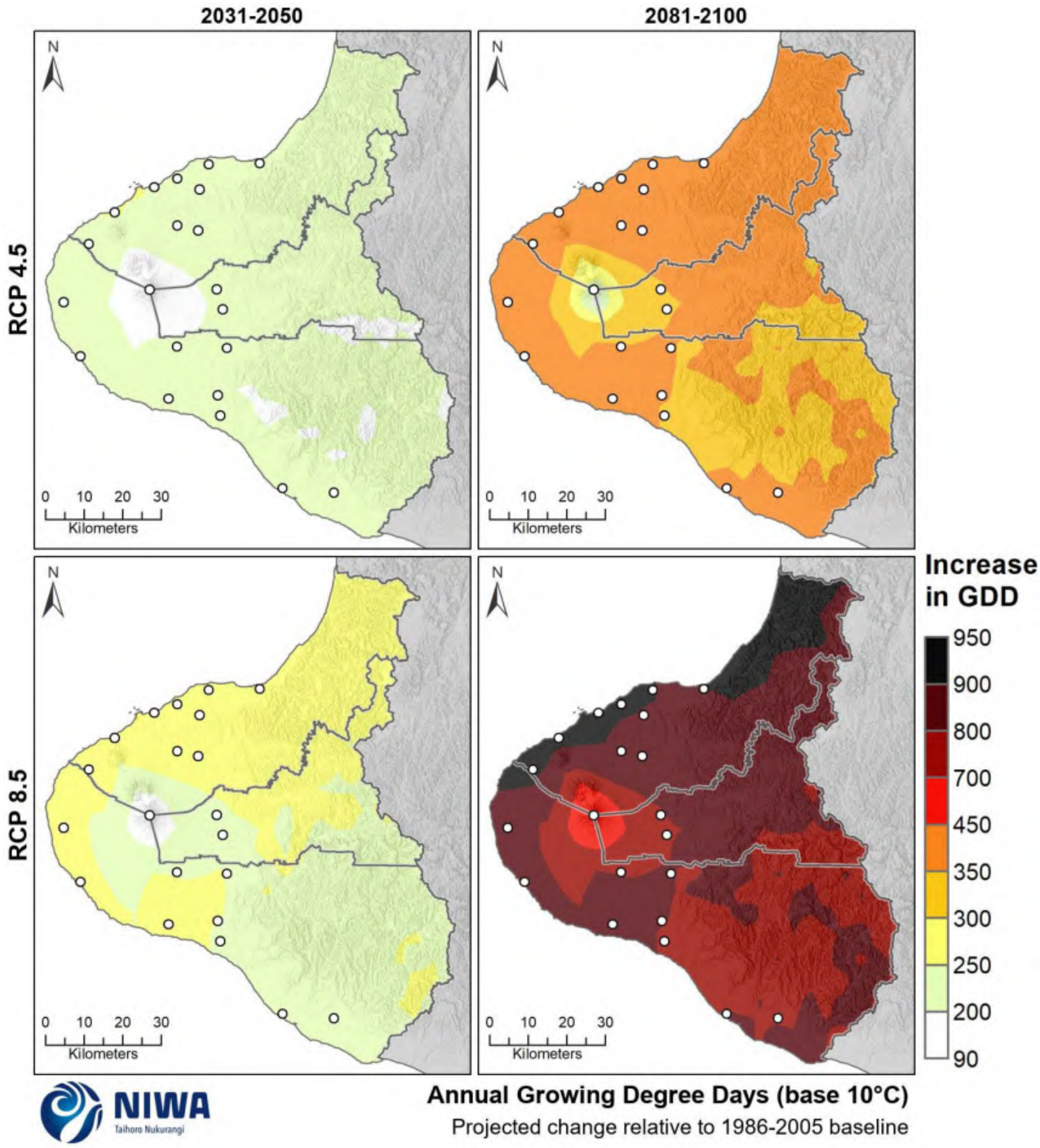


Figure 3-29: Projected increase in number of growing degree days per year (base 10°C) at 2040 (2031-2050) and 2090 (2081-2100) for RCP4.5 (left panels) and RCP8.5 (right panels). Projected change is relative to 1986-2005. Results are based on dynamically downscaled projections and show the average of six global climate models. Resolution of projection is 5km x 5km.

3.2 Rainfall

3.2.1 Rainfall totals

Projected rainfall total changes (%) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	-2% to +4%	Up to +8%
2090	Up to +8%	Up to +12%

Seasonal:

	RCP4.5		RCP8.5	
	2040	2090	2040	2090
Summer	± 4%	-2% to +8%	-2% to +8%	-4% to +12%
Autumn	-6% to +2%	-2% to +8%	-2% to +8%	-6% to +8%
Winter	-2% to +8%	+2-12%	+2-12%	+8-22%
Spring	Up to +8%	Up to -6%	-4% to +2%	-4% to +8%

This section contains maps showing historic total rainfall and the future projected change in total rainfall. Historic rainfall maps are in units of mm per year or season (average over 1986-2005) and future (average over 2031-2050 and 2081-2100) maps show the percentage change in rainfall compared with the historic total. Note that the historic maps are on a different colour scale to the future projection maps.

For the modelled historic period, the highest annual rainfall totals are recorded in the higher elevations near Mount Taranaki, and northeast of Inglewood, with 2000-3000 mm/year (Figure 3-30). For higher elevations of Mount Taranaki, annual rainfall totals of 3000-6500 mm are recorded. The lowest annual rainfall totals are recorded in coastal areas about and south of Manaia, with 1000-1200 mm/year. Summer is typically the driest season, and winter is usually the wettest season (Figure 3-31).

Representative concentration pathway (RCP) 4.5

By 2040, projected change to annual rainfall ranges from -2% to +4% throughout the region (Figure 3-32). Greater changes are projected seasonally, with decreases of 2-6% projected for inland parts in autumn, and increases of up to 8% projected for Taranaki in winter (Figure 3-33).

By 2090, Taranaki is projected to experience increased rainfall of up to 8% (Figure 3-32). Again, there are more noticeable changes projected at the seasonal scale (Figure 3-34). Increases of 4-8% are projected for most of the region in winter, whilst decreases of up to 6% are projecte in spring.

Representative concentration pathway (RCP) 8.5

By 2040, Taranaki is projected to experience increased annual rainfall of up to 8% (Figure 3-32). Increases of 2-12% are projected for winter, while a decrease of up to 4% is projected for northern and inland parts of Taranaki in spring.

By 2090, a stronger pattern of change is evident, especially seasonally. At the annual timeframe, rainfall is projected to increase by up to 12% (Figure 3-32). Seasonal changes project a winter increase of 8-22% for Taranaki (Figure 3-36). Rainfall increases of 2-8% are projected for southern parts in summer, and northern parts in autumn. Spring sees a projected decrease in rainfall of 2-4% for much of the Stratford District.

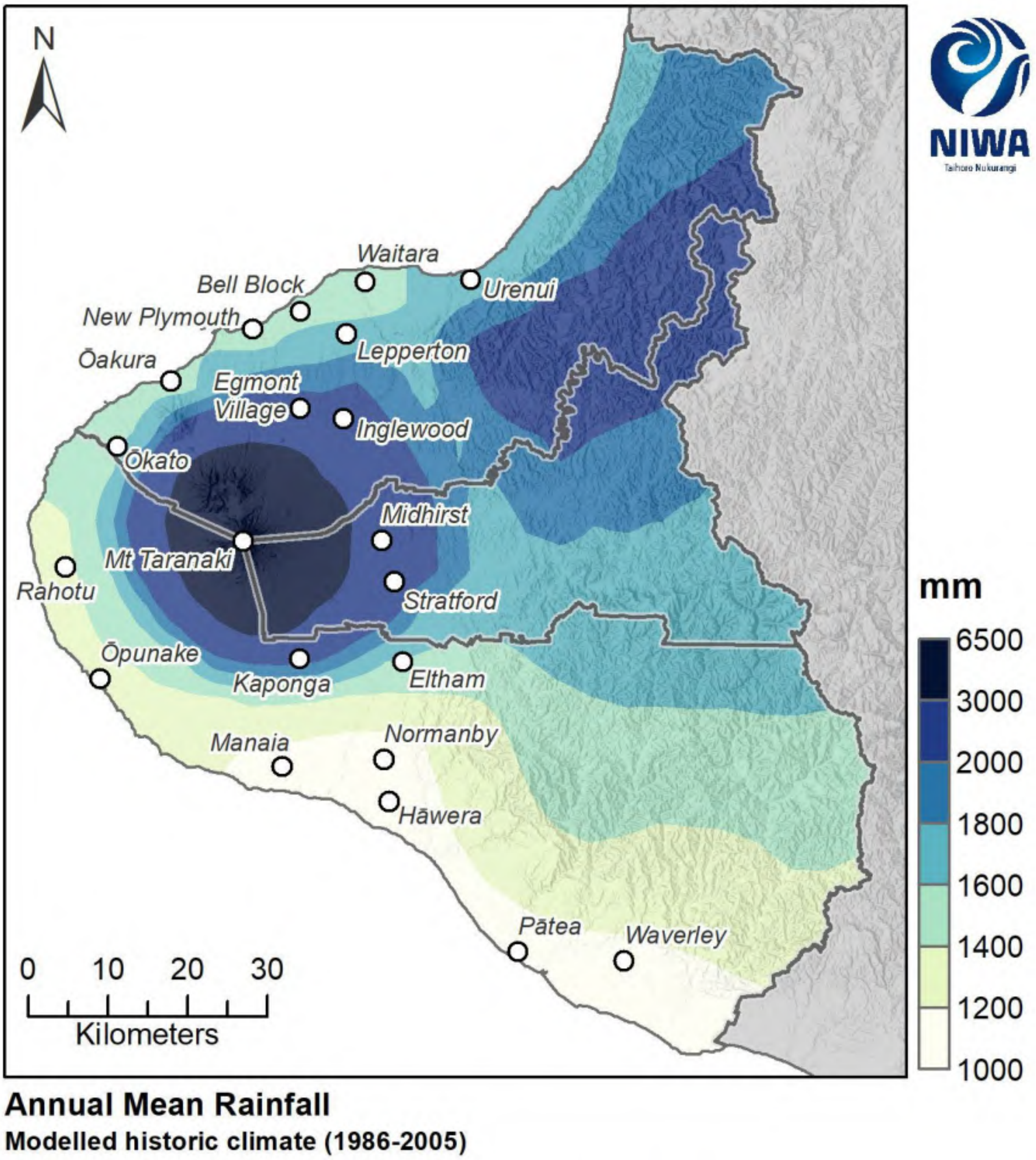


Figure 3-30: Modelled annual rainfall (mm), average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

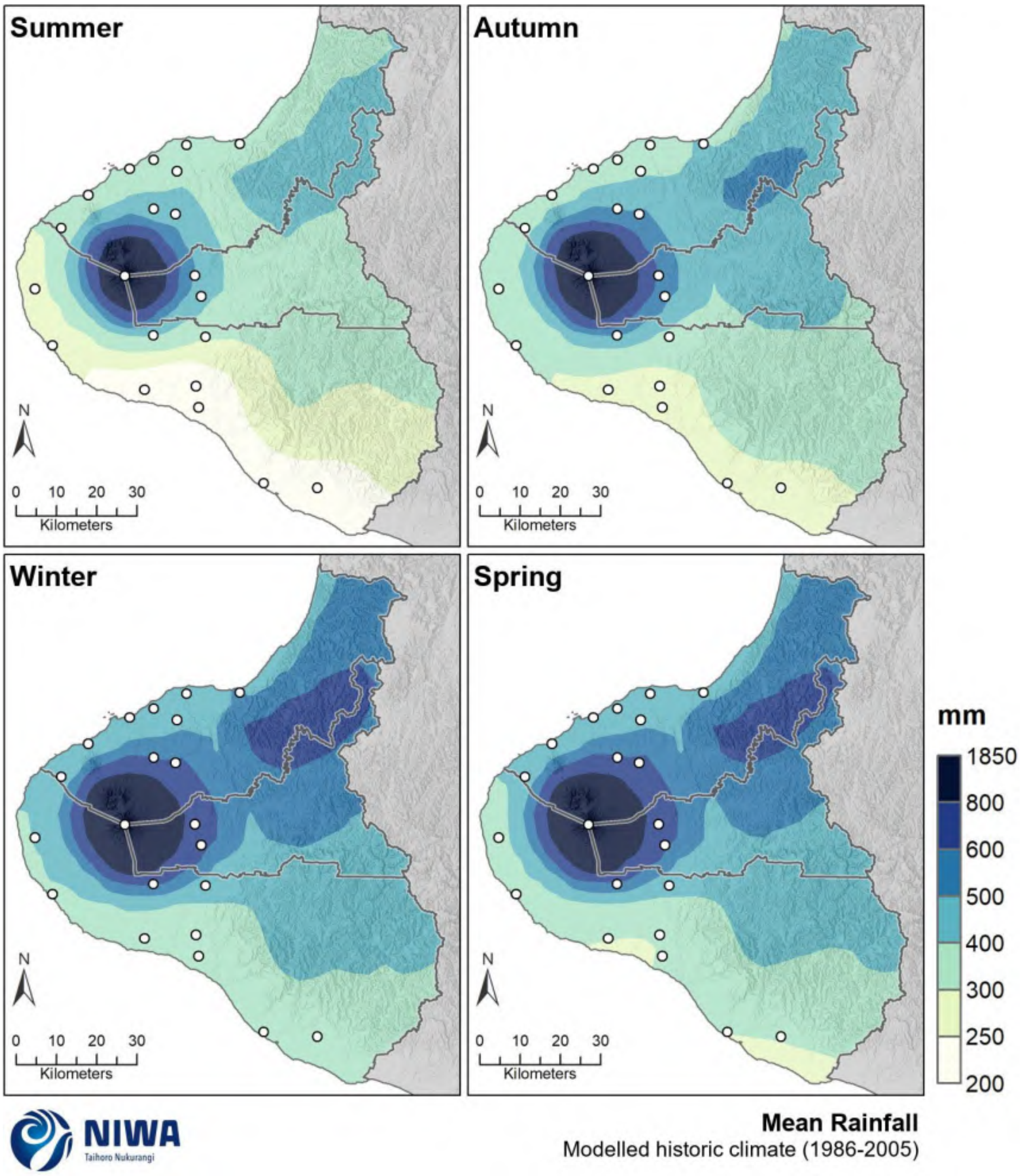


Figure 3-31: Modelled seasonal rainfall (mm), average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

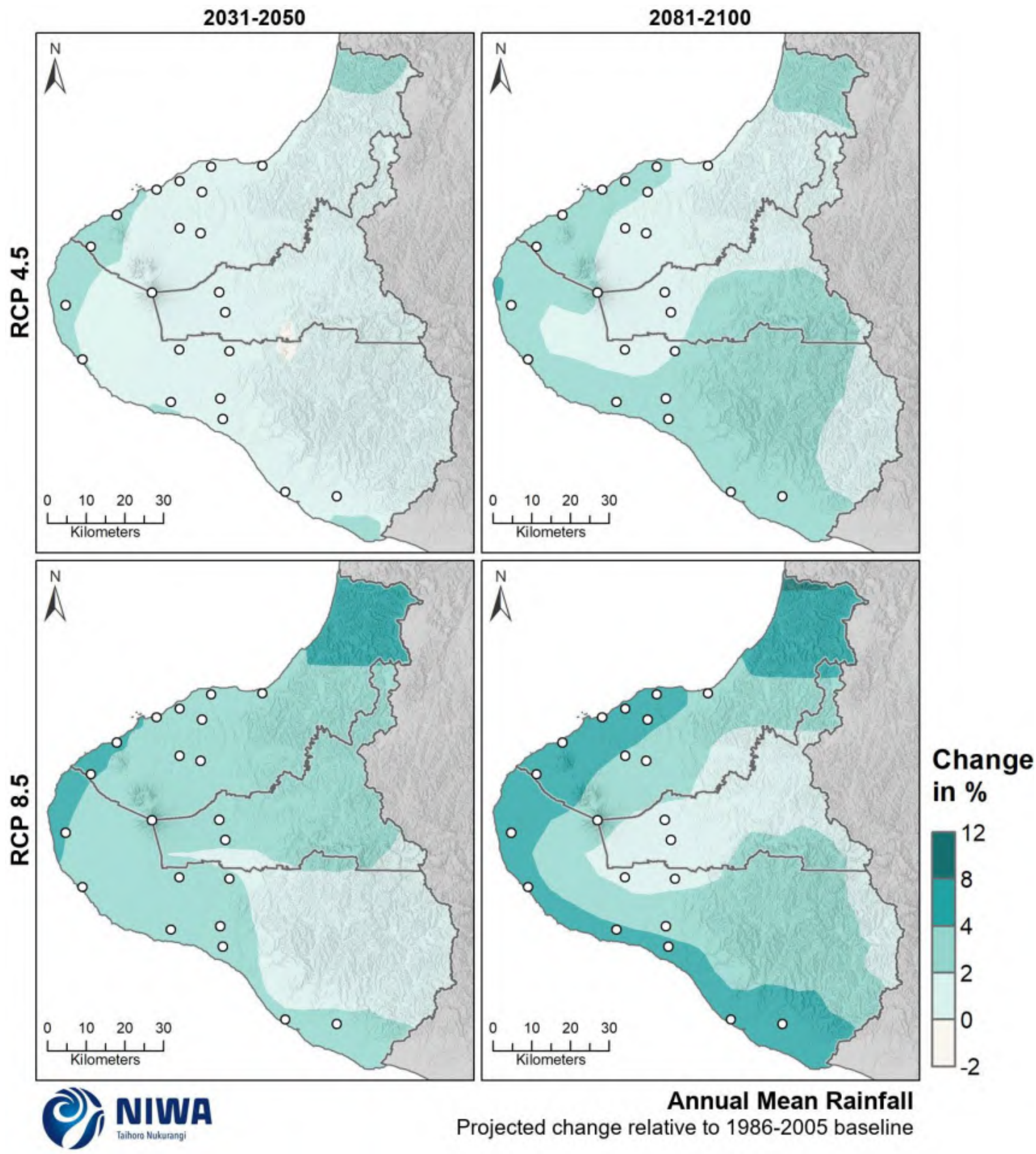


Figure 3-32: Projected annual rainfall changes (%). Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

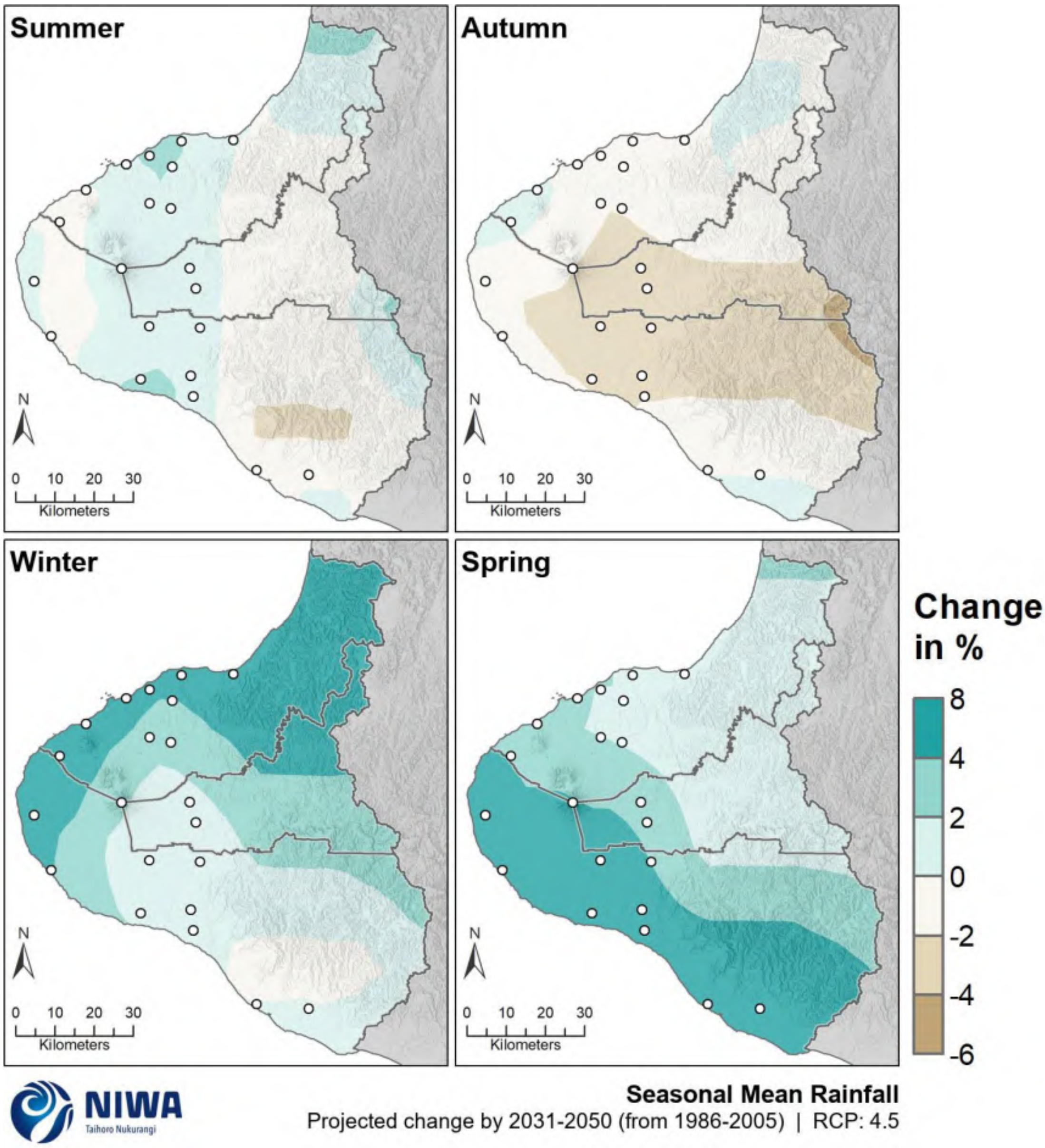


Figure 3-33: Projected seasonal rainfall changes (%) by 2040 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

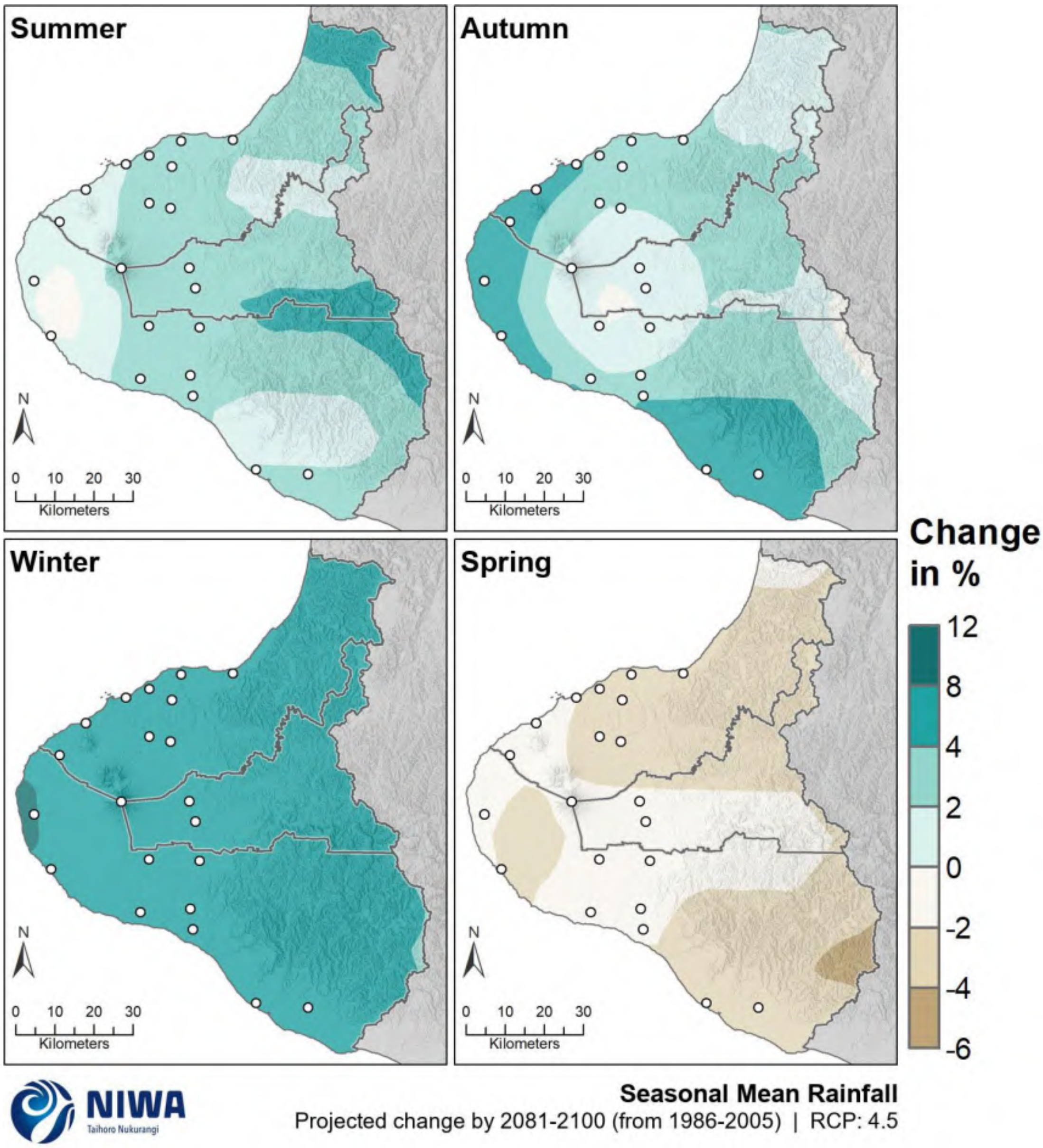


Figure 3-34: Projected seasonal rainfall changes (%) by 2090 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

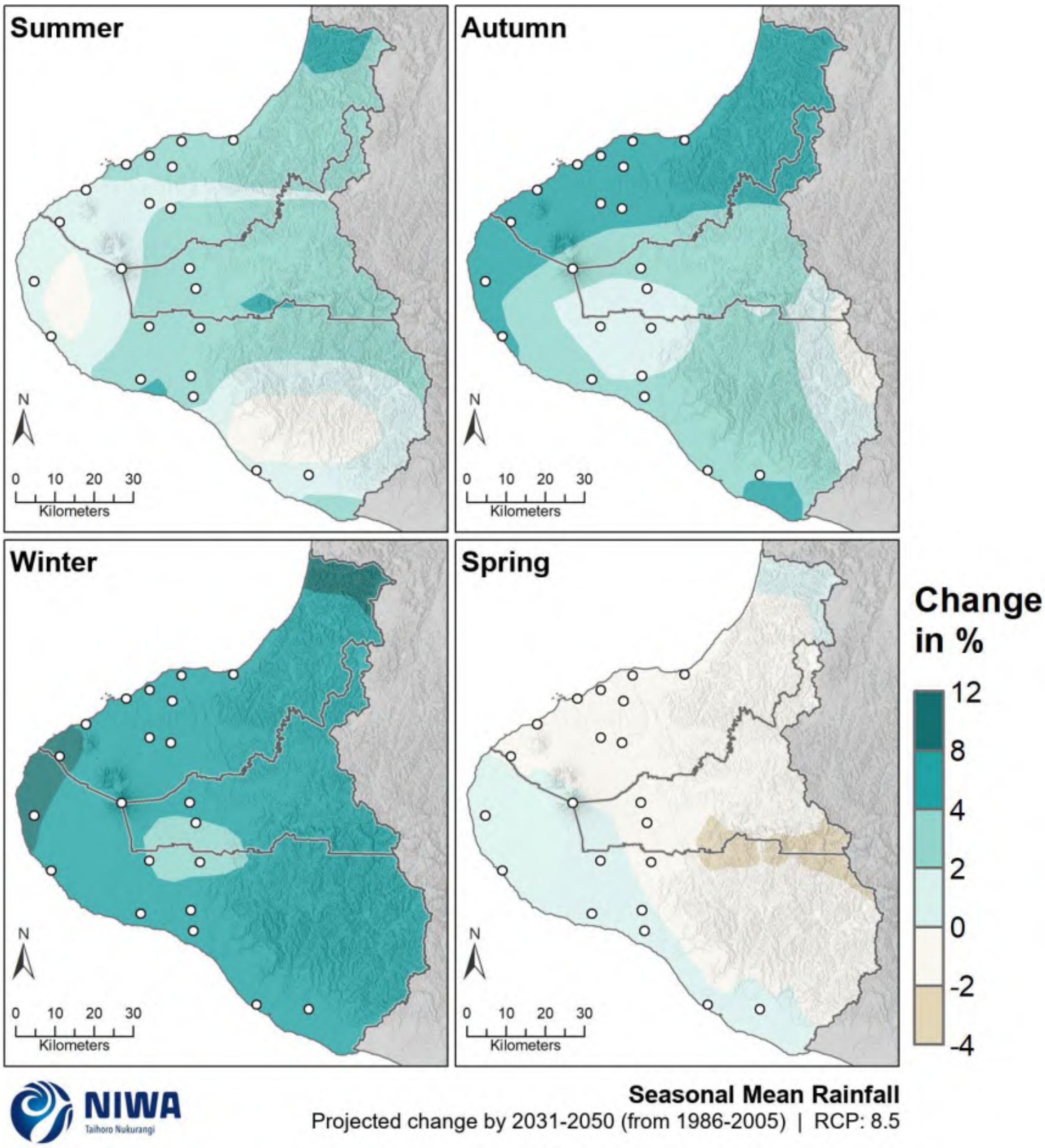


Figure 3-35: Projected seasonal rainfall changes (%) by 2040 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

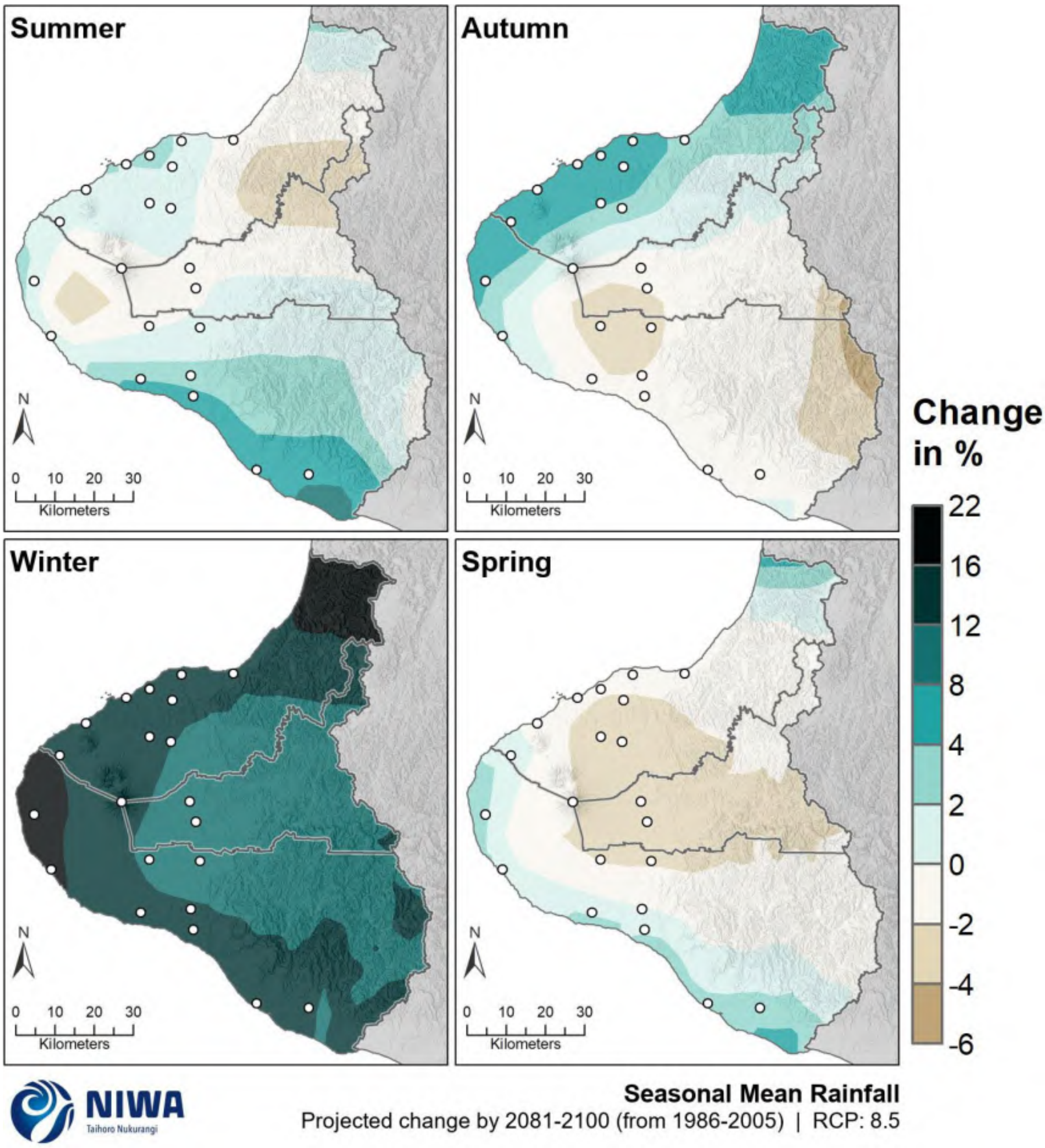


Figure 3-36: Projected seasonal rainfall changes (%) by 2090 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.2.2 Dry days

Projected dry day changes (days) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	+1-8	+1-8
2090	+1-12	+2-17

Seasonal:

	RCP4.5		RCP8.5	
	2040	2090	2040	2090
Summer	+1-3	-1 to +2	+1-3	+1-5
Autumn	-1 to +3	+1-4	-1 to +2	+1-5
Winter	-1 to +2	± 2	-2 to +1	± 3
Spring	-1 to +2	+1-4	-1 to +4	+2-7

A dry day considered here is when less than 1 mm of rainfall is recorded over a 24-hour period. Historic (average over 1986-2005) and future (average over 2031-2050 and 2081-2100) maps for dry days are shown in this section. The historic maps show annual and seasonal average numbers of dry days and the future projection maps show the change in the number of dry days compared with the historic period. Note that the historic maps are on a different colour scale to the future projection maps.

Historically, the largest annual number of dry days is experienced in southern parts of Taranaki about Pātea and Waverley (220-235 days per year; Figure 3-37). Many remaining areas of Taranaki average around 200-220 dry days per year. Fewer annual dry days are generally recorded as proximity to Mount Taranaki increases, with places such as Stratford, Eltham and Kaponga averaging 180-200 dry days per year. There is a notable seasonality in distribution of dry days throughout Taranaki, where winter and spring typically average approximately 10 fewer dry days compared to summer and autumn (Figure 3-38).

Representative concentration pathway (RCP) 4.5

By 2040, annual increases of 1-8 days are projected for Taranaki (Figure 3-39). Seasonal changes ranging from -1 to +2 days are projected in winter and spring.

By 2090, annual increases of 1-12 dry days are projected for the region (Figure 3-39). An increase of 1-4 days in autumn and spring is projected for the region (Figure 3-41), with little change (±1 day) projected for the majority of Taranaki in winter.

Representative concentration pathway (RCP) 8.5

By 2040, the projected pattern of annual change under RCP8.5 is similar to that projected for the same time period under RCP4.5 (Figure 3-39). This is also the case seasonally, with the main difference being a projected increase of 1-4 dry days in spring for much of the region (Figure 3-42).

By 2090, increases of 2-17 dry days per year are projected for Taranaki (Figure 3-39). Projected patterns of seasonal change show increases throughout the region in summer, autumn and spring.

Greatest increases of 4-7 dry days are projected for large parts of Taranaki in spring. Little change (±1 day) is projected for most of Taranaki in winter, although decreases of 1-3 dry days are projected for coastal parts of New Plymouth District.

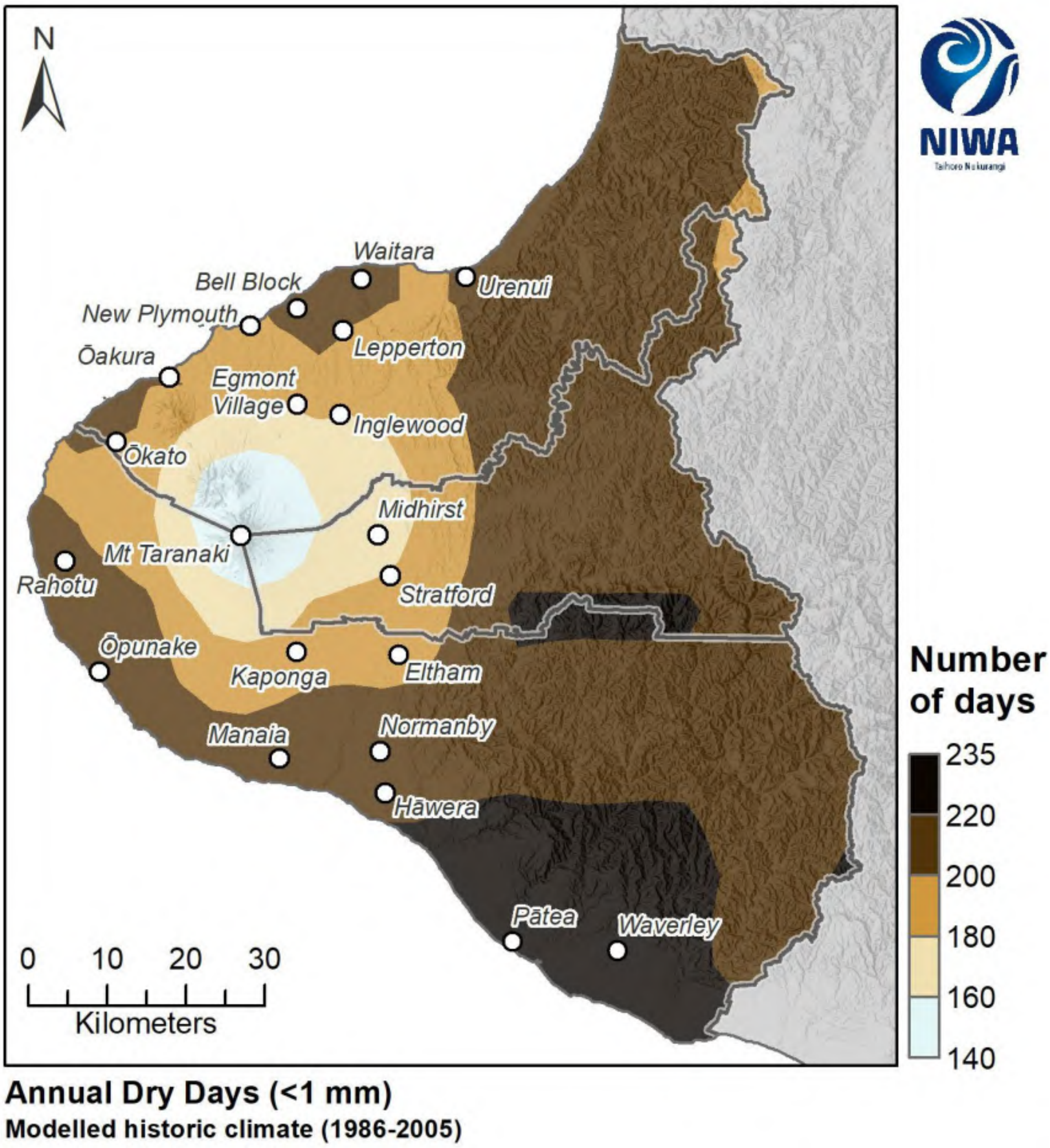


Figure 3-37: Modelled annual number of dry days (daily rainfall <1mm), average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

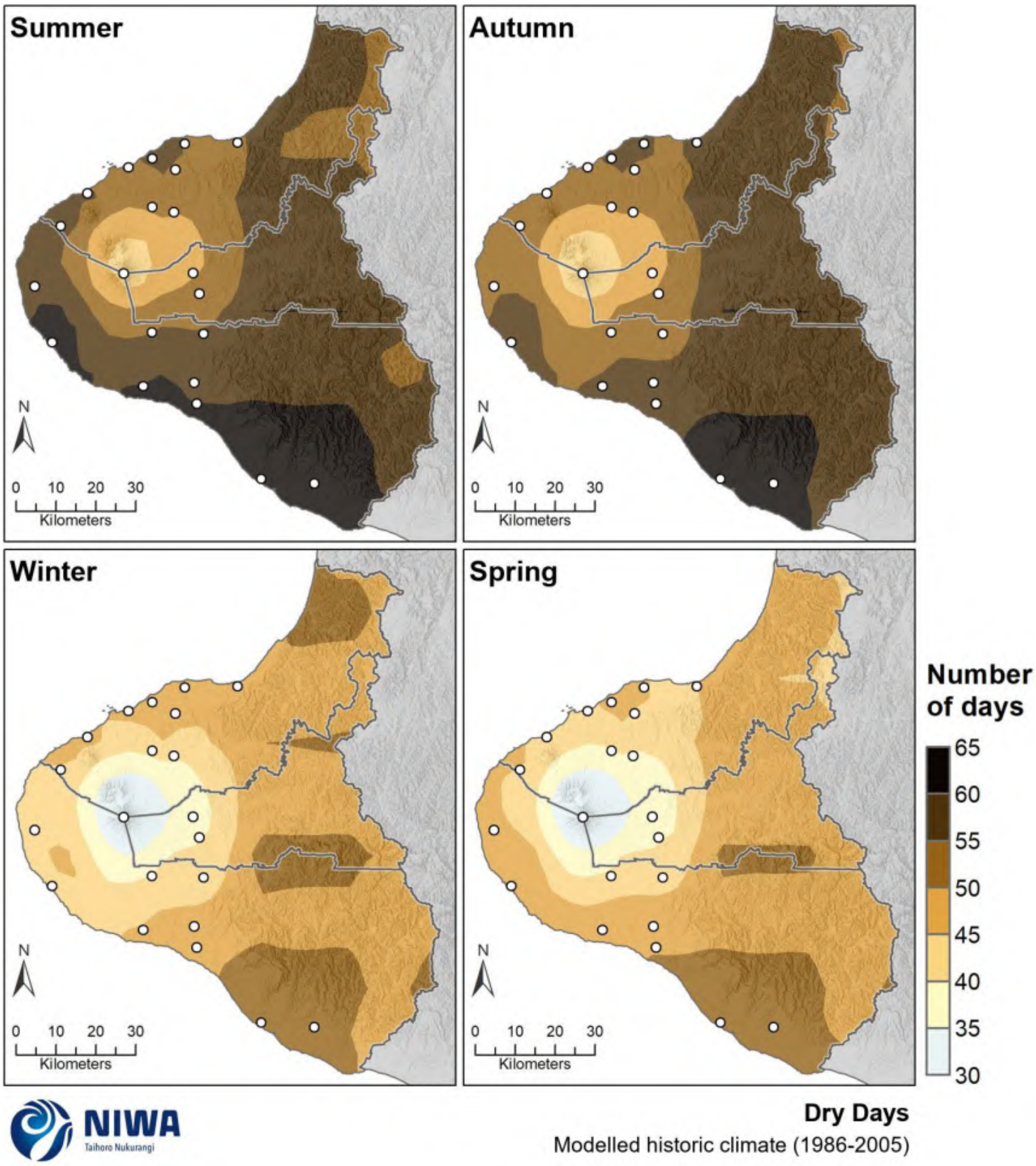


Figure 3-38: Modelled seasonal number of dry days (daily rainfall <1mm), average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

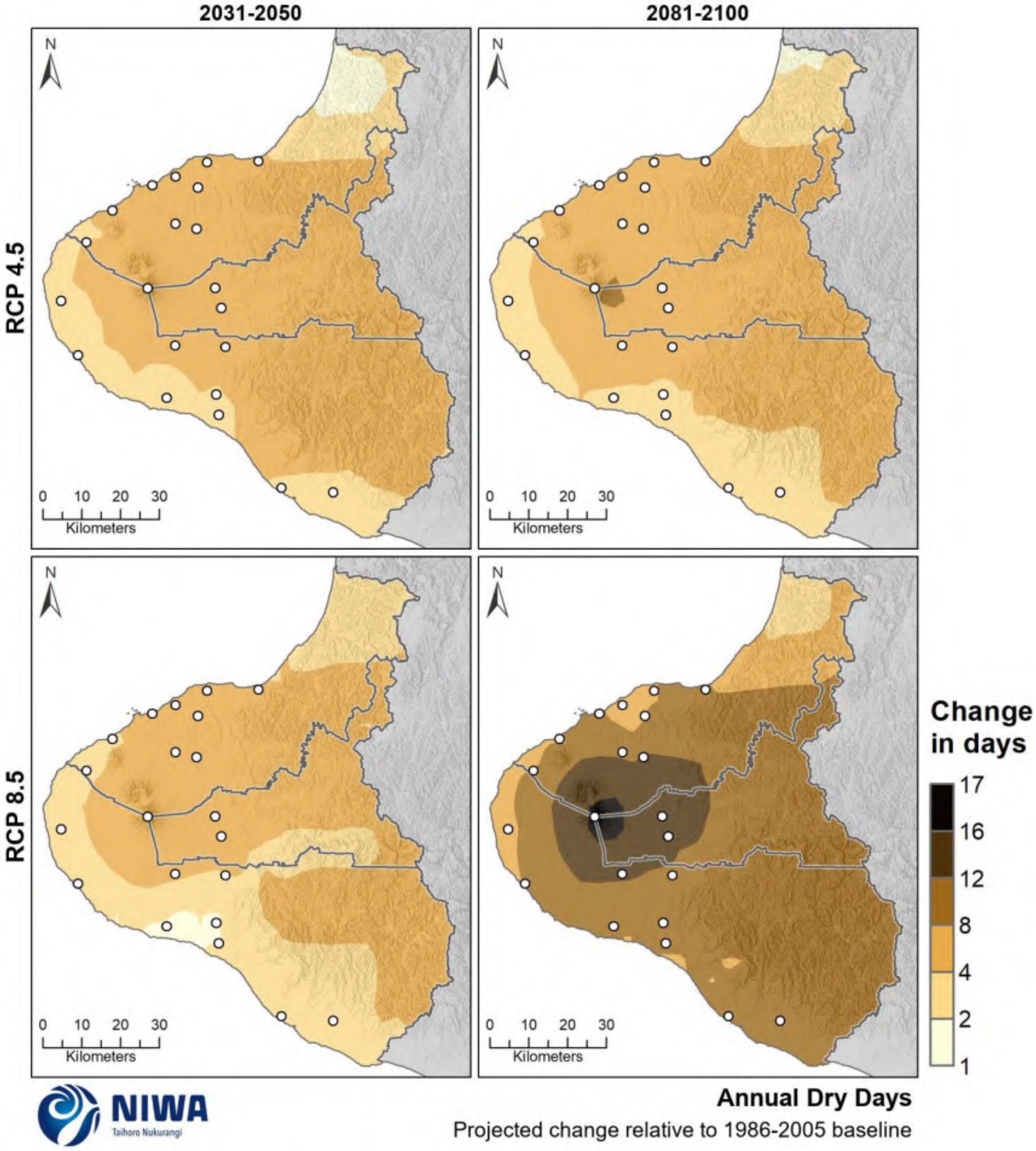


Figure 3-39: Projected annual number of dry day (daily rainfall <1mm) changes by 2040 and 2090, under RCP4.5 and RCP8.5. Changes relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

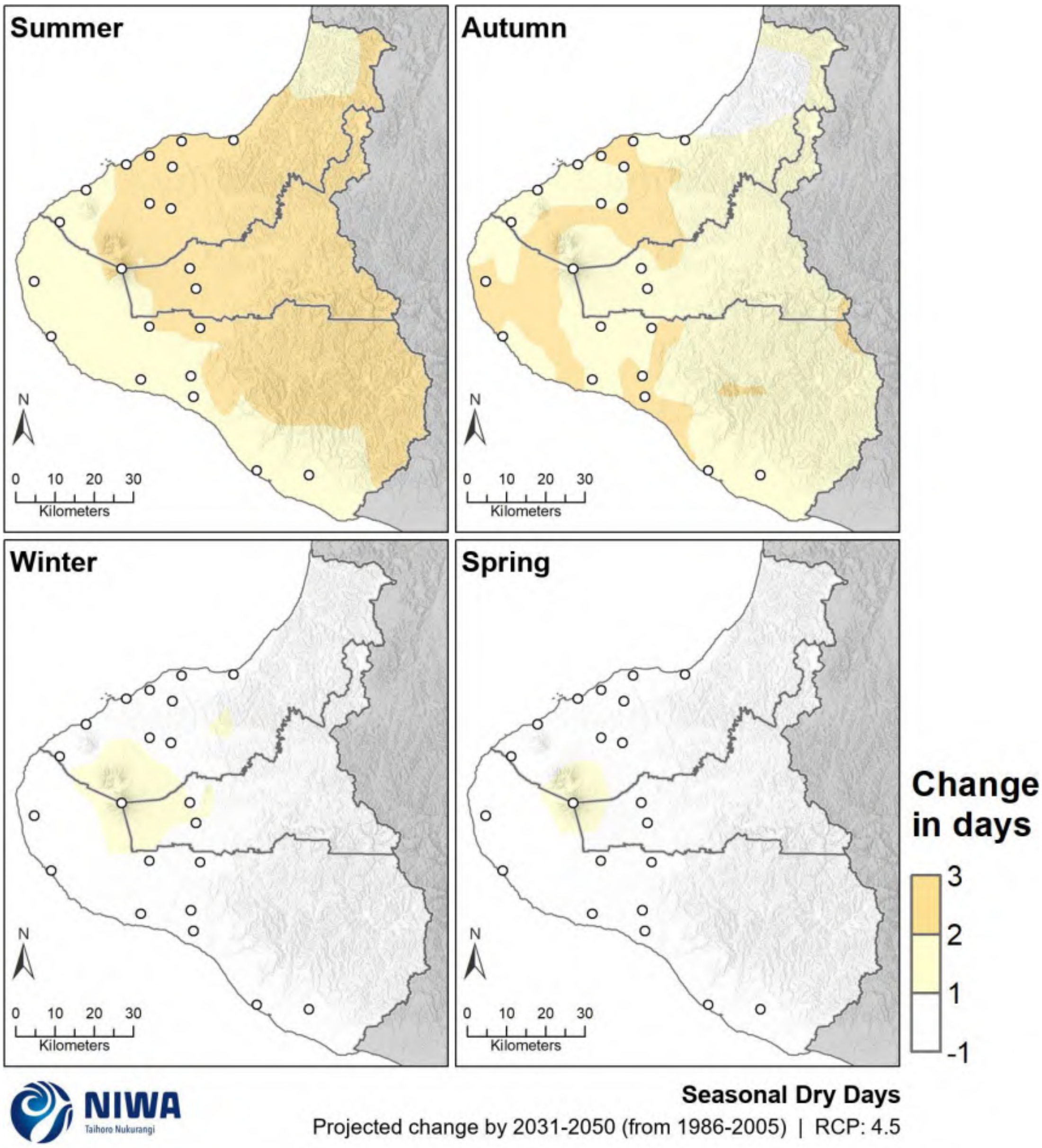


Figure 3-40: Projected seasonal number of dry day (daily rainfall <1mm) changes by 2040 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

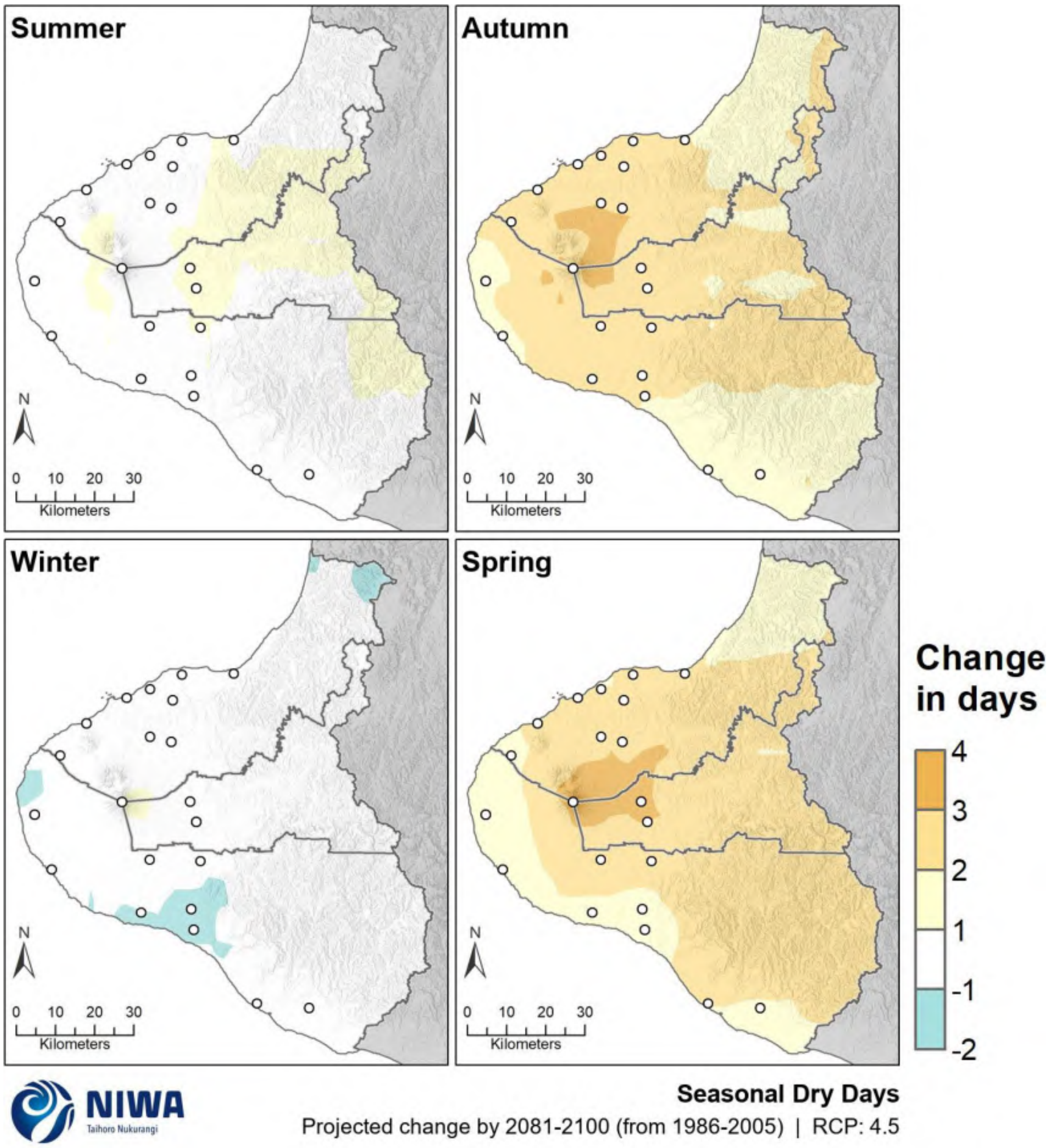


Figure 3-41: Projected seasonal number of dry day (daily rainfall <1mm) changes by 2090 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

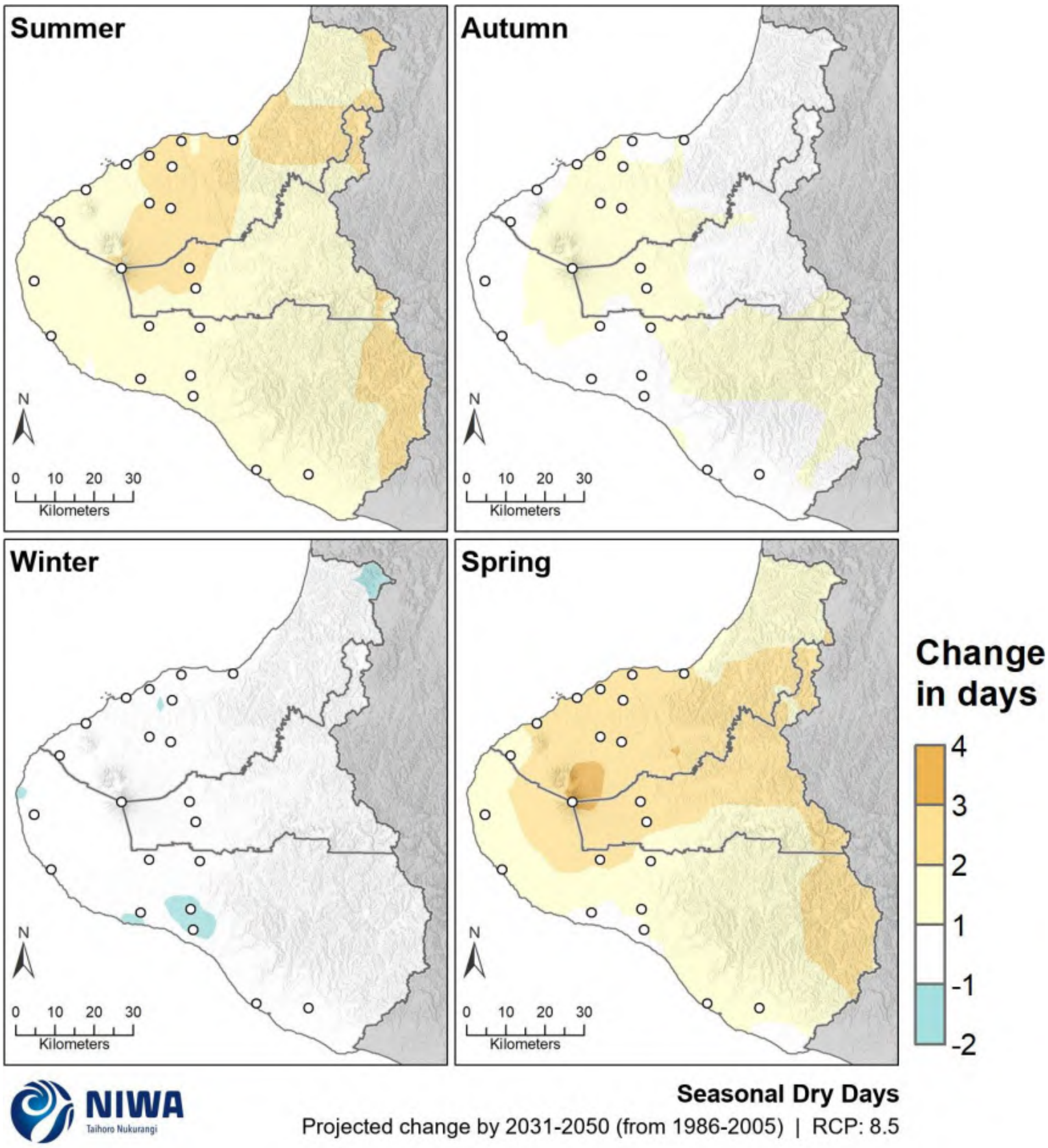


Figure 3-42: Projected seasonal number of dry day (daily rainfall <1mm) changes by 2040 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

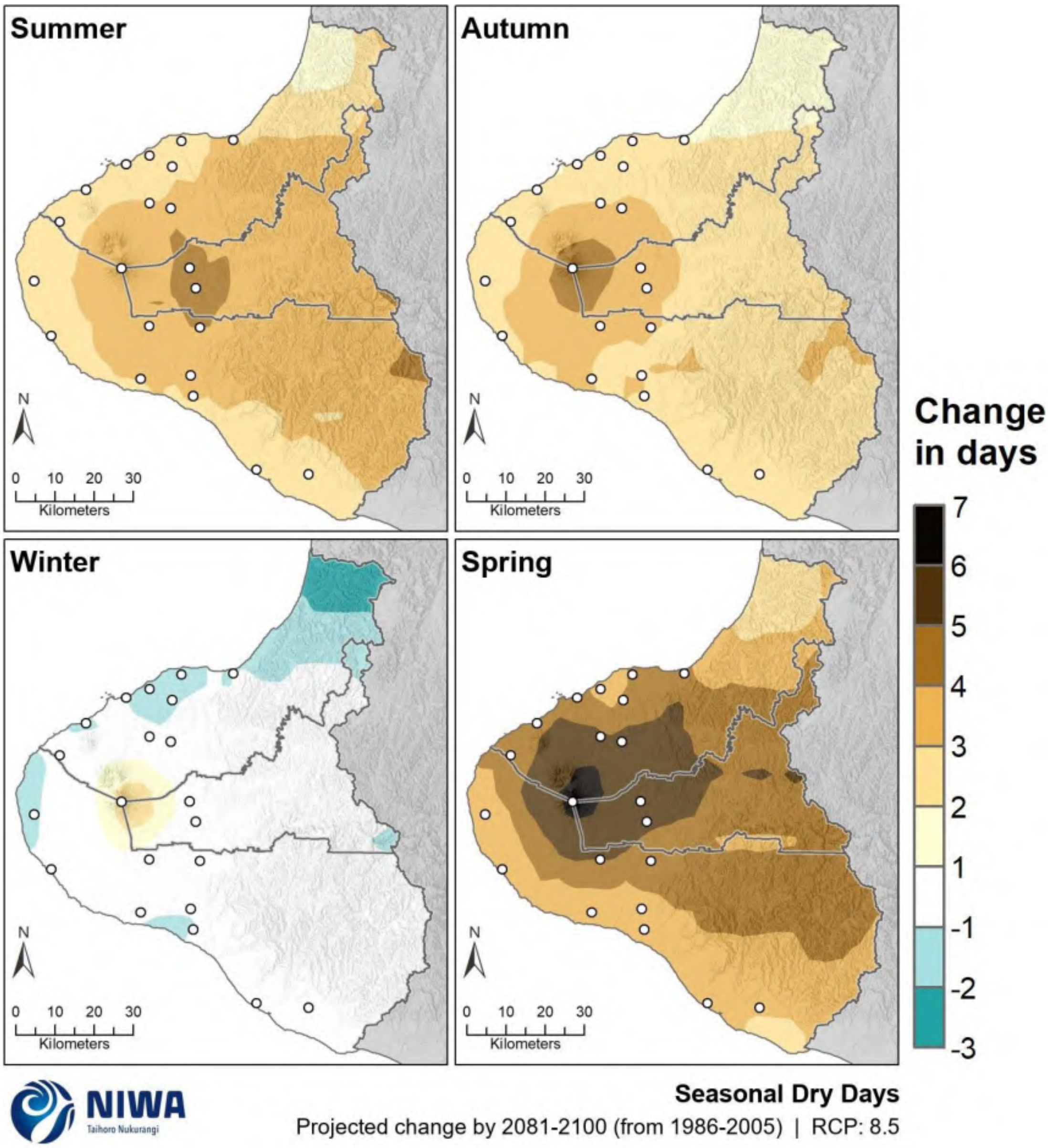


Figure 3-43: Projected seasonal number of dry day (daily rainfall <1mm) changes by 2090 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.2.3 Extreme, rare rainfall events

Projected extreme, rare rainfall event changes in Taranaki (average of the 4 selected sites)

50-year return period rainfalls:

	RCP4.5		RCP8.5	
Rainfall duration	2040	2090	2040	2090
1-hour	+10%	+16%	+11%	+35%
6-hours	+9%	+14%	+10%	+29%
12-hours	+7%	+12%	+8%	+25%
24-hours	+6%	+10%	+7%	+22%
48-hours	+6%	+9%	+6%	+19%

Extreme rainfall events are often considered in the context of return periods (e.g. 1-in-100-year rainfall events). A return period is an estimate of the likelihood of an event. It is a statistical measure typically based on historical data and probability distributions which calculate how often an event of a certain magnitude may occur. Return periods are often used in risk analysis and infrastructure design.

The theoretical return period is the inverse of the probability that the event will be exceeded in any one year (also known as the Average Recurrence Interval, ARI). For example, a 1-in-10-year rainfall event has a 1/10 = 0.1 ARI or 10% chance of being exceeded in any one year, and a 1-in-100-year rainfall event has a 1/100 = 0.01 ARI or 1% chance of being exceeded in any one year. However, this does not mean that a 1-in-100-year rainfall event will happen regularly every 100 years, or only once in 100 years.

With a changing climate, the return periods used below should be thought of only within the 20-year period in which they are defined. For instance, if extreme heavy rainfall events become a lot more frequent under climate change, then the 1-in-50-year rainfall event for 2040 (defined as the 2031-2050 period) will be less extreme than the 1-in-50-year rainfall event for 2040 if it was defined as the 2011-2070 period. This is because the average of the latter period would be dominated by the more frequent heavy rain events during the 2050s and 2060s. The events with larger return periods (i.e. 1-in-100-year events) have larger rainfall amounts for the same duration as events with smaller return periods (i.e. 1-in-2-year events) because larger events occur less frequently (on average).

NIWA's High Intensity Rainfall Design System (HIRDS version 4) allows rainfall event totals (depth; measured in mm) at various recurrence intervals to be calculated for any location in New Zealand (Carey-Smith *et al.*, 2018). The rainfall event durations presented in HIRDS range from 10 minutes to 120 hours (5 days). HIRDS calculates historic rainfall event totals for given recurrence intervals as well as future potential rainfall event totals for given recurrence intervals based on climate change scenarios. The future rainfall increases calculated by the HIRDS v4 tool are based on a percent change per degree of warming, which is averaged across New Zealand. The short duration, rare events have the largest relative increases of around 14% per degree of warming, while the longest duration events increase by about 5 to 6%. HIRDS v4 can be accessed at https://hirds.niwa.co.nz/, and more background information to the HIRDS methodology can be found at https://niwa.co.nz/information-services/hirds/help.

HIRDS rainfall projections for selected sites in the Taranaki region are presented in this section. For each site there are two tables; the first table presents data for 1-in-50-year rainfall events, and the second table presents data for 1-in-100-year rainfall events, with each of these tables listing the modelled historical and projected rainfall depths for one to 48-hour rain events. The results for New Plymouth, Stratford, Ōpunake and Waverley are presented in Table 3-1 to Table 3-8.

For each of the selected locations, rainfall depths are projected to increase across all the future scenarios, and both return periods. For example, Table 3-1 shows that the projected rainfall depth for a 12-hour rainfall event at New Plymouth (50-year ARI) is projected to increase under RCP4.5 from 133 mm (historical depth) to 143 mm by 2040, and 149 mm by 2090. Under RCP8.5 and for the same rainfall event duration, the projected amounts are 144 mm by 2040, and 167 mm by 2090, which indicate a 11 mm and 34 mm rise respectively compared with historical depth.

Table 3-1: Modelled historical and projected rainfall depths (mm) for New Plymouth for different event durations with a 50-year return period (0.02 ARI) Source: HIRDS v4. Location selected: -39.071, 174.082 (WGS84).

Rainfall event duration	Historical depth (mm)	Projected depth (mm)			
		Mid-century average (2031-2050)		Late-century average (2081-2100)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
1-hour	53.1	58.4	59.2	61.8	71.6
6-hour	105	114	115	119	136
12-hour	133	143	144	149	167
24-hour	166	176	178	183	202
48-hour	204	215	217	222	243

Table 3-2: Modelled historical and projected rainfall depths (mm) for New Plymouth for different event durations with a 100-year return period (0.01 ARI) Source: HIRDS v4. Location selected: -39.071, 174.082 (WGS84).

Rainfall event duration	Historical depth (mm)	Projected depth (mm)			
		Mid-century average (2031-2050)		Late-century average (2081-2100)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
1-hour	60.3	66.4	67.3	70.3	81.5
6-hour	119	130	131	136	155
12-hour	151	163	164	170	191
24-hour	189	201	203	208	231
48-hour	232	245	247	253	277

Table 3-3: Modelled historical and projected rainfall depths (mm) for Stratford for different event durations with a 50-year return period (0.02 ARI) Source: HIRDS v4. Location selected: -39.337, 174.305 (WGS84).

Rainfall event duration	Historical depth (mm)	Projected depth (mm)			
		Mid-century average (2031-2050)		Late-century average (2081-2100)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
1-hour	50.3	55.3	56.0	58.5	67.8
6-hour	113	123	124	129	146
12-hour	154	164	166	171	192
24-hour	203	216	217	224	247
48-hour	264	278	280	287	314

Table 3-4: Modelled historical and projected rainfall depths (mm) for Stratford for different event durations with a 100-year return period (0.01 ARI) Source: HIRDS v4. Location selected: -39.337, 174.305 (WGS84).

Rainfall event duration	Historical depth (mm)	Projected depth (mm)			
		Mid-century average (2031-2050)		Late-century average (2081-2100)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
1-hour	57.1	62.8	63.7	66.5	77.1
6-hour	128	139	140	146	166
12-hour	173	186	187	194	218
24-hour	229	244	246	253	280
48-hour	297	314	316	324	355

Table 3-5: Modelled historical and projected rainfall depths (mm) for Ōpunake for different event durations with a 50-year return period (0.02 ARI) Source: HIRDS v4. Location selected: -39.450, 173.850 (WGS84).

Rainfall event duration	Historical depth (mm)	Projected depth (mm)			
		Mid-century average (2031-2050)		Late-century average (2081-2100)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
1-hour	44.9	49.4	50.0	52.2	60.5
6-hour	93.0	101	102	106	120
12-hour	119	127	129	133	149
24-hour	147	156	158	162	179
48-hour	177	187	188	193	211

Table 3-6: Modelled historical and projected rainfall depths (mm) for Ōpunake for different event durations with a 100-year return period (0.01 ARI) Source: HIRDS v4. Location selected: -39.450, 173.850 (WGS84).

Rainfall event duration	Historical depth (mm)	Projected depth (mm)			
		Mid-century average (2031-2050)		Late-century average (2081-2100)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
1-hour	50.8	55.9	56.6	59.1	68.6
6-hour	105	114	115	120	136
12-hour	134	144	145	150	169
24-hour	166	177	178	183	203
48-hour	200	211	212	218	236

Table 3-7: Modelled historical and projected rainfall depths (mm) for Waverley for different event durations with a 50-year return period (0.02 ARI) Source: HIRDS v4. Location selected: -39.764, 174.629 (WGS84).

Rainfall event duration	Historical depth (mm)	Projected depth (mm)			
		Mid-century average (2031-2050)		Late-century average (2081-2100)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
1-hour	37.7	41.5	42.0	43.9	50.8
6-hour	73.1	79.2	80.1	83.1	94.4
12-hour	93.5	100	101	105	117
24-hour	119	126	127	131	144
48-hour	149	158	159	163	178

Table 3-8: Modelled historical and projected rainfall depths (mm) for Waverley for different event durations with a 100-year return period (0.01 ARI) Source: HIRDS v4. Location selected: -39.764, 174.629 (WGS84).

Rainfall event duration	Historical depth (mm)	Projected depth (mm)			
		Mid-century average (2031-2050)		Late-century average (2081-2100)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
1-hour	43.1	47.4	48.1	50.2	58.2
6-hour	82.9	90.0	91.0	94.4	108
12-hour	106	114	115	119	133
24-hour	134	142	144	148	164
48-hour	168	177	179	183	200

3.3 Drought

3.3.1 Potential evapotranspiration deficit

Projected potential evapotranspiration deficit accumulation changes (mm) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	+25-90	+25-90
2090	+25-90	+30-110

The measure of meteorological drought[1] that is used in this section is 'potential evapotranspiration deficit' (PED). Evapotranspiration is the process where water held in the soil is gradually released to the atmosphere through a combination of direct evaporation and transpiration from plants. As the growing season advances, the amount of water lost from the soil through evapotranspiration typically exceeds rainfall, giving rise to an increase in soil moisture deficit. As soil moisture decreases, pasture production becomes moisture-constrained and evapotranspiration can no longer meet atmospheric demand.

The difference between this demand (evapotranspiration) and the actual evapotranspiration is defined as the 'potential evapotranspiration deficit' (PED). In practice, PED represents the total amount of water required by irrigation, or that needs to be replenished by rainfall, to maintain plant growth at levels unconstrained by water shortage. As such, PED estimates provide a robust measure of drought intensity and duration. Days when water demand is not met, and pasture growth is reduced, are often referred to as days of potential evapotranspiration deficit.

PED is calculated as the difference between potential evapotranspiration (PET) and rainfall, for days of soil moisture under half of available water capacity (AWC), where an AWC of 150 mm for silty-loamy soils is consistent with estimates in previous studies (e.g. Mullan *et al*., 2005). PED, in units of mm, can be thought of as the amount of missing rainfall needed in order to keep pastures growing at optimum levels. Higher PED totals indicate drier soils. An increase in PED of 30 mm or more corresponds to an extra week of reduced grass growth. Accumulations of PED greater than 300 mm indicate very dry conditions.

