

Benefits and costs of additional investment in wilding conifer control in the Mackenzie District

Prepared for Boffa Miskell on behalf of Environment
Canterbury

Matthew Williamson and David Moore
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Glossary

| Abbreviation | Stands for |
|---------------------|--|
| BCR | Benefit cost ratio |
| CBA | Cost benefit analysis – a structured method for analysing the economic impact (costs and benefits) of a decision. |
| Density classes | Outlier: 0-1 % OPC infestation Sparse: 1-15% OPC infestation Intermediate: 15-75% OPC infestation Dense: 75-100% OPC infestation |
| DWL | Deadweight loss of taxation |
| EBITR | Earnings Before Interest and Taxes and Rent. Used as a measure of business profitability. |
| ETS | Emissions Trading Scheme – a market-based approach for reducing emissions of greenhouse gases by charging producers for the gases they emit and providing credits for those that remove gases. |
| MPI | Ministry for Primary Industries |
| MU | Management unit – the administrative boundaries the country has been divided into for the National Wilding Conifer Control Programme |
| NWCCP | National Wilding Conifer Control Programme |
| NPV | Net present value – the sum of all costs and benefits discounted to today's dollars. |
| NZU | New Zealand Units – the emissions units that are traded as part of the ETS. |
| OAG | Operational Advisory Group – advisory group within the NWCCP providing advice on how and where operational activities are best delivered. |
| OPC | Overall percentage cover. Used to describe density of wilding infestation. |
| Phase one | Activity funded under the NWCCP between 2016/17 and 2018/19. \$16m was allocated for this phase. |
| Phase two | Activity funded under the NWCCP between 2019/20 and 2020/21. In Budget 2019 (\$21m) was allocated for this phase. |
| PV | Present value – the sum of costs or benefits discounted to today's dollars. Discounting is a way of recognising that a dollar today is worth more than a dollar tomorrow. |
| TEV | Total Economic Framework – a structured framework for valuing the benefits and costs of ecosystem services. |
| WCIS | Wilding Conifer Information System – administered by LINZ, WCIS collects details of infestations, control activities, operational areas and points of interest. |
| WTP | Willingness to pay |

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We acknowledge and thank Maksym Polyakov for providing an advanced copy of the willingness to pay study used to value non-market impacts and for his advice on how to apply these results in this CBA; Dr John Helstrom and Sherman Smith (Manager, Wilding Conifer Management Programme, MPI) for providing advice and quality assurance throughout the development of this CBA; Simon Heddle-Baker, MPI, for supporting with the collection of vast quantities of data required to do this analysis; and Keith Briden (Department of Conservation) and Graham Sullivan (Environment Canterbury) for their valuable feedback on the draft results.

Executive summary

Wilding conifers are invasive weeds that have a serious impact on New Zealand's primary industries and natural environment, affecting native landscapes, land use, biodiversity, and cultural values. Introduced in the 1880s, these trees have spread from forests, shelterbelts and erosion control plantings, and without control they will form dense forests (Department of Conservation, n.d.). Manaaki Whenua modelling shows that if left unchecked, over the next 50 years wildings would spread to a further 500,000 hectares, and 1.8 million hectares would be covered in dense forest. The aims of the New Zealand Wilding Conifer Management Strategy 2015–2030 are to prevent the spread of wilding conifers and to contain or eradicate established areas of wilding conifers by 2030.

This cost benefit analysis (CBA) builds upon the national analysis (Peck et al., 2022) to understand the value gained at the regional level. For interested readers, the 2022 national analysis contains a large amount of additional detail and background discussion and is available on both the Sapere Research Group and MPI websites.

All options represent outstanding value for money, with net present values of between \$1,008 million – \$1,700 million achievable from the investment of comparatively small sums of money, with direct costs ranging from \$22 million – \$42 million in present value terms.

Investment to date recognises the substantial benefits from controlling wilding conifers

\$37 million, covering five years from July 2016 to June 2021, was invested in the National Wilding Conifer Control Programme (NWCCP). A 2018 cost benefit analysis concluded that the benefits of control greatly outweighed the costs (Wyatt, 2018). It also highlighted that sustainable management of wilding conifers would require investment well into the future if the intention is to reduce infestations to a level that is manageable by landowners.

Additional investment was made in Budget 2020 with \$100 million committed over four years to the NWCCP under the Jobs for Nature programme. This has seen the expansion of the control programme across New Zealand and with it, immediate benefits from job creation in regions that were hit hard economically by COVID-19. While the benefits of job creation were important for these communities, controlling wilding conifers has much larger societal benefits by protecting water for hydro power generation and irrigation, and the productive land saved from infestation.

Jobs for Nature funding comes to an end from 2023/24 with ongoing funding of \$10 million per annum committed to the NWCCP. This level of funding would be insufficient for the programme to achieve control of wilding conifers on a national scale, with control activity scaled back from 49 active management units to 10 over a four-year period. Under this scenario, 42 per cent of the known national infestation would be actively managed while spread and regrowth would continue in the abandoned management units (MUs).

For the Mackenzie District, control activity is scaled back from 100 per cent of known infestation, to 72 per cent.

We assessed the costs and benefits of four investment options

This report presents an updated cost benefit analysis of wilding conifer control for the Mackenzie District and assesses the economic impact of additional investment in wilding conifer control for four investment options:

- 1) Status quo “losing the investment” – scale back control activities to ten management units nationally, and three within the Mackenzie District.
- 2) Minimum “protect the investment” – continue control activity across the existing 49 management units¹ nationally, and all management units within the Mackenzie District.
- 3) Intermediate “extend the investment” – expanding the activity to include a further 11 priority management units nationally, none of which are in the Mackenzie District.
- 4) Maximum “national control” – the intermediate option plus a further 19 priority management units nationally, none of which are in the Mackenzie District.

The purpose of this cost benefit analysis is to inform the investment decision. We, therefore, compare the costs and benefits from additional investment to the counterfactual (also referred to as the status quo option) of \$2.8 million per annum estimated ongoing funding in the Mackenzie District.

A total economic value framework has been used for categorising and calculating the costs and benefits of the programme. The framework includes the economic impact on both productive land use values, and ‘non-use’ cultural and biodiversity values of the controlled land. Modelling of wilding conifer spread and ecological system impacts, developed by Manaaki Whenua (Landcare Research), was used to calculate the result and is a significant advancement on previous analyses. The benefits of the programme were monetised using market and non-market valuation techniques. The only benefit that has not been monetised is Māori cultural values, which is described qualitatively and should be presented alongside the monetary results of the CBA.

¹ The administrative boundaries the country has been divided into for the National Wilding Conifer Control Programme.

1. Framework for this cost benefit analysis

We constructed the CBA within a Total Economic Value (TEV) framework, due to the importance of ecosystem services including 'non-use' values such as biodiversity along with 'use' values (or market values). For example, 'use' values would be the value generated by primary producers on controlled land, whereas 'non-use' may be the value people place on biodiversity or pristine natural landscapes or significant cultural or historical sites, in particular for mana whenua, even though the general population may not use or see them; knowing they exist and will exist for future generations is of value.

Within a TEV framework, an allowance is conceptually made for people who are willing to pay for the continued existence of a particular landscape, ecosystem or species. This is important when assessing pest control practices, when there is a reduced risk of losing species and biodiversity is retained or enhanced. The TEV framework is appropriate for this CBA and is widely used when dealing with ecosystem services and environmental impacts (Rohani et al., 2018; Sharp & Kerr, 2005).

An ecosystem services approach is a way of quantifying and incorporating what we implicitly value in the environment into production and governance practices. From a Te Ao Māori perspective (in line with MPI's Fit for a Better World strategic roadmap) the environment and obligation to protect it has value. This value is in addition to the value to iwi and hapū from specific sites and collectively owned Māori land, land which may be at risk from wilding conifers. When the intrinsic value of these services is not recognised in the marketplace, poor decision-making can occur. In contrast, their inclusion enables practices that enhance overall economic, environmental, and social values and advances decision-making that leads to more efficient and acceptable trade-offs between different values (The Royal Society of New Zealand, 2011).

1.1 Investment options being assessed

This CBA assesses the impact of three investment options against the counterfactual. The counterfactual is what would happen if additional funding was not secured; we call this the "status quo" option.

The options were developed through an iterative process with the programme's Operational Advisory Group (OAG). The group reprioritised all management units and used this ranking to determine which areas would be abandoned under the status quo option and which would be included under the minimum, intermediate and maximum options. A full list of the management units controlled under the options is provided in the national report.

Status quo "lose the investment" (control 72 per cent of the known infestation)

Minimal spending occurs over the 2022/23 – 2030/31 period across three management units, with estimated government funding of \$2.7 million per annum continuing from 2022/23. If no further investment is made, the programme is effectively ended, with any control activity occurring funded by community groups and volunteers. This would result in areas which are currently free from wilding conifers becoming re-invaded, the gains made on abandoned land would be lost and future benefits forgone as wilding conifers spread.

Proposed investment options

This report assesses the economic impact of additional investment in wilding conifer control for three investment options:

1. **Minimum “protect the investment” (control 100 per cent of the known infestation)** – continue to support existing control activity across six management units, with estimated government funding of \$4.5 per annum continuing from 2022/23. Control activities are considered sufficient for community groups and volunteers to prevent most reinfestation of controlled management units from the 2031/32 year onwards.
2. **Intermediate “extend the investment” (control 100 per cent of the known infestation)** – continue to support existing control activity across six management units, with estimated government funding of \$5.1 per annum continuing from 2022/23. Control activities are considered sufficient for community groups and volunteers to prevent reinfestation of controlled management units from the 2031/32 year onwards.
3. **Maximum “national control” (control 100 per cent of the known infestation)** – continue to support existing control activity across six management units, with estimated government funding of \$5.5 per annum continuing from 2022/23. Control activities are considered sufficient for community groups and volunteers to prevent reinfestation of controlled management units from the 2031/32 year onwards.

A summary of the total hectares of known infestation that would be controlled under each of the proposed options is shown below.

Table 1: Control (ha) by region for each option assessed

| Region | Infestation (ha) | Hectares controlled for each option | | | |
|---|------------------|-------------------------------------|---------|--------------|---------|
| | | Status quo | Minimum | Intermediate | Maximum |
| Mackenzie district | 405,768 | 293,552 | 405,768 | 405,768 | 405,768 |
| Percent of known infestation controlled | - | 72.34% | 100.00% | 100.00% | 100.00% |

Source: WCIS

1.2 The identified impacts

We identified the following ‘use’ benefits the Mackenzie District would obtain from wilding conifer control:

- primary production / productive land use
- water yields for hydro generation and irrigation
- reduced wildfire spread and damage risk
- protecting iconic landscapes for recreation and aesthetic value.

And ‘non-use’ benefits:

- avoiding biodiversity losses – including preventing soil legacies
- protecting Māori cultural values, e.g. protecting sites of significance to mana whenua, and Māori land, from the impacts of introduced species.

The aim is to monetise the impacts where possible, though where this is not possible a qualitative assessment of the impact is appropriate and should be considered alongside the monetised CBA result.

The impacts on ecosystem services are measured and monetised through the TEV framework. A report published by Treasury (NZIER, 2018) demonstrates the relationship between the ecosystem services approach, its components, and the valuation techniques that monetise their use and non-use values.

Figure 1: The relationship between ecosystem services and the TEV framework

| Identify | | Quantify | | Value | |
|--------------------|-------------------------------|----------|--|------------|---|
| Ecosystem services | | | | Use values | Non-use values |
| Provisioning | Food | ↔ | Various measures depending on subject matter | ↔ | Forgone production, Loss averting expenditures, Alternative sources |
| | Fibre | | | | |
| | Materials | | | | |
| | Energy | | | | |
| | Water Quantity | | | | |
| Regulating | Water quality | ↔ | Various measures depending on subject matter | ↔ | Avoided treatment cost |
| | Water flow variability | | | | |
| | Climate amelioration (local) | | | | |
| | Climate amelioration (global) | | | | |
| | Soil stabilisation | | | | |
| | Biodiversity (resilience) | | | | |
| Cultural | Biodiversity (preference) | ↔ | Various measures depending on subject matter | ↔ | Stated preferences |
| | Recreation | | | | |
| | Aesthetic | | | | |
| | Heritage | | | | |
| Supporting | Nutrient cycling | ↔ | Various measures depending on subject matter | ↔ | Stated preferences |
| | Pollination | | | | |
| | | | | | Forgone production, Alternative sources |

Source: (NZIER, 2018)

1.2.1 Monetised benefits

Using the framework in Figure 1 as a guide, we have monetised productive land use and water yield benefits using market values for forgone production. Specifically, these include:

- productive land use – valued using sheep and beef farm profitability (earnings before interest, taxes, and rent (EBITR) from sheep and beef survey data)
- water yields (in hydro catchments) – value of forgone hydro generation using the resource rents series produced by Statistics NZ, which is broadly equivalent to the EBITR measure
- water yields (irrigation) – valued using the value of irrigation based on profitability of farms on irrigated land (NZIER & AgFirst Consultants NZ Ltd, 2014).

We value reduced fire risk using an avoided costs method. To do this we use a paper on the economic cost of wildfires (BERL, 2009) prepared for Fire and Emergency NZ.

