Summary report: Planting eroding hill country in the Hawke's Bay Region

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Published by: Scion, 49 Sala Street, Private Bag 3020, Rotorua 3046, New Zealand. www.scionresearch.com

Executive summary

Kaitiakitanga and maanakitanga

Planting highly erodible land in the Hawke's Bay could increase financial returns from land and, for each dollar earned, provide one and half times the value in avoided erosion, avoided nitrogen leaching and carbon sequestration. In addition, new forests could provide habitat for species like kiwi and karearea, and the benefits from regenerating headwater streams and riparian areas would flow to downstream waterways.

Native species, which originally covered the land, are suitable for planting across the Hawke's Bay. Management options include permanent carbon forests on steep land and land at high elevations or growing plantation podocarps such as tōtara or rimu. Radiata pine can contribute significant value where access for harvesting and transport make this economically viable. Coast redwood and *Eucalyptus* are good options for plantation species at lower elevations if individual species requirements met. Mānuka for honey is a good choice for warm, sunny slopes.

With increased afforestation comes increased wood supply. While the wood would come to market gradually, and growing radiata for example on a short rotation initially would smooth future wood supply, in 30 years wood supply could triple. Rather than exporting surplus logs as a commodity, as happens today, a range of sophisticated products could be produced locally. The current wood supply is already sufficient for wood processing to expand to provide around 500 jobs, half a million dollars in GDP and reduce the region's carbon footprint. Additionally, processing facilities that specialise in alternative species such as coast redwood, for example, will be needed if significant planting of other plantation species takes place.

Landowners and other members of the community are understandably concerned about the consequences of increased afforestation. Tree planting should target highly erosion prone areas, which tend to be steeper, more exposed and with poorer soils, rather than blanket afforestation of entire farms including productive land. Farmers who have planted erodible areas of their land report they can focus on improving the productive areas of their farms, getting the benefit of increased income from increased stocking, for example, and the income from forestry. They also appreciate the ecosystem services benefits including increased resilience to the impact of severe storms.

Landowners hesitant about farm forestry need to be able to access detailed information about the land classes on their farms to identify high performing areas for afforestation. Many farmers overestimate the returns from their poorest land. In many instances, these poorest performing areas could benefit from afforestation, allowing resources to be focused more intensely on farming the better performing land classes. A complementary approach where less productive land is afforested, and higher quality land is managed more intensively, can lead to higher overall farm returns and benefit communities and environment more than whole property conversions.

There is a clear gap (and opportunity) for a central support and guidance mechanism to work alongside landowners to understand their objectives and constraints, and for the development of a long-term plan that fits with the needs and expectations of landowners. This must be focused on the needs of the individual farm unit and supported by a community dynamic that encourages responsible planting activity. Part of the jigsaw is finance and funding, but this is not the only mechanism that is needed, and it needs to be shaped by the unique characteristics of each project.

Taking an integrated approach to forestry that controls the process from growing seedlings to harvesting would return control to local communities, and iwi to provide permanent jobs and strengthen rural communities.

Carbon trading is complex. Post-1989 ETS eligibility is a variable that will vary from site to site and is key economic contributor to returns. While carbon provides a huge economic incentive for planting trees, participating in carbon trading (selling units) negates any official carbon neutral benefits. Land values for a cutover forest where the carbon has been traded, are likely to be significantly lower than bare land.

The HBRIC and HBRC's roles in achieving the project's desired outcomes will be around driving and influencing landowner behavior. It is likely customised solutions will be required for individual owners and communities. Targeted intervention is recommended as hands-off solutions may result in market forces causing unintended consequences and not significantly improving erosion. Several strategies should be employed together to support landowners to make optimal choices around the right trees being planted in the right places.

Recommendations

The project is potentially transformational and integrates existing forestry projects and knowledge. It provides tools and information that will help decision makers including iwi, landowners, the wider community and regional and national government understand the implications of different afforestation options to develop a strategy that sees the right tree planted in the right place for the desired outcomes:

- Reducing erosion on highly erodible land to benefit soil and water quality
- Improving financial returns through highest and best land use options
- Providing ecosystem service benefits
- Balancing individual, community and regional needs and expectations.

Favoured alternative species should be selected. This will allow focused effort on research, market development, wood processing options and collaboration to develop scale and infrastructure.

Integrated land use with afforestation (as opposed to corporate scale forestry) is recommended to maintain existing regional community structures.

Individual, whole farm assessment needs to be done at a high resolution to facilitate the process of comparing and selecting appropriate areas to consider for forestry.

Wider education on forestry and the benefits of better land use selection and its potential is needed for landowners but also other rural professionals.

Specific interventions and investment strategies will ensure targeted afforestation is optimal and is able to deliver on a range of landowner preferences.

A combination of investment strategies is recommended, particular:

- Developing internal forestry expertise and resources
- Targeted incentives
- Support and leverage existing industry and infrastructure.

Permanent Carbon regimes should be managed like a timber crop in most circumstances. This has forest health benefits and may allow for alternative income streams if there is a very different future environment (i.e. collapse of the ETS and very high fibre or timber prices).

Failure to increase afforestation using the right tree, right place principles could lead to:

- Failure to plant highly vulnerable land and continued or accelerating erosion with climate change and severe storm events (and possible increased infrastructure damage from storms). Land declines in productivity and value.
- Widescale afforestation on non-eroding (productive fertile) landscapes including whole farm conversions
- Poor rates of forest survival, productivity and ecoservices provision
- Not achieving highest and best land use
- Legacy issues
- Community dissatisfaction and lack of engagement and uptake of appropriate afforestation options
- Failure to meet environmental legislation.

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Introduction

The Hawke's Bay Regional Investment Company (HBRIC) and Hawke's Bay Regional Council (HBRC) want to explore and understand opportunities to invest in afforestation to reduce soil erosion that are both economically and environmentally sustainable. Financial returns, whether from timber, carbon, honey and other sources, are key in the event HBRC/HBRIC intend to develop a self-sustaining regional afforestation strategy, especially in terms of ability to create a self-sustaining fund for forest investment. Additionally, ecosystem service delivery and sequestering carbon toward regional carbon neutrality, sediment and nutrient reduction, and terrestrial and aquatic biodiversity are important considerations.

Around 120,000 hectares of land in the Hawke's Bay has been identified as highly susceptible to erosion, losing 1,000 tonnes of material per square kilometre a year. Erosion could be slowed and controlled by afforesting the majority of this land. Afforestation options include commercial plantations of radiata pine, redwood, cypress, *Eucalyptus*, tōtara and mānuka, as well as permanent native forests.

The project explores a broad scale spatial application of a range of appropriate tree species and forest systems, in the right place in the landscape, for the right purpose to achieve positive outcomes for the environment, the economy and communities. The project aims to provide a sound platform for future decision making to enable HBRIC and HBRC to decide on whether to pursue future afforestation implementation, with some perspective on how to do so.

Objectives

Defining priority erosion areas for afforestation priorities.

Proposing afforestation options where species and regimes are matched to specific sites and understanding their merits and drawbacks.

Considering and informing on relevant considerations including carbon and non-market benefits.

Developing spatial ranges for relevant forestry options.

Developing an understanding of landowners' views on afforestation including success factors and barriers to ensure individual landowner and community expectations are met.

Outlining existing and future wood supply issues and wood processing options.

Providing financial analysis at the individual and regional level to enable optimal financial decisions are made; proposing investment options and strategies.

Extent of erosion: Which areas are suitable for planting

The planting of trees across New Zealand's most vulnerable, and unstable landscapes provides benefits including a reduction in soil erosion, increased carbon sequestration, and other ecosystem services like water filtration. Trees protect landscapes especially during periods of intensive storm events by providing a canopy that intercepts rainfall, reducing water in the soil profile, and with roots that provide structural integrity by binding the soil matrix together.

Hawke's Bay was originally covered in native forest that protected the erosion-prone soils found in much of the region. Extensive commercial land use change has occurred that has had ongoing impacts on soil and water quality.

Here we identify and quantify erosion-susceptible areas for targeted afforestation by developing datasets that spatially define the landscape geophysical conditions that will influence tree species selection or where trees should not be planted. Factors such as cooler temperatures, skeletal soil types, steep slopes, exposure to intensive storm events that can influence tree survival will be considered when looking at the suitability of high elevation landscapes for afforestation

Erosion

Sediment yield mapping (SedNetNZ) has identified 150,000 ha (12 percent) in the Hawke's Bay where sediment yield rates are estimated to be at least 1,000 tonnes per square kilometre a year and where the land has a predominant current cover of grassland and is suitable for some form of forest cover. While afforesting this target area will give the most benefit to erosion control, significant benefits may be accrued by targeting afforestation on a further 150,000 hectares that are eroding at more than 500 tonnes per square kilometre a year. Figure 1 shows where sediment yields exceed 1,000 tonnes per square kilometre a year in the Hawke's Bay.

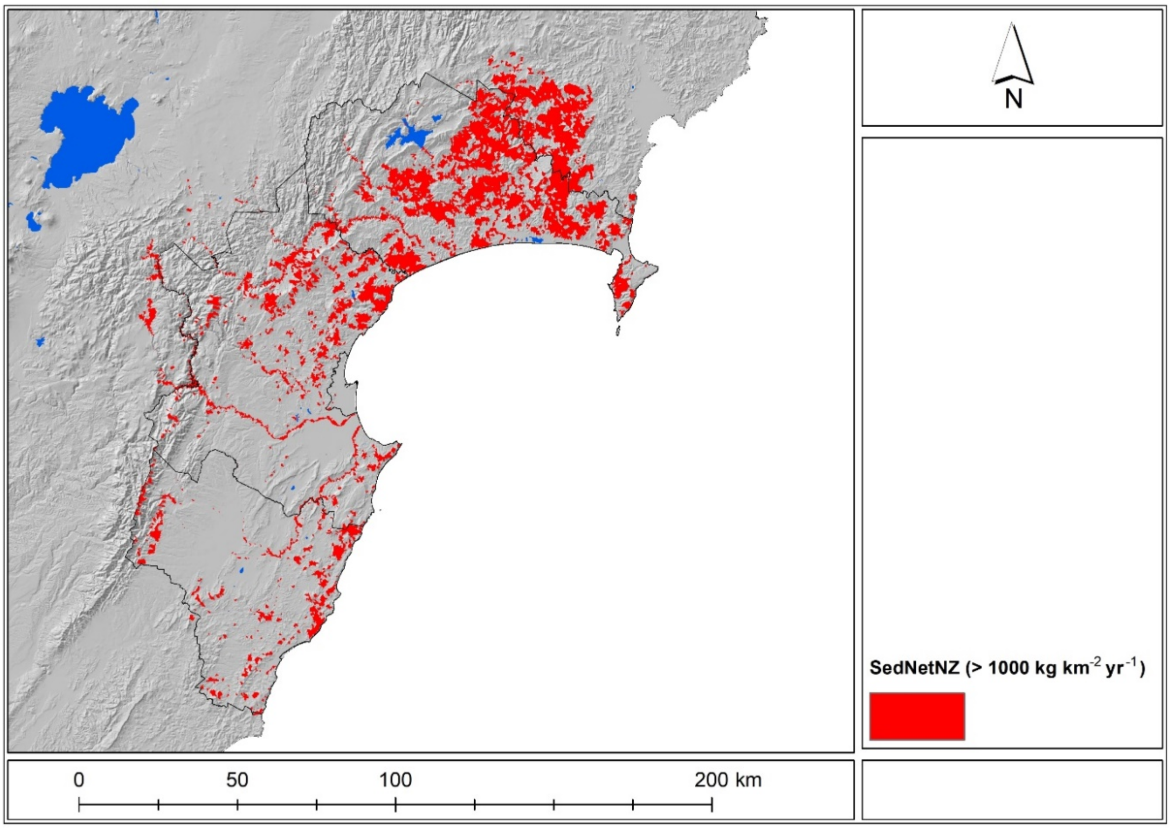

Figure 1: SedNetNZ results illustrating sediment above 1000 tonnes per square kilometre a year across the Hawke's Bay region.

Identifying sites for potential afforestation across erodible landscapes

Afforestation groupings were developed from the Land Use Classes (LUC) units and Table 1 provides an overview of the data developed at a 25-m cell size resolution raster of the Hawkes Bay regional catchments. These data form the foundation of our forest grouping analysis. Generally, lower afforestation grouping values occur across down lands and alluvial landscapes with gentle slopes where erosion is minimal, and where these locations have few limitations to forestry. However, as grouping values increase, so does the risk and severity of erosion across steeper landscapes with rock and soil types prone to erosion. (Table 1 and Figure 2).

Table 1: Afforestation groupings overview.

Group	Area (ha)	Commentary
1	233,568	Generally, alluvial valleys or terraces, fertile, lower altitude.
2	98,180	Generally, rolling to steep on hard geology, fertile & lower altitude.
3	74,289	Rolling to steep, prone to some forms of sheet, rill or gully erosion.
4	42,656	Area on varying topographies, with climatic, altitudinal and erosion limitations.
5	273,235	Moderate to steep landforms that are prone to soil slip or sheet and gully erosion under pasture.
6	14,560	Limited productivity under grazing on steeper terrains and prone to gully erosion.
7: Skeletal	319,777	Limited productivity under grazing, thin soils on steeplands. vulnerable to debris flow /debris avalanche initiation.
8: Reversion	323,210	Generally steep uplands subject to high rates of natural or induced erosion.
9: Earthflow	125,630	Generally moderate to rolling hill country subject to deep seated mass earthflow erosion.

Because these LUC groupings are from coarse polygons, fuzzy membership was used to improve within-polygon spatial resolution by incorporating slope angle, north-eastern aspect (direction of intensive storm events), and the degree of erosion happening.

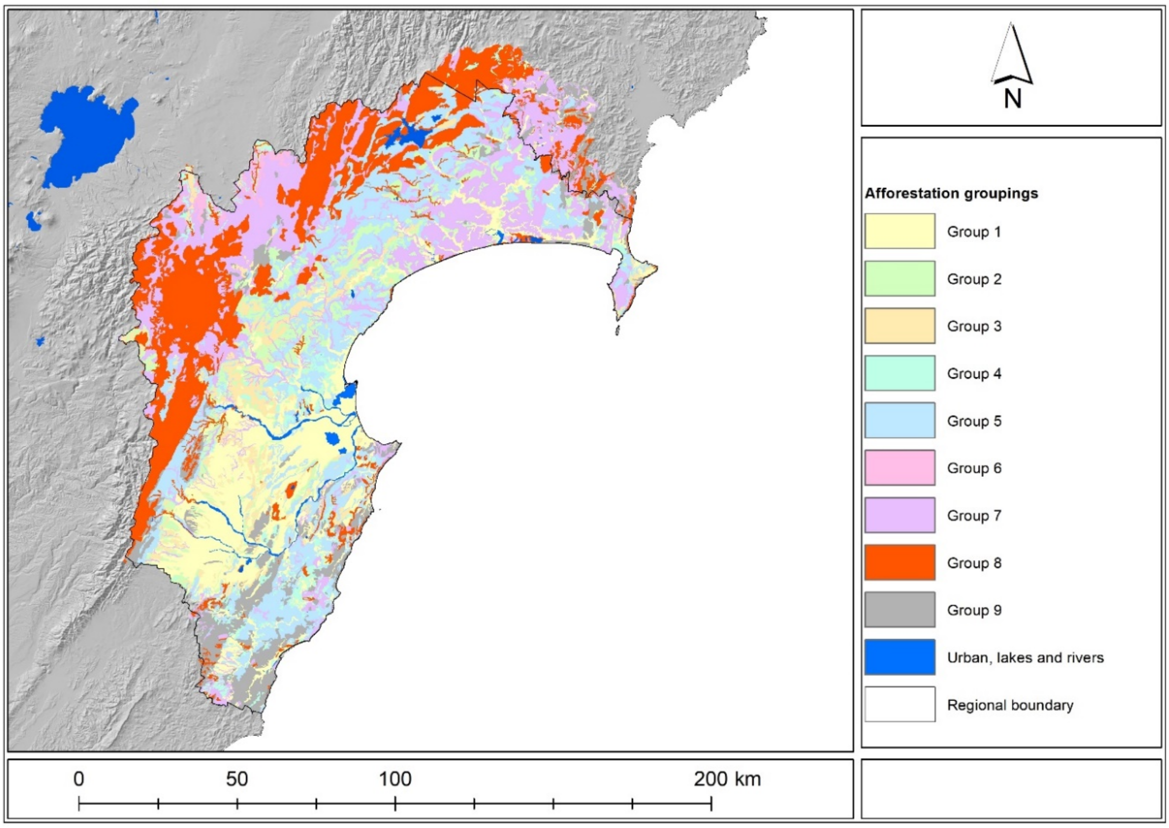

Figure 2: Map developed by grouping Land Use Capability units into nine afforestation groupings representing the Hawke's Bay region catchments.

Greatest effect can be realised by targeting afforestation to the sites with the highest erosion susceptibility, and eligibility for carbon credits due to erosion severity. These criteria have been applied to the 1.28 million hectares of area in the Hawke's Bay region and identified an area of approximately 132,533 hectares for afforestation (Figure 3).

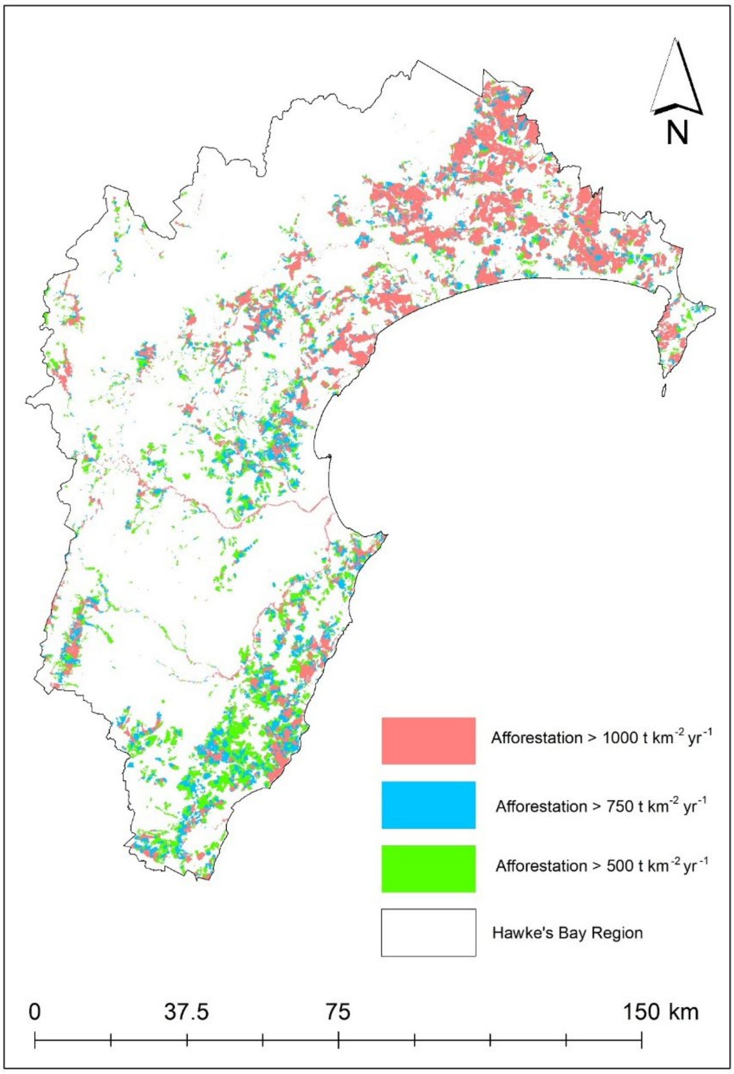

Figure 3: Land with potential for afforestation based on (1) Afforestation Groupings 3 to 9, (2) LUCAS classes that are available for carbon credits, and (3) SedNetNZ total erosion greater than (a) 500 t km^{-2} yr^{-1}, (b) 750 t km^{-2} yr^{-1}, and (c) 1000 t km^{-2} yr^{-1}.

