The Aotearoa Circle

Mā te Kaitiakitanga ko te Tōnuitanga
Prosperity Through Guardianship

Native Forests: Resetting the balance

Letter from the Chairs

2020 has been a unique and challenging year for our planet, and one that has driven home to most New Zealanders how fortunate we are to be living in an incredible country that is comparatively less polluted than many others, sparsely populated and generously furnished with natural resources. The beauty and diversity of New Zealand's landscapes is world renowned and accessible to us all.

However, all is not well in this incredible ecosystem we call home. The intensification of land use in New Zealand is driving huge numbers of our plant and animal species to the brink of extinction, air, soil and water pollution is increasing, and introduced mammals are decimating our native flora and fauna. While there are many projects underway across the country to address these issues, greater effort – at scale and at pace – is required to achieve real impact, and stem irreversible damage to our native biodiversity.

Through a series of discussions, interviews and workshops, the Biodiversity Domain of the Aotearoa Circle agreed that there is an opportunity to expand the role that businesses and government play in accelerating the regeneration of our native biodiversity, and this could be done through incentivising and scaling native planting across the country. Unfortunately, existing structures and mechanisms favour the planting of exotics species (*Pinus radiata* in particular) over New Zealand native species. Changes and further incentives are needed to reduce the feasibility and viability gap between exotics and natives, and 'level the playing field'.

There are already a wide range of activities underway and planned within both the public and private sector, however more needs to be done to tackle our biodiversity challenges. Our research suggests that the current market for carbon units, land availability and the viable commercial opportunities that already exist present an opportunity to develop a mechanism (or suite of incentives or levers) that will work both within the ETS, or be complementary to it.

As a working group, we challenged ourselves to find ways in which native planting could be incentivised, accelerated and scaled, to make a real and meaningful impact in addressing New Zealand's biodiversity crisis.

The recommendations we set out in this report, in seeking to incentivise native planting at scale, fit into three broad categories:

1. **Financial incentives and subsidies** which seek to reduce the financial gap between pine and native planting
2. **ETS changes** that could broaden the scope of eligible land to include land types more suited to natives
3. **Recommendations to reduce barriers and kick-start the market** through increasing the commercial viability and feasibility of native planting at scale

By prioritising funding, action and initiatives, and leveraging the ETS as we have set out in this report, New Zealand has an opportunity to:

- Accelerate the regeneration of New Zealand's native biodiversity
- Address a range of other acute environmental issues we face
- Contribute to establishing additional carbon sinks that will support the country's carbon reduction targets
- Optimise the use of marginal land and,
- Develop new revenue streams for land owners, and employment opportunities for others.

There is a genuine desire from both private and public entities to seize the opportunity to focus carbon offsetting initiatives on addressing New Zealand's biodiversity challenges.
This opportunity will be wasted unless the right support mechanisms and policy settings are urgently put in place to address the feasibility gap that exists between native and exotic plantings.
We urge the Government and New Zealand businesses to consider how they can enable the recommendations within this report to deliver a more holistic and long term benefit to New Zealand.