We have applied a non-market value for the cultural ecosystem services – biodiversity, recreation, and landscape aesthetics. There are monetised using a stated preference method. The non-market valuation study (Polyakov et al., 2021) reveals the use and non-use values from wilding control such as scenery, recreation and the existence of ecosystems and species through willingness to pay (WTP)

survey of households. We used this study’s results through the value transfer methodology for monetisation of these benefits.

A full list of calculated costs and benefits and values used to calculate them is provided in the national wilding conifers report, attached.

1.2.2 Non-monetised benefits

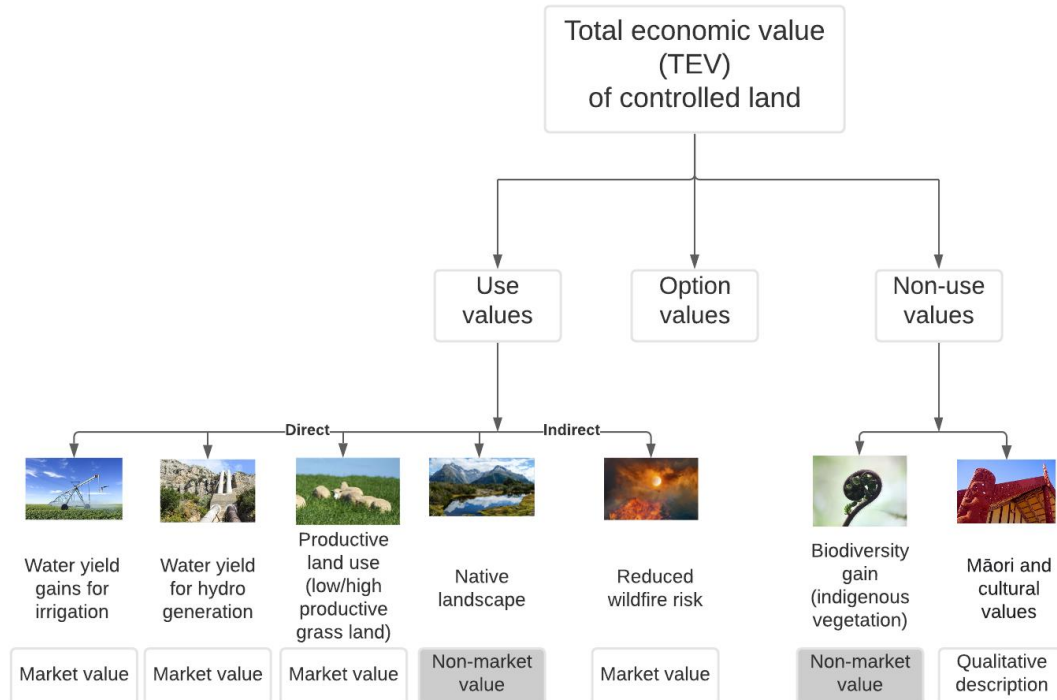
While every effort has been made to monetise the identified benefits, Māori cultural values have not been monetised. There are two main reasons for this:

- Māori values are holistic and can include principles, intrinsic, tangible and intangible values, and there is not enough information available for these values.
- Each iwi/hapū may have its own tradition in this respect, which makes a uniform discussion of ‘Māori heritage values’ problematic.

Therefore, the value Māori might place on control of wilding conifers has been qualitatively described in section 5.8, Māori cultural values. This qualitative assessment should be considered alongside the benefits to cost ratio (BCR) calculation when funding decisions are made for wilding conifer control.

A summary of the benefits under the total economic framework is illustrated below.

Figure 2: Wilding conifer benefits under TEV framework



Source: Sapere. Wildfire photo: credit Brian High

1.2.3 Costs

Costs of each option are defined as the additional financial costs (or required fund) of the option compared with the status quo option. The costs included in this CBA consist of:

- programme control costs
- fixed programme management costs
- assumed regional council and community group contributions
- deadweight loss of taxation (20 per cent of control and programme costs).

Programme control and programme management costs have been provided by MPI for the nine-year period from July 2022 to June 3031.

1.2.4 Valuing the area controlled and avoided spread

By controlling wilding conifers, we gain back some or all of what has been lost due to the impacts of wildings. By reducing or eliminating seed sources, the programme is also protecting against future spread and the losses that result. We have calculated the benefits based on the removal of existing infestations and the spread avoided as a result.

Modelling of future wilding conifer spread was developed by Manaaki Whenua and adapted for this CBA. Forecasts were provided at a highly granular level (1km x 1km grid squares) and included forecasts of infilling (local increase in population density) and invasion to neighbouring grid squares. The modelling does not include the impact of long-distance spread events, so is likely to underestimate the extent of spread and impacts over the longer term.

The methods used and efforts put into calculating wilding conifer spread and the impacts on ecosystem services are a significant advancement on previous cost benefit analyses. Geospatial modelling has been used to ensure the impacts from wilding infestation on water yields, productive land use and biodiversity have been accurately mapped to layers on land use, hydro and irrigation catchments and native vegetation. A description of the methods used by Manaaki Whenua is included in the national report. The application of these forecasts and geospatial modelling methods used to calculate the benefits are described in section 5, calculation of benefits.

1.2.5 Employment gains and Emissions Trading Scheme impacts are excluded

In CBAs, additional benefits from employment are usually ignored. In most cases, there is a displacement effect where the investment results in workforce movement from one job/sector to another, meaning there is no net gain. Gains from employment should be included when there is high unemployment, but this is not the case in the current macroeconomic environment, so we have excluded marginal employment benefits from the CBA.

We have also not included the impact of carbon emissions in the CBA. There are two reasons for this:

1. Emissions are capped under the Emissions Trading Scheme (ETS) so emission reductions in one area in the economy will free up New Zealand Units (NZUs) to be used by emitters in

another area. This is also known as the waterbed effect (Energy Resources Aotearoa, 2021). We have assumed any changes to carbon sequestration or emissions are transfer payments and should not be counted in the CBA.

2. Wilding conifers cannot be registered under the ETS due to their status as tree weeds. Consequently, there is no market value for the carbon sequestered by wilding conifers and no obligations under the ETS to surrender NZUs for the removal of wildings.²

Despite not including emissions in the CBA, we have quantified the benefits of avoided carbon emissions from non-renewable energy generation to provide context on the impact of reduced water yields for hydroelectricity. This analysis is provided in the national report.

² With the exception of a few wilding conifer forests that were registered with the ETS before the rule change to exclude pest trees. The impact of these forests is assumed to be negligible.

2. Summary of the CBA result

Table 2 summarises the present value of costs and benefits for each wilding conifer control option over 50 years (consistent with the time period used in the 2018 CBA). The net present value (NPV) and benefit cost ratio (BCR), two of the efficiency tools that are used in CBAs, are also presented.

We have included the counterfactual option (status quo) for comparison. Cost benefit analyses are used to inform investment decisions and would ordinarily show only the additional costs and benefits for the identified investment options compared to the counterfactual.

Table 2: Summary of the CBA results for the status quo, minimum, intermediate and maximum options modelled over 50 years

| Present value (\$ million) | | Status quo – lose the investment | Minimum – protect the investment | Intermediate – extend the investment | Maximum – national control |
|------------------------------------|-------------------------|---|---|---|-----------------------------------|
| Benefits | Productive land use | \$204 | \$389 | \$389 | \$389 |
| | Hydro | \$32 | \$199 | \$201 | \$201 |
| | Irrigation | \$180 | \$259 | \$312 | \$344 |
| | Cultural / biodiversity | \$585 | \$766 | \$766 | \$766 |
| | Fire | \$33 | \$50 | \$51 | \$51 |
| | Total benefits | \$1,034 | \$1,663 | \$1,719 | \$1,750 |
| Costs | Programme & Control | \$19 | \$32 | \$37 | \$39 |
| | Regional and community | \$3 | \$3 | \$3 | \$3 |
| | DWL | \$4 | \$7 | \$8 | \$8 |
| | Total costs | \$26 | \$41 | \$47 | \$50 |
| <i>Total economic value</i> | | | | | |
| Net present value | | \$1,008 | \$1,621 | \$1,672 | \$1,700 |
| Benefits : cost ratio (BCR) | | 40 | 40 | 36 | 35 |
| <i>Use value</i> | | | | | |
| Net present value | | \$423 | \$855 | \$906 | \$934 |
| Benefits : cost ratio (BCR) | | 17 | 22 | 20 | 20 |

2.1 Status quo would result in lost benefits of \$629 million

The status quo option has a net present value of \$1.01 billion over 50 years. However, this option is a substantial disinvestment that would see the area controlled reduce from 100 per cent of the known infestation to 72 per cent. As a result, there would be a substantial loss in benefits as wilding conifers re-infest land no longer under active management. Relative to the minimum option (continuing funding at the level provided under the Jobs for Nature programme) we estimate losses of \$629 million over 50 years (measured in 2021 dollars) from lost primary production, reduced water yields, and loss of biodiversity and cultural values. These losses are enormous compared against the cost savings (including deadweight loss) of \$15 million by scaling back the programme.

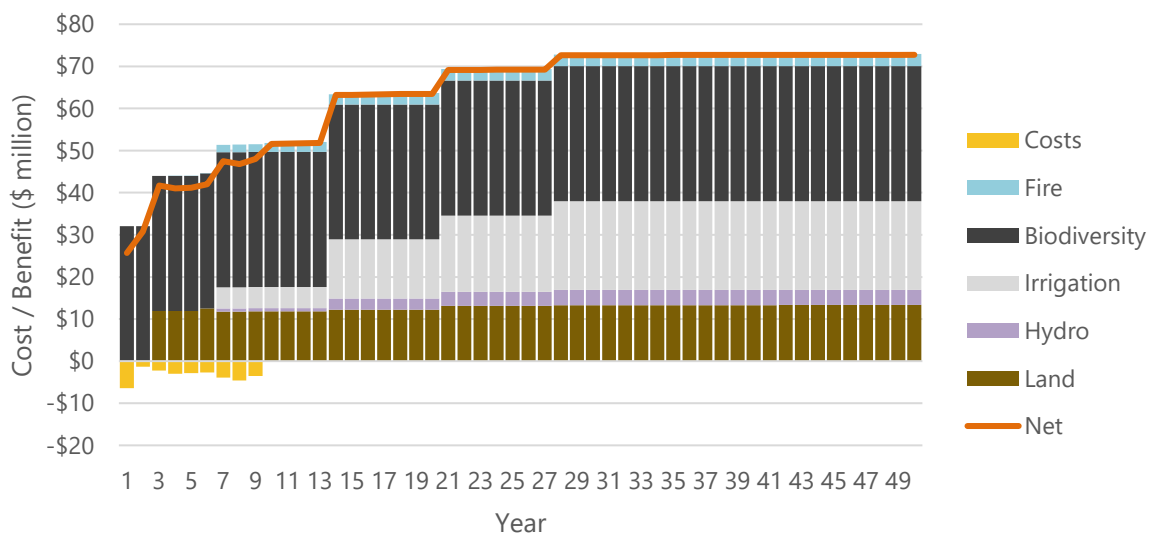
2.2 Significant benefits from additional control

Investment in the minimum, intermediate and maximum options would ensure the losses from scaling back activity are avoided and provide additional benefits. The benefits to cost ratio of wilding conifer control shows significant return for every dollar spent for the minimum option at 40:1, intermediate option at 36:1 and maximum option at 35:1, this is in line with previous analysis (Wyatt, 2018).

We note that, across all three options:

- Irrigation benefits and productive land use account for 39 – 42 per cent of the TEV-based benefits, at around 16 – 20 per cent and 22 – 23 per cent of the total benefits respectively.
- Benefits from reduced fire risk account for 2.9 – 3.2 per cent of the total benefits.
- Cultural / biodiversity value makes up 43.8 – 56.6 per cent of the benefit and is a significant component. We consider this to be a low estimate as Māori cultural values are not monetised. A qualitative discussion on Māori cultural values is included in section 5.8 Māori cultural values.
- Many of the benefits accrue in the medium to long term since they represent the losses that would be avoided by controlling wilding conifers before they spread and densify. Figure 3 illustrates the timeline of marginal costs and benefits (by component) of the minimum option.