Conclusions and recommendations

The approach used here provides a spatial method for identifying the most erodible sites across the Hawke's Bay region that have potential for afforestation. More importantly, this approach provides an assessment of the landscape's suitability to sustain forests. For example, is the landscape and its supporting environment capable of sustaining commercial plantations, or plant and leave retirement options, or carbon sequestration options.

Potential afforestation options

Forest systems

The scale and historical use of radiata pine has enabled significant investment in every level of the value chain including genetic improvement, silvicultural trials, wood processing, marketing and building standards and codes. A key contributing factor for the lack of alternative commercial species in New Zealand is the lack of scale and dependable volumes for market or processing development. Alternative species have not received anywhere near as much focus, and resources have been spread across a plethora of species established in an ad hoc manner throughout the country.

A representative group of forestry systems that include commercial alternatives to radiata pine to represent a range of options that could be selected to provide desired outcomes for erosion control, financial returns and ecosystem benefits are considered here (Table 2). It is important to note that this project is not specifically advocating for any of these species and other species may emerge as viable options over time and in future stages.

Table 2: Forestry systems that represent a range of potential options that could to provide financial returns and ecosystem benefits including erosion control.

Species group	Regime options	Regime code
Radiata pine	Pruned with carbon, 28-30 yr rotation	PRTH
	Framing with carbon, 25-28 yr rotation	UPTH
	Permanent carbon, manage as per framing regime	PRNH
Douglas-fir	Timber crop with carbon, 35-50 yr rotation	DFTH
	Permanent carbon, manage as per timber crop	DFNH
Dryland Eucalypts	Hardwood timber crop with carbon, 20-30y r rotation	EUCS
	Permanent carbon	EUCN
Cypresses	Pruned timber crop with carbon, 30-50 yr rotation	CYPR
	Permanent carbon	CYPN
Redwood	Timber with premium for pruned and heartwood with carbon	REDW
	Permanent carbon – long lived species	REDN
Indigenous	Podocarps for timber (rimu, tōtara, kauri) with carbon	NATV
	Permanent carbon	NATN
	Reversion – retirement, or minimal canopy planting, carbon	REVR
Mānuka	Honey production is focus	MANU
Silvopastoral	Poplars/willows for erosion and portable milling	SILV

A brief description and a summary of benefits and risks of each of the tree species groups considered in this report follows.

Tree species site suitability

Tree Species Site Suitability maps are included for each species to help with decisions around which species, or group of species, is best suited to local conditions.

Tree Species Site Suitability maps were developed by combining the productivity associated with a tree species with whether a species has high survivability under certain site conditions. Data and expert knowledge was used to identify where plantation forestry species are currently growing. Using these spatial locations, we were able to look at environmental conditions to build knowledge of the species preferred growing conditions, such temperature, rainfall, altitude, soil fertility and moisture availability, exposure to damaging winds or salt laden sea spray. Profile Available Water (PAW) was used to represent water holding capacity, rooting volume, and potentially fertility.

Radiata pine (*Pinus radiata*)

Radiata pine is the dominant commercial species in New Zealand (90% of total). New Zealand has an estimated 1.73 million hectares of radiata pine with the Hawke's Bay contributing 134,000 hectares. There are three main regimes options: clearwood (pruned, thinned), framing (unpruned, thinned) and, more recently, permanent carbon. The optimal rotation length is relatively short at 25 to 30 years, which is a major economic advantage compared to most other species.

Radiata pine is suited to a wide range of sites and climates, particularly in Hawke's Bay. Altitude, waterlogged soils and snow can be limiting site characteristics. Slope is becoming an increasingly limiting factor for commercial plantings, primarily for health and safety and environmental reasons. Slope also affects the complexity and cost of harvest operations, and the susceptibility to erosion, especially immediately post-harvesting.

Radiata pine dominates plantation forestry in New Zealand primarily due to superior economics and proven reliability. Other benefits of radiata pine include; fast growth, high early carbon sequestration rates, well developed supply chain, established markets, low wilding spread risk and thus far, relatively tolerant to pests and diseases.

Significant risks and downsides with radiata pine include; low public perception, monocultural catastrophic risk, commodity product in the market and they are relatively short lived which creates uncertainty for permanent carbon regimes.

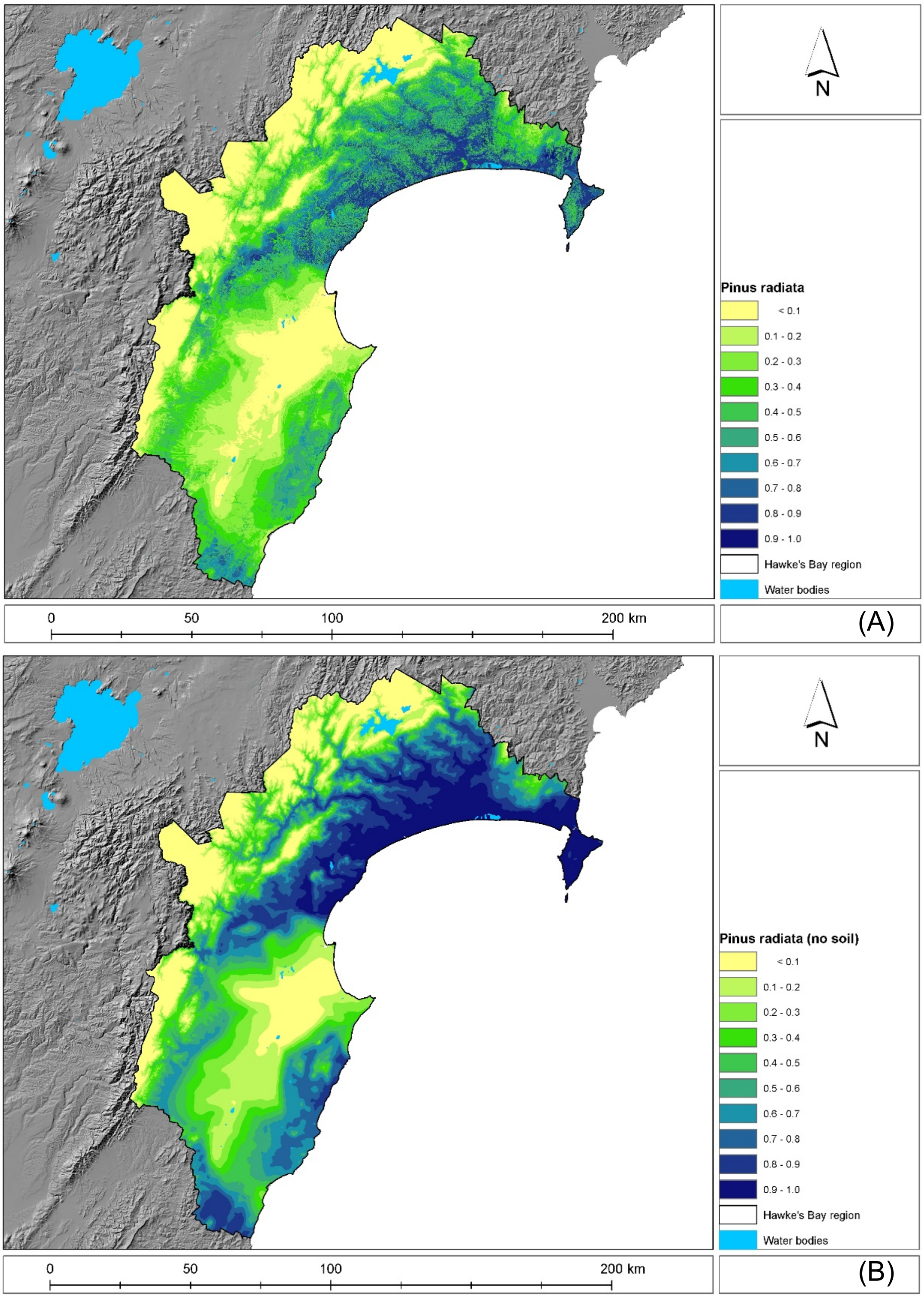

Figure 4: Tree species site suitability degree of membership (A) with, and (B) without Profile Available Water for radiata pine.

Douglas-fir (*Pseudotsuga menziesii*)

Douglas-fir is the second-most widely planted exotic species in New Zealand at an estimated 104 thousand hectares (6% of production forest area), 80% of which is in the south of the South Island.

There are two main regime options; framing (unpruned, thinned) and permanent carbon. The optimal rotation length is longer than radiata pine (35 to 50 years) due mainly to slow growth in the first 10 to 15 years. After this, the annual volume growth is like that of radiata pine and it is a much longer-lived species.

Douglas-fir is suited to cooler sites and has historically been used on higher altitude sites, although it is highly susceptible to out of season frosts. Douglas-fir is a cool temperate species, and in warmer and wetter areas suffers Swiss needle cast disease but it will also struggle in very dry areas. Planting of Douglas-fir has been on the decline in recent years primarily due to the high risk of wilding spread. Work is progressing to produce a sterile variety, but until this is successful, Douglas-fir is not considered an optimal choice for Hawke's Bay.

Markets for Douglas-fir are well established and sawlogs with small knots command good prices. As it is a long-lived species, it could be an option for a permanent carbon regime, particularly at higher altitudes. Overall, the economics of Douglas-fir are hampered by the longer rotation length required and by the slow carbon sequestration rates in the early years.

Dryland *Eucalyptus* species

The current scale of plantation eucalypts in Hawke's Bay is not large but is growing. Importantly, there is a widespread trial network in place and a genetic improvement program. Unlike most plantation species in New Zealand, *Eucalyptus* are hardwoods and they are relatively fast growing. The wood quality allows a diversity of potential regimes and end uses including peeling, durable timber products, production thinning, continuous cover and permanent carbon.

There are a number of promising species in the *Eucalyptus* genus, each of which has unique siting characteristics. This enables *Eucalyptus* to potentially be suited to the wide range of microclimates found in Hawke's Bay, but it will be essential to match species to specific site characteristics. Some species are relatively tolerant to dry conditions and may also be better suited to cope with the potential future effects of climate change.

Eucalypts have several economic advantages over other species including fast growth, short rotation length potential, timber that is less of a commodity product and high levels of carbon sequestration.

Eucalypts are subject to incursions of exotic insect pests and fungal pathogens, which has impacted severely on crop health in some situations. This remains an area of risk that requires ongoing focus with trials, correct species selection and genetic improvement. Other risks or downsides include fire risk, effects on hydrology on dry sites and underdeveloped markets due to current scale.

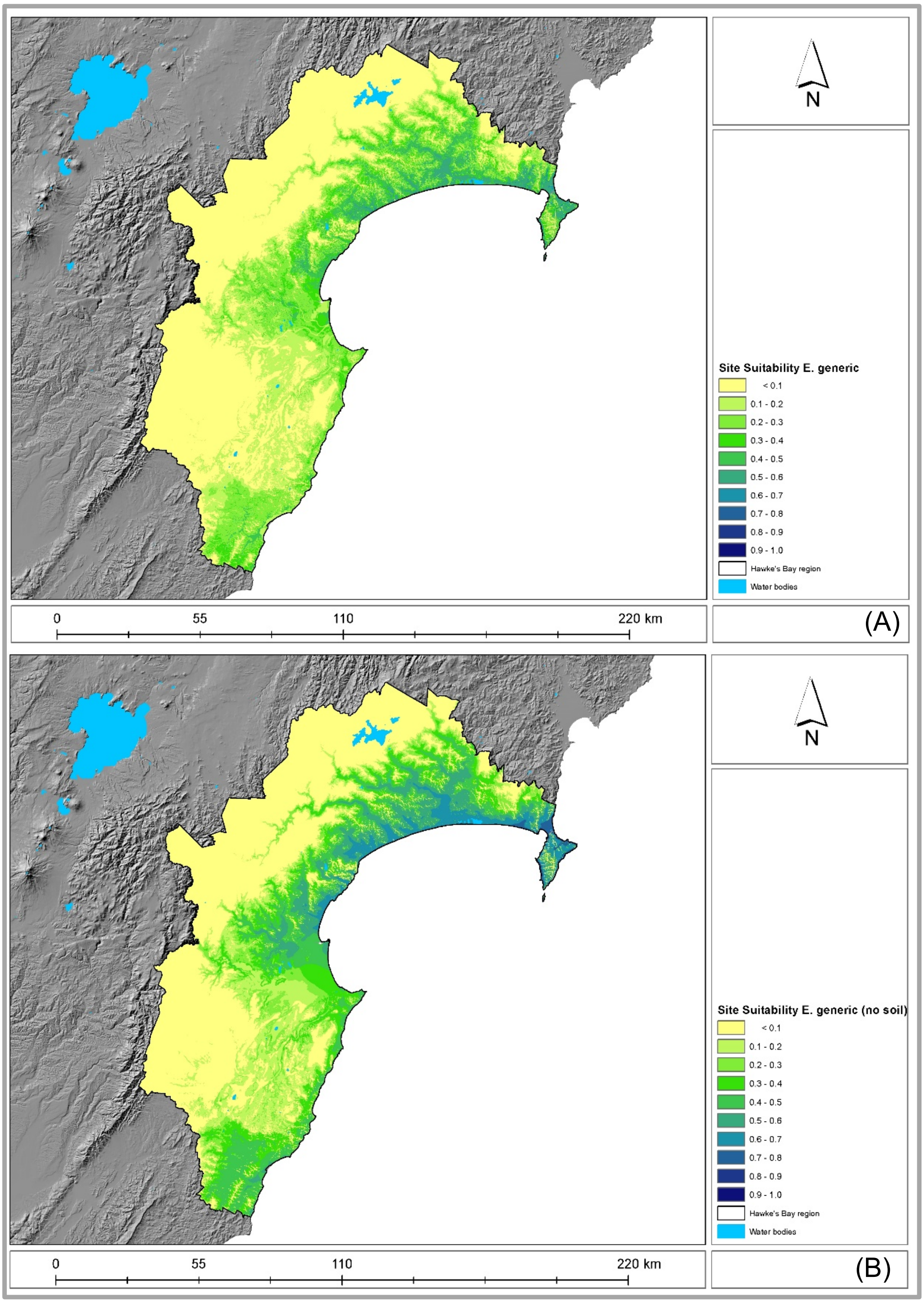

Figure 5: Tree species site suitability degree of membership (A) with, and (B) without Profile Available Water for *Eucalyptus* generic scenario.

Eucalyptus cladocalyx growing in Australia.

Cypresses

There is approximately 10,000 ha of plantation cypress in New Zealand, but only 372 ha recorded in Hawke's Bay. Pruned and permanent carbon regimes are options and significant premiums have been paid for clearwood. Pruned regimes will require a longer rotation length to get sufficient clearwood (35 to 50 years).

Cupressus lusitanica or the *ovensii* hybrid species appear to be the most promising options for Hawke's Bay. Macrocarpa is common in the South Island but has some canker issues in warmer climates. Cypresses will do best on sheltered sites with moderate to high rainfall and free draining soils. It is susceptible to drought and will not do well above 400 m above sea level.

Cypresses would suit portable milling and small-scale lots with likely significant premiums for high quality pruned logs. Relatively long-lived for a longer-term carbon option with a late harvest potentially lucrative.

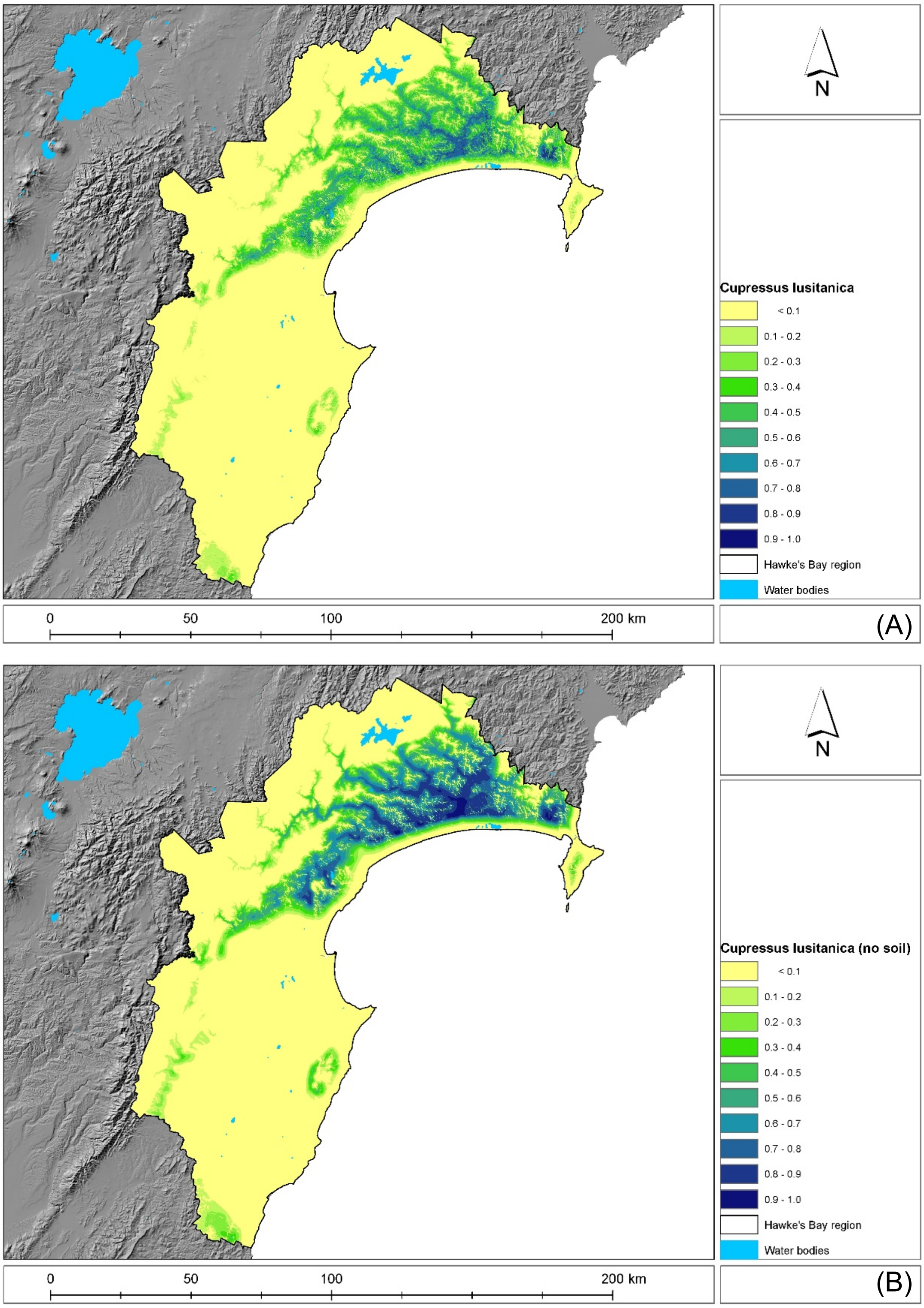

Figure 6: Tree species site suitability degree of membership (A) with, and (B) without Profile Available Water for *Cupressus lusitanica.*

Coast redwood (*Sequoia sempervirens*)

The area of redwood in New Zealand is estimated to be around 10,000 hectares (2018) and is steadily increasing. There are significant premiums for clearwood grades and heartwood. Low stocking (500 stems per hectare) can be established with elite clones. Non-clearwood regimes will require higher stocking required to control branch size. A typical rotation length would be 30 to 50 years for a timber crop. Permanent carbon is potentially a good option due to the very long-lived nature of the trees.