For the modelled historic period, the highest PED accumulation is experienced in coastal areas about and south of Manaia (150-200 mm). For remaining areas of Taranaki, annual PED totals of 50-150 mm are common, although lower totals of 30-50 mm are observed near New Plymouth and Stratford. Low annual PED totals of 10-30 mm are observed about and immediately north of Mount Taranaki (Figure 3-44).

For all future scenarios, annual PED accumulation is projected to increase throughout the region (Figure 3-45). The greatest increase is projected by 2090 under RCP8.5, with an increase of 30-110 mm PED accumulation in Taranaki.

[1] Meteorological drought happens when dry weather patterns dominate an area and resulting rainfall is low. Hydrological drought occurs when low water supply becomes evident, especially in streams, reservoirs, and groundwater levels, usually after an extended period of meteorological drought.

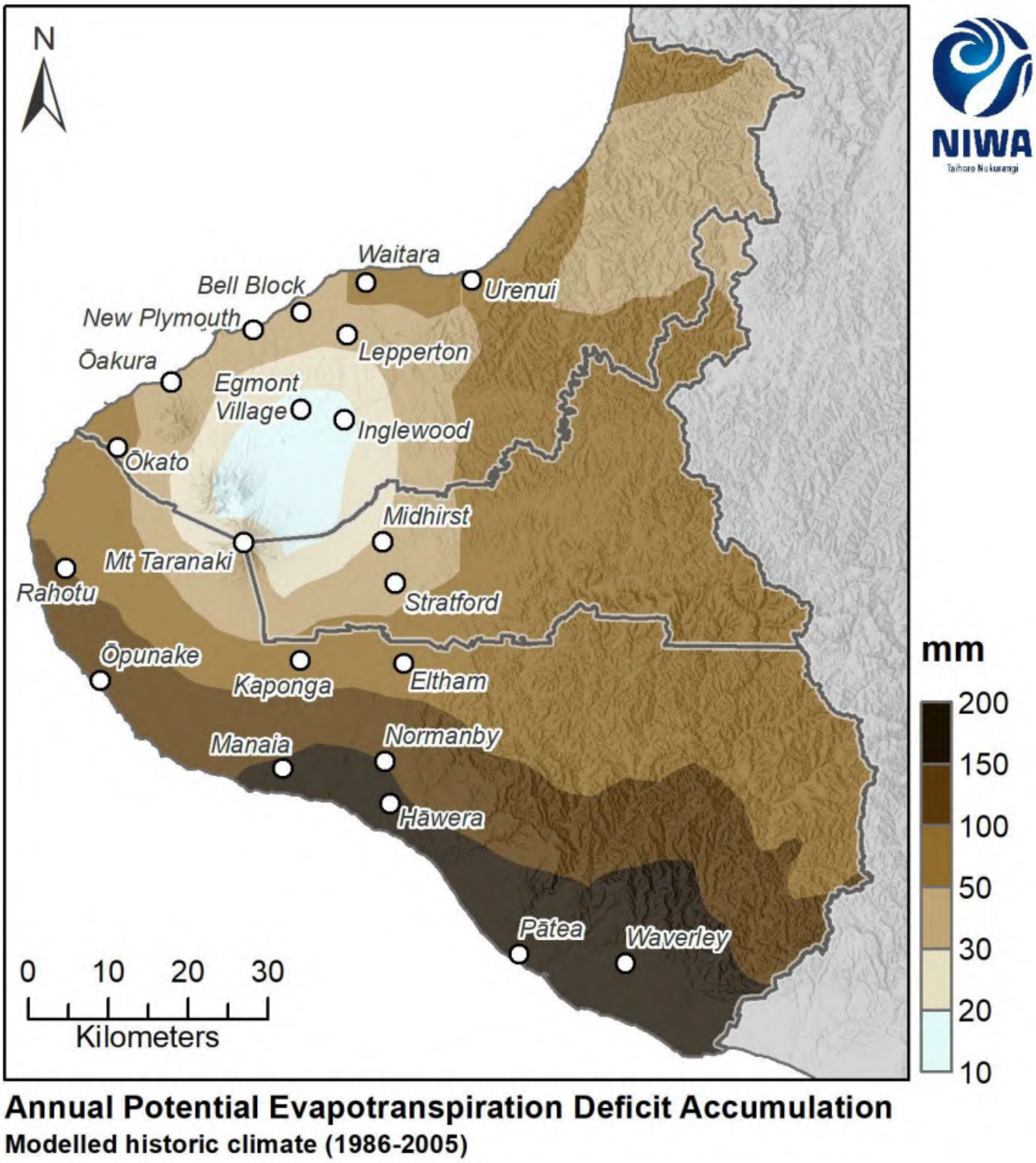


Figure 3-44: Modelled annual potential evapotranspiration deficit accumulation (mm), average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

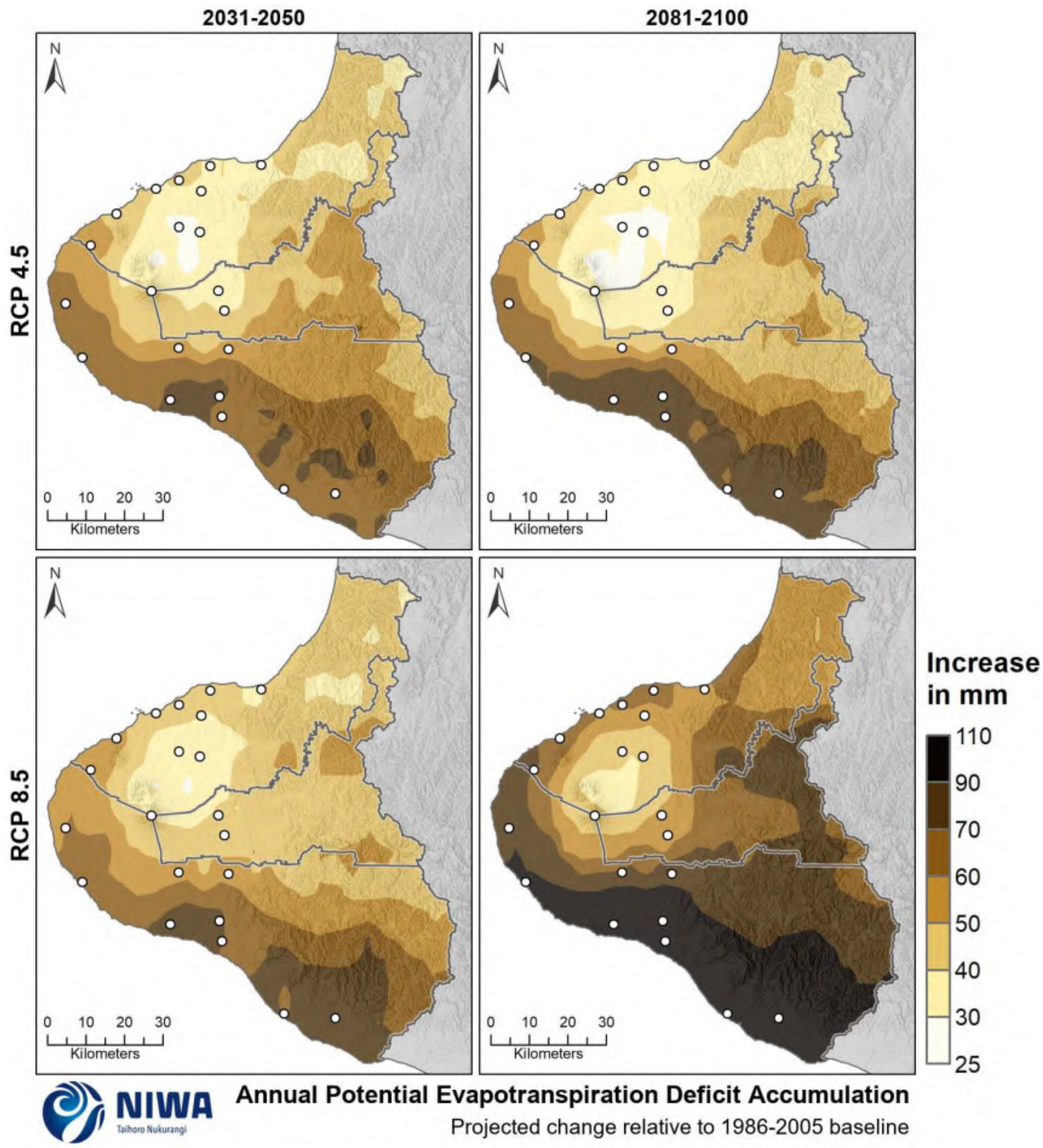


Figure 3-45: Projected annual potential evapotranspiration deficit accumulation (mm) changes by 2040 and 2090 under RCP4.5 and RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.4 Other climate variables

3.4.1 Mean wind speed

Projected mean wind speed changes (%) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	-2% to +1%	-1% to +2%
2090	± 1%	-3% to +2%

Seasonal:

	RCP4.5		RCP8.5	
	2040	2090	2040	2090
Summer	Up to -3%	-2% to +1%	-1% to +6%	-3% to -9%
Autumn	Up to -3%	Up to +2%	Up to -2%	-3% to -6%
Winter	± 2%	-1% to +6%	± 2%	+2% to +9%
Spring	Up to +2%	-2% to +1%	+1% to +6%	Up to +6%

This section contains maps showing future projected change in mean wind speed. Future (average over 2031-2050 and 2081-2100) maps show the percentage change in annual and seasonal mean wind speed compared with the historic average. The change signal in mean wind speed is due to changes in atmospheric circulation and local variables (e.g. temperature).

Representative concentration pathway (RCP) 4.5

By 2040, projected change to annual mean wind speed is small, with changes of -2% to +1% throughout the region (Figure 3-46). Seasonal changes are slightly more pronounced, with increases of up to 2% projected in spring, and decreases of up to 3% in summer and autumn (Figure 3-47).

By 2090, projected change to annual mean wind speed remains small (-1% to +2%; Figure 3-46). Seasonal changes are more notable, particularly in spring, with increases of 2-6% projected for eastern parts of the Stratford and South Taranaki Districts in winter (Figure 3-48).

Representative concentration pathway (RCP) 8.5

By 2040, the projected pattern of change to annual mean wind speed is very similar to that projected for RCP4.5, with changes of ±1% (Figure 3-46). Seasonal projected changes differ to RCP4.5, with a summer decrease of 1-6% projected, and a spring increase of 2-6% east of Mount Taranaki (Figure 3-49).

By 2090, a stronger pattern of change is evident. Annual projected changes in mean wind speed ranging from -3% to +2% (Figure 3-46). Seasonal changes project a winter and spring increase in mean wind speed of 1-6% for most of Taranaki, with projected decreases of 3-6% in autumn and 3-9% in summer (Figure 3-50).

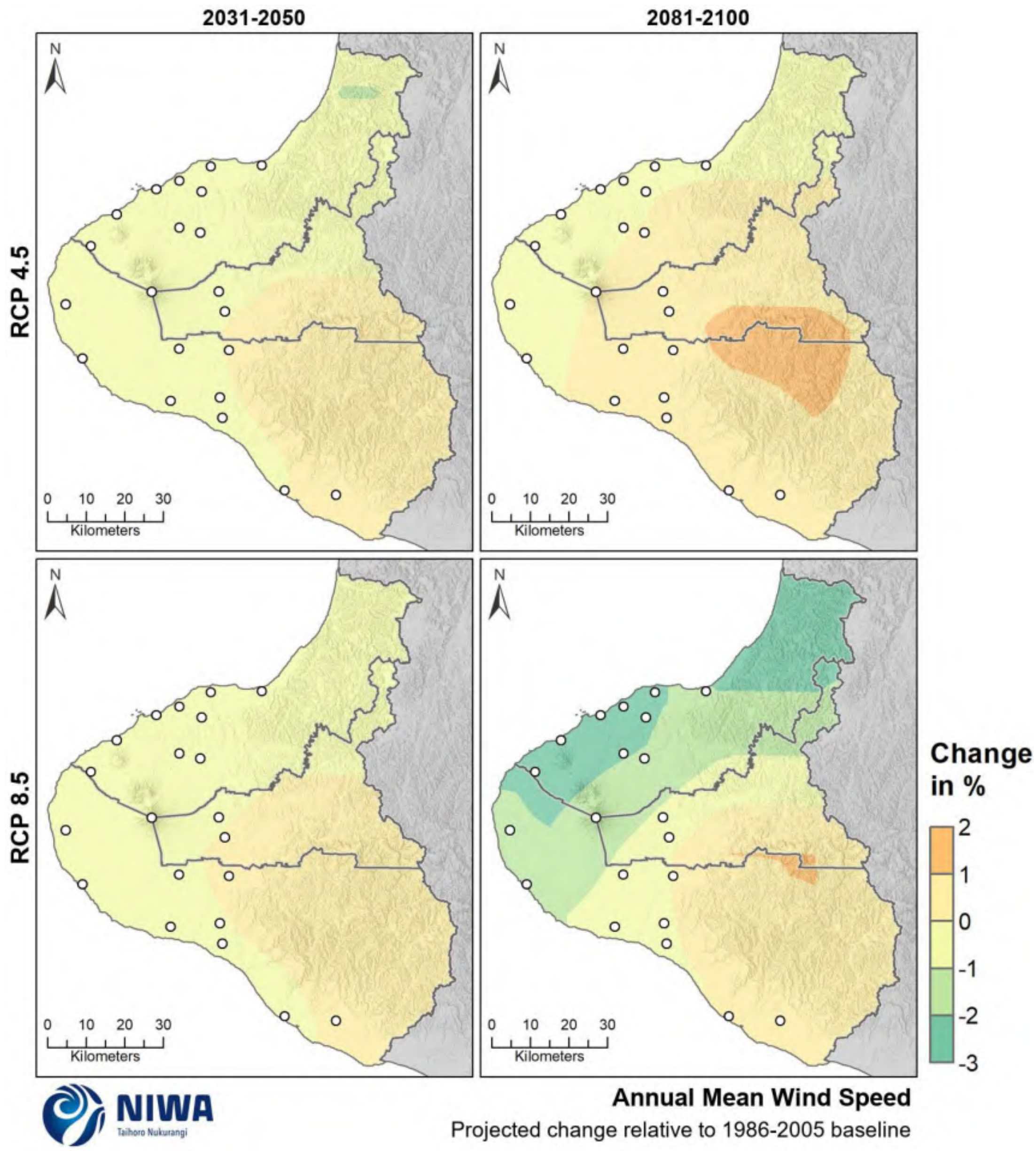


Figure 3-46: Projected annual mean wind speed changes by 2040 and 2090, under RCP4.5 and RCP8.5. Changes relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

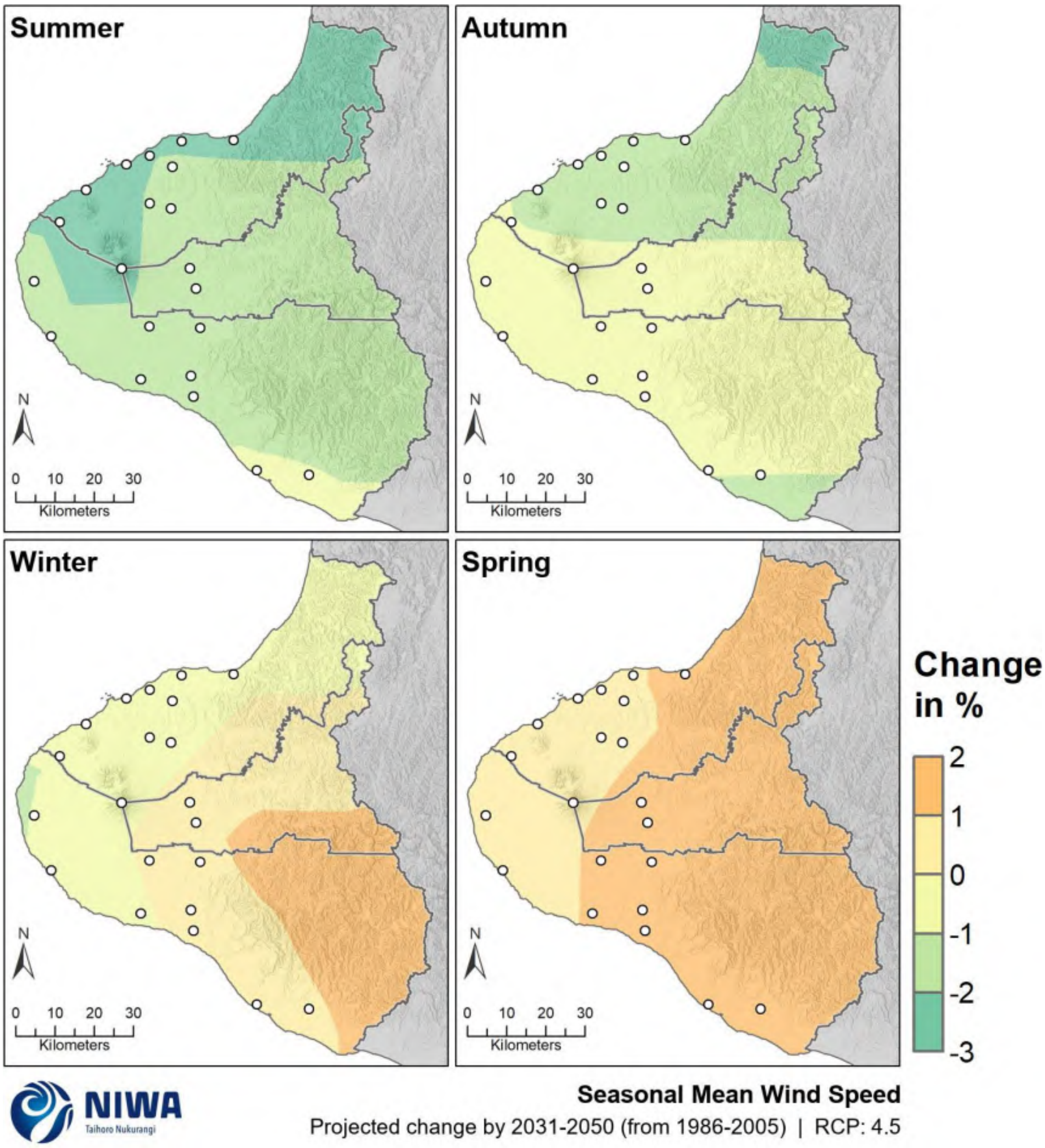


Figure 3-47: Projected seasonal mean wind speed changes by 2040 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

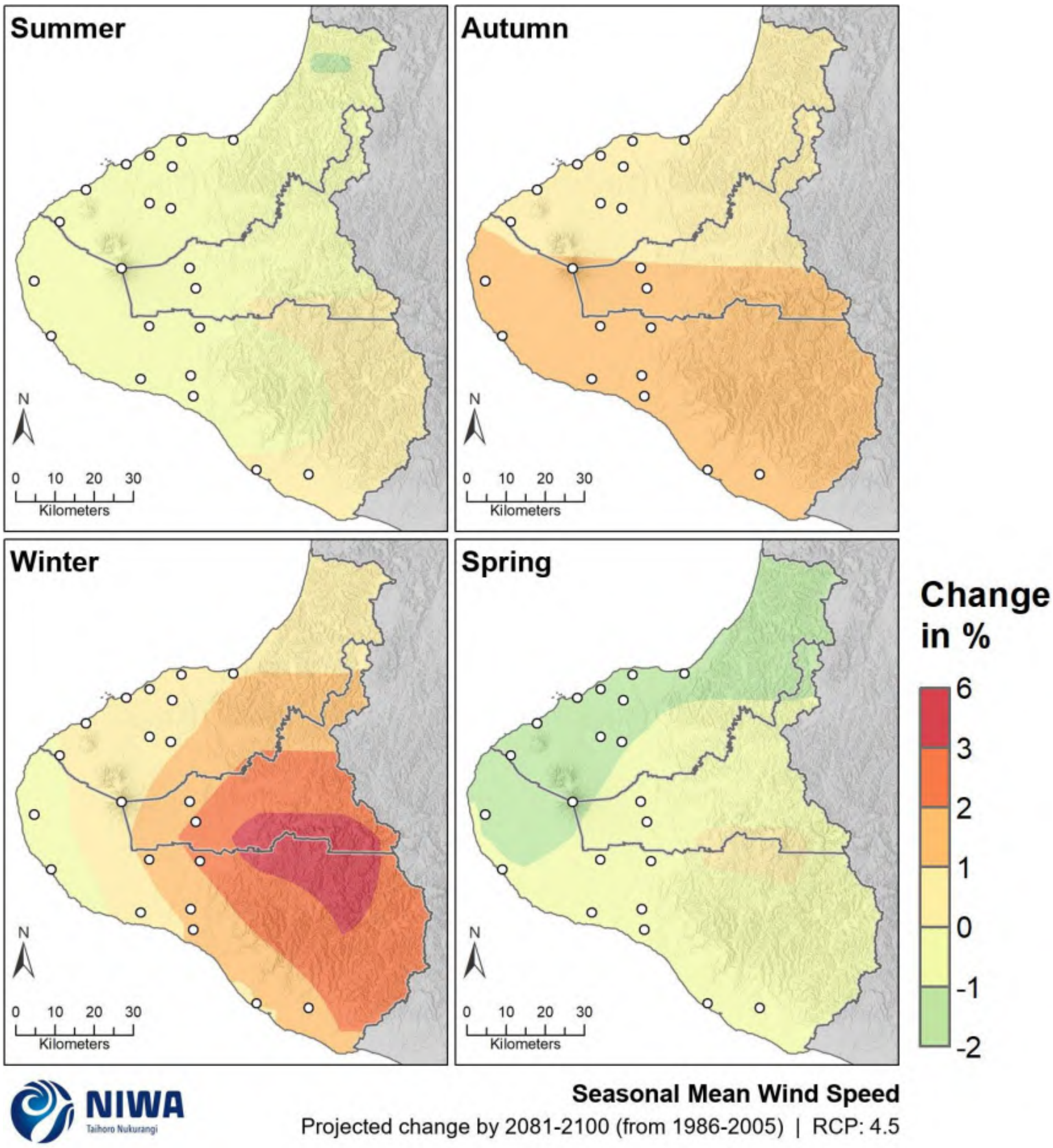


Figure 3-48: Projected seasonal mean wind speed changes by 2090 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

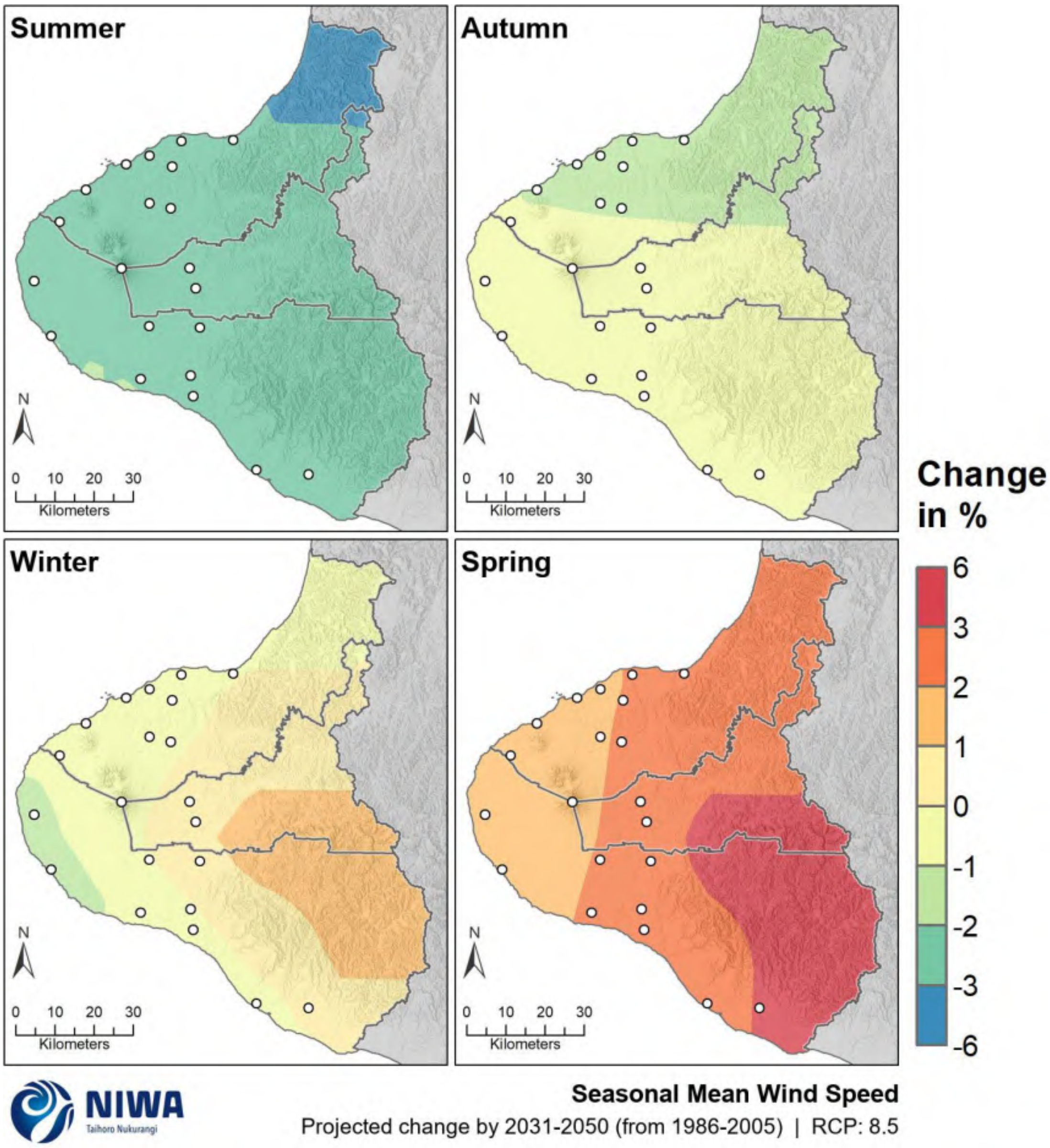


Figure 3-49: Projected seasonal mean wind speed changes by 2040 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

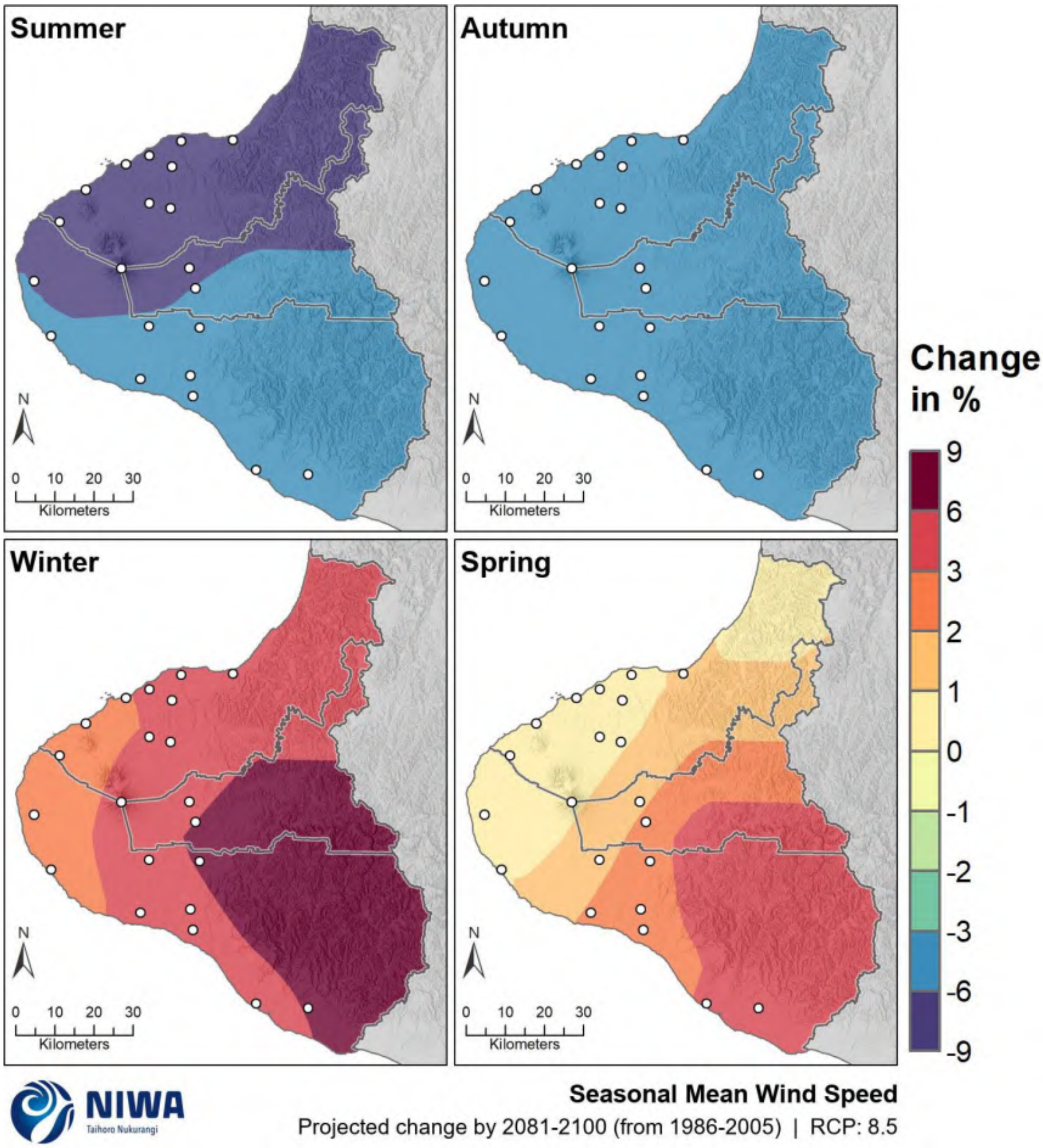


Figure 3-50: Projected seasonal mean wind speed changes by 2090 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.4.2 Strong wind (99th percentile of mean wind speed)

Projected 99th percentile daily mean wind speed changes (%) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	+2% to +1%	Up to -2%
2090	± 1%	+2% to +1%

Strong wind is considered here as the 99th percentile of daily mean wind speeds. This equates to the wind speed that is exceeded by the top 1% of daily mean winds recorded, i.e. the wind speed exceeded by about the top three windiest days each year.

For all future scenarios, projected changes to strong winds throughout Taranaki are relatively small, ranging from -2% to +1% (Figure 3-51).

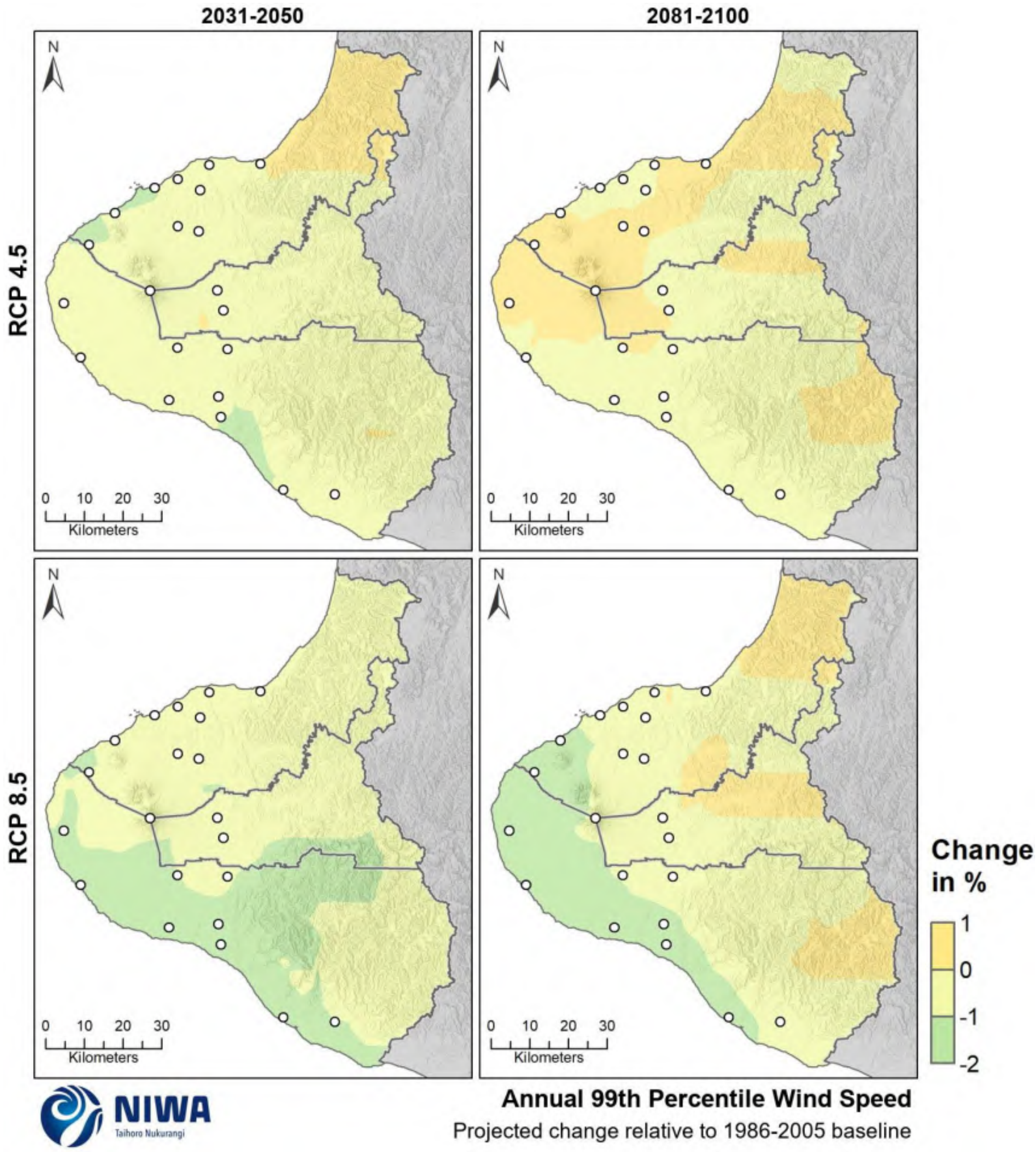


Figure 3-51: Projected annual 99th percentile daily mean wind speed changes (%) by 2040 and 2090 under RCP4.5 and RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.4.3 Surface solar radiation

Projected surface solar radiation changes (%) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	± 1%	-1% to +2%
2090	± 1%	± 2%

Seasonal:

	RCP4.5		RCP8.5	
	2040	2090	2040	2090
Summer	-1% to +4%	-4% to +1%	-2% to +4%	± 4%
Autumn	Up to +2%	+1-4%	± 1%	± 1%
Winter	Up to -2%	Up to -4%	Up to -4%	Up to -6%
Spring	Up to -4%	-1% to +4%	+1-6%	-2% to +7%

This section contains maps showing future projected change in surface solar radiation (solar radiation received at the land surface). The solar radiation reaching the surface is not accurately modelled as the changes presented here reflect modelled changes in clouds which have a low degree of confidence. However, these results are useful to provide an indication of direction of change in solar radiation for Taranaki. Since surface solar radiation is determined by cloud cover, it can also be thought of as a proxy for changes in sunshine. Future (average over 2031-2050 and 2081-2100) maps show the change (in %) in annual and seasonal surface solar radiation compared with the historic average.

Representative concentration pathway (RCP) 4.5

By 2040, projected change to annual surface solar radiation is ± 1% throughout Taranaki (Figure 3-52). Projected changes are slightly more amplified seasonally, with decreases of up to 4% projected in spring, and summer increases of 2-4% in a large area about New Plymouth (Figure 3-53).

By 2090, projected changes to annual surface solar radiation (Figure 3-52) are similar to 2040. Projected changes for summer and winter of up to -4% are common, with autumn and spring increases of 1-4% projected for most of the region (Figure 3-54).

Representative concentration pathway (RCP) 8.5

By 2040, projected change to annual surface solar radiation ranges from -1% to +2%, with increases projected for the majority of Taranaki (Figure 3-52). Seasonal changes project a spring increase of 1-6%, with highest increases of 4-6% about North Egmont Village and Inglewood (Figure 3-55). A winter decrease of up to 4% is projected, with greatest decreases of 2-4% in northern and eastern areas.

By 2090, a stronger pattern of change is evident seasonally, however annual changes in surface solar radiation of just ±2% are projected (Figure 3-52). Seasonal changes project a spring increase in surface solar radiation of up to 7% for most of Taranaki, with small decreases of up to 2% for the northernmost part of the region (Figure 3-56). Winter decreases of up to 6% are projected for Taranaki, with greatest decreases of 4-6% in the north of the region.

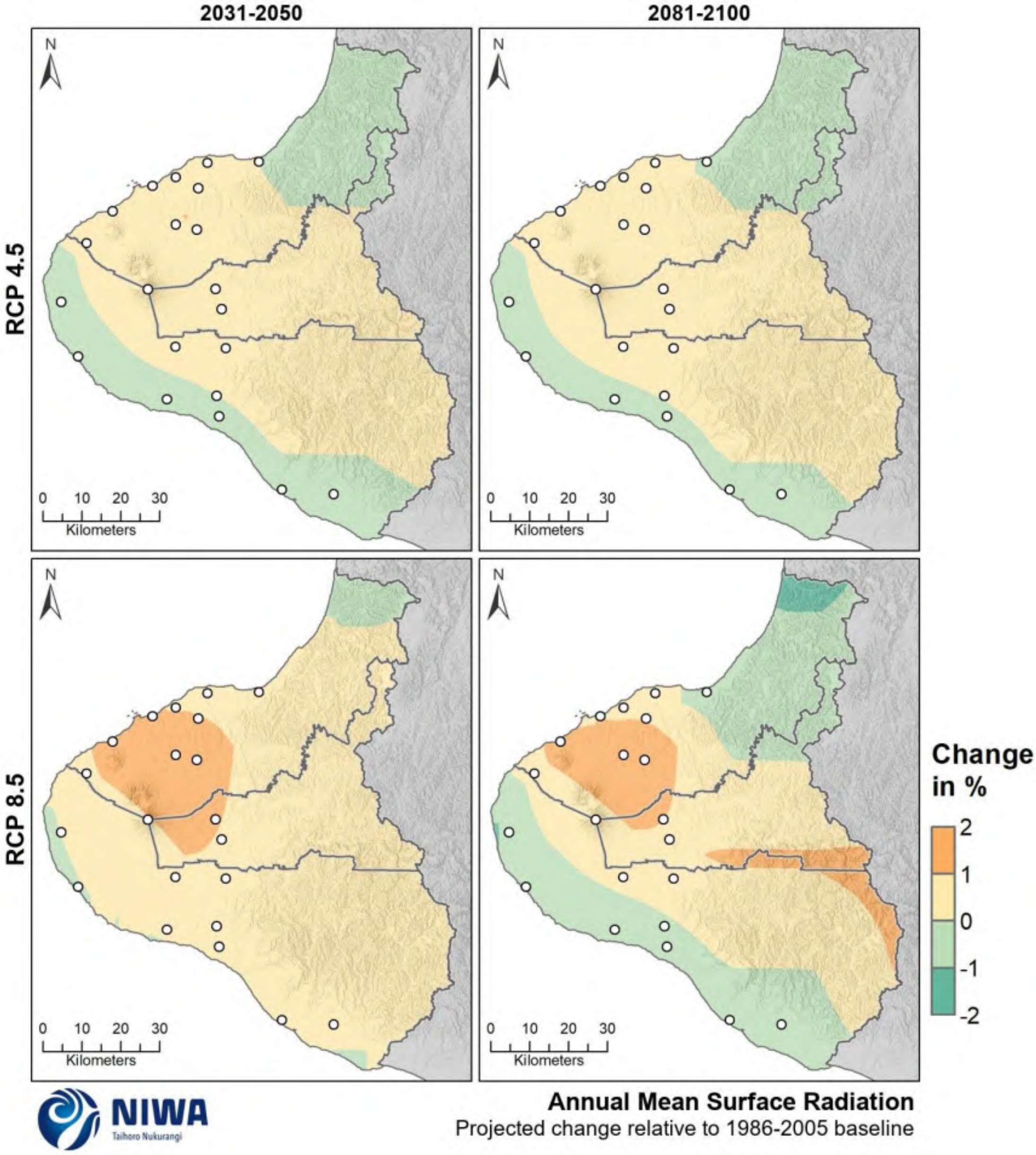


Figure 3-52: Projected annual mean surface solar radiation changes by 2040 and 2090, under RCP4.5 and RCP8.5. Changes relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

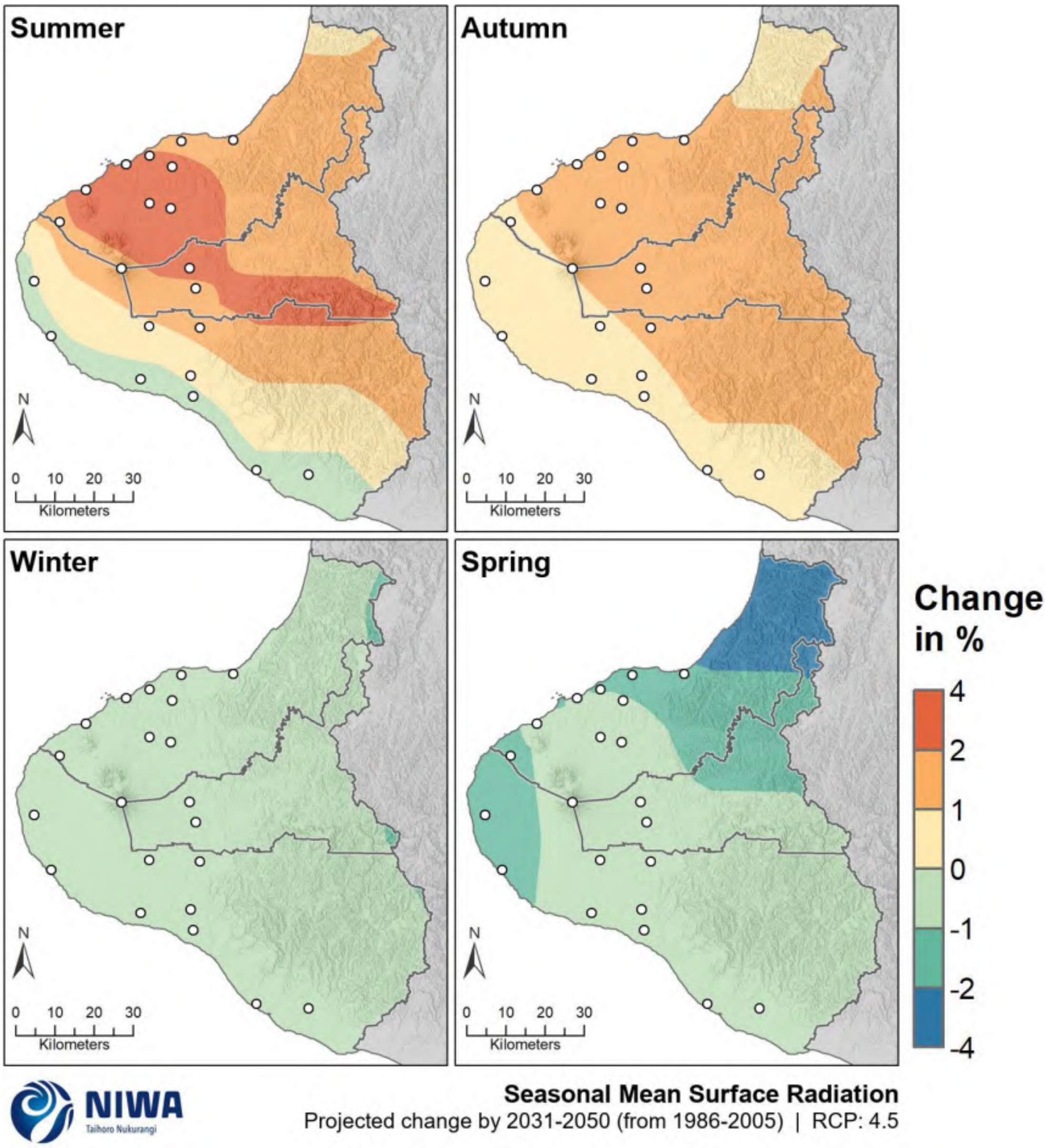


Figure 3-53: Projected seasonal mean surface solar radiation changes by 2040 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

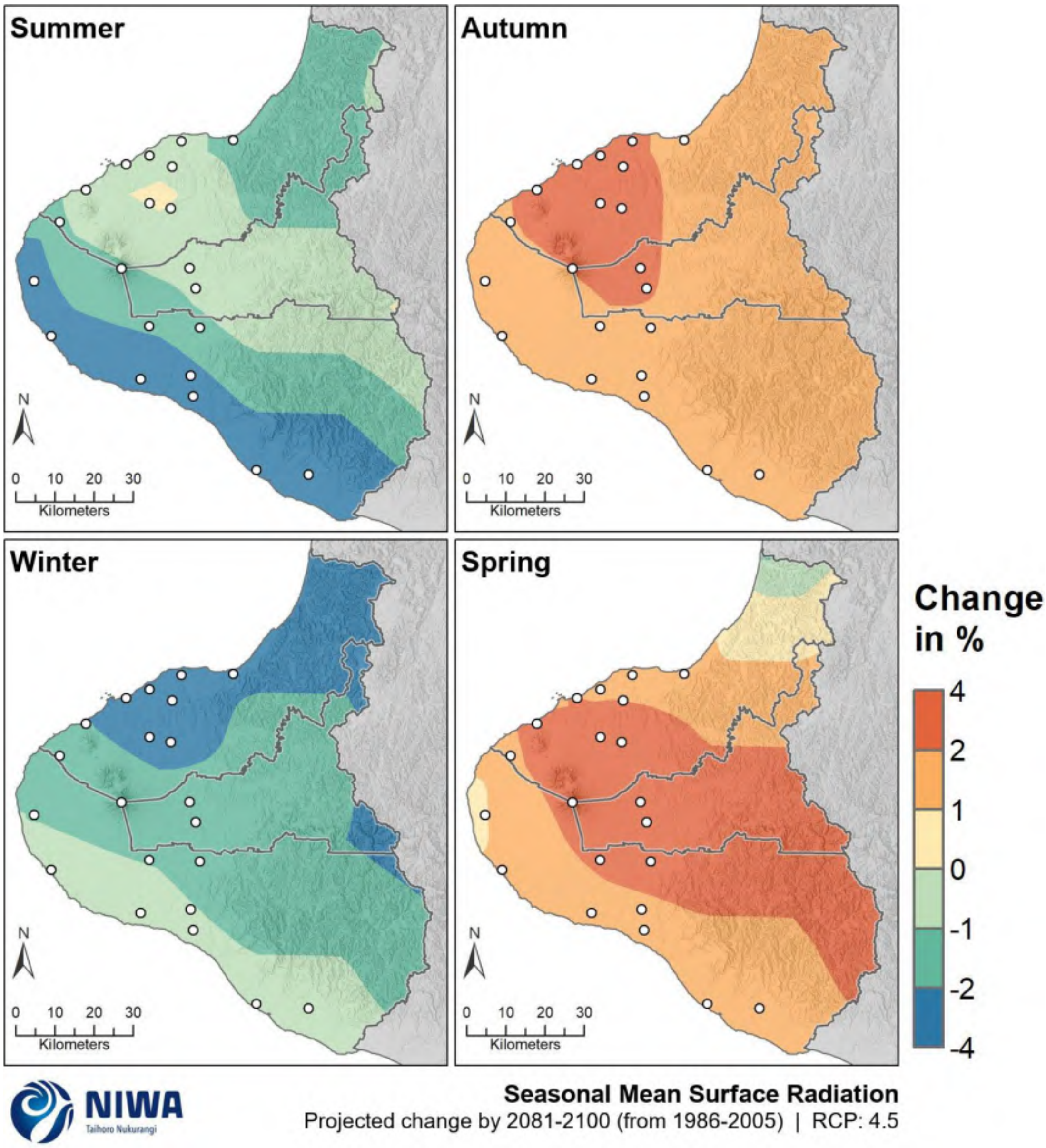


Figure 3-54: Projected seasonal mean surface solar radiation changes by 2090 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

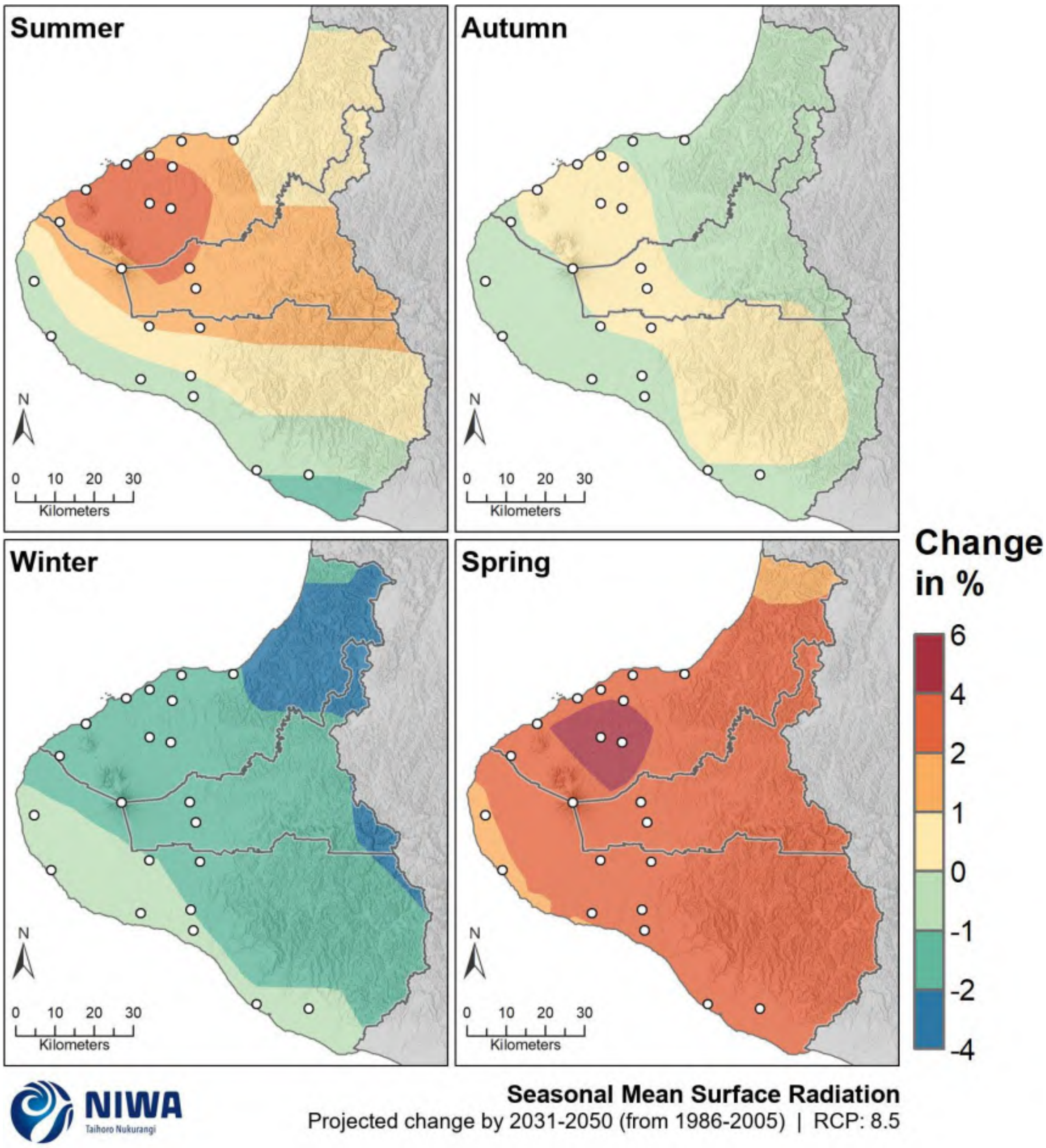


Figure 3-55: Projected seasonal mean surface solar radiation changes by 2040 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

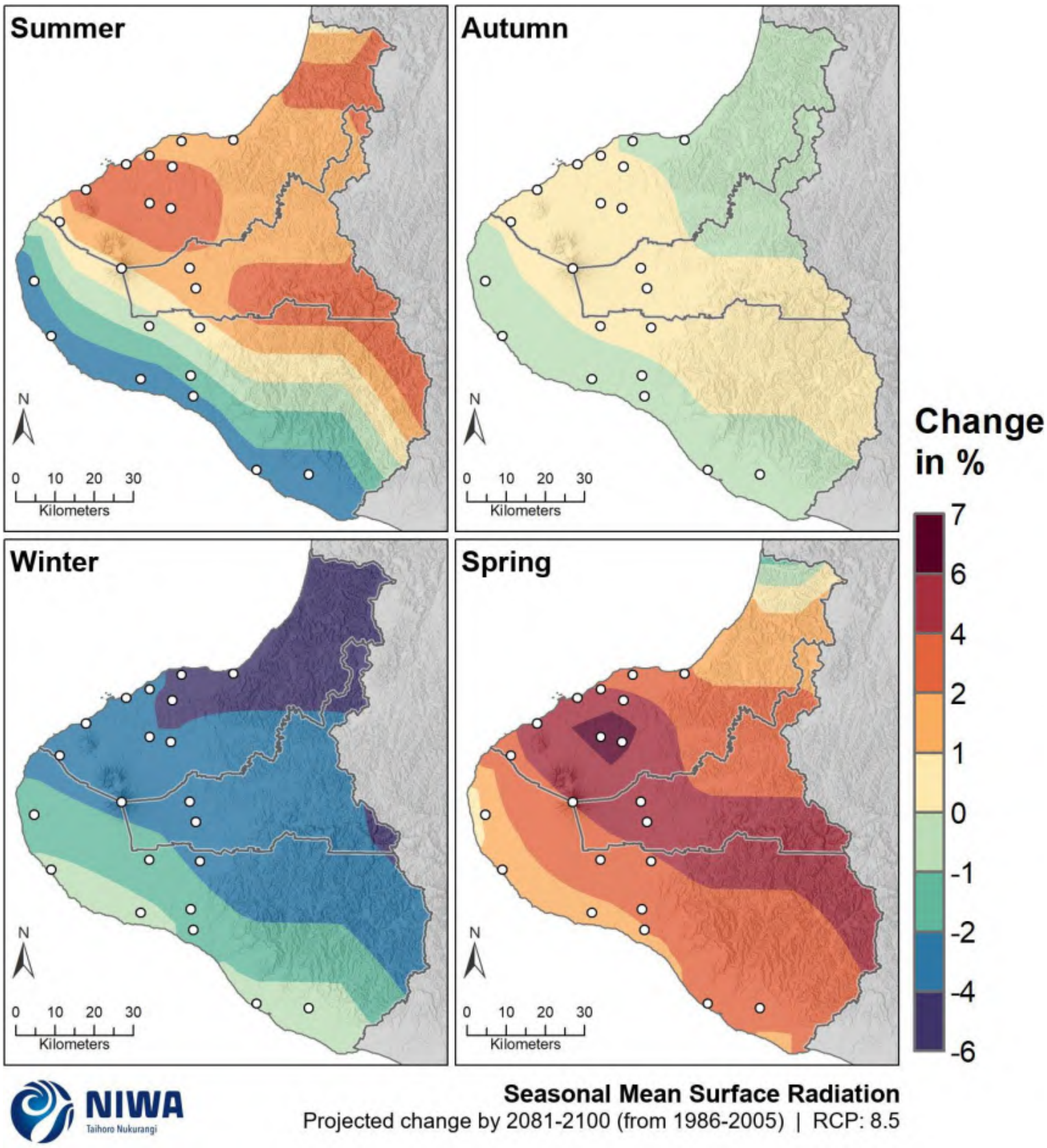


Figure 3-56: Projected seasonal mean surface solar radiation changes by 2090 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.4.4 Relative humidity

Projected relative humidity changes (%) for Taranaki region

Annual:

Period	RCP4.5	RCP8.5
2040	± 1%	Up to -1%
2090	± 1%	-3% to +1%

Seasonal:

	RCP4.5		RCP8.5	
	2040	2090	2040	2090
Summer	± 1%	± 1%	± 1%	-2% to +1%
Autumn	± 1%	± 1%	± 1%	-2% to +1%
Winter	Up to -1%	Up to -2%	Up to -1%	Up to -3%
Spring	± 1%	-2% to +1%	Up to -2%	Up to -3%

This section contains maps showing future projected change in relative humidity. Future (average over 2031-2050 and 2081-2100) maps show the percentage change in annual and seasonal mean relative humidity compared with the historic average. **A note about relative humidity compared to specific humidity:** Projected decreases in relative humidity are a consequence of the higher temperatures. The absolute water content of the air, as measured by specific humidity, increases with time, but the temperature effect is larger; the rate of decrease in relative humidity over New Zealand is mostly 1–2% per degree increase in mean temperature. This is in line with evidence in the recent observations (Simmons *et al.*, 2010) in reanalysis and station data over low and mid latitudes.

Representative concentration pathway (RCP) 4.5

By 2040, projected change to annual mean relative humidity is small, at just ±1% for the region (Figure 3-57). Similar changes are projected seasonally, although in winter only decreases of up to 1% are projected (Figure 3-58).

By 2090, projected change to annual mean relative humidity remains small, at just ±1% (Figure 3-57). Projected seasonal decreases of up to 2% occur in winter, with changes ranging from -2% to +1% in spring (Figure 3-59). In all seasons, small decreases of up to 1% are projected for the majority of Taranaki.

Representative concentration pathway (RCP) 8.5

By 2040, annual mean relative humidity is projected to decrease by up to 1% in Taranaki (Figure 3-57). This represents little change from the historic climate. Seasonal projected changes are similar to RCP4.5, with the exception of spring where a decrease of 1-2% is projected for most of inland Taranaki, and coastal parts of New Plymouth District (Figure 3-60).

By 2090, annual projected changes in mean relative humidity range from -3% to +1% (Figure 3-57). Winter and spring decreases of 1-3% are projected for most of parts of Taranaki (Figure 3-61). Small increases of up to 1% are projected for coastal South Taranaki District in summer and autumn.

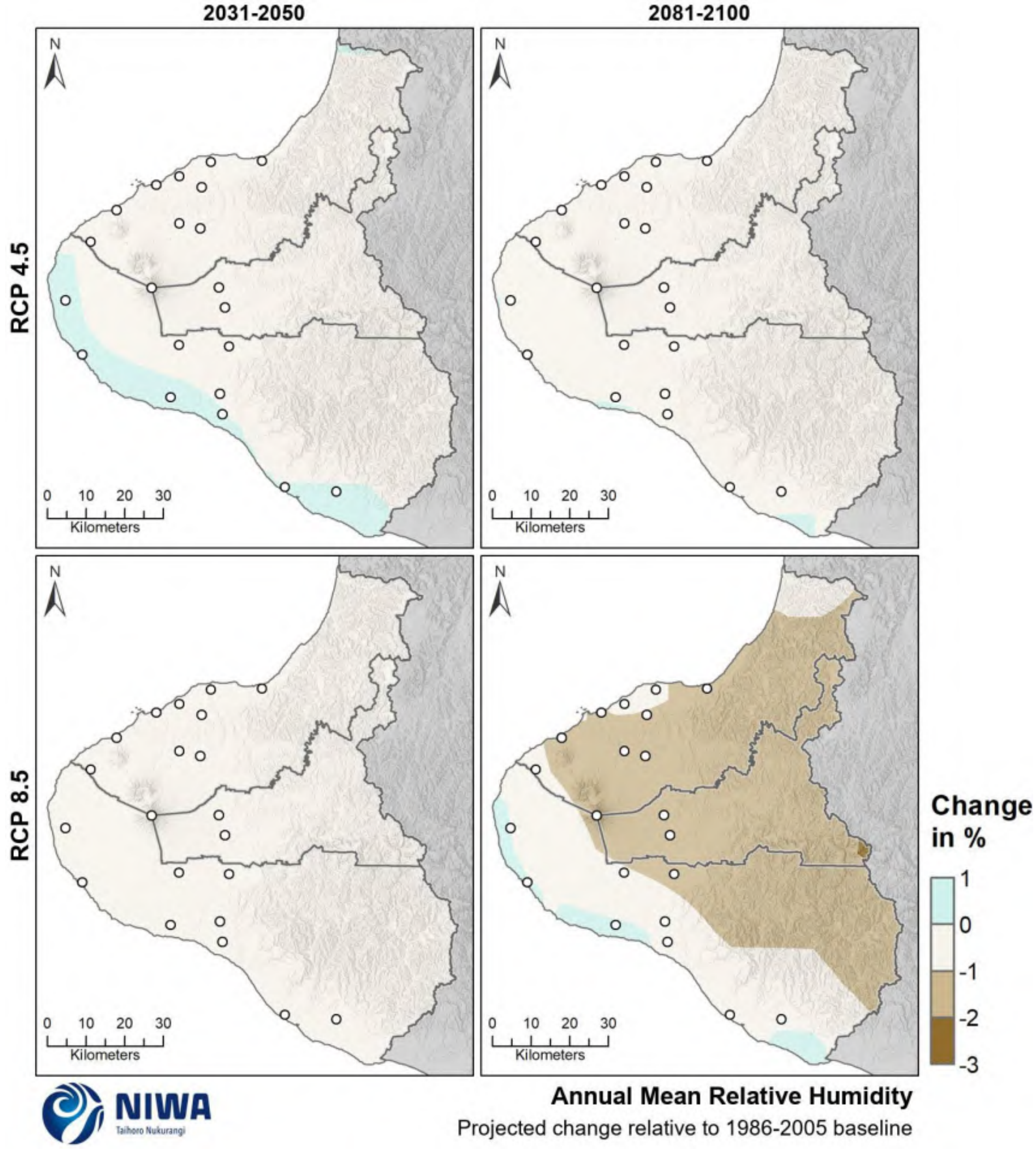


Figure 3-57: Projected annual mean relative humidity changes by 2040 and 2090, under RCP4.5 and RCP8.5. Changes relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

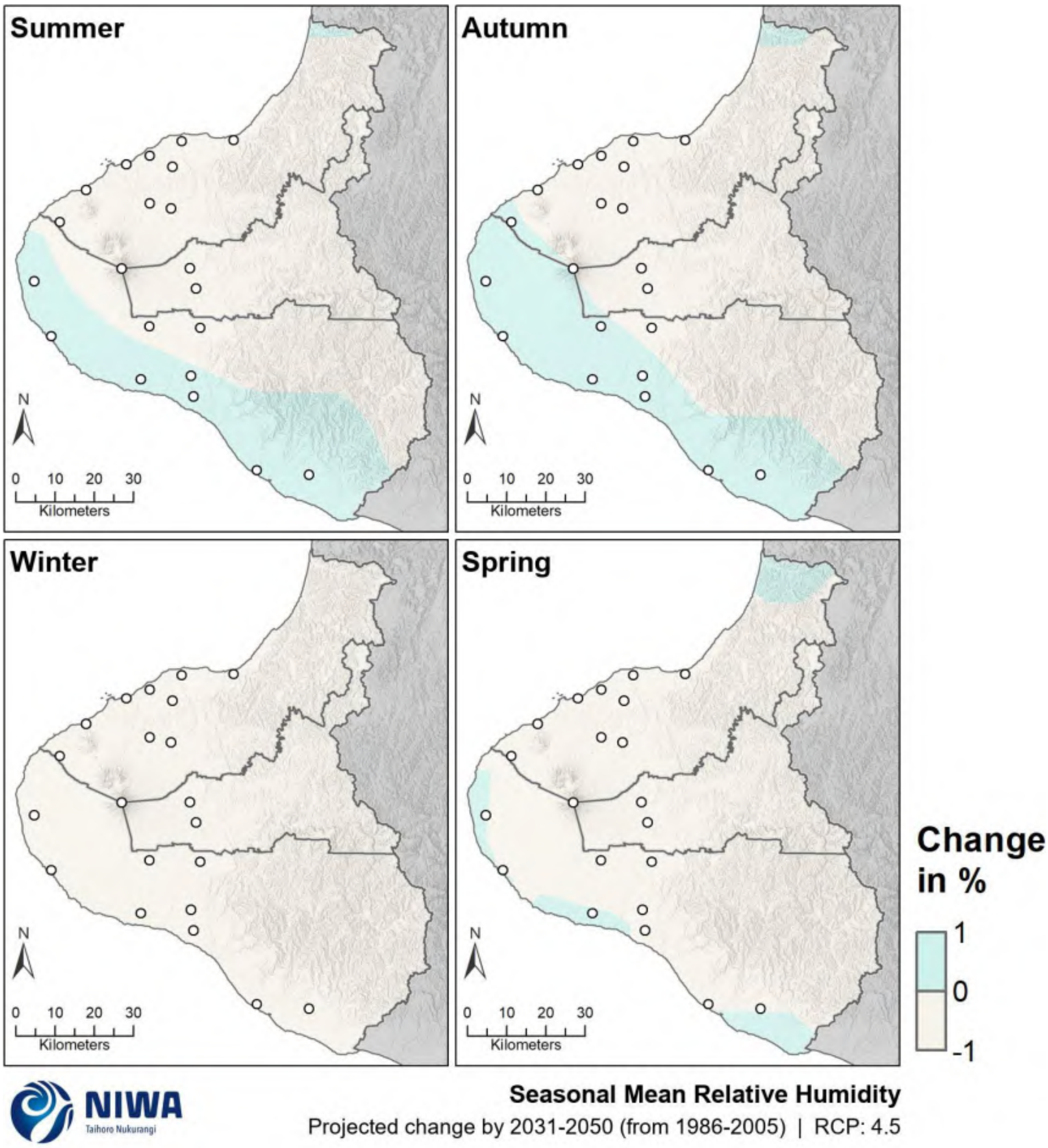


Figure 3-58: Projected seasonal mean relative humidity changes by 2040 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

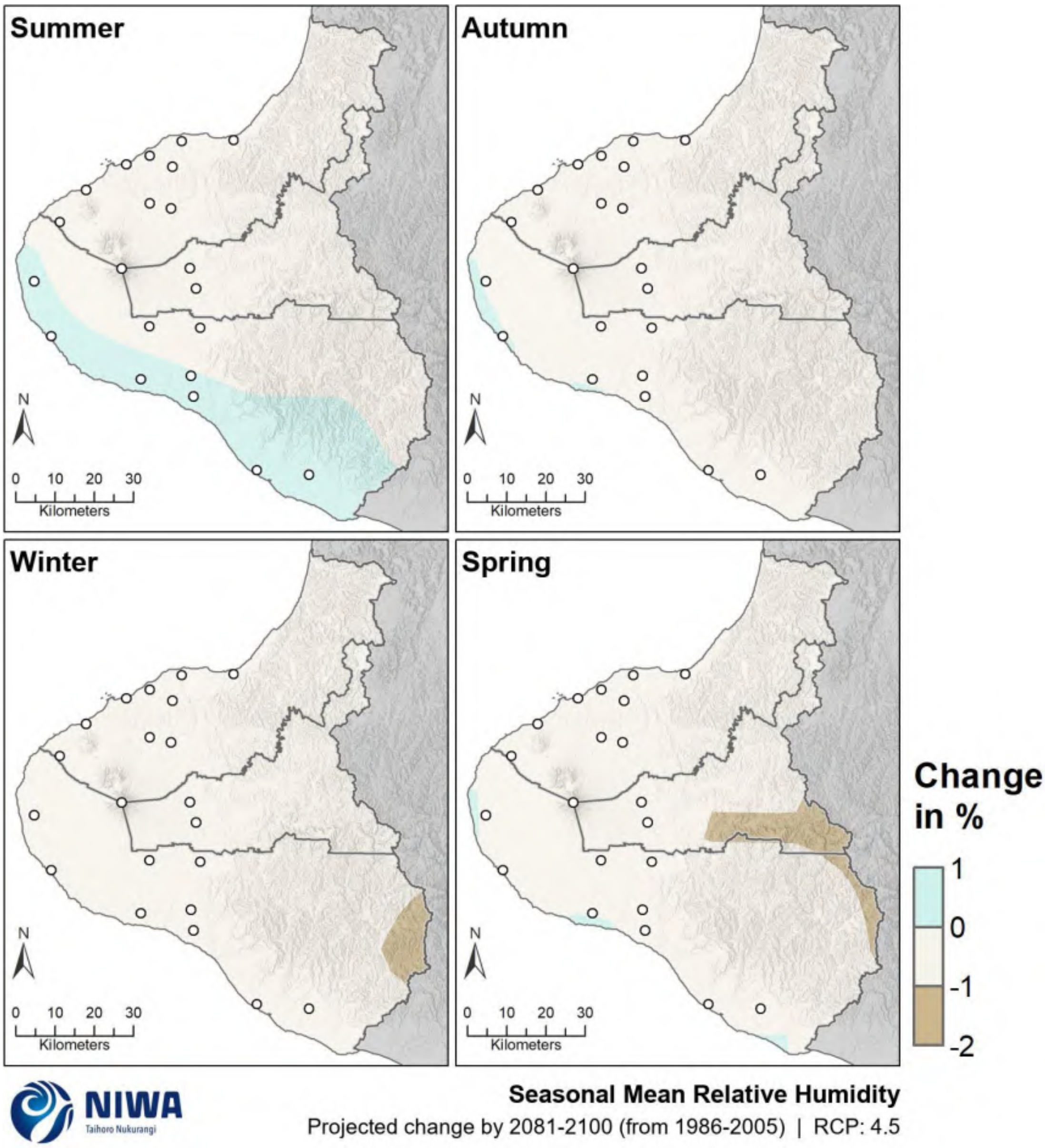


Figure 3-59: Projected seasonal mean relative humidity changes by 2090 for RCP4.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

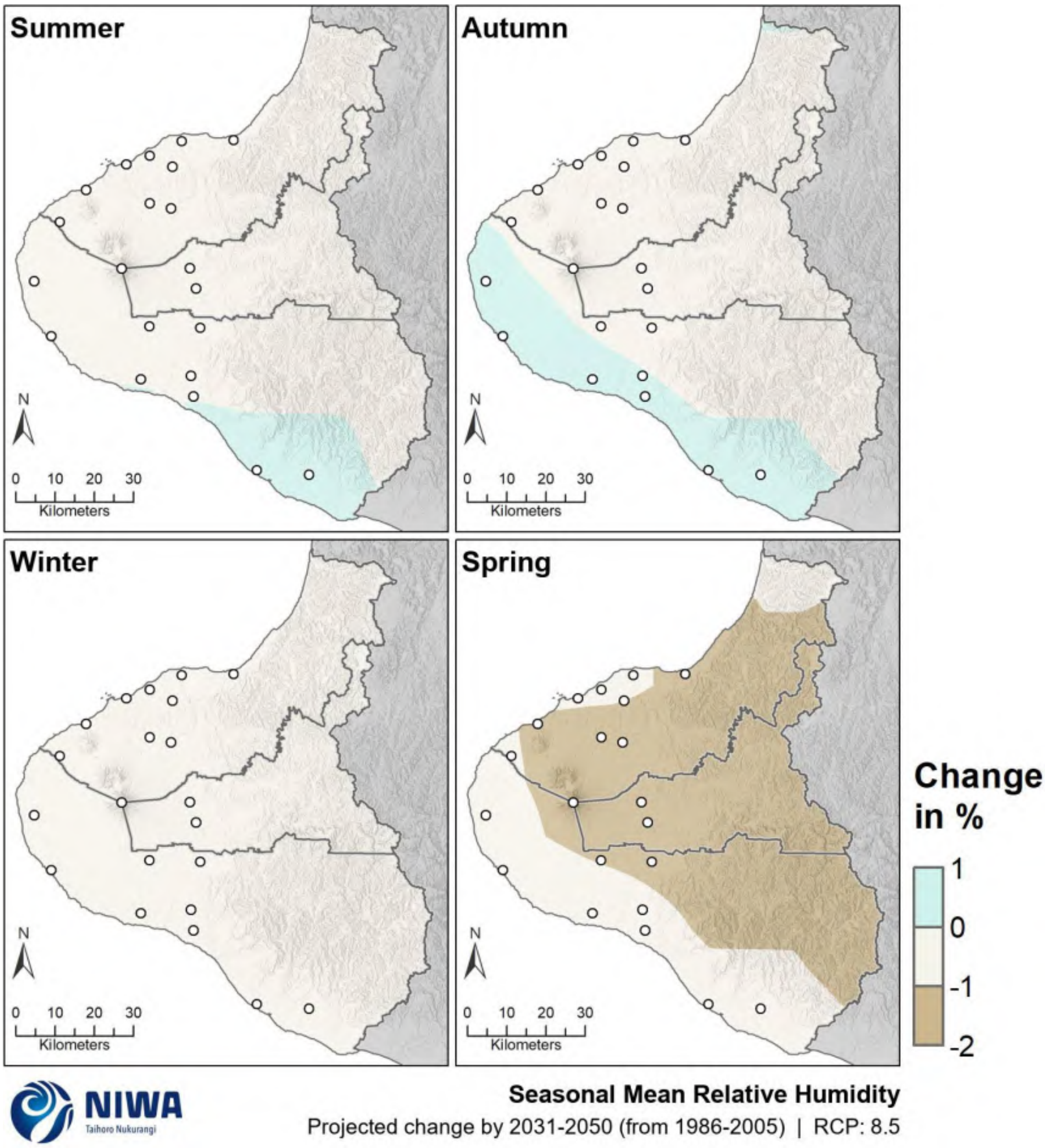


Figure 3-60: Projected seasonal mean relative humidity changes by 2040 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

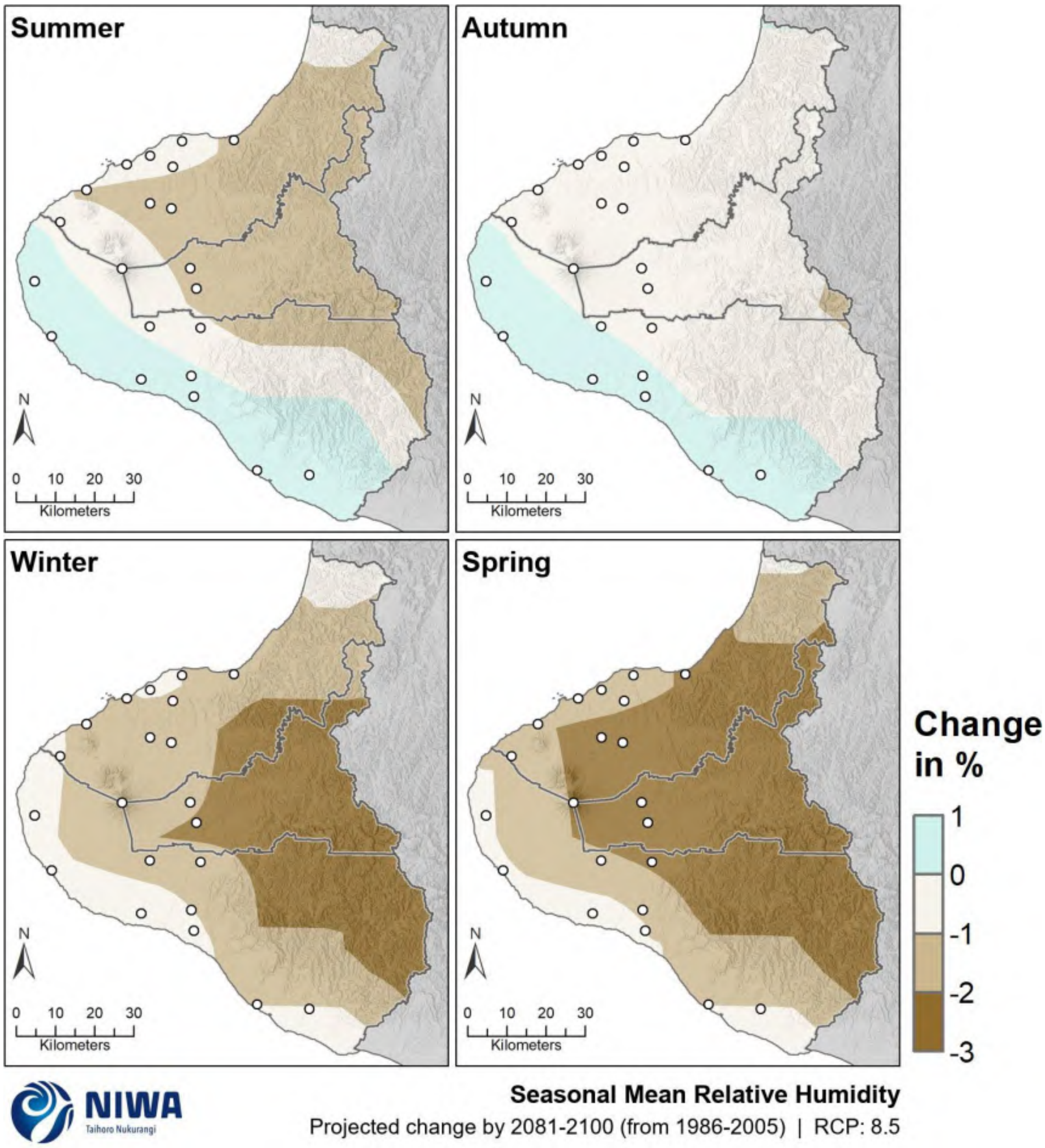


Figure 3-61: Projected seasonal mean relative humidity changes by 2090 for RCP8.5. Relative to 1986-2005 average, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

3.4.5 Air pressure

Key messages

- Mean sea level pressure (MSLP) is projected to increase in summer, causing more north easterly airflow and more anticyclonic patterns (high pressure systems).
- MSLP tends to decrease in model simulations during winter, especially over and south of the South Island, resulting in stronger westerly winds over central New Zealand.