Figure 3: Value of costs and benefits on minimum option over the 50-year time horizon (undiscounted)



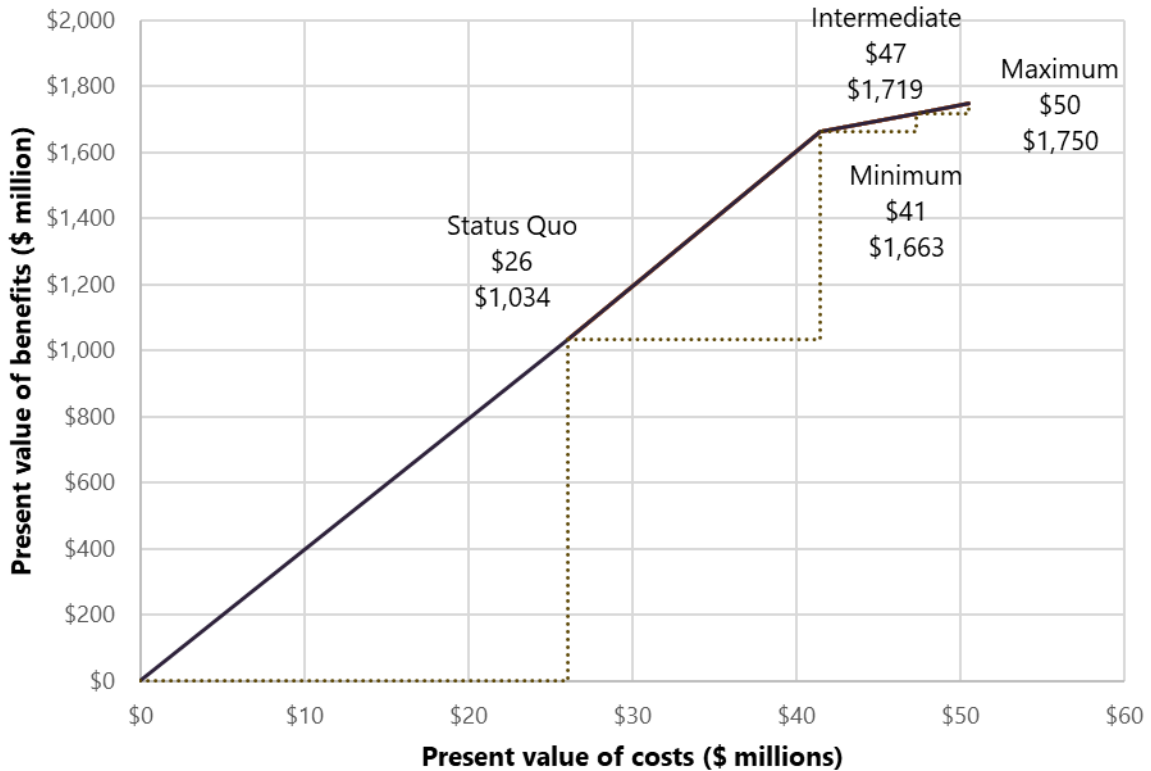
Detailed information of the marginal costs and benefits of each option is provided in sections 4 and 5.

2.3 Minimum option represents the best value for money

The results of the CBA show that the minimum option (BCR of 40) presents the best value for each dollar spent in this programme. Figure 4 shows that the net present value of the control programme increases at a variable rate. The intermediate and maximum options provide similar value for money, with BCR ratios of 36 and 35 respectively, while the minimum option provides great value for money, with greater benefits per dollar spent than the maximum and intermediate option. Ultimately, all

options represent outstanding value for money with BCRs much higher than typically realised in other investment areas.

Figure 4: Marginal benefits compared to costs for each option (\$ millions)



Source: Sapere

2.4 General assumptions

We carried out the CBA based on the following assumptions and considerations:

- Time zero, future costs and benefits are calculated starting 2022/23.
- Base date, the date that is used to standardise the valuation of all monetised benefits and costs, is 2021/22.
- The analysis period starting from time zero is 50 years. The nature of wilding conifer control is that costs are largely incurred up-front, and the benefits accrue gradually thereafter. A 50-year horizon would seem appropriate to ensure the benefits are adequately included in the result.
- While the cost of controlling each MU reduces over time, the cost of control activity will be ongoing until infestations are controlled to a level that they can be managed by landowners and communities. With the required funding, the majority of MUs under the minimum option will be transitioned to local management by 2030/31. MUs under the intermediate and maximum options are likely to be able to transition 6 – 12 years after commencement of control.

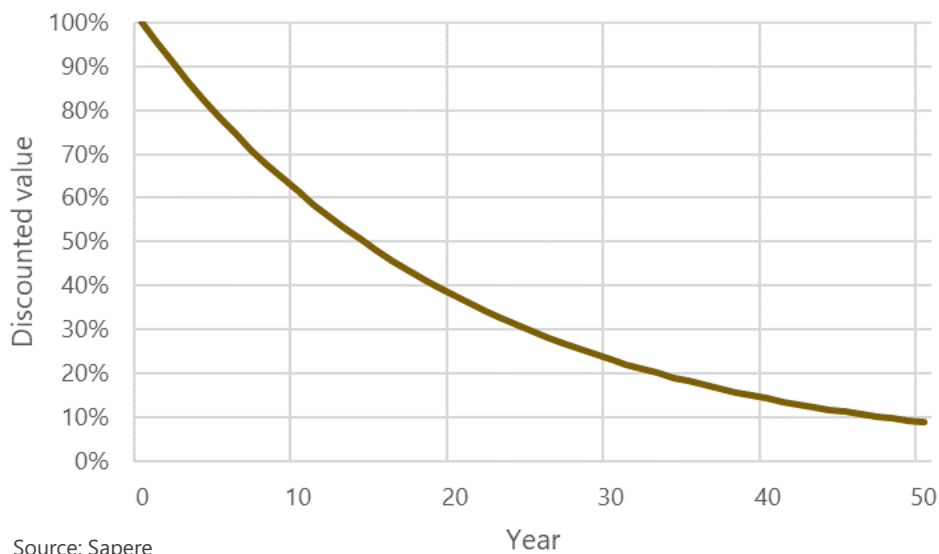
- Discount rate is 5 per cent per annum as per Treasury guidance (The Treasury, 2020) – this is the rate that reflects the time value for money and used to calculate the present value of the costs and benefits at time zero.

The effect of discounting costs and benefits

We discount because a dollar today is worth more than a dollar in a year's time. It also assures the decision maker that when assessing an investment decision it can be compared against any other investment decision of equal risk (The Treasury, 2015).

A 5 per cent discount rate means that at 15 years the benefits and costs are halved, and by 30 years we recognise less than 25 per cent of the value.

Figure 5: Impact of discounting



Source: Sapere

3. Calculation of costs

Additional costs have been estimated for each investment option. These include:

1. Control and fixed programme management costs – the cost of managing and administering the NWCCP, the cost of control activity including control staff, project managers and contractors, and the cost of post control monitoring.
2. Costs borne by community groups and regional councils – an assumed additional 20% of the programme management costs is funded by community and regional council groups.
3. Deadweight loss of taxation (DWL) – this is the welfare loss of taxpayers, and NZ Treasury suggests CBAs should include a deadweight cost equal to 20 per cent of project costs that are funded from general taxation (The Treasury, 2015). Similarly, a 10% deadweight loss is also assumed for regional council funding to reflect the welfare loss associated with rates.

Control and programme management costs have been provided by MPI.

We account for the deadweight loss of taxation where an investment is funded from taxation (or a rate). The deadweight loss of taxation recognises the welfare loss that arises when money is taken away in the form of taxes, for example, income tax on labour income tends to discourage working in favour of leisure or home-based activities (The Treasury, 2015). Treasury guidance is to apply 20 per cent to the cost of a project funded through general taxation.

The costs used in this CBA are summarised below both in nominal terms and as a present value (PV)

Table 3: Costs of the status quo option (\$ millions)

| Status quo | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 | PV |
|-------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Control and Programme | \$5.2 | \$1.1 | \$1.8 | \$2.4 | \$2.2 | \$2.1 | \$3.1 | \$3.7 | \$2.8 | \$19.2 |
| Regional council & community groups | \$0.1 | \$0.1 | \$0.1 | \$0.1 | \$0.1 | \$0.1 | \$0.2 | \$0.2 | \$0.2 | \$2.8 |
| DWL | \$1.1 | \$0.2 | \$0.4 | \$0.5 | \$0.5 | \$0.4 | \$0.6 | \$0.8 | \$0.6 | \$4.1 |
| Total | \$6.4 | \$1.3 | \$2.2 | \$3.0 | \$2.8 | \$2.7 | \$3.9 | \$4.6 | \$3.5 | \$26.1 |

Source: MPI, Sapere analysis

Table 4: Costs of the minimum option (\$ millions)

| Minimum | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 | PV |
|-------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Control and Programme | \$5.9 | \$1.8 | \$4.8 | \$5.7 | \$4.7 | \$3.9 | \$5.3 | \$5.2 | \$3.2 | \$32.0 |
| Regional council & community groups | \$0.1 | \$0.1 | \$0.1 | \$0.1 | \$0.1 | \$0.1 | \$0.2 | \$0.2 | \$0.2 | \$2.7 |
| DWL | \$1.2 | \$0.4 | \$1.0 | \$1.2 | \$0.9 | \$0.8 | \$1.1 | \$1.1 | \$0.7 | \$6.7 |
| Total | \$7.2 | \$2.2 | \$5.9 | \$7.0 | \$5.7 | \$4.8 | \$6.5 | \$6.5 | \$4.0 | \$41.4 |

Source: MPI, Sapere analysis

Table 5: Costs of the intermediate option (\$ millions)

| Intermediate | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 | PV |
|-------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Control and Programme | \$7.3 | \$2.3 | \$5.5 | \$6.4 | \$5.5 | \$4.3 | \$5.6 | \$5.4 | \$3.7 | \$36.6 |
| Regional council & community groups | \$0.1 | \$0.1 | \$0.1 | \$0.2 | \$0.1 | \$0.1 | \$0.2 | \$0.2 | \$0.2 | \$3.1 |

| | | | | | | | | | | |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|
| DWL | \$1.5 | \$0.5 | \$1.1 | \$1.3 | \$1.1 | \$0.9 | \$1.1 | \$1.1 | \$0.8 | \$7.6 |
| Total | \$8.9 | \$2.8 | \$6.8 | \$7.8 | \$6.8 | \$5.3 | \$6.9 | \$6.8 | \$4.7 | \$47.3 |

Source: MPI, Sapere analysis

Table 6: Costs of the maximum option (\$ millions)

| Maximum | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 | 29/30 | 30/31 | PV |
|-------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|
| Control and Programme | \$7.9 | \$2.8 | \$6.2 | \$7.3 | \$5.6 | \$4.3 | \$5.6 | \$5.5 | \$3.8 | \$39.2 |
| Regional council & community groups | \$0.1 | \$0.1 | \$0.1 | \$0.2 | \$0.1 | \$0.1 | \$0.2 | \$0.2 | \$0.2 | \$3.1 |
| DWL | \$1.6 | \$0.6 | \$1.3 | \$1.5 | \$1.1 | \$0.9 | \$1.1 | \$1.1 | \$0.8 | \$8.2 |
| Total | \$9.6 | \$3.5 | \$7.6 | \$9.0 | \$6.9 | \$5.3 | \$7.0 | \$6.9 | \$4.7 | \$50.5 |

Source: MPI, Sapere analysis

4. Area controlled

Costs and benefits are a function of the area controlled. The impact of controlling an area means existing infestations are removed and future spread is avoided.

4.1 Control of existing infestations

Currently the programme has funding to control 293,552 hectares of infestation. Table 7 displays the hectares controlled under each option by density class.³

Table 7: Hectares of known infestation controlled by density class

| Density | Status quo | Minimum | Intermediate | Maximum |
|--------------|----------------|----------------|----------------|----------------|
| Outlier | 11,407 | 16,227 | 16,227 | 16,227 |
| Sparse | 248,558 | 335,411 | 335,411 | 335,411 |
| Intermediate | 27,481 | 43,239 | 43,239 | 43,239 |
| Dense | 6,106 | 10,890 | 10,890 | 10,890 |
| Total | 293,552 | 405,768 | 405,768 | 405,768 |

Source: Sapere analysis

We have applied general assumptions for the time required to control an infestation based on density class. These assumptions are based on an area being controlled once every three years. There will also be some level of ongoing maintenance control that may be required by landowners.