Redwoods require careful siting as they are generally intolerant of strong prevailing winds and require reasonably high, well distributed rainfall and good soil depth with reasonable moisture retention.

Redwood is unique among conifers in that it produces coppice growth from roots and stumps, so regenerates readily in cutover stands. If a tree is cut down or gets windblown it is likely to provide more consistent protection over many other exotic species. Coppicing combined with good early growth rates make coast redwoods potentially an important erosion control species.

Redwood timber is well regarded in the North American market and there is a potential premium for timber, especially if generated at scale. There is a lack of market for pulp and smaller grades that may lead to more residue on site post-harvest. Longer rotation lengths are favoured to generate larger diameter logs.

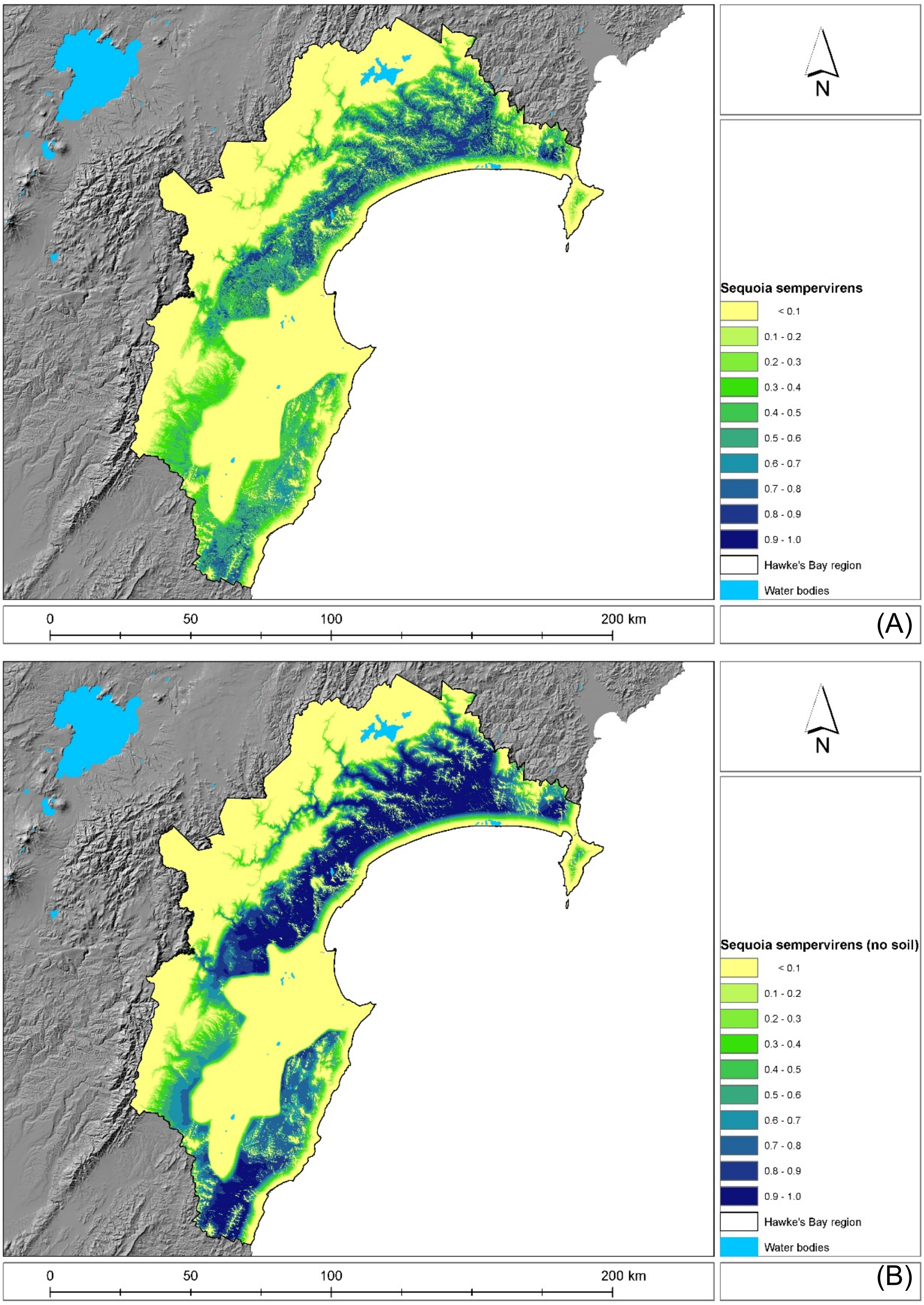

Figure 7: Tree species site suitability degree of membership (A) with, and (B) without Profile Available Water for coast redwood.

Coast redwood harvest

Indigenous species

Indigenous species offer a diverse range of afforestation options that can potentially range from a very low cost 'shut the gate' reversion to an intensively managed restoration costing up to $30,000 per hectare. The regime options include the planting of podocarps for timber or the use of an exotic species to provide a canopy and early carbon capture with the goal of later succession to native species.

Originally, Hawke's Bay was covered in native forest, so the site suitability is comprehensive, but the species mix, and forest type will vary from site to site. Commercial timber options will be limited to where soil and slope can sustain large tree species.

The economics of indigenous species will vary greatly with the best potential option being podocarps for timber and carbon. In all indigenous ventures, ecosystem service benefits are very high and will be an important consideration.

The benefits of indigenous species are very high community and cultural values and the potential ability to secure funding to support indigenous afforestation.

The risks of indigenous species are the high costs to promote survival and even then, results may be unreliable. Growth rates are not certain and rotation length has a significant effect on financial returns such as net present value.

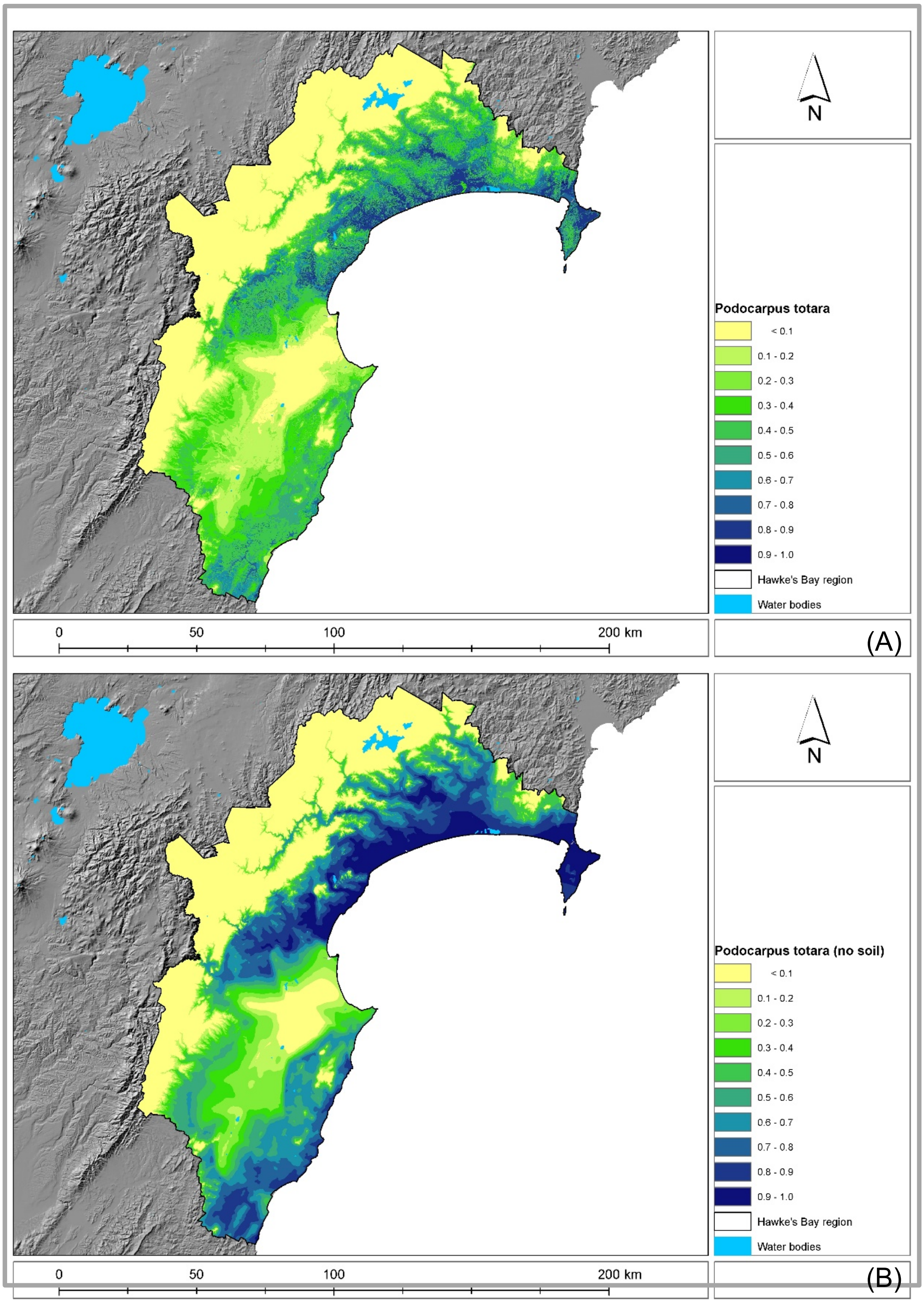

Figure 8: Tree species site suitability degree of membership (A) with, and (B) without Profile Available Water for tōtara.

Mānuka (*Leptospermum scoparium*)

Mānuka is widespread throughout New Zealand but only a relatively small coverage of plantation mānuka is being grown for honey, although this has been steadily increasing in recent years. The most common regime is planting mānuka for honey and carbon with either a reversion to native or a re-establishment of mānuka when the crop reaches floral maturity.

Mānuka has some unique site suitability requirements that affect honey production and Unique Manuka Factor (UMF) ratings. Returns are highly sensitive to volume and UMF rating of honey. In general, warm, sheltered sites with free draining soils are preferred. Honey production and UMF ratings are also significantly better on north facing slopes with low rainfall and wind during the summer months when the mānuka is flowering.

Economic models produced by industry groups such as Mānuka Farming New Zealand show good returns are possible. It is important to note that seasonal climatic conditions can mean that returns can vary significantly from year to year.

The value chain for mānuka honey is well developed and provides diversity to revenue. Mānuka trees are smaller and lighter than exotic plantation species and therefore have the potential to be used to control erosion on relatively shallow and unstable sites. Other benefits of mānuka include good public perception, potential for oil production, potential for reversion to native cover and industry is developing eco-sourced, genetically-improved stock.

Risks of plantation mānuka include sensitivity to weather conditions, annual variability of returns, UMF lifespan for a crop is not well understood, poaching from neighbouring hives. Myrtle rust is a future risk.

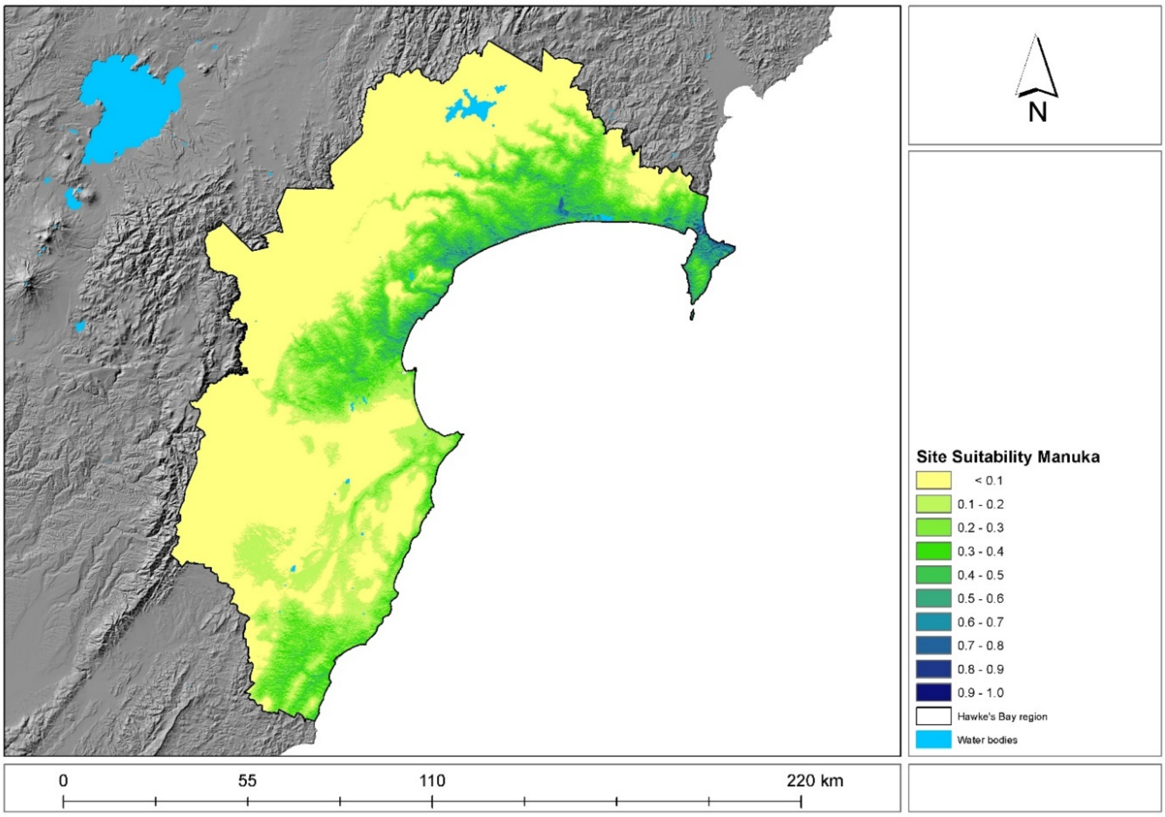

Figure 9: Tree species site suitability degree of membership for mānuka.

Mānuka seedlings (Scion)

Silvopastoral systems – Poplars/Willows

True silvopastoral systems are defined by the production of timber (silviculture) over productive pasture. Poplars and willows are used extensively on farms for erosion control, which is outside the discipline of silvopastoralism. Consequently, there may be an unexplored opportunity here. Harvest returns are problematic to predict for such a system. Success will be dependent on site, successful assignment of species, niche marketing of domestic and export sawlogs or on-farm/portable milling and custom treatment. There are small scale examples of successful enterprises emerging with marketing and trial use of poplar based on a 28 year rotation and portable milling and small batch CCA treatment for farm use, and specialty end uses such as truck decks, furniture and toys. The innovative grower or processor may capitalise on this, probably at low volumes.

As a base regime, subject to enormous variation, rooted cuttings can be established in pasture with single wire electric fencing maintained to exclude cattle but allow controlled grazing by sheep.

The financial returns (NPV, LEV and IRR) for a silvopastoral regime with poplar are not easily quantified due to potential multiple income streams from forestry, carbon and grazing.

Other benefits of poplars include; can be ETS eligible and allow grazing at 300 stems per hectare, and branches can be used as supplement feed during dry seasons.

Future research engagement in this discipline may offer significant benefit in the Hawkes Bay landscape and offers a potentially opportunity on appropriate sites.

Species comparisons

It is not possible to claim that one forest system is better than another. Each site is unique and landowner requirements will vary. The most important consideration is to optimally match each site and landowner to a forest system or systems. Table 3 ranks attributes of various species options for comparative illustrative purposes. Attributes are scored from 0 to 10 with a higher rating representing a generally positive attribute for that species.

Table 3: Species ratings for desirable project attributes (0 to 10)

Species	Market risk	Site suitability	Erosion control	Financial risk
Indig commercial	8	8	6	6
Indig cover	n/a	10	10	n/a
Dryland Eucs	7	5	6	7
Redwood	7	8	8	7
Cypress	7	6	7	6
Douglas-fir	8	3	7	8
Mānuka for Honey	9	7	9	7
Mānuka cover	n/a	10	9	n/a
Radiata	9	8	6	9
Silvopastoral	7	8	8	6

Overall site suitability

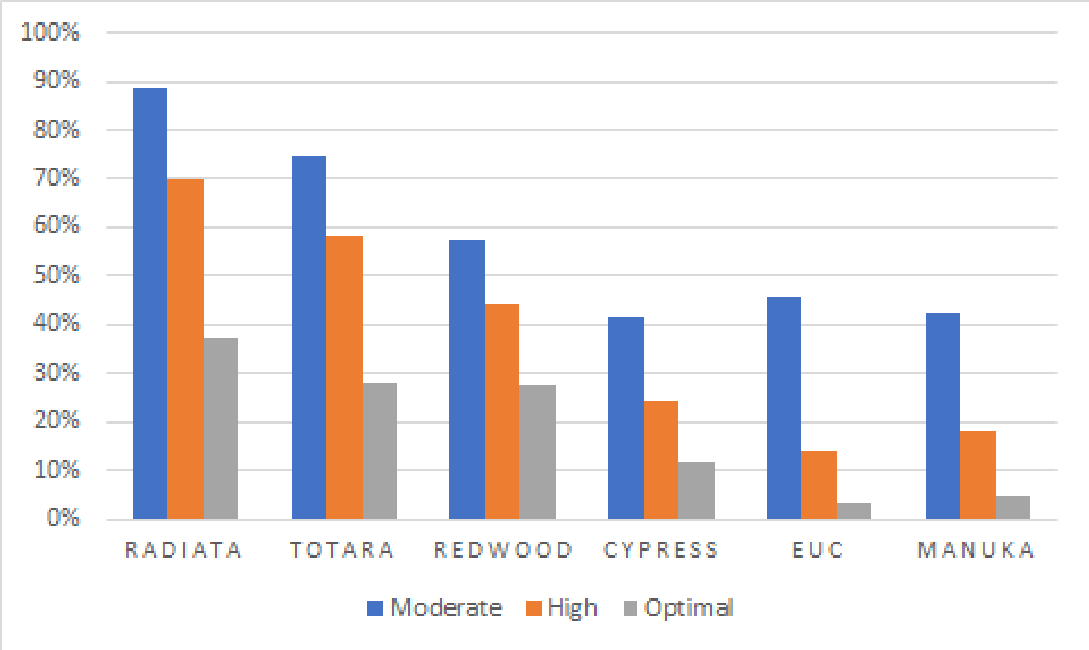

Figure 10: The proportion of the 1000 t km^{-2} yr^{-1} highly erodible land is suitable for each species (as a percentage). Moderate = 0.2, high = 0.35 and 0.5 = optimal.