Mean sea level pressure (MSLP) varies over New Zealand from day to day as different weather systems pass over the country. Figure 3-62 shows average seasonal MSLP over the Southwest Pacific, including New Zealand. Overall, MSLP is relatively low to the south of New Zealand, and relatively high at similar latitudes to the North Island. This pressure pattern creates a general westerly wind flow that dominates over most of New Zealand (including Taranaki) throughout the year. However, topographic features such as Mt Taranaki play an important role in modifying the actual wind directions observed throughout the Taranaki region. For example, the prevailing wind direction in New Plymouth is southeast. This is due to the deflection by Mt Taranaki of winds from a southerly quarter to a south-easterly direction, and south-easterly drainage of cold air (katabatic wind) from the slopes of Mt Taranaki (Chappell, 2014).

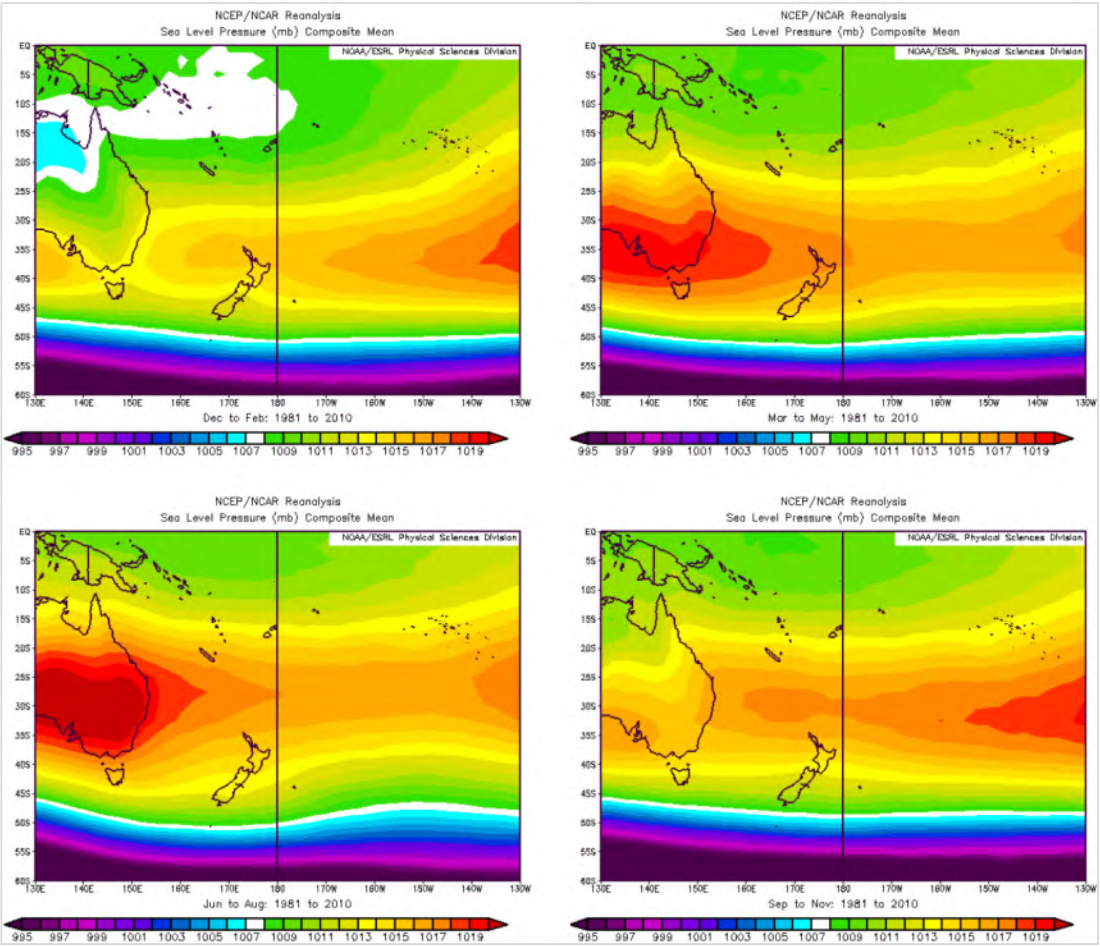


Figure 3-62: Average seasonal mean sea level pressure over the Southwest Pacific, 1981-2010. Top left: summer, top right: autumn, bottom left: winter, bottom right: spring. Sourced from: https://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl.

Future mean sea-level pressure projections have been derived from the Regional Climate Model (RCM) simulations. The key projected changes in mean sea-level pressure (MSLP) and mean winds are as follows (for more detail see Mullan et al., 2016; MFE, 2018):

- MSLP tends to increase in summer (December–February), especially to the south-east of New Zealand. In other words, the airflow becomes more north-easterly, and at the same time more anticyclonic (high pressure systems).
- MSLP tends to decrease in winter (June–August), especially over and south of the South Island, resulting in stronger westerlies over central New Zealand.
- In the other seasons (autumn and spring), the pattern of MSLP change is less consistent with increasing time and increasing emissions. There is, however, still general agreement for autumn changes to be like those of summer (i.e., more anticyclonic), and for spring changes to be like those of winter (lower pressures south of the South Island, and stronger mean westerly winds over southern parts of the country).

4 Sea-level rise and coastal impacts

4.1 Impacts of sea-level rise

One of the major and most certain (and so foreseeable) consequences of increasing concentrations of greenhouse gases and associated warming, is the rising sea level (Parliamentary Commissioner for the Environment, 2015). IPCC (2013) found that warming of the climate system is unequivocal, and many of the changes observed since the 1950s are unprecedented over timescales of decades to millennia. The atmosphere and ocean have warmed, and the amounts of snow and ice globally have diminished, causing sea level to rise.

Rising sea level in past decades is already affecting human activities and infrastructure in coastal areas of New Zealand, with a higher base mean sea level contributing to increased vulnerability to storms and tsunami. Key impacts of an ongoing rise in sea level are:

- gradual inundation of low-lying marsh and adjoining dry land on spring high tides;
- escalation in the frequency of nuisance and damaging coastal flooding events (which has been evident in several low-lying coastal margins of New Zealand);
- exacerbated erosion of sand/gravel shorelines and unconsolidated cliffs (unless sediment supply increases);
- increased incursion of saltwater in lowland rivers and nearby groundwater aquifers, raising water tables in tidally-influenced groundwater systems.

These impacts will have increasing implications for existing development in coastal areas, along with environmental, societal and cultural effects. Infrastructure and its levels of service or performance will also be increasingly affected, such as wastewater treatment plants, potable water supplies, and particularly capacity and performance issues with stormwater and overland drainage systems (particularly gravity-driven networks). Transport infrastructure (roads, ports, airports) in the coastal margin will also be affected, both by increased nuisance shallow flooding of saltwater (e.g., vehicle corrosion) and more disruptive flooding and damage from elevated storm-tides and wave overtopping.

There are three types of sea-level rise (SLR) in relation to observations and projections:

- absolute (or eustatic) rise in ocean levels, measured relative to the centre of the Earth, and usually expressed as a global mean (which is used in most sea-level projections e.g., IPCC);
- offsets (or departures) from the global mean absolute SLR for a regional sea, e.g., the sea around New Zealand, which will experience slightly higher rises (5–10%) than the global average rate. There can be significant variation in the response to warming and wind patterns between different regional seas around the Earth;
- relative sea-level rise (RSLR), which is the net rise in sea level experienced on coastal margins from absolute, regional-sea offsets and local vertical land movement (measured relative to the local landmass). Local or regional adaptation to SLR needs to focus on RSLR, particularly if the coastal margin is subsiding.

The first two types of SLR are measured directly by satellites, using radar altimeters, or by coalescing many tide-gauge records globally (after adjusting for local vertical land movement and ongoing re-adjustments in the Earth's crust following ice loading during the last Ice Age[2]).

RSLR is measured directly by tide gauges. One advantage of knowing the RSLR from gauge measurements is that this directly tracks the SLR that needs to be adapted to locally, or over the wider region represented by the gauge. If, for instance, the local landmass is subsiding, then the RSLR will be larger than the absolute rise in the adjacent ocean level acting alone.

4.2 Historic trend in sea-level rise

Hannah and Bell (2012) analysed SLR trends at 10 gauge sites around New Zealand, to extend the picture of local trends at a wider range of locations than just the four main port sites (Auckland, Wellington, Lyttelton, Dunedin), where records exist from 1900 onwards. While the additional 6 sites (Whangarei, Moturiki, New Plymouth, Nelson, Timaru, and Bluff) comprised shorter records, longer term SLR could be inferred by connecting the modern digital records with historic tide measurements (from LINZ archives) used to establish the local vertical datums around New Zealand.

Records from all four main New Zealand port tide gauges (> 110-year records) indicates a doubling in the rate of sea-level rise around the New Zealand coastline over the last five to six decades, from an average of approximately 1 mm/year earlier last century to nearly 2 mm/year from 1961 to 2015 (Ministry for the Environment, 2017). A summary of historic rates of relative SLR across 10 sites in New Zealand is provided in Figure 4-1, with the New Zealand wide average of nearly 1.8 mm/year up to 2015.

Global coverage (between 66°N and 66°S) of satellite altimeters, which measure the ocean surface, commenced in 1993. The global-average rate for absolute SLR from satellite altimetry in the period 1993 to 1 June 2018 is running at ~ 3.2 mm/year, which is about twice the long-term global rate since 1900. In the ocean waters around New Zealand, the trend since 1993 to present has been higher than the global average, with absolute SLR in the Taranaki region trending at around 4 mm/year (Figure 4-2). The NZ-wide average was 4.4 mm/year up to the end of 2015 (see Figure D3, Appendices; Ministry for the Environment, 2017). Some of this increase in the rate of rise is due to the Interdecadal Pacific Oscillation (IPO), a 20–30-year climate cycle, which is in its negative phase at present, leading to increased sea-surface temperature and therefore sea-surface height in the Western Pacific (see darker colours in Figure 4-2), but also is influenced by a warming atmosphere.

[2] Scientific term is glacial isostatic adjustment (GIA)

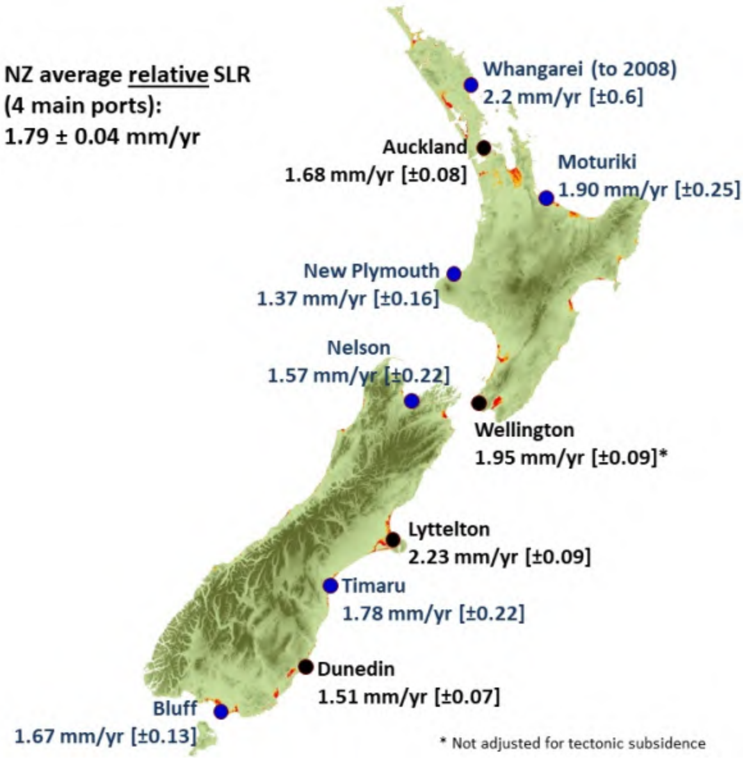


Figure 4-1: Relative SLR rates up to and including 2019 (excluding Whangarei), determined from longer sea-level gauge records at the four main ports (Auckland, Wellington, Lyttelton, Dunedin) and shorter records from the remaining sites. Determined from > 100-year gauge records at the four main ports (black circles) and inferred rates from gauge station records, used in the first half of the 1900s to set the local vertical datums, spliced with modern records (blue circles). Standard deviations of the trend are listed in the brackets. Source: Figure 19; Ministry for the Environment (2017).

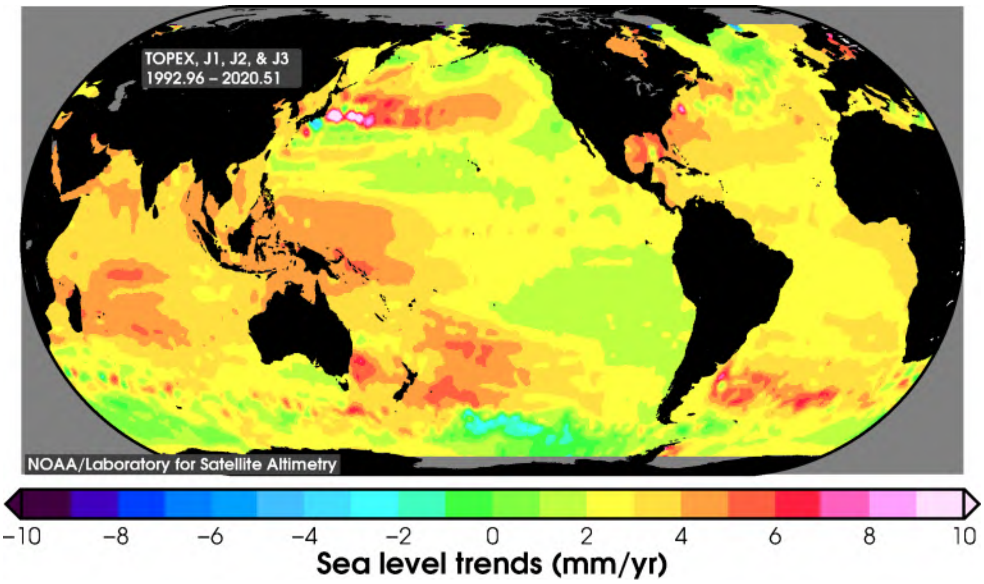


Figure 4-2: Map of regional trend in SLR from 1993 to 1 September 2020 based on satellite altimetry missions. Source: NOAA/NESDIS Center for Satellite Applications and Research.

Relative SLR along the Taranaki coast also incorporates a component due to vertical land movement (VLM). The Taranaki region is located to the northeast of an extremely active tectonic zone along a continental plate boundary (about the lower North Island and upper South Island), and is subject to occasional land movements. It should be noted that benchmarks used for the work pertaining to sea-level within this chapter have all been surveyed post Kaikoura earthquake. Continuous GPS stations have been operated GeoNet and LINZ since the early 2000s, although station distribution near Taranaki is sparse (Beaven and Litchfield, 2012). Up to 2011, the average vertical land movement for stations near Taranaki was either close to 0, or small subsidence[3] (Figure 4-3; Beaven and Litchfield, 2012). Estimated vertical rates for locations nearest Taranaki include sites WANG (0.0 mm/yr) and MAHO (-1.3 mm/yr). Further updated analysis on vertical land movement around New Zealand, and the implications for long-term sea-level rise, is a component of an Endeavour Fund research project NZSeaRise, coordinated by Victoria University of Wellington. Recent research by Denys *et al.* (2020) included the effects of vertical land movement on observed sea level in New Zealand, and calculated an absolute sea level of +1.45 mm/year ± 0.28 mm/year (1891-2013).

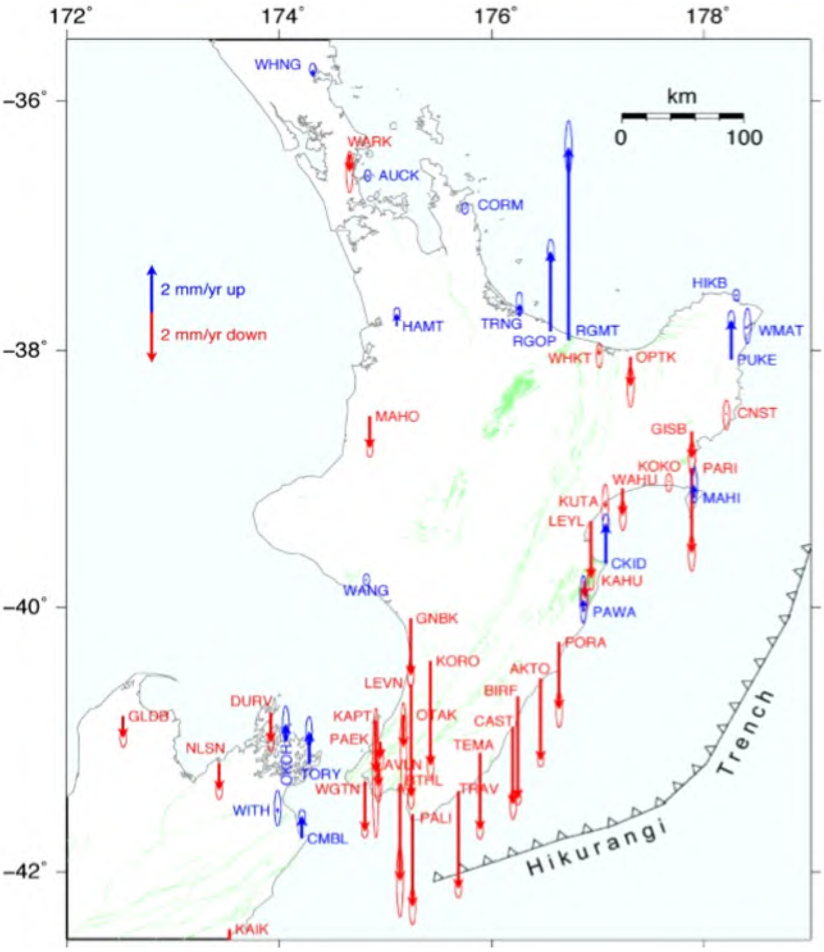


Figure 4-3: Average vertical land movement for near-coastal continuous GPS Sites across the North Island and upper South Island, New Zealand. Blue arrows show average uplift and red arrows average subsidence over around a 10-year period up to 2011. Source: Beavan and Litchfield (2012).

[3] Subsidence means the relative SLR is higher than the absolute rise in the ocean surface (uplift means it is smaller).

4.3 Projections for New Zealand sea-level rise

A synthesis of the historic and future projections of SLR, both globally and for New Zealand, is available in the Ministry for the Environment (MfE) guidance for local government: *Coastal Hazards and Climate Change* (Ministry for the Environment 2017) and an accompanying Summary[4] and set of Fact Sheets.[5]

Chapter 5 of the Coastal Guidance provides four specific New-Zealand based SLR scenarios to use when assessing and planning adaptation to coastal climate change in New Zealand (Figure 4-4). The SLR scenarios in the Coastal Guidance largely follow the synthesis of the IPCC Fifth Assessment Report (IPCC, 2013; Church *et al*., 2013), but are extended from 2100 to 2150, utilising the longer-range probabilistic projections of Kopp *et al*. (2014). Further, an adjustment has been made for ocean waters around New Zealand, where climate-ocean models have shown that SLR in our Pacific region will be somewhat higher than the global average rise – with IPCC projections couched in terms of the global average. The adjustment built into the New Zealand scenarios, for the regional ocean around New Zealand, is up to 0.05 m by 2100 for the higher RCP scenarios. A lesser pro-rata increment applies for the lower concentration RCPs.

The Coastal Guidance also listed a table of the time periods for which particular increments of SLR (relative to the 1986-2005 baseline) could be reached for the four different scenarios (Table 4-1). This information on time brackets can be applied to low-lying coastal areas, once the adaptation threshold SLR is known and agreed on from hazard and risk assessments, beyond which outcomes are not tolerable. All the details on developing firstly, hazard and risk assessments, then adaptation plans using the SLR scenarios, are available in the Coastal Guidance and Appendices (Ministry for the Environment 2017).

Table E-1, Appendices of Ministry for the Environment (2017) lists local values of sea level to use around New Zealand for the baseline (generally the 1986-2005 average MSL), to which the SLR projections are added - being 0.155 m TVD-70 for the Taranaki region when adding future SLR projections from Table 4-1 or Figure 4-4.

Figure 4-4 shows the projected SLR for the four scenarios (Ministry for the Environment, 2017). Due to the closeness of trajectories between the high and low projections in the near term, it is not possible to distinguish which path New Zealand SLR measurements will follow and may require another 1–2 decades of monitoring to conclusively determine which RCP trajectory applies. But, SLR trajectories (relative to the RCP scenarios) may change again in the future if polar ice-sheet instabilities emerge later this century and/or global emissions continue to track high or indeed global emissions may be substantially reduced if the 2015 Paris Agreement is adhered to. This future uncertainty is the reason why the Coastal Guidance (Ministry for the Environment, 2017) recommends the use of all four SLR scenarios to plan for and test adaptation options in an adaptive planning framework.

[4] https://environment.govt.nz/publications/preparing-for-coastal-change-a-summary-of-coastal-hazards-and-climate-change-guidance-for-local-government/
[5] https://environment.govt.nz/publications/preparing-for-coastal-change-fact-sheet-series/

Table 4-1: Approximate years, from possible earliest to latest, when specific sea-level rise increments (metres above 1986–2005 baseline) could be reached for various projection scenarios of SLR for the wider New Zealand region. The earliest year listed is based on the RCP8.5 (83rd percentile) or H^+ projection and the next three columns are based on the New Zealand median scenarios, with the latest possible year assumed to be from a scenario following RCP2.6 (median), which approximates the fully globally-implemented Paris Agreement. Source: Table 11 in Ministry for the Environment (2017). Note: year for achieving the SLR is listed to the nearest five-year value.

	Approximate year for the relevant New Zealand-wide SLR percentile scenario to reach increments of SLR (relative to baseline of 1986–2005)			
SLR (m)	Year achieved for RCP8.5 H^+ (83%ile)	Year achieved for RCP8.5 (median)	Year achieved for RCP4.5 (median)	Year achieved for RCP2.6 (median)
0.3	2045	2050	2060	2070
0.4	2055	2065	2075	2090
0.5	2060	2075	2090	2110
0.6	2070	2085	2110	2130
0.7	2075	2090	2125	2155
0.8	2085	2100	2140	2175
0.9	2090	2110	2155	2200
1.0	2100	2115	2170	>2200
1.2	2110	2130	2200	>2200
1.5	2130	2160	>2200	>2200
1.8	2145	2180	>2200	>2200
1.9	2150	2195	>2200	>2200

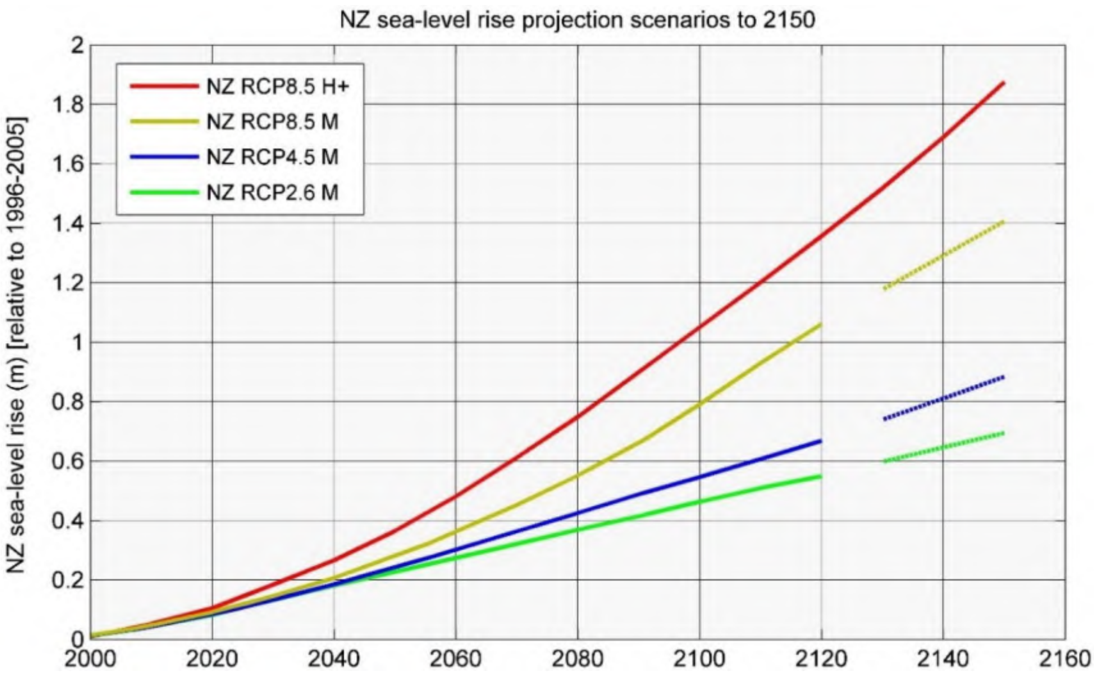


Figure 4-4: Four scenarios of New Zealand-wide regional SLR projections, with extensions to 2150. Based on Kopp *et al.* (2014)-K14. New Zealand scenario trajectories are out to 2120 (covering a minimum planning timeframe of at least 100 years), and the NZ H+ scenario trajectory is out to 2150 from K14. No further extrapolation of the IPCC-based scenarios beyond 2120 was possible, hence the rate of rise for K14 median projections for RCP2.6, RCP4.5 and RCP8.5 are shown as dashed lines from 2130, to provide an indication of the extension of projections to 2150. Note: All scenarios include a small SLR offset from the global mean SLR for the regional sea around New Zealand. Source: Figure 27, Ministry for the Environment (2017).

5 Impacts and implications from climate change in Taranaki

5.1 River flows

Key messages

- Mean annual discharge generally remains stable or slightly increases by mid-century across some coastal and northern parts of Taranaki. By late-century, an enhanced spatial pattern of increase in mean discharge is identified in coastal parts of Taranaki under RCP8.5, however mean annual discharge generally remains stable for the remainder of the region.
- Mean annual low flow is expected to decrease across the region by mid-century. This pattern is similar by late-century, with decreases of up to 50% for most of the river systems in the region.

This section covers the projected differences in several hydrological statistics between the baseline period (1986-2005) and two future periods. These are mid-century (2036-2056) and late-century (2086-2099), and are slightly different from the corresponding time slices of the atmospheric modelling because the hydrological modelling was done before this project was initiated. We do not expect that the conclusions drawn would be substantively different if the periods were aligned. The hydrological modelling analyses presented here were extracted from a national scale assessment (Collins & Zammit, 2016; Collins *et al*., 2018; Collins, 2020). The statistics included in this report are:

- Mean annual discharge;
- Mean annual low flow;

Projected changes to high flows, river flood levels and associated inundation maps for all New Zealand is the subject of a new 5-year research project. Interested readers of this report are asked to contact NIWA for more information.

5.1.1 Mean annual discharge

The projected future changes in the mean annual discharge for RCP4.5 and RCP8.5 at two future time periods are presented in Figure 5-1 for Taranaki. At the annual scale, mean discharge across the Taranaki region remains relatively stable by mid-century across both RCPs, with a slight increase in mean annual discharge in some coastal areas (particularly in the west and north) under RCP8.5. The end of the century is characterised by an enhanced spatial pattern of increased mean annual discharge for coastal parts of Taranaki under RCP8.5, with projected increases of 10-20% for some coastal areas. Mean annual discharge generally remains stable (± 5%) for the remainder of the region across time periods and RCPs.

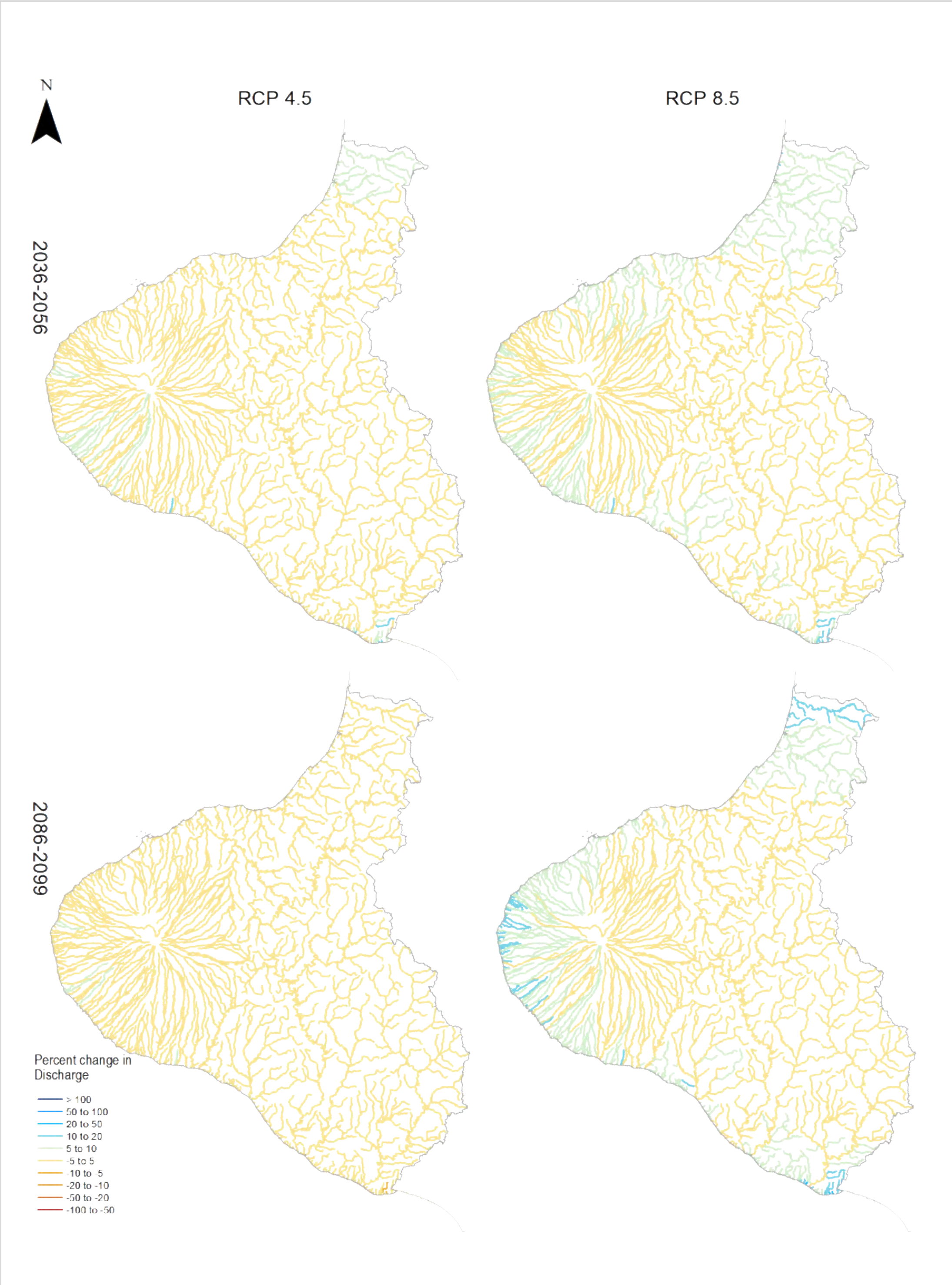


Figure 5-1: Percent changes in multi-model median of the mean discharge across Taranaki for mid (top) and late-century (bottom). Climate change scenarios: RCP4.5 (left panels) and RCP8.5 (right panels). Time periods: mid-century (2036-2056) and end-century (2086-2099).

5.1.2 Mean annual low flow

The mean annual low flow (MALF) is defined as the mean of the lowest 7-day average flows in each year of a projection period. Median projected changes in the MALF are presented for RCP4.5 and RCP8.5 for two time periods in Figure 5-2 for Taranaki. At the annual scale, MALF decreases for at least 95% of the simulated river reaches across both RCPs by mid-century across the Taranaki. Large increases in MALF (i.e. above 50%) is associated with isolated aggregated Strahler 3 reaches for which the baseline simulated MALF is expected to be small, and as such sensitive to any absolute change. Those few reaches are not consistent with subregional behaviour. By the end of the century, the projected changes in MALF are broadly similar to those of the mid-century, with decreases of up to 50% projected for most of the region. The exceptions are southern parts of South Taranaki District, where small increases of 5-10% are projected.

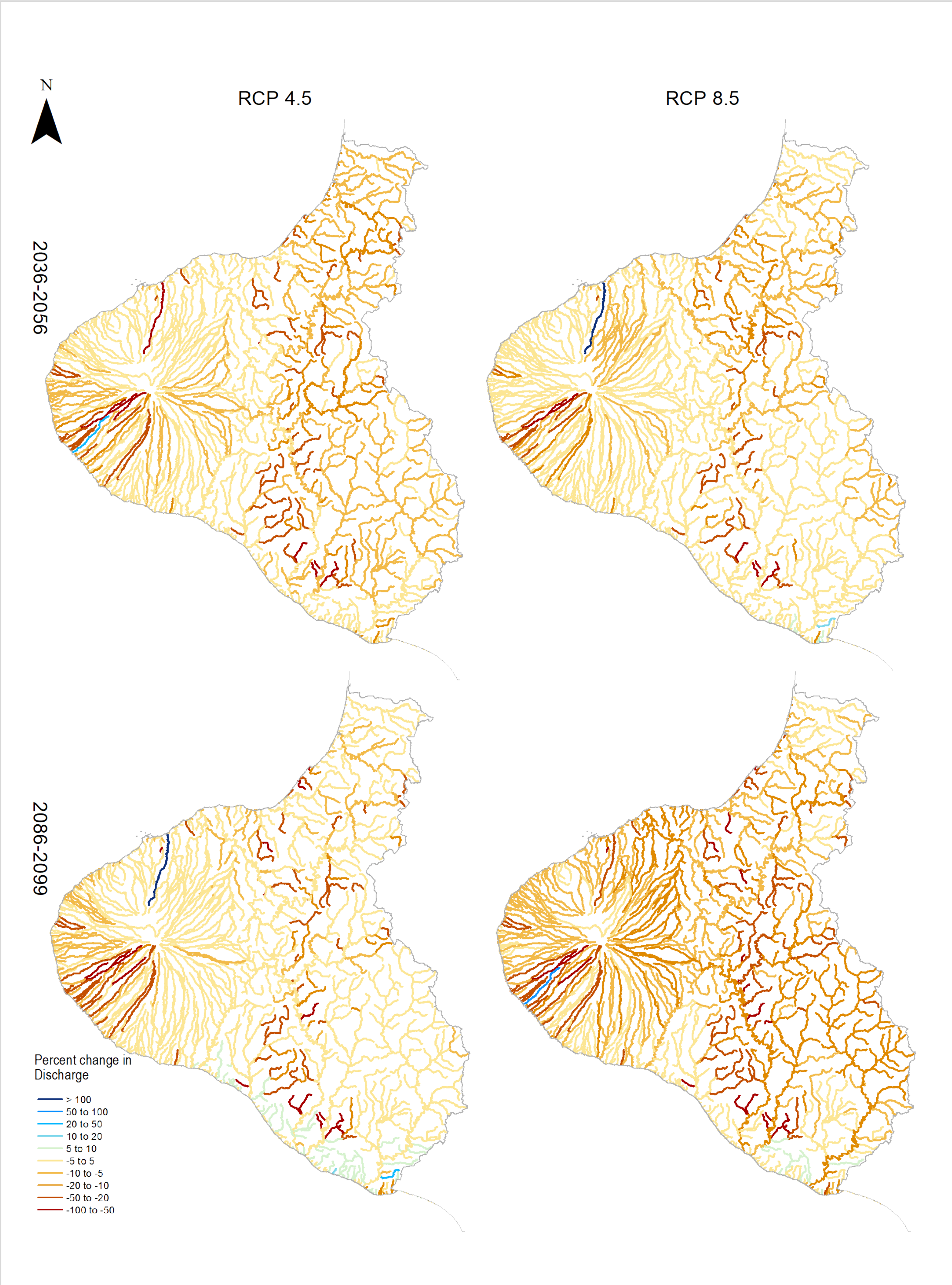


Figure 5-2: Percent changes in multi-model median of the mean annual low flow (MALF) across Taranaki for mid (top) and late-century (bottom). Climate change scenarios: RCP4.5 (left panels) and RCP8.5 (right panels). Time periods: mid-century (2036-2056) and end-century (2086-2099).

5.2 Hill country erosion and landslides

In New Zealand, hill country is defined as land with slope angles above 15° and located below an altitude of 1,000 m above sea level (Cameron, 2016). According to this definition, 37% (10 million ha) of New Zealand's total land area is classified as hill country, with the majority (63%, or 6.3 million ha) located in the North Island (Cameron, 2016). Much of the North Island hill country was converted from forest to pasture in the late-19th century, leaving slopes susceptible to landsliding during heavy rainstorms (Dymond *et al.*, 1999). Landsliding and wind are causes of soil erosion, which is characterised by the denudation of slope materials among hill country land (Brown, 1991). Erosion causes the loss of productive soils on farms and increases sediment entering waterways, with significant impacts on the environment, economy and local communities. Erosion and its effects in hill country areas are estimated to cost New Zealand's economy $250-350 million a year (Ministry for Primary Industries, 2022).

From 19-20 June 2015, heavy rainfall caused landsliding in the Taranaki Hill Country, which was characterised as severe (> 10% of hill slopes affected) about Waverley, and moderate (1-10% of hill slopes affected) for many eastern parts of the Taranaki region (Page *et al.*, 2015). Rainfall totals observed in Taranaki for the 48-hour period ranged from 100-250 mm, with return periods for these rainfall totals generally ranging between 10 and 50 years (Page *et al.*, 2015). Observed landsliding was largely confined to areas in pasture, or recently planted or logged forest (Page *et al.*, 2015). Farmers were affected financially by the event though damage to infrastructure and lost production (Taranaki Regional Council, 2019). Notably, long-term consequences of the event include slip scars with depressed dry-matter production (Taranaki Regional Council, 2019). A study by Derose *et al.* (1995) noted slow pasture recovery on landslide scars in Taranaki, taking 40 years for dry-matter to reach approximately 74% of uneroded levels.

Given the projected increase in severity of extreme, rare rainfall events (Section 3.2.3), increased risk of land degradation resulting from landslides (including debris flows; Gariano and Guzzetti, 2016) and soil erosion may be anticipated in Taranaki. However, it is important to note that although there is a strong theoretical reason for increasing landslide activity due to intensification of rainfall, empirical evidence of climate change contributing to landslides is currently lacking (Olsson *et al.*, 2019). Indeed, human disturbance (e.g. removal of trees) may be a more important future trigger of landslides than climate change (Olsson *et al.*, 2019). Meanwhile, erosion control initiatives (e.g. planting trees) are a means of retaining productive soils on farms, and reducing sediment entering waterways (Ministry for Primary Industries, 2022). When compared to pasture, 90% less erosion occurs under bush/forestry, 80% less under scrub and 70% less where soil conservation trees are planted (Taranaki Regional Council, 2019). This suggests land management will be a crucial tool for addressing soil erosion (Olsson *et al.*, 2019).

5.3 Impacts of drought and future pasture growth

It is likely that much of Taranaki will experience more frequent and severe drought conditions in the future than at present, with larger potential evapotranspiration deficit accumulations and more days of soil moisture deficit (discussed in Sections 3.2.2 and 3.3.1). Drought can have significant impacts on primary industries in Taranaki.

For primary production, rainfall is one of the most important climate drivers, as there are limits (both too much and not enough water) where plants cease to grow or experience harm. When other climatic factors are not limiting, precipitation levels within these limits can have a direct and proportional relationship to productivity (Clark *et al.*, 2012). Changes in rainfall patterns are important when considering future yield variability of crops and pasture grass. This is because crops respond to both amounts and timing of water supply in relation to demand.

Low rainfall (and therefore drought) can limit crop and grass growth in different ways. When water supply is less than demand, crop and grass yield is mainly reduced by limited canopy expansion and increased leaf aging, thereby decreasing sunlight interception, and reduced photosynthesis rates due to stomatal closure (Clark *et al.*, 2012). In pasture grasses, legumes, and maize, reductions in plant growth are manifested by reduced leaf appearance and extension rates, as well as increased tiller (shoot) and plant mortality. The extent of reduction in growth depends on factors such as the severity and duration of the water deficit as well as the plant species, as some species are more sensitive to water deficits than others.

A plant's demand for water and its sensitivity to water stress varies throughout the plant's annual cycle. Therefore, timing of drought is critical: drought in late summer when plants have largely completed growth does not have the devastating impact of late winter/early spring drought that prevents achievement of full productive potential (McGlone *et al.*, 2010).

For fruit, rainfall can have positive or negative effects. Girona *et al*. (2006) found that for grapes, the best fruit-quality parameters were obtained when plants were well watered for the first part of the growing seasons, but then deficit irrigated until harvest to avoid excess vegetative growth. While rainfall in spring and early summer provides needed water and reduces irrigation costs, rainfall later in the season can reduce fruit (and therefore wine) quality. In other fruit crops, similar principles apply. Miller *et al*. (1998) found that the main effect of early-season water stress on kiwifruit was to reduce vine yields, so rainfall early in the season has demonstrable benefits. Deficit irrigation late in the season had little impact on yield, but did improve fruit quality.

Primary industries may turn towards increased irrigation as a method for dealing with increased incidence of drought (Clark *et al.*, 2012). However, this approach may not be suitable depending on the future changes to rainfall and availability of water for irrigation.

The effect of increased carbon dioxide levels on plants under limited water supply may help with the effects of drought. Under limited water supply conditions, the effect of carbon dioxide fertilisation is more evident. Higher carbon dioxide concentrations reduce the loss of water vapour through leaf transpiration and, therefore, improve the water use of crops (Leakey *et al.*, 2009; Clark *et al.*, 2012). The faster growth of plants due to carbon dioxide fertilisation may enable plants to avoid exposure to late-season droughts. However, extreme heat and severe drought (deficits of around two to three weeks in duration) override the effect of carbon dioxide fertilisation in pastures and crops (Clark *et al.*, 2012).

Temperature will also influence the seasonality of pasture growth in Taranaki. Warmer winter and spring periods will allow for increased seasonal growth rates, however growth during summer may be suppressed due to temperatures being too hot and water availability being limited (Clark *et al.*, 2012).

5.4 Forestry

Climate change-induced hazards, such as changes in the temperature, rainfall and carbon dioxide concentration, could impact natural and modified forests substantially (Kirilenko and Sedjo, 2007; FAO, 2018). The possible impacts of climate change on forests include, but are not limited to, shorter or longer growing seasons, modifications in the forest's biodiversity including its macro and microbiota, changes in the pests and disease factors and their spread pattern, and increase of bushfire frequency (FAO, 2018; Kirilenko and Sedjo, 2007; Whitehead *et al*., 1992).

New Zealand's forestry, as the nation's third-largest export sector, has been impacted by global and local hazards induced by a changing climate, and the impacts are expected to continue or accelerate under the future scenarios of climate change (Ministry for Primary Industries, 2018; Watt *et al*., 2019; Whitehead *et al*., 1992). Research indicates there are potential impacts of climate change on New Zealand's natural and plantation forests such as: alteration in the forest productivity due to an increase in the growth rate, more wind-related damage, amplified bush fire risk (very high to extreme), and a possible surge in the pest and weed population (Watt *et al*., 2019). Both exotic and native forest plantation play an important part in soil conservation in the Taranaki region. About half (14,738 hectares) of the 27,278 hectares of exotic forestry in Taranaki is established on erosion-prone land (Taranaki Regional Council, 2022).

Increases to temperature and changing rainfall patterns could negatively influence *P. radiata* productivity. However, the effect of increased carbon dioxide fertilisation is modelled to outweigh these negative impacts, significantly increasing *P. radiata* productivity across New Zealand by 2040 and 2090 some 19% and 37%, respectively (Watt *et al.*, 2019). Note, the extra growth caused by carbon dioxide fertilisation may make trees more susceptible to wind damage.

Extreme rainfall intensity, as discussed earlier in this report, is likely to increase in Taranaki. This may have implications for the forestry sector through exacerbating erosion, landslides, movement of slash, and impacts on access to forests for trucks and machinery. Such impacts may be more prominent in recently harvested forestry sites, as harvesting practices can cause soil compaction (Ares *et al.*, 2005), which in turn decreases the water infiltration capacity of the soil (Viglione *et al.*, 2016). In contrast, severe droughts are likely to become more frequent for the region, which may have implications for forestry through reducing water availability for trees and increasing fire risk.

Fire risk is projected to increase in the future in New Zealand, due to the following conditions (Pearce *et al.*, 2011):

- Warmer temperatures, stronger winds, lower rainfall and more drought for some areas will exacerbate fire risk. Note that projected changes to mean wind speed for Taranaki are generally small at the annual scale, with greater change projected at the seasonal scale (e.g. larger increases to mean wind speed during winter and spring). Further work is needed to evaluate changes to wind at the regional scale;
- The fire season will probably be longer - starting earlier and finishing later;
- Potentially more thunderstorms and lightning may increase ignitions;
- Fuel will be easier to ignite (because of increased drying due to increased evapotranspiration/less rainfall); and
- Drier conditions (and possibly windier periods) may result in faster fire spread and greater areas burned.

The following projections for fire risk are based on the IPCC Fourth Assessment Report emission scenarios (Pearce *et al.*, 2011). For Seasonal Severity Rating (SSR)[6], the 17-model average projection shows minimal change for New Plymouth Aero (a representative climate station for the Taranaki - Whanganui Fire Climate Region) by the 2050s (2040-2059) compared to the 1980-1999 historical period. Similar patterns were observed for the 2080s (2070-2089). The average SSR over fire season months (October-April) for New Plymouth Aero is projected to increase from 0.62 over the historical period to 0.74 in the 2050s, and 0.76 in the 2080s.

The number of days of Very High and Extreme (VH+E) forest fire danger is projected to increase marginally for New Plymouth Aero by the 2050s and the 2080s compared to 1980-1999. The historical number of VH+E forest fire danger days for New Plymouth Aero is 1.1 days, and this is projected to increase to 1.4 days in the 2050s and 1.5 days in the 2080s. Note that some individual models project a higher increase in Very High and Extreme forest fire danger days, as noted by Reisinger *et al.* (2014). The reader is directed to Pearce *et al*. (2011) for more information on the projections of Seasonal Severity Rating and Very High and Extreme forest fire danger days in New Zealand.

Pest species are likely to shift to new habitat areas due to climate change. Increasing average temperatures and changing rainfall patterns across the country may make conditions more suitable for climate-limited tree pathogens such as pitch canker (currently present in northern coastal areas). Insect pests may become more of an issue for forestry plantations with climate change, as the major limiting factor for most insect pests is cold stress. Therefore, subtropical insect pests may be able to establish in a warmer New Zealand in the future, and existing insect pests may increase their distribution within New Zealand. Climate change may also affect the severity of damage from existing insect pests because warmer temperatures can be expected to accelerate insect development and therefore lead to an increase in population levels, especially in species that can complete more than one generation per year (e.g. the Monterey pine aphid *Essigella californica*).

Increasing competition with weeds is also a concern for the forestry industry. New Zealand's future climate may become more suitable for some weeds which are already established in some parts of New Zealand but have not spread, so-called "sleeper weeds" (Kean *et al*., 2015). An example of this is *Melaleuca quinquenervia,* an exotic tree that is currently established in Auckland and Northland. If the species' thermal requirement for reproduction is reached with a warming climate, this could become quite invasive and difficult to control. Also, woody tree species that are native to Australia (e.g. *Acacia spp.*) have very high growth rates and vigorously compete with *P. radiata* seedlings. As tree species, they can compete further into the plantation rotation than other weed species which are predominantly shrubs. Wilding conifers have become a significant threat to New Zealand's ecosystems, covering more than 1.8 million hectares and spreading at a rate of 5% annually (Greene *et al.*, 2020). The climate change impacts on the distribution of wilding pines in NZ has not yet been thoroughly researched. However, without large scale funding and control it is estimated 20% of New Zealand will be covered by wilding conifers within 20 years (Department of Conservation, 2021). Given the rapid spread of wilding conifers, modern technology such as remote sensing (e.g. Greene *et al.*, 2020) may become a critical tool to identify wilding conifer distributions.

[6] Seasonal Severity Rating (SSR) is a seasonal average of the Daily Severity Rating (DSR), which captures the effects of both wind and fuel dryness on potential fire intensity, and therefore control difficulty and the amount of work required to suppress a fire. It allows for comparison of the severity of fire weather from one year to another. Source: Rural Fire Research (2022).

Overall, there are several potential impacts on the forestry sector from climate change. Tree growth may be more vigorous due to increasing concentrations of carbon dioxide in the atmosphere and warmer temperatures, but this may be counteracted by reduced water availability and risk of fire. Forestry operations may be negatively affected by increasing rainfall intensity causing more erosion, flooding, and site access issues, as well as more frequent and prolonged droughts as well as fire risk which may affect safety of workers.

5.5 Horticulture

The Taranaki horticultural sector is small, although large areas of land have been classified as suitable for intensive horticulture, particularly on the ring plain that surrounds Mount Taranaki (Greer, 2014). Therefore, it is worthy to explore the impacts and implications from climate change on the horticultural sector.

The horticulture industry is likely to be subject to increasing impacts of climate change over time (Ministry for Primary Industries, 2012). The production of horticultural crops is projected to be influenced by changes in precipitation patterns, temperature variability, and greenhouse gas concentrations (Ministry for Primary Industries, 2012). For example, temperature rise, either annual or seasonal, alters the evaporation rate, hydrological cycles of the catchment, and water availability; therefore, influencing the quality and quantity of horticultural products (Rehman *et al*., 2015). Table 5-1 shows a snapshot of the potential impacts of climate change on some horticultural products.

Table 5-1: Overall impacts of climate change on the main horticultural crops in New Zealand. Source: Clothier *et al.* (2012).

	Apples	*Grapes*	*Kiwifruit*
Temperature			
Temperature means ↑	Yield ↑ Quality ↑ Disease risk ↑ Sunburn ↑	Yield ↑ Quality ↑ Disease risk ↑	Yield ↓ Quality ↑ (and ↓) Disease risk ↑
Temperature extremes Frost ↓ Heatwaves ↑	Frost damage ↓	Frost damage ↓	Frost damage ↓
CO_2 ↑	Biomass ↑	Biomass ↑	Biomass ↑
Rainfall variability ↑↓	Irrigation ↑	Irrigation ↑ Drought risk ↑	Irrigation ↑
Water quality	Leachate load ↓	Leachate load ↓	Leachate load ↓
Extreme events Hail ~ Wind ~	Damage to fruit ~ Damage to trees ~	Damage to fruit ~ Damage to vines ~	Damage to fruit ~ Damage to vines ~
Combined impacts ~	↑ unless pest & disease impacts override	↑ unless pest & disease impacts override	↑↓

Increasing temperatures will impact all types of crops, as plant phenological development may occur at a faster rate. Different stages of plant growth (e.g. bud burst, flowering, and fruit development) may happen at different times, which may affect the harvested crop. For example, the hottest summer on record for New Zealand in 2017/18 saw wine grapes in multiple New Zealand regions ripen faster than usual, including very early Sauvignon Blanc wine-grape maturation in Marlborough

(Salinger *et al*., 2019). In Central Otago, this resulted in the earliest start to harvest of Pinot Noir grapes on record (almost a month earlier than usual). In Wairarapa, the period from flowering to harvest for wine grapes was about 10 days shorter than usual[7].

Extreme heat affects the rate of evapotranspiration, or the uptake of water by plants. Therefore, increases to extreme heat may affect water availability, as under hot conditions, plants use more water. Extreme heat may also result in current varieties of crops and pasture becoming unsustainable if they are not suited to growing in hot conditions. Extreme heat may also affect fruit quality, such as sunburn on apples and kiwifruit, and 'shrivelling' of grapes (Clothier *et al*., 2012).

Reductions in cold conditions may have positive impacts for diversification of new crop varieties that are not able to currently be grown in Taranaki. In the future, with a warmer climate, there may be opportunities for growers in Taranaki to take advantage of the overall warmer climate to diversify their crops. However, future warmer temperatures may create issues for horticulture in the region. The increasing risk from pests (plants and animals) and diseases is a concern. Currently, many pests are limited by cold conditions, so that they cannot survive low winter temperatures, and therefore their spread is limited (Kean *et al.*, 2015). Under a warmer climate, these pests may not be limited by cold conditions and therefore cause a larger problem for farmers and growers in Taranaki.

Increased prevalence of drought and longer dry spells in Taranaki will likely have impacts on water availability for irrigation and other horticultural uses. The amount of irrigation may need to increase to maintain productivity, however this may be limited by future water availability. Should water availability become increasingly problematic, increased investment in storage options may be required. More frequent and severe droughts may negatively affect horticultural productivity, particularly for crops that require larger quantities of water. Soils may be more exposed to wind erosion with increasing drought severity.

Increases in extreme rainfall event magnitude and frequency may impact horticulture in several different ways. Slips on hill country land may become more prevalent during these events (Basher *et al.*, 2012), and soils may become waterlogged more often. This has impacts on the quality of soil for horticulture, the area of land available for production, and other impacts such as sedimentation of waterways (which can impact flooding and water quality). Slips may also impact transport infrastructure (e.g. roads, farm tracks) which may, in turn, affect the connectivity of farms and orchards to markets. Heavy rain at harvest times for fruit may cause a decline in fruit quality, with skins splitting and increased prevalence of diseases.

Overall, climate change impacts on horticulture are likely. Increasing temperatures may provide opportunities for new crop types to be grown in Taranaki but this may also cause issues for some existing crop types and encourage the spread of new pests. Droughts are likely to cause significant issues for the sector in terms of water availability for irrigation and resulting productivity. However, increasing rainfall intensity is likely to have impacts on soil erosion, sedimentation, and saturation of soils.

5.6 Ecosystem health

The impact of climate change on terrestrial, aquatic and marine ecosystems has been the subject of much research in the past couple of decades (Brodie and Pearson, 2016; Rapport *et al.*, 1998; Wang and Cao, 2011; Malhi *et al.*, 2020). Climate change is expected to be a stressor on terrestrial,

[7] https://michaelcooper.co.nz/2018-regional-vintage-overview-report/

freshwater, coastal and marine ecosystems, particularly under high-warming scenarios. For example, wetlands are highly sensitive areas and are amongst the most threatened ecosystems in New Zealand. In the future, wetlands will be threatened by changes to rainfall patterns, drought and surface and groundwater hydrology. Wetlands close to the coast will also be at risk from sea-level rise (inundation and erosion) and changes to the salinity of groundwater which may impact the distribution and assemblage of species. Although many of New Zealand's ecosystems are being degraded due to climate change-oriented hazards, some of them, such as alpine, freshwater and coastal ecosystems, are more vulnerable than others (Department of Conservation, 2020). For example, rising sea level, coastal inundation and flooding may lead to the loss of habitat for coastal and estuary species, which could cause an interruption in the food chain for a wider range of biodiversity (DOC, 2020).

Climate change hazards could impact the ecosystem's health from two different, but interrelated aspects including: biodiversity and habitat loss, and pests and biosecurity issues.

5.6.1 Native biodiversity (terrestrial, aquatic and marine biodiversity)

Climate change is continuously impacting all aspects of biodiversity on the planet, from terrestrial to marine ecosystems and biodiversity. Anthropogenic climate change is already impacting 19% of threatened species recorded in the IUCN Red List, and pushing them toward extinction (IUCN, 2019). Climate change-induced hazards, such as temperature rise, have significant impacts on native biodiversity, including their abundance, behaviour and genetic properties (IUCN, 2019). Changing the features of the food chain, increasing invasive species, habitat loss, and ocean acidification are only a few examples of climate change impacts that threaten native biodiversity, both globally and in New Zealand (Christie, 2014). For example, changes in temperature and rainfall, and sea-level rise, are expected to lead to secondary effects, including erosion, landslips, and flooding, affecting coastal habitats and their dependent species, for example, loss of habitat for nesting birds.

About 4000 of New Zealand's threatened species are pushed towards the brink of extinction, partly due to climate change (MFE, 2019). Many indigenous New Zealand species are already and will be at further risk from climate-related impacts such as river water abstraction for irrigation (in response to reductions in rainfall and higher drought incidence), hydroelectric power schemes (a potential mitigation response to greenhouse gas emissions), and non-climate-related impacts such as predation, habitat loss and fragmentation from land use change, urban area and infrastructure expansion, and pollution (McGlone and Walker, 2011). Many species will be at risk from new and existing pests that are able to colonise and spread further in New Zealand because of climate change (Kean *et al.*, 2015).

The direct responses of terrestrial biodiversity to future climate changes will be challenging to predict, due to uncertainty about climate projections, species' responses to climate change and the ability of species to adapt (McGlone and Walker, 2011; Christie, 2014). This is particularly because of the existing pressures of invasive species and human-related habitat loss on native biodiversity. The capacity of native species and ecosystems to adapt to a changing climate is unknown, especially given New Zealand's oceanic setting and existing highly variable climate regime. However, the indirect responses of terrestrial biodiversity to climate change can be predicted with more certainty. Indirect impacts involve the exacerbation of existing invasive species problems and human-related threats, such as habitat loss (Christie, 2014). Land use and land management practice change in anticipation of climate change may result in further restrictions of native species abundance and distribution.

The New Zealand National Climate Change Risk Assessment (AECOM *et al.*, 2020) highlights the ten most significant climate change risks to New Zealand, based on urgency. Two of the top ten are in the 'natural environment' domain, with 'major' consequence ratings and urgency scores greater than 70. They are:

- Risks to coastal ecosystems, including the intertidal zone, estuaries, dunes, coastal lakes and wetlands, due to ongoing sea-level rise and extreme weather events; and
- Risks to indigenous ecosystems and species from the enhanced spread, survival and establishment of invasive species due to climate change.

Ten other risks in the natural environment domain were identified which incorporate most ecosystem types in New Zealand and a range of climate-related impacts.

Some mitigation aspects of climate change might have negative impacts on terrestrial biodiversity. Afforestation with exotic tree species (e.g. *Pinus radiata*) may lead to reductions in catchment water yield, with negative impacts on streamflow and freshwater biodiversity, stabilisation of previously dynamic systems (e.g. pines on coastal dunes) with consequent loss of indigenous flora, invading areas where the native forest was either absent or limited and creating flammable forest communities (McGlone and Walker, 2011). The conversion of native scrub and shrubland to forestry may also cause the direct loss of native ecosystems.

Changes to rainfall patterns and river flows, as well as the human impact of greater abstraction of freshwater for irrigation and increasing storage (in the form of reservoirs) for hydroelectricity and urban water supply, will impact freshwater ecosystems (Parliamentary Commissioner for the Environment, 2012). The role of floods in New Zealand rivers is extremely important for maintaining ecological integrity, so changes to the hydrological regime may have dramatic impacts on biological communities (Death *et al.*, 2016; Crow *et al.*, 2013). Altered natural flow patterns may result in invasive predators gaining increased access to habitats crucial for sensitive life cycle stages (e.g. islands in river channels used by nesting birds) and changes in habitat type, and some aquatic species (e.g. invertebrates) are likely to be impacted more than others, depending on their life cycles (McGlone and Walker, 2011). Habitat size, availability and quality may be reduced for some species, and drought may threaten already isolated fish and invertebrate populations.

Egan *et al.* (2020) carried out a climate change vulnerability assessment for freshwater taonga species in New Zealand. Increasing risk of drought is likely to have negative impacts on several taonga species, for example tuna (longfin eel), due to changes in habitat availability. The timing of seasonal rainfall and changes to river levels may affect īnanga (whitebait) reproduction cycles. Increasing water temperature may be beneficial in the cooler part of the year for tuna (shortfin eel), because feeding activity increases when temperatures exceed 12°C. However, changes to temperature regimes throughout the year may impact environmental cues for spawning for a number of species including giant kōkopu (whitebait) and kākahi (mussels).

Sea-level rise may increase salinity at river mouths and further upstream than at present, thereby reducing freshwater habitats, particularly in short catchments. Increases in extreme rainfall intensity may lead to more sedimentation and turbidity in waterways, with consequent habitat loss. Banded kōkopu (*Galaxias fasciatus*) have been found to have reduced abundance in turbid streams, so increasing runoff and sediment flowing into streams could limit their distribution (Rowe *et al.*, 2000). Other oceanic changes (e.g. changes to salinity, sea temperatures, and pH (Law *et al.*, 2018) may also have an impact on diadromous fish species and their migration patterns.

Coastal lakes and lagoons are sensitive to potential climate change impacts resulting from sea-level rise, changes to inflows, rainfall and air and water temperature (Tait and Pearce, 2019). These impacts include:

- Increased sedimentation from extreme rainfall, runoff, and higher flood inflows;
- Reductions in inflows and lower water levels due to reduced rainfall and increased drought conditions;
- The water may become more brackish due to sea-level rise;
- Increased water temperature may increase the abundance of algae and algal blooms and cause heat stress for aquatic species;
- Habitat may become less suitable for aquatic and terrestrial species due to the above physical changes to the lake.

Coastal systems are particularly sensitive to three key drivers related to climate change: sea level, ocean temperature, and ocean acidity (Wong *et al.*, 2014). Soft shorelines (beaches and estuaries) are likely to be more severely affected by sea-level rise than hard (rocky and consolidated cliffs) shores. Due to the extensive development near beaches, estuaries and marshes, it is unlikely that natural adjustment of the coast will be readily allowed in the future (i.e. coastal retreat and reconfiguration as sea level rises). A potential human response to sea-level rise will be by building hard barriers, protecting sand dunes, replenishing beaches, and infilling estuaries to prevent erosion and to protect property and infrastructure.

The lack of space for natural coastal adjustment is often termed *coastal squeeze.* Coastal squeeze has varying definitions, but a narrower focus is the definition by Pontee (2013): “Coastal squeeze is one form of coastal habitat loss, where intertidal habitat is lost due to the high water mark being fixed by a defense or structure (i.e. the high water mark residing against a hard structure such as a sea wall) and the low water mark migrating landwards in response to sea level rise”.

Consequently, running in parallel with the impacts of climate change and sea-level rise (SLR) on coastal and estuarine/marsh systems will be the ongoing direct and indirect pressures of society’s responses to climate-change adaptation (Swales *et al.*, 2020). If cascading climate-change effects are not thoroughly explored and evaluated in a holistic manner, attempts to counteract the SLR impacts on the built environment and existing land-use rights (e.g. shoreline protection works, reclamations to reinstate shoreline buffers, stopbanks and alteration to drainage schemes), will invariably lead to coastal squeeze and loss of intertidal habitats and beaches (Kettles and Bell, 2015).

There are numerous examples of coastal squeeze around New Zealand as coastal erosion affects the areas around hard defenses. In one such example, Figure 5-3 shows erosion next to a sea wall in Whitianga, Coromandel. In addition, the potential erosion and inundation of coastal areas caused by a significant storm event (e.g. ex-tropical cyclones) will be enhanced under future sea-level rise projections. See Paulik *et al.* (2019) for further information on national, regional and district-level risk exposure to inundation in low-lying coastal areas of New Zealand.

Figure 5-3: Erosion beside a sea wall in Whitianga. Credit: R. Bell, NIWA.

Loss of productive estuarine habitats and biota is likely to accelerate with SLR and other climate-related impacts discussed above, with the more visible ecological effects being reduced populations and altered migratory patterns of coastal birds, and declines in certain commercially important marine fishes that use estuaries for part of their life cycle (e.g. snapper, *Pagrus auratus*) (McGlone and Walker, 2011). The effects of changes in waves and freshwater inputs will also have significant adverse impacts on coastal ecosystems (Hewitt *et al.*, 2016).

Warming has been observed in coastal and oceanic waters around New Zealand over the past few decades, with the strongest warming happening off the coast of Wairarapa and the weakest warming signal between East Cape and North Cape (Sutton and Bowen, 2019). Projections for the Southwest Pacific show an increase in SST by mid- and end-century, regardless of RCP and climate model (Law *et al.*, 2016). The mean increase is ~1°C by mid-century, and ~2.5°C by end-century for RCP8.5. Figure 5-4 shows the spatial variation of change in SST for end-century under RCP8.5, with surface warming across the entire Southwest Pacific. The most striking feature is the strong warming of +4°C in the western Tasman Sea (in region 2 on Figure 5-4) associated with the southerly penetration of the East Australian Current off southeast Australia (Ridgeway, 2007). The western Tasman Sea region is warming at a rate four times that of the global average as a result of the climate-driven spin-up of the South Pacific gyre (Roemmich *et al.*, 2016). This warming propagates across the northern Tasman Sea (region 3) along 35°S in association with the Tasman Front, causing the most significant regional SST increase in the New Zealand Exclusive Economic Zone.

Warming oceans are likely to have impacts on the distribution of marine species as well as pests from warmer areas. For example, distribution shifts and changes in abundance of numerous fish species have been observed in the southeast Australia region due to substantial ocean warming that has already occurred there (Last *et al.*, 2011). During the 2017/18 marine heatwaves in the South Island, bull kelp suffered losses in Kaikōura and was completely lost from some reefs in Lyttelton (Thomsen *el al.*, 2019). In aquaculture, heatwaves can increase mortality with associated loss of revenue (Ministry for the Environment & Stats NZ, 2019). In Marlborough Sounds, the 2017/18 marine heatwave impacted mussel growth and yields, and led to an algal bloom that can cause Paralytic Shellfish Poisoning in humans (Sanford, 2018). Warming waters in summer are already affecting fish, with the reproduction of some fish species (e.g. snapper and hoki) appearing to be affected by sea-surface temperature (Ministry for the Environment & Stats NZ, 2019).

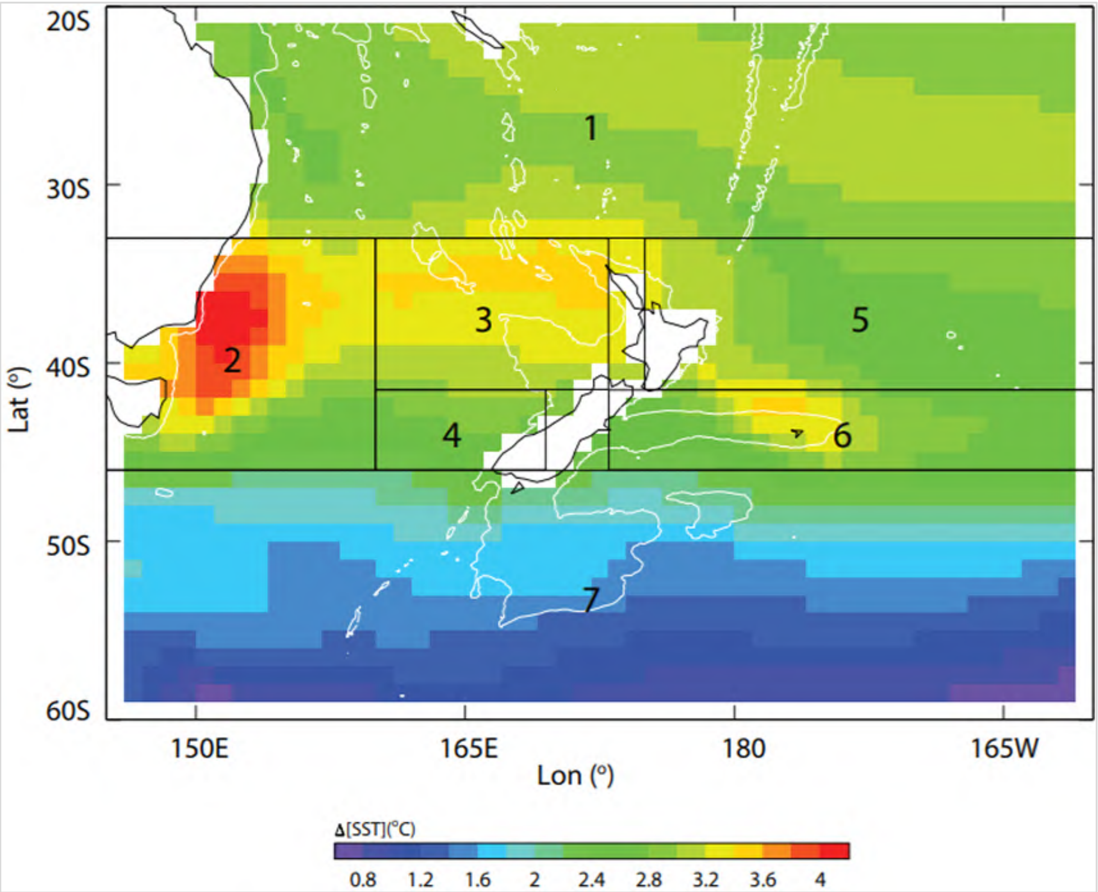


Figure 5-4: Regional variation of the projected change in SST for the End-Century (2081-2100) compared with present-day (1976-2005) under RCP8.5. Source: Law *et al.* (2016).