Table 8: Transition through density classes as a result of control

| Starting density | Infestation at 3 years | Infestation at 6 years | Infestation at 9 years | Infestation at 12 years |
|------------------|------------------------|------------------------|------------------------|-------------------------|
| Dense | Dense | Sparse | Outlier | None |
| Intermediate | Sparse | Outlier | None | |
| Sparse | Outlier | None | | |
| Outlier | None | | | |

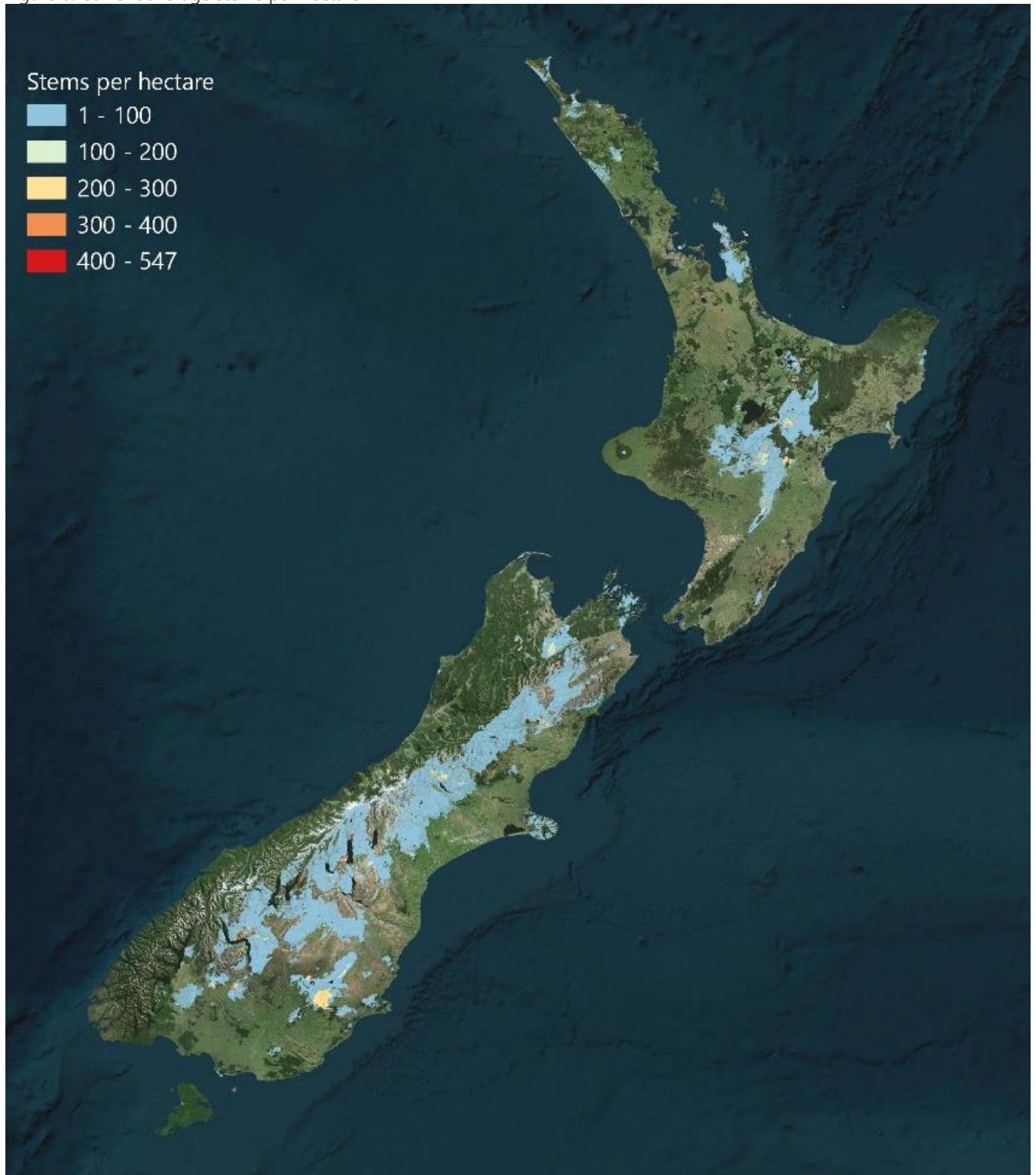
The above assumptions are based on advice from the NWCCP. For the purposes of this CBA we assume that as an end state no wilding conifers remain post-control, but we note that this is not always the case. Control with the aim of removing wilding conifers frequently fails to kill 100 per cent of trees, and may result in post-removal dominance by other non-native species, or reinvasion by wilding conifers (Dickie et al., 2021).

³ Density classes are defined as: outlier 1-0% overall percentage cover (OPC), sparse 15-1% OPC, intermediate 75-15% OPC, dense 100-75% OPC

4.2 Future spread avoided

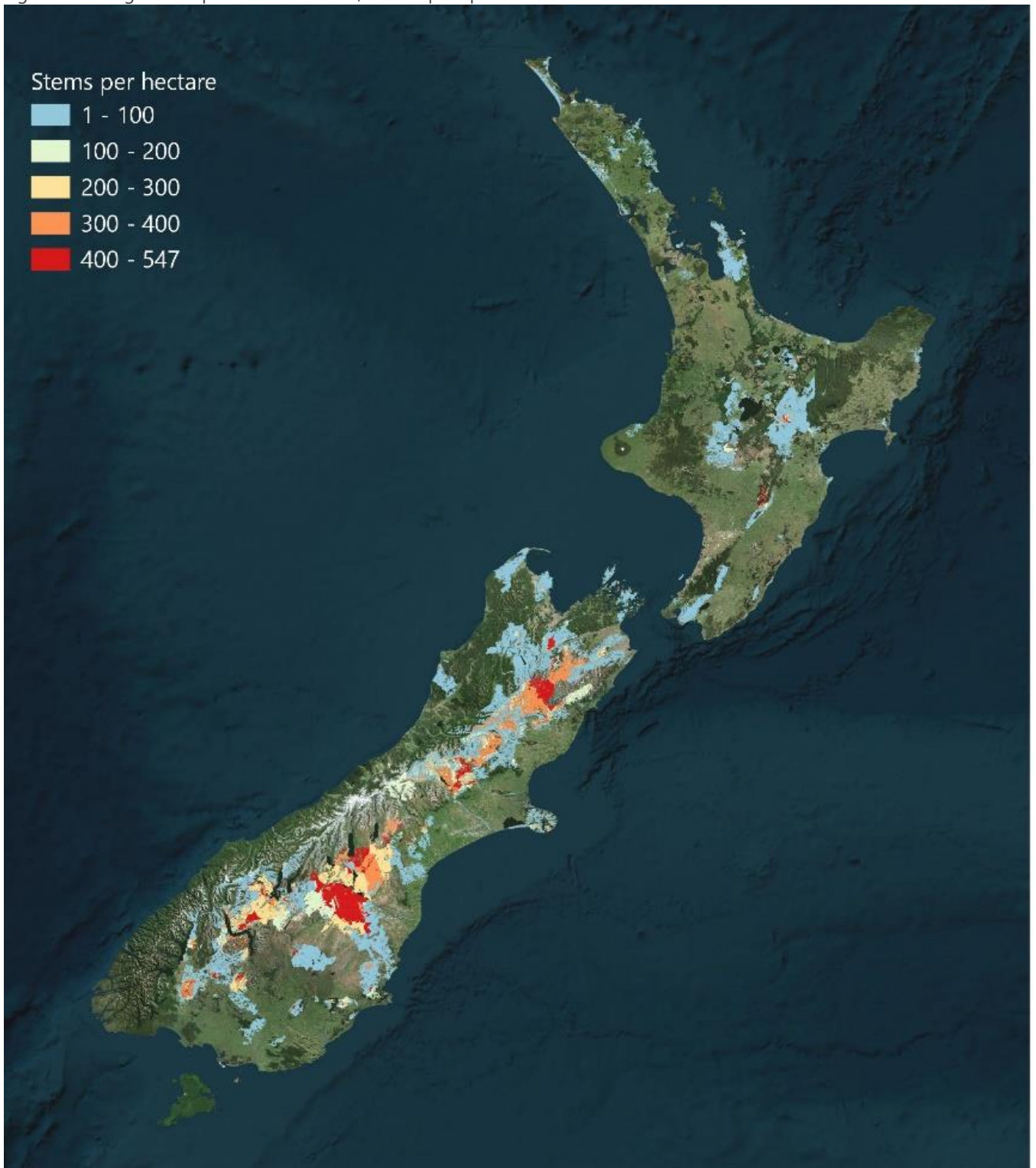
By controlling existing infestations, we avoid future spread and densification. Maps of the current infestation and the infestation following control under each of the options are presented below. The results are marked, particularly the difference in coverage between the minimum and status quo options.

Figure 6: Current average stems per hectare



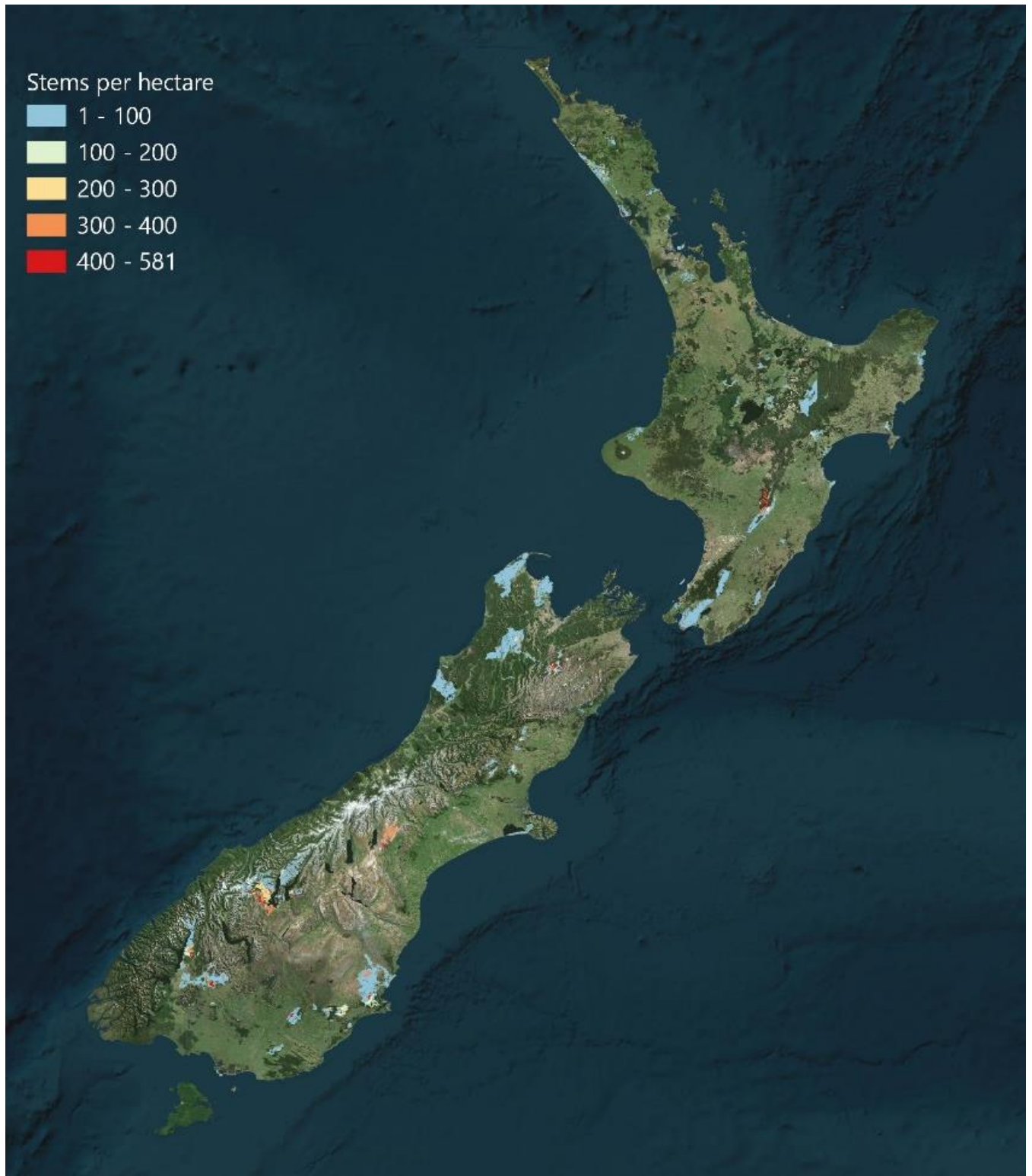
Source: Sapere analysis in conjunction with Landcare Research

Figure 7: Average stems per hectare in 2072, Status quo option



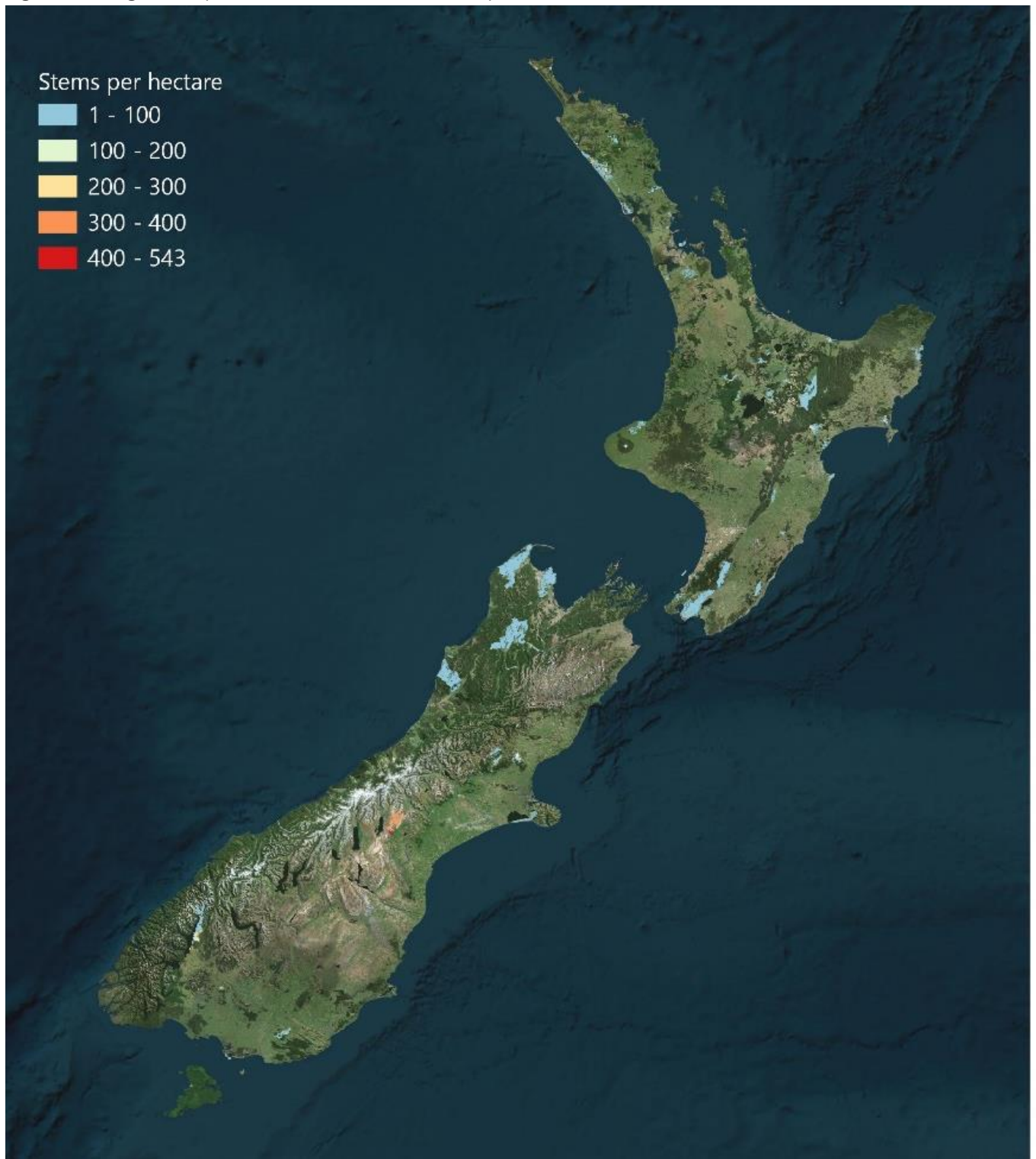
Source: Sapere analysis in conjunction with Landcare Research