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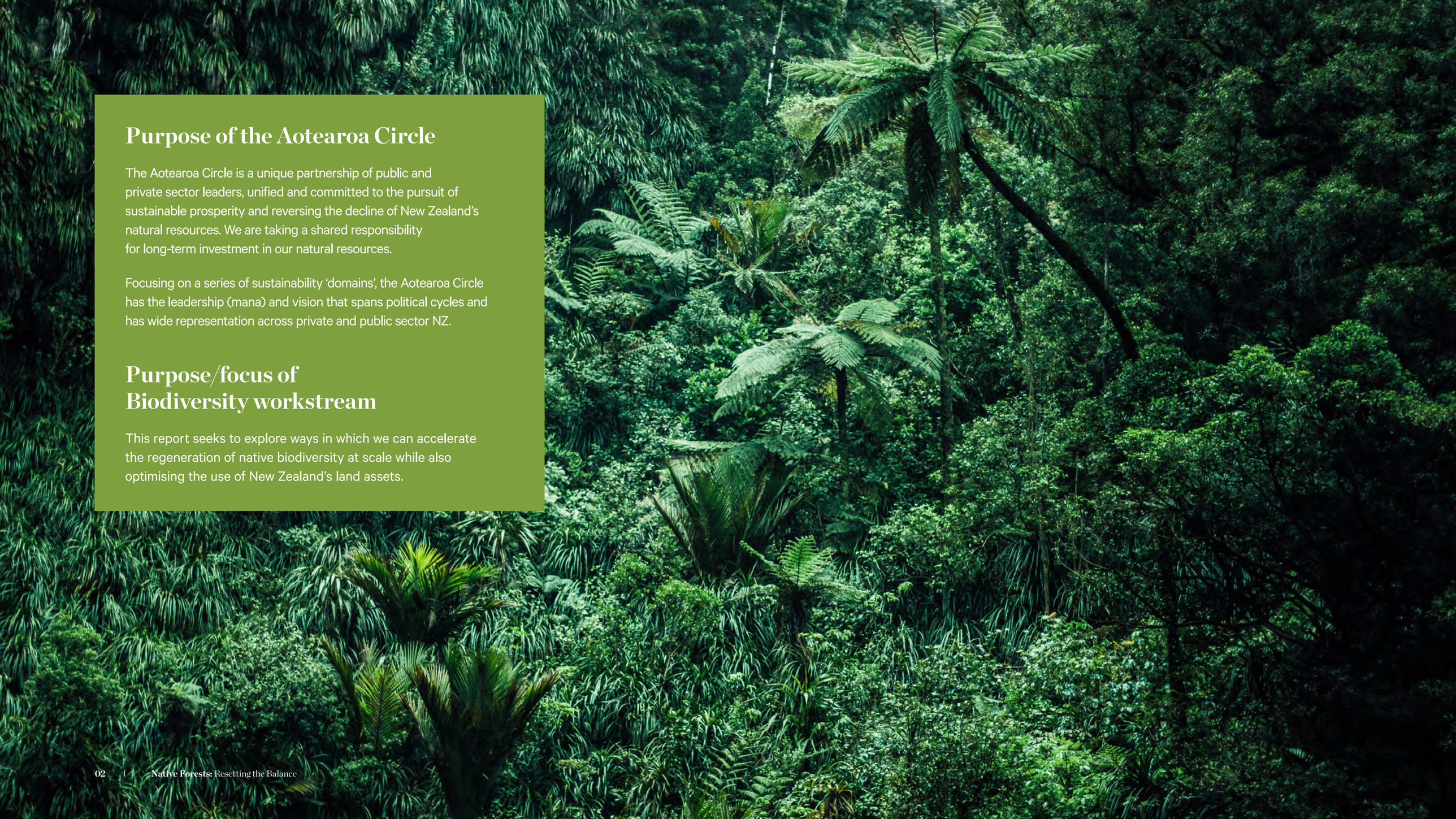


Purpose of the Aotearoa Circle

The Aotearoa Circle is a unique partnership of public and private sector leaders, unified and committed to the pursuit of sustainable prosperity and reversing the decline of New Zealand's natural resources. We are taking a shared responsibility for long-term investment in our natural resources.

Focusing on a series of sustainability 'domains', the Aotearoa Circle has the leadership (mana) and vision that spans political cycles and has wide representation across private and public sector NZ.

Purpose/focus of Biodiversity workstream

This report seeks to explore ways in which we can accelerate the regeneration of native biodiversity at scale while also optimising the use of New Zealand's land assets.

01 – Introduction

New Zealand's native biodiversity is in crisis. The recently released report *Biodiversity in Aotearoa – an overview of state, trends and pressures 2020*[1] serves as sobering evidence that many of the unique plants, animals and ecosystems which characterise New Zealand's cherished natural environment are on the brink of extinction. The intensification and evolution of land use, presence of invasive pathogens and pests, and changes to our climate and weather patterns are causing ecosystems and species to degenerate at a rapid and in some cases irreversible pace.

The decline of New Zealand's native biodiversity presents a complex set of challenges and consequences, with far reaching implications for our ecosystems, climate resilience, culture and prosperity.

Currently, climate change is dominating the political and economic airways to such an extent that there is not yet an understanding that biodiversity loss also has significant financial implications. Threats to healthy ecosystems that provide services to businesses can present real financial risks for those businesses, financial institutions, investors and ultimately the whole economy. The loss of pollination or ecosystem services, for example, could materially affect a wide range of agriculture and aquaculture businesses, among others.

The Aotearoa Circle believes New Zealand business could be playing a greater role in protecting and regenerating the country's native biodiversity, and sees a clear opportunity to leverage the existing mechanism of the Emissions Trading Scheme (ETS) to achieve progress at scale and at pace.