As pH is primarily determined by atmospheric carbon dioxide exchanging with the surface waters and there is no upwelling of low pH water in the Southwest Pacific, surface pH is relatively uniform. The decline in surface pH at mid- and end-century is clearly apparent in Figure 5-5, which shows that the effect of future changes in atmospheric carbon dioxide concentration on pH override spatial variation arising from natural processes. Minor regional variation is evident, with higher pH in northern subtropical waters and the East Australian Current, and lower pH in the south. This meridional gradient of ~0.03 partially reflects the higher solubility of carbon dioxide, and so lower pH, in colder water. Surface waters in the Subtropical Front on the Chatham Rise have marginally higher pH, due to carbon dioxide uptake by phytoplankton in this region.

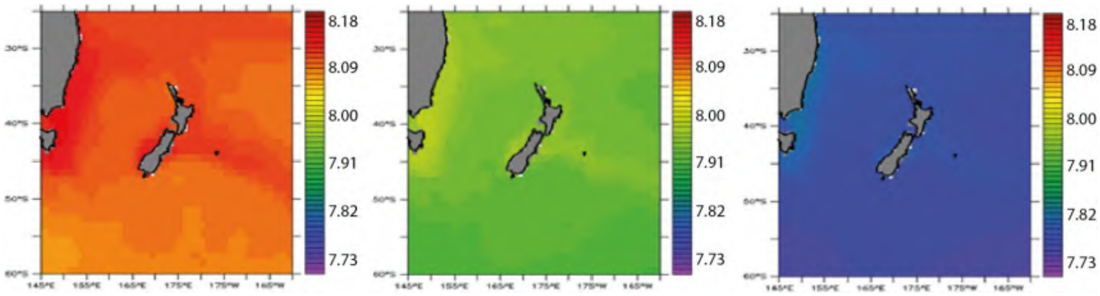


Figure 5-5: The spatial variation in mean surface pH in the Southwest Pacific. For the present-day (1976-2005, left panel), and projected for Mid-Century (2036-2055, central panel) and End-Century (2081-2100, right panel) using the GFDL-ESM2G model under RCP8.5. The legend shows pH.

Marine species are likely to be affected by ocean acidification. Growth rates and shell development of species with carbonate shells, such as oyster, paua, and some phytoplankton are reduced in more acidic waters (Cummings *et al.*, 2013). An investigation into the effects of ocean acidification and heatwave conditions on juvenile snapper (*Pagrus auratus*) was undertaken in New Zealand by McMahon *et al.*, (2019). They found that critical swimming speed and maximum metabolic rates increased with higher temperatures but decreased with higher carbon dioxide (i.e. higher acidity), which means ocean acidification could have negative effects on snapper population recruitment. However, it is uncertain at this stage whether the same behaviours will be affected in a wider range of New Zealand temperate and subantarctic fish species (Law *et al.*, 2018).

5.6.2 Pests and biosecurity

Climate change hazards such as rising temperatures, heatwaves, and changes in precipitation patterns are likely to increase biosecurity issues including rising numbers of invasive species, pests and pathogens (Luck *et al.*, 2014).

Terrestrial biosecurity

Climate change is widely regarded as one of the greatest challenges facing indigenous ecosystems in the coming century. As New Zealand has an economy based on very efficient primary production systems, the risk of exotic pests and diseases affecting the primary industries also needs to be minimised. Climate change will create new biosecurity challenges by enabling the establishment of new exotic pest animals, weeds and diseases which are currently prevented by New Zealand’s climate. The potential establishment of subtropical pests and current seasonal immigrants are of greatest concern, along with species that are already recognised as high risk (Kean *et al.*, 2015).

Although climate change may affect organisms and ecosystems in a range of ways, the most important driver of pest invasion is likely to be temperature, modified by rainfall, humidity and carbon dioxide (Kean *et al.*, 2015). In addition, changes in large-scale weather patterns will influence the frequency and intensity of extreme weather events (e.g. flooding, drought, damaging wind). Regional winds and currents may affect the ability of potential invaders to reach New Zealand and establish. Myrtle rust (*Austropuccinia psidii*) is a fungus that has been recently (in 2017) found in northern New Zealand. It attacks plants belonging to the Myrtaceae family, including pōhutukawa, mānuka, rātā, and feijoa. There is concern that myrtle rust may spread further in New Zealand as the climate warms and other fungi that are spread by wind may become established in the country in the future with changes to atmospheric circulation, temperature, wind patterns, and storminess.

Big headed (*Pheidole megacephla*) and Argentine (*Linepithema humile*) ants are some of the worst invasive pest species in the world, as they can wreak havoc on the native arthropod fauna, and they are already present in New Zealand. Continued warming and drying of climate is likely to encourage their spread. Wasps are highly responsive to climate conditions; wet winters with flooding do not favour nest survival and can lower populations, while warm, dry conditions are ideal for explosive population growth (McGlone and Walker, 2011). Subtropical fruit flies are already considered major threats to the New Zealand horticulture industry. A modelling exercise done for the Queensland fruitfly (Figure 5-6) shows that in the historic period, only the northern parts of New Zealand are suitable for population establishment. However, the envelope of suitability (indicated by red and orange shades) spreads further south during the future periods of 2030-2049 and 2080-2099. Taranaki had low suitability under the historic climate, but suitability increases over time to cover most low elevation parts of the region between 2080-2099 (Kean *et al*., 2015).

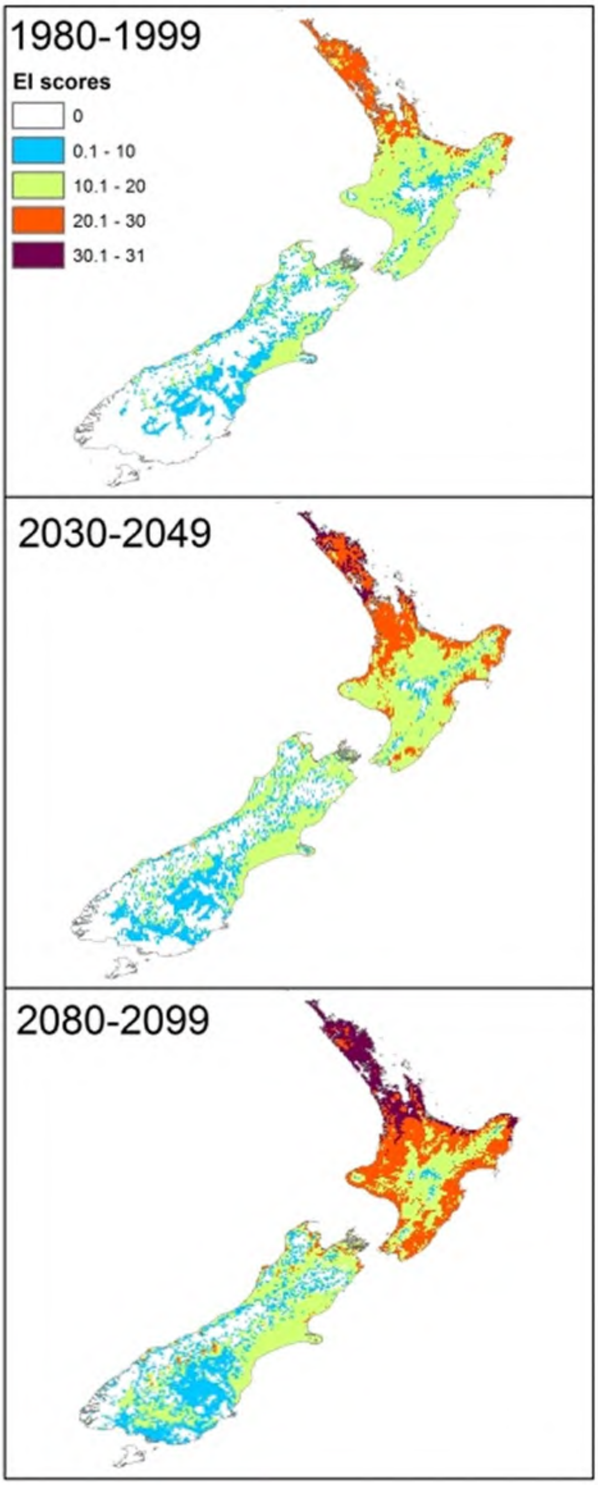


Figure 5-6: Ecoclimatic Index scores for the Queensland fruitfly, Bactrocera tryoni, for three periods 1980-1999, 2030-2049, and 2080-2099. EI scores >19 indicate a high probability that the site is suitable for long-term population persistence (e.g. red and orange shades). The climate data are for the A1B scenario (equivalent to RCP6.0) and the CM2.1-GFDL general circulation model. Source: Kean *et al*. (2015).

The arrival of new pest plants and the increased invasiveness of existing weeds is one of the most significant likely consequences of climate change. More plant species are present in warmer regions, so as frost declines in frequency, winters warm, and more insect pollinator species are able to survive in warmer temperatures, a much larger range of weed species will be able to compete with local species (McGlone and Walker, 2011). Ornamental plants may escape cultivation when climatic constraints (such as frosts) are reduced and subsequently may naturalise and become invasive (Sheppard *et al.*, 2016). Sheppard (2013) modelled the potential distribution of recently naturalised plant species in New Zealand with future climate change (*Archontophoenix cunninghamiana* (bangalow palm), *Psidium guajava* (common guava), and *Schefflera actinophylla* (Queensland umbrella tree)). All three species, which are currently only present in northern New Zealand (Northland and Auckland), have the potential to significantly increase their range further southward in the future, particularly into coastal areas around the country.

The shift towards reliance on drought and heat tolerant plants (in particular, pasture grasses) may cause new pest species to spread and for new host/pest associations to develop (Kean *et al*., 2015). The 2014 emergence of two native moths (*Epyaxa rosearia* and *Scopula rubraria)* as major plantain (a variety of pasture grass) pests demonstrates how a large increase in usage elevated these previously harmless species to pest status. In addition, as kikuyu grass (*Cenchrus clandestinus*) is likely to become the most prevalent forage grass with increasing temperatures, pests that affect kikuyu grass are likely to be important. Some pest species from Australia (e.g. the *Sphenophorus venatus vestitus* weevil) have already been recorded on kikuyu in Northland and pests such as this are likely to spread further in New Zealand as the climate warms. However, the projected reduction in rainfall and humidity in some areas may actually reduce certain fungal disease pressures that require a wetter environment (Coakley *et al.*, 1999).

It is important to note that although much of the biosecurity risk with climate change will come from beyond New Zealand's borders, many of the future's pest, disease and weed problems are currently dormant in New Zealand, awaiting some perturbation, such as climate change, to allow them to spread and flourish. These types of pests are often weeds but may also be invertebrates. A few examples of sleeper invertebrate pests that are affected by temperature include (after Kean *et al*. (2015)):

- Migratory locust *Locusta migratoria,* found in grassland from Christchurch northwards. Because existing temperatures are not usually high enough to trigger swarming behaviour, the insect currently is not regarded as a pest. However, the locusts have retained the capacity to swarm with a small swarm observed near Ahipara, Northland in the 1980s.
- Tropical armyworm *Spodoptera litura.* While this pest can be found through many lowland North Island districts, epidemic outbreak populations, when caterpillars move 'like an army' through crops and pastures, are rare. However, the combination of events that cause outbreaks will be more common under projected climate change scenarios and include above-average summer and autumn temperatures, allowing for additional generations to develop.

For more detailed information about the potential effects of climate change on current and potential terrestrial biosecurity pests and diseases in New Zealand, see Kean *et al*. (2015).

Aquatic biosecurity

The primary source of entry for aquatic biosecurity risk organisms into New Zealand is and will continue to be through international shipping. These risk organisms are contained within ballast water or attached to the hulls of ships. However, changes in water temperature and ocean currents into the future, because of climate change, may result in species (including pests and pathogens) not usually seen in New Zealand waters to arrive and establish. Sea temperatures are projected to increase around New Zealand, particularly to the west of the country, and seawater is likely to become more acidic (Law et al., 2018).

Long-term changes in marine environmental variables, such as seawater temperature, may lead to new ecological compatibilities and may alter existing host-pathogen interactions. It is commonly accepted that warmer sea and freshwater temperatures modify host-pathogen interactions by increasing host susceptibility to disease. Such changes could contribute to the emergence of aquatic diseases in new regions (Castinel *et al.*, 2014).

In terms of freshwater biosecurity, increased water temperatures are likely to favour the expansion of warm water species such as koi carp, goldfish, tench, rudd, and catfish (Office of the Prime Minister's Chief Science Advisor, 2017). These fish can cause water quality degradation and reduced indigenous biodiversity. Increased water temperatures may also facilitate the establishment of tropical fish that are sold in the New Zealand aquarium trade and intentionally or accidentally released. Increasing water temperatures will also favour warm-climate invasive aquatic plant species such as water hyacinth (*Eichhornis crassipes*) and water fern (*Salvinia molesta*).

As discussed above for terrestrial biosecurity, aquatic organisms already established within the New Zealand region that are not currently pests may become problematic under changed environmental conditions with climate change – these are called “sleeper pests”.

5.7 Human health

Most of the information in this section is summarised from Royal Society of New Zealand (2017) – a report titled *Human health impacts of climate change for New Zealand.*

Around the world, climate change has already contributed to increased levels of ill health, particularly in connection with summer heatwaves. Climate change affects human health in numerous ways. The ideal healthy human has complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity. Changes to the climate can impact on these:

- Directly via air and sea temperature, flooding or storms;
- Indirectly due to changes to the environment and ecosystems; and
- Indirectly due to social and economic changes, such as migration stresses, health inequality and socioeconomic deprivation.

In New Zealand, children, the elderly, people with disabilities and chronic disease, and low-income groups are particularly vulnerable to climate change-related health impacts. Māori are also particularly vulnerable due to existing health inequalities, having an economic base invested in primary industries, housing and economic inequalities, and a greater likelihood of having low-income housing in areas vulnerable to flooding and sea-level rise.

5.7.1 Direct health impacts

Increased flooding, fires and infrastructure damage

Increased frequency and magnitude of fires, floods, storm tides and extreme rainfall events will affect public health directly through injury (e.g. being burnt by fire or swept away by floods or landslides). These extreme events may also have negative effects on wellbeing through disease outbreaks, toxic contamination, effects of damp buildings, mental health issues, disruption to healthcare access and damage to homes (lasting from weeks to months after the initial event).

Displacement

Sea-level rise and coastal erosion, as well as river flooding, may require people to leave their homes. This can cause uncertainty and lead to mental health issues from the trauma of leaving familiar surroundings, the breaking of social ties, and the difficulty of resettlement.

Extreme heat

Hot days have well-established negative impacts on the levels of illness and death, and diabetes and cardiovascular disease increase sensitivity to heat stress. Heat stress is particularly significant when hot spells occur at the beginning of the hot season before people have become acclimatised to hotter weather. The increasing number of hot days in Taranaki will likely cause detrimental impacts on health.

Heat also poses health risks for people who work outdoors, including heatstroke and renal (kidney) impairment. The increased heat is also associated with increased incidences of aggressive behaviour, violence, and suicide. Individuals with mental health conditions are especially vulnerable to high temperatures or heat waves, primarily due to not drinking enough fluids, getting access to cool places, or recognising symptoms of heat exposure.

5.7.2 Indirect health impacts

Harmful algal blooms

Increasing temperatures will increase the likelihood of blooms of harmful algae, including blue-green algae (cyanobacteria). These algae produce toxins that can, by either contact or ingestion, cause liver damage, skin disorders, and gastrointestinal, respiratory and neurological symptoms. These blooms can be widespread and long-lasting and can have impacts on commercial seafood harvesting and people reliant on non-commercial harvesting (particularly Māori and Pasifika people), as well as drinking water supplies and recreational water use.

Microbial contamination

Changing weather patterns, including more extreme rainfall events, flooding, and higher temperatures, are likely to interact with agricultural runoff and affect the incidence of diseases transmitted through contaminated drinking and recreational water. Conditions may also be more suitable for bacterial growth – extreme rainfall may be a key climatic factor influencing the incidence of waterborne diseases like *Norovirus. Vibrio* marine bacteria are highly responsive to rising sea temperatures and may cause infected wounds, diarrhoea and septicaemia.

Food availability, quality and safety

Climate change-induced changes to weather patterns and sea-level rise have direct effects on food production, which can affect food affordability and availability, locally and globally. Changes in air and water temperatures, rainfall patterns and extreme events can also shift the seasonal and geographic occurrence of bacteria, viruses, parasites, fungi and other pests and chemical contaminants. This can lead to reduced food safety prior to, during and after harvest, and during transport, storage, preparation and consumption. For example, higher temperatures can increase the number of microorganisms already present on fruit and vegetables, and flooding is a factor in the contamination of irrigation water and farm produce and the *E. coli* contamination of shellfish.

Mental health and wellbeing

Increased temperatures, extreme weather events, and the displacement of people from homes and communities will have significant mental health and wellbeing consequences. These range from minimal stress and distress symptoms to clinical disorders such as anxiety, depression, post-traumatic stress and suicidal thoughts. For New Zealanders, the natural environment is at the heart of the nation's identity. Disruption of bonds with the natural environment (e.g. through relocation of communities) can cause grief, loss and anxiety.

Outdoor air quality

Changes in temperature, rainfall, and air stagnation can affect air pollution levels and human health. Chronic health conditions such as asthma and chronic obstructive pulmonary disease are particularly affected by outdoor air quality. Climate change is expected to increase the risk of fire, which may cause more particulate emissions (PM10 and PM2.5) as well as ozone. Particulate matter smaller than 2.5 µm in diameter (PM2.5) is associated with severe chronic and acute health effects, including lung cancer, chronic obstructive pulmonary disease, cardiovascular disease, and asthma development and exacerbation. The amount of soil-derived PM10 dust in the air may also increase in areas more frequently affected by drought. Due to extended growing seasons with climate change (due to higher CO_2 and higher temperatures), allergenic pollen may become more abundant in the atmosphere (seasonally, spatially and at higher volumes).

However, improvements in outdoor and indoor air quality may be realised with ongoing warming and consequent reductions in wintertime domestic fire use, as well as a move towards an electrified vehicle fleet.

Carriers of new diseases

There are a number of organisms, including mosquitoes, ticks, and fleas that can transmit infectious diseases between humans or from animals to humans. The seasonality, distribution and common occurrence of diseases spread by these carriers are largely influenced by climatic factors, particularly high and low-temperature extremes and rainfall patterns. Therefore, climate change may create favourable conditions and increase the risk of infectious disease transmission in some areas. Increased temperature, in particular, heightens the risk for mosquito-borne diseases which are currently absent from New Zealand because the mosquitoes that carry these diseases (*Aedes aegypti* and *Aedes albopictus*) are not established in our current climate (it is too cold) (Derraik and Slaney, 2015). These diseases include West Nile virus, dengue fever, Murray Valley encephalitis, Japanese encephalitis, Ross River virus, and Barmah Forest virus (most of these are present in Australia). Mosquito-borne diseases like Zika and chikungunya that are already present in the Pacific Islands could become more of a risk for New Zealand if climate change allows important disease-transmitting mosquitoes to become established here. Disease-carrying mosquitoes are often intercepted in New Zealand, particularly at seaports.

Summary

Overall, climate change-induced hazards are likely to expose Taranaki to a variety of direct and indirect health impacts. Both types of impacts could threaten residents' life (existential threats) or degrade their health and wellbeing. Increased flooding and extreme heat are examples of direct drivers of potential health issues in this region. The indirect impacts include the drivers that cause some secondary health issues over time. These impacts include harmful algal blooms and microbial contamination which release toxic substances to drinking water resources, reduced rainfall or flooding that impact food production and distribution system, or increased abundance and distribution pattern of pathogens and disease due to rising temperature. Mental health and wellbeing are other aspects of human health issues that could be impacted by climate change-oriented hazards such as heat stress, flooding and fire events.

6 Summary and conclusions

This report presents climate change projections for Taranaki. Historic climatic conditions are presented to provide a context for future changes. The future changes discussed in this report consider differences between the historical period 1986-2005 and two future time-slices, 2031-2050, "2040", and 2081-2100, "2090".

It is internationally accepted that further climate changes will result from increasing amounts of anthropogenically produced greenhouse gases in the atmosphere. The influence from anthropogenic greenhouse gas contributions to the global atmosphere is the dominant driver of climate change conditions, and it will continue to become more dominant if there is no slowdown in emissions, according to the IPCC. In addition, the climate will vary from year to year and decade to decade owing to natural variability.

Notably, future climate changes depend on the pathway taken by the global community (i.e. through mitigation of greenhouse gas emissions or an ongoing high emissions trajectory). The global climate system will respond differently to future pathways of greenhouse gas concentrations. The representative concentration pathway approach taken here reflects this variability through the consideration of multiple scenarios (i.e. RCP4.5, a mid-range scenario, and RCP8.5, a high-end scenario). The six climate models used to project New Zealand's future climate were chosen by NIWA because they produced the best results when compared to historical climate and circulation patterns in the New Zealand and southwest Pacific region. They were as varied as possible to span the likely range of model sensitivity. The average of outputs from downscaling simulations derived from all six models (known as the 'ensemble average'), is presented in the climate change projection maps in this report. The ensemble-average was presented, as taking averages over a number of simulations reduces the effect of 'noise' in the climate signal.

Changes to the future climate of Taranaki are likely to be considerable. Some of the main impacts projected include an increase in hot days, a reduction in frost days, a shift to larger extreme rainfall events and increased potential for drought. The following list summarises the projections of different climate variables in Taranaki:

- The projected temperature changes increase with time and greenhouse gas concentration scenario. Future annual average warming spans a wide range: 0.50-1.00°C by 2040, and 1.00-1.50°C (RCP4.5) or 2.50-3.00°C (RCP8.5) by 2090.
- Annual average maximum temperatures are expected to increase by 0.75-1.00°C by 2040 under RCP4.5. By 2090, maximum temperatures are projected to increase by 1.25-2.00°C (RCP4.5) or 2.50-3.50°C (RCP8.5). Increasing maximum temperatures will result in more hot days (days with the maximum temperature above 25°C). Up to 15 more annual hot days are projected by 2040, with up to 63 more annual hot days by 2090 (RCP8.5).
- Annual average minimum temperatures are expected to increase by 0.50-0.75°C by 2040 under RCP4.5. By 2090, minimum temperatures are projected to increase by 1.00-1.25°C (RCP4.5) or 2.00-3.00°C (RCP8.5). Increasing minimum temperatures will likely result in fewer frost days for the region (days with the minimum temperature below 0°C). The largest decreases are projected for high elevation and inland locations, with up to 15 fewer frost days projected by 2040, and up to 23 fewer days by 2090 (RCP8.5). Smaller decreases are generally projected for coastal locations from Ōpunake north to Waitara because fewer frosts historically occur in those locations.
- Maximum temperatures are projected to increase more than minimum temperatures, resulting in an increased diurnal temperature range (i.e. the difference between the daily maximum and minimum temperature will increase). Diurnal temperature range is projected to increase by up to 0.50°C by 2040 under RCP4.5, and by up to 1.00°C by 2090 under RCP8.5.
- Projected changes in rainfall show variability across Taranaki. Annually, rainfall is projected to increase for most of the region, with greater increases by 2090 and under RCP8.5 (up to +12%). Larger rainfall increases as well as rainfall decreases are projected at the seasonal scale for parts of Taranaki. By 2090, some parts of the region have projected winter increases of 8-22% (RCP8.5), and spring decreases of up to 6% (RCP4.5).
- Extreme, rare rainfall events are projected to become more severe in the future. Short duration extreme rainfall events (e.g. thunderstorms) have the largest relative increases compared with longer duration extreme rainfall events (e.g. ex-tropical low pressure systems). For the selected locations analysed in this report, rainfall depths for 1-in-50-year and 1-in-100-year events are projected to increase across the representative concentration pathways and future time periods.
- Drought potential is projected to increase across Taranaki, with annual accumulated Potential Evapotranspiration Deficit (PED) totals increasing with time and increasing greenhouse gas concentrations. By 2040, PED totals are projected to increase by 25-90 mm. By 2090, PED totals are projected to increase by 25-90 mm (RCP4.5) or 30-110 mm (RCP8.5).

The effects of climate change on hydrological characteristics were examined by driving NIWA's national hydrological model with downscaled Global Climate Model (GCM) outputs from 1971-2099 under different global warming scenarios. Using a combination of six GCMs and four warming scenarios allows us to consider a plausible range of future trajectories of greenhouse gas concentrations and climatic responses. The changing climate over this century is projected to lead to the following hydrological effects, resulting in the region's hydrological regime shifting towards more hydrological extremes (wet or dry):

- Annual average discharge is projected to remain stable or slightly increase across RCPs and future time periods.
- Mean annual low flows (MALF) are expected to decrease across RCPs and future periods for most catchments. Reduction in MALF of up to 50% is expected for most of the river systems in the region with increased greenhouse gas concentrations and time.

One of the major and most certain (and so foreseeable) consequences of increasing concentrations of greenhouse gases and associated warming, is the rising sea level. Rising sea level in past decades have already affected human activities and infrastructure in coastal areas is New Zealand, with a higher base mean sea level contributing to increased vulnerability to storms and tsunami.

- Absolute sea-level rise (SLR) in Taranaki, calculated from satellite altimetry, is trending at around 4 mm/year (trend for 1993-present): close to the New Zealand-wide average of 4.4 mm/year (calculated up to the end of 2015).
- By 2090, sea-level rise of 0.5 m (RCP4.5) or 0.7 m (RCP8.5) is projected (relative to 1986-2005 baseline).

A changing climate will have impacts on different sectors and environments in Taranaki, which are summarised in the table below:

Sector/Environment	Potential climate change impact/opportunity
Hill country erosion and landslides	Increased risk of land degradation resulting from landslides and soil erosion may be anticipated due to projected increase in severity of extreme rainfall events. Erosion control initiatives (e.g. planting trees) will remain a useful way to retain productive soil on farms and reduce sediment entering waterways.
Pasture growth	Warmer winter and spring periods will allow increased seasonal growth rates. Summer growth may be suppressed by i) temperatures that are too high, and ii) limited water availability due to increased potential evapotranspiration deficit.
Exotic forestry	Increased productivity due to increased temperatures and carbon dioxide. The extra growth caused by carbon dioxide fertilisation may make trees more susceptible to wind damage. Projected increase in fire risk, and drier conditions may result in faster fire spread and greater areas burned.
Ecosystems	Loss of habitat due to sea-level rise and coastal erosion (coastal squeeze) – this could be made worse by human responses to climate impacts e.g. sea walls. Risks to indigenous ecosystems and species due to the increased spread of invasive species. Warming oceans may impact the distribution of marine species (native and invasive).
Human health	Direct impacts on health via increased flooding, fires, and infrastructure damage, displacement of people, extreme heat. Indirect impacts on health via things such as harmful algal blooms, microbial contamination, food availability and quality, mental health and wellbeing, outdoor air quality, and carriers of new diseases.

6.1 Recommendations for future work

This report provides the most comprehensive and up-to-date climate change projections for Taranaki currently available. However, there are areas that were out of scope for this report, or where there is currently no Taranaki-specific information available, which may be considerations for future work. Some of these are indicated below:

- In relation to Freshwater:
  - Projections of changes to large floods (magnitude and frequency) are not currently available, but investigations into how large floods may change in the future are the subject of an ongoing 5-year research programme led by NIWA. It is anticipated that data will likely become available for use by councils in due course.
  - Further work to understand climate change impacts on surface water low flows, groundwater recharge, lake levels, and wetlands, to inform policy development. This is particularly relevant regarding water availability for water allocation limits, which need to consider the foreseeable impacts of climate change (Ministry for the Environment, 2022).
  - Additional work using SedNetNZ (Dymond *et al.*, 2016) to understand the impacts of climate change on soil erosion and suspended sediment loads in Taranaki.
- Given the projected increases in temperature, an investigation could focus on the potential changes to heat stress in the agricultural sector (e.g. projected change in occurrence of heat stress conditions for dairy cows).
- A detailed analysis of wildfire risk in the context of projected climate change was beyond the scope of this report and there is much potential for future research on this front. One possibility for such work could be to analyse and map future areas of high fire risk by combining projected climate data such as temperature, precipitation, and wind with relevant fire risk factors such as vegetation type and flammability. Such work would likely require a collaborative research effort between NIWA and an institute specialised in wildfire research such as Scion.
- Potential changes to crop suitability with climate change – modelling specific to Taranaki could be carried out as this has been done for other parts of New Zealand for a range of crop types (e.g. Ausseil *et al*., 2019; Teixeira *et al*., 2020)[8].

7 Acknowledgements

Victoria McKay and Abby Matthews at Taranaki Regional Council are thanked for their feedback on this report in its draft form, as well as their contribution to identifying recommendations for future work.

[8] For additional information about this work, refer to the "Climate change & its effect on our agricultural land" project at: https://www.deepsouthchallenge.co.nz/projects/climate-change-its-effect-our-agricultural-land

8 Glossary of abbreviations and terms

CMIP5	Fifth Coupled Model Inter-comparison Project
ENSO	El Niño-Southern Oscillation
GCM	General Circulation Models
GPS	Global Positioning System
HIRDS	High Intensity Rainfall Design System
IPCC	Intergovernmental Panel on Climate Change
IPO	Interdecadal Pacific Oscillation
MALF	Mean annual low flow
MSLP	Mean sea level pressure
NIWA	National Institute of Water and Atmospheric Research
RCM	Regional climate modelling
RCP	Representative Concentrations Pathway
RSLR	Relative sea-level rise
SAM	Southern Annular Mode
SST	Sea surface temperature
TRC	Taranaki Regional Council
VCSN	Virtual Climate Station Network
VLM	Vertical land movement

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Appendix A Global and New Zealand climate change

Key messages

- The global climate system is warming and many of the recently observed climate changes are unprecedented.
- Global mean sea level has risen over the past century at a rate of about 1.7 mm/year and has very likely accelerated to 3.2 mm/year since 1993.
- Human activities (and associated greenhouse gas emissions) are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels.
- Estimated human-induced global warming is currently increasing at 0.2°C per decade due to past and ongoing emissions.
- Continued increases in greenhouse gas emissions will cause further warming and impacts on all parts of the global climate system.

Warming of the global climate system is unequivocal, and since the 1950s, many of the observed climate changes are unprecedented over short and long timescales (decades to millennia) (IPCC, 2013). These changes include warming of the atmosphere and ocean, diminishing of ice and snow, sea-level rise, and increases in the concentration of greenhouse gases in the atmosphere. Climate change is already influencing the intensity and frequency of many extreme weather and climate events globally. Increases in average temperatures will result in related increases in the occurrence of extreme temperatures. The Earth's atmosphere has warmed by approximately 0.85°C on average over the period 1880-2012. The rate of sea-level rise since the mid-19th century has been larger than the mean rate of change during the previous two millennia. From the start of New Zealand's records (1901) to 2018, national mean coastal sea levels have risen 1.81 (±0.05) millimetres per year (Ministry for the Environment & Stats NZ, 2019).

Global atmospheric concentrations of carbon dioxide have increased to levels unprecedented in at least the last 3 million years (Willeit *et al.*, 2019). Carbon dioxide concentrations have increased by at least 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land use change emissions (IPCC, 2013). In December 2021, the global carbon dioxide concentration of the atmosphere was 416.9 parts per million (NOAA, 2022). The ocean has absorbed about 30% of the emitted anthropogenic carbon dioxide, causing ocean acidification. Due to the influence of greenhouse gases on the global climate system, it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC, 2013; IPCC, 2018).

Published information about the expected impacts of climate change on New Zealand is summarised and assessed in the Australasia chapter of the IPCC Working Group II Sixth Assessment Report (Lawrence *et al.*, 2022), as well as a report published by the Royal Society of New Zealand (Royal Society of New Zealand, 2016). Key findings from these publications include:

The regional climate is changing. The Australasia region demonstrates long-term trends toward higher surface air and sea surface temperatures, more hot days and heatwaves, fewer cold extremes, and changed rainfall patterns. Increasing greenhouse gas concentrations have contributed to rising average temperatures in New Zealand. Changing precipitation patterns have resulted in increases in rainfall for the south and west of the South Island and decreases in the north of the North Island

(Ministry for the Environment & Stats NZ, 2020). Some heavy rainfall events already carry the fingerprint of a changed climate, in that they have become more intense due to higher temperatures allowing the atmosphere to carry more moisture (Dean *et al.*, 2013). Frosts have become less common, while the number of warm days and heatwaves days is increasing (Ministry for the Environment & Stats NZ, 2020).

The region has exhibited warming to the present and is virtually certain to continue to do so. Based on observations, New Zealand's mean annual temperature has increased by an average of 1.07°C (± 0.24°C) per century since 1909 (Figure A-).

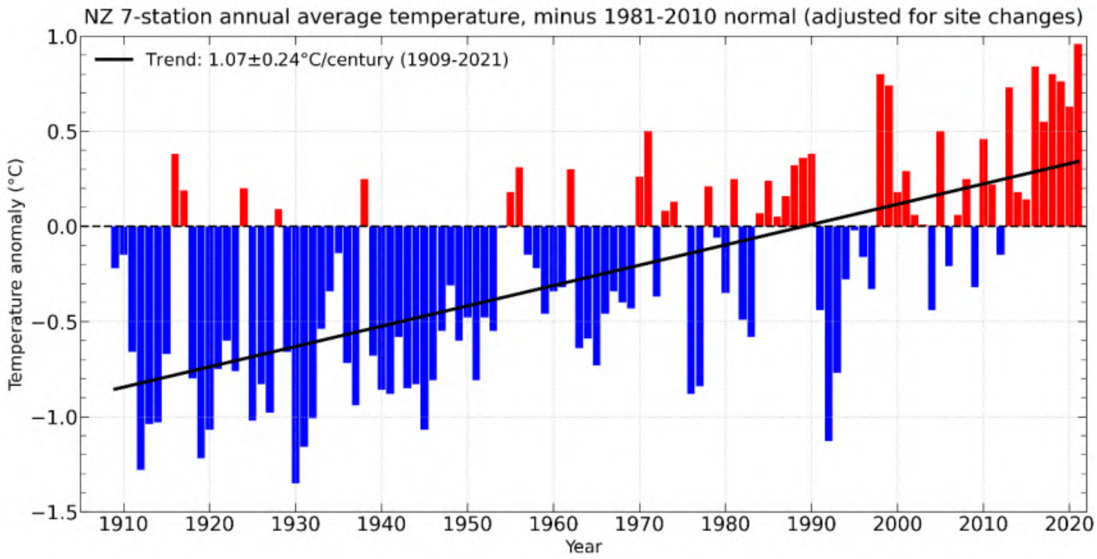


Figure A-1: New Zealand national temperature series, 1909-2021. More information about the New Zealand seven-station temperature series can be found at https://niwa.co.nz/seven-stations.

Warming is projected to continue through the 21st century along with other changes in climate. Warming is expected to be associated with ongoing significant glacier retreat, more frequent hot days, less frequent cold days, and increasing rainfall intensity. Annual average rainfall is projected to decrease in the north and east of the North Island, and to increase in southern and western parts of the South Island (Ministry for the Environment, 2018). Fire hazard is projected to increase in many parts of New Zealand, especially on the eastern coast in the southern half of both islands (Watt *et al.*, 2019). Regional sea level rise will very likely exceed the historical rate, consistent with global mean trends (Ministry for the Environment, 2017).

Impacts and vulnerability: Without adaptation, further climate-related changes are projected to have substantial impacts on water resources, coastal ecosystems, infrastructure, health, agriculture, and biodiversity. However, uncertainty in projected rainfall changes and other climate-related changes remains large for many parts of New Zealand, which creates significant challenges for adaptation.

Additional information about recent New Zealand climate change can be found through the Ministry for the Environment (2018), and the Ministry for the Environment & Stats NZ (2020).

Appendix B Year to year climate variability and climate change

Key messages

- Natural variability is an important consideration in addition to the underlying climate change signal. It will continue to affect the year-to-year climate of New Zealand into the future.
- El Niño-Southern Oscillation is the dominant mode of inter-annual climate variability and it impacts New Zealand primarily through changing wind, temperature and rainfall patterns.
- The Interdecadal Pacific Oscillation affects New Zealand through drier conditions in the east and wetter conditions in the west during the positive phase and the opposite in the negative phase.
- The Southern Annular Mode affects New Zealand through higher temperatures and settled weather during the positive phase and lower temperatures and unsettled weather during the negative phase.

Much of the material in this report focuses on the projected changes to the climate of Taranaki over the coming century due to increases in global anthropogenic greenhouse gas concentrations. However, natural variations will also continue to occur. Much of the variation in New Zealand's climate is random and lasts for only a short period, but longer term, quasi-cyclic variations in climate can be attributed to different factors. Three large-scale oscillations that influence climate in New Zealand are the El Niño-Southern Oscillation, the Interdecadal Pacific Oscillation, and the Southern Annular Mode (Ministry for the Environment, 2008). Those involved in (or planning for) climate-sensitive activities in Taranaki will need to cope with the combination of both anthropogenic change and natural variability.

The effect of El Niño and La Niña

El Niño-Southern Oscillation (ENSO) is a natural mode of climate variability that has wide-ranging impacts around the Pacific Basin (Ministry for the Environment, 2008). ENSO involves a movement of warm ocean water from one side of the equatorial Pacific to the other, changing atmospheric circulation patterns in the tropics and subtropics, with corresponding shifts for rainfall across the Pacific.

During El Niño, easterly trade winds weaken and relatively warm water moves eastward across the equatorial Pacific, accompanied by higher rainfall than normal in the central-east Pacific. La Niña produces opposite effects and is typified by an intensification of easterly trade winds, retention of warm ocean waters over the western Pacific. ENSO events occur on average three to seven years apart, typically becoming established in April or May and persisting for about a year thereafter.

During La Niña events, the strengthened trade winds usually cause New Zealand to experience a stronger than normal north-easterly airflow. This generally brings higher seasonal temperatures to the country and wetter than normal conditions to the north and east of the North Island, as well as to Taranaki (Figure B-2).

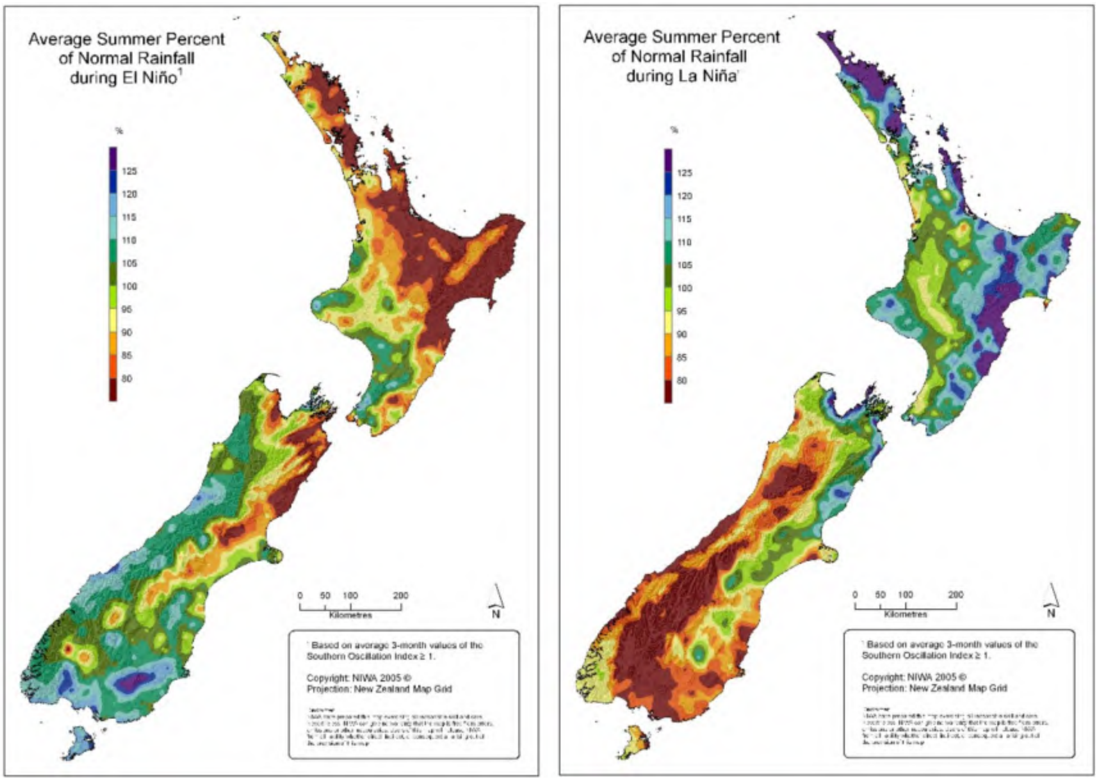


Figure B-2: Average summer percentage of normal rainfall during El Niño (left) and La Niña (right). El Niño composite uses the following summers: 1963/64, 1965/66, 1968/69, 1969/70, 1972/73, 1976/77, 1977/78, 1982/83, 1986/87, 1987/88, 1991/92, 1994/95, 1997/98, 2002/03. La Niña composite uses the following summers: 1964/65, 1970/71, 1973/74, 1975/76, 1983/84, 1984/85, 1988/89, 1995/96, 1998/99, 1999/2000, 2000/01. This figure was last updated in 2005.

According to IPCC (2013), ENSO is highly likely to remain the dominant mode of natural climate variability in the 21st century, and that rainfall variability relating to ENSO is likely to increase due to increased moisture availability. However, there is uncertainty about future changes to the amplitude and spatial pattern of ENSO.

The effect of the Interdecadal Pacific Oscillation

The Interdecadal Pacific Oscillation (IPO) is a large-scale, long-period oscillation that influences climate variability over the Pacific Basin including New Zealand (Salinger *et al*., 2001). The IPO operates at a multi-decadal scale, with phases lasting around 20 to 30 years. During the positive phase of the IPO, sea surface temperatures around New Zealand tend to be lower, and westerly winds stronger, resulting in wetter conditions for western areas of both North and South Islands (including Taranaki). The opposite occurs in the negative phase. The IPO can modify New Zealand’s connection to ENSO, and it also positively reinforces the impacts of El Niño (during IPO+ phases) and La Niña (during IPO- phases).

The effect of the Southern Annular Mode

The Southern Annular Mode (SAM) represents the variability of circumpolar atmospheric jets that encircle the Southern Hemisphere that extend out to the latitudes of New Zealand. The SAM is often coupled with ENSO, and both phenomena affect New Zealand’s climate in terms of westerly wind strength and storm occurrence (Renwick & Thompson, 2006). In its positive phase, the SAM is associated with relatively light winds and more settled weather over New Zealand, with stronger westerly winds further south towards Antarctica. In contrast, the negative phase of the SAM is associated with unsettled weather and stronger westerly winds over New Zealand, whereas wind and storms decrease towards Antarctica.

The phase and strength of the SAM is influenced by the size of the ozone hole, giving rise to positive trends in the past during spring and summer. In the future other drivers are likely to have an impact on SAM behaviour, for example changing temperature gradients between the equator and the high southern latitudes would have an impact on westerly wind strength in the mid-high latitudes.

The influence of natural variability on climate change projections

It is important to consider human-induced climate change in the context of natural climate variability. An example of this for temperature is shown in Figure B-3. The solid black line on the left-hand side represents the annual average temperature for New Zealand based on the average of a number of climate simulations forced by historic greenhouse gas concentrations. All the other line plots and shading refer to the modelled air temperature averaged over the New Zealand region from individual simulations. Post-2005, the coloured line plots show the annual temperature changes for the New Zealand region under four different scenarios of future greenhouse gas concentrations, with the heavier lines showing the six-model average temperature projections for each concentration scenario, and the lighter lines showing the results for each of the six downscaled climate models for both historical and future periods.

For the future 2006-2100 period, the models show very little warming trend after about 2030 under the low greenhouse gas concentration (“RCP2.6”, blue shading) scenario, whereas temperature changes between +2.0°C and +3.5°C by 2100 are projected under the high concentration (“RCP8.5”, red shading) scenario.

Figure B-3 should not be interpreted as a set of specific predictions for individual years. However, it illustrates that although we expect a long term overall continuing upward trend in temperatures (other than for the RCP2.6 scenario), there will still be some relatively cool years. For this particular example, a year which is unusually warm under our present climate could become typical by about 2050, and an “unusually warm” year in 30-50 years’ time (under the higher concentration scenarios) is likely to be warmer than anything we currently experience. The strength of future anthropogenic trends in other climate variables will be smaller in relation to their large year-to-year variability, with the notable exception of sea-level rise.

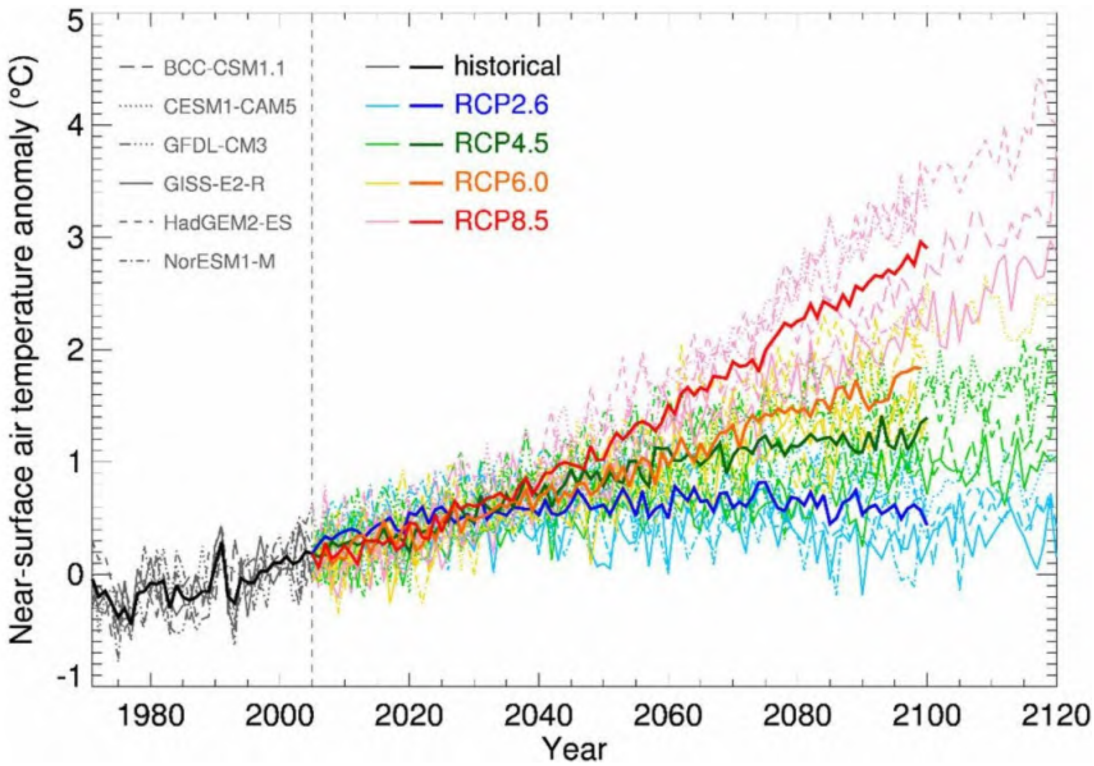


Figure B-3: New Zealand modelled air temperature. Historical (black) and future projections for four RCPs and six downscaled climate models, illustrating future year-to-year variability. See text for full explanation. From Ministry for the Environment (2018).

Appendix C Methodology

Climate modelling

NIWA has used global climate model simulations from the IPCC Fifth Assessment to generate climate change projections for New Zealand using both dynamical (regional climate modelling, RCM) and statistical downscaling procedures. These are described in more detail in a climate guidance manual prepared for the Ministry for the Environment (2018), but a short explanation for the dynamical procedure is provided below. All climate variables and indices presented in this report are based on the dynamical downscaling approach.

Coupled global atmosphere-ocean general circulation models (GCMs) are used to generate climate change projections for prescribed future greenhouse gas concentration scenarios, and results from these models are available through the Fifth Coupled Model Inter-comparison Project (CMIP5) archive (Taylor *et al*., 2012). Simulations from six GCMs were selected by NIWA for dynamical modelling, and the bias corrected sea surface temperatures (SSTs) from these six CMIP5 models were used to drive a global atmosphere-only GCM, which in turn drives a higher resolution regional climate model (RCM) for the New Zealand domain. These CMIP5 models were chosen because they produced the most consistent results when compared to historical climate and circulation patterns in the New Zealand and Southwest Pacific region. Additional selection criteria for the parent global models was that they were the least similar to each other such that they spanned the likely range of model differences. The dynamical downscaling procedure involves forcing a higher-resolution regional climate model (RCM) with data from a coarser global model (GCM) at the lateral boundaries to obtain finer scale detail over a limited area.

The six GCMs chosen for the sea surface temperatures were BCC-CSM1.1, CESM1-CAM5, GFDL-CM3, GISS-E2-R, HadGEM2-ES and NorESM1-M. The NIWA downscaling (RCM) produced simulations that contain daily climate variables, including precipitation and surface temperature, from 1971 through to 2100. The native resolution of the regional climate model is approximately 30 km (0.27 degrees). However, climate models are known to have considerable biases due to inadequate representation of some critical processes and features (e.g. clouds, precipitation). The daily precipitation projections, as well as daily maximum and minimum temperatures, were bias corrected so that the probability distributions from the RCM were aligned with those derived from the Virtual Climate Station Network (VCSN) data on the model resolution when the RCM is driven by the observed large scale circulation across New Zealand (known as 're-analysis' data, REAN; Sood, 2015). When the RCM is driven from the free-running GCMs, forced by CMIP5 sea surface temperatures (SSTs), additional biases occur due to biases in the large-scale circulation in the global model without data assimilation. Therefore, the climate variables from the RCM nested in the free running GCMs forced by historic greenhouse gas concentrations (RCPpast) are expected to have larger biases than where the lateral boundaries of the RCM are forced by reanalysis (REAN) data derived from observations.

The RCM output is then downscaled using interpolation and physically based models from ~30 km to a ~5 km grid at a daily time-step. The ~5 km grid corresponds to the VCSN grid[9]. Figure C-4 shows a schematic for the dynamical downscaling method used in this report.

[9] Virtual Climate Station Network, a set of New Zealand climate data based on a 5 km by 5 km grid across the country. Data have been interpolated from 'real' climate station records (Tait *et al*., 2006).

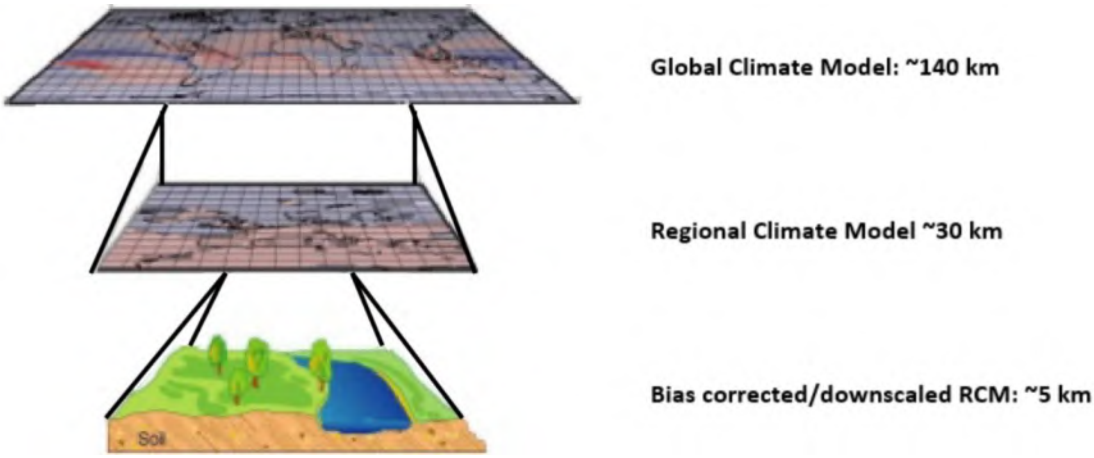


Figure C-4: Schematic diagram showing the dynamical downscaling approach. This approach utilises outputs from global climate models (relatively low spatial resolution; ~140 km) to generate regional climate model projections of a relatively high spatial resolution (~5 km) that better accounts for New Zealand's complex topography.

The change in the mean climatologies of climate variables averaged from the six model simulations, the 6-model ensemble mean, is presented for the climate simulations rather than for any individual model. The model ensemble mean climatology of climate variables is a better representation of the corresponding climate change signal (i.e. projected change of climate variables compared to historic average; also termed signal), since the averaging process reduces the internal variability of the climate system (also termed noise). This is particularly relevant where the signal to noise ratio is small. Though only a small number of model simulations (six) were possible due to large computing resources required for running climate model simulations, they were very carefully selected to cover a wide range of the larger CMIP5 model ensemble.

Climate projections are presented as a 20-year average for two future periods: 2031-2050 (termed '2040') and 2081-2100 (termed '2090'). All maps show changes relative to the baseline climate of 1986-2005 (termed '1995'), as used by IPCC (2013). Hence the projected changes by 2040 and 2090 should be thought of as 45-year and 95-year projected trends. Note that the projected changes use 20-year averages, which will not entirely represent and smoothen the natural variability of the selected period. The baseline maps (1986-2005) show modelled historical climate conditions from the same six models as the future climate change projection maps.

Representative concentration pathways

Assessing possible changes for our future climate due to human activity is challenging because climate projections strongly depend on estimates for future greenhouse gas concentrations. In turn, those concentrations depend on global greenhouse gas emissions that are driven by factors such as economic activity, population changes, technological advances and policies for mitigation and sustainable resource use. This range of uncertainty has been dealt with by the IPCC through consideration of 'scenarios' that describe concentrations of greenhouse gases in the atmosphere. The wide range of scenarios are associated with possible economic, political, and social developments during the 21st century. In the 2013 IPCC Fifth Assessment Report, a selection of these scenarios were called Representative Concentrations Pathways (RCPs).

These representative pathways are abbreviated as RCP2.6, RCP4.5, RCP6.0, and RCP8.5, in the order of increasing radiative forcing in Watts/m^2 of area from increasing greenhouse gases (i.e. the change in net energy in the atmosphere due to greenhouse gas concentrations). RCP2.6 requires net global emissions to reduce to zero around the 3rd quarter of this century, leading to low anthropogenic greenhouse gas concentrations (also requiring removal of carbon dioxide from the atmosphere), and called the 'mitigation' pathway (and the scenario closest to the aspirational goal of the 2015 Paris Agreement of reducing global temperature rise below 2°C above pre-industrial times). RCP4.5 and RCP6.0 are two 'stabilisation' pathways (where greenhouse gas concentrations stabilise by 2100), and RCP8.5 represents continuing high global emissions without effective mitigation, which will lead to high greenhouse gas concentrations (a 'high end' pathway). Therefore, the RCPs represent the outcomes of a range of 21st-century climate policies.

Table C-1 shows the projected global mean surface air temperature for each RCP. The full range of projected globally averaged temperature increases for all pathways for 2081-2100 (relative to 1986-2005) is 0.3 to 4.8°C (Figure C-5). Warming will likely continue beyond 2100 under all RCPs except RCP2.6. Warming will continue to exhibit inter-annual-to-decadal variability and will not be regionally uniform.

Table C-1: Projected change in global mean surface air temperature. For the mid- and late- 21st century relative to the reference period of 1986-2005 for different RCPs. After IPCC (2013).

Scenario	Alternative name	2046-2065 (mid-century)		2081-2100 (end-century)	
		Mean (°C)	Likely range (°C)	Mean (°C)	Likely range (°C)
RCP2.6	Mitigation pathway	1.0	0.4 to 1.6	1.0	0.3 to 1.7
RCP4.5	Stabilisation pathway	1.4	0.9 to 2.0	1.8	1.1 to 2.6
RCP6.0	Stabilisation pathway	1.3	0.8 to 1.8	2.2	1.4 to 3.1
RCP8.5	High end pathway	2.0	1.4 to 2.6	3.7	2.6 to 4.8

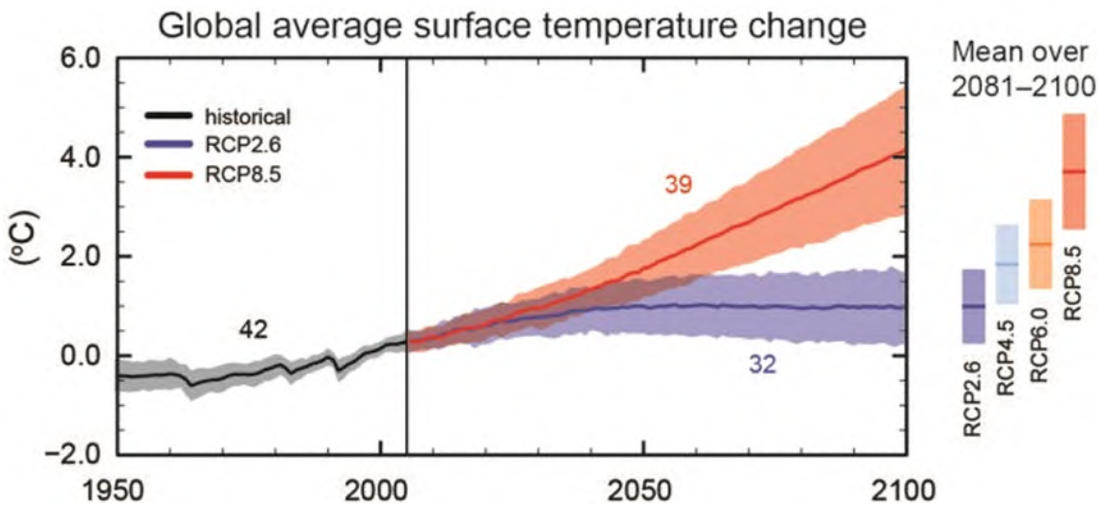


Figure C-5: CMIP5 multi-model simulated time series from 1950-2100 for change in global annual mean surface temperature relative to 1986-2005. Time series of projections and a measure of uncertainty (shading) are shown for scenarios RCP2.6 (blue) and RCP8.5 (red). Black (grey shading) is the modelled historical evolution using historical reconstructed forcing. The mean and associated uncertainties averaged over 2081−2100 are given for all RCP scenarios as coloured vertical bars to the right of the graph (the mean projection is the solid line in the middle of the bars). The numbers of CMIP5 models used to calculate the multi-model mean is indicated on the graph. From IPCC (2013).

Cumulative greenhouse gas emissions will largely determine global mean surface warming by the late 21st century and beyond. Even if emissions are stopped, the inertia of many changes in global climate will continue for many centuries to come, with the longest lag effect being sea-level rise. This represents a substantial multi-century climate change commitment created by past, present and future emissions – particularly for coastal areas facing ongoing sea-level rise.

Hydrological modelling

To assess the potential impacts of climate change on agricultural water resources, a hydrological model is required that can simulate soil moisture and river flows continuously and under a range of different climatic conditions, both historical and future. Ideally the model would also simulate complex groundwater fluxes but there is no national hydrological model capable of this at present. Because climate change implies that environmental conditions are shifting from what has been observed historically, it is advantageous to use a physically based hydrological model over one that is more empirical, with the assumption that a better representation of the biophysical processes will allow the model to perform better outside the range of conditions under which it is calibrated.

The hydrological model used in this study is NIWA's TopNet model (Clark *et al.*, 2008), which is routinely used for surface water hydrological modelling applications in New Zealand. It is a spatially semi-distributed, time-stepping model of water balance, that is used commonly in New Zealand for catchment, regional and national scale hydrological modelling. It is driven by time-series of precipitation and temperature, and of additional weather elements where available. TopNet simulates water storage in the snowpack, plant canopy, rooting zone, shallow subsurface, lakes and rivers. It produces time-series of modelled river flow (without consideration of water abstraction, impoundments or discharges) throughout the modelled river network, as well as evapotranspiration, and does not consider irrigation. TopNet has two major components, namely a basin module and a flow routing module.

The model combines TOPMODEL hydrological model concepts (Beven *et al*., 1995) with a kinematic wave channel routing algorithm (Goring, 1994) and a simple temperature based empirical snow model (Clark *et al.*, 2008). As a result, TopNet can be applied across a range of temporal and spatial scales over large watersheds using smaller sub-basins as model elements (Ibbitt and Woods, 2002; Bandaragoda *et al*., 2004). Considerable effort has been made during the development of TopNet to ensure that the model has a strong physical basis and that the dominant rainfall-runoff dynamics are adequately represented in the model (McMillan *et al*., 2010). TopNet model equations and information requirements are provided by Clark *et al.* (2008) and McMillan *et al.* (2013).

For the development of the national version of TopNet used here, spatial information in TopNet was provided by national datasets as follows:

- Catchment topography based on a nationally available 30 m Digital Elevation Model (DEM).
- Physiographical data based on the Land Cover Database version two and Land Resource Inventory (Newsome *et al*., 2012).
- Soil data based on the Fundamental Soil Layer information (Newsome *et al*., 2012).
- Hydrological properties (based on the River Environment Classification version one (REC1) (Snelder and Biggs, 2002).

The method for deriving TopNet's parameters based on GIS data sources in New Zealand is given in Table 1 of Clark *et al.* (2008). Due to the paucity of some spatial information at national/regional scales, some soil parameters are set uniformly across New Zealand.

To carry out the simulations required for this study, TopNet was run continuously from 1971 to 2100, with the spin-up period 1971 excluded from the analysis. The climate inputs were stochastically disaggregated from daily to hourly time steps. As the GCM simulations are "free-running" (based only on initial conditions, not updated with observations), comparisons between present and future hydrological conditions can be made directly (as each GCM is characterised by specific physical assumptions and parameterisation), but this also means that simulated hydrological hindcasts do not track observational records.

Hydrological simulations are based on the REC 1 digital river network aggregated up to Strahler catchment order three (approximate average catchment area of 7 km^2) used within previous national and regional scale assessments (Pearce *et al*., 2017; 2018); residual coastal catchments of smaller stream orders remain included. The simulation results comprise hourly time-series of various hydrological variables for each computational sub-catchment, and for each of the six GCMs and two RCPs considered. To manage the volume of output data, only river flows information was preserved; all the other state variables and fluxes can be regenerated on demand.

Hydrological projections are presented as the average for two future periods: 2036-2056 (termed 'mid-century') and 2086-2099 (termed 'late-century'). All maps show changes relative to the baseline climate (1986-2005 average). The periods analysed are slightly different from the corresponding time slices of the atmospheric modelling because the modelling was done before this project was initiated. We do not expect that the conclusions drawn would be substantively different if the periods were aligned. Hydrological projections were analysed for the following hydrological statistics: Mean annual discharge and Mean annual low flow (MALF).

Because of TopNet assumptions, soil and land use characteristics within each computational subcatchment are homogenised. Essentially this means that the soil characteristics and physical properties of different land uses, such as pasture and forest, will be spatially averaged, and the hydrological model outputs will approximate conditions across land uses. The data used in the hydrology section of the report is consistent with Collins and Zammit (2016).

MEMORANDUM
Policy & Planning

Date 7 June 2022

Subject: **Freshwater Implementation Programme Update**

Approved by: A D McLay, Director - Resource Management

S J Ruru, Chief Executive

Document: 3065890

Purpose

1. The purpose of this memorandum is to provide the Committee with a Freshwater implementation project update.

Recommendations

That the Taranaki Regional Council:

a) receives the update on Freshwater implementation programme.

Background

2. The Council has prepared an implementation programme of the Government's Freshwater programme. The purpose of this memorandum is to update Members on progress in implementing the project. The implementation programme has previously been presented to, and approved by, the Committee.

Financial considerations—LTP/Annual Plan

3. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

4. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

5. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.

Community considerations

6. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

7. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices/Attachments

Document 3073322: Freshwater Implementation Project - Report to Policy & Planning Committee (May 2022)

Taranaki Regional Council

Freshwater Implementation Project Report to Policy & Planning Committee

30 May 2022

Document Number: 3073322

Executive Summary

Progress has continued well, with all programme areas on or slightly ahead of planned May activities.

Detailed implementation plan developed for the next six months of implementation, through to the end of December 2022. Alongside this, a lookback review of the past six months showed that all key tasks had been completed as planned. The few tasks that were still outstanding were largely for reasons beyond officers' control (eg. lack of consulting resource to enable completion of key studies) – and none were considered critical path that could delay implementation.

On a related note, good initial meeting with Iwi CEO's on the first draft of a Heads of Agreement for the Waitara River Committee. General support for the draft proposed by officers, with a series of specific recommendations received. Second draft shared with CEO's to enable consultation with their Boards, prior to meeting again in July to discuss next steps. That meeting will also likely engage on the Ngati Maru JMA – which is very much dependent on and linked to the Waitara River Committee.

Project Programme

Key project achievements during the last reporting period

- Specific implementation activities:
    - Continuing Special Interest Group ("SIG") engagement, focusing on four sessions on water take to be held late May/early June
    - Policy and plan drafting continuing – internal workshops on structures and water takes; drafting begun on wetlands; targeting starting provisions on Te Mana o Te Wai by early June.
    - Looking to re-establish Wai Maori group to support engagement and input to NRP.
    - Discussions with iwi taiao staff about delivering a series of briefings to FW focused officers about iwi management plans.
    - EQ focus on drafting State of the Environment ("SoE") report, which will be presented to Council in July. Other key work activities on FMU stocktake and audit of fish passage structures/obstacles.
    - Consents reviewing consent rules and requirements for structures and (with Compliance) farm dairy effluent renewals.

Key upcoming activities and milestones in the next reporting period

- Continue iwi engagement – including management plan briefings from iwi te taiao staff.
- Continue plan drafting – focusing on wetlands and Te Mana o Te Wai.
- Continue roll out of limit setting – science led activities to inform policy drafting and engagement.
- Continue first round of focused, SIG engagement as follow up to initial workshops,
- Drafting a decision making process document – setting out the required steps for internal and external (ie. governance) review and approval of key deliverables.
- Compliance audit for feed pads, including assessing the data and developing appropriate follow up plans and monitoring programmes.
- Riparian planting programme audit continues.

HSE Updates

Nothing significant to report

Workstream Status Summary		
Workstream	**Tracking**	**Comments/Clarifications**
Tangata whenua partnerships		• Overall iwi engagement programme is underway – discussions with iwi taiao staff about delivering a series of briefings to FW focused officers about iwi management plans. Currently targeting June/July for meetings. • Recruitment of the two Council funded Iwi Planning Officers by Iwi is currently underway. • Working with Ngati Mutunga to build GIS capacity – including providing a list of FW implementation resources that are available for sharing.
Policy and Planning		• Completed NRP fact sheet and shared with other teams/officers. • On-going cycles of engagement with iwi – met with Ngati Ruanui. • Working to re-establish Wai Maori working group, with an initial focus on Te Mana o Te Wai. • Plan drafting – internal workshops held on structures and water takes; drafting begun on wetlands; targeting starting provisions on Te Mana o Te Wai by early June.
Science Services		• Main focus on completing State of the Environment ("SoE") report for presentation to Council on 7 June. • Good progress on FMU stocktakes - text written and out for external communications review. • Some work has commenced on broader SoE FW review - wider project kick off by end of the month. • Work underway on fish passage review – in particular around dams and weirs (including Otahi weir removal discussions).
Consents		• No noticeable increase in consent applications related to FW Implementation. • Reviewing in stream structures consent conditions and working with Compliance to review farm dairy effluent consent replacement processes.

Compliance		• Continuation of BAU from last month:
		  o Limited activity at present, due to government postponing/delaying implementation timelines of key elements.
		  o Continuing providing key FW related messaging to farmers during dairy round (eg., N-Cap reporting, feed-pads, effluent discharge rules).

Operations		• Riparian programme audit moving to field fest phase – with slight delay due to errors that became apparent in the test app. • Slightly behind target of 10,000ha new farm plans - working with Comms to prepare material for farmers to try to pick up the total.
Engagement		• Business cases being prepared for SteerCo review for key engagement steps – rural sector advertising and Social Pinpoint licence (engagement tool). • Preparing for four engagement sessions with Special Interest Groups late May/early June. Following up key themes and messages from the April round of engagement sessions. • Continuing recruiting for Engagement Officer position. Initial round unsuccessful after preferred candidate withdrew for personal reasons.

Project Risk/Opportunity Management

Description	Effect	Mitigation Strategy	Risk Rating (unmitigated)	Actions currently being taken
Lack of a clear strategy and timeline for engagement on key strategic issues.	Engagement in this sense is the two way discussions needed to obtain external stakeholder input on key FW programme and FW Plan elements. Engagement requirements for FW are significantly higher than previous TRC experience (due to NPS-FW requirements). Experience from other RC's is that the process can be long and involved. Lack of dedicated engagement (as opposed to comms) resources to manage this process.	Build greater alignment around the nature and timing of the engagement that is needed. Develop specific strategies and plans to undertake the focused engagement. Consider ways to address Council's current gaps in capacity and capability to lead engagement processes.	High	Currently developing position description and beginning recruiting process for engagement officer role. Detailed engagement plan developed and being implemented. Plan identifies two key stakeholder groups who will receive more extensive engagement – as well as higher level consultation and information for more general groups. Plan will be implemented in parallel with the current workstreams to develop iwi partnering (led by CEO and Iwi Communications, with support from all FW Focus Leads).

Description	Effect	Mitigation Strategy	Risk Rating (unmitigated)	Actions currently being taken
Lack of clarity and guidance due to gaps in key Government advice or changes in the policy/legal framework	Some FW Implementation elements need to be developed in the absence of clear guidance – which may result in changes later if Government position changes. This lack of guidance also increases risks of a need for rework. Examples of areas where there are gaps in clear guidance include: • Managing diffuse nitrogen loss risks (including the applicability of Overseer) • Managing climate change impacts on freshwater.	Recognise that some level of risk is unavoidable. Maintain strong presence on Government (especially MfE) and sector working groups. Maintain contacts with other regional council *Essential Freshwater* teams. Develop tools and processes that based on established or determined best practice.	High	Risk has impacted delivery and is a factor behind the revised project timeline. Officers are progressing activities to the extent that they can – with a constant attempt to balance between maintaining progress and minimising the risk of potential rework. Policy & Planning and Science Services activities are the most impacted. Risk is expected to remain high for the duration of the project.

Taranaki Regional Council

MEMORANDUM
Policy & Planning

Date 7 June 2022

Subject: **Key Native Ecosystems Programme Update**

Approved by: D Harrison, Director - Operations

S J Ruru, Chief Executive

Document: 3042628

Purpose

1. The purpose of this memorandum is to present for Members' information an update on the identification of sixteen new Key Native Ecosystem (KNE) sites.