Figure 8: Average stems per hectare in 2072, Minimum option



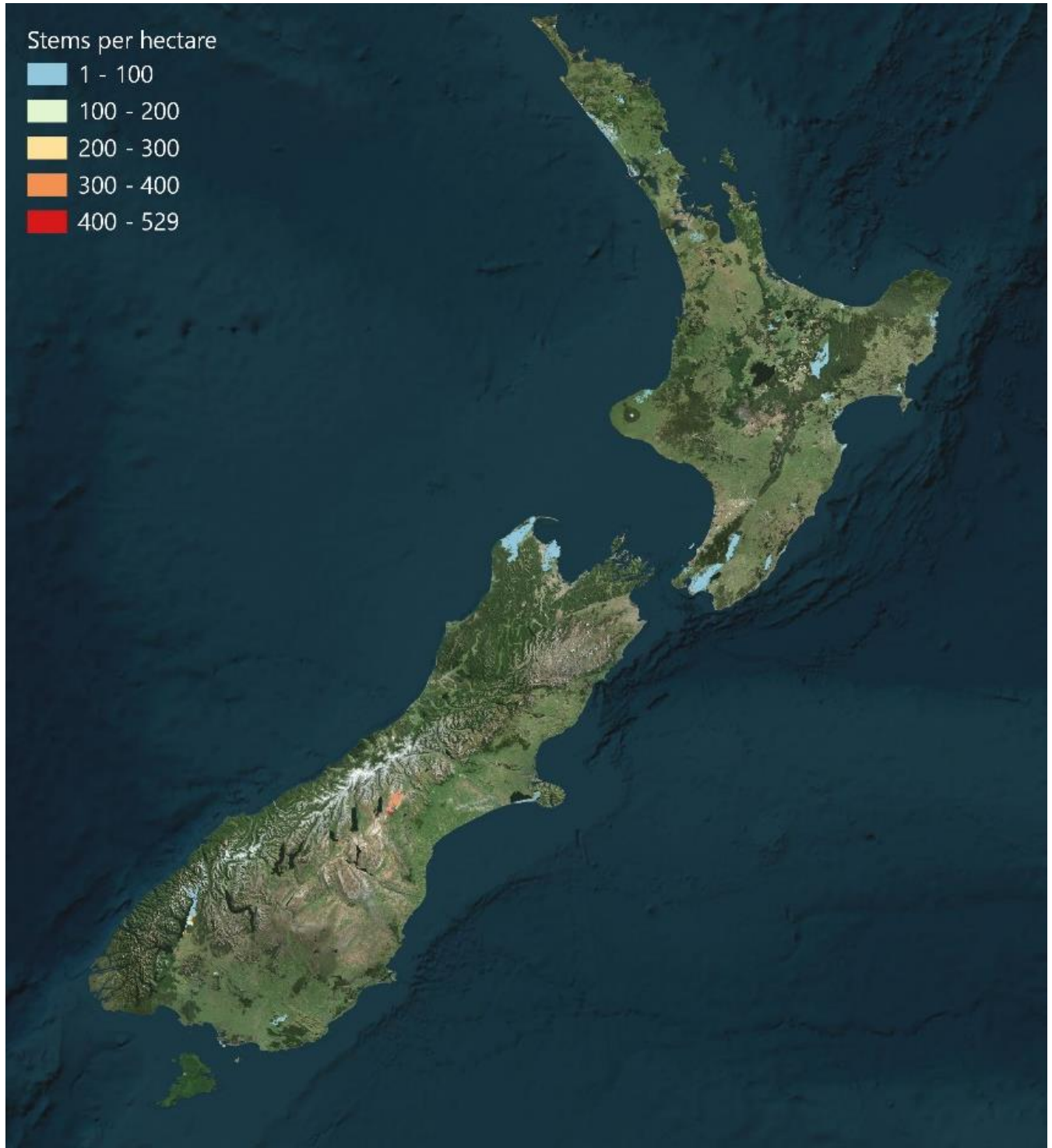
Source: Sapere analysis in conjunction with Landcare Research

Figure 9: Average stems per hectare in 2072, Intermediate option



Source: Sapere analysis in conjunction with Landcare Research

Figure 10: Average stems per hectare in 2072, Maximum option



Source: Sapere analysis in conjunction with Landcare Research

5. Calculation of benefits

This section steps through the benefits from control of wilding conifers. We outline the volumes, values and assumptions used to arrive at the result.

5.1 Productive land use

Invasion of wilding conifers reduces the productive potential of land. Spread occurs most readily on ungrazed land with low vegetation density, and is least likely to occur in dense vegetation, or where intensive grazing is practised (Ledgard, 2001, Buckley et al., 2005). In the absence of control, moderately or infrequently grazed grassland and pasture will be lost to wilding pine invasion, and economic potential with it.

5.1.1 Defining vulnerable productive grassland impacted by wilding invasion

We define the land most susceptible to production loss as low-producing and high-producing grasslands using the Ministry for the Environment's land use classifications 2016 (Ministry for the Environment, 2020). Subclassifications were used to identify grazed and ungrazed land. Other productive land use types, like forestry and horticulture, are assumed to be less vulnerable to wilding conifer spread, and self-manage the impact of wilding spread on their operations.

Manaaki Whenua modelling of infilling and long-distance spread is used to define invasion of low- and high-producing grasslands. Spread assumptions are determined by land cover and grazing intensity and use establishment rates derived from Buckley et al. (2005). Based on this modelling, we assume spread on intensively grazed land is zero and on all other grasslands the average population growth rate has been applied.

Grazing intensity is defined at a regional level using Statistics NZ Agricultural Census data. Regions with an average sheep per hectare of eight or higher across land dedicated to sheep farming are considered to have intensive sheep farming.

Table 9: Grazing intensity, sheep per hectare by region

| Region | Grazing intensity | Sheep per ha |
|--------------------|-------------------|--------------|
| Auckland | Low | 6 |
| Bay of Plenty | High | 8.3 |
| Canterbury | Low | 4.2 |
| Gisborne | High | 9.1 |
| Hawke's Bay | High | 9.4 |
| Manawatu-Whanganui | High | 9.4 |
| Marlborough | Low | 3.1 |
| Nelson | Low | ..c* |
| Northland | High | 9.1 |
| Otago | Low | 3.9 |
| Southland | High | 8.4 |
| Taranaki | High | 8.5 |
| Tasman | High | 8.5 |
| Waikato | High | 9.4 |
| Wellington | High | 9.1 |
| West Coast | Low | 5.1 |

Source: Sapere analysis using Statistics NZ data, *data suppressed for confidentiality reasons

5.1.1.1 Adjustment for loss of vulnerable productive grassland to permanent forestry

An emerging issue is the impact of the Emissions Trading Scheme on land conversions. High carbon prices are driving sales and conversion of marginal productive grassland into permanent forest. Since we have assumed the impacts of carbon credits and emissions balance out in the economy, we do not value this income. However, looking at recent land sales and conversions (Orme & Orme, 2021) as a percentage of all grasslands, we estimate this affects less than 1 per cent of vulnerable productive land. Given the impacts are expected to grow as carbon prices increase, we have assumed no benefits would be gained on 1 per cent of vulnerable productive grassland.

5.1.2 Value of productive sheep and beef land

The value of productive grassland has been estimated by applying the earnings before interest, tax, and rent (EBITR) per hectare for sheep and beef farming. Beef + Lamb NZ recommend using EBITR as a measure of "earning power" (Beef + Lamb New Zealand, n.d.). The values we have applied for low- and high-producing grasslands are:

Figure 11: Values applied to low- and high-producing grasslands

| Land use classification | Value per hectare, per annum |
|--------------------------------|-------------------------------------|
| Low-producing grassland | \$52.89 ⁴ |
| High-producing grassland | \$344.45 ⁵ |

Source: Beef + Lamb NZ: Sheep and beef farm survey

5.1.3 Production loss from invasion

We apply the following loss assumptions based on density class:

Table 10: Assumed production loss by density class

| Density | Production loss |
|----------------|------------------------|
| Outlier | 2% |
| Sparse | 20% |
| Intermediate | 30% |
| Dense | 100% |

⁴ 2020/21 estimated EBITR for Class 1 S.I. High Country New Zealand.

⁵ Mean EBITR for all Hard Hill Country and Hill Country classes.

5.1.4 Productive land use benefits

Table 11 shows the value of the additional benefits derived over 50 years under the four investment options. Notably, impacts here are smaller than in other regions, due to the assumption of the impact of intensive grazing on wilding conifer spread.

Table 11: Productive land use benefits 50-year PV (\$ millions)

| Component | Status quo | Minimum | Intermediate | Maximum |
|------------------------------------|--------------|--------------|--------------|--------------|
| Low-producing sheep and beef | \$172 | \$311 | \$311 | \$311 |
| High-producing sheep and beef | \$34 | \$82 | \$82 | \$82 |
| Loss of productive land due to ETS | -\$2 | -\$4 | -\$4 | -\$4 |
| Total present value | \$204 | \$389 | \$389 | \$389 |

Source: Sapere analysis

5.2 Water yield benefits

The spread of wilding conifers reduces surface flows and aquifer recharge in water-sensitive catchments. Less water reduces the productive value derived from irrigation and hydro generators, and the use values enjoyed in outdoor recreation. Several studies have attempted to estimate the water yield reduction attributable to wilding conifer spread. When pastoral land becomes densely infested with wilding conifers, annual water yield reductions of between 30 – 81 per cent have been found.⁶ Work undertaken by Scion found an average reduction during low-flow conditions of approximately 16 per cent across three South Island catchments in water-afforestation studies. Scion noted that for the purposes of estimating the water impact of wilding conifers, this value could be conservative as wilding conifer stands have a much higher interception effect because of their rougher canopy surface. Wilding conifer stands can also grow in the upper reaches of catchments where plantation planting wouldn't and can therefore reduce low-flow yields more significantly. Water yield reduction in this CBA relies on the analysis of Manaaki Whenua, which uses the WATYIELD model (Fahey et al., 2010). Fahey's research found a 40 per cent reduction in mean annual flow with 2/3 of an experimental catchment planted in pines.

The previous CBA (Wyatt, 2018) evaluating phase two of the wilding conifer control programme found that impacts on water yields dominated the results. This remains the case for phase three of the control programme.