As the Government's main tool for meeting domestic and international climate change targets, the ETS encourages the removal of carbon from the atmosphere through the planting of forests. Demands from businesses for both mandatory and voluntary carbon offset products to meet carbon reduction commitments continue to grow ensuring healthy demand, however a range of limitations, barriers and specific attributes of the scheme favour exotic forests – almost exclusively of *Pinus radiata* (Pine) – over biodiverse native forests.

The imbalance between natives and exotics within the ETS has implications on the regeneration and maintenance of New Zealand's biodiversity and in some instances, soil and waterway health. As less diverse ecosystems, monoculture forests are also less resilient to climate change and plant pathogens than permanent, biodiverse native forests. Therefore, investment in exotic monocultures represents not only a lost opportunity to regenerate our native biodiversity, but it may also represent an approach that is increasing material financial risks, rather than decreasing them.

This report explores the financial gap favouring monoculture exotic forests over biodiverse native forests in New Zealand, and the incentives, policy settings and funding mechanisms required to 'reset the balance' by levelling the playing field for native forests.

Addressing biodiversity loss is a task too great for the public sector alone and the New Zealand private sector has an increasingly vested interest in actively contributing to the regeneration of native biodiversity. However, like many economic or cultural shifts Government intervention will be a key enabler of these efforts.

Through this report, the Aotearoa Circle hopes to spark much needed debate around the unique opportunity for the Government and New Zealand Inc. to jointly drive the regeneration of New Zealand's biodiversity at scale, through the widespread establishment of biodiverse, permanent forest sinks.

The ETS manages the trading of New Zealand Units (NZUs) or 'carbon credits' which equate to one tonne of carbon dioxide and equivalent greenhouse gases. Currently, an NZU can be created through carbon sequestration of new trees (planted on land otherwise not in forestry since 1990).

The revenue potential of a forestry participant in the ETS is a direct reflection of the estimated carbon sequestered by the forests they have registered within the scheme. A consequence of this has been a tendency to favour the planting of pine and other fast growing exotic species. These species have the advantage of being cheaper and having a higher carbon earnings rate. Costs associated with planting are lower, and earnings in the form of sequestering carbon, (particularly in the first 50 years) are higher than native species.

02 – Biodiversity in New Zealand

Biodiversity

/ bʌɪə(ʊ)dʌɪˈvəːsɪti /
noun

The variety of all biological life – plants, animals, fungi, and microorganisms – the genes they contain and the ecosystems on land or in water where they live. It is the diversity of life on earth.[2]

Together, the loss of nature and climate change are the "twin emergencies" facing humanity; turning a blind eye to either can leave businesses vulnerable and exposed to risks.

– The Nature of Risk Report, WWF, 2019

The term 'biodiversity' is a contraction of 'biological diversity'. Biodiversity is complex and has many different levels of organisation, from genes through to ecosystems and landscapes. There is also variety at all of these levels, from variation in the genetic makeup of an individual species, to variation among the ecosystems and species that occur in different landscapes. Biodiversity is maintained by preventing simplification of this variety.[3]

Enhancing biodiversity entails representing 'a full range' of life forms that can persist and continue to evolve. 'Representation' is a measure of how much of the complete spectrum of natural ecosystems, and the species they support, remains or is protected.

Protecting and enhancing the biodiversity of New Zealand is central to supporting our unique natural environment which is fundamental to our very existence, our culture, our way of living, international brand and key sectors of our economy.

New Zealand's biodiversity is in a state of rapid decline

New Zealand is facing a biodiversity crisis. Intensification of land use in New Zealand as well as the presence of invasive pathogens and pest plants and animals has caused our native ecosystems and species to degenerate at a rapid and in some cases irreversible pace. Environments typically unsuitable for extractive human activities are where the majority of our native biodiversity remains.

A range of factors are contributing to the acceleration of this decline:

- Changing climatic conditions brought on by global warming is already impacting habitats and ecosystems
- Business and economic drivers favour alternative land use and intensification of activities (e.g. forestry, agriculture, urbanisation)
- Native plantation growth rates and therefore carbon sequestration rates aren't competitive with exotics in the short term, and establishment costs are higher. This is driving commercial forestry preferences for exotic monoculture plantations to maximise the value of both timber and carbon
- Rapid urban growth in parts of New Zealand is reducing versatile land and native biodiversity
- Air, soil and water pollution, and increasing volumes of waste and chemical use such as pesticides from human activity continue to degrade our natural assets
- Introduced mammals such as possums and stoats threaten native bird, invertebrate and plant species through predation as well as competition for habitat and food sources.