Executive summary

2. The *Biodiversity Strategy for the Taranaki Regional Council* ('the Biodiversity Strategy') sets out four strategic priorities for the Taranaki Regional Council (the Council), one of which relates to the protection of KNEs on privately owned land.
3. KNEs refer to terrestrial (land) areas identified by the Council as having regionally significant ecological values and are targeted for ongoing protection.
4. Officers work with interested landowners, including iwi, and community groups to promote the voluntary protection and enhancement of ecological values associated with the sites.
5. Any landowners can seek an ecological assessment of their particular site for potential involvement in the KNE programme. When opportunities arise, new sites are assessed by Council officers to determine their regional significance, and/or identify agreed management actions to maintain and enhance those values.
6. Protection of KNEs is part of the Council's non-regulatory work and involves working with interested landowners and others through the preparation and implementation of biodiversity plans, the provision of environmental enhancement grant funding, and/or assisting with pest and weed control.
7. Sixteen new sites have been identified this financial year covering a total area of 1,354.6 ha.
8. With the addition of the new sites, and the addition of one site where an existing KNE was split in two, the Council has so far identified 358 KNEs covering approximately 129,029 hectares in the region.

9. 304 of the KNE sites are partially or completely privately owned. Together, they cover approximately 19,283 hectares or 30% of the privately owned indigenous vegetation in Taranaki.
10. 209 KNE sites are currently under active management through a Council biodiversity plan, which provides site-specific information on agreed actions for protecting that site. A biodiversity plan typically addresses such matters as formal protection, fencing, weed control, pest control and restoration.

Recommendations

That the Taranaki Regional Council:

a) receives this memorandum and the attached inventory sheets for Patui, Barrel's Creek, Morrison's Bush (QEII 5/06/358), Pukekotahuna Headwaters Reserve, Whare Piwakawaka, NRGE Orchid Haven and Swamp Forest, Middle Bush, Cool Acres, Sunman Farms QEII Covenant, Gillett Family Bush, Patea Saltmarsh Estuary, Fangorn and Forbidden Forest, Ben's Block, Bruce's Bush & Danny's Pond, Mangamaio, Manui Farm QEII Covenants

b) notes that the aforementioned sites have indigenous biodiversity values of regional significance and should be identified as Key Native Ecosystem sites.

Background

11. The Biodiversity Strategy sets out the Council's vision, aims, priorities and work programmes for maintaining and enhancing indigenous biodiversity in the region. In so doing, it assists in giving effect to its statutory functions for indigenous biodiversity under the *Resource Management Act 1991*. The Biodiversity Strategy sets out four strategic priorities, one of which relates to the Council focusing on protecting KNEs on privately owned land.
12. The Council's management approach is to work with interested landowners, community groups and other interested parties to promote the voluntary protection and enhancement of ecological values associated with KNE sites on privately owned land. It involves the provision of a property planning service and other assistance, including the preparation and implementation of biodiversity plans, the provision of environmental enhancement grant funding, and/or assisting with pest and weed control.
13. The identification of KNEs is a comprehensive but ongoing exercise by the Council. The Council maintains an inventory and database identifying KNEs. However, any landowners can seek an assessment of their particular site for potential involvement in the KNE programme. When opportunities arise, new sites are assessed in relation to their regional significance, and/or existing information and databases updated.

KNE site inventory process

14. Council officers have recently investigated and consulted with landowners to identify a further sixteen sites totalling 1,354.6 hectares and recommend they be adopted as KNEs. The candidate sites are:
    - Patui
    - Barrel's Creek
    - Morrison's Bush (QEII 5/06/358)

- Pukekotahuna Headwaters Reserve
- Whare Piwakawaka
- NRGE Orchid Haven and Swamp Forest
- Middle Bush
- Cool Acres
- Sunman Farms QEII Covenant
- Gillett Family Bush
- Patea Saltmarsh Estuary
- Fangorn and Forbidden Forest
- Ben's Block
- Bruce's Bush & Danny's Pond
- Mangamaio
- Manui Farm QEII Covenants.

15. All the sites have been assessed by officers as significant in accordance with criteria set out in Bio Policy 4 of the *Regional Policy Statement for Taranaki* (2010), i.e. rarity and distinctiveness, representativeness or ecological context. Copies of the inventory sheets for the new sites are attached to this item.
16. With the addition of the new sites, the Council has so far identified 358 KNEs (covering approximately 129,029 hectares), which includes some public conservation land. Of the 289,000 hectares of indigenous vegetation in the region, approximately 64,000 hectares is in private ownership.
17. A total of 304 of the KNE sites, covering approximately 19,283 hectares, are partially or completely privately owned. This represents around 30% of the privately owned indigenous vegetation in the region. However, of note KNE sites do not cover all indigenous vegetation in the region but rather the most vulnerable and at risk types of indigenous vegetation.
18. Identification of a site as a KNE does not have any extra bearing on the rules or controls that already apply to such sites in regional or district council plans.
19. Identification of sites is undertaken by the Council to focus its non-regulatory efforts to work with and support landowners to protect biodiversity values on their land. As previously noted, protection is implemented through the preparation and implementation of biodiversity plans, the provision of environmental enhancement grant funding, and/or assisting land occupiers and/or care groups with pest and weed control.
20. The 2021/2031 Long Term Plan includes, amongst other things, a target to maintain and regularly update the Council's Inventory of KNEs. The identification of the additional KNEs gives effect to that commitment.

Financial considerations—LTP/Annual Plan

21. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included

in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

22. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

23. This memorandum and the associated recommendations are consistent with the Council’s policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.

Community considerations

24. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

25. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices/Attachments

Document 2850467: Patui

Document 2784971: Barrel's Creek

Document 2859738: Morrison's Bush (QEII 5/06/358)

Document 2957181: Pukekotahuna Headwaters Reserve

Document 2957616: Whare Piwakawaka

Document 2959931: NRGE Orchid Haven and Swamp Forest

Document 2975942: Middle Bush

Document 2948151: Cool Acres

Document 3000655: Sunman Farms QEII Covenant

Document 3003280: Gillett Family Bush

Document 3018019: Patea Saltmarsh Estuary

Document 3040073: Fangorn and Forbidden Forest

Document 3040000: Ben's Block

Document 3041250: Bruce's Bush & Danny's Pond

Document 3052552: Mangamaio

Document 3035060: Manui Farm QEII Covenants.

Patui

At a glance

TRC Reference: BD/9729

Ecological District: Matemateaonga

Land Tenure: Private

Area(ha): 260

GPS: 1736635X & 5647024Y

Habitat: Forest Remnant

Bioclimatic Zone: Lowland

Ecosystem Type: MF7.2: Rata, tawa, kamahi, podocarp forest
MF7.3: Tawa, pukatea, podocarp forest

LENZ: F7.2a At risk
F1.1d Not threatened

National: Priority 1 – Threatened Land Environment
Priority 2 – Sand Dunes and Wetlands
Priority 4 – Threatened Species

Regional: Key Native Ecosystem

Regional Ecosystem Loss: At risk 20-30% left
Less reduced >50% left

Protection Status: Local Government

Catchment: Patea (343)

General Description

Patui forest remnants are located on privately owned land approximately 22 kms east of Stratford near Makahu in east Taranaki. The site lies within the Matemateaonga Ecological District and Patea River catchment. The remnants cover approximately 260 hectares and are a mix of original and cut over lowland old growth forest with smaller areas of modified regenerating native vegetation, (mainly manuka), in places. The forest is typical of remnant habitats found in the eastern Taranaki area. At the western end, the site connected to adjacent areas of native forest including the Tututawa Conservation Area and Tututawa Local Purpose Reserve. Other nearby protected areas include the Waitiri Scenic Reserve and Popuanui Conservation Area. Two constructed wetlands are also present on the forest margin and provide a small area of wetland habitat at the site.

Ecological Features

Flora

The main canopy is dominated by mature tawa and rewarewa mixed with miro, matai, totara, maire, northern rata and hinau. Occasional large emergent canopy trees, such as rimu and kahikatea, are also present. Lower stature vegetation includes pigeonwood, mapou, mahoe and tree ferns, although is sparse in places. The block also contains some areas of regenerating native scrub in relatively good condition. Notable species include five species of rata, kanuka and manuka.

Fauna

Birdlife at the site is reasonably diverse and includes notable species such as brown kiwi, bush falcon, North Island robin and whitehead. Other forest birds present include the grey warbler, silvereye, pied tomtit, tui, bellbird, fantail, kotare and morepork. Wetland birds include the New Zealand dabchick, greyduck (notable) and paradise shelduck. Long-tailed bats are confirmed present and are notable for the site. The site provides habitat for and will contain other notable fauna including reptiles, native fish and invertebrates.

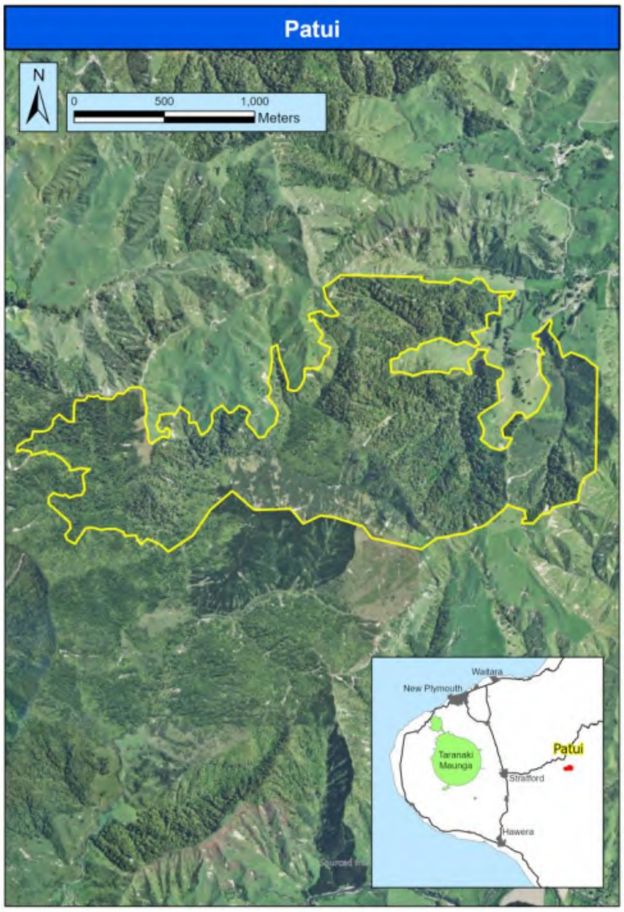
Ecological Values

Sustainability - Positive	In good vegetative condition and large in area. Key ecological processes still influence the site. Under appropriate management, it can remain resilient to existing or potential threats.
Representativeness - Medium	Contains ecosystems listed as 'At Risk' and 'Less Reduced' MF7.2: Rata, tawa, kamahi, podocarp forest (Less Reduced) and MF7.3: Tawa, pukatea, podocarp forest (At Risk). Over 70% of 'At Risk'

	forest has been lost in Taranaki and remnant areas remain under threat from introduced predators and browsers.
Rarity and Distinctiveness - High	Contains a range of notable fauna including the North Island brown kiwi, North Island robin, whitehead and long-tailed bat. A range of other notable fauna will be present. Also contains notable flora species such as five species of rata, kanuka and manuka.
Ecological context - High	The site is moderately large (260 ha) and connected to other existing native habitats in the area including the Tututawa Conservation Area and Tututawa Local Purpose Reserve. Other nearby protected areas include the Waitiri Scenic Reserve and Popuanui Conservation Area.

Other Management Issues

Habitat Modification - Medium	Parts of the forest have been subject to historical logging. The underlying geology of the area also increases the risk of natural erosion.
Herbivores - High	Forest regeneration and the sustainability of palatable species are at high risk from browsers such as possums, goats and stock in this area. Occasional goat control is undertaken on the forest margins.
Predators - High	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site.
Weeds - Low	Weeds, such as Himalayan honeysuckle, are occasionally present in places.



Barrels Creek

At a glance

TRC Reference:	BD/9730	**LENZ:**	F5.2b Acutely threatened
Ecological District:	Egmont	**Local:**	Significant Natural Area
Land Tenure:	Private	**National:**	Priority 1 – Threatened Land Environment
Area(ha):	2.4		Priority 4 – Threatened Species
GPS:	1706933X & 5674841Y	**Regional:**	Key Native Ecosystem
Habitat:	Forest Remnant	**Regional Ecosystem Loss:**	Chronically threatened 10-20% left
Bioclimatic Zone:	Semi-Coastal	**Protection Status:**	QEII Covenant
Ecosystem Type:	WF13: Tawa, kohekohe, rewarewa, hinau, podocarp forest		Local Government
		Catchment:	Waiongana (394)

General Description

The Barrels Creek site is located on privately owned land 2.3km southeast of Lepperton and lies in the Egmont Ecological District and Waiongana Stream catchment. The site is approximately 2.4ha in size and comprised of cutover semi-coastal Tawa, kohekohe, rewarewa, hinau, podocarp forest remnants on hill slopes, flat land and stream terraces. The remnants are of a native forest type that is classified as 'Chronically Threatened' in Taranaki and falls within 'Acutely Threatened' Land Environment (LENZ) F5.2b. Remnants such as this provide important habitat for common, rare and threatened species. Barrels Creek contributes good connectivity with other nearby habitats, covenants and Key Native Ecosystems, such as Wells Cross Road, Hoopers Bush, Lepperton Bush, Tegel QEII and Te Wairoa.

Ecological Features

Flora

The forest canopy is dominated by tawa, kohekohe and puriri, with occasional individuals or small stands of rewarewa, pukatea and titoki. The understory is dominated by kawakawa, with a mix of other species including kanono, pate, pigeonwood, mahoe and tree ferns. Ground cover ferns and seedlings are common. A simple range of climbers and epiphytes are present. Notable flora includes two species of threatened rata and the At Risk, Declining' Kingfern and the 'Regionally Distinctive' jointed fern.

Fauna

Birdlife at the site is reasonably diverse and includes kereru, tui, fantail, grey warbler, silvereye and morepork. A range of exotic species are also present. Good habitat exists for native reptiles including dense vegetation, epiphytes, loose bark, leaf litter, logs and ground cover. Notable reptile species may be present such as the goldstripe gecko. The habitat will contain a diverse range of terrestrial invertebrates, likely including notable species such as peripatus. Two small streams are present which may contain common and notable native species including eel, bullies, galaxid fish and koura.

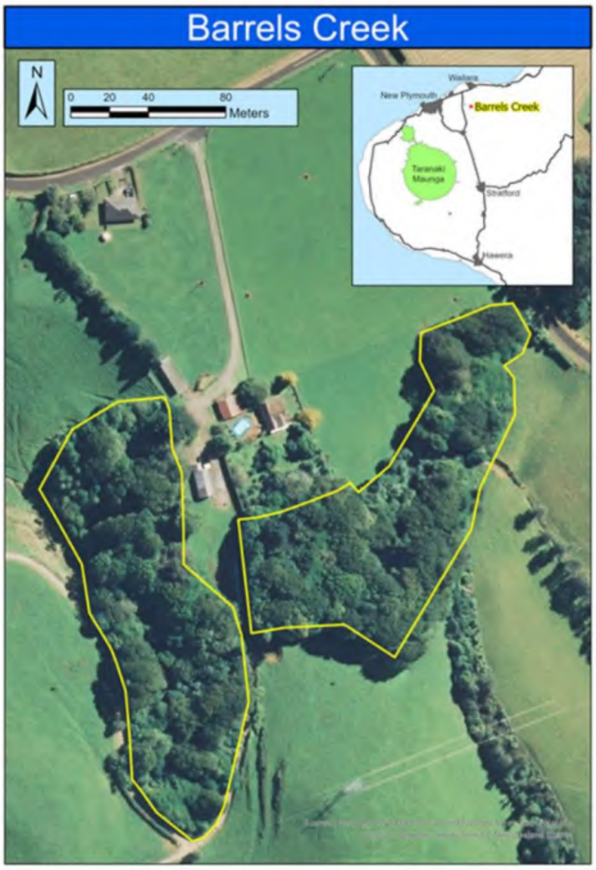
Ecological Values

Sustainability - Positive	In good vegetative condition, though with a moderate edge/compactness ratio. Key ecological processes still influence the site. Under appropriate management, it can remain resilient to existing and potential threats.
Representativeness - High	Contains a land environment type classed as 'Acutely Threatened' (LENZ F5.2b), and an ecosystem type classed as 'Chronically Threatened' (WF13: Tawa, kohekohe, rewarewa, hinau, podocarp forest. Over 83% of this forest type has been lost in Taranaki and

	remnant areas remain under threat from introduced predators and browsers.
Rarity and Distinctiveness - Medium	Contains notable flora including two species of threatened rata and the 'At Risk, Declining' kingfern, and the 'Regionally Distinctive' jointed fern. May provide habitat for other notable fauna such as reptiles, fish and invertebrates.
Ecological Context - Medium	The site is of a threatened land environment and ecosystem type, and provides important 'stepping stone' habitat between near-by forest fragments in a landscape.

Other Management Issues

Habitat Modification - Low	Covenanted with a QEII National Trust conservation covenant.
Herbivores - Medium	There are no browsing ungulate species at the site or near-by on the Taranaki ring plain. While the site is within the possum self-help programme area, a residual possum population will continue to present a low level but constant threat to site flora.
Possum Self-help	The site is within the possum self-help programme area, in the Inglewood North block.
Predators - High	Native fauna, invertebrates and fish would benefit from control of rodents, possums, hedgehogs, mustelids and feral cats.
Weeds - High	The ground cover plant Tradescantia is presenting a major threat to the ecosystem in the eastern forest fragment. There are a range of other pest plants present across both fragments, though these could be relatively easily addressed.



Morrison's Bush (QEII 5-06-358)

At a glance

TRC Reference: BD/9504

Ecological District: Manawatu Plains

Land Tenure: Private

Area(ha): 2.49

GPS: 1731105X & 5596722Y

Habitat: Wetland

Bioclimatic Zone:	Semi-Coastal
Ecosystem Type:	MF7.3: Tawa, pukatea, podocarp forest WF8: Kahikatea, pukatea forest
LENZ:	F5.2c Acutely threatened
National:	Priority 1 – Threatened Land Environment Priority 4 – Threatened Species
Regional:	Potential KNE
Regional Ecosystem Loss:	At risk 20-30% left Acutely Threatened <10% left
Protection Status:	QEII Covenant
Catchment:	Whenuakura (342)

General Description

Morrison's bush remnant consists of a 2.49ha semi-coastal forest dominated by karaka. Forest remnants like this are under-represented in Taranaki owing to widespread clearance for agriculture and urban development. The site lies within the Whenuakura River catchment within the Manawatu Plains Ecological district. Morrison's Bush is in close proximity to Whenuakura Estuary, another Key Native Ecosystem, and provides connectivity to the few remaining fragmented forest remnants within the area.

Ecological Features

Flora

The forest canopy is dominated by karaka with the occasional tawa. The understory is mainly kawakawa, hangehange and karamu with few ferns, grasses and seedlings covering the ground. Recent myrtle rust threats have elevated potentially vulnerable native flora species to 'Threatened' status. Notably, one these new threatened species, white rata, is present at the site. Two 'Regionally Distinctive' species are present at the site; Ngaio, in abundance, and Coastal Tree Daisy which occurs naturally just outside the fenced area, and has also been planted inside the KNE.

Fauna

Native birds present include kereru, tui, silvereye, grey warbler, fantail, harrier and kingfisher. There is good habitat for native reptiles including dense forest canopy, loose bark and logs on the forest floor. The landowners have seen reptiles near the site, species are yet to be identified but may be notable. Koura are also present at the site.

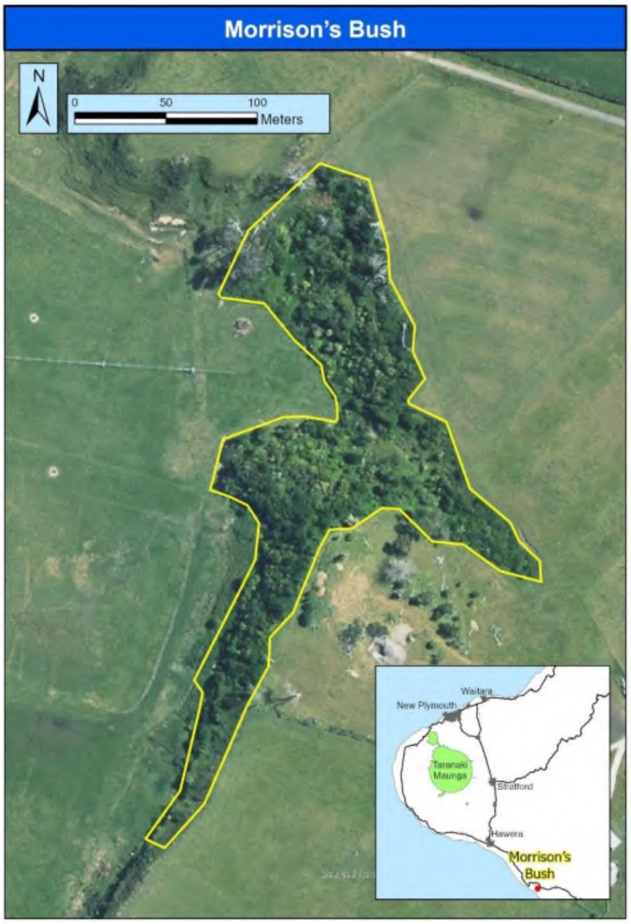
Ecological Values

Ecological Context - Low	Sparse, fragmented remnants of native vegetation remains in the area, other than Whenuakura Estuary, and unprotected tracts of forest on private land.
Representativeness - High	Contains indigenous vegetation on an 'Acutely Threatened' (F5.2c) land environment. Less than 10% indigenous vegetation remains in these environments. Species threatened by habitat loss are often reliant on these remaining habitats for their continued survival. Is a remnant of ecosystems considered 'Acutely Threatened' (WF8: Kahikatea, pukatea forest) and 'At Risk' (MF7.3: Tawa, Pukatea, podocarp forest).
Rarity and Distinctiveness - Medium	Contains one newly listed 'Threatened' flora species due to potential vulnerability to myrtle rust (white rata). Two Regionally

	Distinctive species; Ngaio and Coastal Tree Daisy. Also likely to contain notable fauna species including reptiles and invertebrates.
Sustainability - Positive	Key ecological processes still influence the site and with appropriate management, it can remain resilient to existing or potential threats.

Other Management Issues

Habitat Modification - Medium	Original values of the site will have been altered due to historical drainage. Although the habitat is vulnerable to modification there are no immediate threats.
Herbivores - Low	Fencing around the sites are fully stock proof, therefore threats from grazing animals are low.
Possum Self-help	The site is within the Possum Self - help area and receives occasional control.
Predators - Medium	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site.
Weed Control	Occasional pest plant control has been carried out with help from the QEII Trust.
Weeds - High	Shrub weeds, climbers and spreading ground cover weeds pose the biggest threat to the site.



Pukekotahuna Head Waters Reserve

At a glance

TRC Reference: BD/9740		**LENZ:**	F5.3b Not threatened
Ecological District: Egmont		**Local:**	Significant Natural Area
Land Tenure: Private		**National:**	Priority 4 – Threatened Species
Area(ha): 6		**Regional:**	Key Native Ecosystem
GPS: 1690925X & 5660333Y		**Regional Ecosystem Loss:**	Less reduced >50% left
Habitat: Forest Remnant		**Protection Status:**	QEII Covenant
Bioclimatic Zone:	Lower Montane	**Catchment:**	Te Henui (391)
Ecosystem Type:	MF8.2: Rimu, rātā, kamahi forest		

General Description

Pukekotahuna Headwaters Reserve is located is located off the top end of Mangorei Road, 14 kilometres south west of New Plymouth. The covenant provides connectivity to other priority KNE's and habitats in the area including Te Papakura o Taranaki, Korito Heights, Mount View and Carrington Road KNE's. The site is falls within the Te Henui Catchment and Egmont Ecological District. Covering about 6ha, the site is comprised of cutover forest dominated by Kamahi and includes multiple small unnamed tributaries of the Pukekotahuna Stream.

Ecological Features

Flora

The canopy of the remnant is dominated by kamahi with a mix of hinau, toro, miro, rimu and rewarewa. A good sub canopy and understorey is also present and dominated by toro and toropapa, with kanano, pigeonwood, raukawa, rangiora, pigeonwood and hangehange. Tree ferns and ground ferns are common in places and seedlings and saplings are also abundant. The area falls within the 'Less reduced, better protected' LENZ environment F5.3b.

Fauna

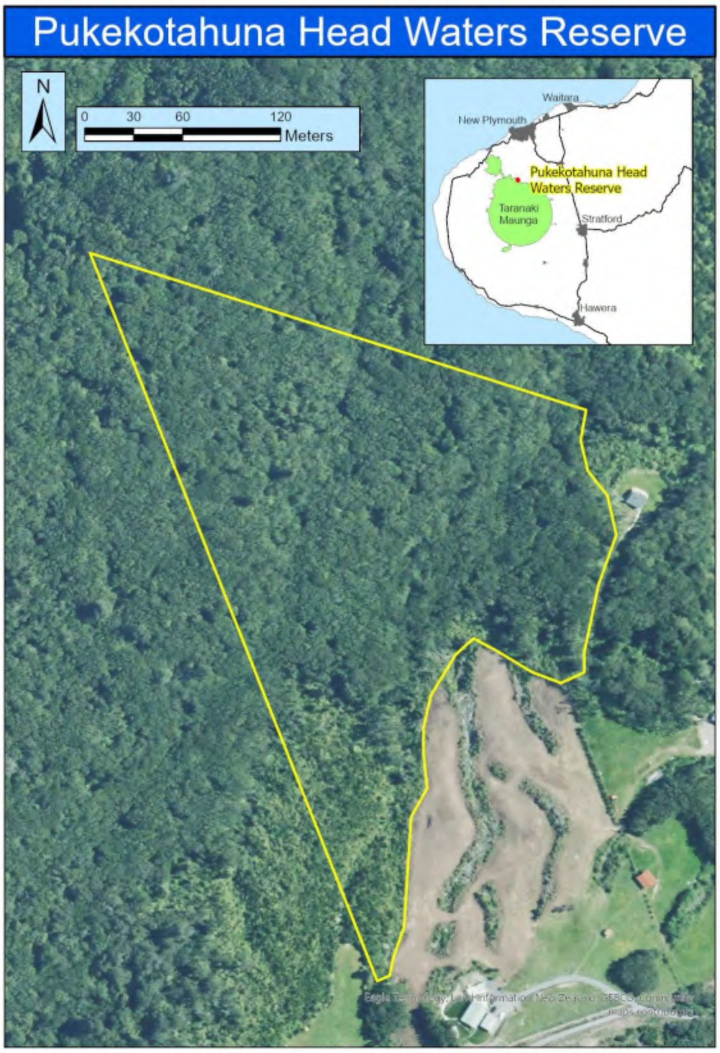
Notable native birdlife recorded within the site include whitehead, kārearea/falcon, rifleman and long tailed cuckoo. Other birdlife includes kererū, tūī, bellbird, fantail, tomtit, silvereye, grey warbler and ruru. Very good habitat exists for notable freshwater fish such as kōkopu species, kōaro and longfin eel. Native freshwater crayfish are present and notable native lizards and invertebrates may also occupy this site.

Ecological Values

Ecological context - High	Contiguous with other priority ecosystems including Te Papakura o Taranaki, recognised as a Significant Natural Area and provides connectivity to other KNEs Korito Heights, Mount View and Carrington Road. Also provides core habitat for 'At Risk' native fauna species and 'Threatened' native flora species.
Rarity and Distinctiveness - Medium	Contains four species of 'Threatened' rata and several notable native bird species including rifleman, kārearea/falcon, long tailed cuckoo and whitehead. Visits from North Island robin and North Island brown kiwi are also likely. Provides good habitat and likely to contain other 'Threatened' and 'At Risk' native species, including freshwater fish and reptiles.
Representativeness - High	Contains indigenous vegetation on F5.3b ('Less reduced, better protected') LENZ environment and is a remnant of an ecosystem

	type (MF8-2 Rimu, rata, kamahi forest) classified as 'Less reduced or intact'. Is close to, and the same forest type as an area identified as a priority representative site for management.
Sustainability - Positive	In good vegetative condition. Key ecological processes still influence the site. Under appropriate management, it can remain resilient to existing or potential threats.

Other Management Issues	
Habitat Modification - Low	Localised modification for access has been carried out. Tracks being cut by the landowner will be primarily for predator control.
Possum Self-help	The sites falls within the possum self-help area, and receives regular control by the landowner.
Predators - Medium	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site.
Weeds – Low	Currently a low threat at this site with occasional shrub weed species present on the margins only.
Herbivores - Low	Feral deer and pigs are absent from this area and feral goats are controlled to very low densities in the surrounding forest.



Whare Pīwakawaka

At a glance

TRC Reference: BD/9743
Ecological District: North Taranaki
Land Tenure: Private
Area(ha): 1.5
GPS: 1713525X & 5650007Y

Habitat: Forest Remnant
Bioclimatic Zone: Lowland
Ecosystem Type: MF7.2: Rātā, tawa, kamahi, podocarp forest

LENZ: F5.2a Acutely threatened
National: Priority 1 – Threatened Land Environment
Priority 4 – Threatened Species
Regional: Key Native Ecosystem
Protection Status: QEII Covenant
Catchment: Waitara (395)

General Description

Whare Pīwakawaka is a small (1.5ha) forest remnant located on privately owned land approximately 4.5km east of Midhirst. The site lies in the Waitara River catchment within the North Taranaki Ecological District. Tawa dominates the canopy, with a few pigeonwood, pukatea and māhoe around the edges. The remnant contains indigenous vegetation in an areas classified as an 'Acutely Threatened LENZ environment (F5.2a). The nearest protected sites (within 5km) include other KNEs in the area such as Makara Farms, Stanley Road and Te Kapua Park Bush.

Ecological Features

Flora

The forest canopy is dominated by tawa, with pigeonwood, pukatea and around the edges. The understorey is absent, although ground ferns, epiphytes and climbers are common. Notably, two species of rātā (recently classified as 'Threatened' due to potential threats by myrtle rust) and the 'Nationally Vulnerable' poroporo are present in this remnant.

Fauna

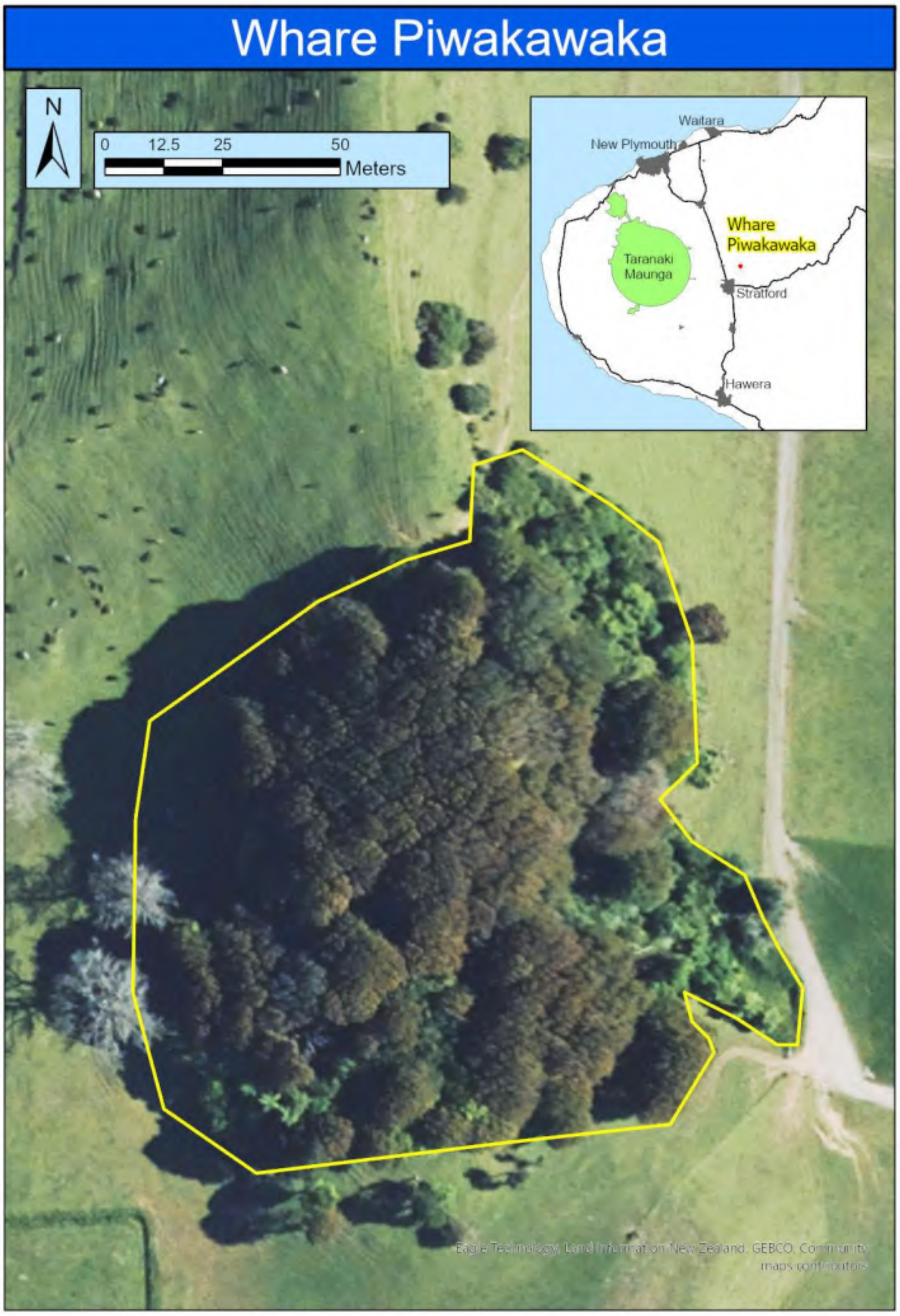
Native birds at the site include fantail, tūī, kererū, silvereye, kingfisher, shining cuckoo, grey warbler, morepork and harrier. The site contains a limited amount of reptile habitat in the way of dense forest canopy, deep leaf litter and logs on the forest floor.

Ecological Values

Ecological Context - Low	This site is isolated from other KNE and private QEII sites in the area but other small fragments of native bush are nearby.
Rarity and Distinctiveness - Medium	Contains two species of 'Threatened' rata and the 'Nationally Vulnerable' poroporo.
Representativeness - Medium	Contains indigenous vegetation on F5.2a (Acutely Threatened) LENZ environment and is a remnant of an ecosystem type (MF7.2 Rata, tawa, kamahi, podocarp forest) classified as 'Less reduced or intact'.
Sustainability - Positive	If left unmanaged, the condition of the site would continue to deteriorate. With appropriate management, the site can recover and begin to regenerate.

Other Management Issues

Habitat Modification - Medium	The site has been heavily browsed by stock, altering the ability of the site to regenerate.
Herbivores - High	Dairy cattle currently graze the site on rotation. The landowners are eager to fence off and protect the site.
Possum Self-help	The sites falls within the possum self-help area, and receives occasional control by friends of the Hancocks.
Predators - Medium	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site.
Weeds - Low	Weeds at the site are currently present in low numbers.



NRGE Orchid Haven and Swamp Forests

At a glance

TRC Reference: BD/9742

Ecological District: Egmont

Land Tenure: Private

Area(ha): 7.5

GPS: 1684214X & 5641815Y

Habitat: Forest Remnant/Wetland

Bioclimatic Zone: Lower Montane

Ecosystem Type: MF7.2: Rata, tawa, kamahi, podocarp forest; MF8.3: Kahikatea, rimu, kamahi forest

LENZ: H1.3b Under protected

National: Priority 4 – Threatened Species; Priority 1 – Threatened Land Environment; Priority 2 – Sand Dunes and Wetlands

Regional: Representative ecosystem type; Key Native Ecosystem

Regional Ecosystem Loss: Less reduced >50% left; Reduced 30-50% left

Protection Status: Local Government

Catchment: Waiaua 2 (Waiaua) (364)

General Description

NRGE Orchid Haven Swamp Forest remnant is located on privately owned land, approx. 13.5km north east of Opunake. The site is in the Egmont Ecological District and located within the Waiaua river catchment. The remnant is comprised of native forest types that have been greatly reduced in Taranaki. The nearest protected sites include other Key Native Ecosystems in the area, such as Wiremu Road Wetland, Kaweora Road Forest and Te Papakura o Taranaki (Egmont National Park)

Ecological Features

Flora

Tawa, kamahi, rimu, raukawa, pigeonwood and hinau, along with rewarewa and a few emergent northern rata make up the majority of the cutover canopy. Swamp maire, pukatea and kahikatea can be found in wetter areas. The subcanopy is lacking due to many years of stock access and browse, however, tree ferns, ground ferns and seedlings and saplings of pate, hangehange, NZ fuchsia are plentiful where access is more difficult. Epiphytes and climbers are abundant. Recent myrtle rust threats have elevated potentially vulnerable native flora species to 'Threatened' 'At Risk' status. Notably, six of these vulnerable species are present at this site including four species of rata, swamp maire (also Regionally Distinctive) and manuka. 'Nationally Critical' poroporo is also present and 'At Risk' Kirk's kohuhu is growing just outside the KNE.

Fauna

Native birds present include tomtit, kereru, tui, silvereye, grey warbler, fantail, kingfisher, harrier and morepork. Bellbird and whitehead are likely to be present, but were not observed during the initial visit. There is very good habitat for a range of other notable native species including freshwater fish, reptiles and invertebrates.

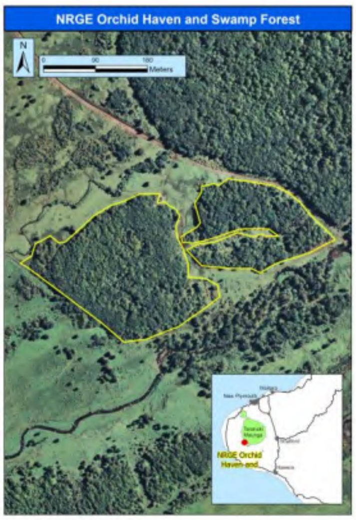
Ecological Values

Ecological context - High	Contiguous with other priority ecosystems including Te Papakura o Taranaki. Provides connectivity to other KNE's including Kaweora Road Forest, Wiremu Road Wetland and many unprotected forest remnants nearby. Provides habitat for 'At Risk', 'Threatened' and 'Regionally Distinctive' native flora species.
Sustainability - Positive	The site will improve dramatically with appropriate management, especially stock exclusion. Without intervention, regeneration will be significantly altered and overall sustainability of this site will be poor.

Representativeness - High	The site has been identified as a priority for management to ensure a representative sample of all ecosystems in the region are maintained (MF8.3: Kahikatea, rimu, kamahi forest and MF7-2 Rata, Tawa, kamahi, podocarp forest). The indigenous vegetation in this area is classified as Underprotected (LENZ environment H1.3b). Less than 30% native vegetation cover remains in these areas and less than 20% are underprotected. More native habitats remaining in these areas require formal protection and conservation management to preserve remaining biodiversity values.
Rarity and Distinctiveness - High	Contains notable species including 'Regionally Distinctive' and 'Threatened' swamp maire, four species of 'Threatened' rata and manuka - all species susceptible to myrtle rust. 'Nationally Critical' poroporo is also present. The 'At Risk' Kirk's kohuhu is growing just outside the KNE boundary. Notable bird species which may be present include bellbird and whitehead, along with 'Threatened' New Zealand Falcon.

Other Management Issues

Habitat Modification - Medium	The understorey has been extensively modified by grazing stock. Stock-proof fencing is necessary to reduce the risk of continued modification.
Herbivores - High	Stock presently have access to the site and have been impacting on the bush by trampling roots and browsing young seedlings and saplings for decades - more so on the forest edge. The new landowners plan to fence to exclude stock in the near future.
Possum Self-help	Falls within the Egmont Stage 3 Possum self-help area. The landowners have recently taken over this property.
Predator Free signed up: Yes	Trap boxes present around the farm by TPFT contractors, but could be shifted to more suitable locations and away from stock.
Predators - Medium	Predators including rodents, mustelids, possums, hedgehogs and feral cats will be present in the wider landscape and impacting on native species at the site.
Weeds - Low	Blackberry is present on the edges of the bush along with small patches of African clubmoss. These weeds could become problematic after stock exclusion and may require management as the site regenerates.



Middle Bush

At a glance

TRC Reference: BD/9744		**LENZ:**	F1.1d Not threatened
Ecological District: Matemateaonga		**National:**	Priority 1 – Threatened Land Environment
Land Tenure: Private			Priority 4 – Threatened Species
Area(ha): 19.6		**Regional:**	Close proximity to a representative ecosystem site
GPS: 1732547X & 5643746Y			Key Native Ecosystem
Habitat: Forest Remnant		**Regional Ecosystem Loss:**	Less reduced >50% left
Bioclimatic Zone:	Lowland		At risk 20-30% left
Ecosystem Type:	MF7.2: Rata, tawa, kamahi, podocarp forest	**Catchment:**	Patea (343)
	MF7.3: Tawa, pukatea, podocarp forest		

General Description

Middle Bush is located on privately owned land near Tututawa in eastern Taranaki. The site lies in the Patea River catchment and is located in the Matemateaonga Ecological District. Covering 19.5 ha, the remnant contains a mix of original and cutover lowland forest, with fringes of regenerating native forest. The site is surrounded by pasture/drystock farmland, some of which is proposed to be planted in manuka and left to regenerate. Other nearby protected areas include the Waitiri Conservation Area, the Eight Hundred Trust KNE and Glanafon Wetlands.

Ecological Features

Flora

The forest canopy is dominated by tawa, with occasional pigeonwood, rimu, rewarewa and kahikatea. The understory and groundcover is fairly sparse, mainly due to goat browse, but epiphytes and climbers are diverse and common. Notably, four 'Threatened' species of climbing rata and manuka the 'Regionally Distinctive' Tawhirikaro (Pittosporum cornifolium) and 'Threatened' Kirk's daisy (Brachyglottis kirkii) were observed during the initial visit.

Fauna

Birdlife at the site is diverse and includes whitehead, tomtit, tui, kereru, silvereye, fantail, grey warbler, shining cuckoo and morepork. Notably, the 'Threatened' New Zealand falcon visits the site and native bats are also likely to be in the general area. Good in stream habitat exists for koura and potentially other native freshwater fish species. Notable native reptiles and invertebrates also may occupy this site.

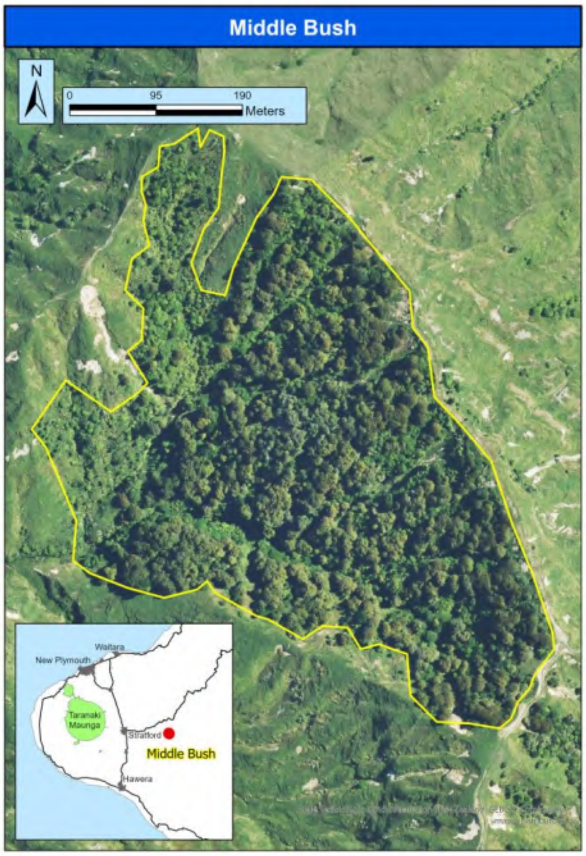
Ecological Values

Ecological Context - Medium	Provides stepping stone connectivity to other forest remnants and KNEs including Waitiri Conservation Area, the Eight Hundred Trust KNE and Glanafon Wetlands. Also provides core habitat for 'Threatened' and 'Regionally Distinctive' flora species.
Rarity and Distinctiveness - High	Contains four species of 'Threatened' rata, the 'Threatened' Kirk's Daisy and 'Regionally Distinctive' Tawhirikaro. Notable bird species includes the 'Threatened' karearea/falcon, which occasionally visit the site. Provides good habitat and likely to contain other notable species including reptiles and invertebrates.
Representativeness - Medium	Contains indigenous vegetation on F1.1d (Less reduced, better protected) LENZ environment and is a remnant of ecosystem types

	(MF7.3 Tawa, Pukatea, podocarp forest and MF7.2 Rata, kamahi, podocarp forest) classified regionally as 'At Risk' and 'Less reduced or intact', respectively. Is nearby and similar in composition to an area identified as a priority representative site for management.
Sustainability - Positive	In good vegetative condition. Key ecological processes still influence the site. Under appropriate management, it can remain resilient to existing or potential threats. Current and planned efforts by the landowners will enhance the site.

Other Management Issues

Habitat Modification - Medium	The original forest has been cutover and cleared in places but is regenerating. Ongoing modification is occurring due to grazing/browsing from stock, feral goats and occasional deer and pigs.
Herbivore Control	The contour of the site makes it near impossible and cost prohibitive to fence to fully exclude sheep. Some natural barriers are in place which restricts sheep mostly to the outer edges of the site. The landowners undertake frequent goat mustering. Pigs are hunted when detected seasonally farm wide. Deer moving through from neighbouring farms are monitored for, and hunted as necessary.
Predators - Medium	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site. Occasional possum control is undertaken using acute toxins.
Weeds - Low	Weeds are not an issue within the site.



Cool Acres

At a glance

TRC Reference: BD/9739		**LENZ:**	F7.2a At risk
Ecological District: Manawatu Plains			F1.3b Less reduced, better protected
Land Tenure: Private			F5.2c Acutely threatened
Area(ha): 925		**National:**	Priority 1 – Threatened Land Environment
GPS: 1726621X & 5618898Y			Priority 4 – Threatened Species
Habitat: Forest Remnant		**Regional:**	Key Native Ecosystem
Bioclimatic Zone:	Lowland	**Regional Ecosystem Loss:**	At risk 20-30% left Less reduced >50% left
Ecosystem Type:	MF21: Tawa, kamahi, rimu, northern rata , black beech forest	**Protection Status:**	Local Government
	MF7.2: Rata, tawa, kamahi, podocarp forest	**Catchment:**	Manawapou (347)
	MF7.3: Tawa, pukatea, podocarp forest		

General Description

The Cool Acres site is located on private land, approximately 13 kilometers east of Hāwera off Inagahape Road, in South Taranaki. The site is large (925 hectares) and made up of a mix of mature cutover native forest, regenerating native forest, and gorse reverting to native. Topography is mainly steep to very steep slopes leading down to the Otoki stream and stream tributaries in the upper Manawapou River catchment. The site lies within the Matemateāonga and Manawatū Plains Ecological Districts. It is directly connected to the Tarere Conservation Area and Raurimu KNEs, providing very good connectivity between indigenous habitats in this area.

Ecological Features

Flora

The areas of old forest canopy are dominated by tawa with a mixed and varied range of other species, including pukatea, rewarewa, kāmahi, miro, rimu, hīnau, kahikatea and pigeonwood. The understory is dominated by unpalatable species, such tree ferns, mingimingi and tree daisy. Notable flora species are present including three species of threatened rata.

Fauna

Birdlife at the site is reasonably diverse and includes notable species such as the North Island brown kiwi, long-tailed cuckoo, North Island robin and whitehead. Other native birds recorded include grey warbler, silvereye, pied tomtit, tui, bellbird, fantail, kereru and morepork. Long-tailed bats are confirmed present and are notable for the site. The site provides habitat for and will contain other notable fauna including reptiles, native fish and invertebrates.

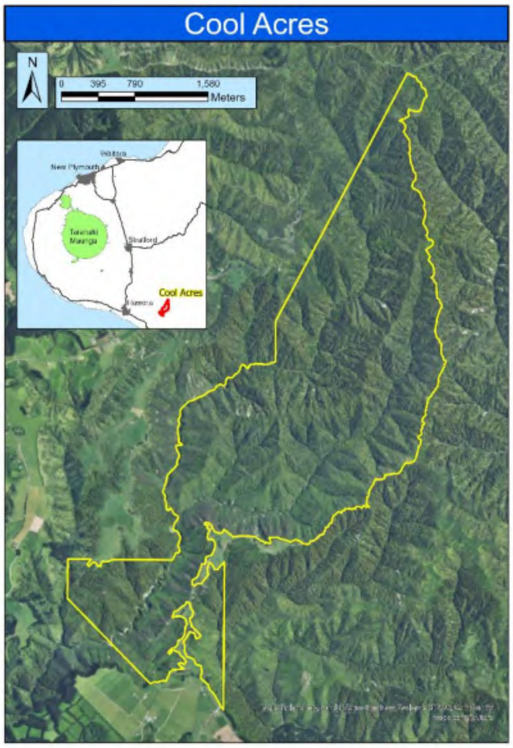
Ecological Values

Sustainability - Positive	In good vegetative condition and large in area. Key ecological processes still influence the site. Under appropriate management, the site can remain resilient to existing or potential threats.
Representativeness - Medium	Contains an ecosystem type listed as 'At Risk' (MF7-3 Tawa, pukatea, podocarp forest). Over 70% of this type of forest has been lost in Taranaki and remnant areas remain under threat from introduced predators and browsers.

Rarity and Distinctiveness - High	Contains a range of notable fauna including the North Island brown kiwi, long-tailed cuckoo, North Island robin, whitehead and long-tailed bat. A range of other notable fauna will also be present including native fish, reptiles and invertebrates. Also contains notable flora species such as five species of threatened rātā and ramarama.
Ecological context - High	The site is large (925 ha) and connected to existing native habitats in the area. The site provides good connectivity to other Key Native Ecosystems and habitats in this area, including the Tarere Conservation Area and Raurimu KNEs.

Other Management Issues

Weeds - Low	A few large areas of gorse are present although reversion to native vegetation is well underway in these areas. Gorse is acting as a good nursery for regenerating seedlings and will be outcompeted by native vegetation in time.
Predators - High	Predator species including rodents, mustelids, possums, feral cats and hedgehogs, will be having an impact on native species at the site.
Herbivores - High	There is high risk to palatable flora species from browsers such as possums and goats in this area. Occasional goat and possum control is currently undertaken along the forest and pasture margins at the south end, however the site is large and well connected to extensive habitat for these pest species, so re-incursion will be ongoing. Feral pigs are occasionally present. Good fencing contains stock on the small pasture margin at the south end.
Habitat Modification - Medium	The soil and underlying geology make the area potentially more at risk from natural erosion.



Sunman Farms QEII Covenant

At a glance

TRC Reference: BD/7006
Ecological District: Egmont
Land Tenure: Private
Area(ha): 1.17
GPS: 1695428X & 5635418Y

Habitat: Forest Remnant
Bioclimatic Zone: Lowland
Ecosystem Type: MF7.2: Rata, tawa, kamahi, podocarp forest
MF7.3: Tawa, pukatea, podocarp forest

LENZ: F5.2a Acutely threatened
National: Priority 1 – Threatened Land Environment
Priority 4 – Threatened Species
Regional: Key Native Ecosystem
Regional Ecosystem Loss: At risk 20-30% left
Protection Status: QEII Covenant
Catchment: Kaupokonui (355)

General Description

The Sunman Farms QEII covenant is a small (1.17ha), privately owned remnant of cut over lowland forest, located approximately 4kms north west of Kaponga. The remnant is mainly situated on flat ground tapering to a small stream on the southwest side. The bush remnant lies in the Egmont Ecological District and Kaupokonui River catchment and provides connectivity to other habitats in the vicinity. Forest remnants such as this are now very rare in this area. The remnant contains vegetation associated with an 'Acutely Threatened' (F5.2a) LENZ environment.

Ecological Features

Flora

The canopy of the forest remnant is dominated by tawa with occasional pukatea, pigeonwood and mahoe. The understory and ground cover is mainly intact and is a mix of kanono, mahoe, pigeonwood, tree ferns and ground ferns. Native climbers and epiphytes are common and include jasmine, muehlenbeckia, perching lily, tank lily and native orchids. Four species of threatened rata and the threatened swamp maire are also present and are notable for the site.

Fauna

Native birds confirmed present include kereru, tui, grey warbler, fantail, pukeko, welcome swallow, pukeko and harrier. Other native birds are likely to be present or use this area such as morepork, shining cuckoo and kingfisher. The site is likely to contain a variety of other native fauna including reptiles, native fish and invertebrates.

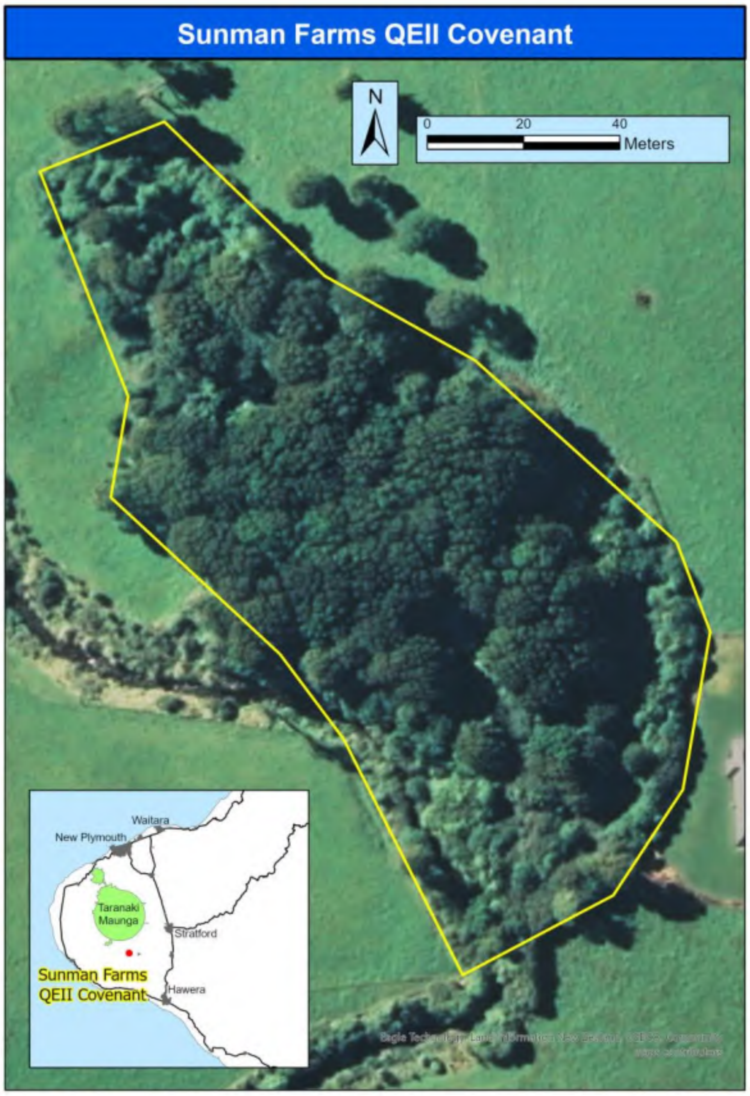
Ecological Values

Ecological Context - Medium	An important example of native forest in an area on the ring plain where forest remnants of this type are very rare.
Rarity and Distinctiveness - Medium	The site provides habitat for a variety of notable threatened species including four species of threatened rata and the threatened swamp maire. Other notable species are likely to be present including native fish, reptiles and invertebrates.
Representativeness - High	Contain vegetation associated with an 'Acutely Threatened' (F5.2a) LENZ environment. The remnant is an example of cutover MF7.3: Tawa, pukatea, podocarp forest (At Risk) ecosystem type.

Sustainability - Positive	In good vegetative condition. Key ecological processes still influence the site, and under appropriate management, it can remain resilient to existing or potential threats.

Other Management Issues

Habitat Modification - Medium	Currently fenced and in good condition. Potential risk from stock breach and human modification.
Herbivores - Medium	Feral goats, pigs and deer are largely absent from the ring plain. Potential high risk from stock browsing although currently fenced and stock proof. Recent evidence of bark stripping on kanono from rabbit browse.
Possum Self-help	The property is within the Waimate possum self-help area and receives sustained possum control.
Predators - Medium	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site.
Weeds - High	Localised infestations of weedy species such as barberry, blackberry, wandering willy, ivy and holly.



Gillett Family Bush

At a glance

TRC Reference:	BD/9745	LENZ:	F5.2a Acutely threatened
Ecological District:	Egmont	National:	Priority 1 – Threatened Land Environment Priority 4 – Threatened Species
Land Tenure:	Private	Regional:	Key Native Ecosystem
Area(ha):	2.1	Regional Ecosystem Loss:	Chronically threatened 10-20% left
GPS:	1706941X & 5669446Y	Protection Status:	Landowner may pursue QEII Covenant
Habitat:	Forest Remnant	Catchment:	Waiongana (394)
Bioclimatic Zone:	Semi-Coastal		
Ecosystem Type:	WF13: Tawa, kohekohe, rewarewa, hinau, podocarp forest		

General Description

The Gillett Family Bush site is located on privately owned land 4.5 km northeast of Inglewood and lies in the Egmont Ecological District and Waiongana Stream catchment. The site is approximately 2.1 ha in size and is comprised of a cutover lowland tawa dominant forest remnant on hill slopes and stream terraces. The remnant is of a native forest type that is classified as 'Chronically Threatened' in Taranaki and falls within 'Acutely Threatened' Land Environment (LENZ) F5.2a. Remnants such as this provide important habitat for rare and threatened species. Gillett Family Bush also offers good connectivity to other nearby habitats, private QEII covenants and Key Native Ecosystems in the area such as the Everett Park Scenic Reserve KNE, Allerby's Bush KNE, and Waiongana Flats A and B KNEs.

Ecological Features

Flora

The forest canopy is dominated by tawa, kohekohe, and pukatea, with occasional pigeonwood and rimu. The understory and groundcover is primarily kawakawa, mahoe, and ferns e.g., hen and chicken fern. Three rata species are present, which have recently been elevated to 'Threatened' status due to new myrtle rust threats.

Fauna

Native birds include tui, shining cuckoo, kingfisher, fantail, silvereye, grey warbler and Australasian harrier. Morepork and kereru, although not observed on the day of assessment, are also likely to be present. There is good habitat for a range of other native species such as freshwater fish, reptiles, and invertebrates.

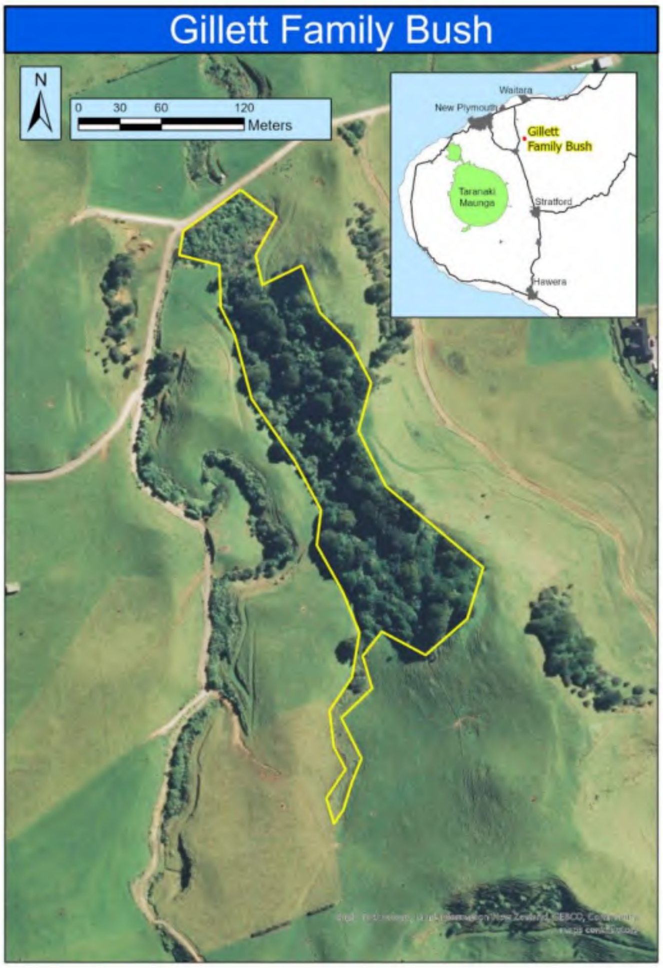
Ecological Values

Ecological Context - Medium	Close to and interconnected with other small forest remnants and riparian vegetation in vicinity.
Rarity and Distinctiveness - Medium	Provides habitat for and also likely to contain other notable fauna species including reptiles and invertebrates. Also contains three rata species which are newly listed as 'Threatened' flora due to potential vulnerability to myrtle rust.
Representativeness - High	Contains indigenous vegetation on F5.2a, an 'Acutely Threatened' LENZ environment. It is also a good example of a forest type that is considered Chronically threatened in Taranaki (WF13 Tawa,

	kohekohe, rewarewa, hinau, podocarp forest), with only about 16% of its original area left.
Sustainability - Positive	In good vegetative condition. Key ecological processes still influence the site. Under appropriate management, it can remain resilient to existing or potential threats.

Other Management Issues

Habitat Modification - Low	Although the habitat is at risk of modification from stock and weed incursions from surrounding pasture, there are no immediate threats facing this site.
Herbivores - Medium	The site is partially fenced from stock, however, the west side of the remnant is unfenced. Despite this, stock access appears minimal due to the steep slope down to the stream on that side. Browsing by possums does pose a threat to the site, however.
Possum Self-help	The site is within the current Inglewood North possum self-help area.
Predators - Medium	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site.
Weeds - High	There is a relatively large patch of Tradescantia (wandering willy) near the southeastern edge of the site, along with edge weeds such as Japanese honeysuckle, barberry, woolly nightshade, and Himalayan honeysuckle.



Patea Saltmarsh

At a glance

TRC Reference: BD/9735

Ecological District: Manawatu Plains

Land Tenure: District

Area(ha): 7.3

GPS: 1726917X & 5598294Y

Habitat: Coastal/Wetland

Bioclimatic Zone: Coastal

Ecosystem Type: SA2: Searush, oioi, glasswort and sea primrose rushland/ herbfield

National: Priority 1 – Threatened Land Environment

Priority 2 – Sand Dunes and Wetlands

Priority 3 – Originally Rare Ecosystem

Regional: Representative ecosystem type

State of Environment Site

Regionally Significant Wetland

Key Native Ecosystem

Regional Ecosystem Loss: Less reduced >50% left

Protection Status: Local Government

Catchment: Patea (343)

General Description

The Patea Saltmarsh consists of a significant patch of saltmarsh vegetation covering several hectares along the tidal reaches of the Patea River. The main area of habitat occurs just upstream of the SH3 road-bridge on the true right (town) side of the river and is the largest area of saltmarsh ribbonwood/sea rush vegetation between the Manawatu River and the Tongaporutu estuary. South Taranaki District Council administer the majority of the land adjacent to the saltmarsh and the Patea River. Included in the KNE is an adjacent area of brackish/freshwater swamp with associated wetland vegetation such as raupo and marsh clubrush.

Ecological Features

Flora

Saltmarsh ribbonwood is abundant at this site along with several other native species associated with this type of estuarine wetland habitat, including a scrambling sea celery (Apium prostratum sub sp. prostratum var. filiforme). The saltmarsh has few weeds or other evidence of human disturbance. There is a zone of freshwater and brackish swamp between the saltmarsh and State Highway 3, which is more weedy, but also has plants not common to the district e.g., kukuraho (Bolboschoenus fluviatilis). The slopes above this wetland, however, are much more weedy.

Fauna

Provides habitat for a variety of common bird species although few were observed during the site visit. Freshwater fish such as eels, bullies and native galaxiids are likely to use the river and intertidal areas of the saltmarsh. Other species are likely to be present or use the area, such as reptiles and migratory wading birds.

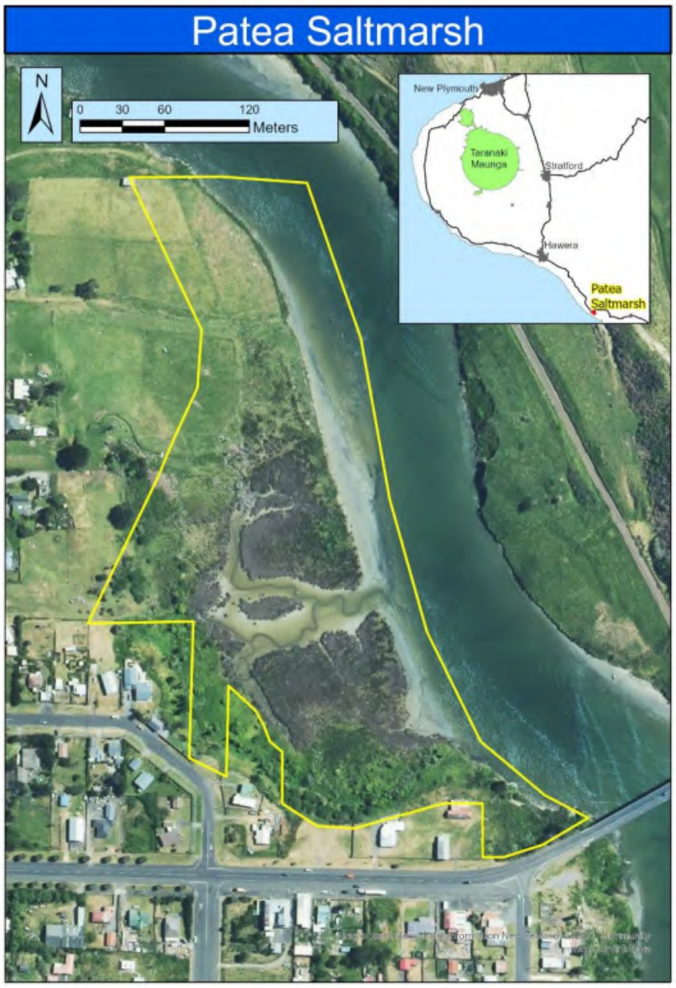
Ecological Values

Rarity and Distinctiveness - High	Contains notable species including saltmarsh ribbonwood and New Zealand celery. Other notable flora and fauna species are likely to be present. Saltmarsh habitats are rare in Taranaki and this site is possibly the largest in the region.

Ecological Context - Medium	This site lacks buffer vegetation, but the saltmarsh is relatively intact and connected to the estuary, providing links to the wider catchment.
Representativeness - High	Contains indigenous vegetation on 'Acutely Threatened' (C3.1a) LENZ environment. Estuaries are nationally rare/naturally uncommon ecosystems.
Sustainability - Positive	In good vegetative condition. Key ecological processes still influence the site. Under appropriate management, it can remain resilient to existing or potential threats.

Other Management Issues

Habitat Modification - Medium	The natural buffer vegetation around this wetland is completely modified and is dominated by exotic pasture. There is a medium risk of modification to wetland area from pest plant invasion.
Herbivores - Medium	Fenced from large herbivores, however the site is vulnerable to possums, hares etc.
Possum Self-help	The site is outside the current possum self-help program boundary and does not receive possum control. High possum numbers have the potential to impact on ecosystem health.
Predators - Medium	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site.
Weeds - Medium	A small number of willow are present that have potential to impact the natural values of the wetland.



Fangorn and Forbidden Forest

At a glance

TRC Reference: BD/9747

Ecological District: Egmont

Land Tenure: Private

Area(ha): 1.1

GPS: 1687973X & 5669914Y

Habitat: Forest Remnant

Bioclimatic Zone: Semi-Coastal

Ecosystem Type: WF13: Tawa, kohekohe, rewarewa, hinau, podocarp forest

LENZ: F5.2b Acutely threatened

National: Priority 1 – Threatened Land Environment

Priority 4 – Threatened Species

Regional: Key Native Ecosystem

Regional Ecosystem Loss: Chronically threatened 10-20% left

Protection Status: QEll Pending

Catchment: Tapuae (386)

General Description

Fangorn and Forbidden Forest KNE is located on privately owned land on Pheney Road, 2km south of Omata. The site lies in the Egmont Ecological District and Tapuae Stream catchment. Fanghorn and Forbidden Forest is made up of twin forest remnants which are separately fenced. Combined, the twin remnants consists of 1.1ha of semi-coastal kohekohe, tawa forest and are in close proximity to several existing KNEs; McNeil KNE, Woodside and Berridge Twin Bush, Ralph Arnold KNE; Atkinson's Bush and Watatao KNE.

Ecological Features

Flora

The forest remnant is a good example of semi-coastal tawa forest and is located in an 'Acutely Threatened' LENZ environment (F5.2b, less than 10% indigenous forest remaining). The main canopy is a mix of puriri, tawa, kohekohe, rimu, pukatea and rewarewa and is generally in good condition. The understorey and ground cover is in good condition in one section and is made up of a variety of species including kawakawa, kanono and regenerating kohekohe. The second section of this area has a relatively good condition understory with significantly more ground cover but more shrub weeds are present.

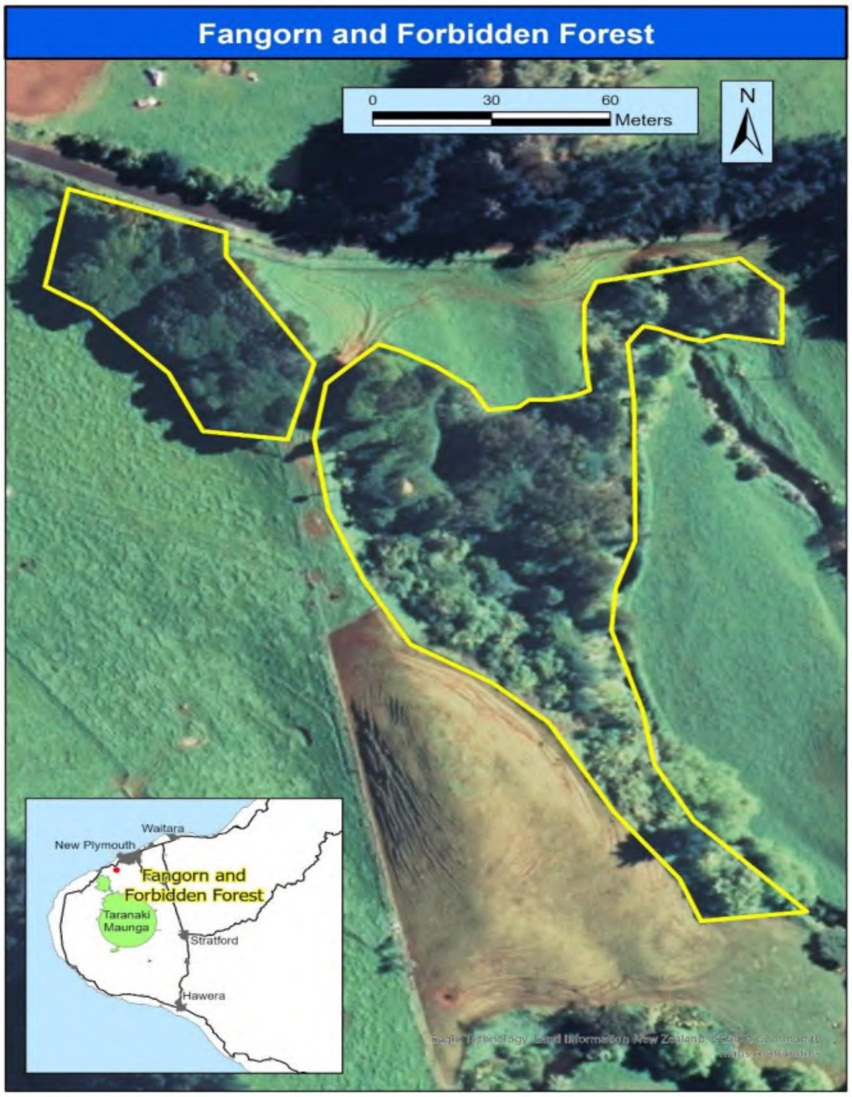
Fauna

Native birdlife recorded in and around Fangorn and Forbidden Forests include the New Zealand pigeon, grey warbler, fantail, tui, morepork and shining cuckoo. Excellent habitat exists for reptiles, invertebrates and freshwater fish.

Ecological Values

Ecological Context - Medium	The remnant provides connectivity to other Key Native Ecosystems nearby including Woodside KNE and Brookwood KNE
Rarity and Distinctiveness - Medium	Contains three species of climbing rata and Manuka which are classified as 'Threatened' and 'At Risk' due to their potential vulnerability to myrtle rust.
Representativeness - High	Contains indigenous vegetation that is poorly represented in Taranaki and classified as F5.2b - an 'Acutely Threatened' LENZ environment
Sustainability - Positive	Key ecological processes still influence the site. Under appropriate management it will remain resilient to existing and potential threats.