5.3 Hydro impacts

The spread of wilding conifers in hydro lake catchments can reduce water yields and therefore the electricity generating capacity of our hydro dams. This is a substantial economic cost. Additionally, it is worth noting that a reduction in the generating capacity of our hydro dams (without an equal

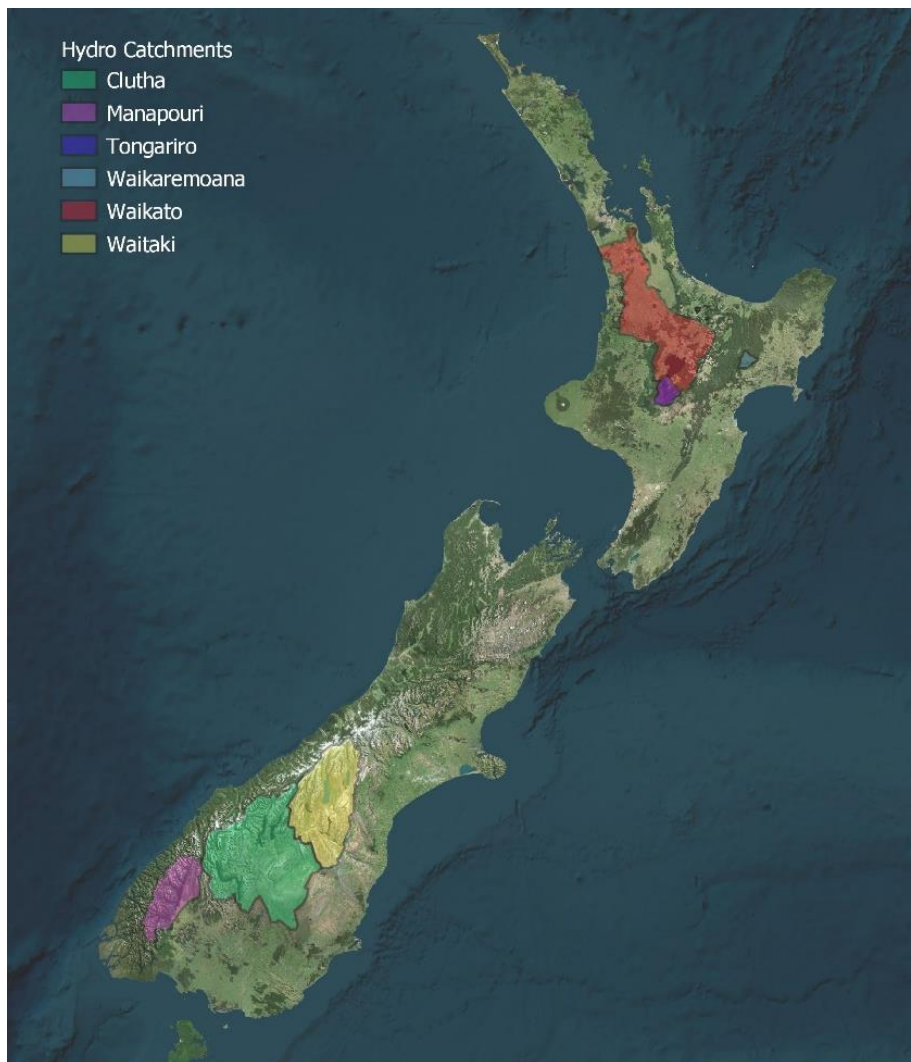
⁶ Data from a number of catchment studies have shown that where pasture has been replaced by radiata pine forest, there was a reduction in annual surface water yields of 30-81%.

reduction in electricity demand) would see that demand met by alternative electricity generators. This would most likely be from non-renewable sources in the short term, gradually being replaced by renewable sources as New Zealand plans to move to 100 per cent renewable energy ('Labour Promises 100% Renewable Electricity Generation by 2030', 2020).

5.3.1 Water yield loss in hydro catchments

The impact of wilding conifer spread on hydro catchments was determined by combining Landcare Research analysis on the reduction in water yield attributable to wilding conifer spread, with a geospatial analysis of the catchments of hydro power generators. Catchments are determined using NIWA's River Environment Classification dataset, which includes all water segments in the country and their up and downstream relationships to each other. Catchments are determined by including all upstream nodes from selected hydro generation plants. A reduction in upstream water yields reduces the amount of water passing through a plant and therefore it's generating capacity. Figure 12 displays the extent of hydro catchments used in this analysis.

Figure 12: Hydro generator catchments



Source: Sapere analysis

5.3.2 Value of hydro generation

Consistent with the CBA undertaken for phase two of the wilding conifer control programme, the hydro resource rent series produced by Statistics NZ is used to express the value of hydroelectricity catchments. This is broadly equivalent to the EBITR measure used to estimate productivity losses from land use changes and the value derived from hydroelectricity generation when calculating GDP.

Table 12: Resource rents for hydro catchments

| Hydro catchment | Estimated annual value of hydro resource rent (2018, forecast to 2021) |
|------------------------|---|
| Waitaki | \$176,072,000 |
| Waikato | \$89,806,000 |
| Manapouri | \$118,911,000 |
| Clutha | \$91,768,000 |
| Tongariro | \$30,917,000 |
| Waikaremoana | \$7,826,000 |

Source: Statistics NZ

5.3.3 Hydro generation benefits by option

The benefits represent the additional water yield loss avoided by controlling the spread and densification of wilding conifers. The present value of controlling wilding conifer spread on hydro generation ranges from \$32.12 to \$201.37 million over the next 50 years under the range of options assessed. Wilding conifer control under the status quo option is inadequate to prevent net hydroelectricity disbenefits from occurring; losses pictured here are due to wilding spread on land no longer controlled when moving from the minimum to the status quo option.

Table 13: PV of hydroelectricity benefits over 50 years (\$ millions)

| Hydro catchment | Status quo | Minimum | Intermediate | Maximum |
|------------------------|-------------------|-----------------|---------------------|-----------------|
| Waitaki | \$33.58 | \$198.20 | \$198.20 | \$198.20 |
| Clutha | -\$1.47 | \$0.86 | \$3.17 | \$3.17 |
| Total benefits | \$32.12 | \$199.06 | \$201.37 | \$201.37 |

Source: Sapere analysis

5.4 Irrigation impacts

The spread of wilding conifers upstream from irrigated land can reduce water yields and the value derived from these irrigation systems.

Consistent with the previous CBA, the value of irrigation is determined at the regional level, extrapolating forward a 2014 *Value of Irrigation* study (NZIER & AgFirst Consultants NZ Ltd, 2014) to determine the value per hectare of irrigated land. This is then adjusted for the increase in irrigated land using an irrigated land area geospatial dataset created by Aqualinc Research Limited and adapted by Statistics NZ and the Ministry for the Environment. The estimated value obtained from irrigation for non-forestry activities is displayed in Table 14.

Table 14: Value received from non-forestry irrigated land

| Region | Regional value of irrigation (2022) | Irrigated hectares of productive non-forestry land (2020) |
|---------------|--|--|
| Canterbury | \$1,394,100,000 | 478,026 |
| Otago | \$264,400,000 | 94,073 |
| Marlborough | \$148,600,000 | 26,545 |
| Hawke's Bay | \$88,368,000 | 21,855 |
| Bay of Plenty | \$62,720,000 | 12,939 |
| Tasman | \$58,800,000 | 9,592 |
| Manawatu | \$48,272,000 | 19,176 |
| Waikato | \$35,168,000 | 26,043 |
| Wellington | \$25,984,000 | 14,284 |
| Northland | \$22,176,000 | 7,289 |
| Southland | \$19,300,000 | 13,800 |
| Auckland | \$15,344,000 | 7,631 |
| Taranaki | \$13,664,000 | 6,355 |
| Gisborne | \$10,528,000 | 3,030 |
| West Coast | \$2,800,000 | 2,751 |
| Total | \$2,210,224,000 | 743,389 |

Source: Aqualinc Research, Ministry for the Environment, Statistics NZ, NZIER

Similar to the methodology used to determine hydro generation catchments, the water yield reduction from wilding conifer spread was determined using a combination of an irrigated land area geospatial dataset created by Aqualinc Research Limited and NIWA's River Environment Classification dataset. Maps of irrigated land (Figure 13) and its corresponding upstream catchments (Figure 14) are shown below. Some regional catchments overlap, providing additional value from controlling spread

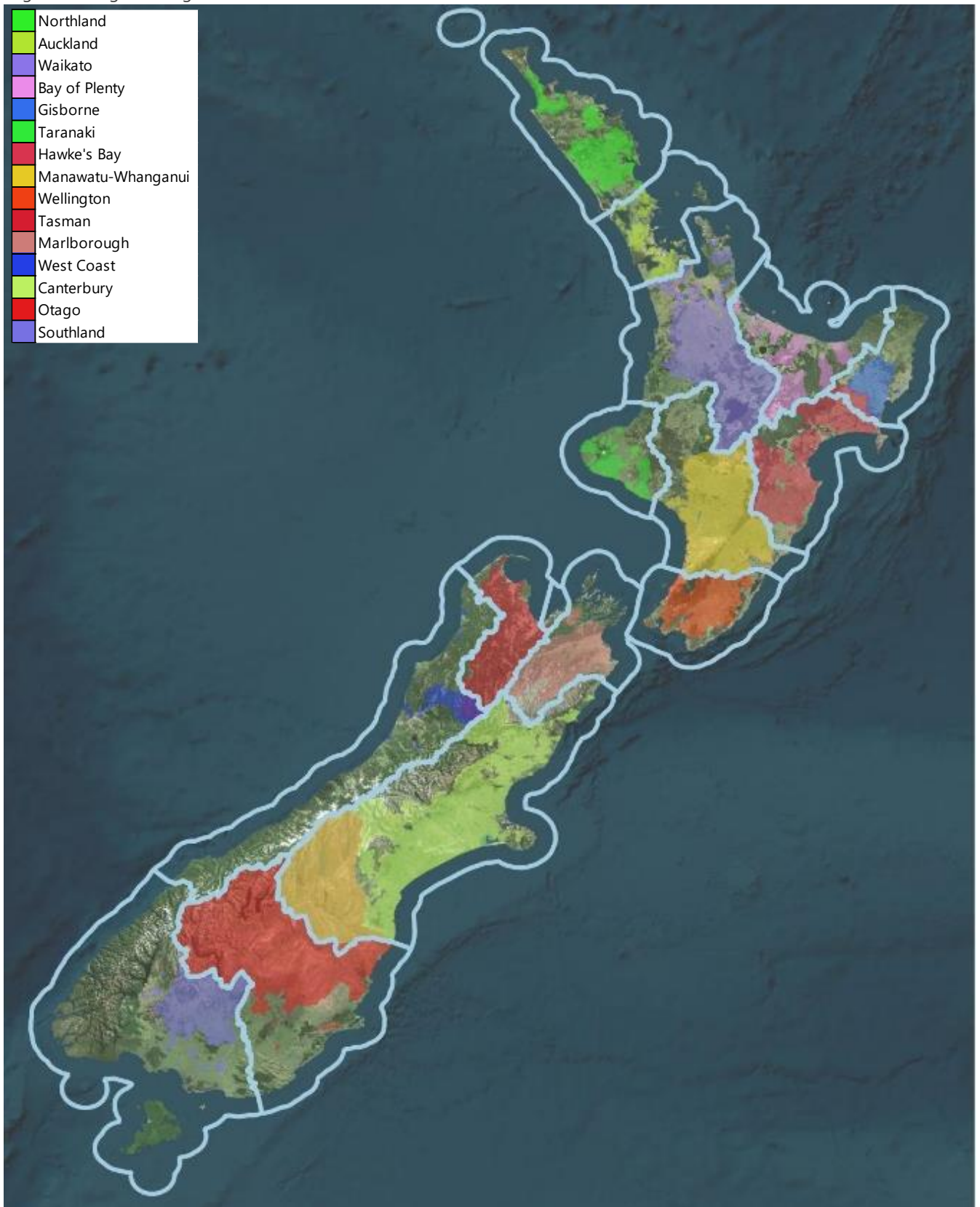
in these areas, notably the orange shaded area in South Canterbury where the Canterbury catchment overlaps with the Otago catchment and the dark purple shaded area at the top of the West Coast where the West Coast and Tasman catchments overlap.

Figure 13: Irrigated land areas, 2020



Source: Aqualinc Research Limited

Figure 14: Regional irrigation catchments



Source: Sapere analysis using Aqualinc Research Limited and NIWA's River Environment Classification data

Under the status quo option, a significant reduction in water yields will occur across irrigation catchments as wilding conifers spread. The benefits displayed in Table 15 represent the water yield loss avoided by controlling the spread of wilding conifers. The Mackenzie District takes in a lot of this land which serves as upstream catchment for irrigation activities in both Otago and Canterbury displayed in Figure 14. Irrigation benefits from controlling spread in this area are therefore substantial for both regions.

The PV of controlling wilding conifer spread on irrigation ranges from \$180.3 to \$343.9 million over the next 50 years under the range of options assessed.

Table 15: PV of irrigation benefits over 50 years (millions)

| Irrigation catchment | Estimated proportion of catchment controlled | Status quo | Minimum | Intermediate | Maximum |
|-----------------------------|---|-------------------|----------------|---------------------|----------------|
| Canterbury | 17.89% | \$118.4 | \$187.9 | \$218.1 | \$249.5 |
| Otago | 17.95% | \$61.8 | \$71.0 | \$94.4 | \$94.4 |
| Total | - | \$180.3 | \$258.9 | \$312.5 | \$343.9 |

Source: Sapere Analysis

5.5 Avoided cultural / biodiversity losses

Wilding conifer spread has a negative impact on cultural ecosystem services (biodiversity, recreation, aesthetic, and heritage values) as wilding conifers grow and outcompete natives for resources and quickly overtake natural landscapes. For cultural ecosystem services, a stated preference method can be used to monetise the values. Stated preference methods attempt to learn people’s willingness to pay by directly asking them how much they value a certain environmental good or service. Careful survey design is key to the success of stated preference methods at eliciting willingness to pay information from participants. A recent willingness to pay study on wilding conifer control in New Zealand has been used as the basis for analysis on avoided cultural/biodiversity losses.

5.5.1 Monetised using non-market valuation (WTP) study

The non-market valuation study reveals the use and non-use values from wilding control such as scenery, recreation and the existence of ecosystems and species through willingness to pay (WTP) survey of households (Polyakov et al., 2021). We used this study’s results through the value transfer methodology for monetisation of these benefits.

Polyakov’s study looked at New Zealand households’ willingness to pay for wilding conifer control using a choice experiment. Participants were presented with a choice set, which displayed different control scenarios across different regions combined with a dollar value displaying the cost to the participant’s household under each option. The control scenarios were to allow wildings to spread, to contain infestation to its current extent, or to reduce the infestation.