Conclusions and recommendations

Three factors influence whether a species should go on a particular site:

1. The physical site
2. Landowners preference
3. To a lesser extent, what the council strategy would prefer (i.e. a balance of native, alternative species and radiata)

The HBRC/HBRIC has the opportunity to promote a focused approach to invest in a select group of alternative species (i.e. picking winners) best suited to Hawke's Bay. HBRC/HBRIC could support and partner with existing forest industry efforts to diversify plantation forestry in New Zealand.

Financial considerations

The financial implications of large-scale afforestation need to be understood for and by the different stakeholders, including:

- Individual landowners – the financial case for afforestation needs to be compelling and, in most cases, allow for the existing lifestyle to continue.
- HBRC and HBRIC – investments need to be targeted for specific outcomes and where possible, support a recirculation of funds.
- Regional community – RTRP afforestation should have a positive impact on wider communities and generate secondary employment and services.

A financial model has been developed to generate cashflows and financial outputs of potential species and regimes for afforestation in Hawke's Bay. This model is used here to:

- Demonstrate how potential returns can vary between various forest systems.
- Compare species to assist with decisions on which species to support.
- Compare forest systems to understand how targeted incentives or regulations may be required to achieve a desirable species mix (i.e. ensure native or alternative species are as equally attractive as radiata pine to a landowner).
- Understand how site variables impact returns and influence planning decisions.
- Provide data in relevant form for agricultural comparisons.
- To demonstrate a future potential tool to assist with right tree, right place implementation.

Potential financial returns (using a 6% discount rate) are presented as:

- Net present value (NPV) is calculated to represent the current value of a single rotation.
- Land expectation value (LEV) is calculated to represent the current value of multiple rotations in perpetuity.
- Equivalent annual annuity is calculated to represent an average annual return from afforestation to allow direct comparison to agriculture, which is generally represented by annualised earnings.

Regional scale economic analysis

At the regional level, the intended scale of the project objective dictates that total costs and revenues from implementation are major. Afforestation of 100,000 hectares would generate billions of dollars of future revenue from timber and carbon. As the costs and returns associated with each forest system vary significantly, this can have huge financial implications at this scale.

The significant potential differences between various forest systems at scale are illustrated in the following tables. It is also important to note the significant impact of the One Billion Trees Programme[1] (1BT) funding on non-radiata options. The 1BT funding timeframe is finite and it is uncertain what central government funding will be available in the future.

Table 4 is high-level estimate comparing the NPV for planting 100,000 hectares of commercial radiata pine, mānuka for honey and indigenous trees for timber in Hawkes Bay. The revenue includes the sale of carbon credits received through the Emissions Trading Scheme (ETS). Also presented is a mixed scenario assuming 50,000 ha of native species, 20,000 ha of radiata, 10,000 ha each of *Eucalyptus*, coast redwood and mānuka for honey.

[1] https://www.mpi.govt.nz/funding-and-programmes/forestry/planting-one-billion-trees/

Table 4: Projected NPVs (6% discount rate) for afforestation of 100,000 hectares for various species.

	Radiata pine ($ mil)	Mānuka ($ mil)	Native timber ($ mil)	Mix ($ mil)
Total Net Present Value	512	365	129	358
Total Net Present Value (no 1BT)	512	185	-271	110

Often a barrier to forestry investment is the cost of establishment. Table 5 illustrates how the initial costs may vary between forestry systems, with and without 1BT funding.

The impact of 1BT is hugely significant for non-radiata pine options. The impact of 1BT on radiata pine is minimal because the forest owner forgoes the first six years of carbon when opting for the grant. The value of the grant and six years of carbon is similar.

Table 5: Project establishment costs (total expenditure in first five years) for planting 100,000 hectares for various species.

	Radiata pine ($ mil)	Mānuka ($ mil)	Native timber ($ mil)	Mix ($ mil)
Establishment Cost (1BT)	223	120	68	128
Establishment Cost (no 1BT)	223	300	468	375

Economic impact of site variables

Within a specific species and regime, potential returns from afforestation will vary significantly from site to site depending on location. Variables such as distance to ports or sawmills and steepness of the terrain to be harvested influence costs and returns. The impact of these factors can be estimated through modelling.

For a first rotation forest, the ability to generate early cashflow from carbon is a crucial attribute. If carbon revenue is excluded, as it will be in following rotations, returns could be negative in some situations (6% discount rate (Table 6).

Table 6: Impact of distance to port and terrain on NPV per hectare for radiata pine with and without carbon.

Market distance (km)	Hauler terrain (%)		
	0%	50%	100%
Radiata pine **with carbon**			
25	8,900	8,200	6,900
50	8,000	7,400	6,000
75	7,200	6,500	5,200
100	6,300	5,700	4,300
Radiata pine **timber only**			
25	3,500	2,900	1,500
50	2,700	2,000	700
75	1,800	1,200	-200
100	1,000	300	-1,000

Further site-specific factors that can have a major effect on returns are forest scale and the accessibility of the tree crop. Table 7 shows that returns from small forests are highly sensitive to the amount of roading required to access the timber at harvest, whereas, a larger forest can absorb this fixed cost.

Table 7: NPV per hectare of a radiata framing stand at various scales with varying roading access requirements.

Scale (ha)	Roading Access Required (km)		
	0.1	1	2
1	5,100	-12,600	-32,200
10	7,000	5,100	3,100
100	7,100	7,000	6,800
1,000	7,200	7,200	7,100

Variation of potential returns between species and regimes

Radiata pine is a fast growing and proven species. Over 90 percent of all planted forest in New Zealand is radiata pine and the economics and risk associated with it are well-understood. One of the preferred outcomes of the Right Tree, Right Place project is to explore the implications of establishing a more diverse forestry landscape and economic base.

A range of investment models may be needed to balance the returns for some afforestation systems and achieve a balanced afforestation portfolio. Table 8 shows the financial outputs modelled of some key species and regimes discussed here. The output is expressed per hectare and applies to a typical “Hawke’s Bay” site. Actual financial metrics will vary significantly between specific sites, and forestry regimes will vary in sensitivity to different variables. For example, returns for a permanent carbon regime for any species will not be sensitive to distance from processing facilities and markets whereas this could have a significant impact on a commercial harvest regime.

Table 8: Financial assessment of the various species and regimes modelled for one hectare. (See Table 2 for regime codes).

Regime option	Low LEV (ha^{-1})	Med LEV (ha^{-1})	High LEV (ha^{-1})	Low Annuity ($ ha^{-1} yr^{-1})	Med Annuity ($ ha^{-1} yr^{-1})	High Annuity ($ ha^{-1} yr^{-1})
UPTH	591	6,317	10,300	35	379	618
PRNH	4,983	5,738	5,738	299	344	344
PRTH	-1,731	5,001	8,648	-104	300	519
EUCN	4,071	4,832	4,832	244	290	290
EUCS	404	4,372	8,835	24	262	530
MANU	1,763	4,052	4,052	106	243	243
REDW	-808	3,708	6,341	-48	222	380
DFNH	1,689	2,540	2,540	101	152	152
NATV	-797	2,488	3,018	-48	149	181
REVR	2,007	2,450	2,450	120	147	147
CYPR	-2,357	2,313	5,357	-141	139	321
NATN	-6,216	1,756	1,756	-373	105	105
REDN	442	1,446	1,446	27	87	87
CYPN	230	1,043	1,043	14	63	63
DFTH	-642	998	2,138	-39	60	128

Targeting grants

The potential variance in NPV between forestry systems could present a barrier to landowners that discourages them from choosing alternative exotics or native species. Targeted grants could be a mechanism for achieving a desired mix of forest species. If a grant matched the variance, a landowner could be encouraged to choose an alternative species over the highest returning option. Table 9 below shows an estimate of NPV for a range of forest systems for a particular site. It is important to note that the NPV and relative differences between the systems will vary significantly from site to site. This is also shown graphically in Figure 11.

Table 9: The variance per hectare for alternative forest system could approximate the incentive required to ensure the choice of system by the landowner is financially neutral. (See Table 2 for regime codes).

Afforestation system	NPV per ha with 1BT	NPV per ha no 1BT	Incentive ($\$ha^{-1}$) required (1BT)	Incentive ($\$ha^{-1}$) required (no 1BT)
PRNH	5,700	5,700		
UPTH	5,000	5,000	700	700
EUCN	4,900	3,400	800	2,300
PRTH	3,800	3,800	1,900	1,900
MANU	3,800	2,000	1,900	3,700
EUCS	3,300	1,800	2,400	3,900
REDW	2,900	1,400	2,800	4,300
DFNH	2,600	1,100	3,100	4,600
REVR	2,400	-1,600	3,300	7,300
NATV	2,100	-1,900	3,600	7,600
NATN	1,900	-2,100	3,800	7,800
CYPR	1,500	0	4,200	5,700
REDN	1,500	0	4,200	5,700
CYPN	1,100	-400	4,600	6,100
DFTH	700	-800	5,000	6,500

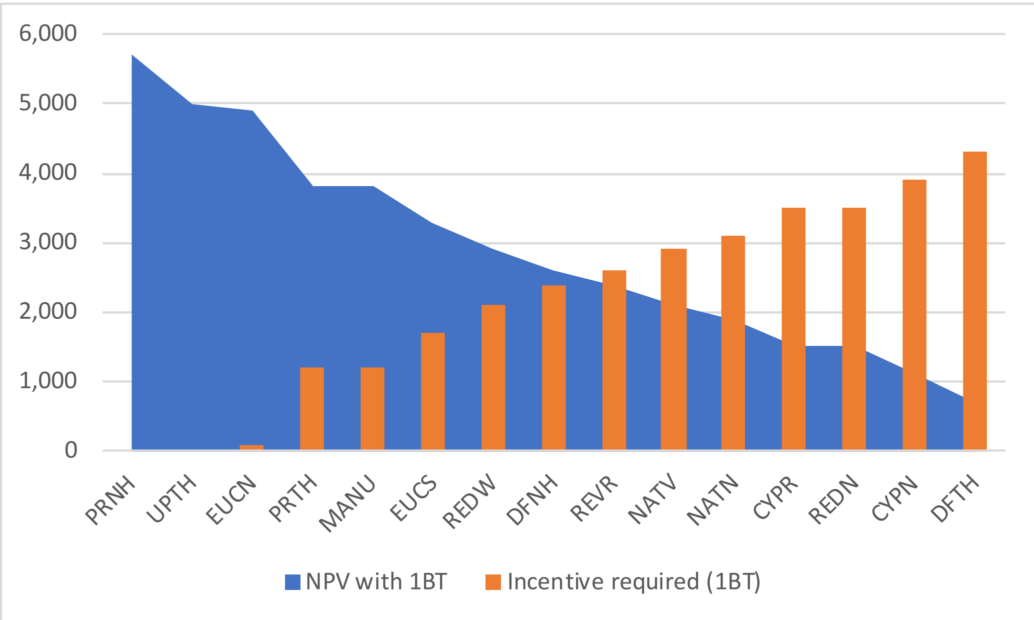

Figure 11: The variance per hectare for alternative forest systems could approximate the incentive required to ensure the choice of system by the landowner is financially neutral. (See Table 2 for regime codes).

This variance in forest systems is relevant for setting expectations regarding forestry systems mix. Table 10 illustrates how varying the species mix could be affected if targeted grants are relied on to influence species selection. An assumption here is that if the returns from radiata pine are attractive enough for underperforming agricultural land, it would be the species of choice without requiring additional grants.

Table 10: Effect on targeted grants on species selection.

Species	Preferred scenario		Compromise scenario	
	Area (ha)	Grant total ($/mil)	Area (ha)	Grant total ($/mil)
Radiata	20,000	0	50,000	0
Mānuka	10,000	30	10,000	30
Eucalypts	10,000	32	10,000	32
Redwoods	10,000	36	10,000	36
Reversion	0	0	10,000	0
Native timber	50,000	345	10,000	69
Total	**100,000**	**443**	**100,000**	**167**

Conclusions and recommendations

The financial figures quoted in this report are for illustrative purposes and have been calculated using a multitude of assumptions, including:

- A flat carbon price of $25 per unit; costs and revenues are based on individual participants with less than 100 hectares registered in the ETS.
- Land value or cost is not included.
- Future log prices are generally based on three year actual pricing to July 2019.
- Where Forecaster is used to estimate future yields, a 10% reduction to recoverable volume was applied.
- Actual returns will vary significantly from site to site.

Afforestation and ecosystem services

Planted forests provide benefits beyond timber fuel and fibre. These include carbon sequestration, erosion control, flood mitigation, improved water quality, biodiversity and recreational resources. Together, the benefits people gain from the environment are known as ecosystem services. Many of the ecosystem services provided by forests do not have a market value. As a result, the benefits of ecosystem services such as avoided erosion or avoided nutrient leaching are less understood or appreciated compared to timber values.

Valuing ecosystem services using Forest Investment Finder

The broader value of potential forests in the Hawke’s Bay have been quantified using the spatial economic tool Forest Investment Framework (FIF) which combines Geographic Information System (GIS) technology and economic valuation techniques.

FIF calculates the costs of forest establishment, management, harvest, road and landing development, and transportation to processors or ports relative to their returns from timber. It can also be used to quantify and describe non-market benefits such as nutrient mitigation, avoided erosion and biodiversity enhancement.

Timber value

The timber viability component of FIF has been used to model radiata pine timber production costs and revenues from afforestation in the target sites. The variables used include timber price, costs associated with establishment, silviculture, Emissions Trading Scheme (ETS) compliance, harvesting and transport, carbon revenues and forest productivity.

Figure 13 shows that radiata pine gown on highly erodible sites could return between $330 and $640 per hectare per annum (annualised NPV). Afforestation would likely be most profitable on steep terrain with high erosion rates in afforestation groups 3 and 9.

Avoided erosion

The annualised value of avoided erosion in new forest areas in Hawke’s Bay, assuming a 28-year forestry rotation, is shown in Figure 14. The value was calculated as the potential volume of sediment movement that can be avoided by afforesting the target sites. The calculation includes a component that accounts for higher levels of erosion after planting and before canopy closure, and the harvesting and post-harvest period until canopy closure.

Potential forests in the northeast, west and southeast of the region would provide high avoided erosion values. Afforesting steep terrain with high erosion rates in afforestation groups 7, 8 and 9 currently in livestock would provide the highest average avoided erosion values (greater than $200 per hectare per year).

Avoided nutrient leaching/loss

Figure 15 shows the annualised value of avoided nitrogen in new forest areas in Hawke’s Bay assuming a 28-year forestry rotation. FIF results suggest that the average value of avoided nitrogen from afforestation would be highest in dairy areas in afforestation groups 5 and 8 (greater than $240 per hectare per year).

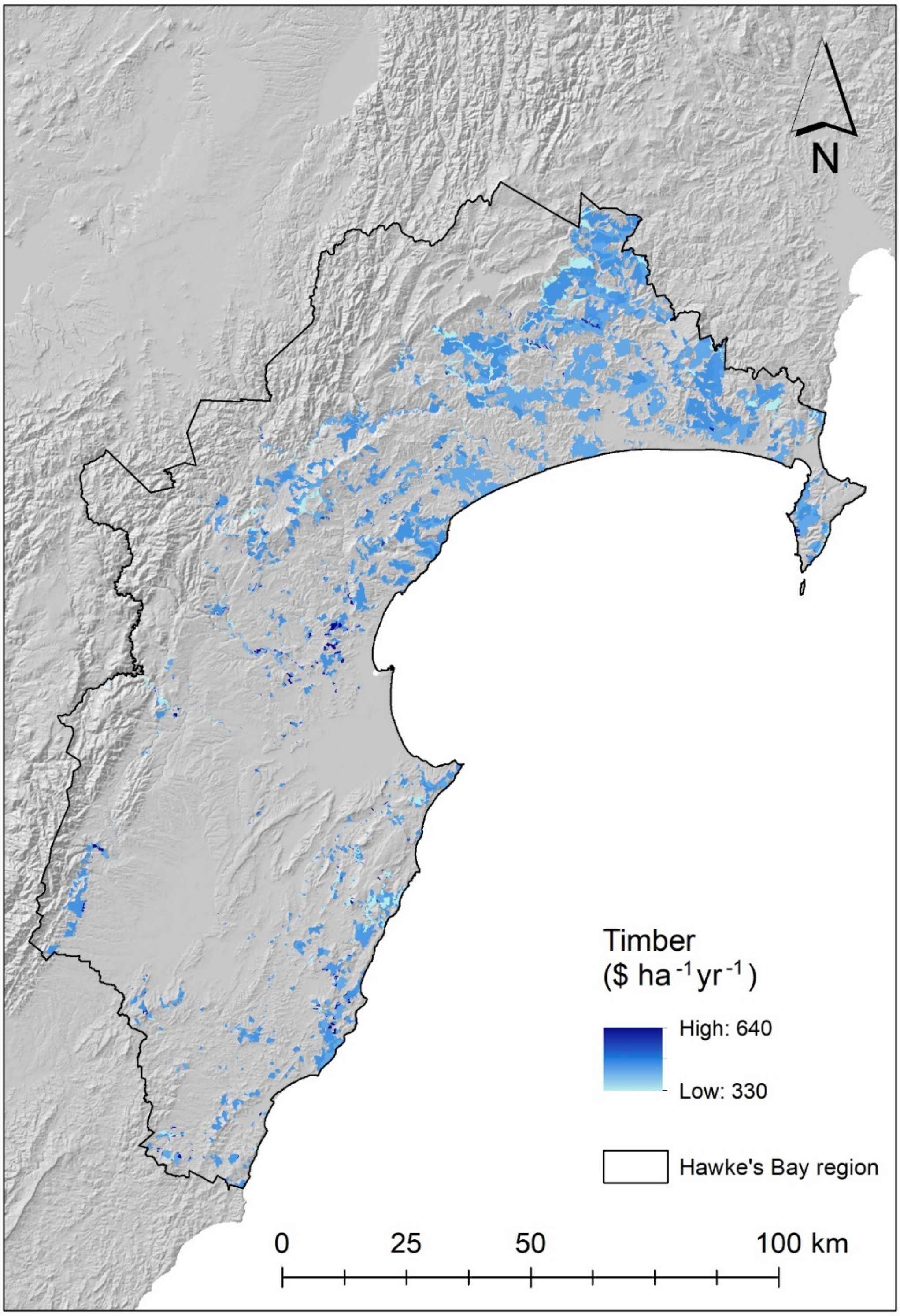

Figure 13: Annualised radiata pine timber profitability surface for potential afforestation areas.