According to MfE's report series *Our Land 2018* and *Environment Aotearoa 2019* we have around 4,000 species threatened or at risk of becoming extinct.[4]

Biodiversity is protected through various legislative measures and implementation is undertaken through the New Zealand Biodiversity Strategy. In addition, Government ministries and agencies are taking active and innovative measures in conjunction with corporates and iwi. However these actions don't currently achieve the scale and momentum needed to stem the biodiversity crisis we are facing.

75

At least 75 animal and plant species have become extinct since humans arrived in New Zealand.

90%

of New Zealand's seabirds,

76%

of freshwater fish,

84%

of reptiles, and

46%

of vascular plants are currently threatened with or at risk of extinction.[5]

New Zealand's prosperity is built on our unique, natural environment

Our key sectors of primary production and tourism rely on benefits from nature. Our country's brand – built on an image of a pristine natural environment – gives these industries a competitive advantage in the international market. A study undertaken by the Ministry for the Environment estimates that our 'clean, green' brand is likely to be worth hundreds of millions, possibly billions, of dollars per year.[6]

Our native species play a critical role in supporting this environment

New Zealand's farming, forestry and horticulture sectors typically rely on non-native species, but native biodiversity contributes to their success through ecosystem services such as clean water, nutrient cycling and pollination. Marine species form the basis of our fisheries industries, whether taken from wild stocks or aquaculture.

Our natural environment is a core part of our culture

A thriving natural environment provides space for the experiences and recreational activities loved by Kiwis and visitors to New Zealand and enables tangata whenua to connect with the environment and each other. The native biodiversity of New Zealand is fundamental to Māori culture, as nature and people are entwined through whakapapa (genealogy), te reo (the Māori language), tikanga (custom), toi (the arts), kai (food), rongoā (medicines) and taha wairua (spirituality).[7] The loss of biodiversity and the growing distance between the people and what biodiversity remains are undermining relationships, responsibilities and practices (Waitangi Tribunal 2011).

Ecosystem Services

Our native species deliver a range of ecosystem services, from erosion control and water purification to cultural and economic benefits.

Cultural services

- Species conservation and education
- Recreation and tourism
- Cultural identity and expression
- Mental and physical health

Provisioning services

Food | Water | Medicines | Wood and fibre

Cultural value

A healthy ecosystem enables tangata whenua to connect with the environment and each other. It provides sustenance and materials for cultural practices and expressions like waiata, karakia, and wairua.

Graphic based on ecosystem services diagram by Ministry for the Environment, 2019

Building the case for native planting

The opportunity costs associated with the removal of higher quality land use classes from pastoral or arable agriculture means that land available for native forests is often on poorer soils, steep sites and tending to be further from built infrastructure. While these areas are also suitable for exotic forest plantations, permanent native forests offer considerable ecosystem service benefits in the form of reducing sediment, nitrate leaching and phosphorus loss alongside net carbon sequestration.[8] Native forests also offer the best habitats for most native species of plant, insect and fungi.

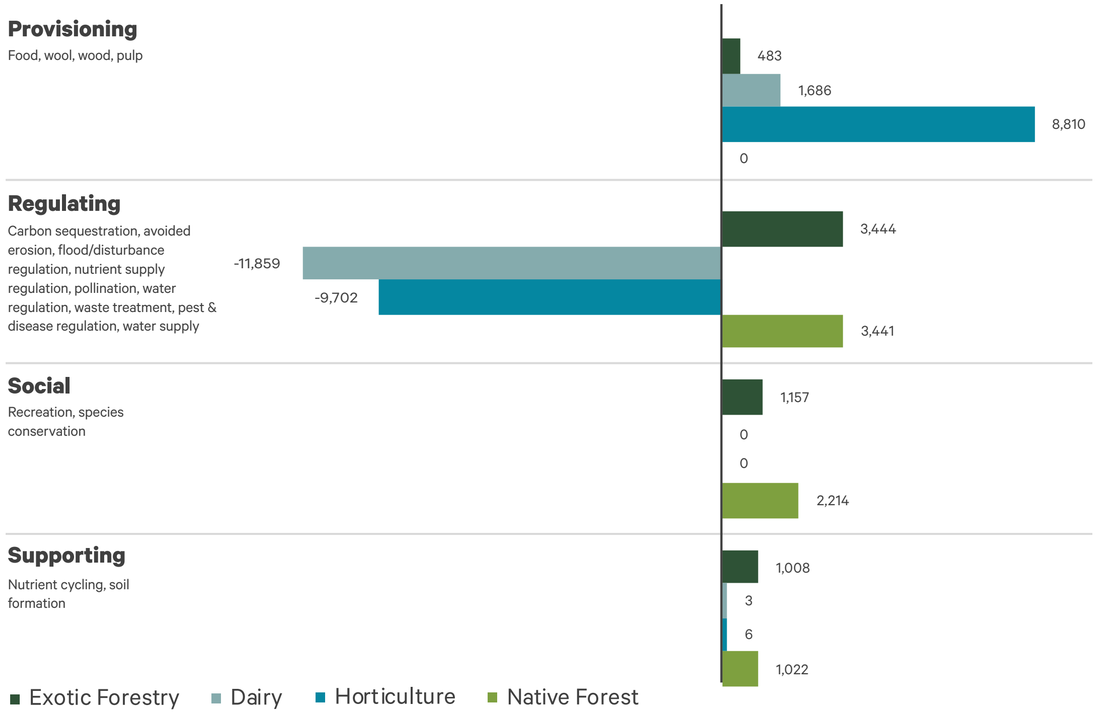
Recently published research suggests that exotic plants reduce carbon sequestration when they are eaten by insects and exposed to microbial bugs in the soil 2.5 times more than natives.[9] In addition, native forests offer the best habitats for most native species of plant, insect and fungi.