The study controlled for:

- household incomes
- the region of the participant
- whether the participant had been hiking in the last five years

- the level of invasion within the participant's region
- whether they were financially impacted by COVID-19
- whether they lived in the city centre, suburbs or countryside.

By presenting choice sets with different control outcomes for different regions, the study also controlled for the distance from the participant's region to the invasion.

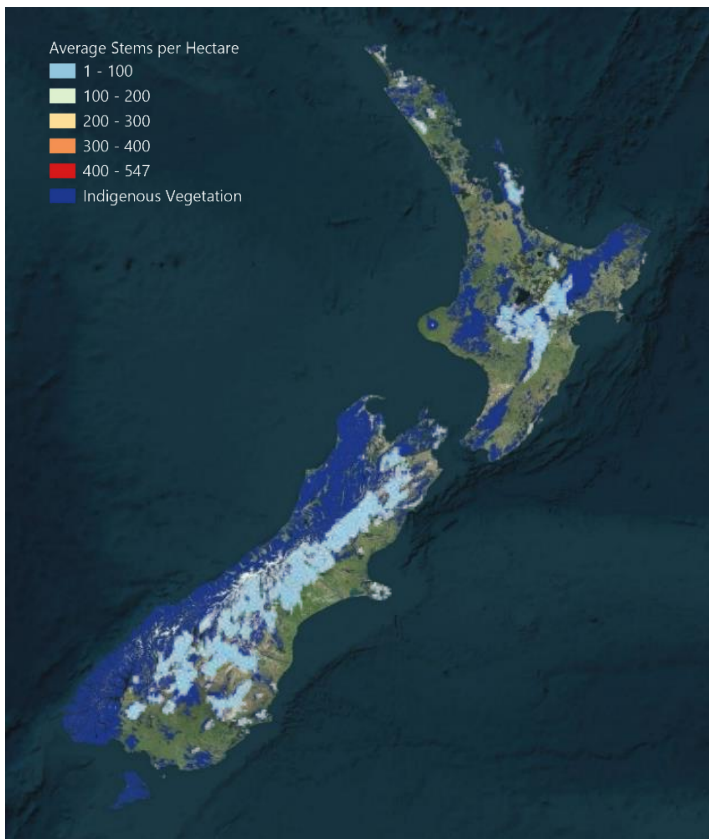
The average household is willing to pay \$105 a year for five years to reduce the area infested with wilding conifers by 1,000 km² (Polyakov et al., 2021). This value diminishes the greater the areas controlled, the further away the household is from the control area and for low-income groups or those financially impacted by COVID-19. High-income groups and rural households are willing to pay slightly more.

5.5.2 Area valued

The study only looked at control and invasion across areas of indigenous vegetation. This makes it useful for evaluating willingness to pay in the context of protecting and enhancing native biodiversity values.

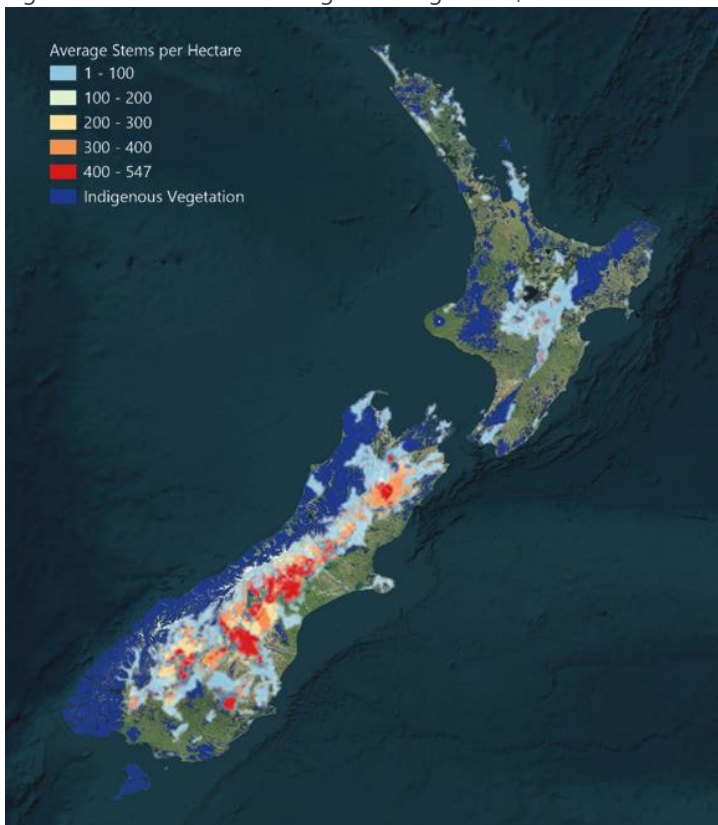
Polyakov selected landcover database classes 43 – 70 as 'indigenous vegetation'. The following figures show the current invasion overlaid on top of the areas considered indigenous vegetation and the invasion in year 50 under the different options. The purple shaded areas are indigenous vegetation with no wilding conifers present.

Figure 15: Existing infestation and indigenous vegetation



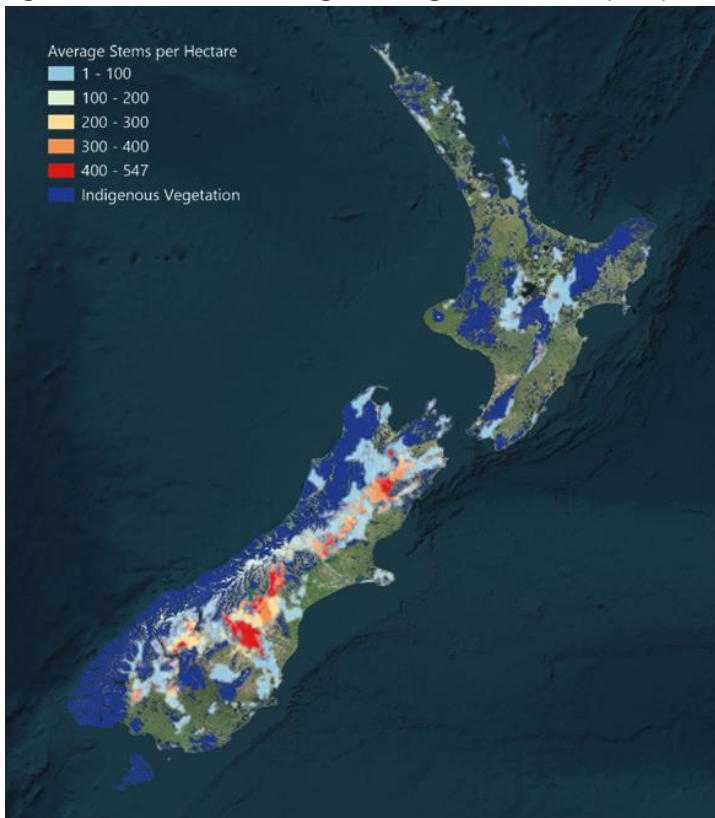
Source: Sapere analysis, Landcare Research

Figure 16: Infestation and indigenous vegetation, abandon all control activities, 2072



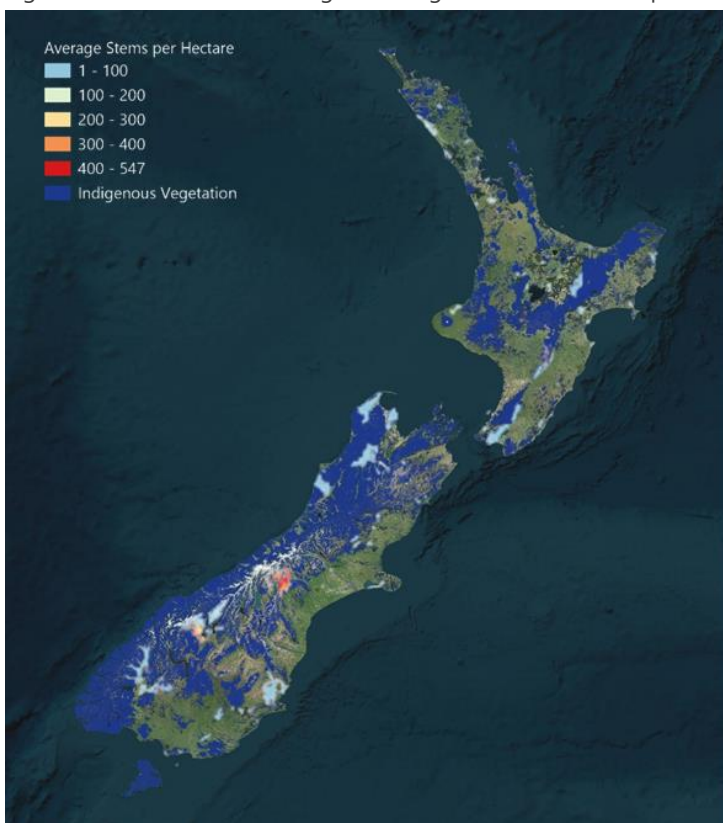
Source: Sapere analysis, Landcare Research

Figure 17: Infestation and indigenous vegetation, status quo option, 2072



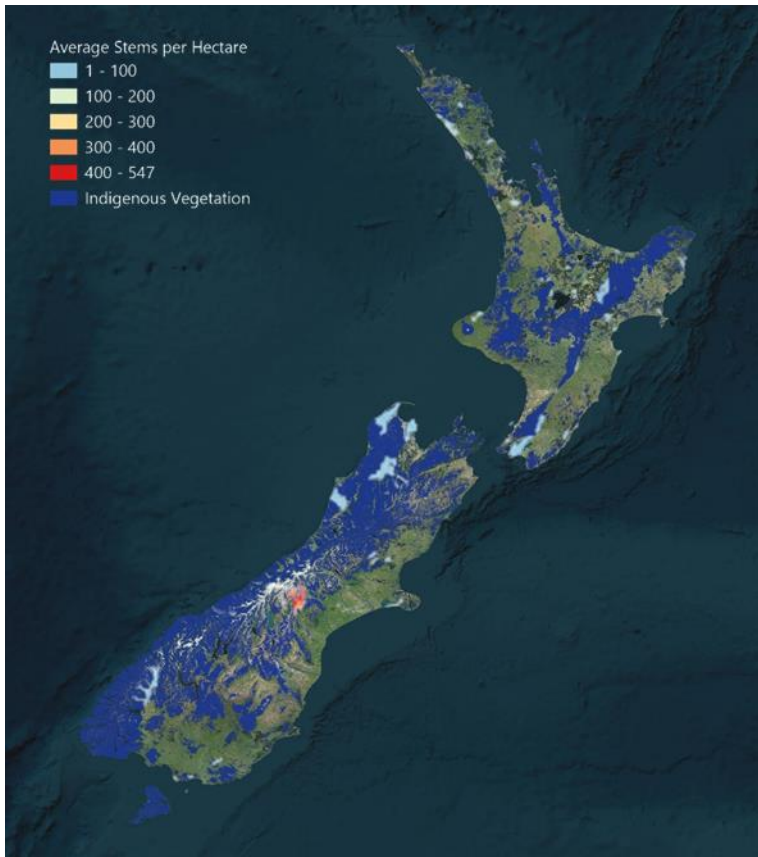
Source: Sapere analysis, Landcare Research

Figure 18: Infestation and indigenous vegetation, minimum option, 2072



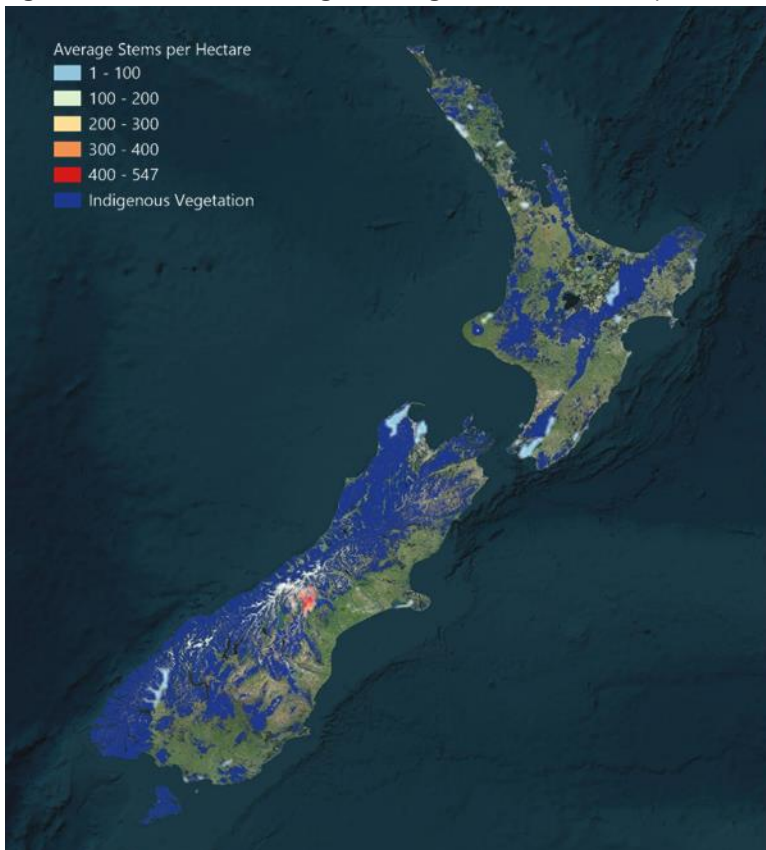
Source: Sapere analysis, Landcare Research

Figure 19: Infestation and indigenous vegetation, intermediate option, 2072



Source: Sapere analysis, Landcare Research

Figure 20: Infestation and indigenous vegetation, maximum option, 2072



Source: Sapere analysis, Landcare Research

5.5.3 Values used per ha controlled

We use the logit model developed by Polyakov to estimate the total willingness to pay (each year for five years) for all households in New Zealand based on the areas controlled under the three options. This gives the following values:

Table 16: Value of cultural/biodiversity benefits based on WTP study (\$ millions)

| | Status quo | Minimum | Intermediate | Maximum |
|---|------------|---------|--------------|---------|
| Willingness to pay by all NZ households each year for 5 years (\$ millions) | \$150 | \$197 | \$197 | \$197 |
| Value per year (\$ millions) | \$32 | \$42 | \$42 | \$42 |
| Present value over 50 years (\$ millions) | \$585 | \$766 | \$766 | \$766 |

Source: Sapere analysis

The total willingness to pay is each year for five years. This gives us the total non-market value for the use and non-use benefits arising from control of wilding conifers. We have assumed that cultural/biodiversity values are ongoing so the value of control per year is the total willingness to pay for five years spread across 50 years.