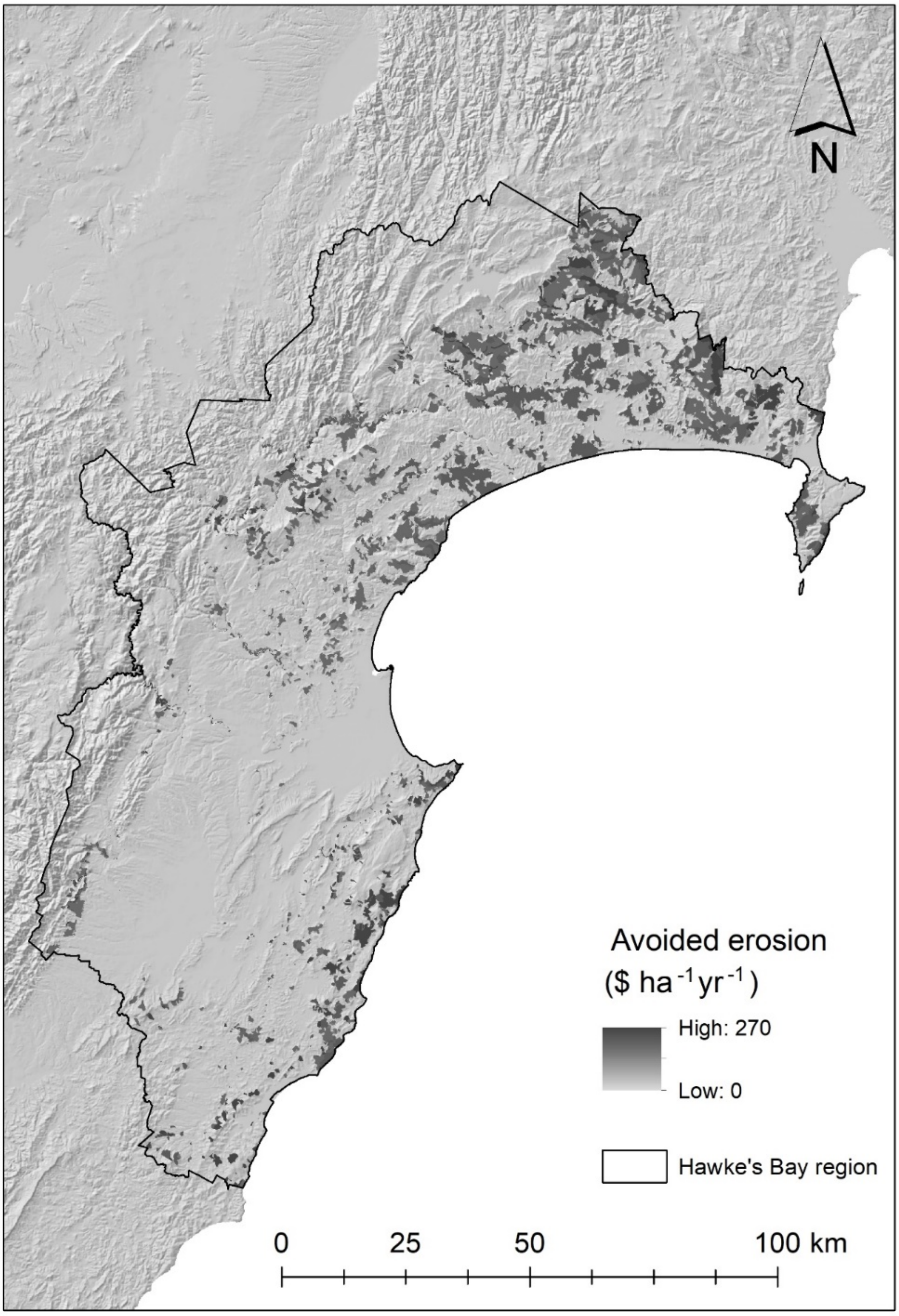

Figure 14: The annualised value of avoided erosion in new forest areas in Hawke's Bay assuming a 28-year forestry rotation.

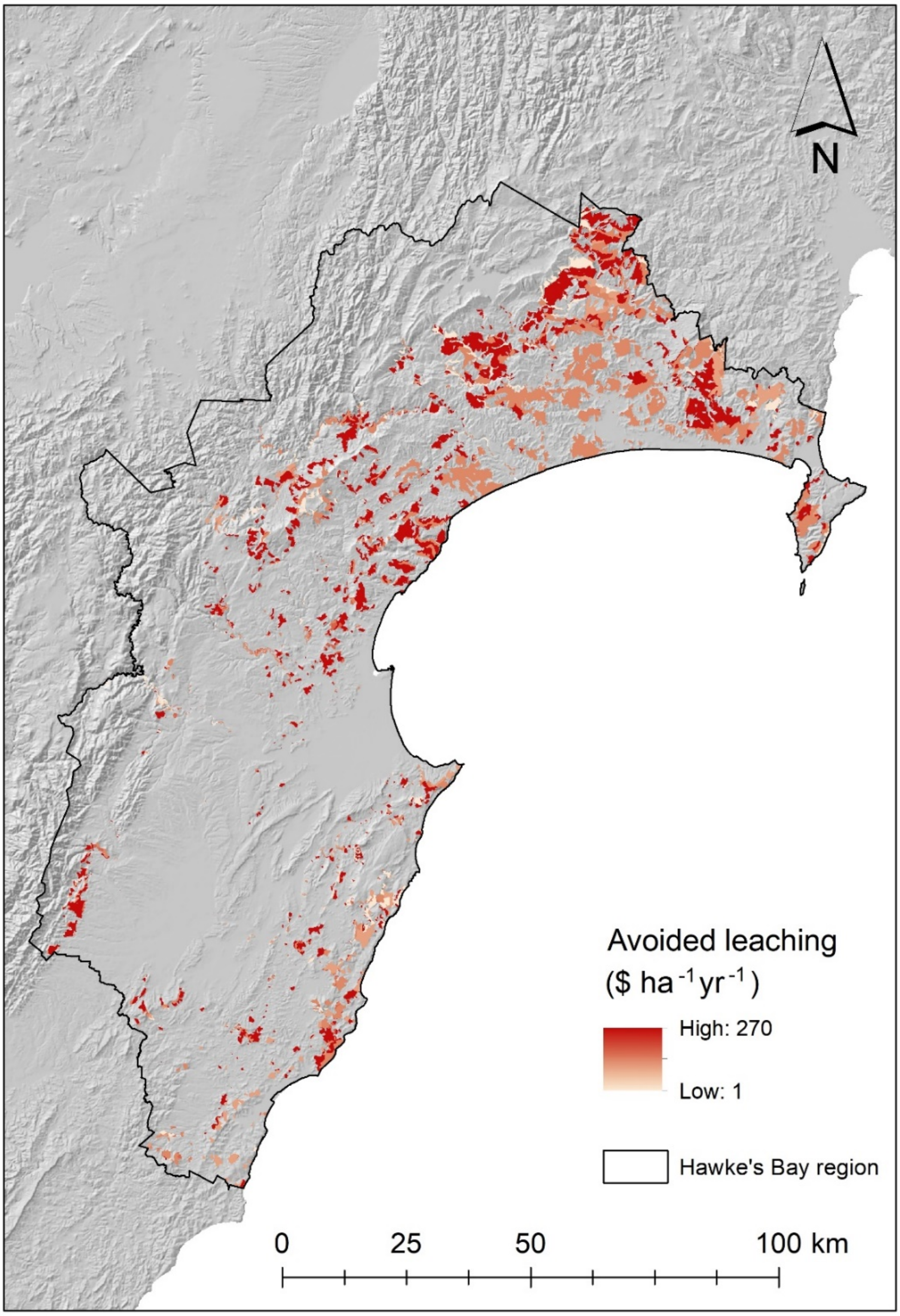

Figure 15: The annualised value of avoided nitrogen in new forest areas in Hawke’s Bay assuming a 28-year forestry rotation.

In many cases, the annual value of the non-timber ecosystem services values can be greater than timber. A significant proportion of the region provides ecosystem services: timber ratios between 1.50 to 2.00 (Figure 16). These numbers suggest that for every dollar in annual profit provided by the new forests, the value of non-market ecosystem services is at least one and half times that.

The value of non-market ecosystem services is greatest in steep, erodible land in livestock for afforestation groupings 7, 8 and 9 (Figure 17). These are the areas that could be prioritised if the provision of non-timber ecosystem services is an objective in the potential afforestation programme in Hawke's Bay.

Biodiversity

Increased afforestation will extend the habitat available for native flora and fauna. Planted forests are home to a surprising number of different species, including more than 118 threatened species.[2] These include kiwi, karearea (bush falcon), native orchids, kākābeak, frogs, lizards and insects.

A significant population of brown kiwi are already found in the region. Afforestation (with predator control) would potentially allow them to extend their range. Karearea also thrive in planted forests, with Kaingaroa Forest supporting the largest population in New Zealand. As New Zealanders we value our native plants and animals and would be prepared to financially support conservation initiatives on both private and public land, even in exotic planted forests.

North Island brown kiwi (Maungatautari Ecological Island Trust)

[2] Pawson, S. M., Ecroyd, C. E., Seaton, R., Shaw, W. B., & Brockerhoff, E. G. (2010). New Zealand's exotic plantation forests as habitats for threatened indigenous species. *New Zealand Journal of Ecology*, *34*(3), 342.

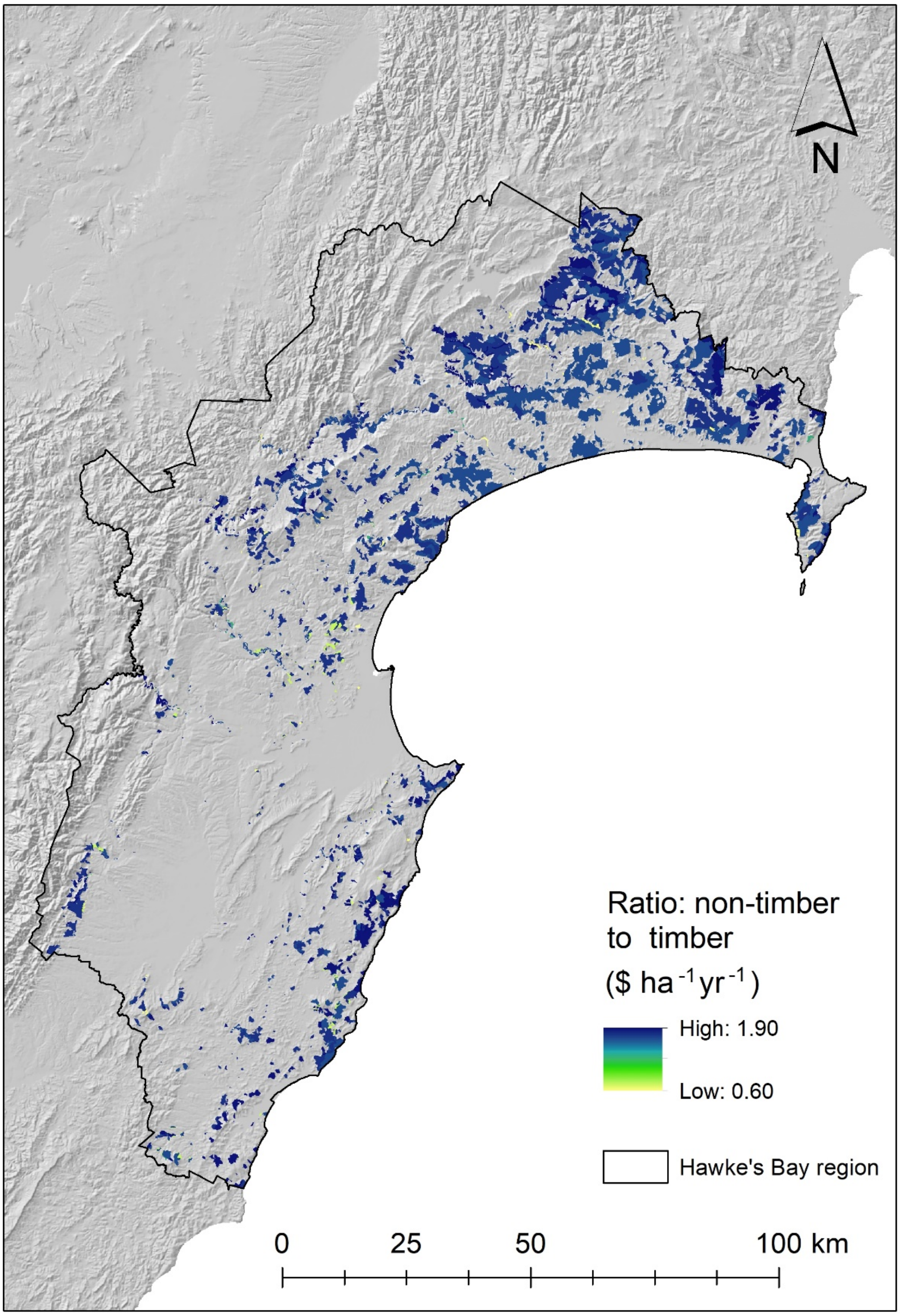

Figure 16: The ratio between non-market ecosystem services and timber.

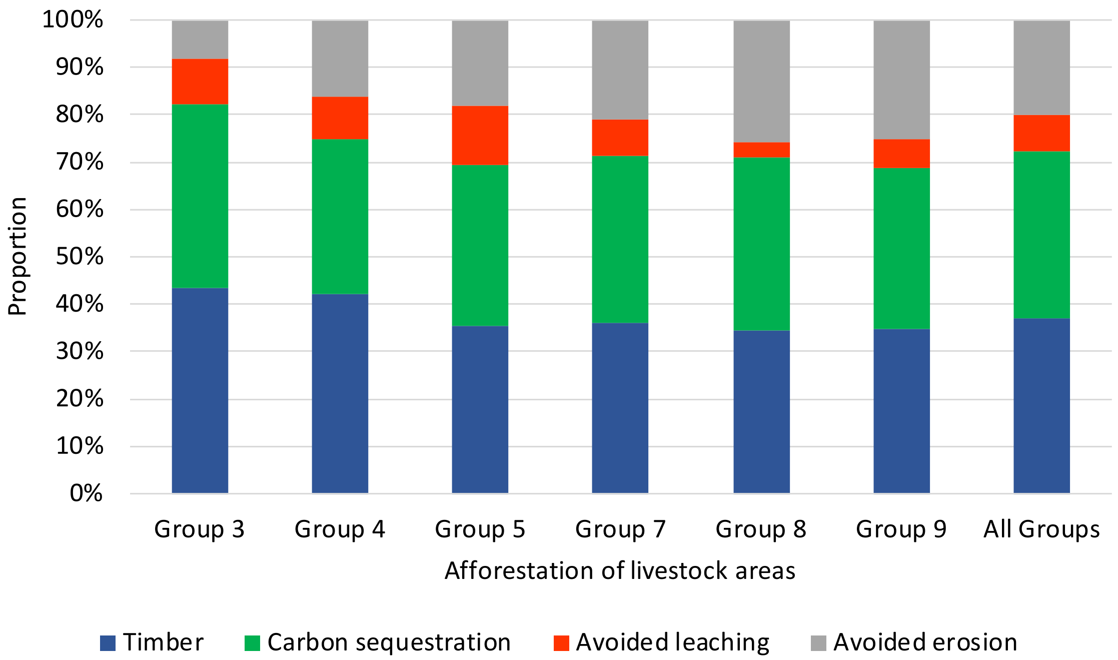

Figure 17: Stacking up the four ecosystem services provided potential afforestation areas.

Riparian areas in headwater catchments

Riparian areas are valued for their high biodiversity and the wide range of functions, processes and ecosystem services that they provide. The importance of these areas often exceeds the proportion of area that they occupy because of their unique location within the landscape as transitional areas between aquatic and upslope terrestrial ecosystems.

Many of the areas identified as having both high timber and ES values (Figures 13 to 15) are in steep erodible headwater catchments. These areas have the highest density of stream and riparian areas and comprise a large percentage of total stream length in many catchments.

Riparian areas in steep headwater streams differ from those further downstream on more moderate topography. These riparian areas tend to be narrower and are inextricably linked to their terrestrial and aquatic environments. Hence disturbances such as landslides, debris flows, droughts and floods along with forest management activities will have a strong influence on their function and condition.

Provision of ecosystem benefits by riparian areas in not currently included in FIF. However, the key functions, processes and services of riparian areas in headwater catchments that could contribute to sediment and nutrient reduction, improved water quality, carbon sequestration and biodiversity have been reviewed. These are outlined in Figure 18.

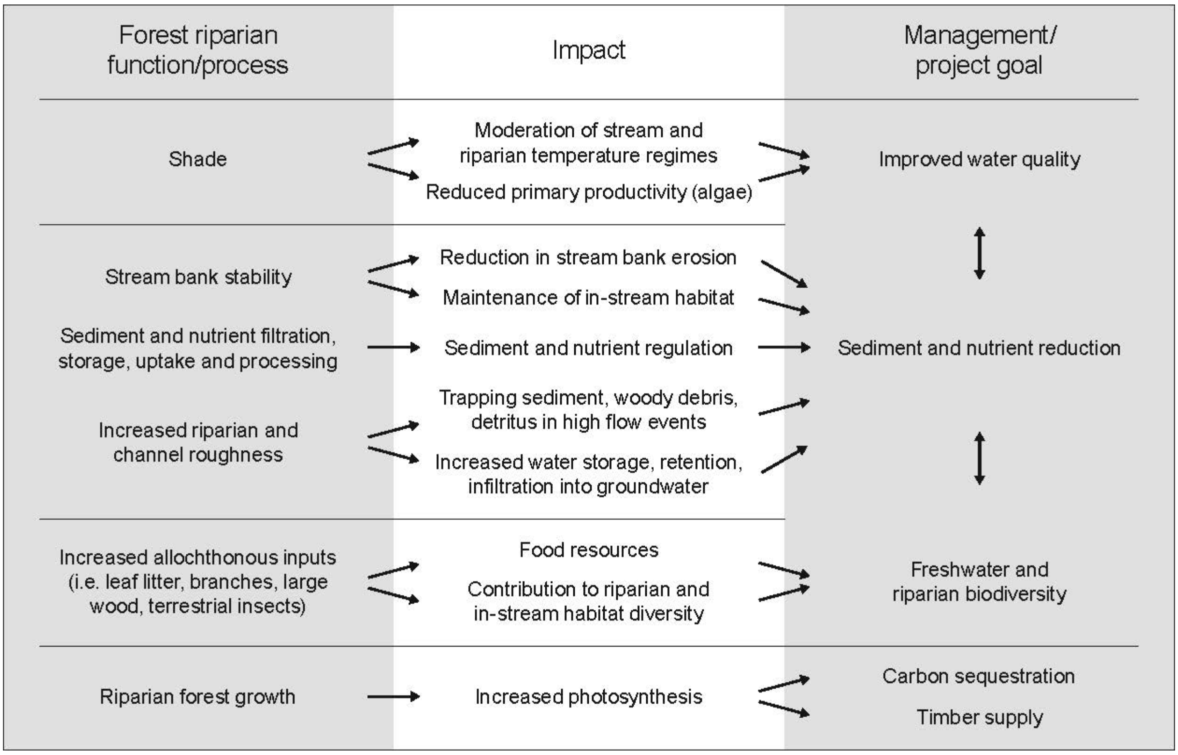

Figure 18: Select key functions and processes in forested riparian areas.