The introduction of exotic conifers is more likely to co-introduce exotic fungi, while also replacing both light-demanding and shade-tolerant phases of forest development, potentially modifying site conditions such that native forests can no longer thrive there.[10]

The benefits of native biodiversity – a case study

A wide analysis of ecosystem services in the Ōhiwa catchment found that native forest created greater overall value than other land uses.[11] Notably, by contrast with exotic forestry, native forest produced greater value for its species conservation, recreation benefits, and superior regulation of erosion and floods. These benefits offset exotic forestry's superior levels of carbon sequestration until maturity, given the generally faster growth rates of exotic trees species.

Figure 1: Estimated value of ecosystem services per hectare in the Ōhiwa catchment ($)[12]



The total value of ecosystem services per hectare were estimated at:

$6,092
for exotic forestry

-$10,170
for dairy

-$885
for horticulture

$6,677
for native forests

Note, the monetised values of the benefits of native forests (other than carbon sequestration) are currently only estimates – without markets, true monetary value is not known.

03 – Incentivising and scaling native planting in New Zealand

By not actively incentivising natives within the ETS, New Zealand is missing the opportunity to address our native biodiversity crisis.

325,000

hectares of forest land are registered in the ETS. Of this, only

31,000

hectares are native. Almost 90% of this native afforestation occurred between 1990 and 2000 so was not established in response to the ETS.[13]

A successful solution requires scale and commercial viability

The 1 Billion Tree Programme (1BT) has been particularly successful in encouraging planting of exotic trees for carbon sequestration purposes. Recent amendments to the ETS are also working to further incentivise afforestation. An unintended consequence of this is a lost opportunity to further support the regeneration of New Zealand's native biodiversity. The current market for carbon units (both voluntary and mandatory), the amount of land available for these purposes and the momentum and viable commercial opportunities that already exist, present an opportunity to develop a mechanism (or suite of incentives and levers) – that will work both within the ETS, or be complementary to it – that will support parity between natives and exotics.

There are a number of other initiatives currently looking to address New Zealand's biodiversity and carbon emissions challenges, however commercial model feasibility and scalability varies. These initiatives include:

- **Trees that Count/Project Crimson** has been working to develop and trial a financial instrument to support the planting of native trees, including socialising a concept paper for 'biodiversity credits' with the Government.
- **Te Uru Rākau** has a project to develop guidance for owners of post-1989 indigenous forests who may choose to aggregate their land to measure carbon sequestration using the field measurement approach under the ETS.
- **Auckland Council** are looking at the feasibility of developing the methodology, model and platform for carbon off-setting for small plantings, soil carbon and blue carbon.
- **He Waka Eke Noa (HWEN)** – the government and primary sector partnership to reduce agricultural greenhouse gas emissions – has an on-farm sequestration workstream underway focused on finding a way to value and incentivise all non-ETS eligible plantings and soil regeneration.