One limitation in using this study is that participants were not presented with a choice to remove wilding conifers completely. At most, an option to remove half of the existing infestation was presented. In addition, households' willingness to pay diminishes the greater the area controlled. As a result, in the national report we hit a ceiling at the minimum option and no additional value is generated under the intermediate or maximum option. This is because the hectares controlled under these options are greater than the scope of the WTP study. It would not be appropriate to extrapolate the model beyond its limits as this results in negative marginal willingness to pay values. This limitation meant that the benefits from avoiding cultural/biodiversity losses are understated. This problem is avoided when undertaking regional analysis, however, and goes a long way to explaining the high BCRs found at the regional level.

5.6 Benefits from reduced wildfire risk and hazard

The likelihood of wildfires (fire risk) is determined by weather and a source of ignition, e.g. machinery, burn-offs, and rubbish fire. Fire behaviour (or fire hazard) is affected by the interaction between the topography of the land, fuel load (what is available to burn) and weather conditions.

The impact of wilding conifer spread on the cost of wildfires has not been quantified, but the commonly held view is that the establishment of wilding conifers increases fire risk and hazard. Wilding conifers typically replace grasslands which are associated with lower fire intensity and less damage to vegetation and property (V. Clifford et al., 2013).

Some control methods can also contribute to fire risk and hazard. Increases in fuel loads (either as dead standing or felled trees on the ground, or as more grass or scrub cover) will result in an increased chance of ignition, greater potential for fire spread and higher fire intensity. The length of

this increased flammability will depend on the amount of material left on the ground, the rate of decomposition, fuel moisture and other vegetation present (V. Clifford et al., 2013).

Wildfires fuelled by wilding conifers are rare; however, there are some notable examples: the 2008 Mount Cook wildfire covering 756 hectares was fuelled by dense stands of wilding pines (V. R. Clifford & Pearce, 2009); the Aoraki/Mount Cook fire in August-September 2020, which burnt through more than 3,100 ha of wilding forest and tussock on private land; and the 2020 Lake Ōhau fire covering 5,043 hectares (Fire and Emergency New Zealand, 2021), which destroyed or damaged 53 houses.

In researching the potential costs avoided by controlling wilding conifers we spoke with staff at Fire and Emergency NZ (FENZ) and Scion Research. The impact of wilding conifers on wildfire costs is an area requiring further research, but the costs would depend on specific and localised factors such as the control method, the characteristics of the area controlled, potential ignition sources and the presence of fire breaks. The resources committed to suppressing fires would also be weighed against the potential for damage, i.e. more would be put into suppressing a fire close to residential areas and sites of cultural significance. As a result, we have opted for a simple but defensible approach to valuing the benefits of control on wildfire costs.

For this CBA we assume the impact of wilding conifer control reduces the cost of wildfires by controlling trees before they spread and grow, preventing them from becoming a major fuel source. We do not assume that wildfire risk is removed entirely but as a result of control we assume benefits from a reduction in future suppression costs and associated damages.

5.7 Value of avoided costs

The value of avoided suppression costs and damages is based on an economic analysis of the cost of wildfires (BERL, 2009), inflation adjusted to 2021 dollars. Using this we get the following values:

Figure 21: Avoided wildfire costs

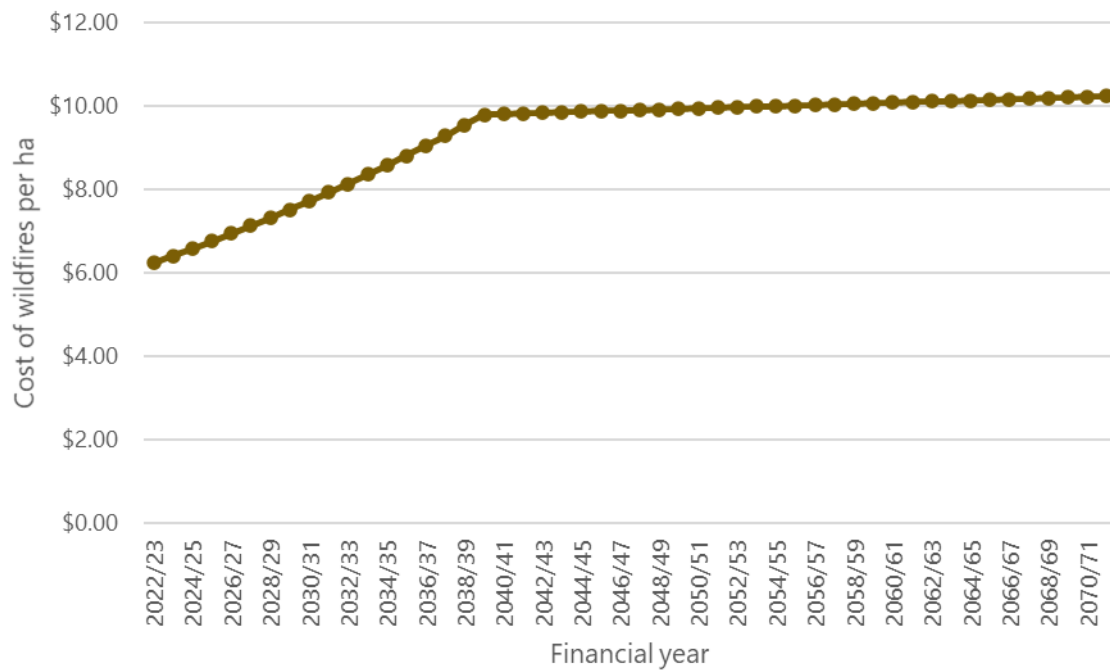
| Component | Cost per ha per year |
|--|----------------------|
| Suppression costs | \$2.13 |
| Cost of damages | \$4.11 |
| Benefit per hectare controlled per annum | \$6.24 |

Source: BERL

5.7.1 The value is adjusted to reflect the increased risk of wildfires because of climate change

Climate change is also expected to have an impact on wildfires with an increase in the frequency and severity of wildfire events. Modelling shows a 70 per cent increase in very high and extreme fire risk days by 2040, increasing to 82 per cent by 2090 (Watt et al., 2019). The benefits per hectare controlled are adjusted to account for the expected change in very high and extreme fire risk days due to climate change as shown in Figure 22.

Figure 22: Benefits per hectare controlled adjusted for increased very high and extreme fire risk days due to climate change



Source: Sapere analysis

5.7.2 The benefits from avoided wildfire costs

We assume that all land controlled, plus the avoided spread, contributes to the avoided cost of wildfires. Applying the cost of fire to this area we derive the following benefits over 50 years from control activity on wildfire costs.

Figure 23: Present value of fire benefits by investment option (\$ millions)

| Component | Status quo | Minimum | Intermediate | Maximum |
|---|------------|---------|--------------|---------|
| Avoided spending on wildfire suppression costs | \$11.2 | \$17.3 | \$17.3 | \$17.3 |
| Avoided spending on damages caused by wildfires | \$21.6 | \$33.1 | \$33.1 | \$33.1 |
| Proportion of costs caused by climate change | 49.0% | 49.7% | 49.6% | 49.6% |
| Total benefits (PV) | \$32.8 | \$50.4 | \$50.5 | \$50.5 |

Source: Sapere analysis

The benefits from reduced fire risk range from \$32.8 million over 50 years under the status quo option to \$50.5 million under the maximum option. The impact of climate change risk is significant, accounting for 49% to 49.7%, or \$16.0 – \$25.1 million of the avoided costs.

5.8 Māori cultural values (qualitative)

The term 'cultural value' has wide meaning and can include historic and aesthetic value of sites or landscapes, recreation, indigenous biodiversity, ancestral and spiritual values, people's sense of place and identity, kaitiakitanga (guardianship), and bequest value for future generations. This list is not exhaustive, but it highlights how difficult it is to simply define cultural value. In their report on non-market impacts of wilding conifers on cultural values, Greenaway et al. use the definition:

The collective norms and expectations that influence how ecosystems accrue meaning and significance to people (Greenaway et al., 2015)

For Māori, there are clear links between healthy ecosystems and people's cultural and spiritual well-being (Harmsworth & Awatere, 2013). The depth of Māori cultural values is well articulated in the introduction to Indigenous Māori Knowledge and Perspectives of Ecosystems:

Indigenous Māori have an intricate, holistic and interconnected relationship with the natural world and its resources, with a rich knowledge base – mātauranga Māori – developed over thousands of years and dating back to life in Polynesia and trans-Pacific migrations. This ancestral traditional bond links indigenous Māori to ecosystems and governs how they see and understand ecosystems and ecosystem services (Harmsworth & Awatere, 2013).

In effect, some Māori values are deep-rooted and accrue indefinitely so are not able to be adequately monetised in this CBA. Protection of waterway health (te mana o te wai) and native landscapes (whenua ora) is also important in Te Ao Māori, and at iwi level, sustainable productive land use will also be of importance to many iwi and hapū. Some of these values have been included, through the monetised benefits of productive land use and water yields, fire risk and in biodiversity values. In their willingness to pay study, Polyakov et al. estimate non-market values such as existence values of ecosystems and species resulting from wilding conifer control.

In the 2011 Wilding Conifer Status report it is noted that the impact on Māori cultural values has been low but could become significant should wilding spread reach a tipping point. Impacts described in this report included the loss of culturally significant sites and impact on water flows and health of waterways (Froude, 2011).

Cultural assessment models can be used to provide a cultural lens to policy and decision making on ecosystem projects. The Wilding Conifer Management Programme also recognises Māori cultural values in its activities. Iwi are involved in a number of projects, and all conifer control programme applications ask for information on the Māori cultural values and to note where there is support or involvement of local iwi or hapū.

Qualitatively, the following Māori values can provide a basis for what is valued (Harmsworth & Awatere, 2013).

- Rangatiratanga: The right to exercise authority and self-determination within one's own iwi and/or hapū realm.

- Kaitiakitanga: Guardianship, stewardship, trusteeship, trustee. Kaitiakitanga is an important Māori value that bestows an obligation of stewardship on Māori to care for the environment.
- Whanaungatanga: Relationship, kinship, sense of family connection – a relationship through shared experiences and working together, which provides people with a sense of belonging.
- Wairuatanga: The immutable spiritual connection between people and their environments.
- Mātauranga: Māori/mana whenua knowledge and understanding.

6. Areas for further research

Post-completion of this CBA, discussion with stakeholder groups revealed areas of further research that could complement this analysis.

- **Economic value from harvesting wildings:** some value is generated from harvesting wilding logs and biomass. Incorporating this effect would reduce the net costs of clearing wildings in areas where it is practical, further increasing the BCR.
- **Slope stability, flooding intensity and root system aquifer retention impacts:** clearing trees has environmental impacts regardless of whether the tree is a 'pest' or not. Wilding conifers do provide some environmental benefits which would be lost if land is transitioned to another, non-forestry use. Monetising and incorporating these benefits of wilding pines would decrease the net benefits from clearing wildings in some areas.
- **Wider biodiversity impacts:** as a function of limitations discussed in the body of the report, as a measure of biodiversity, this report has only considered the impact of wilding conifers on areas of native vegetation.

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David Moore

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Email: dmoore@thinkSapere.com

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| Level 9 1 Willeston Street PO Box 587 Wellington 6140 | Level 8 203 Queen Street PO Box 2475 Shortland Street Auckland 1140 | Level 18 135 King Street Sydney NSW 2000 | Level 5 171 Collins Street Melbourne VIC 3000 | PO Box 252 Canberra City ACT 2601 |
| P +64 4 915 7590 F +64 4 915 7596 | P +64 9 909 5810 F +64 9 909 5828 | P +61 2 9234 0200 F +61 2 9234 0201 | P +61 3 9005 1454 F +61 2 9234 0201 (Syd) | P +61 2 6100 6363 F +61 2 9234 0201 (Syd) |

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