Other Management Issues	
Weeds - High	Large areas of blackberry, Tradescantia and Montbretia. Smaller, scattered patches of Himalayan honeysuckle, inkweed, ginger and wooly nightshade.
Predators - Medium	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site. The site falls within the current Towards Predator Free Landscape predator control programme.
Possum Self-help	The site falls within the Hurford Self-Help area.
Habitat Modification - Medium	The western side of the forest shows signs of grazing from chickens as the land owner grazes his chickens within the area as a method of Tradescantia control.
Herbivores - Medium	This site is fully fenced from sheep and cattle. There are pet chickens within the site which are used by the land owner for wandering willy control, however they may also have an impact native seedlings within the forest. This site is also vulnerable to possums.



Ben's Bush

At a glance

TRC Reference: BD/7078		**LENZ:**	F1.1b Not threatened
Ecological District: North Taranaki			F5.2a Acutely threatened
Land Tenure: Private		**National:**	Priority 1 – Threatened Land Environment
Area(ha): 62.3			Priority 4 – Threatened Species
GPS: 1720403X & 5677867Y		**Regional:**	Key Native Ecosystem
Habitat: Forest Remnant		**Regional Ecosystem Loss:**	Chronically threatened 10-20% left
Bioclimatic Zone:	Semi-Coastal	**Protection Status:**	QEII Covenant
Ecosystem Type:	WF13: Tawa, kohekohe, rewarewa, hinau, podocarp forest	**Catchment:**	Onaero (398)

General Description

Ben's Bush QEII covenant is located on private land, approximately 4.8km south of Urenui in North Taranaki. The remnant is comprised of semi-coastal forest and includes three unnamed tributaries of the Mangapoua stream, near the center of the Onaero catchment. The covenant is situated in close proximity to Kaipikari Road Forest Remnants KNE and Hickman Road (Luxton) KNE.

Ecological Features

Flora

This covenanted area contains a good quality example of semi coastal/lowland mixed tawa forest (WF13). Less than 20% of this type of forest remains in the Taranaki region. Some of the forest is mature with a canopy consisting of tawa, miro, pukatea, rewarewa, puriri and rimu. The site contains three species of threatened climbing rata and is likely to include other notable species such as king fern. The understory and ground cover in the forest is in fair condition, likely due to feral goats and occasional stock incursions, but the condition improves in some areas further within the forest.

Fauna

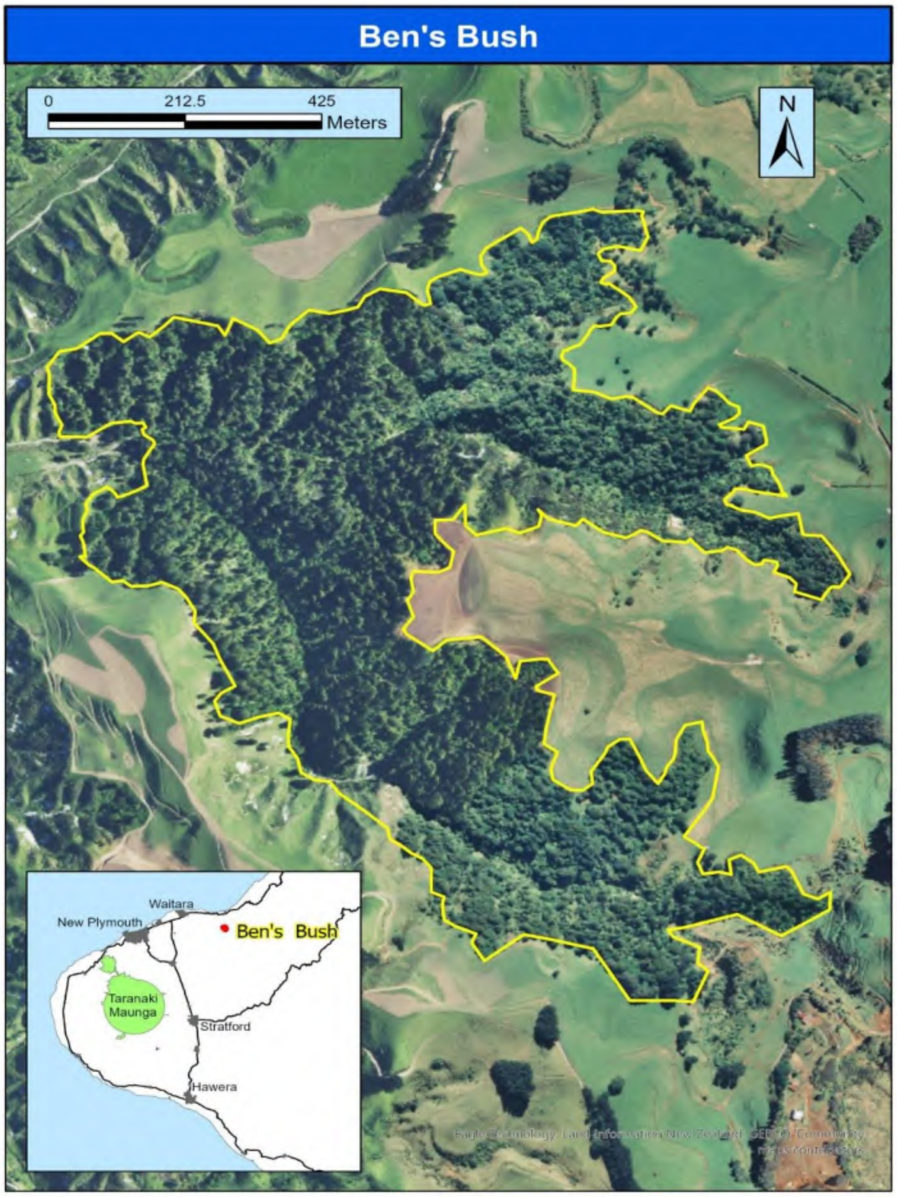
Native birdlife recorded in and around the remnant include the kereru, grey warbler, fantail, bell bird, tui, morepork, kingfisher and shining cuckoo. There is good habitat for a range of reptiles and invertebrates. Native fish and bats may also be present.

Ecological Values

Rarity and Distinctiveness - Medium	Provides habitat for, and also likely to contain, other notable fauna species including native bats, reptiles and invertebrates. Also contains three climbing rata species listed as 'Threatened' flora and Manuka which is listed as 'At Risk'.
Ecological context - High	Provides well forested cover for tributaries of the Mangapoua stream as well as additional habitat and greater connectivity with other Key Native Ecosystems in this area such as the Hickman Road (Luxton) KNE and Kaipikari Road Forest Remnants KNE.
Sustainability - Positive	In good vegetative condition. Key ecological processes still influence the site. Under appropriate management, it can remain resilient to existing or potential threats
Representativeness - High	Contains indigenous vegetation on F5.2b, an 'Acutely Threatened' LENZ environment. It is also a good example of a forest type that is

considered Chronically threatened in Taranaki (WF13 Tawa, kohekohe, rewarewa, hinau, podocarp forest).

Other Management Issues	
Herbivores - High	Browsing by possums, stock, goats and deer pose a high risk to the regeneration of this remnant.
Predators - High	Rodents, mustelids, possums and feral cats are present and will be having an impact on native species.
Weeds - Medium	Weeds are currently a low threat at this site with scattered invasive species present including woolly nightshade, montbretia and blackberry which are mainly isolated to edge understory.
Habitat Modification - Medium	Limited stock grazing has modified accessible parts of this remnant. Fencing repairs and maintenance will reduce this risk.



Bruce's Bush and Danny's Pond

At a glance

TRC Reference:	BD/9752	**LENZ:**	F5.2b Acutely threatened
Ecological District:	Egmont	**National:**	Priority 1 – Threatened Land Environment Priority 2 – Sand Dunes and Wetlands Priority 3 – Originally Rare Ecosystem Priority 4 – Threatened Species
Land Tenure:	Private		
Area(ha):	2ha + 1ha		
GPS:	1679192X & 5657382Y 1680495X & 5657064Y		
Habitat:	Forest Remnant/Wetland		
Bioclimatic Zone:	Lowland	**Regional:**	Key Native Ecosystem
Ecosystem Type:	MF7.3: Tawa, pukatea, podocarp forest WF8: Kahikatea, pukatea forest	**Regional Ecosystem Loss:**	Acutely Threatened <10% left At risk 20-30% left
		Protection Status:	QEll Pending
		Catchment:	Kaihihi (381)

General Description

Bruce's Bush and Danny's Pond forest remnants are located approximately 5.4km south-east of Okato on the western Taranaki ring plain. The site consists of the 2ha forest remnant (Bruce's Bush) adjoining to Corbett Lake Scenic Reserve and 1ha of regenerating bush around a small artificial wetland (Danny's Pond). The site lies within the Egmont ecological district and the Kaihihi river catchment. Ecosystem types include 'Acutely Threatened' WF8 - Kahikatea, pukatea forest and 'At-Risk' MF7.3 Tawa, pukatea, podocarp forest. The site provides excellent connectivity with other KNEs and the Te Papakura o Taranaki/ Egmont National Park. Good riparian connections exist throughout the property and wider area.

Ecological Features

Flora

Bruce's Bush: The canopy is dominated by pukatea, tawa and swamp maire, with rimu, miro and kahikatea also common. Around the forest margin on the drier hillslopes, mahoe is common and there are several groves of kohekohe. Scarlet and white rata are common throughout the forest and can be seen around both the bush margins and within the canopy. The interior of the forest is dominated by tree ferns, supplejack and kiekie. A small stream feeding into the wetland area is dominated by regenerating kanuka and mahoe.

Danny's pond: The bush is generally younger than in Bruce's bush and is dominated by mahoe, kanuka, tree ferns and tawa. Threatened swamp maire and poroporo are both present in places around the bush. The pond has several large patches of exotic water lilies and raupo is common around the edges.

Fauna

Native fauna which have been identified on site include kotare, riroriro and piwakawaka. There is good habitat for native reptiles and notable reptiles are known in the area and may be present at this site. There is also good habitat for native freshwater fish and Bruce's Bush would possibly be suitable for the 'At-Risk' and 'regionally distinctive' brown mudfish.

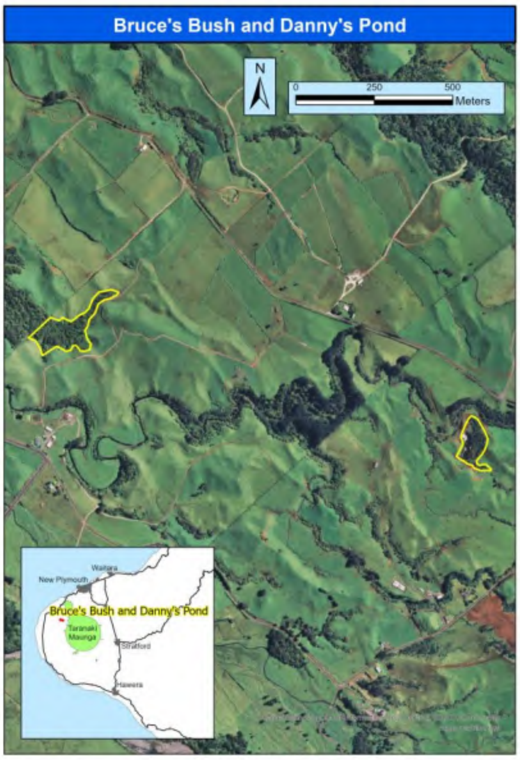
Ecological Values

Ecological Context - Medium	Provides connectivity to other habitats, KNE's and priority ecosystems in this vicinity, including a direct connection with Corbett Lake Scenic Reserve and continuous established riparian

	connections connecting with Te Papakura o Taranaki/Egmont National Park.
Rarity and Distinctiveness - High	Contains threatened species including white and scarlet rata, poroporo and kanuka and the 'Nationally Critical' swamp maire.
Representativeness - High	Are remnants of native forest on land classified as an 'Acutely Threatened' land environment and are representative examples of 'At Risk' and 'Acutely Threatened' ecosystem types (MF7.3: Tawa, pukatea, podocarp forest, WF8: Kahikatea, pukatea forest).
Sustainability - Positive	Key ecological processes still influence the site and the site is being evaluated for a QEII covenant which would ensure the continuation of these processes in the future.

Other Management Issues

Habitat Modification - High	Danny's pond is an artificial pond with no permanent outlet, and so suffers from poor/no downstream connectivity. Introduced water lilies also dominate the waterway.
Herbivores - Medium	Effect of stock is obvious around the margin of Bruce's bush, with little understory in places around the hillside surrounding the bush remnant. Little sign of possum browse - palatable species such as rata are common and in good health.
Possum Self-help	The property is within the possum self-help area and receives sustained possum control.
Weeds - Medium	Weeds are somewhat under control but blackberry and barberry are common around the margins of Bruce's bush and water lilies are prevalent in Danny's pond.
Predators - Medium	Predators including rodents, mustelids, possums, feral cats and hedgehogs will be having an impact on native species at the site.



Mangamaio

At a glance

TRC Reference: BD/9754		**LENZ:**	F1.1b Not threatened
Ecological District: North Taranaki		**Local:**	Significant Natural Area
Land Tenure: Private		**National:**	Priority 1 – Threatened Land Environment
Area(ha): 45.53			Priority 4 – Threatened Species
GPS: 1730664X & 5682340Y		**Regional:**	Key Native Ecosystem
Habitat: Forest Remnant			Representative site for management
Bioclimatic Zone:	Lowland	**Regional Ecosystem Loss:**	Chronically threatened 10-20% left
Ecosystem Type:	Wetland mosaic		Acutely Threatened <10% left
	WF13: Tawa, kohekohe, rewarewa, hinau, podocarp forest	**Protection Status:**	Local Government
		Catchment:	Mimi (400)

General Description

Mangamaio is a privately owned 45.5ha bush block of various forest types, 10km east of Urenui in the North Taranaki ecological district. The site lies in a broad landscape of forested hills with excellent connections to the Pouiatoa Conservation area 6km to the south, Okoki Kereru KNE 5km to the west, Pukatea KNE 5km to the north and the Uriti conservation area 6km to the East. There is a diverse range of flora and ecosystem types partly owing to the historical land-use of the site. The block contains areas of remnant semi-coastal tawa/rewarewa/podocarp forest, regenerating manuka scrubland, beech forest ridgetops and formerly-grazed open valley floors. A small area of modified wetland dominated by rushes and Carex species is also present near the south eastern corner of the property. There are a number of notable species present on site including western brown kiwi, long-tailed bats, the epiphytic tawhirikaro and three species of threatened rata.

Ecological Features

Flora

The remnant forest stands are dominated by tawa and rewarewa and contain a mix of large podocarps, pukatea, and nikau. Beech trees are common along the elevated ridgelines, with both hard beech and black beech present. Regenerating manuka scrub is the other dominant habitat type, housing many species of ferns and early successional forest species. There is also a wet-bottomed grassy valley dominated by Carex and rush species. Fungi were not specifically surveyed but many species are present within the property.

Fauna

There is a range of avifauna on site typical of the surrounding area. This includes western brown kiwi as well as tui, bellbrid/korimako, tomtit/miromiro, grey warbler/riroriro, silver eye/tauhou and paradise shelduck/putangitangi. Long-tailed bats are confirmed present and good habitat is available including roost trees. There is good habitat for native lizards. Notable lizard species are known in the general area and may be present at this site. There is a small stream which may provide habitat for native invertebrates and freshwater fish.

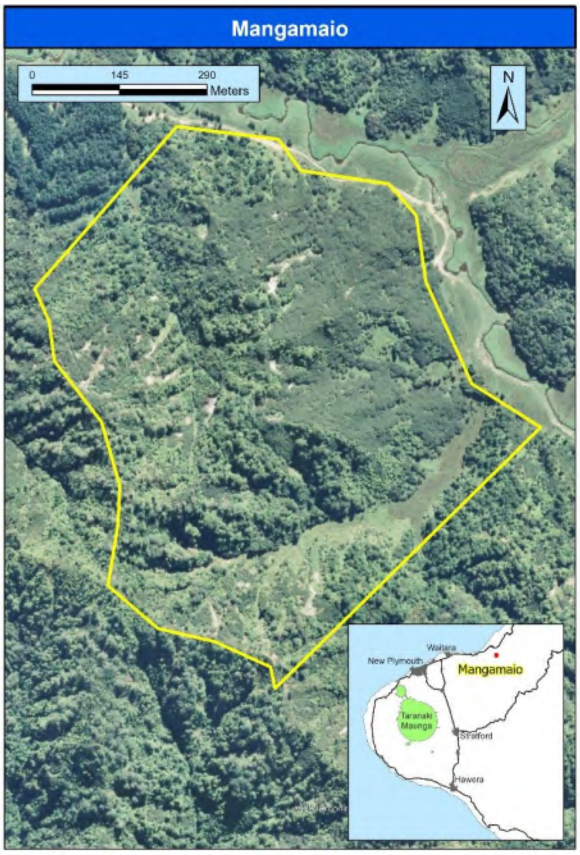
Ecological Values

Ecological context - High	The site lies in the middle of a larger area of relatively continuous forest that connects a number of other KNE's. Continuous bush corridors connect it to Pukatea KNE 4km to the North, Okoki Pa/Okoki Kereru KNE's 4.7km to the West, and Pouiatoa KNE

	4.6km to the South. There is also good connectivity to the Uriti scenic reserve 5.5km to the East.
Rarity and Distinctiveness - High	Long-tailed bats and Western brown kiwi are present on site, as well as tawhirikaro. Three species of 'At-Risk' climbing rata are found within the site: M. fulgens, M. carminea and M. perforata.
Representativeness - High	While the site exists within LENZ F1.1b (less reduced, better protected) environment, it contains a section of 'acutely' and 'chronically threatened' habitat within Taranaki (wetland mosaic and WF13 - Tawa, kohekohe, rewarewa ecosystems), while the south-western half also is identified as a priority terrestrial habitat for Taranaki.
Sustainability - Positive	The site is of a good size and well connected to surrounding habitat. Key ecological processes still influence the site. Under appropriate management, it can remain resilient to existing or potential threats

Other Management Issues

Habitat Modification - Medium	While currently ungrazed, the damp open valley floor has been fully cleared from its initial vegetated state.
Herbivores - High	Goats, pigs, deer and possum are all known to exist on site, and fresh signs of these species are common throughout the block.
Predators - High	Predators including rodents, mustelids, possums and hedgehogs will be having an impact on native species at the site.
Weeds - Low	Weeds are scattered and not significantly changing ecosystem functions of the site.



Manui Farm QEII Covenants

At a glance

TRC Reference: BD/9748		**LENZ:**	F7.2a At risk
Ecological District: North Taranaki			F5.2a Acutely threatened
Land Tenure: Private			F1.1b Not threatened
Area(ha): 7.2		**National:**	Priority 1 – Threatened Land Environment
GPS: 1715657X & 5663984Y			Priority 4 – Threatened Species
Habitat: Forest Remnant		**Regional:**	Key Native Ecosystem
Bioclimatic Zone:	Lowland	**Regional Ecosystem Loss:**	Acutely Threatened <10% left
			Chronically threatened 10-20% left
Ecosystem Type:	MF7.3: Tawa, pukatea, podocarp forest	**Protection Status:**	QEII Covenant
	WF13: Tawa, kohekohe, rewarewa, hinau, podocarp forest	**Catchment:**	Waitara (395)

General Description

Manui Farm QEII Covenants are locates on privately owned land on Tarata Road approximately 11km east of Inglewood between Kaimata and Tarata. The site is located in the North Taranaki ecological district. Manui Farms QEII Covenants are made up of three separate bush remnants catchment (2.7, 2.3 and 2.2 ha in size) of mostly lowland tawa forest in the Waitara). The three areas are in the process of being covenanted and are in close proximity to other Key Native Ecosystems in the area, including Totara Mahanga directly across the road, another private QEII covenant and the Tarata Conservation Area.

Ecological Features

Flora

The main canopy is a mix of totara, tawa, kahikatea, rewarewa, miro and matai and is generally in good condition. The understorey and ground cover of the areas that have been fenced for some time is in good condition and is made up of a wide number of shrub and fern species. Unfenced areas are obviously more limited to non-palatable species. Climbers and epiphytes are also relatively common.

Fauna

Native birdlife recorded in and around the site include Kereru, tui, fantail, grey warbler, silvereye and kingfisher. Morepork, bellbird and the North Island robin are also likely to inhabit the site.

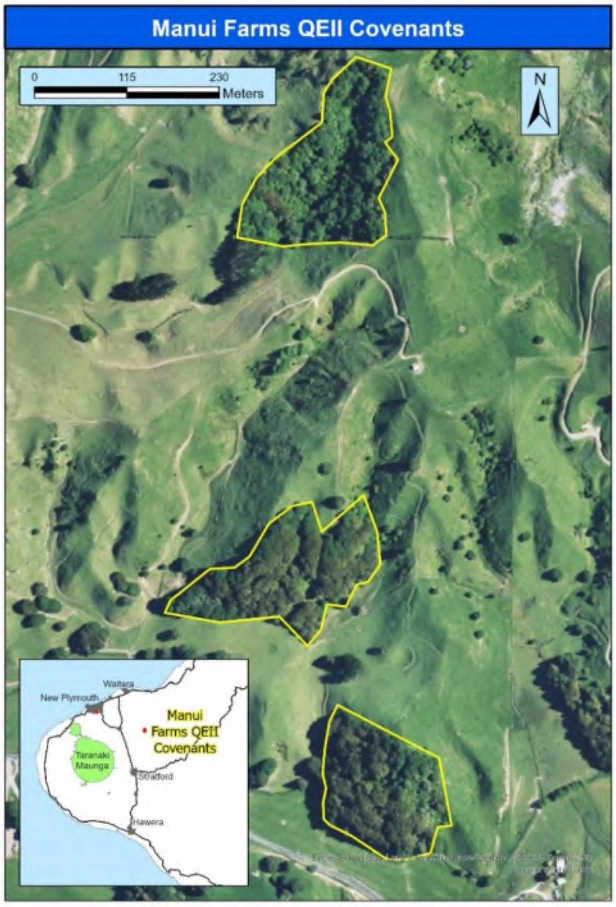
Ecological Values

Ecological Context - Medium	Provides additional habitat and greater connectivity with other Key Native Ecosystems in this area such as the Tarata Conservation Area and the Totara Mahanga KNE.
Sustainability - Positive	Key ecological processes still influence the site and with appropriate management, these remnants can remain resilient to existing and potential threats. The site has the added benefit of most likely being formally protected with the QEII Trust in the near future.
Representativeness - High	Contains indigenous vegetation on 'Acutely Threatened' (F5.2a) and 'At Risk' (F7.2a) land environments. Is a remnant of ecosystems considered 'Chronically Threatened' (WF13: Tawa, kohekohe,

	rewarewa, hinau, podocarp forest) and 'At Risk' (MF7-3 Tawa, pukatea, podocarp forest) from it's pre-European extent.
Rarity and Distinctiveness - Medium	Contains three species of climbing rata which were recently classified as 'Threatened' due to their potential vulnerability to myrtle rust. North Island robin are close to their western extent in Taranaki here, but have been sighted frequently across the road, and are likely to visit this site.

Other Management Issues

Possum Self-help	The site falls outside the possum self-help area.
Herbivores - High	The property lies outside the self help possum boundary. The back block and roadside blocks are mostly or fully fenced to exclude stock, while the middle block is able to be accessed by stock and has evidently been grazed through.
Habitat Modification - Medium	The back block and roadside blocks are mostly or fully fenced to exclude stock. Remaining areas will be proposed to be fenced in conjunction with the covenanting process.
Weeds - Medium	African clubmoss and Jerusalem cherry are abundant in the roadside block. A few barberry and strawberry dogwoods are present.
Predators - High	Possums, cats, mustelids hedgehogs and rodents will be present within this landscape and are likely to be impacting on native flora and fauna.



Taranaki Regional Council

MEMORANDUM
Policy & Planning

Date 7 June 2022

Subject: **Submission on Space invaders: A review of how New Zealand manages weeds that threaten native ecosystems**

Approved by: D Harrison, Director - Operations

S J Ruru, Chief Executive

Document: 3057445

Purpose

1. The purpose of this memorandum is to introduce the Council's submission prepared in response to the report and recommendations made by the Parliamentary Commissioner for the Environment in *Space invaders: A review of how New Zealand manages weeds that threaten native ecosystems* (the Report).
2. The submission was sent to the Environment Committee to meet the deadline date 6 May 2022. A copy of the submission is attached to this agenda item.

Executive summary

3. The Parliamentary Commissioner for the Environment is calling on the Government to improve protection of native ecosystems from the thousands of exotic plants spreading through Aotearoa New Zealand.
4. In doing so, the Report reviews current approaches to managing the risks of exotic plants on native ecosystems and reviews the way in which central and regional government agencies go about business of tackling native ecosystem weeds under the *Biosecurity Act 1993* (BSA).
5. The Report aims to promote better leadership, focus and action on native ecosystems and weeds in New Zealand. The report presents the following seven recommendations to the Ministers, in brief:
    - Clearer national direction on the priority to manage native ecosystem weeds that are already present in New Zealand
    - Joint leadership for managing native ecosystem weeds that are already present in New Zealand from the Ministry for Primary Industries (MPI) and Department of Conservation (DOC)
    - As part of the above, jointly develop (in collaboration with regional councils) national policy direction on native ecosystem weeds

- National policy direction specifically directed to native ecosystem weeds should be provided by rewriting the existing National Policy Direction for Pest Management 2015 or by amending section 56 of the BSA
- National policy direction that includes policy on native ecosystem weeds should require engagement with iwi and hapū and provide clear direction on national priority weeds, provide clear direction on the management of emerging weeds and specify roles to define what is to be done nationally
- MPI should work with DOC, 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
- MPI, DOC, regional councils, 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.

6. Council officers have participated in a sector response to the Report and have prepared the attached submission.
7. The submission largely supports key findings and recommendations set out in the Report. In particular the submission supports more leadership for ecosystem weed threats, clear national direction and the creation of a database of all exotic plants in New Zealand.
8. Notwithstanding that, the submission highlights points of concern or where further efficiencies in the system are required. Broadly, these are sufficient resourcing from a national level, limitations of the BSA, effective national leadership, consistent Central Government investment and a centralised platform which pulls together all information.
9. The deadline for submissions on the Proposal was 6 May 2022.

Recommendations

That the Taranaki Regional Council:

a) receives this memorandum entitled *Submission on Space invaders: A review of how New Zealand manages weeds that threaten native ecosystems*

b) endorses the attached submission.

Background

10. The Parliamentary Commissioner for the Environment, Simon Upton, undertook a review into weed management in New Zealand and the impact that weeds are having on indigenous biodiversity, the Report was released November 2021. As noted in the Commissioner's press release, mammalian predators are already a matter of national concern with a range of predator-free initiatives around the country. However, no such call to arms exists on the weeds front. Despite some weeds being of concern for over 150 years, the entire system for managing exotic weeds in New Zealand appears to have never been reviewed. The historical focus on weeds that affect production land (such as farmland and plantation forests) begs the question of whether current legislation gives due regard to the risks that weeds pose to our native ecosystems.
11. On 7 April 2022, the Parliamentary Commissioner for the Environment released his report for public comment. The deadline for comments was 6 May 2022.

12. As noted in the Report, New Zealand's unique native ecosystems are at risk from a green occupation of weeds. Over the years, humans have introduced more than 25,000 exotic vascular plant species to Aotearoa, and nearly 3,000 of them have been found growing in the wild. Without more effective intervention, harm to native ecosystems will continue to increase, not only as the existing naturalised invaders continue to spread but as they are joined by new exotic plants that naturalise as they move away from where they have been deliberately planted.
13. The Commissioner suggests that New Zealand's biosecurity system is only managing weeds in theory. The Commission suggests that the biosecurity system is very broad, covering pre-border requirements, border measures and management within our borders. The system aims to defend New Zealand from unwanted intrusions by harmful organisms that range from four-legged animals to invisible pathogens to plants. In trying to do it all, some aspects get less attention than others.
14. MPI, which is in charge of New Zealand's biosecurity system, devotes most of its efforts to defending the border. But for the exotic plants that have already made it into the country, MPI largely leaves management to others, including DOC, regional councils and landowners. MPI only provides limited oversight and coordination.
15. The Commissioner recommends making several improvements to the biosecurity system to better protect indigenous biodiversity from weeds. He suggests that these adjustments will improve leadership and coordination, clarify desired outcomes and help align national, regional and local efforts.
16. The Commissioner highlighted three key areas which need particular attention, these being: inadequate leadership, limited information and haphazard un-coordinated action. The Commissioner suggests a need for better tools, information and coordination with central government having a vital role to play. There is also a need for a degree of prioritisation at the national level. The report emphasises that any improvements in focus, prioritisation and the tools required to combat exotic plants must be developed closely with regional councils and drawing on the very significant practical intelligence that has been amassed from community-based initiatives.
17. The report sets out seven recommendations to strengthen the system to better manage weeds that threaten native ecosystems. These recommendations are addressed to Ministers, since action on the ground is shaped by the national framework created under the BSA.
    - **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 MPI (Biosecurity New Zealand) and the Director-General of DOC 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 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

b) by amending section 56 of the BSA to allow for multiple targeted national policy directions.

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

  a) 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.

  b) provide clear direction on the management of emerging weeds, including a requirement for regular, coordinated scanning and surveillance

  c) 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:** MPI should work with DOC, 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.

  a) 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
  — 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:** MPI, DOC 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.

18. The Report is attached to this item in Appendix I. The Commissioner invited submissions on the Report with the deadline for comments being 6 May 2022.

Key submission points

19. Council officers have participated in a sector response to the Report and have prepared the attached submission (refer Appendix II). The submission is aligned with the sector response to this review and forwarded to the Environment Committee on 6 May 2022.

20. The submission largely supports key findings and recommendations set out in the Report. In particular the submission supports more leadership to prioritise national ecosystem weed threats, clear nationally supported direction assisting Councils triaging

threats, and specifically recommendation 6 calling for the creation of a single authoritative and publically accessible database of all exotic plants in New Zealand.

21. Notwithstanding that the submission highlights a number of points of concern or where further efficiencies in the system are required.

22. The key points made in the attached submission are as follows:

- With respect to recommendations 1, 2, 3 and 7, the Council agrees that more national leadership is required to prioritising national ecosystem weed threats, specifically emerging risks. However, it is important that there is resourcing from a national level to provide guidance and direction around the emerging risks
- With respect to 'legacy' weeds, the submission highlights that national leadership, funding and resourcing is required to inform and support the work of the Council
- It is also important that Central Government are leading by example and are supporting Crown departments to manage ecosystem weeds on Crown lands appropriately. The submission contends that meaningful leadership by the Department must involve increased resourcing of weed management on Public Conservation Land priority ecosystems
- In response to Recommendations 4 and 5, the submission suggests that clear nationally supported prioritisation and direction would greatly assist councils 'triaging' weed threats. Noting that time and money could be saved if clear national priorities were clearly communicated, roles specified, and resources prioritised
- The submission noted the limitations to the system relying on the BSA, regional councils and regional pest management plans to manage native ecosystem weeds. Other players and other tools are needed to address the current piecemeal approach to weed management
- There still needs to be strategic priorities for weed management set at the regional level. With this in mind, to a point, the debate over what weed species are managed by Council will never go away. There is a deep-seated misunderstanding in the public over what is a priority with respect to biosecurity interventions and the appropriateness and cost effectiveness of regulatory interventions versus non regulatory interventions. Concepts such as the invasion curve, feasibility and long-term return on investment are not well understood. Because of this, the contention usually stems back to why the Council is not prioritising the widespread environmental weeds the community can see and usually, see everywhere. When weeds get to that extent, the Council invests in tools like biological control agents or site-based initiatives (e.g. biodiversity projects) to protect values at place. But this commonly does not address the removal of the threat the community sees in front of them (and the demand for regulation)
- In Taranaki, the Biosecurity and Biodiversity Strategy provides for the management of pest plants outside of the use of rules such as site-led weed control on key native Ecosystems and the formation of the Yellow Bristle Grass Action Group which sits outside of the Regional Pest Management Plan. Furthermore, the BSA is very enabling by way it is written, which does not specifically instruct Council's to do specific tasks but rather vests certain powers to them giving them discretion about what they're able to do in regards to weed management. This then puts the onus on parties in the biosecurity space to opt out of participating in weed management and therefore contribute

- The submission strongly supports Recommendation 6. This recommendation feeds into all the prior recommendations and links to having effective national leadership in place. However, it is imperative that regional councils are engaged at the outset with this work to collaborate and provide meaningful input into its development
- The submission recommended that there needs to be a central platform that pulls together the information from all sources and allows for an analysis at a national level. The output of this would feed directly into priorities, recommendations for 'national significance' or even investment analyses. Council would recommend that the conversation is about the type of information collected and how it can either be fed into or drawn from existing platforms
- The Council is supportive of additional national work leadership and funding for biological control and finding new tools and enhancing existing tools. It is recommended that Central Government invest more consistently to provide this leadership and enable further research, roll out of approved agents and also prioritisation of biocontrol targets/agents.

Financial considerations—LTP/Annual Plan

23. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

24. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

25. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum..

Community considerations

26. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

27. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices

Document 3058953: Space Invaders: A report of how New Zealand manages weeds that threaten native ecosystems.

Document 3055630: Taranaki Regional Council submission on Te Kaitiaki Taiao a Te Whare Pāremata: Space invaders: A review of how New Zealand manages weeds that threaten native ecosystems.

C.12

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

November 2021

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

This report has been produced pursuant to subsections 16(1)(a) to (c) of the Environment Act 1986. The Parliamentary Commissioner for the Environment is an independent Officer of Parliament, with functions and powers set out in the Environment Act 1986. His role allows an opportunity to provide Members of Parliament with independent advice in their consideration of matters that may have impacts on the environment.

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November 2021

ISBN

978-0-947517-26-7 (print)

978-0-947517-27-4 (electronic)

Photography

Cover image: *Tropaeolum speciosum*, Chilean flame creeper, kiwidave, iNaturalist.

Chapter header images: *Lamium galeobdolon*, Nathan Odgers, iNaturalist; *Hedychium gardnerianum*, Bruce Calvert, iNaturalist; *Ipomoea indica*, wolfette9653, iNaturalist; *Chrysanthemoides monilifera* subsp. *monilifera*, Catherine Beard, iNaturalist; *Clematis vitalba*, emanon, iNaturalist; *Lomatia fraseri*, Leon Perrie, iNaturalist; *Epilobium hirsutum*, jabba, iNaturalist; *Pistia stratiotes*, Bernard DUPONT, Flickr; *Archontophoenix cunninghamiana*, ryvesie, iNaturalist; *Euphorbia paralias*, hooch_the_pooch, iNaturalist; *Asparagus scandens*, richardprovo, iNaturalist; *Persicaria chinensis*, John Brew, iNaturalist; *Alternanthera philoxeroides*, swatutukaka, iNaturalist.

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

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Acknowledgements

The Parliamentary Commissioner for the Environment is indebted to a large number of people who assisted him in conducting this investigation. Special thanks are due to Dr Anna Hooper, who led the project, supported by Dr Angela Brandt and Dr James Newman, who worked hard to bring this investigation to completion. Thanks are also due to Leana Barriball, Tessa Evans, Dr Geoffroy Lamarche, Megan Martin and Dr Helen White.

The Commissioner would also like to thank Patrick Whaley and Darion Embling from Waikato Regional Council who helped assemble the weed list recorded in his introduction.

The Commissioner would like to acknowledge the following organisations for their time and assistance during the preparation of this report:

- AgResearch
- Ardmore Nurseries Ltd
- Auckland Botanic Gardens
- Auckland Council
- Australian Department of Agriculture, Water and the Environment
- Bay of Plenty Regional Council
- Boffa Miskell
- Christchurch City Council
- Department of Conservation
- Dunedin City Council
- Environment Canterbury Regional Council
- Environment Protection Authority
- Environmental Defence Society
- Forest & Bird
- Gisborne District Council
- Greater Wellington Regional Council
- Hawke's Bay Regional Council
- Horizons Regional Council
- KiwiRail
- Lincoln University
- Manaaki Whenua – Landcare Research
- Marlborough District Council
- Ministry for Primary Industries
- Ministry for the Environment
- National Institute of Water and Atmospheric Research
- National Science Challenge: New Zealand's Biological Heritage – Ngā Koiora Tuku Iko
- Nelson City Council
- New Zealand Defence Force
- New Zealand Plant Producers Incorporated
- Ngā Whenua Rāhui
- Northland Regional Council
- Otago Regional Council
- Pāmu Landcorp Farming Limited
- Place Group Environmental Planning
- Project De-Vine Environmental Trust
- Queen Elizabeth II National Trust
- Save The Otago Peninsula
- Scion
- Southland Regional Council
- Stewart Island/Rakiura Community & Environment Trust
- Taranaki Regional Council
- Tasman District Council
- Te Roroa
- Toitū Te Whenua Land Information New Zealand
- Unitec Institute of Technology
- University of Auckland
- University of Canterbury
- University of Otago
- University of Western Australia
- Waikato Regional Council
- Waka Kotahi NZ Transport Agency
- Weed Action Native Habitat Restoration Trust
- Wellington City Council
- West Coast Regional Council
- Wildland Consultants.

The Commissioner wishes to thank the following individuals for reviewing earlier drafts of the report. While he has benefited hugely from their insights, any errors, omissions or opinions are entirely his own.

- Dr Imogen Bassett
- Dr Peter Bellingham
- Dr John Hellstrom
- Professor Philip Hulme
- Susan Timmins.

Contents

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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

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 ināianei, 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 ināianei, 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.

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[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.

[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

Chrysanthemoides monilifera subsp. *monilifera*

1 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.

[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]

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[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]

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[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.

[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.

[27] Brummer et al., 2016.

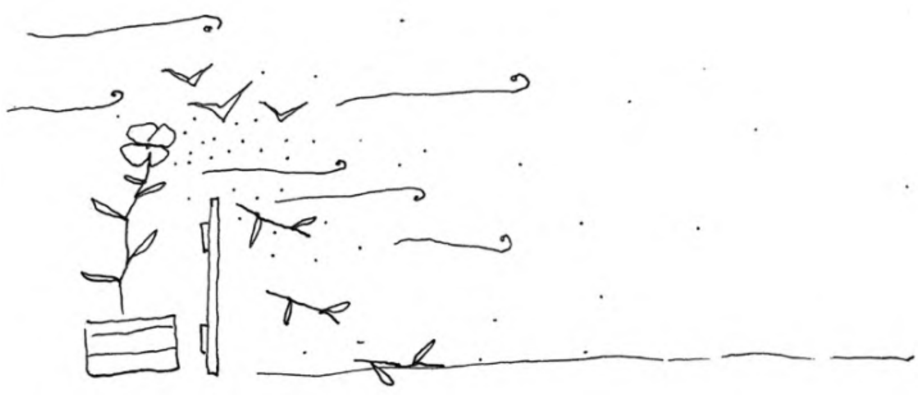
[28] Wiser and Allen, 2006, p.197, Table 13.1.

[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.

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[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]

[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.

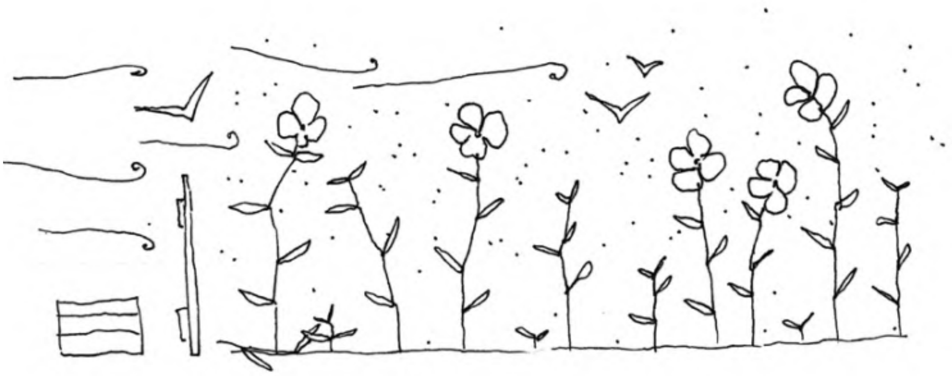
[41] Richardson et al., 2000a; Theoharides and Dukes, 2007.

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.

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[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.

[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.

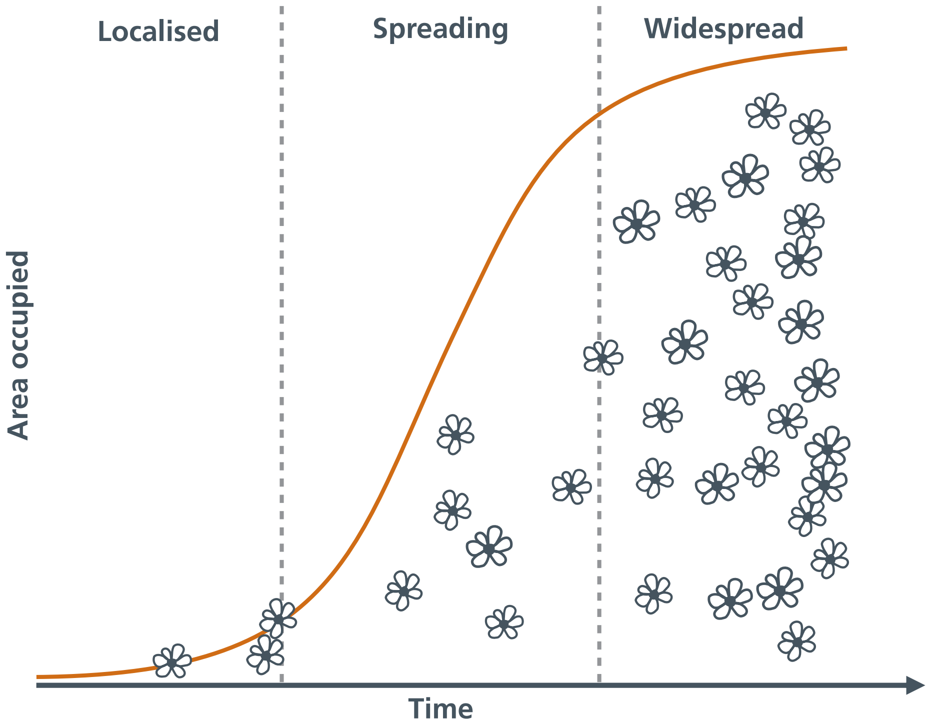
[51] Gardner and Early, 1996. Moreton bay fig trees planted in Auckland in about 1850 feature in The New Zealand Tree Register (e.g. https://register.notabletrees.org.nz/tree/view/783).

[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 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]

[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.

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[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]

[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.

[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).

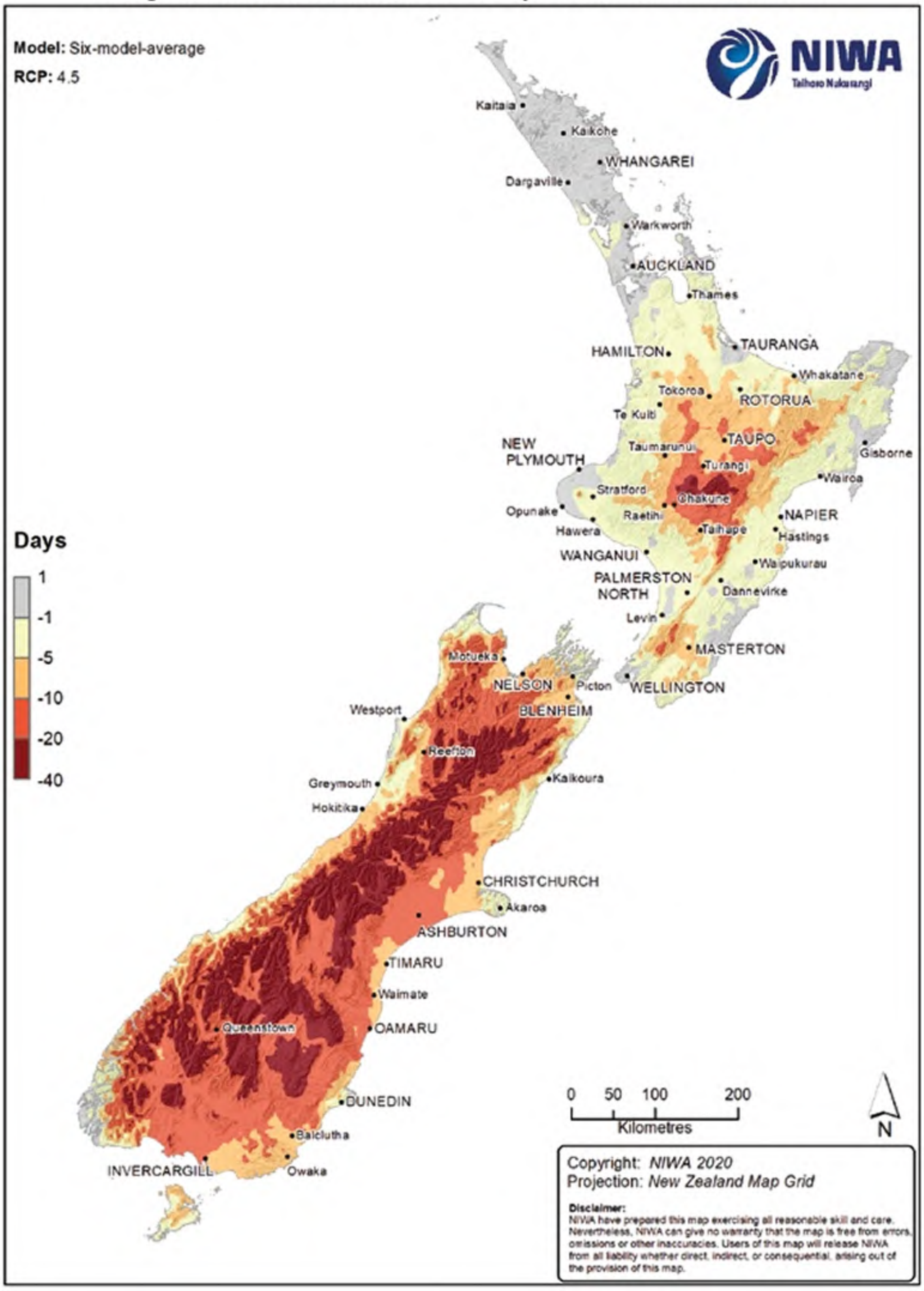
28 Sheppard et al., 2014, 2016.

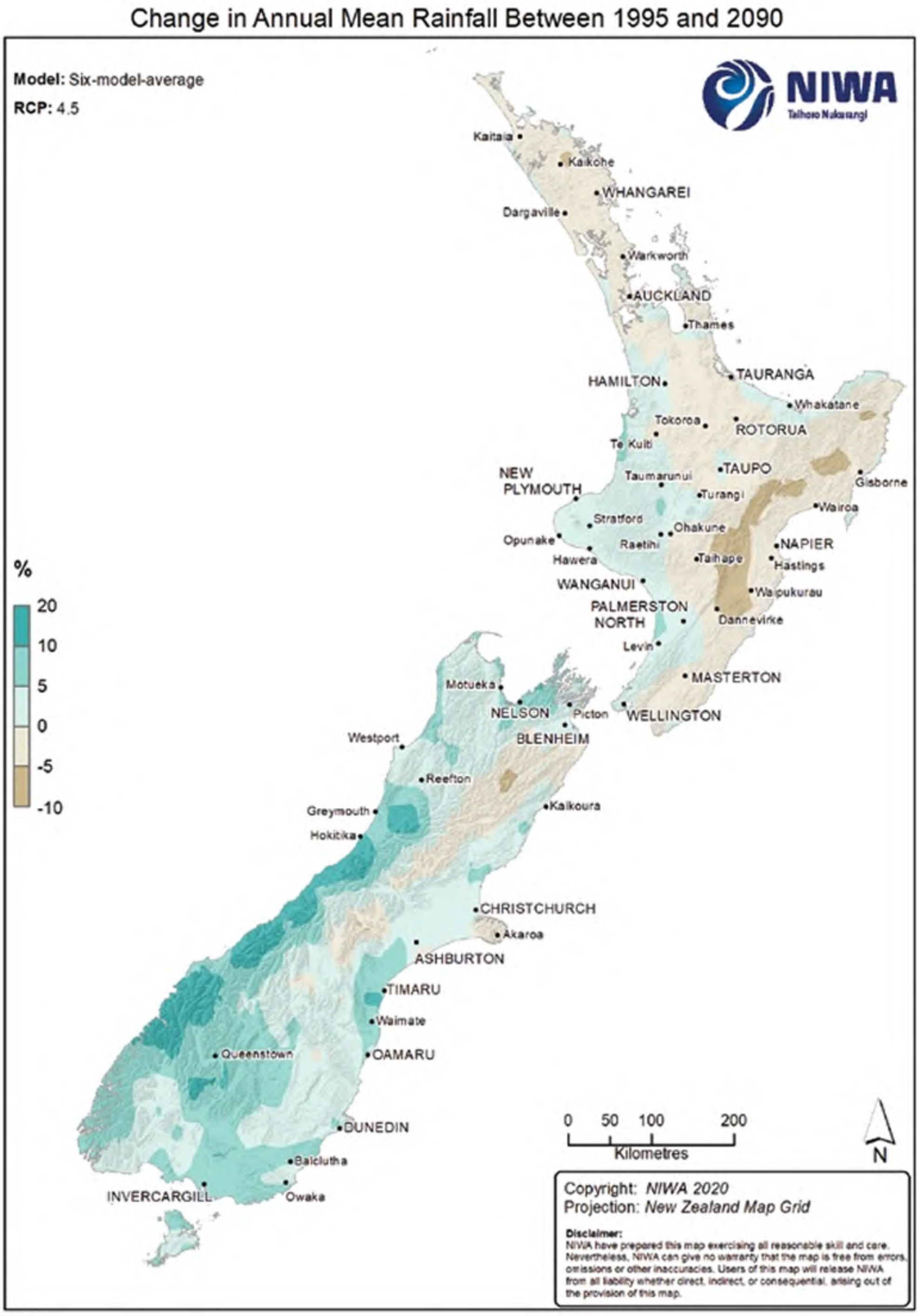
29 Almost all plants, including most trees and shrubs, are in a group known as C3 plants. These plants are considered to benefit, at least to some degree, from increasing levels of atmospheric CO_2. A smaller group known as C4 plants, which includes plants such as maize and sugarcane, are better adapted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

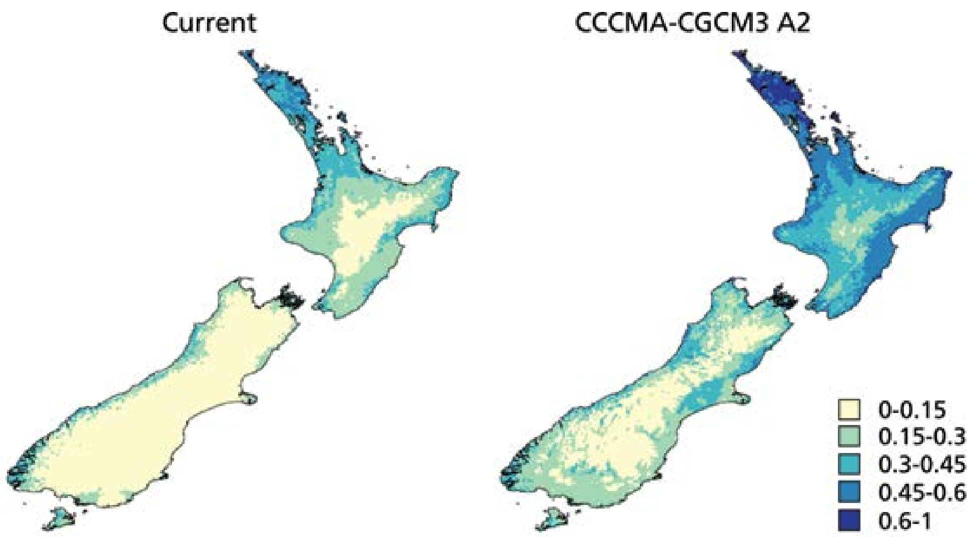
[34] This is out of 1,730 naturalised plant species for which the Global Biodiversity Information Facility (GBIF) had records (Etherington and Brandt, 2020).

[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).

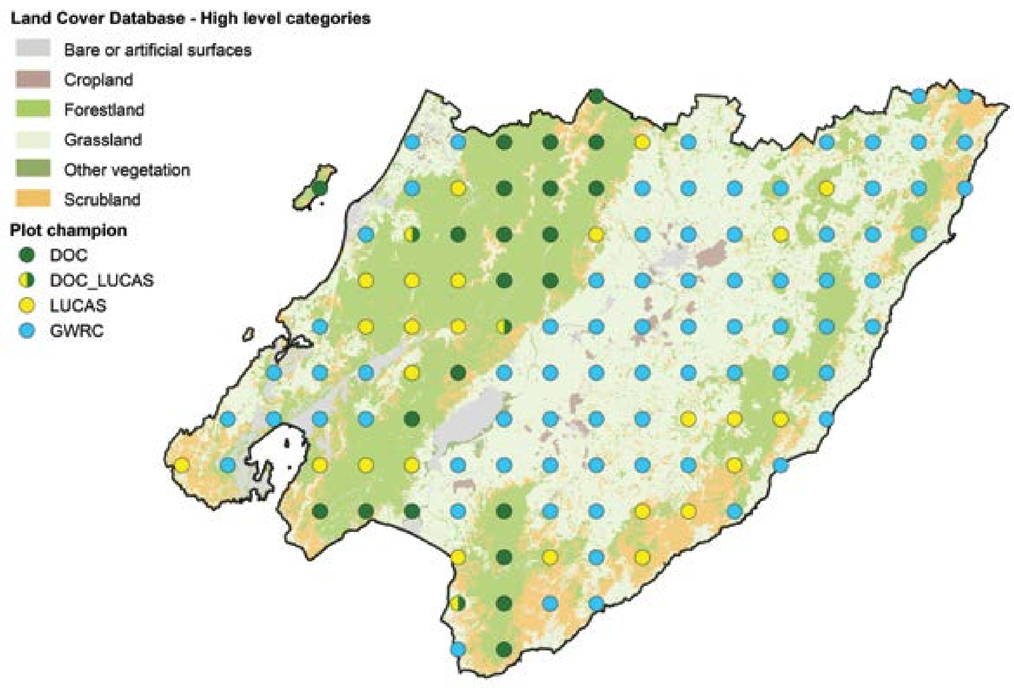
[4] In addition, approximately 700 LUCAS plots were established in exotic forests around the country. For details see MfE (2010), Searles (2018) and Paul et al. (2021).

[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

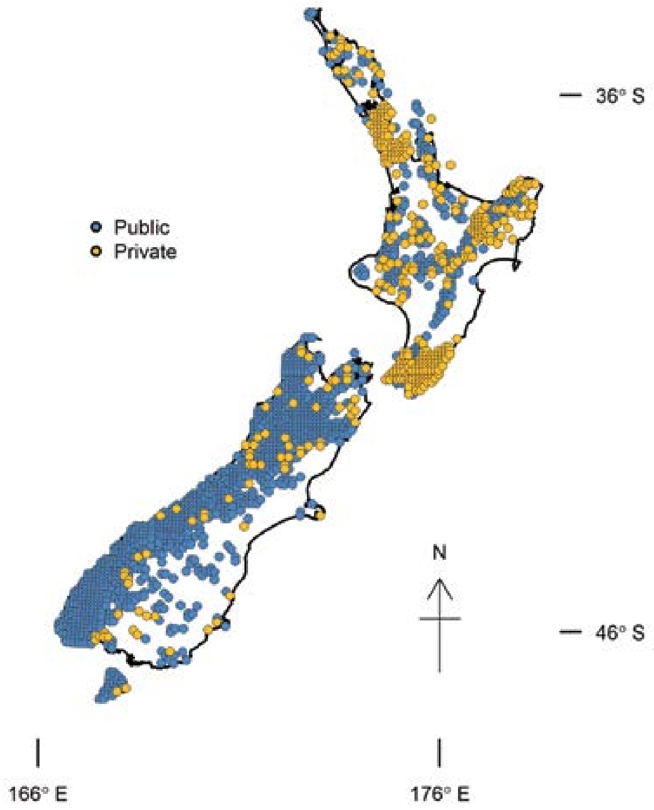
Figure 4.1: Comprehensive broadscale monitoring grid in the Greater Wellington region.

[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]

[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]

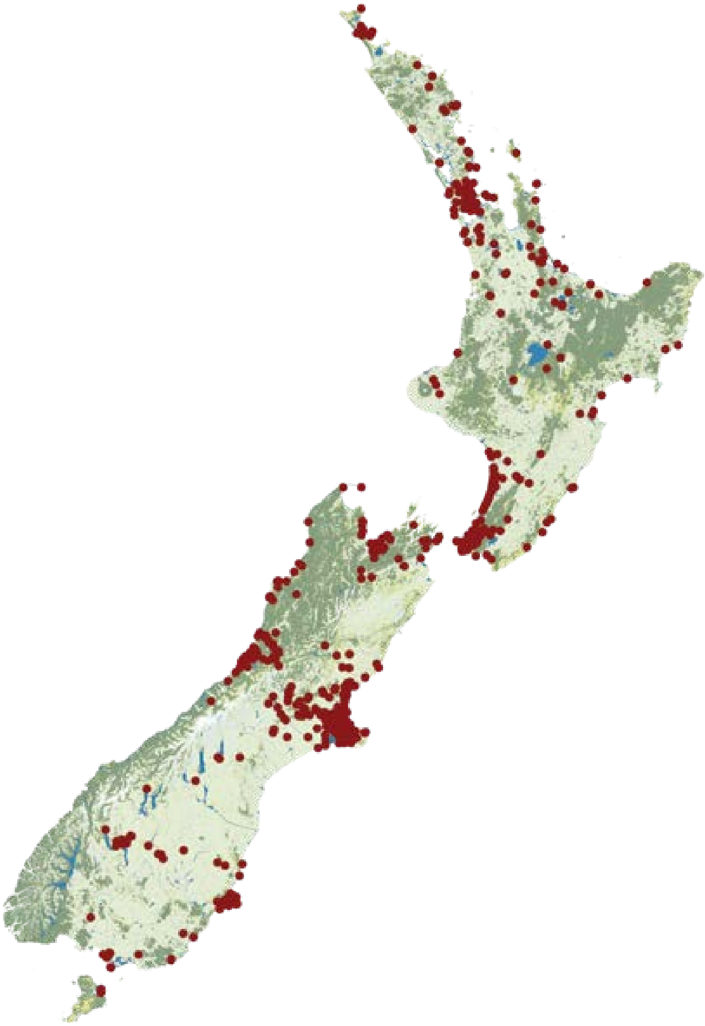
In addition to any monitoring by government agencies, some useful information on where exotic plant species are growing is provided by interactive databases that provide a place to marshal observations by members of the public as well as professionals. The website iNaturalist is the most widely used 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/).

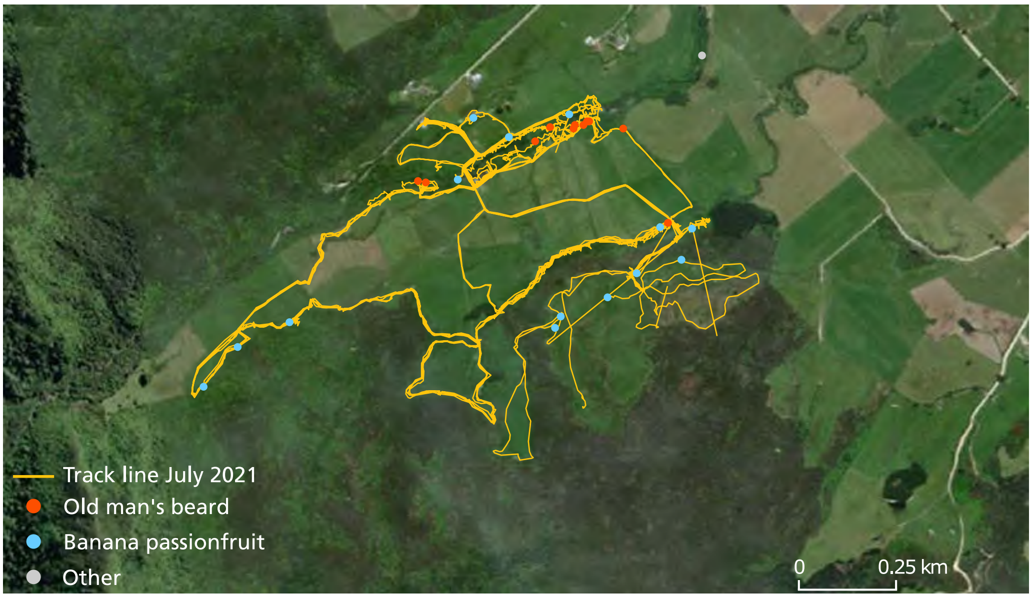


Source: adapted from iNaturalist

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.

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[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]

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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).

[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

100 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.

[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.

104 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.

[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.

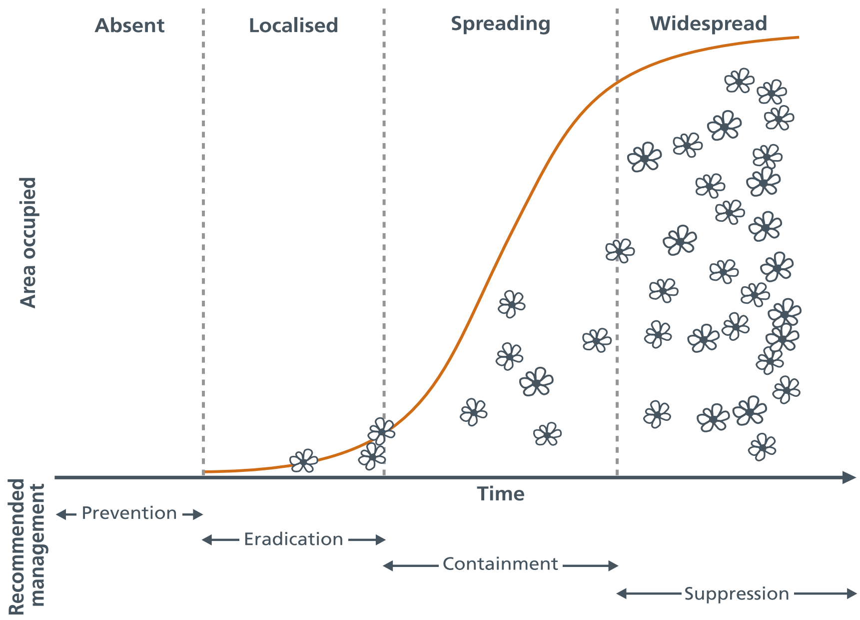
[7] Naturally uncommon ecosystems are those with an extent less than 0.5% of New Zealand's total land area. Forty-five of 71 naturally uncommon ecosystems are considered Vulnerable, Endangered or Critically Endangered (DOC, 2020c).

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.

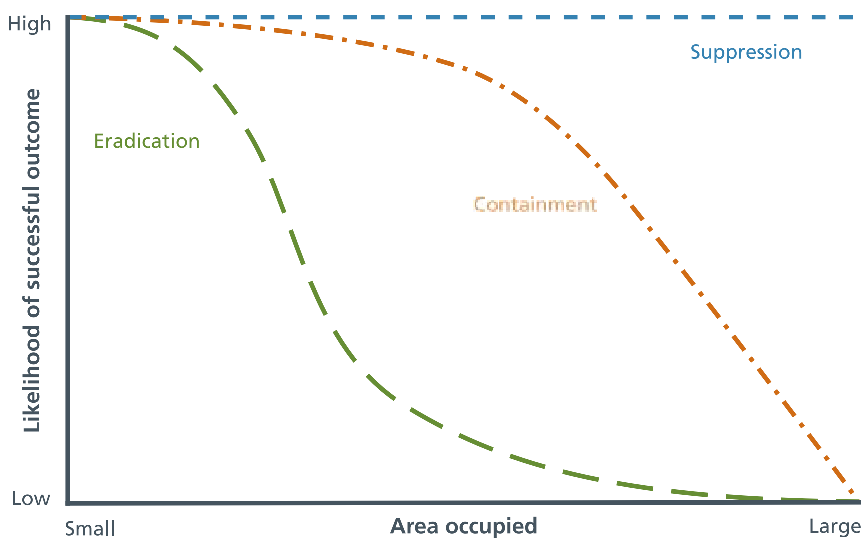
[8] Sites both 'sensitive' and 'susceptible' to exotic plant invasion should be prioritised to mitigate risk (McGeoch et al., 2016). Roadsides in New Zealand tend to accumulate exotic plants from other habitats so could be a useful target for surveillance (Aikio et al., 2012).

[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.

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[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.

[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)).

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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.

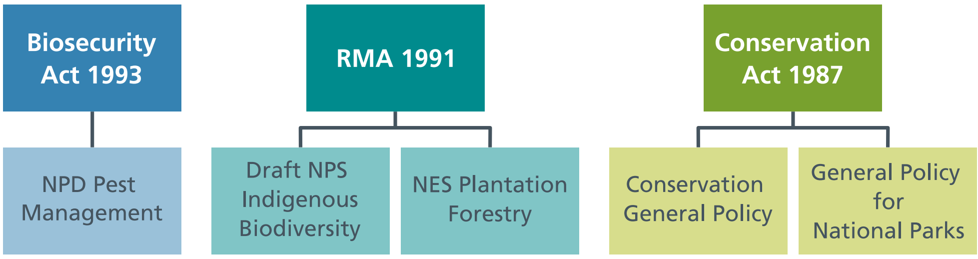
The Government identified multiple workstreams across different agencies that were affected by the claim. Those that touched on exotic plant management included:

- 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]

[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]

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[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.

[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).

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[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.

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[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.

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[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]

[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).

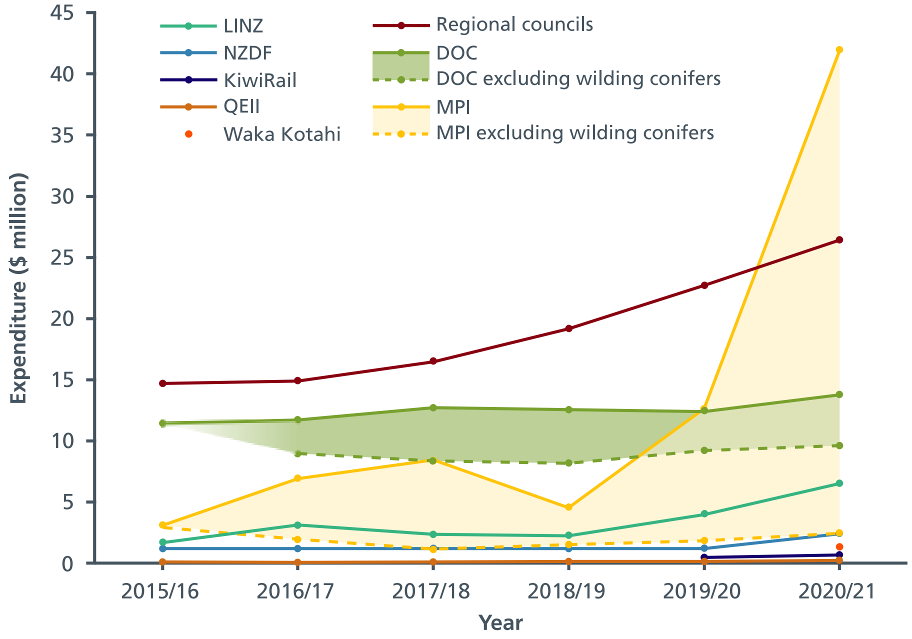
These amounts include money allocated for managing exotic plants for any purpose, so spending focused on native ecosystems is a subset of this. The biggest single item comprises the large National Wilding Conifer Control Programme, which began in 2016. The huge increase in spending by MPI in recent years 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, NZDF, 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]

[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.

[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.

[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.

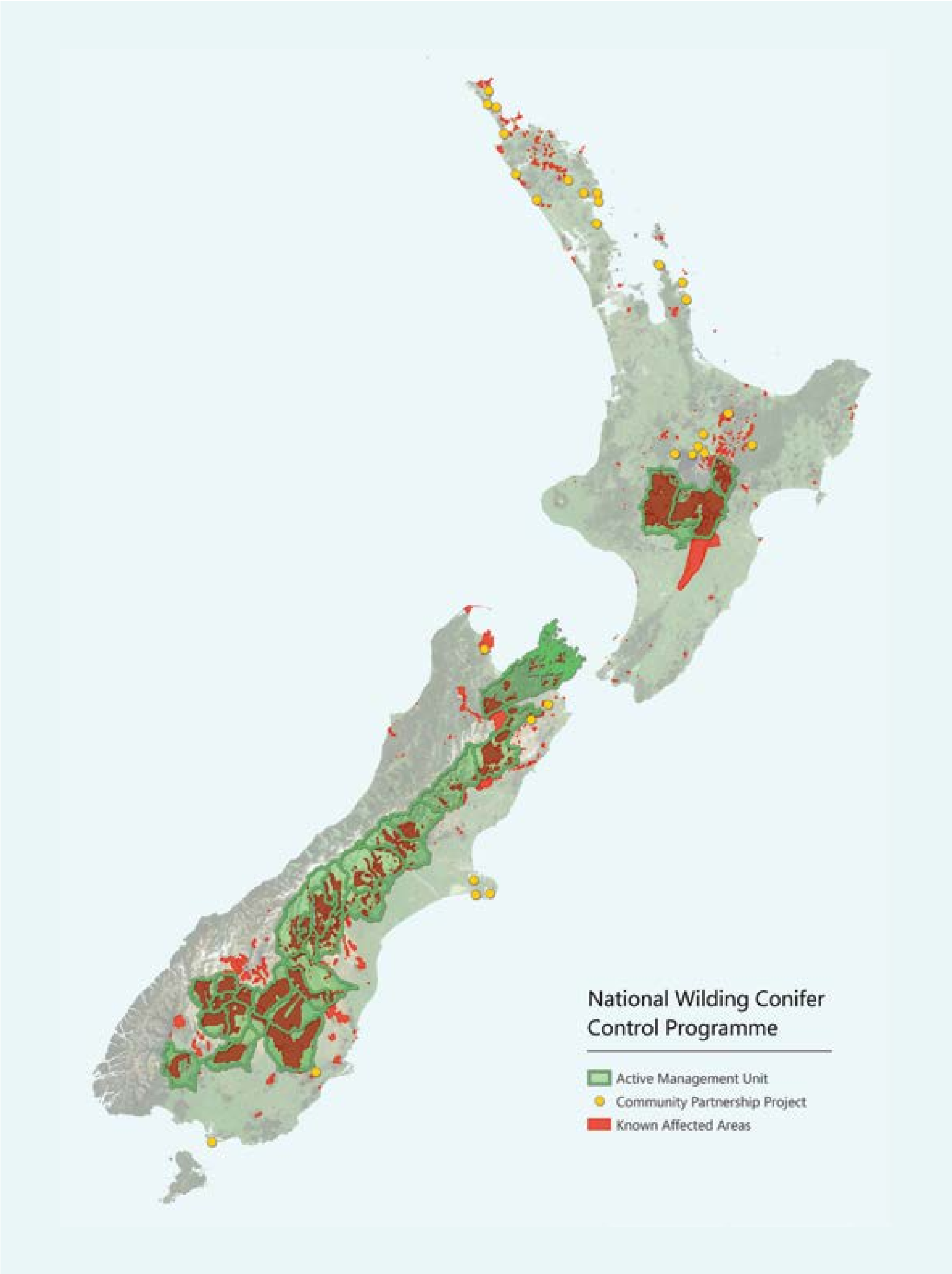
[38] Heenan and Champion, 2016.

[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]

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[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).