New Zealand's carbon market ecosystem

In 2018[14] there were:

- 2,134 participants within the ETS
- 35.3 million units surrendered in total
  - 7.5 million Forestry NZUs earned by foresters
  - 8.2 million Other NZUs including those allocated to industrial allocation recipients
  - 0.29 million NZ AAUs (Kyoto Units from the first commitment period)
  - 16.8 million tonnes of CO2e covered through use of the Fixed Price Option ($25 cash payment to Government)

A growing number of New Zealand businesses are opting to voluntarily offset their carbon emissions through funding projects associated with establishing permanent forestry, generating renewable energy or replacing existing technology with carbon efficient alternatives. These projects can be based in New Zealand or internationally with prices ranging from ~$5 to $45 per tonne.[15] Generally New Zealand based projects, particularly those involving the establishment of permanent native forests, come at a significantly higher cost to the emitter than international projects.

Demand

NZ companies and individuals buying NZUs and carbon offsets

Enabler

NZ Government

Supply

- Land owners: Farmers, Māori, Department of Conservation
- Native trees: seed suppliers, nurseries and tree planters

Demand: New Zealand companies

There is demand for natives and NZ based projects, within the mandatory and the voluntary offset markets

Many New Zealand corporates have indicated a preference to support New Zealand based native planting projects through their offsetting efforts. However, in many cases the cost premium and limited availability of these types of offsets in the domestic market ultimately result in offsetting spending decisions that support exotic and/or international projects. This is despite businesses acknowledging additional benefits that investing in natives can bring when it comes to brand, reputation, deepening engagement with stakeholder communities and wider ecosystem benefits.

Previous actions, including a briefing to the Incoming Minister for Climate change issued in 2017 titled *Opportunity for New Zealand to remove barriers to native forestry offsetting and value co-benefits of afforestation*, evidence the interest from public and private sector bodies in pushing for change in favour of natives. The briefing was developed by Air New Zealand and signed by executive and board members of Air New Zealand, Environmental Defence Society, Royal Forest & Bird Protection Society of NZ, Z Energy, Federated Farmers of New Zealand and Westpac NZ.

3,600h

Since 2008, only 3,600 hectares of native forest has been afforested and included in the ETS; this represents 7% of afforestation in the ETS since 2008 (Ministry for Primary Industries 2016).[16]

> *Air New Zealand's voluntary carbon offsetting programme, FlyNeutral is supporting permanent native forests in New Zealand with increasing volumes being required. Future supply of those high quality offsets is now becoming constrained and risks being unable to keep pace with demand. We've also engaged on the issue of encouraging more natives within the ETS for several years, with previously commissioned research highlighting that lower sequestration rates are the major factor, but not the only one.*[17]
>
> Air New Zealand

> *We have been talking to our clients about how planting pine can be an effective way of reducing their cost of carbon. Our clients would generally prefer to plant natives. However, the additional cost is too high and the rate at which carbon is earnt is too slow, compared to pine. If this gap was eliminated, we believe a substantial increase in native planting would occur.*
>
> PwC

> *"Mercury invested in long-term forest contracts in 2010 to meet emission trading scheme obligations. We would certainly consider giving native forest-carbon projects preference if the economics were comparable to non-native alternatives, particularly in light of our long-term view of kaitiakitanga (guardianship)".*
>
> Mercury

> *Fonterra recently collaborated with Foodstuffs North Island to launch Toitu carbonzero certified Simply Milk. Sourcing credits from native New Zealand forest has constraints with regards to volume and security of supply for the product. As a result we are sourcing 50% of the credits for Simply Milk from native forest regeneration in New Zealand from land previously in the PFSI scheme, and 50% through Toitu from international credits issued under the Gold Standard. We have a preference for native New Zealand forest credits, particularly for the complementary benefits associated with biodiversity, water and soil quality, and would look to source more credits from native forest regeneration in New Zealand if there was greater confidence in volume and security of supply.*
>
> Fonterra

Supply: Land

There is a significant amount of land in New Zealand that could support native forests.

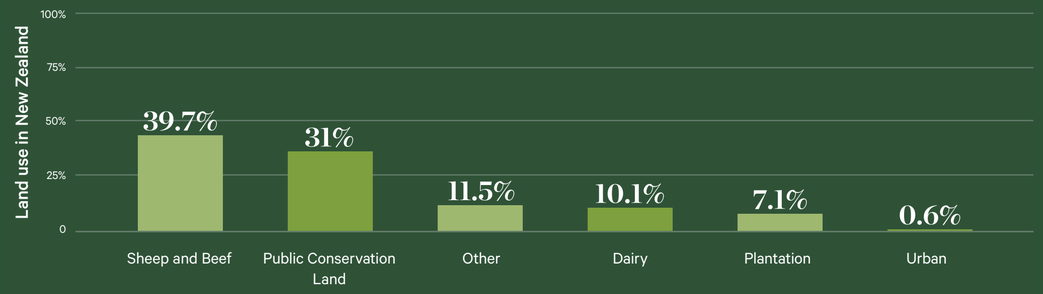
Analysis carried out by Manaaki Whenua concluded that if we consider land which:

- is privately owned land parcels over 5ha in total size
- is not already in forest
- can be marginal for pastoral agriculture (i.e. Land Use Classes 6, 7 & 8 under the NZ Land Resources Inventory Land Use Capability classification)
- is suitable to support tree species (based on altitude and other environmental factors such as soil condition)
- is not suitable for commercially-grown exotic forests
- is not an ecologically sensitive area
- could naturally regenerate tall forest

there is a total of 260,000ha in the North Island and 480,000ha in the South Island which could potentially regenerate native forests.

Much of this land area would naturally regenerate, with less intensive measures such as fencing and pest management. For some of this land area, the time to achieve a forest canopy could be accelerated with more intensive measures such as initial site preparation, seedling planting and release from weeds.

Figure 2: Percentage of land area in different land uses[18]



With a more even playing field for financial yield, many landowners are more likely to support natives over exotics.

> *"New Zealand food producers have an opportunity to regenerate areas of their land through appropriate native plantings. In doing so they can show global consumers how their farming systems protect and care for biodiversity and create food that consumers can trust."*
>
> Silver Fern Farms

Marginal farmland

A survey of 500 sheep and beef farmers showed that close to 80% felt that protecting and managing native biodiversity on their farms was important.[19]

Collectively, sheep and beef farms comprise the most extensive land use in New Zealand, accounting for 40% of the total land area (compared to 31% of NZ which is public conservation land).[20]

The land stewardship ethic and inter-generational thinking that characterises much of pastoral farming in New Zealand, especially sheep and beef farming, represents an opportunity to increase the native biodiversity present on (marginal) pastoral land.

Collectively owned Māori land

Regenerating native forests have long been used by Māori as sources of fuel, medicine and food[21] and there are many reasons why iwi, hapu and Māori entities may prefer native forests over exotic ones, especially if this choice does not necessitate economic sacrifice.

As recognition grows that forestry is a longer-term option that fits well with Māori aspirations in terms of spiritual, environmental, social, cultural, and economic needs, so does a lingering dissatisfaction with current forestry practices.[22]

Māori owned enterprises such as Ngati Hine Forestry Trust are actively managing their forestry operations to phase out pine,[23] however, a long-term land use strategy and focus on innovation across the wood product supply chain is required in order to drive financial return comparable to pine.

Solutions which level the playing field between native and pine would support adequate economic return and cultural benefit for Māori.

Public Conservation Land

As the body which manages New Zealand's Public Conservation Land, the Department of Conservation is ultimately responsible for maintaining and/or regenerating biodiversity across approximately one third of New Zealand's total land area.

Supply: Native seedling supply

To drive regeneration of native biodiversity at scale, the native seedling industry will need to scale up significantly. Growth of the industry requires an integrated strategy and targeted government support.

Results from the 2019 New Zealand Plant Producers Inc. (NZPPI) native nurseries industry survey, Growing New Zealand, suggest that the native seedling industry is growing at an increasing rate (12% – 15% per year over the past three years). However, in the face of increasing demand from programmes such as the 1BT programme and an increased focus on riparian and revegetation planting in New Zealand (mainly for major roading projects), NZPPI predicts that the rate of growth is not sustainable for the industry indefinitely without affecting debt, profitability, and skilled labour supply.

NZPPI's analysis indicates that only a small proportion of new production has been committed to tree species. This trend is expected to continue and NZPPI projects that meeting 1BT's goal of more than 200 million native trees planted by 2028 will require an additional 50 million native trees beyond the projected sustainable growth.[24] NZPPI believes that 'attaining this extraordinary growth in native tree production needs a planned industry strategy that includes a partnership between Government, industry and the public.'

Enabling sustainable industry growth should focus on addressing a range of market inefficiencies that currently constrain growth including:

- Unsustainable tendering and project management practices. These are currently leading to cost undercutting and nurseries carrying the financial risk associated with project delays or mismanagement.
- The competitive advantage granted to government subsidised community-based nurseries over those which are commercially driven.
- The lack of understanding of growing lead times and project timeline constraints creating friction between nurseries and large scale buyers (particularly with respect to eco-sourcing and the 2-4 year lead time required to produce seedlings).[25]

Enabler: The government

The New Zealand Government is a key enabler in driving the regeneration of native biodiversity, and has allocated funding to achieve related goals and targets.