Riparian area benefits

Shade and stream temperature

The benefit of stream shade provided by forest riparian areas is maximised in smaller headwater streams and, if converting from a current pasture land use, will re-instate shade regimes typical of those in native forests.

Streambank stability

The root reinforcement provided by forested stream margins contributes to the maintenance of bank stability, reducing bank erosion and sedimentation, and increasing aquatic biodiversity from the habitat provided, particularly from undercut banks and tree roots.

Filtration of diffuse/fine sediment, nutrients and other contaminants

Riparian areas are uniquely situated in the landscape to intercept sediments, nutrients and microbial contamination from upland areas before they enter the stream system. However riparian areas in headwater catchments tend to be narrow and high shade from afforestation may restrict undergrowth, limiting their filtration capacity. Greater gains in fine sediment, nutrient and microbial reductions will most likely result from afforestation of upslope areas, reduction in fertiliser use and stock removal with riparian areas complementing this process.

Afforestation of agricultural land can improve water quality, mainly through the reduction of agricultural contaminants and is particularly effective in smaller-sized catchments.

Channel roughness

The root systems and stems of riparian vegetation increase channel roughness slowing the speed of flood waters during overbank flow, decreasing the erosive capacity of small to moderate flood events and aiding the retention of sediment, debris and flood waters. The ability of forested riparian areas in steepland areas to prevent landslides and debris flows entering waterways is limited. However, where they are in depositional zones, they can be effective at trapping some of the woody debris transported off-slope and downstream during floods and debris flows.

Organic matter inputs

Forested riparian areas provide a diverse food resource for both aquatic and terrestrial ecosystems and contain higher quantities of plant biomass than non-forested areas. They provide the main source of food (i.e. litter, terrestrial insects) in small shaded headwater streams. Large pieces of wood provided by riparian margins are a major feature in forested headwater streams, contributing flow modification, habitat provision and the retentive capacity of streams.

Riparian terrestrial biodiversity

Riparian areas are a source of high biodiversity and species richness. In addition, their location and extent within a headwater catchment provide movement, dispersal and colonisation pathways for both terrestrial and aquatic plants and animals. Their location in headwaters provides re-colonisation sources to downstream impacted habitats and potential aid to any downstream restoration/enhancement activities

Freshwater biodiversity

Headwater streams and riparian areas have a strong influence on aquatic invertebrate biodiversity. Following the afforestation of hill-country streams, the invertebrate communities shift from those associated with open pasture streams to communities similar to those in indigenous forest streams. Headwater forested streams in planted forests close to the coast and with no downstream barriers can support high native fish biodiversity and in-stream wood plays an important role in habitat provision for some species such as longfin eel, banded kōkopu and whio (blue duck) (Figure 19).

Location in the landscape

Headwater stream and riparian systems occupy a high point in the landscape and influence the delivery of water quality and quantity and organic and inorganic matter to downstream reaches. The capacity of headwater stream and riparian headwaters to trap, retain and slow the downstream movement of sediment affects sediment delivery further downstream. In forested headwater systems, forest cover can mediate the downstream impact of peak flows, at least for smaller-sized flood events. Headwater tributaries also provide a source of nutrients and a large proportion of terrestrial organic matter delivered into headwater streams is transported from headwater tributaries to downstream receiving environments. These combined processes and inputs from upstream tributaries influence physical and biological processes in the downstream reaches and the composition of the biological communities living within them.

Connectivity to indigenous remnants in the landscape

Afforestation of erosion-prone land in headwater catchments of the Hawke's Bay Region provides the opportunity to assess potential linkages with nearby indigenous terrestrial and aquatic areas that would maximise the desired ecosystem service and biodiversity outcomes of this project.

In a broad-scale assessment and prioritisation of remaining indigenous biodiversity in terrestrial, lake and river ecosystems in the Hawke's Bay region by Leathwick (2017)[3], connectivity was one of the factors included in the analyses. For the majority of the highly erodible land identified as suitable for afforestation, the majority of the remnant native vegetation is ranked in the bottom 25% in terms of its condition and the estimated condition of rivers and streams in these erodible areas is mainly ranked in the bottom 30% (Leathwick, 2017). While these combined factors result in low rankings for indigenous biodiversity priority for these areas (Figure 20), there exists a great l opportunity to enhance the overall condition of these stream and rivers and to explore options to maximise connectivity to remaining remnants of indigenous vegetation scattered throughout the region.

Figure 19: Examples of freshwater biodiversity in headwater streams. From left to right: aquatic invertebrates, banded kokopu, blue duck, longfin eel. Eel photo courtesy of DOC.

Riparian buffers

Riparian areas can be narrow in steep headwater systems and riparian buffers will likely need to extend beyond natural boundaries to meet regulatory requirements and to fully benefit from the services they provide. Riparian buffers ≤ 10 m in width will be limited in their ability to provide a full range of functions and services and to buffer streams from the impacts of harvesting. Function and protection increases with increasing buffer widths and 30 m buffers in most instances are sufficient to maintain the ecological integrity and ecosystem functions of both riparian and stream environments.

Restoration

Riparian restoration has the greatest impact on small headwater streams and the state of these headwater systems will influence the quality of ecosystem services provided further downstream. Restoration of these areas also provides the opportunity to maximise connectivity between both terrestrial indigenous remnants and freshwater ecosystems. Hence, headwater riparian areas are a logical start point for catchment restoration projects.

There are a variety of options for re-establishing forest cover in riparian areas ranging from a hands-off approach and allowing natural regeneration, through to intense planting regimes. It would be advantageous to identify species suitable for planting in headwater riparian areas as their site characteristics will differ from upslope areas and downstream riparian areas. However, some of these options are expensive, all will require some degree of pest and weed control and the largely

[3] Leathwick, J. R. (2017). *Biodiversity rankings for the Hawke's Bay Region.* Conservation Science Consultant, Waikato New Zealand. Prepared for Hawke's Bay Regional Council, Napier, New Zealand.

non-economic benefits in afforesting headwater riparian areas will need to be assessed against the costs, both in terms of dollars and loss of potentially production land.

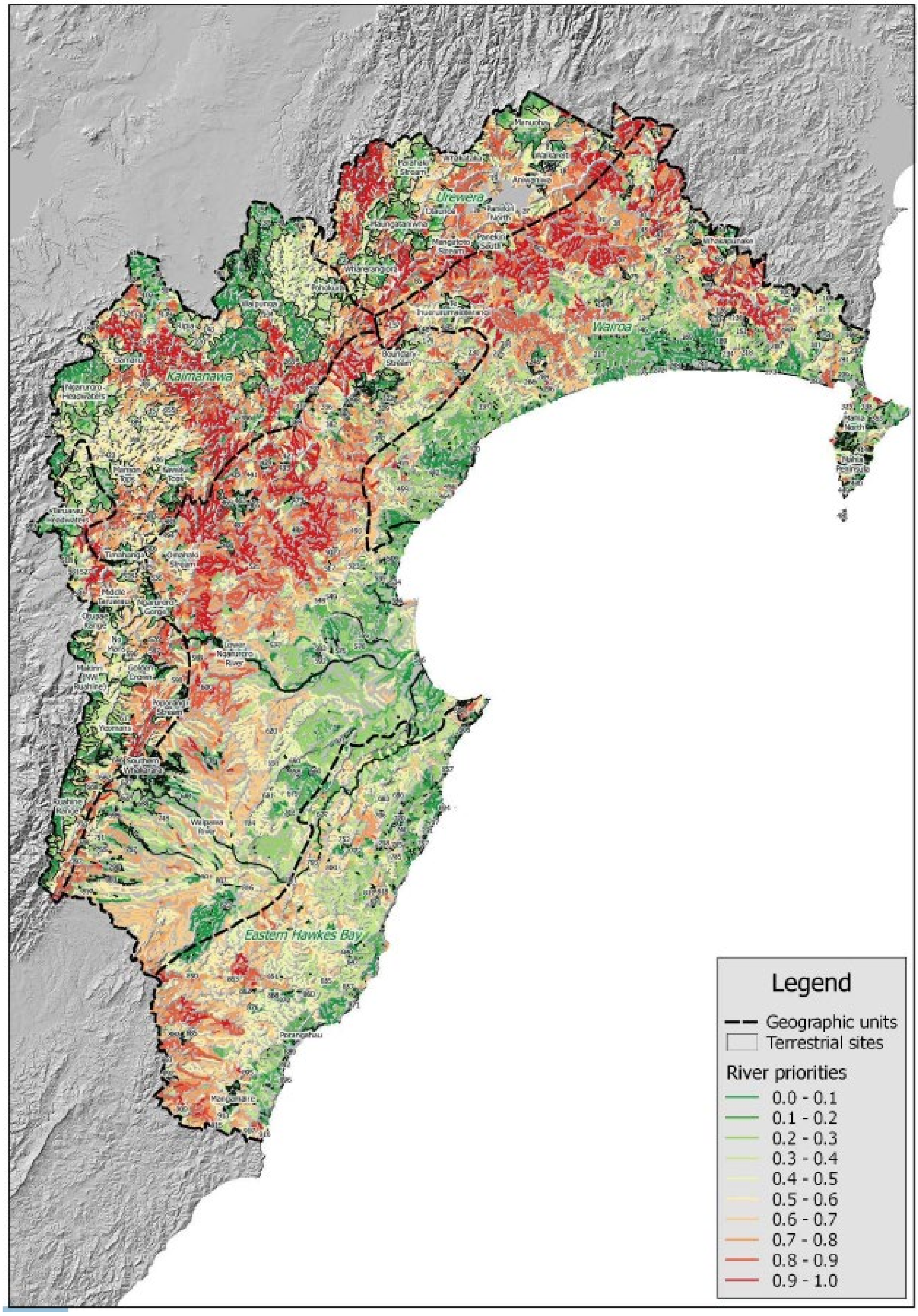

Figure 20: Indigenous biodiversity priorities for rivers and streams of the Hawke's Bay region, based on an integrated ranking designed to maximise representation of a full range of indigenous-dominated ecosystems. Terrestrial priority sites (top 30%) are also shown to highlight the correspondence between riverine and terrestrial priorities (Figure 7 from Leathwick, 2017).

Conclusions and recommendations

Afforestation of the erodible sites identified will provide multiple benefits to society such as timber, carbon sequestration, improved water quality through reduction in nutrients and avoided erosion, and conservation of iconic species.

Afforesting of riparian areas in headwater systems would also contribute to a range of beneficial ecosystem services including high water quality, flood mitigation, reduced nutrient and sediment loads, cooler water temperatures and sources of biota for re-colonisation.

The state of downstream waterways and their biological communities will be influenced by the processes occurring upstream. There would be significant benefits in prioritising the establishment of riparian areas when undertaking afforestation projects in the headwater catchments before progressing to their implementation downstream. Restoration and enhancement of riparian headwater areas and maximising connectivity to remaining indigenous forest remnants will also contribute to the HBRIC and HBRC goals of improving water quality and biodiversity.

There are a variety of options for re-establishing forest cover in riparian areas ranging from a hands-off approach and allowing natural regeneration, through to intense planting regimes. It would be advantageous to identify species suitable for planting in headwater riparian areas as their site characteristics will differ from upslope areas and downstream riparian areas. However, some of these options are expensive, all will require some degree of pest and weed control and the largely non-economic benefits in afforesting headwater riparian areas will need to be assessed against the costs, both in terms of dollars and loss of potentially production land.

Advancing to a case study scenario (such as the Wairoa catchment) and engaging a multi-disciplinary team would facilitate a more in-depth assessment and mapping of riparian areas, identification of suitable plant species and restoration options to achieve the management goals of this project. Long-term community buy-in and managing expectations of what riparian restoration can achieve will be critical to the success of this project.

The ecosystem services provided by forested riparian areas in headwater streams will complements the wider catchment ecosystem services identified by FIF, which was used to calculate the market and non-market values that could accrue from afforesting land vulnerable to erosion. The results suggest that for every dollar in annual profit provided by new radiata pine forests, the value of non-market ecosystem services is at least one and half times that.

Input parameters for modelling market returns for other species are needed. It is likely that other species with longer rotations and different growth and carbon uptake rates would provide even greater ecosystems service benefits. Data on permanent and selectively harvested native forest is also needed.

Recognising and understanding how afforestation affects the way ecosystem services with non-market values vary across the Hawke’s Bay region and how these might affect the region’s economy, environment and communities will support policy and investment decision making.

Wood supply and processing options

Wood supply

The Hawkes Bay has a significant plantation forest estate, approximately ~133,000 ha of which, or 97.6% by area, is radiata pine. The other species established as plantations in Hawkes Bay are Douglas-fir (446 ha), cypresses (372 ha) and less specifically, 919 ha of other softwoods; 927 ha of *Eucalyptus* and 498 ha of other hardwoods.

The current supply of radiata pine saw logs is greater than local processing demand and the surplus is exported. In the long term, as the log supply varies over time, the supply of saw logs available for expanded local processing is around 700,000 cubic metres per annum.

The log supply could be stabilised at the current level by planting 10,000 ha of radiata pine over the next five to 10 years under a 16 to 17-year rotation regime. Long term wood supply available for expanded wood processing under this scenario would be in the order of 1.6 to 1.7M cubic metres per annum of unpruned saw logs.

Wood processing

With or without new plantings, expanded wood processing is possible. Based on the current plantation forest estate, sawmilling coupled with CLT and remanufacturing of lumber were assessed as being financially attractive, along with OEL™ manufacture and sawing of logs into big squares for export. If this expanded wood processing were taking around 700,000 m^3 per annum it would provide around 430 to 440 direct jobs and contribute \$440 to \$450M to the country's gross domestic product.

Assuming 10,000 ha of planting over the next five to 10 years, wood processing could expand to approximately twice the size of that based of the current estate.

Around 130,000 ha of erodible land has been identified as suitable for afforestation, with much of it suitable for production plantation forestry. If half of the land was planted in radiata pine, a considerable future resource would come online in the next 20 to 30 years. A forest establishment plan spreading the planting and using regimes with different rotation lengths could ensure a stable wood supply of 4.5M cubic metres per annum (the current harvest is 3.4M cubic metres, with significant variation over time).

This expanded estate would allow a significant expansion of onshore wood processing in the long term. As the larger supply increase would not occur until the first of the new plantings of the longer rotation regime mature, it is not possible to predict what the wood processing would occur.

Considering alternative plantation species, only some *Eucalyptus* species and coast redwood currently have attractive financial metrics for wood processing. Cypresses from some stands are not attractive for processing, largely due to the comparatively low recovery rates of quality lumber that sometimes occurs. Douglas-fir will have limitations on where it should be planted due to it propensity to create wildings.

Options for processing timber from other species will depend on the volume available on an annual basis. For quantities up to 10,000 cubic metre per annum, a portable sawmill is a viable option. Tōtara, cypress, *Eucalyptus,* etc could be milled this way. A small sawmill with a head rig would have the capacity to a process a mix of species of 30,000 to 50,000 cubic metres per annum. Ideally, it would be aligned with a secondary processor who makes the lumber into value added products suited to the species such as using cypress for cladding/outdoor furniture, tōtara for furniture or carving, *Eucalyptus* for flooring, and coast redwood for cladding or to export logs to the USA. Any mill/processor would need the capacity to carry out specialist drying regimes. *Eucalyptus*, for example, require long periods of air drying.

Industrial symbiosis

An ‘industrial symbiosis’ is a local collaboration where different industries provide, share and reuse materials, energy, water, and/or by-products to create shared value. Resources are used more efficiently by the group than by any individual company. The possibilities of establishing industrial clusters to reduce waste and greenhouse gas emissions, create jobs and contribute to New Zealand’s bottom line are substantial.

Opportunities for industrial symbiosis based around wood processing have been identified the Hawke’s Bay using maps of forestry resources and heat demands, a model to estimate wood and harvest residue supply and the WoodScape model to calculate return on capital investment (ROCE) (Figure 21).[4]

There are no coal fields in Hawkes Bay, but coal is used for industrial heating at Awatoto eight km south of the post of Napier, and at Wairoa. Coal has to be transported into the region to meet this demand. Instead of coal, the significant quantity of logs being exported from Hawkes Bay via the Port of Napier represents an opportunity to expand wood processing and use wood resources for industrial heating.

There are sufficient residues from in-forest harvesting to meet two thirds of the demand for industrial heating at Awatoto if the wood processing options mentioned above were established. While these processing plants would require substantial capital investment (~NZ$204 million), they could provide up to 566 direct jobs and up to 1,503 jobs when indirect and induced employment are included. The total increase in GDP would be in the order of $518 million per annum. Greenhouse gas reductions would be in the order of 15,000 tonnes per annum

[4] From Hall, H & Hock, B (2018) *Assessment of wood processing opportunities aligned with industrial heat demand in Hawkes Bay.* Scion, Rotorua.

In Wairoa, there are sufficient wood supply and in-forest residues in the district to allow expanded wood processing, and to meet the energy demand of the local meat works, eliminating the need for coal. A plant at Wairoa would require around $57 million of capital investment and could have a 37% return on investment. It would provide 81 direct jobs and 216 indirect and add $159M to GDP whilst reducing greenhouse gas emissions by 30,000 tonnes per annum.