[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]

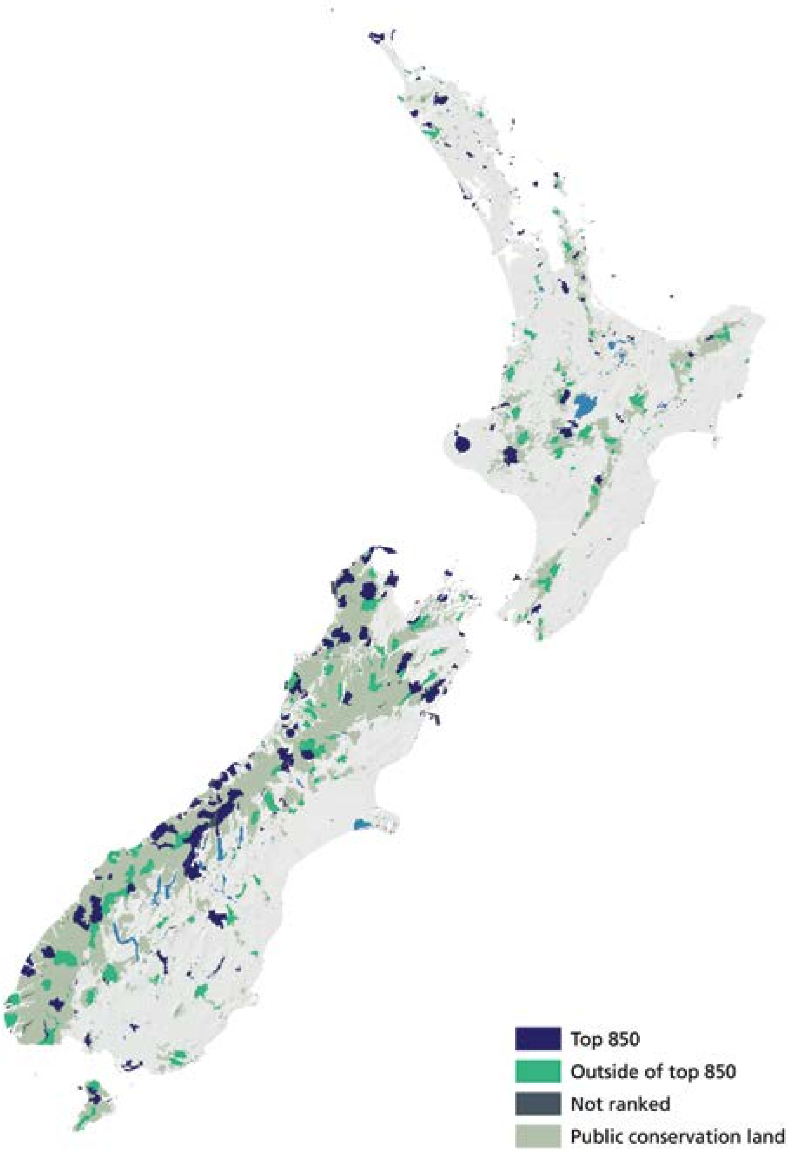
[59] DOC staff, pers. comm., 24 September 2021.

[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

176 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]

[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.

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[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]

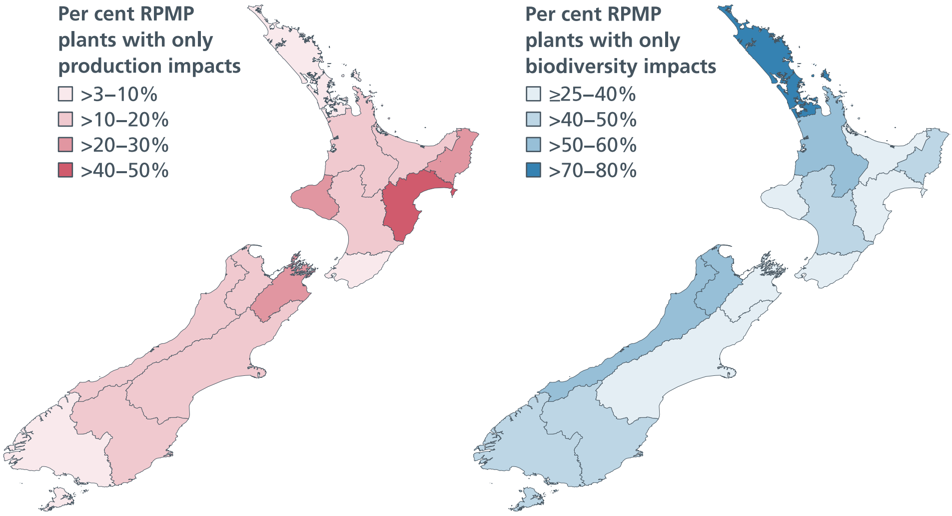
[104] Analysis commissioned for this review revealed that the average date of first discovery of naturalised populations of exotic plants included in RPMPs is 1935, with only 13% of exotic plants on RPMPs across the country being first discovered in the wild on or after 1980 (Hutchison et al., 2021, 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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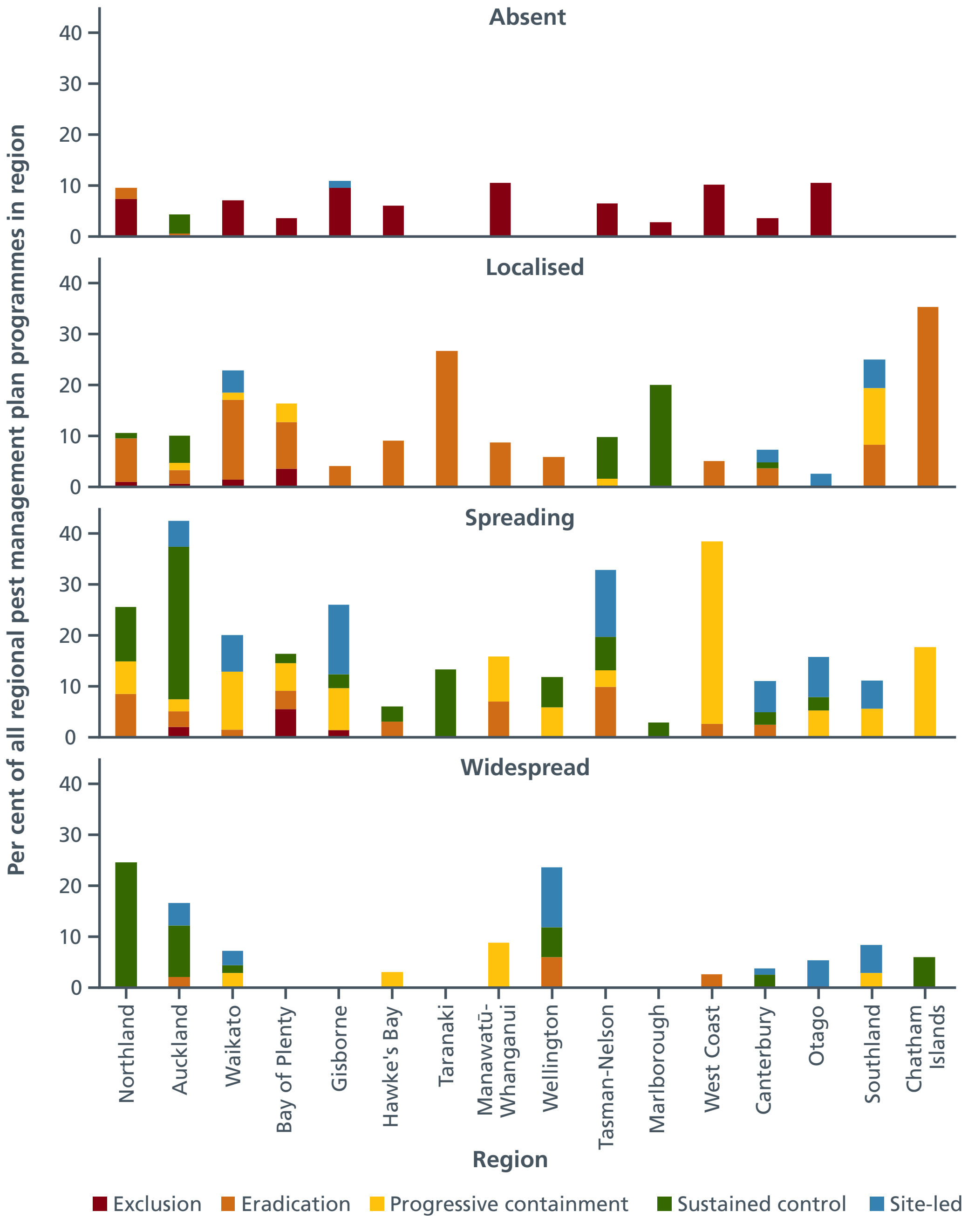
[109] Williams and Braithwaite, 2003.

[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 (*Sesbania 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.

[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).

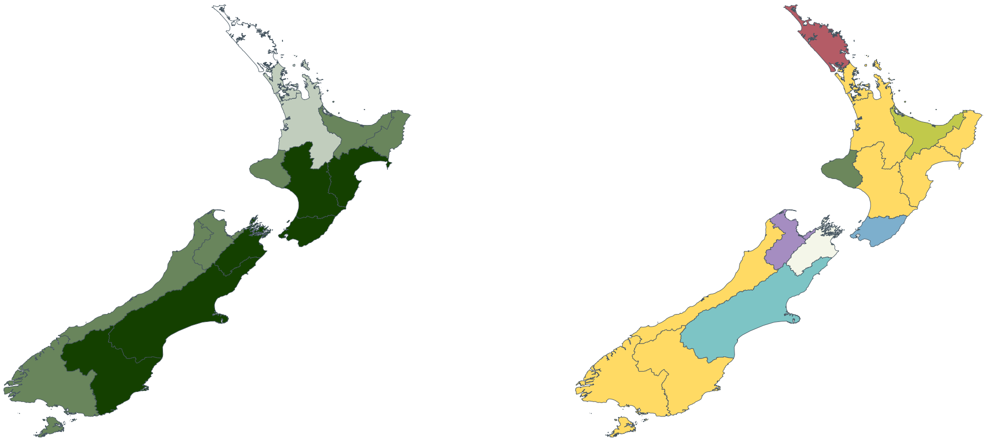
[122] For example, see Table 5 in Auckland Council (2020).

[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).

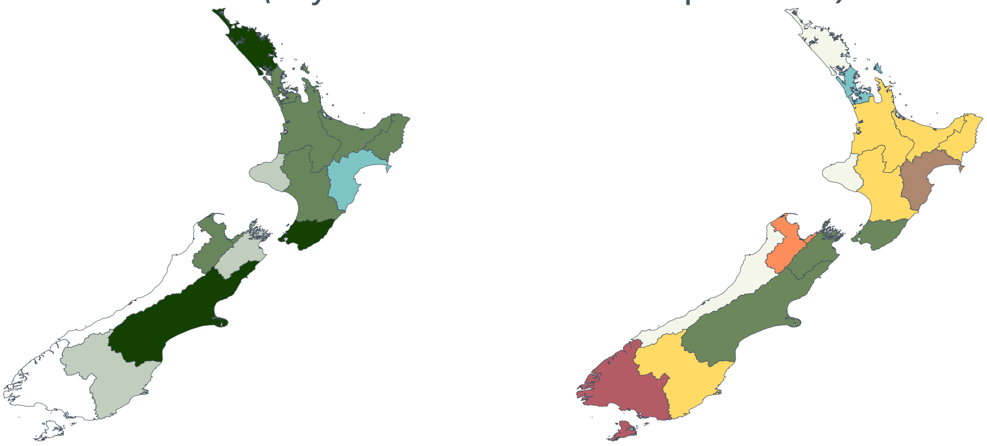
[124] Palmer, 2020, p.11.

[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.

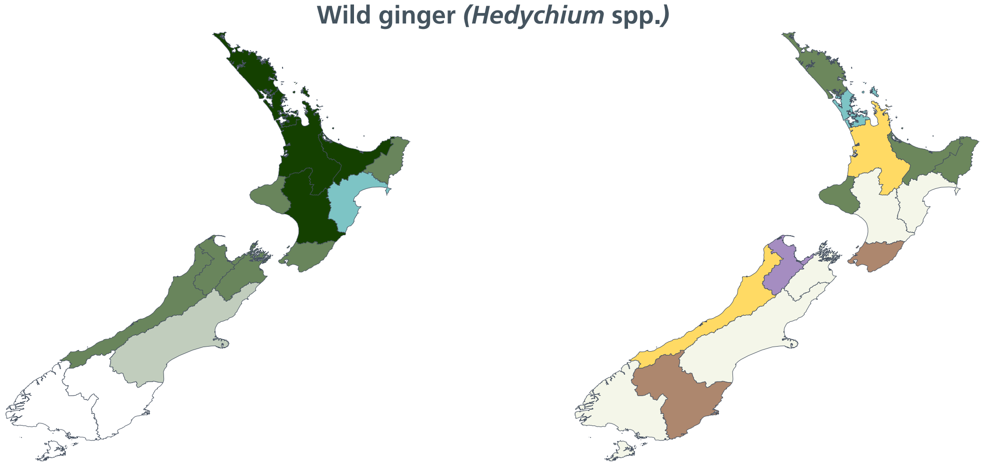
Old man's beard (*Clematis vitalba*)

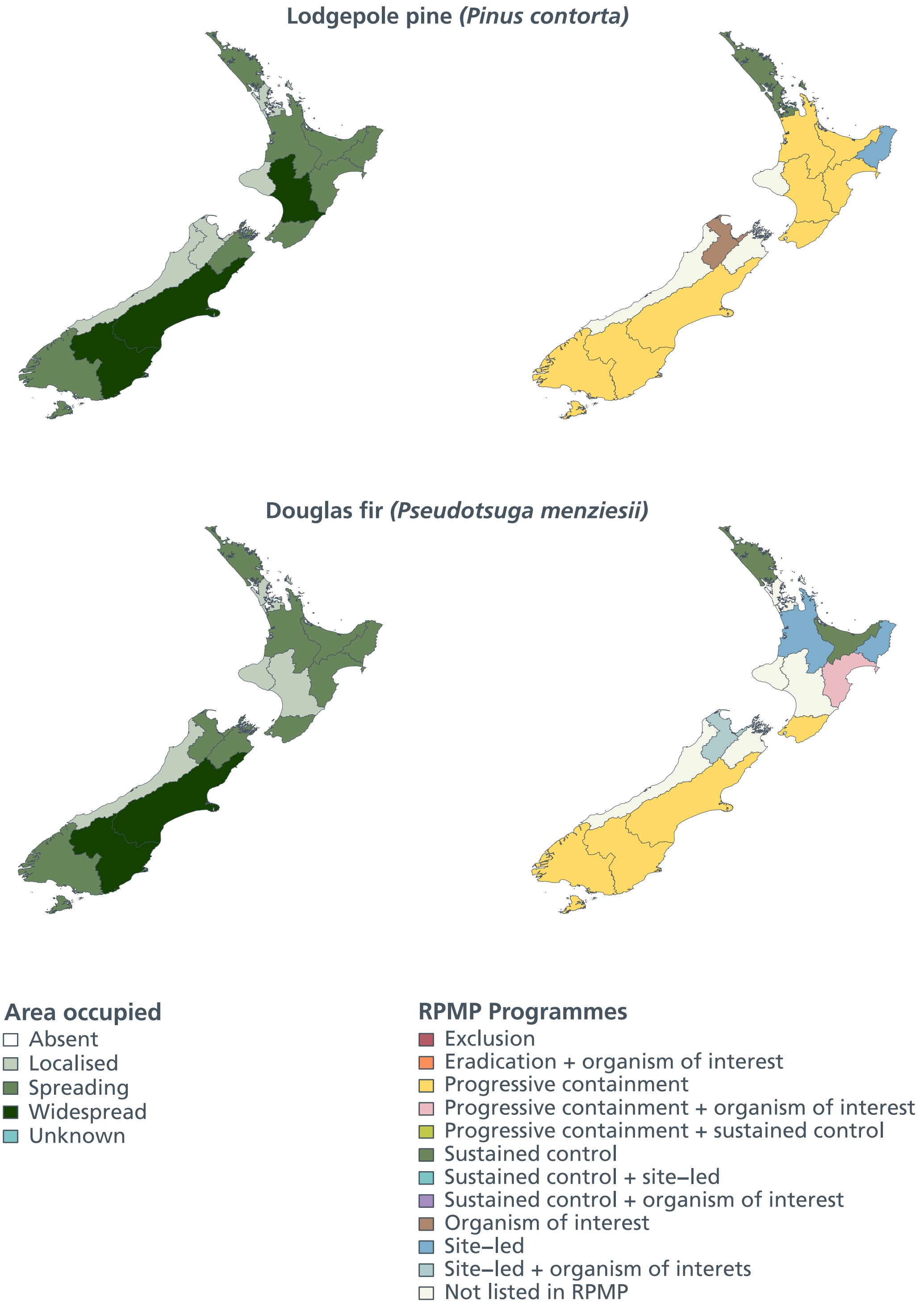


Boneseed *(Chrysanthemoides monilifera* subsp. *monilifera)*



Wild ginger *(Hedychium* spp.*)*





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.

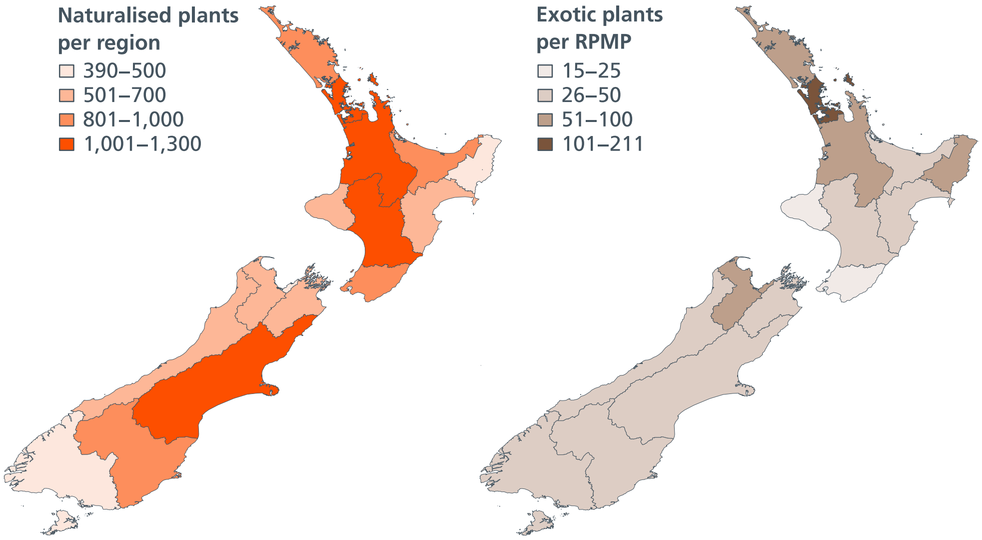
Lack of transparency in decision making remains an issue

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.

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[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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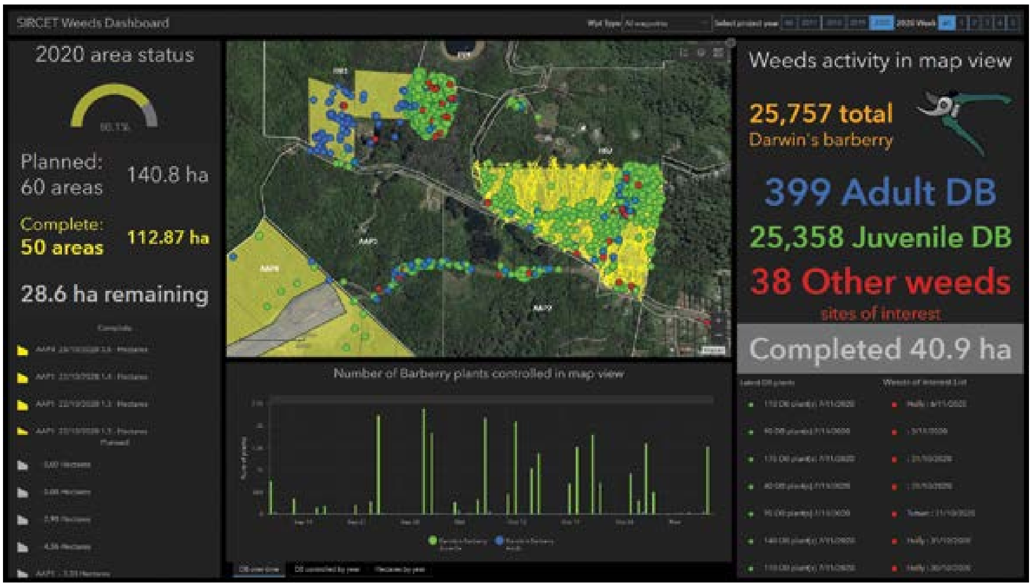
[3] Environment Southland, 2019.

[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.

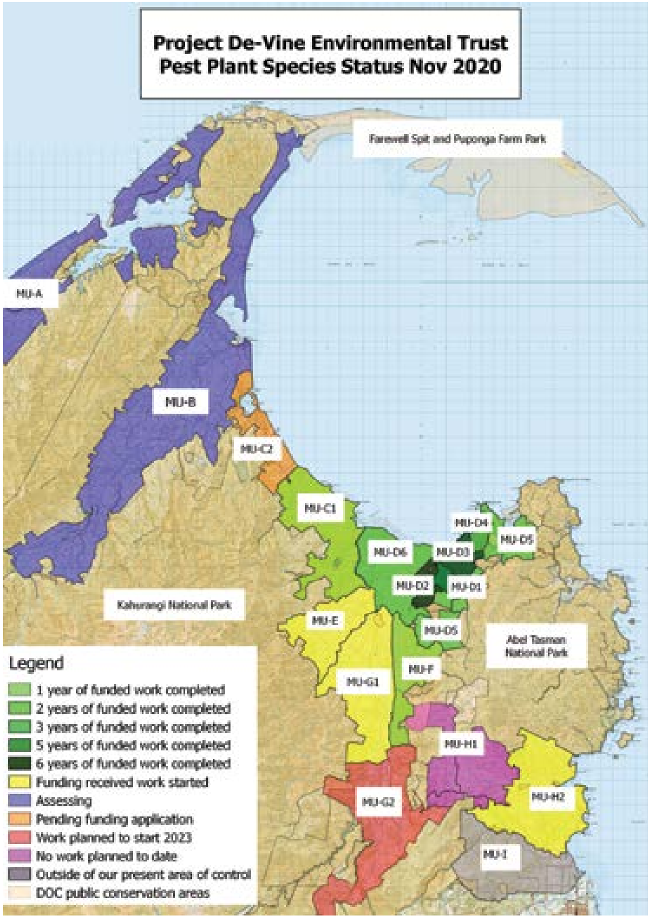
The results are notable. To date, PDVET reports having killed about 1 million weeds.[8] It has assessed over 850 private properties, equating to around 25,000 hectares, and controlled plants on nearly 500 of these properties (11,600 hectares).

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

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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

200 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.

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[14] McGowan, 2021.

[15] McGowan, 2021, p.18.

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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.

[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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November 2021

ISBN
978-0-947517-26-7 (print)
978-0-947517-27-4 (electronic)

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

06 May 2022
Document: 3040013

Environment Committee and Primary Production Committee

Submission on Te Kaitiaki Taiao a Te Whare Pāremata: Space invaders: A review of how New Zealand manages weeds that threaten native ecosystems

Introduction

The Taranaki Regional Council (the Council) thanks the Environment Committee and Primary Production Committee (the Committee) for the opportunity to make a submission on the Report of the Parliamentary Commissioner for the Environment, *Te Kaitiaki Taiao a Te Whare Pāremata: Space invaders: A review of how New Zealand manages weeds that threaten native ecosystems* (the Report).

The Council makes this submission in recognition of its:

- functions and responsibilities for native ecosystem weeds under the *Biosecurity Act 1993* (BSA), and the *Local Government Act 2002* (LGA);
- regional advocacy responsibilities whereby the Council represents the Taranaki region on matters of regional significance or concern; and
- experience in implementing regulatory and non-regulatory programmes maintaining and enhancing indigenous biodiversity and undertaking pest and weed control in the Taranaki region.

The Council has also been guided by its Mission Statement *'To work for a thriving and prosperous Taranaki'* across all of its various functions, roles and responsibilities, in making this submission.

Recommendations by the Parliamentary Commissioner

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 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.

1. With respect to recommendations 1, 2, 3 and 7, the Council agrees that more leadership is required to prioritising national ecosystem weed threats, specifically emerging risks. Harmful organisms are constantly being assessed and prioritised by Council, and commonly supported by an analysis of benefits and costs that assist decisions to intervene or not.

2. It is important that there is resourcing from a national level to provide guidance and direction around the emerging risks.

3. With respect to legacy weeds, there are some species that could be managed much more successfully, and national leadership could inform and support the work of the Council. If this is the case, it is important that there is funding and resource dedicated to this at the national level. This would ensure the efficient flow of information and a clear direction for all Regional Councils to follow. It is equally important that Council also maintains its core ability at the local level to have some priorities based on community desires. It is recommended that a specific team is set up which would bring together the best in-house skills hosted by these organisations with experts from the science sector, including the Crown Research Institutes and universities.

4. Lastly, it is also important that Central Government are leading by example and are supporting (through funding and resourcing) Crown departments managing ecosystem weeds on Crown lands appropriately to set an example to other landowners and occupiers. The Commissioner's report shows that nationally, investment in weed management by the Department of Conservation has remained static over many years, thus severely failing to keep pace with the increasing weed burden facing the conservation estate. Meaningful leadership by the Department would involve increased resourcing of weed management on Public Conservation Land priority ecosystems.

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

- *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:*

- *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.*

5. In response to Recommendations 4 and 5, clear nationally supported prioritisation and direction would greatly assist Councils triaging threats. Time and money being consumed in regions across New Zealand debating 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.

6. It is important to note that there are limitations to Regional Pest Management Plans as they are not the only tool that is used to manage native ecosystem weeds. In Taranaki, the Biosecurity and Biodiversity Strategy provide for the management of pest plants outside of the use of rules such as site-led weed control on key native Ecosystems and the formation of the Yellow Bristle Grass Action Group which sits outside of the Regional Pest Management Plan. Furthermore, the Biosecurity Act is very enabling by way it is written, which does not specifically instruct Council's to do specific tasks but rather vests certain powers to them giving them discretion about what they're able to do in regards to weed management. This then puts the onus on parties in the biosecurity space to opt out of participating in weed management and therefore contribute to a piecemeal approach of weed management.

7. Even with some national priorities set, there will still need to be strategic priorities for weed management set at the regional level. With this in mind, to a point, the debate over what weed species are managed by Council will never go away. There is a deep-seated misunderstanding in the public over what is a priority with respect to biosecurity interventions and the appropriateness and cost effectiveness of regulatory interventions versus non regulatory interventions. Concepts such as the invasion curve, feasibility and long-term return on investment are not well understood. Because of this, the contention usually stems back to why the Council is not prioritising the widespread environmental weeds the community can see and usually, see everywhere. When weeds get to that extent, the Council invests in tools like biological control agents or site-based initiatives (e.g. biodiversity projects) to protect values at place. But this commonly does not address the removal of the threat the community sees in front of them (and the demand for regulation).

8. In the development of any national policy direction, or initiatives targeting ecosystem weeds nationally, a critical factor that will need to be considered is the strong linkages between the Council's role in the biosecurity system and that of protecting biodiversity. There are large pieces of work occurring in that area including, but not limited to, *Te Mana o Te Taiao – NZ Aotearoa Biodiversity Strategy* and a *National Policy Statement on Indigenous Biodiversity*. In addition, the BSA is also subject to a current review.

9. It is important to consider that many pests are low incidence in some parts of the country, yet already abundant elsewhere and therefore have widely varying

management needs. We suggest that national coordination in relation to individual species management is likely most effective if focused on species that are low incidence nationally (or at least low incidence throughout one of the main islands). For species that are already at least locally abundant, a key focus must be site-led management of whole suites of environmental weeds. This is where, as noted above, increased resourcing of weed control on the conservation estate would be invaluable, along with biocontrol development.

10. Any national ecosystem weed priorities will likely align with the very robust and accepted principles of the invasion curve, feasibility and achievability. Addressing the impacts of the more widespread ecosystem weeds will likely rest with an effective and well-resourced biodiversity protection system aimed at protecting places of value across both private land/Council land and Crown lands. Inherently, this should involve a large degree of ecosystem weed management to ensure robust habitats are protected, maintained, or restored in the long term. Too often the focus can be on the short-term relief from predation, when there is slower habitat degradation occurring because of ecosystem weeds [and ungulate browse].

11. With respect to the amount of current investment occurring in this area, Figure 7.1 in the Report clearly shows both the current state and if anything, highlights a lack of Central Government investment in ecosystem weed management.

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).

12. Council recommends that if one action is taken from this report it would be to address Recommendation 6. This recommendation feeds into all the prior recommendations and links to having effective national leadership in place. It is imperative that regional councils are engaged at the outset with this work to collaborate and provide meaningful input into its development.

13. In terms of emerging threats, there needs to be a central platform that pulls together the information from all sources and allows for an analysis at a national level. The output of this would feed directly into priorities, recommendations for 'national significance' or even investment analyses. As noted in the supplementary report, there are many existing data sources, some of which are not kept up to date. Council would recommend that the conversation is not about any specific database *per se*, but the type of information collected and how it can either be fed into or drawn from existing platforms.

Other recommendations that the Sector would like to be considered (not mentioned in the report):

Biological control

14. Councils have been leading and the primary funder of environmental weed biocontrol for some time. It is recommended that Central Government should invest more consistently to provide leadership and enable further research, roll out of approved agents and also prioritisation of biocontrol targets/agents.

15. Biocontrol is hugely important for environmental weed management. While the report rightly prioritised increasing the emphasis on emerging weed issues, nonetheless, weed species that are already widespread and ineradicable continue to place a substantial burden on our indigenous biodiversity. These already widespread species are the ones that are most visible to our communities, and there is strong public desire for increased management of them.

16. The Sector has long collaborated on the development and approval of new biocontrol agents, through the National Biocontrol Collective. While the Sector welcome the recent additional central government funding to primary sector weed biocontrol, through the Sustainable Food and Fibres Fund, central government's contribution to environmental weed biocontrol remains extremely limited.

17. The Sector considers that increased central government participation in the National Biocontrol Collective would be a valuable action in response to the Commissioner's recommendation that central government should provide more leadership for environmental weed management. Furthermore, it is our experience that legislation governing Public Conservation Land management (including the *Reserves Act* and *Conservation Act*) acts as a barrier to biocontrol releases on Public Conservation Land. Removing this impediment through the upcoming conservation legislation review would be a low-cost intervention to improve weed control outcomes on Public Conservation Land and beyond.

Other tools for ecosystem weed control

18. By his own admission, the Commissioner did not delve into physical control tools around ecosystem weed control work. Of note however, is the disparity between the large amount of funding going into research and development for pest animal control, versus that of ecosystem weed management. The Sector believes that more investment in research to assist with finding new or to enhance existing tools, would both greatly enhance detection and control of ecosystem weeds.

Summary and conclusion

19. Council supports an emphasis on national co-ordination and the prioritisation of weeds. It is important to acknowledge that this should also be supported with funding and resourcing to ensure that long term outcomes sought by this work are achievable. National policy direction(s) are also supported should they be strategic and support the attainment of nationally set priorities.

20. The highest priority action considered by Council is that in Recommendation 6 of the report whereby having a dedicated platform for all weed information is resourced, managed, and updated by the Ministry of Primary Industries in their leadership role

of the biosecurity system. Council of course will be a vital collaborator on this but having this led nationally will assist in our nationwide ‘war against weeds’.

Yours faithfully
S J Ruru
Chief Executive

per: D R Harrison
Director - Operations

MEMORANDUM
Policy & Planning

Date	7 June 2022
Subject:	**Weedbusters Taranaki Guide**
Approved by:	D Harrison, Director - Operations
	S J Ruru, Chief Executive
Document:	3038615

Purpose

1. The purpose of this memorandum is to introduce the Taranaki Regional Council's (the Council) newly published *Weedbusters Taranaki* guide.

Executive summary

2. The *Weedbusters Taranaki* guide was published in April 2022.
3. The Guide was prepared in response to an increasing need from our community on information and advice about the priority weed species in the Taranaki region.
4. The Guide is consistent with the Restoration Planting guide series for Taranaki.

Recommendations

That the Taranaki Regional Council:

a) receives this memorandum entitled *Weedbusters Taranaki guide*

b) notes that the *Weedbuster Taranaki* guide is available to the community online or for free as a hard copy upon request to the Council.

Background

5. Weedbusters (www.weedbusters.org.nz) published a series of *Plant Me Instead Guides* in 2010, these guides were designed to profile the environmental weeds of greatest concern to those who work and volunteer in their back yard, local parks and reserves, national parks, bush remnants, wetlands and coastal areas. The guides also provide suggestions of locally sold non-weedy species, both native and non-native, that could be planted to replace the weeds once they had been removed.
6. The *Plant Me Instead Guides* were not produced for Taranaki, leaving the region to utilise a combination of the guides for Waikato, Central Districts and Wellington. In seeing the value of the *Plant Me Instead Guide*, the Council has produced its own version, which has been called the *Weedbusters Taranaki* guide.

7. In doing so, the Council continues to fulfil its role through the *Biosecurity Strategy for the Taranaki Regional Council* (2017) of providing advice and information, to reduce the infestation levels of legacy pests in Taranaki in the long term.

Discussion

8. In 2020, in response to increased action in the community, the Council undertook to invigorate the Weedbusters programme for Taranaki. The Weedbuster programme includes a wider range of species than those included in the *Pest Management Plan for Taranaki* (RPMP), and sets directions for identifying, reporting and removing weeds and selecting native plant species to plant in its place.
9. In response to an increasing number of requests for advice on non-Regional Pest Management Plan species and to raise awareness of pest management, the Council has produced a *Weedbuster Taranaki* guide based upon the concept of the *Plant Me Instead guides*.
10. The *Weedbuster Taranaki* guide advocates to the community to 'recognise, report and remove weeds and replant with native species' that contribute to biodiversity values in Taranaki.
11. The Guide does not include non-native alternatives as a planting options . All of the native species recommended in the Guide are also consistent with the *Restoration Planting Guide* series for our region. The *Weedbuster Taranaki* guide complements the Restoration Planting Guide series as the efforts of weed control and planting go hand in hand.
12. The Council's pest plant specialists consulted with ecologists from both within the Council and Waikato University in the development of the Guide to ensure appropriate suggestions for replacement native plants were included in the *Weedbuster Taranaki* guide. Local author Janet Hunt was contracted to compile the *Weedbuster Taranaki* guide to promote alignment with existing restoration guides (which she had also compiled).
13. The *Weedbuster Taranaki* guide is appended to this item and is available online and free as a hard copy upon request to the Council.
14. Council officers have already received a positive response from the community on the publication of the *Weedbuster Taranaki* guide and the Council have been printing a steady stream of hard copies since publication. Copies have been provided to individual landowners, hapū, tutors at WITT, District Council staff and Catchment Communities.
15. The *Weedbuster Taranaki* guide will help the community address the 'weed shaped hole' referred to in the Parliamentary Commissioner for the Environment Report *Space Invaders: A Review of How New Zealand Manages weeds that threaten native ecosystems*. For more information on this report and the Council's submission in response please see the Agenda Submission on *Space invaders: A review of how New Zealand manages weeds that threaten native ecosystems*.

Financial considerations—LTP/Annual Plan

16. This memorandum and the associated recommendations are consistent with the Council’s adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

17. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

18. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.

Community considerations

19. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

20. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices/Attachments

Document 3050702: Weed free Taranaki booklet

Weedbusters Taranaki

- RECOGNISE,
- REPORT AND
- REMOVE WEEDS

Restore biodiversity by planting native species

What's in a name?

— *A **weed** is simply any plant that is growing in the wrong place*

— *A **pest plant** is one Taranaki Regional Council has classified as being a pest. It is most likely to become widespread and have a harmful impact on native plants, habitats, farms and gardens in our region.*

Published by Taranaki Regional Council 2022

Acknowledgements

Thank you to the following people who helped with production of this booklet; Quin Amoore, Mike Beech, Bill Clarkson, Bruce Clarkson, Craig Davey, Steve Ellis, Sam Haultain, Leigh Honnor, Janet Hunt, Catherine Law, Lucy Roberts, Brenda Waterman.

Thanks also to New Zealand Plant Conservation Network, Weedbusters, Auckland Botanic Gardens, Taranaki Regional Council, Auckland Regional Council.

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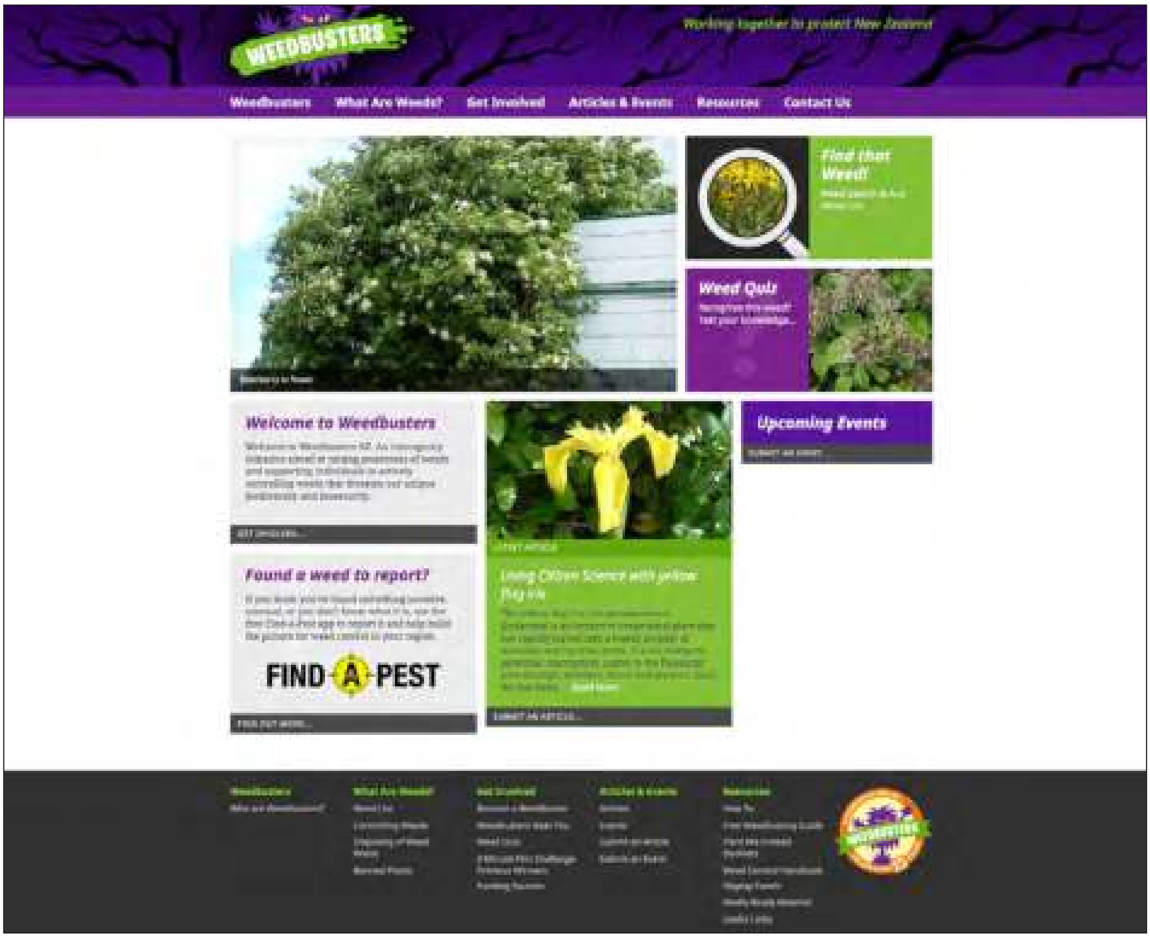

WEEDBUSTERS
Working together to protect New Zealand
Weedbusters
What Are Weeds?
Get Involved
Articles & Events
Resources
Contact Us
Find that Weed!
Weed Quiz
Welcome to Weedbusters
Upcoming Events
Found a weed to report?
FIND A PEST
Using Citizen Science with yellow flag iris

INTRODUCTION

How to use this booklet

The plants in this guide are grouped according to their structure and the way they grow. In each section, weeds are listed first, followed by desirable native alternatives. Identify your weed, report and/or remove it, then select a native to take its place. *Sweet!*

What about weeds?

There are more weed species growing wild in Aotearoa/New Zealand than native plants! They are found everywhere. They invade the natural environment from dumped garden waste, by seeds blown in the wind, and by being eaten and dispersed by birds and animals. Weed fragments travel along waterways and are carried in socks and boots and on vehicle tyres.

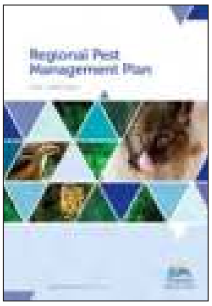
Weeds degrade natural ecosystems by displacing native species and cost our economy billions of dollars annually through lost productivity, control measures and their effect on human and animal health.

We need to stop this! We need your help! We must reduce the extent of weeds in our communities.

The legislation

All weeds in this booklet are recommended for control or removal. However, some species are even more unwelcome than others! The most undesirable are governed by two pieces of legislation, the Regional Pest Management plan for Taranaki (2018) and the National Pest Plant Accord (2020). There are additional notes in the plant lists for these species that indicate their classification.

REGIONAL PEST MANAGEMENT PLAN FOR TARANAKI (2018)



The Regional Pest Management Plan (RPMP) is the statutory framework by which the Taranaki Regional Council undertakes the management of pest animals and pest plants in the region for the next 10 years. It sets out a management programme for 16 pest plant species the council believes warrant *regional intervention*. These pest plants are of most concern to the environment and economy of our region. They are not able to be sold, propagated, distributed or displayed. See https://www.trc.govt.nz/environment/farmhub/biosecurity-biodiversity/pest-management-what-you-need-to-know/

There are two classifications:

1. **Eradication**: These not many of these pest plants in the region but the long term plan is to eradicate them altogether. **Report these species to the council as soon as you see them** and *the Council will undertake control*. The sooner an infestation is observed and reported, the greater the saving in time and money. Email biosecurity@trc.govt.nz or phone on 0800 736 222. If you can, send a photo.
2. **Sustained Control**: These pest plants are more abundant. The long-term goal is to prevent them from spreading to new areas or neighbouring properties.

Pest plants under the RPMP

Common name	Scientific name	Programme
Climbing spindleberry	*Celastrus orbiculatus*	Eradication
Giant reed	*Arundo donax*	Eradication
Madeira vine (mignonette)	*Anredera cordifolia*	Eradication
Moth plant	*Araujia hortorum/A. sericifera*	Eradication
Senegal tea	*Gymnocoronis spilanthoides*	Eradication
Giant buttercup	*Ranunculus acris*	Sustained control, GNR
Giant gunnera	*Gunnera manicata & G. tinctoria*	Sustained control, G
Gorse	*Ulex europaeus*	Sustained control, GNR
Nodding, plumeless and variegated thistles	*Carduus nutans, C. acanthoides, Silybum marianum*	Sustained control, GNR
Old man's beard*	*Clematis vitalba*	Sustained control, G
Wild broom	*Cytisus scoparius*	Sustained control, GNR
Wild ginger (Kahili and yellow)	*Hedychium gardnerianum, H. flavescens*	Sustained control, G
Yellow ragwort	*Jacobaea vulgaris*	Sustained control, G

G = A General Rule applies, meaning that the land occupier is required to undertake control.

GNR = A Good Neighbour Rule (GNR) applies. If your rural property is free of the plant, you can notify the Council of any infestation/s on adjoining rural property/ies. The adjoining occupier/s will then have to take the required action.

* Some sections of the Waingongoro and Patea Rivers are exempted for old man's beard. See the council website (previous page) for details.

NATIONAL PEST PLANT ACCORD (2020)

The National Pest Plant Accord (NPPA) was set up to prevent the further spread of pest plants within Aotearoa New Zealand. If allowed to spread further these pest plants could seriously damage the environment and economy. The Accord is a co-operative agreement between Ministry for Primary Industries, Department of Conservation, Regional and District Councils and the NZ Plant Producers Incorporated.

All plants listed in the Accord are unwanted organisms under the Biosecurity Act. There are approximately 240 species. They are banned from sale, propagation and distribution throughout Aotearoa New Zealand. The Accord contains a physical description of each species, with accompanying photographs, a summary of its impact and what to do. The Taranaki region contains many of the pest plant species described in the Accord. These species are invading and damaging our natural areas.

The Accord can be found at https://www.mpi.govt.nz/biosecurity/how-to-find-report-and-prevent-pests-and-diseases/partnerships-programmes-and-accords/national-pest-plant-accord/

For some pest plants you may also need to notify the Ministry for Primary Industry (MPI) on Pests & Diseases hotline, 0800 80 99 66. MPI is responsible for managing exotic pests when they enter our country. Visit the MPI website (www.mpi.govt.nz/biosecurity) to see if the pest is known to be in New Zealand.

Pest plant sightings can also be logged at https://inaturalist.nz/projects/pest-plants-weeds-of-nz or at www.findapest.nz. If you can, send a photo to provide additional valuable information.

PART 1

Recognise, report

& remove **Weeds**

Replant with

native species

Weed ground covers & herbs

Weed ground covers grow vigorously to form dense smothering mats on the ground. These mats often grow rapidly to form large infestations. Weed ground covers outcompete and shade out native ground cover species and suppress seedlings. Many species are shade tolerant. They are spread by wind, water and birds and many seed prolifically.

CONTROL OR REMOVE THESE SPECIES.

Artillery plant / aluminum plant

Lamium galeobdolon

- Mat forming
- Oval green leaves with large silver patches
- Purple creeping stems
- Yellow flowers

Artillery plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Carolyn Lewis*; inset: *Trevor James*

Bear's breeches

Acanthus mollis

- Clumps up to 120cm high
- Leaves are large, multi-lobed and shiny on a stalk
- White flowers on a central spike

Photo & inset: *Carolyn Lewis*

Plectranthus

Plectranthus ciliatus

- Creeping
- Hairy textured oval leaves with purple underside
- Erect stems of white flowers

Plectanthrus is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Giant gunnera

Gunnera tinctoria / Gunnera manicata

- A herb that resembles giant rhubarb
- Grows in clumps up to 2m high
- Rubbery prickles on huge leaves and stems

Under the Regional Pest Management Plan giant gunnera *must be under sustained control.*

Photo & inset: *Carolyn Lewis*

Elephants ears

Alocasia brisbanensis

- A herb
- Grows up to 2m high
- Leaves are large and arrow-shaped on stems
- Small cream flowers
- Red fleshy fruit

Photo & inset: *Carolyn Lewis*

Fairy crassula

Crassula multicava

- Creeping succulent
- Fleshy leaves with small pitted dots
- Clusters of small pale pink flowers

Fairy crassula is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Carolyn Lewis*; inset: *Trevor James*

Giant knotweed

Fallopia sachalinensis

- Shrub-like herb up to 4m high
- Red-purple shoots then green canes
- Leaves long, triangular
- Creamy white flowers

Giant knotweed is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Ginger species,

Hedychium gardnerianum and *Hedychium flavescens*

- Kahili ginger & yellow ginger
- Erect stems to 2.5m high; large shiny leaves
- Tall yellow or cream flower heads; orange fruit
- Thick rhizome clumps and strong roots

Under the Regional Pest Management Plan ginger species *must be under sustained control.*

Photo: Carolyn Lewis; inset: Wendy Feltham

Mexican daisy

Erigeron karvinskianus

- Sprawling daisy up to 40cm high
- Long thin stem
- Small narrow leaves
- White or pink flower

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: Carolyn Lewis

Nasturtium

Tropaeolum majus

- Hairless, scrambling
- Long fleshy stems
- Round leaves on stalks
- Tubular red/orange/yellow flowers

Photo: Carolyn Lewis; inset: Trevor James

Periwinkle

Vinca major

- Scrambling ground cover or vine
- Stems are long, strong and trailing
- Shiny leaves
- Solitary violet flowers

Photo: Carolyn Lewis; inset: Trevor James

Pink ragwort

Senecio glastifolius

- Up to 1m high at flowering
- Stems grow from crown
- Oval, toothed light green leaves
- Clusters of bright pink/purple flowers

Photo & inset: Carolyn Lewis

Ragwort

Jacobaea vulgaris

- Erect plant <60cm high
- Stems grow from crown
- Waxy, lobed, dark green leaves
- Clusters of bright yellow flowers

Under the Regional Pest Management Plan this plant *must be under sustained control.*

Photo: Trevor James; inset: naturewatchwidow

Snow poppy

Eomecon chionantha

- Small oval leaves with scalloped edges
- White four-petalled flower with yellow stamens
- Extensive rhizomes

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: Carolyn Lewis

Wandering willy

Tradescantia fluminensis

- Ground cover with succulent creeping stems
- Dark green shiny smooth oval leaves
- White flowers

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: Carolyn Lewis

Native ground covers

Native ground covers are found naturally in our ecosystems. They are suited to local conditions and will thrive. Their low growing sprawling nature prevents bare soil from being washed away and helps retain moisture. They cover the ground so suppress weeds.

Their foliage adds texture and their abundance of flowers adds colour. Planting native ground cover will provide fruit, nectar and leaves for birds and habitat for insects and lizards.

Plant these species. Select from any of the options on pages 13 to 15.

Puatea

Anaphalioides trinervis

- Dark green leaves
- Straw-paper-like white flowers on long stems
- Prefers partially shaded moist banks, such stream sides or the edges of waterfalls

Photo: *Rob Lucas*

Bead plant

Nertera depressa

- A tiny, mound-forming plant
- Bright green leaves
- Tiny greenish-white flowers
- Small shiny orange berries

Photo: *Melissa Hutchison*

Harakeke

Phormium tenax

- Up to 5m high
- Large long leaves arising from base and floppy at ends
- Tubular red flowers
- Flat black seeds

Photo & inset: *Janet Hunt*

Kakaha / bush lily

Astelia fragrans

- Broad-green flax-like leaves stiffly arched with a silvery sheen
- Scented flowers
- Orange berries on female plants

Photo & inset: *Rob Lucas*

Leptinella squalida

Leptinella squalida subsp *squalida*

- Fast growing
- Member of the daisy family
- Single erect lobed green leaves
- Yellow button-like flowers

Photo: *Bruce Clarkson*

Panakenake / pratia

Lobelia angulata

- Fast growing
- Tiny circular leaves with toothed margins Small white/ violet flowers
- Purplish red berries

Photo: *Janet Hunt*

Parataniwha

Elatostema rugosum

- Long textured leaves with saw-like edge Green or red-purple
- Tiny fruit
- Prefers shade and damp

Photo: *Janet Hunt*

Pinatoro

Pimelea carnosa

- Very low growing sprawling shrub
- Tan/grey stems
- Overlapping pairs of thick fleshy oval leaves
- Clusters of small white flowers, white fruit

Photo: Simon Waugh; inset: Melissa Hutchison

Piripiri / bidibid

Acaena anserinifolia

- Slender stems
- Pairs of oblong toothed leaves
- Flower heads spherical each with a long, hooked spike when fruiting

Photo: Chris Ecroyd

Rengarenga

Arthropodium cirratum

- Clump forming to 60cm high
- Strap-like green arching leaves
- Spikes of white star-shaped flowers

Photo: Janet Hunt

Eco-source your plants if possible.
This means getting your plants from seed and cuttings obtained from within, rather than outside, your region.

These plants are better adapted to local conditions and are more likely to thrive.

Weed grasses, bulbs and ferns

Weed grasses, bulbs and ferns grow vigorously and rapidly to smother the ground. They often form colonies that prevent the establishment of native seedlings. This group ranges in size from tall Pampas grass to shorter species such as African clubmoss. Many of this group are shade tolerant. They are spread by wind, birds, water and vegetative matter.

CONTROL OR REMOVE THESE SPECIES.

African clubmoss

Selaginella kraussiana

- Carpet forming fern-like plant with creeping, slender, irregular branched stems
- Tiny leaves up to 4mm long in rows on stem
- Spread by spores on boots or feet

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: Carolyn Lewis; inset: *Trevor James*

Agapanthas

Agapanthas praecox subsp. *orientalis*

- Herb up to 1.2m
- Long leathery leaves arise from base of rhizomes
- White/purple/blue flowers on erect stems

Photo: *Carolyn Lewis*; inset: *Carolyn Lewis*

Aristea

Aristea ecklonii

- Stiff upright iris-like leaves growing in clumps up to 70cm high
- Small blue-purple flowers

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Carolyn Lewis*; inset: *Carolyn Lewis*

Bamboo

Bambusa glaucescens

- Tall erect grasses up to 5m high
- Clump forming
- Long green/brown smooth hollow stems
- Leaves long thin

Photo & inset: Janet Hunt

Formosan lily

Lillium formosanum

- Up to 1m high
- Narrow leaves up to 13cm in length off main stem
- Large white trumpet –shaped flowers
- Many wind-blown seeds in pod

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: Trevor James

Field horsetail

Equisetum arvense

- Forms dense mats
- Erect jointed stems: sterile are green and branched, fertile are pale brown and unbranched

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: Trevor James

Giant reed

Arundo donax

- Bamboo-like grass up to 5m high
- Clump forming
- Hollow stems
- Bluish-white leaves
- Plume-like flower head

Under the Regional Pest Management Plan this plant *must be eradicated.* Report it to the Taranaki Regional Council.

Photo: Carolyn Lewis; inset: Trevor James

Himalayan fairy grass

Miscanthus nepalensis

- Tufted grass up to 1m high
- Leaf blades with a mid-rib
- Drooping brown flower head on long stem

Photo & inset: Carolyn Lewis

Arum lily

Zantedeschia aethiopica 'Green Goddess'

- Clump forming plant up to 1.5m
- Large arrow-shaped glossy leaves and white flowers
- Green/orange fruit

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: Carolyn Lewis

Italian arum

Arum italicum

- Poisonous plant up to 60cm high
- Dark green arrow-shaped leaves with cream veins
- Green/white flowers
- Orange berries on spikes

Photo: *Trevor James*; inset: *Carolyn Lewis*

Canna lily

Canna indica

- Clumping plant up to 2m high
- Large green oblong leaves on sturdy stems
- Yellow/orange/red flowers on stem

Photo: *Carolyn Lewis*; inset: *Trevor James*

Himalayan giant lily

Cardiocrinum giganteum

- Large lily up to 3.5m high
- Big shiny green heart-shaped leaves
- Clusters of large tubular pink/white flowers on tall stems

Photo & inset: *Carolyn Lewis*

Marram grass

Ammophila arenaria

- Erect densely tufted grass to 1m high
- Grey-green tightly rolled leaves
- Seed head a dense golden spike

Photo & inset: *Trevor James*

Mexican feathergrass

Nassella tenuissima

- Tussock-forming grass
- Fine wiry leaves <70cm high
- Feathery flowerhead

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Megan Hansen*; inset: *Stan Shebs*

Montbretia

Crocosmia x crocosmiiflora

- Clump forming plant
- Sword shaped leaves <90cm high arise from base of corms and rhizomes
- Orange flowers overtop foliage

Photo: & inset: *Janet Hunt*

Palm grass

Setaria palmifolia

- Large dense grass
- Large elongate palm-like leaves
- Narrow seed heads with fuzzy tips on long arching stems

Photo & inset: Carolyn Lewis

Pampas grass + purple pampas grass

Cortaderia selloana + Cortaderia jubata

- Clump forming grass up to 4m high
- Long thin sharp leaves
- Erect fluffy flower heads — white-pinkish or purple

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: Janet Hunt; inset: Carolyn Lewis

Stinking Iris

Iris foetidissima

- Clump forming herb <80cm high
- Sword-shaped leathery leaves from base
- Pale yellow flowers on stems
- Fruit capsules

Photo & inset & insets: Carolyn Lewis

Tuber ladder fern

Nephrolepis cordifolia

- Up to 1m high
- Tuft forming
- Long erect fronds with serrated divided leaflets

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: Carolyn Lewis; inset: Trevor James

Native grasses, bulbs and ferns

Native grasses, bulbs and ferns thrive in local conditions. They stabilise the soil, prevent erosion and suppress weeds. They provide food and habitat for insects and lizards.

Grasses are versatile and low maintenance and come in a variety of sizes and colours. Plant one or two species for simplicity. Ferns are a beautiful garden addition. They like free-draining soil, consistent moisture and an appropriate level of light.

Plant these species! Select from any of the options on pages 22 to 27.

Alpine hard fern

Blechnum penna-marina

- Low growing and compact up to 20cm high
- Narrow erect dark green fronds
- Young fronds are tinged red

Photo: Bruce Clarkson

Broad-leaved poa

Poa anceps

- Tufted up to 70cm high
- Coarse light green, green-brown to blue-green erect or drooping leaves
- Flowering stalk

Photo: Mike Thorsen

Bush rice grass

Microlaena avenacea

- Fine blue green grass
- Sword like erect or drooping leaves
- Arching flower stems

Photo: Rob Lucas

Common maidenhair fern / puhinui

Adiantum cunninghamii

- Tufted with creeping stem
- Dark green to blue green fronds, paler underside
- Oblong leaflets attached by a stalk

Photo: L Jensen; inset: Rob Lucas

Huruhuruwhenua / shining spleenwort

Asplenium oblongifolium

- Tufted up to 1m high
- Dark green fronds
- Bright green shiny narrow leaflets up to 15cm in length

Photo: Rob Lucas

Kiwikiwi

Blechnum fluviatile

- Dark brown spiky upright fronds in centre
- Drooping green ladder-like fronds with round leaflets

Photo: Rob Lucas

Kuta

Eleocharis sphacelata

- Sedge with submerged roots
- Thick hollow mid to dark green stems up to 1m high
- Small cream to brown flower spike on tip of foliage

Photo: Colin Ogle; inset: Wayne Bennett

Makaka / true maidenhair fern

Adiantum aethiopicum

- Spreading clumps with fronds up to 0.5m high
- Small bright green leaflets on wiry black stems

Photo: Auckland Botanic Gardens

Mikoikoi / NZ Iris

Libertia ixioides

- Fan-shaped
- Stiff sword-like yellow tinged green flat leaves
- Small white flowers
- Orange/yellow seed pods

Photo: nativeplants.co.nz

Oioi / jointed wire rush

Apodasmia similis

- Fine grey-green leaves
- Regular brownish joints running up stems
- Up to 1m high

Photo: Janet Hunt

Petipeti / crown fern

Blechnum discolor

- Upright up to 1m high
- Shuttlecock shaped crown
- Closely spaced oblong leaflets green above, paler below

Photo: Carolyn Lewis; inset: Carolyn Lewis

Pikopiko / hen and Chicken fern

Asplenium bulbiferum

- Tufted and erect
- Pale green arching feathery fronds with plantlets on the upper surface

Pukio

Carex secta

- Tussock forming sedge up to 1m high
- Circular clump shape
- Drooping yellow- green leaves

Pukio / swamp sedge

Carex virgata

- Clump forming
- Bright green leaves up to 1m high
- Leaves arching and fine
- Dark brown seed heads

Pukupuku / rasp fern

Blechnum parrisiae or *Doodia australis*

- Clump forming
- Erect up to 1m high
- Rough arching green fronds, pink-red when young
- Narrow leaflets

Shield fern

Polystichum neozelandicum
or *Polystichum wawranum*

- Erect stems
- Blue-green scaly fronds up to 1m high
- Leaflets oblong, toothed, pointed at tip

Photo: Bruce Clarkson

Speckled sedge

Carex testacea

- Erect and densely tufted up to 60cm high
- Fine dark red to orange-red arching foliage
- Flower spikes

Photo: Auckland Botanic Gardens

Swamp astelia

Astelia grandis

- Clump up to 1.5m high
- Erect wide leaves
- Olive green with silvery sheen beneath
- Orange berries

Photo: Bruce Clarkson; inset: Mike Thorsen

Swamp kiokio

Parablechnum minus

- Green and arching up to 0.5m high
- New fronds red tinge
- Leaflets long and pointed
- Brown hairs on fronds and stems

Photo: Bruce Clarkson

Thread fern

Blechnum filiforme

- Climbing fern that creeps along the ground before climbing a tree trunk
- Juvenile has short fronds with serrated oblong leaflets;
- Adult fronds are larger with elongated tapering leaflets, then long thread-like leaflets

Photo: Wayne Bennett

Toetoe

Austroderia fulvida or *Austroderia toetoe*

- Robust grass up to 1.5m high
- Long leaves, sharp edged
- Leaves dull on the upper side, shiny below
- Upright dense feathery plumes

Photo: Janet Hunt

Pepepe

Machaerina sinclarii

- Drooping bright green wide flat leaves up to 1.5m high
- Long drooping panicles of fine rusty red flowers

Photo: Wayne Bennett

Turutu

Dianella nigra

- Resembles a fine leafed flax
- Grows up to 50cm high
- Bright blue/purple berries on long stems
- Tiny white flowers

Photo: Wayne Bennett

Weed climbers and vines

Weed climbers and vines grow vigorously and rapidly up into the canopy. They are a serious threat to native forest. They spread to form a thick blanket which smothers and strangles native shrubs and trees. Some climbers and vines form a dense layer on the forest floor that suppresses low growing native species. Weed climbers and vines grow from seeds, stems and root fragments.

CONTROL OR REMOVE THESE SPECIES.

Asparagus–bushy

Asparagus aethiopicus

- Scrambling
- Multi stemmed and bushy
- Small white flowers
- Red berries

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Carolyn Lewis*

Asparagus–climbing

Asparagus scandens

- Climbing fern-like plant
- Wiry stems up to 2m long, widely branched
- Scale-like thin leaves; small white flowers, red berries

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo and inset: *Janet Hunt*

Asparagus–ferny

Asparagus plumosus

- Scrambling fern-like plant
- Branched stems up to 2m long
- Thin fern-like leaves
- Small white flowers
- Purple/black berries

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Carolyn Lewis*

Asparagus–smilax

Asparagus asparagoides

- Scrambling, up to 3m high
- Wiry branched stems
- Oval pointed leaves
- Green/white flowers
- Red berries

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Trevor James*; inset: *Carolyn Lewis*

Blue morning glory

Ipomoea indica

- High climbing vine
- Twining purplish hairy stems
- 3-lobed hairy leaves
- Blue-purple funnel-shaped flowers

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Bomarea vine

Bomarea multiflora

- Vine with long thin pointed leaves
- Clusters of trumpet-shaped red flowers with yellow on inside

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Cape Ivy

Senecio angulatus

- Scrambling, up to 2m high
- Thick ivy-shaped leaves coarsely toothed
- Clusters of yellow daisy-like flowers

Photo & inset: *Carolyn Lewis*

Cathedral Bells

Cobaea scandens

- Woody vine with clawed tendrils
- Bell-shaped flowers green when young then turn purple
- Green seed capsule

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: Carolyn Lewis; insets: *Trevor James*

Chilean flame creeper

Tropaeolum speciosum

- Vine with slender stems and five-fingered leaves
- Scarlet flowers
- Blue/black berries

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Carolyn Lewis*; inset: *Trevor James*

Chocolate vine

Akebia quinata

- Climbing vine or scrambling ground cover
- Leaves palmate <5 leaflets
- Purple-brown flowers
- Purple-violet flattened seed pods

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Climbing dock

Rumex sagittatus

- Scrambling vine up to 4m long
- Arrow shaped leaves hanging down
- Clusters small green/pink flowers
- Kumara-like rhizome

Photo & inset: *Carolyn Lewis*

Climbing spindleberry

Celastrus orbiculatus

- Vine up to 12m long
- Serrated heart-shaped leaves
- Small clusters of green flowers
- Young stems have sharp spines
- Yellow and red fruit

Under the Regional Pest Management Plan this plant *must be eradicated*. Report it to the Taranaki Regional Council.

Photo & inset: *Carolyn Lewis*

German Ivy

Delairea odorata

- Scrambling vine up to 5m long
- Thin soft glossy ivy-shaped leaves
- Clusters of yellow button-like flowers

Photo & inset: *Carolyn Lewis*

Great bindweed / convolvulus

Calystegia silvatica subsp *disjuncta*

- Creeping herb with stems up to 2m long
- Smooth arrow-shaped leaves
- Large white funnel-shaped flowers

Photo: *Janet Hunt*; inset: *Jeremy Rolfe*

Japanese honeysuckle

Lonicera japonica

- Scrambling branched climber
- Brown smooth flexible stems
- Dark green leaves
- Paired white-yellow flowers

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Jasmine

Jasminum polyanthum

- Climber up to 12m long
- Tough wiry stems
- Dark green leaflets
- Pink flower buds
- White star-like flowers

Photo & inset: *Carolyn Lewis*

Ivy

Hedera helix

- Climber with woody stems
- Clings using aerial rootlets
- Shallow lobed leaves
- Tiny yellow/green flowers

Photo & inset: *Carolyn Lewis*

Madeira vine

Anredera cordifolia

- Vine with reddish stems and small aerial tubers
- Glossy heart shaped leaves
- Small drooping cream flowers

Under the Regional Pest Management Plan this plant *must be eradicated*. Report it to the Taranaki Regional Council.

Photo & inset: *Carolyn Lewis*

Mile a Minute

Dipogon lignosus

- Vine
- Leaves with three heart-shaped leaflets
- Pea-like white/pink/purple flowers
- Sickle shaped seed pods

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Moth plant

Araujia sericifera syn A hortorum

- Vine up to 10m long
- Dark green leaves
- Clusters white flowers
- Large pods with black thistle down-like seeds

Under the Regional Pest Management Plan this plant *must be eradicated.* Report it to the Taranaki Regional Council.

Photo & inset: *Carolyn Lewis*

Old Man's Beard

Clematis vitalba

- Vine up to 20m long
- Long woody stems with 6 ridges
- Cream-white flowers, from December–May
- Seeds have white fluffy plumes

Under the Regional Pest Management Plan this plant *must be under sustained control.*

Photo & inset: *Carolyn Lewis*

Banana passionfruit

Passiflora 'Tacsonia' subgroup

- Climbing vine up to 6m long
- Tendrils on stems, lobed leaves; pink/white/purple pendulous flowers
- Oval green/yellow/orange fruit

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale*

Photo & inset: *Carolyn Lewis*

Blue passion flower

Passiflora caerulea

- Climbing vine up to 6m long
- Tendrils on stems, lobed leaves; pink/white/purple pendulous flowers
- Round green/yellow/orange fruit

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Native climbers and vines

Native climbers and vines are suited to local conditions and will thrive. They provide nectar and fruit for birds, insects, and lizards and also provide seasonal interest and screening without taking over the space at ground level. They add scent and colour with their multitude of beautiful flowers. Climbers and vines are hardy, fast growing and add diversity to the upper tier of your planting.

Plant these species! Select from any of the options on pages 34 to 36.

Akakiore / kaihua / NZ jasmine

Parsonsia heterophylla

- Twining growth habit up to 4m high
- Slender stems, glossy green leaves
- Clusters of sweetly scented creamy white flowers

Photo & inset: *Rob Lucas*

Akatea / climbing rata / scarlet rata

Metrosideros fulgens

- Vine up to 10m long
- Twine/rope like stems
- Oval shaped, dark green glossy leaves
- Bright red flowers

Photo: *Rob Lucas*

Akatorotoro / small white rata

Metrosideros perforata

- Small round green leaves on stiff stems
- Clusters white flowers
- Can take the shape of a bushy shrub when support is unavailable

Photo: *Rob Lucas*

Kohia / NZ passionfruit

Passiflora tetrandra

- Climber up to 10m long
- Tendrils
- Glossy green leaves
- Small fragrant creamy flowers
- Round orange fruit

Photo: Rob Lucas

Kokihi / native spinach

Tetragonia implexicoma

- Scrambler
- Long trailing stems up to 4m long
- Initially succulent, woody with age
- Fleshy leaves and fruit

Photo: Bruce Clarkson

Pohuehue / large leaved pohuehue

Muehlenbeckia australis

- High climber with many branched stems, tendrils
- Adult leaves oval, juvenile leaves 3-lobed; irregular margins
- Small creamy flowers

Photo: Janet Hunt

Small leaved pohuehue

Muehlenbeckia complexa var. *complexa*

- Twining vine
- Dense wire-like stems, inter-laced tiny round light green leaves
- Tiny creamy-green flowers

Photo & inset: Janet Hunt

Pouwhiwhi / NZ bindweed

Calystegia tuguriorum

- Scrambler
- Numerous, slender, twining stems
- Heart shaped green leaves
- Large white funnel-like flowers

Photo: John Barkla

Puawananga / clematis

Clematis paniculata

- High climber
- Stems up to 9m long
- Leaves have 3 oval bright green leaflets
- Star shaped large white flowers in spring

Photo & inset: Janet Hunt

Tataramoa / bush lawyer

Rubus cissoides

- Scrambling vine
- Lance-shaped leaflets with toothed edges and prickles to cling to adjacent vegetation
- Orange-red fruit

Photo & inset: Janet Hunt

Tataramoa / swamp lawyer

Rubus australis

- Scrambling vine
- Round leaflets with toothed edges and prickles to cling to adjacent vegetation
- Orange-red fruit

Photo: Jeremy Rolfe

Weed shrubs, trees and palms

Weed shrubs, trees and palms grow vigorously and rapidly to form dense stands. They grow into the canopy where they crowd and replace native species, preventing regeneration. Many weed shrubs, trees and palms were planted historically and are long-lived. Many are shade tolerant and spread aggressively by seeds, root suckering and stump sprouting.

CONTROL OR REMOVE THESE SPECIES.