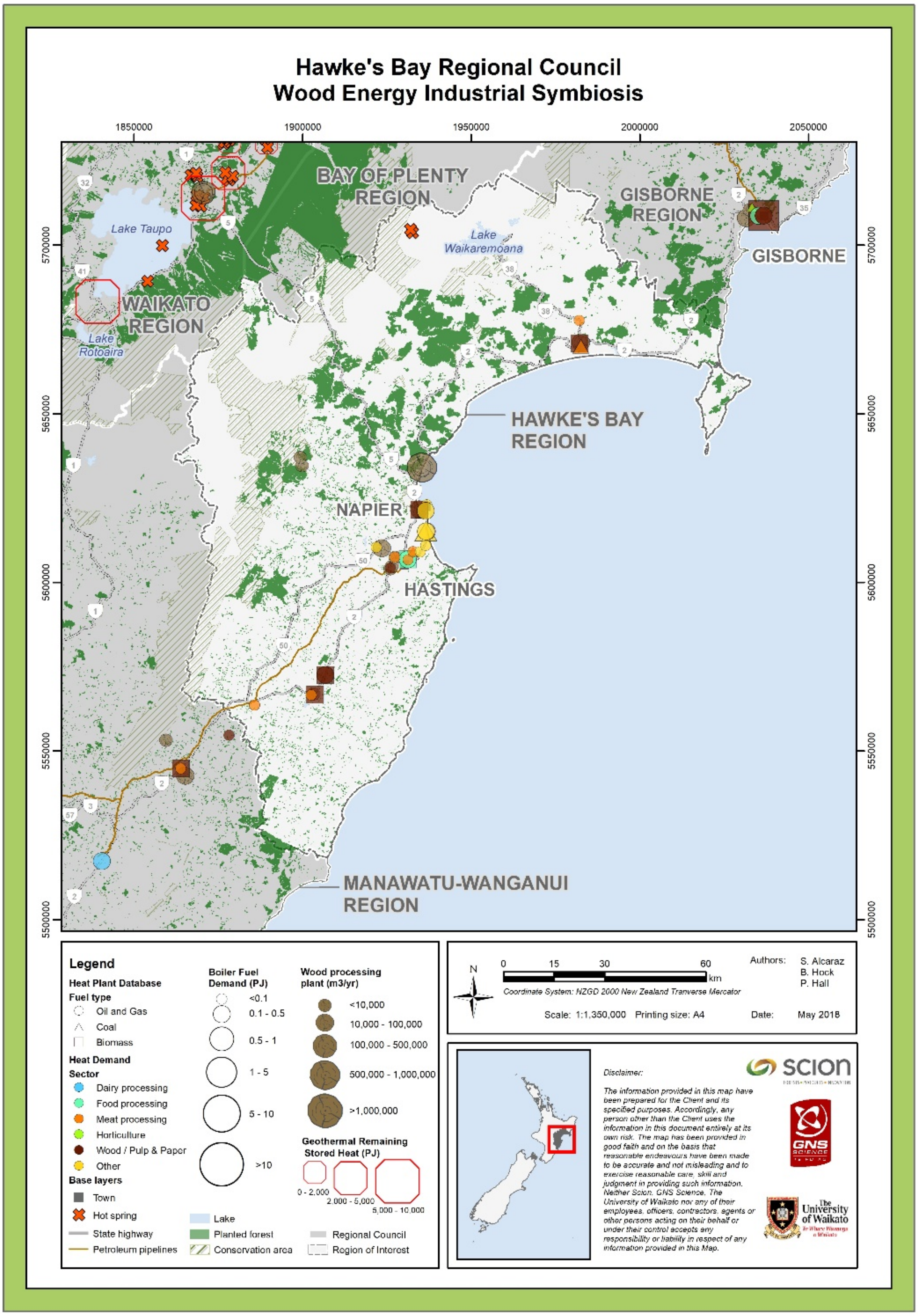

Figure 21: Planted forests and existing wood processing and other industries in the Hawke's Bay – opportunities for wood energy industrial symbiosis.

Biofuel opportunities

Biofuel production from forestry waste is another processing option. The *New Zealand biofuels roadmap: Growing a biofueled New Zealand* (Scion, 2018)[5] found that large-scale biofuel production to produce drop-in diesel, petrol and other fuels was feasible. The work started from the premise that fuel would still be needed for vehicles such as heavy trucks, farm and construction vehicles and machinery and shipping that may be difficult or impractical to electrify. Using heat to reduce biomass to a crude bio-oil (pyrolysis), followed by upgrading the oil, was found to be one of the most efficient technologies, especially when processing was located close to forests.

The most suitable places for planted energy forests included the Hawke's Bay and the east Coast. In one scenario for Gisborne/East Coast, establishing biofuel production would require an extra 75,000 ha of forest, building four pyrolysis and four upgrading plants (with nearly one billion in capital investment) and create over 1,000 jobs.

Milled tōtara (Scion). More information and experience about milling and processing tōtara will become available from the Tōtara Industry Pilot running in Northland.[6] This is a two-year study to test the opportunity for a new industry based on careful management of regenerating tōtara on private land bringing together the potential advantages of conservation, timber production, environmental and economic enhancement, social and cultural enrichment.

It is estimated a Northland tōtara industry could produce $7.5 million of timber per year in three years. Further processing the timber into higher value wood products increases the potential value to up to $60 million and 2000 direct and indirect jobs.

[5] *New Zealand biofuels roadmap summary report: Growing a biofueled New Zealand* (2018). Scion, Rotorua.

[6] https://www.totaraindustry.co.nz/

When does it become worthwhile to plant trees?

Some landowners are actively involved, or are looking to become involved, in production forestry on their properties. Others, however, are hesitant, or unconvinced about the benefits of planting some areas of their properties. They also worry about the effect of forestry on the communities that they live in and are concerned that wholesale afforestation without the full recognition of the economic lost opportunity, as well as social, political and environmental impacts.

Landowners have shared how they evaluate land use options and consider the relative returns between production forestry and pastoral options to decide at what point it become economically worthwhile to plant pastoral land in trees.

Almost every landowner has some affinity to the concept of the right trees in the right place, whether to control erosion, add biodiversity or aesthetic value. They also have in common a love of land and a desire to protect or be guardians (kaitiaki) for future generations. Some are keen farm foresters, others are open to reviewing the role of forestry/carbon in their farm businesses and in their farming communities. And some see themselves primarily as pastoral farmers and are concerned about good land being taken up by pine forest monoculture pine forest and how it will affect their families, communities and New Zealand.

Landowners thinking about forestry (either positively or negatively) need reassurance that both timber and carbon markets are viable and sustainable. Carbon markets are strongly influenced by political policy, but the sale of carbon credits is also seen as a cashflow that can allow them to diversify into forestry on poorer producing land. The most conservative are worried about the consequence of long-term decisions made based on short term price trends, viewing production forestry on traditional pastoral land similarly to the way dairy conversions were viewed a decade ago by many sheep and beef farmers.

Landowners understanding of land use

Any assessment on land use change needs to be done at a whole farm level, rather than on a basis gross margin/ha basis. Landowners need to analyse their land economic returns down to a land use class basis and be aware of the relativities that exist between these classes. Not doing this can lead to the value of the better land being underestimated while the value of poorer land is overestimated. Higher resolution land inventory mapping would facilitate the process of comparing and selecting appropriate areas to consider for forestry.

A big fear is that reducing stocking rates will reduce farm income. While every farmer knows their stocking rate, this is an imprecise measure of productivity. Identifying true profit from pastoral land is difficult. Calculating an economic farm surplus (or EBIT) per hectare provides farmers with more reliable data than just their tax accounts alone and/or cash flow.

Figure 22 illustrates how land quality affects farm and forestry returns differently. This provides an opportunity for many land owners to understand the approximate land use class at which forestry can provide greater returns than existing farming. This information can then be used to assist with developing a rational afforestation plan.

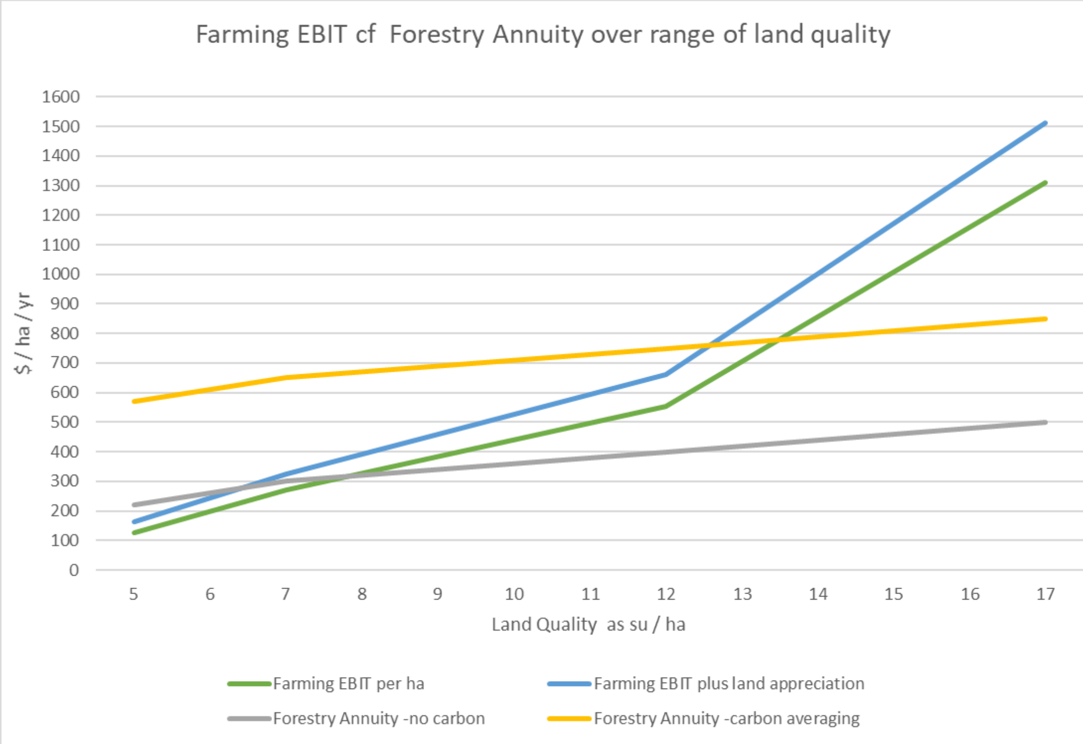

Figure 22: Relationship between land quality (expressed as stock unit per hectare) and financial returns.

Where farmers and researchers have closely monitored production and income generation they most always conclude that the best land and highest quality forage deliver greater income benefits than anticipated. And the poorer quality land/low feed quality pastures produce a lower income and profit than would be subjectively assessed.

"In our opinion many farm businesses do not know these core numbers. If they were more aware, and honest about their financial results they may be more motivated to accept the need for change/improvement."

Case studies

Farm consultants AgFirst (Hawke's Bay) have evaluated many land use options and analysed the breakeven point and returns in the choice between production forestry and pastoral options.

On one property, comparing land quality vs financial returns indicated that when pastoral returns dropped below an EBIT of $300/ha/year (around seven stock units) forestry was the more attractive option financially. This shifts to around 13 stock units if the value of carbon (at $25 a tonne) is included.

On another1,250 ha pastoral farming property, AgFirst concluded that by converting the least productive 500 ha to production forestry and focusing on improving the remaining 750 ha could results in overall lift in EBIT ($20,000 per annum) above what would be achieved by leaving all the land in pastoral production. The land use change would also reduce nitrogen and phosphate losses across the property.

In a third case, a farmer reported forestry on his property strengthened his business from a cashflow perspective as well as making it more robust financially in varying climatic patterns. It also opened up opportunities for farm succession.

"We have reduced the area we farm livestock on by about 25% but now produce more meat than before by a focus on developing the good country."

Integrating farming with forestry also improved farm resilience. A severe storm caused massive damage in April 2011.

“That storm cost us an estimated $250K. The flood gates at the bottom of forestry blocks were intact. The unplanted country flood gates all gone. The tree income bailed us out.”

Conclusions and recommendations

Any assessment on land use change needs to be done at a whole farm level rather than on a basis gross margin/ha basis. Higher resolution land inventory mapping would facilitate the process of comparing and selecting appropriate areas to consider for forestry. Expressing forestry returns as an annuity ($EBIT per hectare per year) simplifies the comparison financial benefits. A complementary approach where less productive land is afforested, and higher quality land is managed more intensively can lead to higher overall farm returns.

There is also a need for wider education on forestry and the benefits of better land use selection and its potential addressed not only to farmers but also to other rural professionals.

Landowners speak

"If you sit down and talk logically to most farmers, they will have blocks of land suitable for planting. But on the other hand, there will be push back because of the risk and worry."

How can landowners be encouraged and supported as they consider and engage with tree planting activity on their land? Interviews have been conducted that focus on the behaviours, attitudes and perceptions of landowners in Hawke's Bay so that these can be better understood and addressed to increase the likelihood tree planting.

A total of 15 in-depth interviews were conducted with:

- Success stories (farm foresters) who have had previous success and experience in commercial planting operations on farm.
- Future engagements, or those who are just beginning to think about commercial tree planting and have not yet to fully developed or implemented plans.
- Industry players/influencers who have current or previous roles in farm forestry/farm consultancy/land management and were able to provide a view based on their interactions with and experiences of landowners

Wairoa residents were heavily represented amongst the participants given the needs and concerns of that community.

Success factors

The common factors of integrated management, a clear role for trees, the range of benefits and a willingness to learn and adapt combine to support 'success' from an individual perspective. Due to the unique nature of each operation, the weighting applied to each of these factors differs and can only be determined by looking at an operation as a whole. Within this, there is also a very clear direction in terms of how tree planting is perceived by farmers that may differ from others in the industry. That is, it is complementary and integrated within their overall farm/business as opposed to operating in isolation.

Barriers

Perceived (and real) financial, implementation and reputational risks are the main barriers to landowners not engaging in potential tree planting initiatives. Given the time, resource and financial pressures most landowners are under, it is very easy for them to de-prioritise tree planting activity in favour of the status quo. When this is combined with knowledge gaps and lack of clarity around end benefits, this often results in lack of action implementing something that at a logical level usually makes sense.

Potential role of the HBRIC and HBRC

There is an opportunity (and appetite) for engagement and relationship development that works alongside the landowner to support them towards a desired end, in a way that they are comfortable. For landowners, this is perceived as a central party (or facilitator) that can understand, provide expertise and introduce relevant parties for the betterment of the farming operation. There is also potential for enablers to support individual landowners and communities in navigating the tree-planting journey (Figure 23).

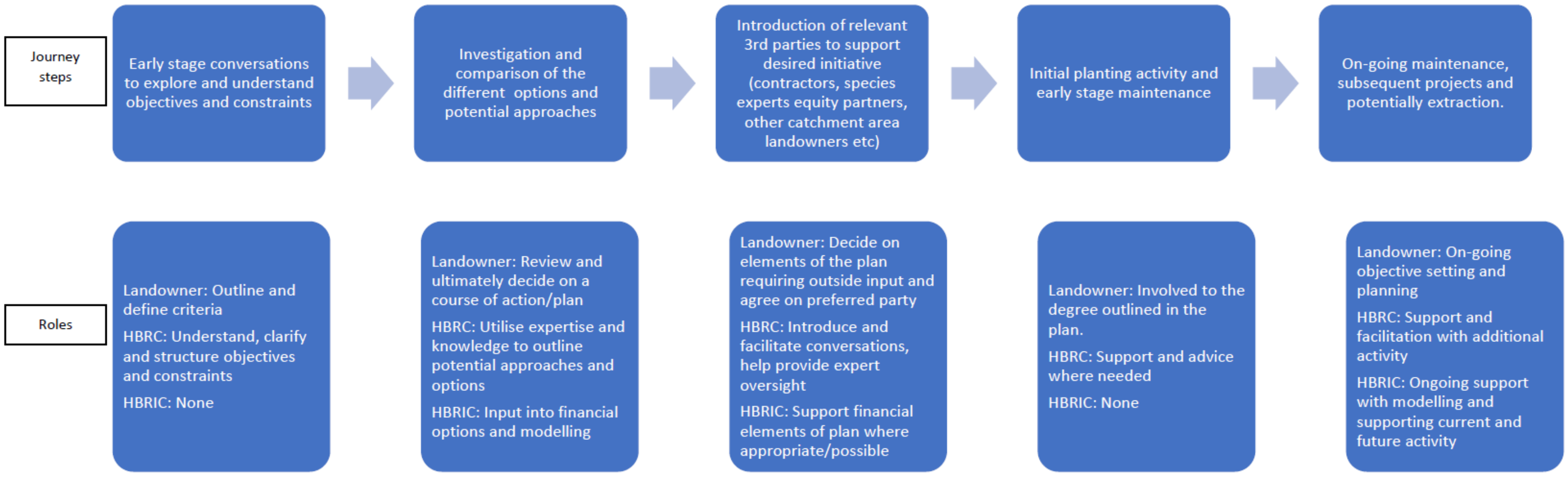

Figure 23: Suggestions for facilitation roles.

The facilitation roles could lead to solutions/approaches/arrangements that include:

- Attracting and introducing appropriate equity partners
- Community co-operation where groups of landowners may be able to work together to make a community initiative more attractive than its individual parts (e.g. shared roading infrastructure, merging of neighbouring blocks. etc).
- Supporting mass purchasing by identifying species needs at an overall level and mass/bulk purchasing facilitated with cost advantages passed on to landowners.
- Creation or access to (new) markets by identifying species volumes at an overall level and support/facilitation of access to markets for these species (especially if they are less common)
- Introduction to full-service delivery entities, which could result in a complete handover to a third-party contractor who delivers the full planting project and on-going maintenance on behalf of the landowner.

The wider narrative

There is a social 'gap' in terms of perceptions and attitudes that needs to be addressed alongside the gaps at an individual level. HBRC has a role to play in creating a 'fertile ground' for messages and initiatives to drive behaviour and normalise tree planting activity. This includes showcasing the success stories and different approaches that are already present in the wider community, demonstrating that tree planting is an appropriate land use and complements other farming practices and illustrating the full range of potential environmental benefits including role of trees in creating a more resilient region. The council also need to show its commitment to long-term decision making and support in this area.

Conclusions and recommendations

Landowners have a very mixed awareness and comfort levels around larger scale or commercial tree planting activity. As a result, there is an acknowledged gap in knowledge (and therefore comfort gap) with the realities and practicalities of tree planting from those who haven't been exposed to it to a larger degree

At a broader level, there is an obvious and explicit emerging cynicism and disillusion with some facets of tree planting in the region. This is largely based on negative perceptions around "blanket planting" behaviour and the absence of long-term and land optimisation thinking by key parties.

Alongside this is also a very clear gap (and opportunity) for a central support and guidance mechanism to work alongside landowners to understand their objectives and constraints and develop a long-term plan that fits with the needs and expectations of the landowner. Part of the jigsaw is finance and funding, but this is not the only mechanism that is needed, and it needs to be shaped by the unique characteristics of each project.

The HBRC/HBRIC has an opportunity to influence and drive behaviour, but this needs to be focused on the needs of the individual farm unit and supported by a community dynamic that encourages responsible planting activity. Conversations around the dining table are needed, not pre-packaged solutions.

Northern Hawke's Bay: Wairoa focus

The majority of the highly erodible land that is suitable for planting is in the Wairoa district, northern Hawke's Bay (Table 11). This land is also likely to gain the most environmental benefits from afforestation. Most of the rivers and streams in these areas are in poor condition and headwater afforestation would be expected to bring benefits to downstream waterways.

Table 11: Highly erodible land that is suitable for planting in Hawke's Bay districts.

District	Area of erodible land suitable for planting (ha)	Area of erodible land (% of total)
Central Hawke's Bay	22,140	15
Hastings	37,742	25
Wairoa	87,228	59
Other	1,039	1
Total	148,151	100

There are 220 farms in the catchments of the Mahia, Nuhaka, Wairoa and Waihua, with an average size of 762 ha. The gross farm income per hectare for the typical Wairoa farm (averaged over the last four years) is $727 per hectare, with an economic farm surplus of $212 per hectare, giving an average farm surplus of $161,544 before interest, taxation, depreciation and personal drawings.

Of the land area in commercial use, 9% is in a LUC classification of fou ror less, 56% is in LUC Class six and 34% is in LUC Class seven. If carbon is used in economic returns at $25 per tonne, then land with a stocking rate of less than 13 stock units per hectare is financially better in forestry for the landowners. This would place all the Class seven and at average pastoral production in contention. With on-farm land use classifications, and better management of this land class, then approximately half of this class could be suited for afforestation (~50,000 ha).