Alder

Alnus glutinosa

- Deciduous tree up to 15m high
- Fissured bark
- Oblong toothed leaves
- Clusters of catkins mature to cones

Photo: *Trevor James*

Bangalow palm

Archontophoenix cunninghamiana

- Palm up to 14m high
- Grey trunk
- Leaves are uniformly divided
- Hanging purple flowers
- Spherical fruit

Photo & inset: *Trevor James*

Barberry

Berberis glaucocarpa

- Evergreen spiny shrub up to 7m high
- Leathery leaves
- Clusters yellow flowers
- Red/black berries when ripe

Photo & inset: *Carolyn Lewis*

Black locust

Robinia pseudoacacia

- Tree up to 25m high
- Thin round leaflets in pairs on leaf stalk
- Drooping clusters of pea-like white/yellow flowers

Photo: *Carolyn Lewis*

Boneseed

Chrysanthemoides monilifera

- Evergreen shrub up to 3m high
- Leathery serrated bright green leaves
- Yellow flowers followed by hard green-black fruit

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & insets: *Carolyn Lewis*

Boxthorn

Lycium ferocissimum

- Erect shrub up to 6m high
- Branched stems with spines
- Fleshy oblong leaves
- Cream/purple flowers
- Red fruit

Photo: *Carolyn Lewis*

Brush wattle

Paraserianthes lophantha

- Shrub to small tree
- Leaflets on either side of a stem
- Green/yellow flowers
- Long brown seed pods

Photo: *Bruce Clarkson*

Buddleia

Buddleia davidii

- Shrub up to 3m high
- Multi-stemmed
- Thin drooping leaves
- Hanging clusters of white/ purple flowers

Photo: Bruce Clarkson

Castor Oil Plant

Ricinus communis

- Shrub or small tree up to 4m high
- Glossy palmate serrated green/red/purple leaves
- Red/green flowers
- Spiky pod full of large seeds

Photo: Carolyn Lewis

Chinese windmill palm

Trachycarpus fortunei

- Palm up to 12m high
- Fibrous trunk
- Leaves are fan-shaped with sharp marginal teeth
- Numerous yellow flowers

Photo: Carolyn Lewis; Inset: Trevor James

Coastal banksia

Banksia integrifolia

- Tree up to 15m high
- Narrow elliptical leaves with white underside
- Erect stalks of yellow flowers
- Woody cones

Photo: Carolyn Lewis; Inset: Trevor James

Cotoneaster species

- Evergreen shrubs up to 3m high
- Dark glossy leaves
- Clusters small white flowers
- Bunches of red berries

Cotoneaster simonsii is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Trevor James*

Darwin's barberry

Berberis darwinii

- Shrub up to 4m high
- Clusters leaves spiny edges and below
- Clusters orange flowers
- Purple/black berries

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Elder

Sambucus nigra

- Shrub up to 6m high
- Serrated leaflets
- Clusters of white flowers and black fruit on red/purple stems

Photo & inset: *Carolyn Lewis*

Elaeagnus

Elaeagnus x reflexa

- Dense scrambling shrub up to 20m high
- Oval wavy leaves
- Clusters small whitish flowers
- Oblong orange fruit

Photo & inset: *Carolyn Lewis*

Grey willow

Salix cinerea

- Deciduous shrub or small tree up to 7m high
- Shiny oval serrated leaves
- Erect catkins appear before leaves

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Trevor James*

Hawthorn

Crataegus monogyna

- Dense tree up to 14m high
- Thorny stems
- Lobed and toothed leaves
- Small white flowers
- Red fruit

Photo & right inset: *Trevor James*; left inset *Carolyn Lewis*

Heather

Calluna vulgaris

- Bushy shrub <60cm high
- Woody stems
- Tiny leaves in rows
- Spikes of small purple or pink flowers

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Trevor James*; inset: *Carolyn Lewis*

Himalayan honeysuckle

Leycesteria formosa

- Shrub up to 2m high
- Many stemmed
- Heart-shaped leaves
- White flowers surrounded by red/purple bracts

Photo & inset: *Janet Hunt*

Holly

Ilex aquifolium

- Tree up to 12m high
- Glossy serrated leaves with a spine at each point
- Small white flowers
- Red berries

Photo & inset: Carolyn Lewis

Japanese spindle tree

Euonymus japonicus

- Shrub or small tree up to 7m high
- Glossy oval leaves; clusters of small green flowers
- Round pink seed capsules

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: Carolyn Lewis

Japanese walnut

Juglans ailantifolia

- Tree up to 15m high
- Large leaves <17 stalkless leaflets
- Produces catkins
- Walnut with a green husk

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: Carolyn Lewis; insets: Trevor James

Lantana

Lantana camara (all varieties)

- Shrub up to 2m high
- Wrinkled leaves, toothed edges
- Clusters small yellow/pink/orange flowers
- Berry-like blue/black fruit

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: Carolyn Lewis; insets: Trevor James

Lodgepole pine / wilding pine

Pinus contorta

- Tree up to 24m high
- Reddish brown rough bark
- Green needle-like leaves in clusters
- Egg-shaped cones

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Trevor James*

Mistflower

Ageratina riparia

- A low-growing shrub
- Scrambling, erect
- Up to 1.5m high
- Many hairy stems
- Serrated leaves
- Small clusters of white flowers

Photo & inset: *Carolyn Lewis*

Monkey apple

Syzygium smithii

- Tree up to 20m high
- Glossy oval leaves
- Whitish flowers
- White/pink berry-like fruit

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & insets: *Trevor James*

Phoenix palm

Phoenix canariensis

- Diamond patterned trunk
- Large leaves with spines on stalks
- White/yellow flowers
- Orange berries

Photo & right inset: *Trevor James*; left inset *Carolyn Lewis*

Privet species

- Four tree species
- up to 15m high
- Lumpy warts on stems
- Glossy leaves
- Tiny cream flowers
- Blue/black berry-like fruit

Ligustrum lucidum is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Rowan

Sorbus aucuparia subsp *aucuparia*

- Tree up to 8m high
- Erect trunk, spreading branches
- Leaves up to 8 pairs of leaflets
- White flowers
- Red berries

Sexton's Bride

Rhaphiolepis umbellatum

- Bushy shrub up to 3m high
- Oval leathery leaves
- White flowers with pink stamens
- Purple/black fruit

Spanish heath

Erica lusitanica

- Shrub up to 2m high
- Needle-like leaves in whorls of 3-4
- Bell-shaped white/pink flowers

Strawberry dogwood

Dendrobenthamia capitata

- Tree up to 6m high
- Paired leaves with prominent veins
- Pale yellow flower
- Strawberry-like fruit

Photo & inset: *Weedbusters.org.nz*

Sweet pea shrub

Polygala myrtifolia

- Shrub up to 2m high
- Smooth branched stems
- Smooth oval leaves
- Clusters of pea-like purple flowers

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Carolyn Lewis*

Sycamore

Acer pseudoplatanus

- Deciduous tree up to 35m high
- Grey trunk
- Large palmate leaves
- Cluster small yellow/green flowers
- Winged seeds in pairs

Photo & inset: *Trevor James*

Taiwan cherry

Prunus campanulata

- Deciduous tree up to 8m high
- Serrated leaves
- Bell-shaped dark pink flowers
- Fruit - shiny scarlet cherries

Photo & inset: *Carolyn Lewis*

Tree of Heaven

Ailanthus altissima

- Deciduous tree up to 25m high
- Compound leaves with alternating leaflets
- Flowers are yellow/white/green

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: Carolyn Lewis; inset: Trevor James

Tutsan

Hypericum androsaemum

- Small shrub 1.5m high
- Oval leaves turn red in autumn
- Yellow flowers
- Round red berries which ripen to black

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: Bruce Clarkson; inset: Bruce Clarkson

Velvet groundsel

Roldana petasitis

- Shrub up to 2m high
- Large rounded toothed hairy leaves
- Clusters yellow daisy-like flowers
- Winged seeds

Photo & inset: Carolyn Lewis

Victorian tea tree

Leptospermum laevigatum

- Shrub up to 6m high
- Oblong grey/green leaves
- White and red/pink flowers
- Fruit is a capsule

Photo: Brian Walters

Wattle species

Acacia spp

- Shrubs to large trees
- Leaflets in rows on stalk / leaves extend from stem
- Yellow flowers
- Long flat seedpods

Photo & inset: *Trevor James*

Wild Cherry

Prunus avium

- Tree up to 12m high
- Oval ribbed serrated leaves
- Clusters of white flowers
- Red cherry-like berries

Photo & inset: *Janet Hunt*

Woolly nightshade

Solanum mauritianum

- Smelly shrub up to 10m high
- Velvety oval leaves that are covered in dusty hairs
- Clusters purple flowers
- Round berries

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Janet Hunt*

Dispose of weeds in such a way that they cannot regrow into new infestations.

See more on p.68.

Kahili ginger seed head and roots will regrow. Send them to landfill or otherwise dispose of them.

But the leaves and stalks can be chopped and then mulched or put in the compost.

Native shrubs, trees, palms & tree ferns

Native shrubs, trees, palms and tree ferns suit local conditions and thrive in our environment. Taller species provide shelter from frost, wind and direct sunlight; they filter the air, prevent flooding and provide privacy. They also provide food and habitat for birds insects and lizards. Trees, palms and tree ferns are also some of our most iconic and greatly reduced plant species — you can provide a refuge for them in your own backyard.

Plant these species! Select from any of the options on pages 47 to 63.

Akeake

Dodonaea viscosa

- Bushy shrub or small tree
- Flaky reddish bark
- Long thin wavy green to red-purple leaves
- Clusters of small greenish flowers

Photo & inset: Rob Lucas

Coastal tree daisy

Olearia solandri

- Bushy shrub
- Yellow sticky stems with clusters of small long green leaves, white underneath
- White flowers

Photo & inset: Mike Thorsen

Common (native) broom

Carmichaelia australis

- Small tree
- Many flattened narrow green twigs off grey-brown branches
- Small inconspicuous leaves
- Small white and purple flowers

Photo: Wayne Bennett; inset: Donna Worthy

Coprosma species

- Shrubs or small trees
- Smooth-edged leaves in opposing pairs
- Tiny holes underneath on each side of the main vein
- Small, wind-pollinated flowers
- Berries are brightly coloured and popular with birds

Karamu
Coprosma robusta

Shining karamu
Coprosma lucida

Swamp coprosma
Coprosma tenuicaulis

Taupata
Coprosma repens

Thin leaved coprosma
Coprosma areolata

Twiggy coprosma
Coprosma rhamnoides

Swamp Coprosma photo: *Wayne Bennett*; Swamp coprosma inset: *Patrick Enright*; All others: *Rob Lucas*

Hangehange

Geniostoma rupestre var *ligustrifolium*

- Shrub
- Pale green oval leaves that end in a point
- Clusters small green/cream flowers
- Orange seeds

Photo: *Jeremy Rolfe*

Heketara / tree daisy

Olearia rani

- Small tree
- Thin toothed oval green leaves white underneath
- Visible veins
- Clusters of daisy-like white flowers

Photo: Mike Thorsen

Hinau

Elaeocarpus dentatus

- Tall tree
- Long thin leaves with small teeth along margins, pits on the underside
- Twigs with small hairs
- Clusters of white lacy flowers
- Oval purple fruit

Photo & inset: Wayne Bennett

Houhere / lacebark

Hoheria sexstylosa

- Tree with grey trunk
- Long oval leaves, widest near middle, with toothed edges
- Large white flowers

Photo & inset: Janet Hunt

Horoeka / lancewood

Pseudopanax crassifolius

- Tree up to 15m high
- Trunk with a small diameter
- Long narrow-toothed juvenile leaves
- Bushy round head and straight trunk when mature

Photo & inset: Janet Hunt

Kaikomako

Pennantia corymbosa

- A dense tangled shrub
- Stems with small leaves, lobed at the tip
- Grows into a small tree with larger leaves
- Clusters of small white flowers

Photo: Jesse Blythell; inset: Melissa Hutchinson

Kanuka

Kunzea robusta

- Tree
- Bark flaking in long leathery strips
- Masses of soft oval pointed leaves
- White red-centred flowers

Photo & inset: Janet Hunt

Kapuka/broadleaf

Griselinia litoralis

- Bushy tree
- Rough dark trunk and yellowish stem
- Large green leaves, thick, shiny and rounded
- Small green–cream flowers

Photo: Mike Thorsen

Kawakawa

Macropiper excelsum

- Shrub
- Dark jointed twigs
- Large green glossy heart-shaped leaves, often with insect holes; veins radiating from middle
- Orange fruit

Photo & inset: Janet Hunt

Kohuhu/black matipo

Pittosporum tenuifolium

- Small tree
- Dark twigs with green glossy wavy leaves
- Dark flowers
- Green seed capsule with black sticky seeds

Photo & right inset: *Mike Thorsen*; left inset: *Jeremy Rolfe*

Koromiko

Hebe stricta var *stricta*

- Bushy shrub
- Pairs of long narrow pointed leaves
- Flowers white or pinkish on a spike

Photo & inset: *Bruce Clarkson*

Kotukutuku / tree fuchsia

Fuchsia excorticata

- Small tree
- Peeling orange-tinted bark
- Oval pointed leaves with veins
- Clusters of small green-yellow to purple-red flowers from trunk or branches

Photo & insets: *Janet Hunt*

Kowhai

Sophora microphylla

- Tree
- Leaves with pairs of leaflets
- Bunches of drooping yellow flowers
- Dry knobbly seed pods
- Hard yellow seeds

Photo & inset: *Janet Hunt*

Lowland horopito

Pseudowintera axillaris

- Small shrub
- Wavy glossy green leaves, pale underneath
- Aromatic
- Greenish-yellow flowers
- Red berries

Photo & inset: *Jeremy Rolfe*

Mahoe

Melicytes ramiflorus

- Small-to-medium tree
- Knobbly pale trunk
- Light green toothed leaves
- Flowers greenish, in clusters along twigs
- Purple fruit

Photo: *Rob Lucas*

Makomako/ wineberry

Aristotelia serrata

- Small bushy tree
- Thin heart-shaped sharply toothed leaves
- Rose coloured flowers
- Black berries

Photo: *Janet Hunt*

Manuka

Leptospermum scoparium

- Small shrub or tree
- Flaky bark
- Masses of hard oval pointed prickly leaves
- White or pinkish red-centred flowers

Photo: *Janet Hunt*

Ngaio

Myoporum laetum

- Spreading tree
- Glossy green spotted oval leaves
- White flowers with purple spots
- Pink fruit on a stalk

Nikau

Rhopalostylus sapida

- Palm
- Ringed trunk
- Narrow leaflets up to 1m along central stem
- Pinkish flowers on multiple spikes at the top of trunk
- Red fruit

Pate

Schefflera digitata

- Medium tree, bushy
- 7 soft leaves with serrated margins in a fan on a long stalk
- Tiny greenish-white flowers
- Purple berries

Pokaka

Elaeocarpus hookerianus

- Small tree
- Interlaced juvenile form
- Maturing with larger olive green serrated leaves
- Small white drooping flowers
- Purple fruit

Porokaiwhiri/ pigeonwood

Hedycarya arborea

- Small tree
- Oval, green, glossy leaves with toothed margins, in pairs
- Small sprays greenish flowers
- Orange fruit

Photo: Wayne Bennett; inset: Rob Lucas

Poroporo

Solanum laciniatum

- Poisonous shrub
- Dark green, thin leaves divided into 1-3 large sharp lobes
- Ruffled purple flowers
- Yellow or orange fruit

Photo: Janet Hunt

Putaputaweta / marble leaf

Carpodetus serratus

- Small spreading tree with a tangled juvenile form
- Adult leaves are oval and serrated with light green marbling
- Tiny white flowers

Photo: Rob Lucas; inset: Gillian M. Crowcroft

Rangiora

Brachyglottis repanda

- Large shrub or small tree
- Very large wavy leaves, white and felted underneath
- Large sprays of small fragrant cream flowers

Photo: Janet Hunt

Red mapou

Myrsine australis

- Bushy shrub
- Bright red branches
- Green leaves with wavy margins
- Clusters of small white flowers

Photo: Rob Lucas

Salt marsh ribbonwood

Plagianthus divaricatus

- Dense tangled shrub
- Silvery stems
- Small long narrow leaves
- Small aromatic cream flowers
- Prefers damp coastal sites and estuarine areas

Photo: *Wayne Bennett*; left inset: *Melissa Hutchinson*; right inset: *John Barkla*

Swamp maire / waiwaka

Syzygium maire

- Tree with pale smooth trunk and buttressed roots
- Pointed oval leaves, mottled and often blistered
- Clusters of flowers with white stamens
- Red fruit

Photo: *Bruce Clarkson*; left inset: *Peter J. de Lange*; right inset: *Ian Bell*

Tall Mingimingi

Leucopogon fasciculatus

- Bushy shrub
- Hard narrow prickly leaves which fan out from a stem
- Small white bell-shaped flowers

Photo: *Rob Lucas*

Tauhinu

Ozothamnus leptophyllus

- Bushy shrub
- Small green leaves
- Silver/white stems
- Clusters of tiny cream daisy flowers
- Down-covered seed heads

Photo: Wayne Bennett; inset: Mike Thorsen

Taurepo / NZ gloxinia

Rhabdothamnus solandri

- Bushy shrub
- Twigs with thin rounded leaves with a toothed edge
- Tubular orange streaked papery flowers

Photo: Rob Lucas

Tawhirikaro

Pittosporum cornifolium

- Shrub
- Often growing on other trees
- Whorls of oval glossy pointed leaves
- Red/yellow flowers

Photo & inset: Rob Lucas

Ti kouka / cabbage tree

Cordyline australis

- Palm-like tree
- Erect trunk with rough bark
- Tough long narrow pointed leaves
- Sprays of small white flowers

Photo & inset: Janet Hunt

Titoki

Alectryon excelsus

- Small tree
- Dark fluted trunk with spreading branches
- Pairs of glossy green long oval leaflets
- Clusters small red flowers

Photo: Peter J. de Lange

Turepo / small-leaved milk tree

Streblus heterophyllus

- Shrub or small tree
- Tangled juvenile stage
- Small oval toothed leaves
- Small cream/red flowers on short spike

Photo: Rob Lucas

Wharangi

Melicope ternata

- Small bushy tree
- Glossy green wavy leaves, in threes, at the end of a long stalk
- Flowers green–white

Photo: John Barkla; inset: Jeremy Rolfe

Whauwhaupaku / five finger

Pseudopanax arboreus

- Bushy shrub
- Glossy green oval toothed leaves arranged in fans of five
- Green/yellow flowers
- Purple fruit

Photo: Melissa Hutchinson; inset: Jeremy Rolfe

White maire

Nestegis lanceolata

- Tree
- Narrow leaves
- Small greenish-yellow flowers
- Red berries

Photo & inset: *Jeremy Rolfe*

Gully tree fern

Cyathea cunninghamii

- Slender trunk up to 20m high
- Green-stalked soft leaves up to 3m long
- Old leaves fall off leaving a clean trunk
- Leaf stems covered in hairs and scales

Photo: *Rob Lucas*

Ponga / silver fern

Cyathea dealbata

- Trunk up to 10m high, covered by the bases of old fronds
- Green-stalked soft leaves up to 4m long, silver on the underside
- Leaf stems covered in hairs

Photo: *Rob Lucas*

Mamaku / black tree fern

Cyathea medullaris

- Trunk up to 20m high with scars from old leaves
- Black-stalked leaves up to 5m long
- Leaf stems covered in scales

Photo: *Janet Hunt*

Katote / soft tree fern

Cyathea smithii

- Trunk up to 5m high, skirted by old leaves
- Green-stalked soft leaves up to 2.5m long
- Leaf stems covered in hairs and scales

Photo: Rob Lucas

Wheki

Dicksonia squarrosa

- Trunks up to 7m high with a messy skirt of dead fronds
- Green-stalked rough leaves up to 2.4m long
- Usually forming colonies

Photo: Rob Lucas

Wheki-ponga

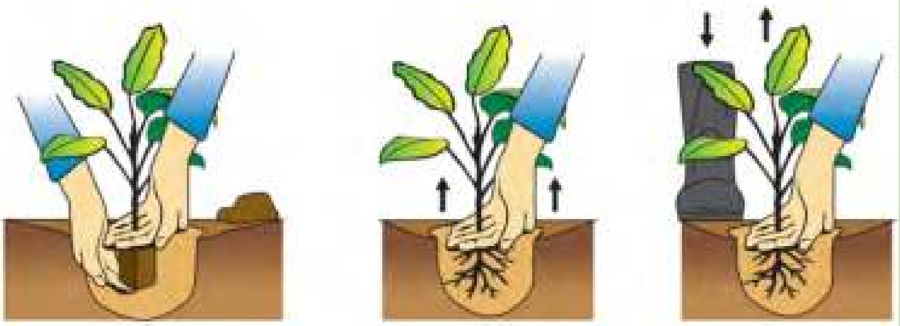
Dicksonia fibrosa

- Solitary
- Trunk up to 10m high, stout and covered in roots
- Tidy skirt of dead fronds
- Green-stalked leaves up to 2m long, form a dense crown

Photo: Jeremy Rolfe

After carefully selecting your site, plant your native shrub, tree, palm or tree fern.

You will have great pleasure in watching it grow over the years.



Very large trees

These giants have been given their own subsection because they grow to 20 metres or more when mature. Plant them with care, especially in an urban setting, and keep in mind that one day they will be very, very tall.

Black maire

Nestegis cunninghamii

- 20+m high
- Thick straight trunk
- Bark coarse and square patterned
- Pairs of green long wavy leaves
- Red fruit

Photo: Jeremy Rolfe; inset: Peter J. de Lange

Kahikatea

Dacrycarpus dacrydioides

- 20+m high
- Trunk often fluted and buttressed; flaky grey bark
- Branchlets slender and drooping, leaves small and awl-shaped
- Red/orange fruit

Photo & inset: Janet Hunt

Kamahi

Weinmannia racemosa

- 20+m high
- Irregular trunk, sometimes more than one
- Oval leaves are with deeply toothed margins
- Spikes of white or pink flowers

Photo & inset: Janet Hunt

Kohekohe

Dysoxylum spectabile

- Up to 15 m high
- 4 pairs of large green glossy leaflets along a stem with a fifth leaflet at the tip
- Clusters of small white flowers off branches and trunk

Photo & inset: Janet Hunt

Matai

Prumnopitys taxifolia

- 20+m high
- Grey flaky 'hammered' bark
- Tangled juvenile form; broad crown with spreading branches on mature form
- Small long thin green leaves with silver-blue underside

Photo & inset: Janet Hunt

Miro

Prumnopitys ferruginea

- 20+m high,
- Grey flaky 'hammered' bark
- Dark green, feathery, needle like leaves flattened into two rows
- Large red fruit

Photo: Rob Lucas

Northern rata

Metrosideros robusta

- 20+m high
- Pairs of small olive green oval leaves
- Clusters of crimson red flowers
- As an epiphyte sends roots down a host tree

Photo & inset: Janet Hunt

Pukatea

Laurelia novae-zelandiae

- 20+m high
- Greyish trunk with fluted base
- Pairs of oval glossy dark green toothed leaves; reddish stems
- Tiny white/green aromatic flowers

Photo & inset: *Janet Hunt*

Puriri

Vitex lucens

- 20+m high
- Knobbly trunk, thin, pale, flaky bark
- Dark green leaves, five wrinkled leaflets
- Pink, bell-shaped flowers
- Red, 20mm wide berries

Photo & inset: *Janet Hunt*

Rewarewa

Knightia excelsa

- 20+m high
- Cylindrical trunk
- Dark green long toothed leathery leaves
- Dense spikes of red flowers

Photo: *Janet Hunt*

Rimu

Dacrydium cupressinum

- 20+m high
- Brown–grey, knobbled bark
- Tiny bright green leaves overlap tightly around a branchlet
- Drooping branchlets
- Round-topped crown

Photo: *Janet Hunt*

Tawa

Beilschmiedia tawa

- 20+m high
- Dark trunk
- Leaves pale green, narrow with pointed tip and drooping
- Sprays of yellow flowers
- Large purple fruit

Photo: Janet Hunt

Totara

Podocarpus totara

- 20+m high
- Large trunk
- Bark thick and furrowed; falling in long strips
- Leaves small thick narrow and pointed, brownish to dark green

Photo: Rob Lucas; inset: Jeremy Rolfe

Forest giants behind Pukeiti Visitor Centre

Aquatic & semi aquatic freshwater weeds

Aquatic freshwater weeds have enormous potential for environmental damage. They spread readily through wetlands, lakes, streams, ponds and drains forming sediment-trapping, choking masses that are very hard to control. They displace native aquatic and streamside plants, blocking water flows, stagnating water and killing fish. Some are toxic to mammals.
They spread on uncleaned equipment or recreational gear.

CONTROL OR REMOVE THESE SPECIES.

Egeria

Egeria densa

- Large, bottom-rooted oxygen weed; leaves in whorls of 4–5
- White 3-petal flowers with float on surface in summer
- Slender, branched, buoyant stems

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Paul Champion*; inset: *Trevor James*

Hornwort

Ceratophyllum demersum

- Submerged
- Can occur as stems anchored to sediment, as a floating mat, or drifting segments
- Branched stems up to 7m; whorled, branched, narrow leaves; tiny flowers

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Rohan Wells*

Yellow flag iris

Iris pseudacorus

- Poisonous
- Clump forming, up to 1.5m high
- Sword-shaped leathery leaves from base
- Yellow flowers
- Prefers damp ground

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale*

Photo & inset & insets: *Carolyn Lewis*

Purple loosestrife

Lythrum salicaria

- Erect, marginally-aquatic plant up to 2m high
- Many-branched stems
- Narrow leaves
- Spike of purple-magenta flowers

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo: *Trevor James*; inset: *Carolyn Lewis*

Oxygen weed

Lagarosiphon major

- Submerged, bottom-rooted
- Leaves recurved along the stem, in closely-packed spirals
- Long, slender, branched stems; tiny, pinkish flowers

This plant is registered with the National Pest Plant Accord. *It is prohibited from propagation, distribution and sale.*

Photo & inset: *Trevor James*

Senegal tea

Gymnocoronis spilanthoides

- Marginally aquatic plant up to 1m
- Hollow stems, dark green waxy leaves
- Clover-like white flower heads

Under the Regional Pest Management Plan this plant *must be eradicated*. Report it to the Taranaki Regional Council.

Photo & inset: *Carolyn Lewis*

KEEP OUR WATERWAYS WEED FREE

Freshwater weeds can be spread by your activities in and around waterways. If you've been in a lake, river, stream or wetland and plan to move to another within 48 hours, you must clean all gear that has been wet using the 'Check, Clean, Dry' method.

For more information, visit mpi.govt.nz/check-clean-dry or talk to the Taranaki Regional Council.

PART 2

Useful Information

Weed control

Plan

To make the most of your effort it is important to develop a plan before you begin. Set objectives for your project and then plan how you are going to achieve them. Consider which species you should tackle first, where you should focus initially and how you are going to manage the area once the weeds are gone.

- Know your weeds. Make a list of what you have. Control the weeds you have least of first.
- Tackle your weeds in sections. Don't try and take on too much at once. Once a weed or area has been cleared undertake regular follow up to control any new growth.
- Remove weed sources to prevent spread i.e. flowers removed before they set seed.
- Practice weed hygiene. Use garden bags to contain weeds and fragments to prevent spread when moving weed waste around.
- Once the weeds have been removed you will have bare ground which will easily be re-colonised by more weeds. Plant these areas with native species to suppress them.
- Take before and after photos to remind yourself of how much progress you have made.

For more information and a planning template refer to: http://pestplants.aucklandcouncil.govt.nz/pest-plants/planning-your-pest-control

Control

The method you choose will depend on the species, the location and the size of the infestation. There are a range of control methods, many involving the use of herbicide:

- Foliar spray — Identify which herbicide to use and the best time of year to apply it. Wait for fine calm weather. Follow the herbicide manufacturer's instructions. Mix only what you need and apply the herbicide correctly and safely. A penetrant may improve the effectiveness of the spray. You can use a marker dye to see where you have been.
- Drill and fill — best for big trees in areas where fall will not pose a risk to people or property. Drill holes around the trunk and squirt in herbicide.
- Ringbark — cut a section of bark off the trunk and apply herbicide.
- Stump paint — apply herbicide to the surface of the cut stump.
- Vial treatment — individual flower vials can provide selective control for climbers/vines.
- Hand pull or dig — only if the entire root system can be removed.
- Machine dig — occasionally useful to remove large or deep infestations.

Dispose

It is vital that weed waste is disposed of in such a way it cannot regrow and form new infestations. Three quarters of the problem weeds in Aotearoa New Zealand are garden escapees or plants that have been dumped at parks, reserves, beaches, lakes and rivers. Decide on a suitable disposal method for the weeds you are controlling before you start work.

Disposal options

Refer to: www.weedbusters.org.nz/what-are-weeds/disposing-of-weed-waste/

- Compost on site. Never try to compost or mulch weed waste containing seed or fruit, corms, tubers or rhizomes, or stems or roots from species that can grow from these fragments. Some weeds will need to be treated i.e. dried or rotting before being composted.
- Transport to an approved transfer station using a tarpaulin to cover your load.
- Burn when cut and/or dried.
- Weed waste that won't regrow can be disposed of at a Greenwaste facility.
- Use a commercial green waste collector

New Plymouth District: www.npdc.govt.nz

Green waste can be disposed of at the New Plymouth, Waitara or Inglewood Transfer stations.

- Stringy plants are not accepted i.e. Agapanthus, Bamboo, Ginger, Norfolk pine
- Nor are branches greater than 150mm.
- Put noxious weeds such as Wandering Willy, pest plants such as Ginger, Old Man's Beard, Yellow ragwort or non-compostable plants such as Agapanthus in the landfill bin.

Stratford District: www.stratford.govt.nz

Green waste can be disposed of at a transfer station.

The following are not accepted:

- Stringy plants i.e. Yucca, Bamboo and branches over 100mm in diameter
- Noxious weeds and invasive species i.e. Agapanthus, Ginger, Box thorn, Norfolk pine
- Plants that have been sprayed

South Taranaki District: www.southtaranaki.com

South Taranaki District have a Voluntary Green Waste Kerbside Collection Service using a 240L wheelie bin. Green waste can also be disposed of at a transfer station.

The following are not accepted:

- Stringy plants and branches over 150mm in diameter
- Noxious weeds and invasive species i.e. Agapanthus, Ginger, Box thorn, Norfolk pine
- Plants that have been sprayed

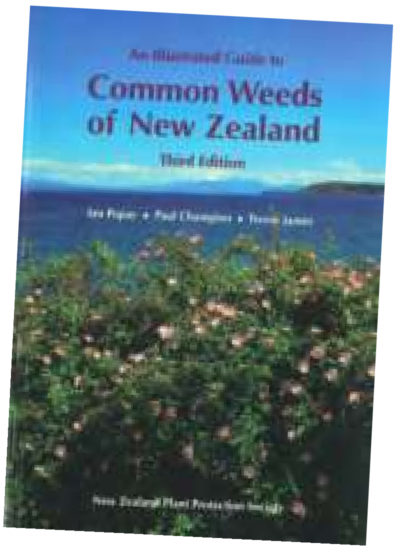
Ask for help if you need it!

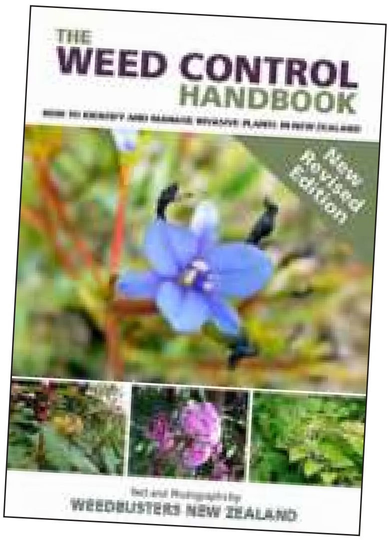
Weedbusters, Taranaki Regional Council, Ministry for Primary Industries and Department of Conservation are ready and waiting to help with identification, advice and control of weeds.

ORGANISATION	WEBSITE	EMAIL	PHONE
Weedbusters	www.weedbusters.org.nz	weedbusters@trc.govrt.nz	
Taranaki Regional Council • for Taranaki Regional Pest Management Plan • for Taranaki Regional Council Biosecurity Strategy	www.trc.govt.nz	biosecurity@trc.govt.nz	0800 736 222
Ministry for Primary Industries • for National Pest Plant Accord	www.mpi.govt.nz	info@mpi.govt.nz	06 755 9311 or 0800 00 83 33
Department of Conservation • for pest plants on public conservation land	www.doc.govt.nz	newplymouth@doc.govt.nz	Ngamotu Office: 06 759 0350

Resources available:

- *The Weed Control Handbook*: — see the Weedbusters website or purchase from the Taranaki Regional Council for $25.00.
- *An Illustrated Guide to Common Weeds of New Zealand* Third edition (2010); Ian Popay, Paul Champion, Trevor James. RRP $59.99
- NZ Plant Conservation Network is a great place to go for plant identification: www.nzpcn.org.nz or email them at info@nzpcn.org.nz





Become a Weedbuster

Get involved by creating or joining a weedbusting community group. Look up weedbusters.org.nz and click on the Taranaki region to find a group near you.

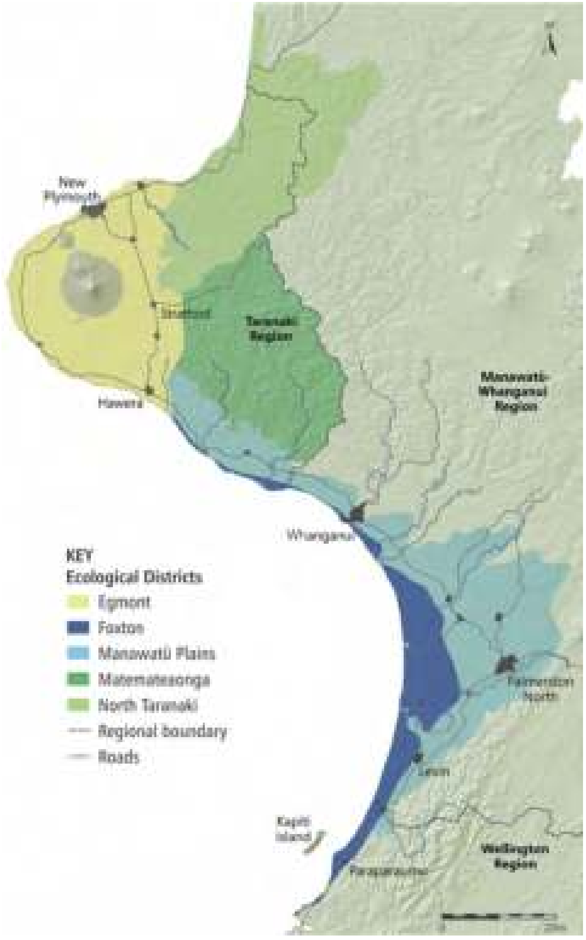
Or, if you already belong to an environmentally-active group, your group can register as weedbusters. You can then use the weedbusters logo to promote your work, advertise events through the website and receive promotional items and publications. Fill in the form on the weedbusters website.

This informal group (below) has, over a period of many months, cleared weeds and replanted a section of PG Nopps Reserve on the banks of Inglewood's Kurapete Stream. They meet once a month on a Sunday afternoon.

Check it out next time you are passing.
PG Nopps Reserve is on the south side of town.

WEEDBUSTERS

Restoration planting in Taranaki



All native species in this booklet can be planted across the region and contribute to restoration of our native flora but if you wish to go further with your planting project, the following restoration planting guides will be useful. They complement this booklet and are available at https://restoretaranaki.nz/resources/. They will enable you to undertake further planting as you remove pest plants from your backyard and your community.

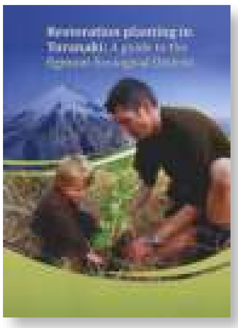
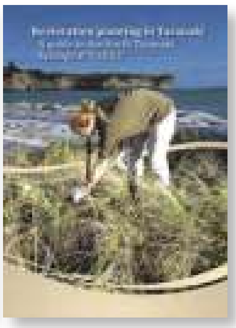
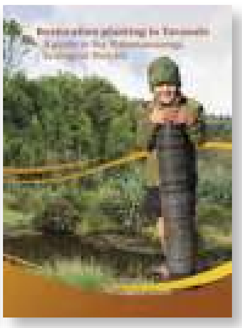
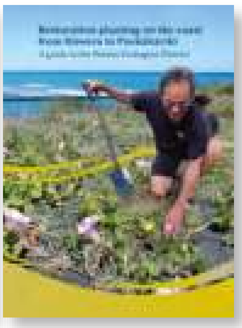
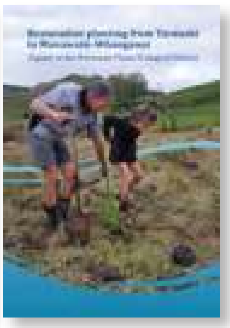
Taranaki contains five Ecological Districts; North Taranaki, Egmont, Matemateaonga, Foxton and Manawatu Plains.

Each ecological district has different landforms, climate and soils and a correspondingly distinct native vegetation. A restoration planting guide has been written for each ecological district.

The restoration planting guide series are for landowners and community groups who wish to plant native species that best suit their site and conditions, and for people who just want to plant the 'right' species for biodiversity in their backyards.

Native trees and plants are part of the greater, interlinked forest ecosystem, providing shelter and food for native birds, bats, fish, lizards and insects and other invertebrates. Each native plant you plant is a small addition to the greater regional landscape.

Providing a seed source increases the potential for the spread of native plants that will protect the soil and water. Best of all at some distant time your children and theirs may stand among plantings that are small seedlings now.

Weed species index

Native species index

Taranaki
Regional Council

WEEDBUSTERS

Taranaki

www.weedbusters.org.nz

weedbusters@trc.govt.nz

Get involved

Taranaki Regional Council

MEMORANDUM
Policy & Planning

Date 7 June 2022

Subject: Towards Predator-Free Taranaki Project

Approved by: D Harrison, Director - Operations

S J Ruru, Chief Executive

Document: 3069938

Purpose

1. The purpose of this memorandum is to present for Members' information a quarterly update on the progress of the *Taranaki Taku Tūranga Our Place - Towards Predator-Free Taranaki* project.
2. A presentation will be provided by officers.

Executive summary

3. On 30 May 2018, the Minister of Conservation launched the *Taranaki Taku Tūranga Our Place -Towards Predator-Free Taranaki* project.
4. *Taranaki Taku Tūranga Our Place -Towards Predator-Free Taranaki* is the first large-scale project with the long-term aim of progressing towards removing introduced predators from a region.
5. Three different phases of work are continuing around the mounga, working from north to south. This item reports on the three different elements to the project: urban trapping, rural control, and zero possums.
6. Monitoring work and site-led work is continuing and Council officers have had input into several technological innovations.
7. The project has received a $750,000 funding boost through 'jobs for nature' allocated through Predator Free 2050 Ltd. This has allowed for the employment of four additional internal staff and three additional external staff to be engaged in the project.
8. Roll out of phase 4 of the Rural programme is now complete, contributing to a significant increase in predator control on the western side of the mounga.
9. Within the Kaitake Zero possum project the A block area continues to be classed as possum-free after 10 months, though the B block individual remains elusive despite considerable trapping and hunting efforts. The virtual barrier is functioning well within the Kaitake Zero project, with 15 possums caught in the reporting period; in line with catch trends seen in previous years.

10. A workshop to review the Kaitake Zero Possum project with the hopes of identifying potential areas of improvement, reviewing the long-term viability of the project, and assessing the possibility of an extension to the project area was held in late January. A number of changes to the Kaitake Zero project have been proposed, including a change to the project's detection programme, the eradication strategy, and planning for an extension to the project and the trial of additional tools to support boundaries to effective possum movement across pastoral land.
11. Following on from the proposed changes to the Zero Possum Project, our supporting research has had to refocus to ensure that outcomes most useful to the programme be prioritised for the remainder of the financial year. Some useful preliminary insights into the efficacy of the Rural Predator Control Project's mustelid trap density have been provided to our team, with a more in-depth report due shortly.
12. While COVID-19 restrictions have resulted in some engagement opportunities being delayed, the Urban predator free team have done a great job of engaging with people when possible, remotely or on a small-scale, to support new and existing trappers within our urban communities.

Recommendations

That the Taranaki Regional Council:

a) receives this memorandum *Taranaki Taku Tūranga Our Place - Towards Predator-Free Taranaki project*

b) notes the progress and milestones achieved in respect of the urban, rural and zero density possum projects of the *Taranaki Taku Tūranga Our Place - Towards Predator-Free Taranaki* project.

Background

13. On 30 May 2018, the Minister of Conservation launched the *Taranaki Taku Tūranga Our Place -Towards Predator-Free Taranaki* project.
14. The *Taranaki Taku Tūranga Our Place -Towards Predator-Free Taranaki* project is the first large-scale project with the long-term aim of progressing towards removing introduced predators from the region. Supported by more than $11 million from Predator Free 2050 Ltd (the company set up by the Government to help New Zealand achieve its predator-free 2050 goals), the Taranaki Regional Council (the Council) aims to restore the sound and movement of our wildlife, rejuvenate native plants in urban and rural Taranaki, and protect agriculture.
15. The project's ultimate aim is to support the eradication of mustelids, rats, and possums across the region by 2050. This ambitious goal has not been attempted before, and the first phases of the project have trialled control methodologies and new tools to inform future implementation, both regionally and nationally. The latest technologies – including remote sensors, wireless nodes and a trapping app are being used to remove predators and prevent re-infestations. This high-tech equipment makes trapping more efficient, particularly in rural areas, and sends an alert to the user when a trap goes off.
16. Project work is well underway around the mounga. There are three elements to the project:
    - Rural landscape predator control
    - Urban predator control

- Zero density possums.

17. There has been a hugely positive response from communities wanting to restore our regional biodiversity by getting behind the *Taranaki Taku Tūranga Our Place -Towards Predator-Free Taranaki* Project as it continues to roll out across the region. Monitoring work and site-led work is well advanced and officers have had input into several technological innovations.
18. Set out below is a summary of key progress and milestones in respect of the main elements of the project and details future work.

Urban predator control

19. The urban project continues to grow with traps distributed at public workshops, markets, schools and retail outlets in New Plymouth.
20. While COVID-19 restrictions have resulted in some delays in engagement, community trapping has been continuing in earnest. Within the Restore projects on TrapNZ, urban users have recorded an impressive 1,253 pest catches over the last quarter period.
21. Community champions are continuing to join the programme and are providing excellent localised support to backyard trappers.
22. Corporate supporters programme is continuing to help get businesses trapping and engaged with the predator free initiative.
23. Ongoing support from New Plymouth District Council through management of the urban reserve trapping through volunteers and contractor actions.

Rural landscape predator control

24. Year four of the project has now been completed, with an additional 23,000 ha now under the mustelid control programme, bringing the total to 97,400 hectares under the mustelid control programme, and an additional 2,207 traps were placed in the Oeo and Opunake areas, bringing the project total to 7,795 (mustelid specific traps).
25. Planning for year five of the project is now underway. Delivery lag times of some key equipment are predicted, so ordering of year five supplies has already largely been undertaken.

Zero-density possums

26. The Kaitake Zero possum project is continuing to progress well towards eradication in a number of its project block areas. Block A continues to be in an incursion detection and response phase, with only a single possum incursion detected in the last 10 months. No possums were detected in the last quarter and we are confident in continuing to class the A block as a possum-free area.
27. The B block area continues to be in a survivor mop-up phase. Only a single possum was detected in the area in the last quarter. Despite considerable trapping and detection efforts this individual remains elusive. However, eradication efforts will continue.
28. The 'mop up' phase of the project is continuing across the Kaitake range or C block area. The primary focus of the project within the Kaitake range is still night hunting with possum detection dogs and thermal imaging monocular. The lean trap network based on remote reporting leg-hold traps continues to remove individuals, and the catch rate in this network continues to decline.

29. The trap barrier at Pukeiti is continuing to perform well, with fifteen possums captured during the last quarter. While this number is higher than the previous quarter, this is in line with previous years where a summer peak in numbers occurs due to dispersing individuals (mostly sub adult males).
30. A workshop was held in January to review the Kaitake Zero Possum project with the hopes of identifying potential areas of improvement, reviewing the long-term viability of the project, and assessing the possibility of an extension to the project area.
31. The workshop was attended by our project team and partners from Taranaki Mounga Project (TMP) as well as eradication experts from Manaaki Whenua - Landcare Research (MWLC), Zero Invasive Predators (ZIP), the Department of Conservation (DOC), Predator Free 2050 Ltd (PF2050Ltd) and other predator free projects.
32. The workshop concluded that given the tools available the project is unlikely to achieve success within the foreseeable future. Therefore, it was decided that the trial as originally designed has achieved as much as it can.
33. It was agreed that one of the key limitations impacting on the project's ability to achieve its Zero possum goal across the entire project area is the extremely high rat population on the Kaitake range (tracking currently at >90%).
34. These numbers effectively rule out any targeted possum baiting, leaving trapping and hunting with dogs and thermal cameras as the only options. The project team (Council and Taranaki Mounga Project) have persisted with these methods for around 12 months; however, possums continue to be detected.
35. The revised trial aims to re-open the eradication toolbox to target surviving possums by undertaking an aerial 1080 baiting operation, removing rats and the majority of the remaining possums.
36. The current dog team resources will also re–work and extend the surrounding buffer areas to ensure possums are not pressuring the boundary of the core project area. Additionally, an overhaul and refresh of detection infrastructure will be undertaken.
37. The workshop also discussed options around extending the current zero area to the next defendable barrier, the Hangatahua/Stony River to the west of the current project boundary. This would allow the testing of a farmland barrier system in the upper reaches of the extension block that could support the success of Predator-Free New Zealand nationally as we learn to protect clear areas. The specifics of this trial are still in development but it will test barriers, stopping reinfestation through farmland, this will be vital if we are truly going to achieve eradication.
38. These proposed changes have support from our project partners, specifically Taranaki Mounga Project, and the local Department of Conservation office, and we aim to finalise discussions around these changes and an additional funding and support from Predator Free 2050 Ltd in the coming quarter.

Decision-making considerations

39. Part 6 (Planning, decision-making and accountability) of the *Local Government Act 2002* has been considered and documented in the preparation of this agenda item. The recommendations made in this item comply with the decision-making obligations of the *Act*.

Financial considerations—LTP/Annual Plan

40. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

41. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

42. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan.
43. All eight iwi provided letters of support for the funding of this project, Council are in regular contact with both Ngāti Tairi and Ngā Mahanga regarding the Zero-density possum operation within their rohe and iwi chairs are updated through the Taranaki Mounga Board.

Legal considerations

44. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices/Attachments

Document 2896463: October 2021 Quarterly report to PF2050.

PREDATOR FREE 2050 Limited

LANDSCAPE PROJECTS

Quarterly reporting

Project Title: Towards Predator Free Taranaki

Report Author: Sam Haultain

Project period reported on: Jul – Sep 2021

Highlights of overall progress

Provide any positive highlights from the reporting period, from technical, social engagement and research activities (200 words max)

- The Kaitake Zero possum project has hit a significant milestone, with no possums detected within the A block for over 5 months,
- Roll out of phase 4 of the Rural programme is now underway,
- A number of new staff have now been employed under the J4N funding and to fill several vacancies,
- The virtual barrier is functioning well within the Kaitake Zero project, with only 5 possums captured during this reporting period,
- Roll out of traps within urban areas has been ongoing with good success,
- New community liaison roles proving beneficial, with great community engagement benefits starting to become evident through increased trapping within urban spaces,
- Agreement for the next FYs funding and research priorities has now been confirmed with Manaaki Whenua/Landcare Research.

Part 1 – Reporting against Progress Indicators, Milestones and Decision Points

1. Current Indicators, Milestones or decision point

Code	Description	Due date	Status	Comments
TRC UPDP8a	Canopy condition assessment, as per monitoring plan shows recovery of canopy over time	1-Nov-20	In progress	Canopy condition monitoring is ongoing.
TRC P6	Payment Invoice Due	20-Nov-20	Achieved	This was sent 16/11/2020
TRC TEG4	Discuss with 'experts' possible extension scenarios for the remainder of the ringfenced funding ($2,432,509)	20-Apr-21	In progress	Delayed with COVID
TRC SLDP1b	Rodent numbers in 1st extended area of the Pukeiti landscape (100ha) are below a 5% tracking card index.	1-May-21	Not achieved	Numbers very high – see notes below.
TRC OM1b	A minimum 3:1 funding ratio to be maintained annually throughout the project	30-May-21	Completed	Funding maintained

TRC ZDDP7	Systems in place to maintain zero possum zones into perpetuity Eg inclusions in TRC pest management plan	30-May-21	In progress	Further discussions required
TRC LSDP10	New milestones and decision points for Roll out of the rural landscape predator control (as per control and monitoring plan) - year 3 zone	1-Jun-21	In progress	Further discussions required
TRC LSM11	Roll out of the rural landscape predator control (as per control and monitoring plan) - year 3 zone	1-Jun-21	Completed	Completed as per agreed plan.
TRC UPM10a	Traps deployed in private properties throughout Egmont village, Inglewood & Eltham urban areas, as per agreed control plan	30-Jun-21	In progress	First year of traps going out in these areas so 1 in 5 not yet achieved, but good progress is being made.
TRC ZDM4c	Possums controlled in Block D, as per agreed eradication plan	30-Jun-21	Completed	As per agreed plan. RTC has been very low in these buffer areas.
TRC TEG5	Plan for extension completed following discussion with 'experts'	20-Jul-21	In progress	Discussions delayed with COVID (is this a duplicate with TRC TEG4?)
TRC AR3	ANNUAL REPORT due	30-Sep-21	In progress	Late

Commentary Please see comment sections above.

I have included previous milestones and decision points outside of the reporting period which have not been updated.

Specifically to TRCSLDP1b – Following control, high rat numbers were recorded in Pukeiti which were lower than non-treatment areas, but exceeded the 5% tracking card index required for this decision point. This promoted a review of control techniques for the 2021/2022 season to try to reach this goal in the following year.

2. Future Indicators, milestones or decision points

Code	Description	Due date	Status	Comments
TRC TEG2	Possums eliminated from Zero area (A, B and C) (aligned with an adjustment to earlier decision point ZDDP3)	20-Oct-21	In Progress	Numbers are zero for 5 months in A, detections low in B. C detections ongoing but decreasing. Unlikely to meet this goal by the due date.
TRC ZDDP3	Zero possums detected in control blocks A,B,C, as per agreed monitoring plan	31-Oct-21	In progress	Numbers zero for 5 months in A, detections low in B. C detections ongoing but decreasing. Unlikely to meet this goal by the due date.
TRC UPDP4b	Overall reduction in possum numbers to <2% BMI	30-Nov-21	In progress	Possum control delayed with COVID, monitoring will be delayed also. Unlikely to meet this goal by the due date.

TRC ZDDP6b	Evidence that zero possum density is being maintained within Blocks A,B,C; monitoring plan revised (with associated new milestones and decision points) as necessary	30-Nov-21	In progress	Zero density is unlikely to be achieved or maintained through all blocks by this due date.
Commentary Please see comment sections above for each item. Very pleased with current tracking of the project towards the next quarter's goals. A number of reports are in preparation to confirm these milestones have been achieved. Some variations to timeframes are predicted, but these are being pulled together on the variation request template (to be sent soon after this report).				

3. Progress to eradication

Commentary

The Kaitake Zero possum project is progressing well towards eradication. Block A is in an incursion detection and response phase and has had no positive possum detections for almost 6 months. The B block areas are in a survivor mop-up phase and are still harbouring possums, but these numbers are declining monthly. Block C is in a survivor mop-up phase and continues to harbour possums, but numbers are also declining in this area through the use of the lean detection network and the intensive, ongoing use of possum detection dogs and a highly experienced contractor team.

The virtual barrier is preforming well, with only routine battery and magnet sensor issues occurring during the reported period. Five possums were captured during the reported period, comprising of three adult males and two unsexed juveniles.

We have reviewed and revamped our public online possum reporting system, with some additional comms asking for continued reporting of any suspected possums sightings. This system has prompted a number of possum sightings in the B block, as well as the buffer areas, and has allowed us to quickly investigate anything almost immediately after it is reported, even if staff are out in the field, through the use of ArcGIS tools. The survey can be found here https://arcg.is/10019b1.

We are also looking to incorporate ArcGIS tools into other aspects of our eradication work in this space, particularly to streamline and improve reporting of information gathered by contractors undertaking detection work, and to record the details of any actions undertaken by the team to respond to detections or public reports. This work will improve the accuracy of our reporting, and will allow easy data sharing between staff and contractors working on this project, speeding up response times.


Predator Free 2050 - Zero Possum Block
Oakura
Oakura River
A
B1
B2
B3
C
D
E
F
KAITAKE RANGE
Legend
A: Trial block
B: Private Zero possums
C: DOC Zero
E: Buffer
F: Pukeiti zero possums
D: River_Buffer
Bridge
Updated Trap Lines
0 500 1,000 2,000
Meters
N

Part 2 – Reporting against other operational aspects

1. Health and Safety
Commentary *Provide details of any Health and Safety developments that have been made, or issues that have arisen (particularly 'notifiable events' as defined in the HSWA 2015), during the reporting period. Please include all incidents recorded during the period (attach separately if required).* No incidents to report for this period.

2. Risks, issues and opportunities	
Commentary *Provide details of any new risks, issues or opportunities in the last quarter (a risk is something that may happen, an issue is something that has happened*	
Type (What is the risk, issue, opportunity?)	**Mitigation/Comments**
Risks: Trap supply issues in the future (DOC200 and DOC250 specifically) due to material shortages caused by COVID 19 delays, and increased demand due to surge of new predator free projects.	We're looking to trial alternative traps, specifically the Trapinator mustelid tunnels, which may not be affected by plywood shortages or demand surges, so that we can create an effective contingency plan should this risk come into effect.
Issues:	
Opportunities:	

3. Financial performance
Spreadsheet to be sent separately by TRCs finance team.
Is Project financial performance proceeding as planned? Yes **If No, please provide details** *(included suggested mitigation)*

4. Innovation, learnings and research
Commentary *Provide details of any project innovations that are additional to your project plan and which are likely to benefit other projects (200 words max).* The research priorities for the next FY have been set and agreed to with LCR/MW.

5. Media, communications and events
Commentary *Provide details, if relevant, of any social or environmental events coming up in the next quarter This will help us be proactive with PF2050 community story-telling (200 words max).* In-person community events have largely been delayed for this reporting period due to COVID-19 restrictions. However, community engagement through social media and remote engagement from our liaisons has remained high, with some significant gains through this period including the on boarding of

additional community champions, continued backyard trapping and reporting, and general interest in the project from the public.

6. Benefits for Mana whenua

Commentary *Provide details, if relevant in the quarter, of any benefit to Māori including training opportunities (200 words max).*

Engagement with mana whenua remains positive and is ongoing through the project's relationship with the Taranaki Mounga Project.

7. Benefits to the community

Commentary *Provide details, if relevant in the quarter, of any social or environmental benefit to the community, including training opportunities (200 words max).*

Community benefits and engagement has remained high, with staff providing ongoing support to interested landowners both inside and outside the project's roll-out boundaries where appropriate.

8. Benefits for the economy

Commentary *Provide details, if relevant in the quarter, of any benefit to the economy e.g eco tourism (200 words max).*

A reduction in mustelids and possums throughout the project's boundaries has continued to support a reduction in bovine tuberculosis (TB), leptospirosis, and toxoplasmosis vectors. This reduction in vector numbers provides an economic benefit to both the dairy and sheep industry through reduced losses and disease risk, as well as a potential benefit to human health.

Benefits for the environment

Commentary *Provide details, if relevant in the quarter, of any climate change mitigating activities eg Tree planting, protecting, or other environmental benefits (200 words max).*

This project continues to support substantial environmental benefits through the removal of introduced browsers and restoration of appropriately functioning ecosystems. Targeted control of rats within the boundaries of the project has continued to provide significant long-term benefits through increased seedling success, and general ecosystem restoration.

Taranaki Regional Council

MEMORANDUM
Policy & Planning

Date 7 June 2022

Subject: **Hill Country Sustainable Land Management Programme**

Approved by: D Harrison, Director - Operations

S J Ruru, Chief Executive

Document: 3032738

Purpose

1. The purpose of this memorandum is to provide Members an overview of Council's hill country sustainable land management programme and what it has achieved to date and provide insight on the future work planned to meet the requirements of Government's Essential Freshwater reforms.
2. A presentation on the programme will be provided at the meeting.

Executive summary

3. Loss of soil through accelerated erosion is a significant issue in the eastern Taranaki hill country. Council has a statutory responsibility for soil conservation, and sustainable land and freshwater management. Around 101,000 hectares of steep land in pasture are vulnerable to accelerated soil erosion; the remainder is either in bush/scrub or on land classes less susceptible to erosion. Of the privately owned land in the hill country, 68.7% has a Council-prepared farm plan under Council's sustainable land management programme.
4. Farm plans and Land Management Officers working one-on-one with landowners are key mechanisms for delivering Council's soil plan and freshwater improvement goals. All Comprehensive and Agroforestry plans include a physical plan document in booklet form and digital spatial data including farm extent, Land Use Capability (LUC) classification, current land cover, waterways and wetlands, and recommended soil conservation works. Over the years, the plan document content has varied, adhering to the purpose of increasing landholder knowledge of their physical land resource and providing information to support managing the land more sustainably, as well as respond to environmental demands placed on their farm business by industry and increasingly by regulators. With all farm plans in digital format, their implementation can be reported through a geographical information system (GIS).
5. Monitoring results for 10 years of Council's soil plan show that 90% of planholders have implemented their plan in whole or in part. Combined, all planholders have implemented 67% of the current recommendations made in farm plans. Additionally,

the sustainability of the overall hill country (land with and without TRC plans) is measured through Council's state of the environment programme. From 25 representative sites, 87% of the hill country is being sustainably managed.

6. The introduction of the National Policy Statement for Freshwater Management (NPS FM) and National Environmental Standards for Freshwater (NES F) in September 2020, gave local authorities management direction and standards to regulate activities that pose risks to the health of freshwater and freshwater ecosystems.
7. Recognising the challenges and opportunities the new freshwater policies and regulations would provide, Council agreed to increase resourcing of the Hill Country team in 2021. In November 2021, the Hill Country team had recruited the required five additional roles and have a full team of ten in place. In December 2021, after some Covid-19 related delays, new staff were able to begin their role specific training and development. The additional resourcing has allowed the Hill Country team to align work with new regulations and policies; and increase implementation of sustainable land management practices and reduce sediment loss to waterways through: increasing landowner education and servicing, ongoing preparation of new farm plans, monitoring and updating of existing farm plans and promotion and implementation of Council's South Taranaki and Regional Erosion Support Scheme (STRESS).

Recommendations

That the Taranaki Regional Council:

a) receives the memorandum on the Council’s current hill country sustainable land management programme
b) notes the progress that the sustainable land management programme has achieved and the focus areas for future work.

Background

11. The soils of the hill country are the base for a farm's productive capacity. Loss of soil through accelerated erosion caused by any farm management system or practice is considered unsustainable in the long-term. Loss of native vegetation also increases the risk of accelerated erosion, increased sediment generation and reduces biodiversity habitat.
12. The eastern hill country is around 411,115 hectares of which 306,000 hectares is in private ownership. The remainder is indigenous vegetation within the Department of Conservation estate and is not considered at risk to accelerated soil erosion.
13. Since 1989, the Taranaki Regional Council (TRC) – and its predecessor the Taranaki Catchment Commission (and Board) - have delivered their statutory soil conservation functions under the Resource Management Act 1991, and the Soil Conservation and Rivers Control Act 1941. The regional soil plan for Taranaki specifies the sustainable land management programme (SLMP) as the main vehicle for achieving this.
14. The preparation of farm plans and working with landowners have been the key methods of achieving Council's soil conservation and sustainable land use goals. Over the years, the content of farm plans has varied and there have been various funding mechanisms to help increase their implementation. The farm plan documents are underpinned by farm-scale Land Resource Inventory and Land Use Capability (LUC) classification which provides scientific support for sustainable land management

recommendations. All plans identify and record current land cover including indigenous and exotic forest, waterways and wetlands, and make recommendations for farm and site-specific soil conservation works.

15. Early monitoring and reporting focussed on outputs, quantifying the establishment of proposed works and showing their location on basic maps and aerial photographs. From 2001 onwards, TRC moved into the digital era, which enabled farm plans and their works programmes to be recorded in a geographical information system (GIS). The ongoing preparation of farm plans and the delivery of various grant schemes through the years has resulted in 219,000 hectares (68.7%) of the privately owned hill country with a digital farm plan; there has been a 60% increase in forestry; a 229% increase in spaced pole planting; 58,000 hectares is under managed retirement; and 12,200 hectares of forestry has been established.
16. The development of technology and innovative customisation of software has enabled TRC to provide more sophisticated monitoring and reporting systems. Council will soon be able to report on the progress of its sustainable land management programme in relation to policy, and planholder implementation at the farm, catchment and regional level.
17. In addition to output monitoring, Council undertakes outcome monitoring through its state of the environment monitoring programme. Twenty-five representative sites in the hill country are used to measure sustainable land use. This is achieved by comparing the actual land use to the recommended sustainable land use for that land type. Findings from the last round of monitoring identified that 87% of the hill country is being sustainably managed.
18. In 2020, the Government released the Essential Freshwater package, which included the National Policy Statement for Freshwater Management (NPS-FM) and National Environmental Standards for Freshwater (NES-F), which came into force on 3 September 2020. Recognising the challenges and opportunities that the new regulations would provide, Council agreed to increase the Hill Country team's capacity to support hill country landowners to understand and comply with the new policies and regulations.
19. The team's capacity increase included the employment of four new permanent hill country staff and the establishment of a team leader role. With ongoing training and development, the hill country team are continuing the promotion and implementation of sustainable land management through ongoing plan preparation, monitoring and updating of existing plans, provision of advice and assistance, as discussed below.

Discussion

20. The release of Government's Essential Freshwater package has necessitated the need to align the hill country work programmes more closely with current and future regulatory requirements.
21. The existing hill country plan coverage consists of 450 Comprehensive Farm Plans and 65 Agroforestry Plans. In order to ensure that these existing plans are fit for future use as required by the Freshwater package and the forthcoming Natural Resources Plan, the existing monitoring programme has been updated. This has included the requirement for staff to meet with planholders, discuss with, and provide advice on a range of current and future regulations relevant to their land and farming system which include but are not limited to: Compulsory Freshwater Farm Plans; Intensive Winter Grazing; Stockholding areas; natural wetland protection and stock exclusion from waterways. Monitoring also requires the identification and recording of the full suite of soil

conservation recommendations for a property to inform future Freshwater Farm Plan requirements, and the development of short-term and long-term works programmes to target critical source areas and ensure efficient allocation of available soil conservation resources. Monitoring also includes the updating of plan geospatial information comprising the identification and recording of all wetlands greater than 0.05ha, waterways requiring stock exclusion and all existing farm land use and vegetation cover to ensure accurate monitoring and reporting of sustainable land use outcomes.

22. With preparation of new farm plans continuing, the need to increase regional coverage and ensure that plans are fit for future use is also important. Work is underway to bring the remaining 30% of privately owned land in the hill country into TRC's sustainable land management programme. This will include targeted communications and promotion, and outcome-based prioritisation of new plans. New plans also require the identification and recording of the full suite of soil conservation recommendations for a property to inform future Freshwater Farm Plan requirements, and the development of short-term and long-term works programmes to target critical source areas and ensure efficient allocation of available soil conservation resources. Ensuring new plans are fit for future use has also required minor updates to align farm plan documents with current policy and regulations. This work will be ongoing as regulations and policies are developed.

23. Applications for the latest round of Government's Hill Country Erosion Fund opened in April 2022 and work is underway to continue TRC's participation in this scheme. To date the South Taranaki and Regional Erosion Support Scheme (STRESS) has successfully allowed Land Management Officers to work alongside hill country landowners and implement soil conservation works on the ground via grants for fencing, reversion/retirement, afforestation and planting of soil conservation poles. Success in securing the new round of funding will allow this work to continue, and for new tools and initiatives to be investigated. Requirements of the scheme administrator and regulatory drivers will also require updates to the current allocation protocols to ensure that resources are available to all eligible landowners, whilst also achieving the greatest positive outcomes for sustainable land management, soil conservation and freshwater improvements.

Financial considerations—LTP/Annual Plan

24. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

25. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

26. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-

term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.

Community considerations

27. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

28. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

MEMORANDUM
Policy & Planning

Taranaki Regional Council

Date 7 June 2022

Subject: **Riparian Programme and Public Waterways and Ecosystems Restoration Fund Achievements**

Approved by: D Harrison, Director - Operations

S J Ruru, Chief Executive

Document: 3063895

Purpose

1. The purpose of this memorandum is to provide the Members with an overview of the Council's riparian programme and the delivery of the Ministry for the Environment's Public Waterways and Ecosystem Restoration Fund.
2. A presentation on the programme will be provided at the meeting.

Executive summary

3. Taranaki Regional Council have participated in two Government grant schemes over the last three years, the most recent being the MfE's Jobs for Nature fund in 2021.
4. Transforming Taranaki was awarded $5 million from the Public Waterways and Ecosystem Restoration Fund (PWER) to accelerate the implementation of riparian planting and fencing in 2021, contributing to just under one million plants being dispatched. The combined planting and fencing value for the PWER project was expected to be $10.8 million, however, the project has achieved a total expenditure of $12.34 million due to the increased value of external contributions, totalling $7.37 million.
5. The council has worked collaboratively with 711 eligible planholders and 11 planting contractors to meet or exceed all deliverables, including the below:
   - 886,600 plants (100% of target) planted into over 660 km of streambank (102% of target achieved)
   - Over 728 km of fencing for stock exclusion from waterways (112% of target achieved)
   - Creation of 83.8 full time equivalent jobs in response to the COVID-19 recovery initiative (101% of target achieved).
6. As the young plants mature, they will provide bank stability, shading and additional filtering strips, further improving water quality and enhancing biodiversity as hundreds of hectares of new habitat are created, generating wildlife corridors from Te Papakura o

Taranaki to the sea. Eighty nine percent (89%) of Taranaki's waterways are fenced and 80% have vegetation where recommended. There is 1,742 km of fencing and 2,466 km of planting left to complete, as the programme addresses all waterways (including wetlands and drains) of any size.

7. The introduction of the National Policy Statement for Freshwater Management (NPS FM) and National Environmental Standards for Freshwater (NES F) in September 2020, requires regional councils to develop regional plans and rules to address water quality issues by the end of 2024.
8. Recognising the challenges and opportunities the new freshwater policies and regulations provide, Council agreed to increase resourcing of the Riparian team in 2021 by two additional fixed term roles. In December 2021, the Riparian team had a full team of 12 in place.
9. Additional resourcing has allowed the acceleration of the roll out of the riparian plan audit process to ensure plans are mapped with the full suite of recommendations that planholders will be required to comply with under the new regulations, and increase riparian implementation through landowner education and servicing, preparation of new riparian plans, annual monitoring of existing plans, and ensuring the successful delivery of the PWER fund.

Recommendations

That the Taranaki Regional Council:

a) notes the recent completion of the Transforming Taranaki PWER funding project and its achievements, and the focus areas for future work.

Background

10. Council adopted its riparian management implementation strategy in 1993 to address the adverse effects of diffuse source contaminants from overland runoff. This has been delivered through Council’s voluntary riparian management programme, which has focussed on the preparation of customised plans, advice and information. Landowners pay for fencing, plants, and planting, while the Council supplies native plants at wholesale rates.
11. The Council has prepared 3,000 plans that cover 16,638 km of streambank and recommend 7,746km of new fencing and 7,042km of new planting.
12. Riparian margins are 89.5% fenced and 80.9% planted (or vegetated) as a result of 6,003 km of new fencing and 4,575 km of planting. More than 7.2 million native plants have been supplied to landowners at cost. This is significant under a voluntary approach and puts Taranaki ahead of the rest of the country with plan preparation and implementation.
13. In mid-2017 Council agreed to progress the Riparian Certificate of Compliance concept. Since then an audit process has been developed and built using a mobile technology software AppStudio. This is now being rolled out and prioritised as one of the core workstreams for the next couple of years, and will underpin future compliance requirements. Noting that this is still non-regulatory and the issuing of audit reports over the next one to two years will have no regulatory backing. However, it is seen as an important step to provide plan holders with clarity on what is required and to signal to some that they need to get on and implement their riparian plans.

14. In 2020, the Government released the Essential Freshwater package, which included the National Policy Statement for Freshwater Management (NPS-FM) and National Environmental Standards for Freshwater (NES-F), which came into force on 3 September 2020. Recognising the challenges and opportunities that the new regulations would provide, Council agreed to increase the Riparian team's staffing capacity by two, three year, fixed term contracts. This will enable the Riparian team to have the capacity to provide advice on a range of current and future regulations with a particular emphasis on promotion and preparation of riparian plan audits, stock exclusion from waterways and natural wetlands, intensive winter grazing compliance, assist with the compliance and enforcement of rules, and biodiversity and wetland enhancement.
15. The Council was awarded $5 million from the Public Waterways and Ecosystem Restoration Fund (PWER) to accelerate the implementation of riparian planting and fencing in 2021. Following initial promotion in 2020, Council Land Management Officers (LMOs) engaged with planholders who demonstrated a commitment to the Council's riparian programme by consistently planting/fencing to promote and plan the implementation of remaining planting/fencing works. To determine planholder implementation and eligibility, GIS was used.
16. Council offered planholders native plants through its plant scheme for $1 each, with a minimum order of 500 plants and a maximum of 2,000 plants per riparian plan. The price included the plant, a contractor to pre-spot spray, plant, and residual post-spray. All work was carried out by Council approved contractors in line with MfE's objective of job creation.
17. Plan holders have contributed by collecting their plants from a nominated depot and taking care of them until they were planted by a contractor. Planholders also erected fences to protect the plants, at an estimated value of $4.1 million.
18. Council approved contractors were sourced through a contract tendering system to plant all 886,000 plants; providing pre-plant spot spraying, planting, and residual post-spraying. Upon completion, the farmer provided sign-off to the contractor confirming they were happy with the work completed before the contractor progressed the invoice to the Council for payment.
19. Following completion of planting, LMOs audited and recorded in GIS all fencing and planting implemented up until the end of March 2022.

Discussion

20. Over 2020-2021, LMOs successfully engaged with 711 eligible planholders to plan and implement riparian works. Eligibility was assessed on each planholder's extent of implementation through GIS, where a planholder had to have shown a significant portion of works implemented to take priority.
21. LMOs scoped projects during their annual monitoring visits through obtaining commitment by a signed plant order form and landowner payment of $1 per plant through a TRC generated invoice. A minimum plant order size of 500 plants was required, up to a limit of 2,000 plants per plan, however, a few exemptions were given to approve plant orders of 300 plants.
22. A tender was advertised in three newspapers, GETS website and TRC Facebook page seeking contractor riparian planters. The tender ran for two weeks and closed on the 11 November. Nine of the 10 contractors were awarded short form TRC Contracts and invited to attend a briefing at TRC on 24 November. The unsuccessful tenderer was

declined due to a submitted planting price of $9.98. Eighty percent of plants tendered for were priced at or less than $3.10 per plant for planting. All nine contractors attended the pre-contract meeting in February that discussed project objectives, specifications and expectations, 'Jobs for Nature' reporting, and allocation of the first tranche of planting maps. All contractors completed a Health and Safety induction when commencing their first job and have been monitored on an ongoing basis until completion of contract by LMOs.

23. Contractors commenced work from 1 March 2021 with a due date of end of September 2021. COVID-19 lockdown in mid-late August 2021 stalled the already back-logged implementation, prompting the Council to review and adapt planting procedures and deadlines with approval from MfE to meet deliverables. Contractors have struggled with the inability to build staffing levels due to a limited pool of job seekers or the ability to retain them with the nature of work required. TRC, with approval from MfE, adapted the planting procedures and pushed out the deadline to ensure planting occurred in a timely manner, to those at highest risk, with particular focus on the coastal zone. This allowed a small portion of landowners (26) to claim reimbursement for planting said plants at $1 per plant. In addition, contractors were given approval to skip the pre-spot spray, in order to play catch-up and ensure root establishment before the dry season, in exchange for a post hand-release (90 planholders). Two temporary forestry planting crews were brought on-board during September and October to help complete the last of the planting. Effective communication between all parties enabled the above options to be rolled out successfully, on budget, and on-time.

24. LMOs have monitored all works completed by contractors as part of annual field monitoring and captured all implemented fencing and planting using GIS. A total of 660 km of streambank planting and 728 km of streambank fencing erected by planholders was completed over the life of the project. This exceeded the deliverable of 650 km of streambank riparian planting and 650 km of streambank fencing required under the fund.

25. The combined value of time for planting contractors, LMOs, nursery depot staff, and planholders erecting new fencing, has meant the Council has successfully achieved the Jobs for Nature deliverable of 83 full time equivalent jobs.

26. The project has a total expenditure of $12.34 million, with $7.37 million coming from external sources and $4.97 million from PWER. The project has achieved all deliverables, and remains under-budget. An independent audit is due in August 2022.

27. The Council has encouraged planholders to implement their riparian plans with annual fencing and planting. There is 1,742 km of fencing and 2,466 km of planting left to do, as the programme addresses all waterways (including drains) of any size. The Council has tendered for just over 500,000 riparian plants for supply in 2022 winter, and as of 27 May, 404,000 plants have been ordered by planholders.

28. Over the past year, staff have been refining the finer details of the riparian plan audit process and supporting documentation. The Riparian team received training and calibration toward the end of 2021, and were fully equipped to commence auditing in January 2022. Two hundred and fifty full audits have been prepared since January with delivery of the reports to planholders to commence in July 2022. The reporting function to planholders has been delayed due to technology upgrades that are nearing completion, to ensure the audit platform is aligned with new regulations and supported so background formulae run correctly.

Financial considerations—LTP/Annual Plan

29. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

30. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

31. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.

Community considerations

32. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

33. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Taranaki Regional Council

AGENDA
Policy & Planning

Whakataka te hau

Karakia to open and close meetings

Whakataka te hau ki te uru	Cease the winds from the west
Whakataka te hau ki tonga	Cease the winds from the south
Kia mākinakina ki uta	Let the breeze blow over the land
Kia mātaratara ki tai	Let the breeze blow over the ocean
Kia hī ake ana te atakura	Let the red-tipped dawn come with a sharpened air
He tio, he huka, he hauhu	A touch of frost, a promise of glorious day
Tūturu o whiti whakamaua kia tina.	Let there be certainty
Tina!	Secure it!
Hui ē! Tāiki ē!	Draw together! Affirm!

Nau mai e ngā hua

Karakia for kai

Nau mai e ngā hua	Welcome the gifts of food
o te wao	from the sacred forests
o te ngakina	from the cultivated gardens
o te wai tai	from the sea
o te wai Māori	from the fresh waters
Nā Tāne	The food of Tāne
Nā Rongo	of Rongo
Nā Tangaroa	of Tangaroa
Nā Maru	of Maru
Ko Ranginui e tū iho nei	I acknowledge Ranginui above and
Ko Papatūānuku e takoto ake nei	Papatūānuku below
Tūturu o whiti whakamaua kia	Let there be certainty
tina	Secure it!
Tina! Hui e! Taiki e!	Draw together! Affirm!

AGENDA AUTHORISATION

Agenda for the Policy and Planning Committee meeting held on Tuesday 7 June 2022.

Confirmed:

1 Jun, 2022 2:23:00 PM GMT+12

A D McLay

Director Resource Management

Approved:

1 Jun, 2022 3:55:10 PM GMT+12

S J Ruru

Chief Executive