The better tree species choices for the highly erodible sites in the Wairoa district are include radiata pine, tōtara and coast redwood. Mānuka may be suitable for planting near the coast and on the Mahia Peninsula.

Studies carried in the Waiapu Valley near Ruatōria could be used as examples of native planting options. One piece of work[7] compared three native planting options to control erosion and generate an income: mānuka for honey (MO), mānuka and later maturing tōtara for timber (MT) or mānuka then tōtara followed by an understory of kawakawa grown for its medicinal properties. At a discount rate of 5%, the MO option provided an income the most quickly. Using a 1% discount rate, which is appropriate for generational investments, all options made money. A second study that included radiata pine and used rimu instead of tōtara[8] found that on flat land, only a scenario where mānuka was grown for oil was profitable. On steep land, both the radiata pine and rimu steep-land scenarios had improved NPV returns due to a lower opportunity cost. On steep land, radiata pine is generally profitable with a discount rate of 6% or lower and a stumpage rate of over $100 cubic

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[7] Monge, J. J., Daigneault, A. J., Dowling, L. J., Harrison, D. R., Awatere, S., & Ausseil, A. G. (2018). Implications of future climatic uncertainty on payments for forest ecosystem services: The case of the East Coast of New Zealand. *Ecosystem Services*. https://doi.org/10.1016/j.ecoser.2018.04.010

[8] Pizzirani, S., Monge, J. J., Hall, P., Steward, G. A., Dowling, L., Caskey, P., & McLaren, S. J. (2019). Exploring forestry options with Māori landowners: an economic assessment of radiata pine, rimu, and mānuka. *New Zealand Journal of Forestry Science*, *49*.

metre. Rimu is generally profitable with a discount rate of 2% or lower and a stumpage rate of over $650 cubic metres.

The Wairoa district already supports a large area of planted forest and wood processing operations are located around Wairoa.

The current wood supply is sufficient to allow expanded wood processing (OEL™, 100k log per annum). The wood residues, along with in-forest residues, would provide enough energy to power the wood processing and the local meat works, which currently uses coal. Developing an OEL™ plant in Wairoa would require around $57 million of capital investment. It would provide 81 direct jobs and 216 indirect jobs, add $159M to GDP and reduce greenhouse gas emissions by 30,000 tonnes per annum.

The Wairoa district with its proximity to large forest resources is also well situated to be a site for future biofuel production.

Carbon counting

The Emissions Trading Scheme

The New Zealand Emissions Trading Scheme (ETS)[9] began operation in 2008. The ETS is a way of meeting our international obligations around climate change. It puts a price on greenhouse gases to provide an incentive to reduce emissions and encourage landowners to establish and manage forests in a way that increases carbon storage.

The main unit of trade in the ETS is the New Zealand Unit (NZU). One NZU represents one tonne of carbon dioxide. The Government issues NZUs for increases in carbon stock in post-1989 eligible forests, and these may be held or bought and sold within New Zealand.

Generally, where forest land is established after 31 December 1989 on previously non-forest land, it is post-1989 forest land. Where forest land was first established before 1 January 1990, it is pre-1990 forest land.

Identifying land for post-1989 eligibility is key component of the financial viability of afforestation in most situations.

Carbon neutrality objectives

An important concept to understand is the relationship between capitalising carbon and carbon neutrality objectives. The financial returns discussed in this report are underpinned by trading in carbon. It is important to note that this precludes the contribution to carbon neutrality or a zero carbon goal. If carbon is traded (i.e. sold), as per most of the economic modelling in this report, that carbon can no longer be considered to be offsetting carbon emissions.

Forgoing carbon revenue for carbon neutrality objectives would come at a significant economic opportunity cost. For example, the carbon from 50,000 hectares of eligible radiata pine forest at today's carbon prices could be worth approximately $500 million even when harvesting for timber revenue.

Carbon trading opportunities

Carbon trading opportunities exist for afforestation on registered post-1989 eligible land. Currently the onus is on landowners to provide evidence to the Ministry of Primary Industries (MPI) when applying to register post-1989 land and MPI make the final determination on eligibility areas.

There are two carbon accounting categories for receiving carbon units for trading that are dependent on the chosen forest system. Rotational harvesting regimes will receive units via Carbon Averaging and carbon only (non-harvest) regimes can be registered as Permanent Carbon forests.

Carbon averaging – rotation timber regimes

Forests registered in the ETS after 31 December 2020 that are intended to be harvested will be subject to carbon averaging. As such, forests will earn NZUs up to their forest's "average age". This age will be determined primarily by the expected harvest age of each species. Only first rotations are eligible for Carbon Averaging. Other important, recently announced, attributes of carbon averaging are:

- Offsetting will be made available to post-1989 participants using averaging accounting. This ensures that some flexibility of land-use is maintained.
- Foresters using averaging accounting won't have to pay back NZUs after adverse events (assuming re-establishment occurs within four years). Instead, earning units will be paused until the forest has recovered to its pre-event level.

[9] https://www.mfe.govt.nz/ets

Permanent carbon

Permanent carbon is an option for situations where harvesting or access is problematic and where harvesting is not commercially viable. There are risks for a landowner associated with a permanent carbon regime, including:

- Being fully dependent on the carbon price for revenue.
- Political exposure in that a termination or a change in the ETS could potentially render the crop worthless.
- In remote locations or where access is not established, the investment is vulnerable to adverse events. It is likely this would be the case for many permanent carbon regimes.

As per Carbon Averaging, MPI recently confirmed that Permanent Carbon forests won't have to repay NZUs after adverse events (assuming re-establishment) and will instead pause earning units until the forest has recovered. An adverse event is still a risk, but without this new ruling a participant would have to either take very expensive insurance or run the risk of facing huge penalties if the price of carbon continued to rise.

Variations between forest systems

Carbon sequestration rates vary significantly between forest systems. The major determinants of sequestration rates are growth rates and the density of the wood. Generally, heavier wood species such as hardwoods contain significantly more carbon per cubic metre than the equivalent volume of a low-density softwood species.

An important economic consideration for afforestation system choice is the rate at which each system sequesters carbon in the early years. This has a significant impact on present value and rates of return. Figure 24 illustrates the variance in early carbon sequestration rates between species (from the ETS lookup tables for Hawke's Bay). The radiata pine and exotic hardwood is significantly ahead of the other options in the early years.

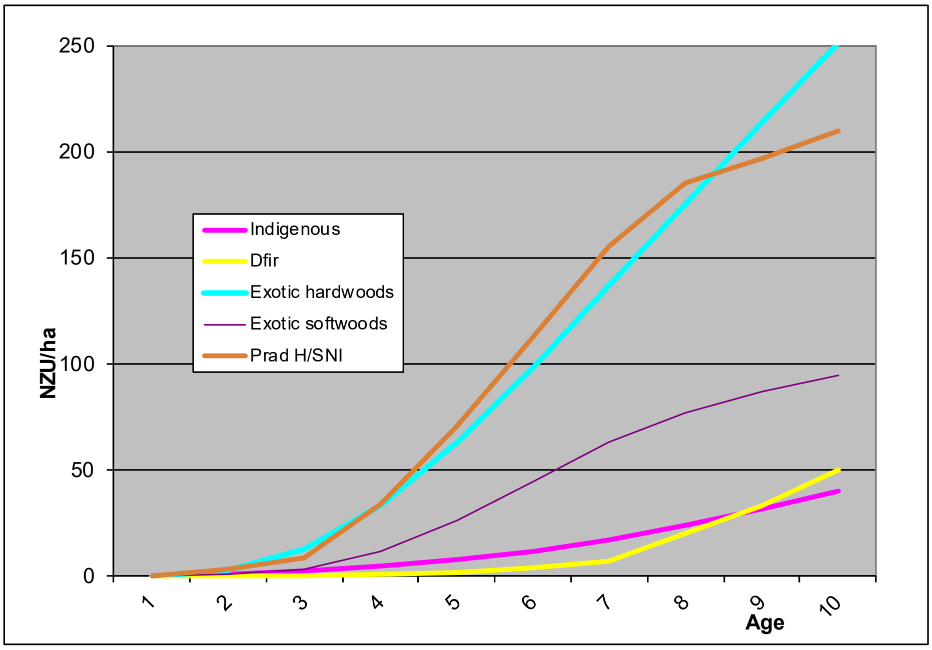

Figure 24: Carbon sequestration rates of different groups of species (from the ETS lookup tables for Hawke's Bay) for first 10 years of growth.

Carbon summary and opportunities

Key elements to the ETS that potentially affect afforestation initiative in the Hawke's Bay:

- ETS registrations below 100 hectares receive NZUs as per the ETS lookup tables. Above 100 hectares the Forest Measurement Approach (FMA) must be used where participants get a customised carbon table based on the actual growth rate of their trees.
- Forests registered after 1 January 2021 are forced to account for their carbon using carbon averaging.
- Once a carbon unit is sold, it is no longer offsetting carbon emissions. Carbon offsetting for carbon neutrality or zero carbon can only be achieved by the participant holding earned carbon units. The value of carbon is significant and could run into the billions with a successful afforestation scheme and carbon price appreciation.
- Unless the ETS is terminated or the price of carbon crashes, selling carbon units is likely to commit the land to forestry in perpetuity. To illustrate, at today's carbon price, a future conversion from forestry to another land use could cost approximately $10,000 per hectare just for carbon and thousands more for physical conversion. Well considered siting is very important.
- All the commercial carbon benefits of forestry in the ETS occur in the first rotation. Subsequent rotations will have to rely primarily on returns from timber. Land values for second rotation forest land are likely to be significantly lower than non-forested land that is post-1989 eligible.
- Third party ownership of carbon from the ETS is complex and can have significant implications for the landowner. Any carbon sharing or regional carbon scheme would require thorough due diligence.

Investment strategies

An important consideration for the HBRIC and HBRC in developing an investment strategy for this project is that they do not own the land that has been identified as a priority target area for afforestation. Therefore, any investment needs to focus on influencing existing landowner behaviour to achieve the desired outcomes from afforestation. Successful investment would need to incorporate the following:

1. Investment must result in actual behaviour/land use change.
2. Investment must be targeted to achieve desired outcomes and minimise unintended consequences.
3. Investment must benefit individual landowners, HBRC/HBRIC, and the wider regional community.
4. Outcomes must consider long-term impacts on the community and environment.

The HBRC/HBRIC developing and maintaining a long-term self-sustaining fund will be a significant challenge. Carbon revenue is significant, but it is a one-off opportunity that is only available in the first rotation. In most future scenarios, the selling of carbon effectively locks the land in forestry in perpetuity. Carbon markets have also been subject to volatility and carbon policy may be subject to future manipulation, iterations or cessation. Grants that ensure higher and better land use will have benefits to the regional economy but will not necessarily contribute directly to a sustainable fund.

Success is dependent on influencing landowner behaviour to achieve integrated land use and rational afforestation. Interventions are proposed, as opposed to relying on market forces. Investments leading to wide scale afforestation of stable and highly productive landscapes in Hawke's Bay do not meet project or community objectives. Observations of recent afforestation encouraged by the ETS and 1BT funding confirm that a strategy involving active intervention will be required. Active intervention can assist with achieving the following:

- Planting occurring on the most erosion susceptible sites.
- Achieving a preferred species mix.
- Existing profitable practices are maintained and negative impacts on regional communities are minimised.
- Accrual of non-market benefits.
- Limiting full property farm conversions.

There are a multitude of potential investment strategies, investment modes and tools that are available to influence and facilitate landowner behaviour change to achieve project objectives. It is important to note that multiple strategies can be implemented together and that the most appropriate strategies may change over time due to external influences and internal requirements.

For the purposes of this report, investment options have been aggregated into the following categories:

- Direct financial interventions with landowners.
- Supporting industry and infrastructure.
- Partnerships.
- Develop HBRC forestry expertise and resources.

Direct financial interventions with land owners

This would involve HBRC/HBRIC using project allocated funds for directly incentivising landowners to establish forestry on their property in alignment with the project's desired outcomes. The simplest form of incentive is a grant. It is recommended that any grant scheme would be targeted to specific outcomes. The grant levels could vary on key attributes such as the erosion susceptibility of the site and the species that the landowner chooses. Alternative species, especially indigenous species, are likely to require higher grants to ensure widespread adoption.

Grants could be used in conjunction with regulations or punitive measures to further target afforestation on priority sites. Farm plans and nitrogen trading are examples of regulatory schemes that have been implemented to influence behaviour change. Loans to landowners for afforestation with recovery via targeted rating reductions is another viable mechanism.

The funding of afforestation feasibilities and forestry plans are another way that HBRC can support landowners to make informed afforestation decisions. Feasibilities can recommend the most appropriate species and estimate future returns that can be compared to returns from existing land use.

Supporting industry groups and infrastructure

There are multiple stages in the value chain where HBRC/HBRIC could support existing forest industry efforts to further the objectives of planting the right tree in the right place. Developing nurseries that produce alternative and indigenous species will assist with locally sourced seedstock as well as increasing the supply of non radiata pine treestocks, which is currently a constraint. New, local nurseries could also provide jobs in rural communities.

Supporting industry groups would allow HBRC/HBRIC to encourage the selection of a smaller number of specific alternative species. As discussed earlier, one of the major disadvantages of alternative species is the fact that they individually lack scale. This negatively affects treestock availability, genetic improvement, marketing and wood processing. A good example of an aligned project is the Specialty Wood Products Partnership (SWP) which has ‘developing integrated regional strategies’ with alternative species as one of its main research aims.

At the other end of the value chain, supporting the development of additional wood processing and other emerging wood-based technologies such as biofuel production will allow value added opportunities and create skilled employment opportunities for regional communities.

Partnership investments

The HBRC entering into partnerships, or facilitating third party partnerships, could be an effective mechanism for ensuring targeted afforestation. Various partnership models are currently used between landowners and investors in the forest industry including annual rental paid to landowner, sharing of net harvest revenue and how carbon units are allocated. In some instances, a combination of all of these are used. Partnerships have the following potential benefits:

- They provide a level of control around planting the right tree in the right place.
- They potentially provide future revenue streams that could assist with supporting a longer-term reticulating afforestation fund.
- Investment models can be flexible and individual agreements can be tailored to specific landowners’ situations.

Development of internal forestry resources

This right tree in the right place project is a potentially ground-breaking and transformational undertaking that will require expertise, resources and commitment for multiple years. Having internal resources and expertise would assist with providing the impetus to ensure that project objectives and desired outcomes are met. Internal resources should also facilitate individual landowner and community engagement.

Recommending investment options

It is recommended that a successful investment strategy will incorporate a combination of several of the options discussed above. A key component will be investing in building internal forestry expertise and resources. The scale of the objectives is too significant to either expect existing staff to manage or outsource it in its entirety to external organisations.

Recommendations and conclusions

This project offers an opportunity for HBRC and its landowner population to engage with new and improved understanding of productive land uses and diversified returns. To be harmonise with the long-term nature of the human, biophysical and financial challenges impacting its rohe, HBRC will need to adopt long term strategies, relationships and programs to meet them successfully.

Looking ahead, the research summarised here offers opportunity to integrate, and engage with landowners in new ways, toward better, more integrated land use. With a range of tree species and forest systems available in the quiver for land managers, the opportunity for more resilience is enhanced.

Spatial data and financial results may later be integrated into new tools to accelerate understanding for landowners and their supporting providers, and to provide for deeper understanding of the drivers of tree species suitability. There is a volume of data and background information in this project and this could be brought to fore in an accessible form to meet the needs of the community.

The challenge here is to meaningfully apply the measures, data and learnings to best effect. This will require that strategy is formed, and commitments are made to select and pursue those factors seen as most applicable first, and develop plans, resources and then to execute accordingly. This will surely lead to enhanced outcomes across a range of domains.

Financial returns and other community and ecosystem benefits will be driven by an array of variables, drivers and policies at local, central and even global level.

This is the beauty of diversification – when one stream of value or return is in decline, others may buffer ill-effects. But with a drive for diversification comes the responsibility to understand, research, collaborate and market a broader range of products. This will require sustained community commitment.

Stepping up to claim the offerings communicated here will most dependably occur through HBRC engaging with the community. By collaboratively designing approaches, sharing learnings, and tackling new challenges as they rise, HBRC and its community can then create the best possible conditions and culture for success.

Now the task is to apply the learnings here and translate them into optimal action for each landowner. Processes and toolkits will need to be developed for working with landowners and ensuring forest investments align to their aspirations, while ensuring fiscal responsibility around council expenditure. Community efforts around education, collaboration and potentially facilitating new business relationships will ensure that synergies are then able to be captured.

The prize will be better living, investing, working conditions for the people of Hawkes Bay Region. Along with cleaner water, more resilience to natural and cultural events, increased biodiversity, and steeply improved long-term prospects for environmental health.

Acknowledgements

This report could not have been put together without the help of the people named below. Thank you very much.

Paul Millen, NZ Dryland Forest Initiative

Tim Martin, Wildlands

Stephen Lee, Mānuka Farming NZ

Maggie Olsen, Mānuka Farming NZ

Simon Rapley, NZ Redwoods

Rob McGowan, Tane’s Tree Trust

David Bergin, Tane’s Tree Trust

Lochie MacGillivray, Agfirst

Phil Tither, Agfirst

Bruce Manley, NZ School of Forestry

Marie Taylor, Plant Hawke’s Bay

Troy Duncan, QE2 Trust

Dr Willie Smith

Ewan McGregor

David Trubridge

Chris Perley, Thoughtscapes

Mike Halliday

Sam Robinson

Mark Warren

Max Purnell

Greg Hart

John Knauf

Sefton Alexander

Dave Read

Robin Black

Alec Olsen

Tim Forde

Ian Millner

Geoff Burke, Agro-Ecological

Mark Mitchell, HBRC

Keiko Hashiba, HBRC

Campbell Leckie, HBRC

Dr Barry Lynch, HBRC

Dr Andy Hicks, HBRC

Melissa de Landes, HBRC

Jolene Townsend, HBRC

Cerasela Stancu, Envirostrat

Tracee Te Huia ,NKII

Ben Douglas, HBRC

Dr Sean Weaver, EKOS
Amanda Langley, Projecthaus
Ben Anderson, Projecthaus
Mike Marden
Pete Shaw, Lifeforce Restoration Trust
Marco Lausberg, Specialty Wood Products
Dr. Chris Phillips, Landcare Research
Brett Gilmore, Brett Gilmore Consulting
Simon Taylor, FP Insight
Andrew Clarke, PF Olsen
Kit Richards, PF Olsen
Mike Duckett, PF Olsen
Bob Pocknall, PF Olsen
Jeff Schnell
Michelle Harnett, Scion
Richard Yao, Scion
David Palmer, Scion
Tim Payn, Toi Ohomai Institute of Technology and Scion
Grant Dodson, City Forests
Peter Hall, Scion
Dean Meason, Scion
John Moore, Scion
Graham Coker, Scion
David Pont, Scion
Peter Manson, HBRC
Nathan Heath, HBRC
Dean Evans, HBRC
Warwick Hesketh, HBRC
Madeline Hall, HBRC