The New Zealand Government has ambitious goals and targets relating to native biodiversity including eliminating selected introduced mammalian predators (Predator Free 2050), and maintaining and restoring native biodiversity (as outlined in a recent consultation on the draft National Policy Statement for Indigenous Biodiversity.)

The 2020 Budget saw $1.1 Billion allocated to restoring the environment with a focus on regional environment projects, pest eradication and management, conservation and restoring biodiversity.

The regeneration and management of native forests also contributes to other national environmental ambitions such as those associated with water quality, erosion and conservation of native wildlife.

04 – The pine/native imbalance

The key considerations driving a preference for pine over natives within the ETS currently are:

1. Carbon sequestration revenue: differing carbon sequestration rates over a short to medium timeframe mean that the revenue potential of pine per hectare outweighs that of natives

2. Establishment and maintenance costs: differing establishment and maintenance costs mean that natives require considerably more up front funding

3. ETS eligibility criteria: a number of criteria and limitations within the Scheme design disadvantage natives

1. Carbon sequestration revenue

Revenue for an ETS participant is based on the estimated carbon sequestered by forests they have registered within the scheme. The default sequestration rates which NZUs are allocated against are given in MPI's Look-Up Tables (values graphed on the right). The tables encourage a preference for exotic species given their higher rates of sequestration, especially pine.

Note:

- the native forest values are based on naturally regenerated forest, not plantation forests
- if greater than 100ha of forest is registered then the Field Measurement Approach will apply, i.e. participants are able to measure and model the carbon sequestration from their forest stand instead of using the Look-Up Tables.

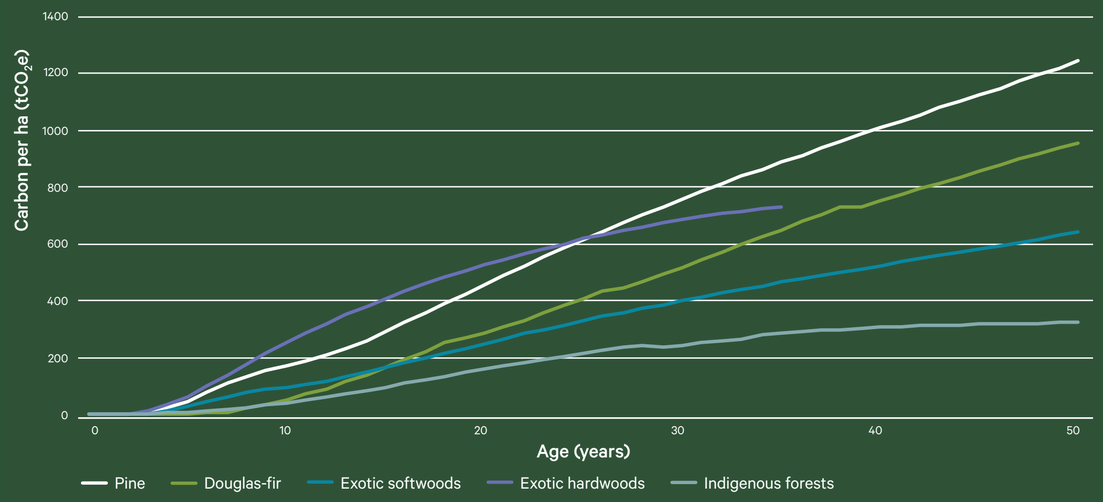
It is generally accepted that exotics such as pine sequester more carbon and therefore make a more viable investment when it comes to the carbon market. However there are several reasons why the current look up tables further disadvantage natives. These tables apply to all native species across all regions despite research showing significant variation in the sequestration of different species, forest ages and regions for planted stands. The tables also only extend to 50 years, whereas plantations of native species require at least 60 to 80 years to achieve maximum growth rates. Naturally regenerated forests will accumulate carbon for hundreds of years. In both instances, the artificially shortened sequestration curve underestimates the true total carbon stocks of native forests.

Carbon sequestration:
the rate at which carbon is stored

Carbon stock:
the volume of carbon stored.

Pine stores carbon faster but native trees hold greater carbon stock over the forest life cycle.

Figure 3: carbon sequestration as a function of forest age[26]

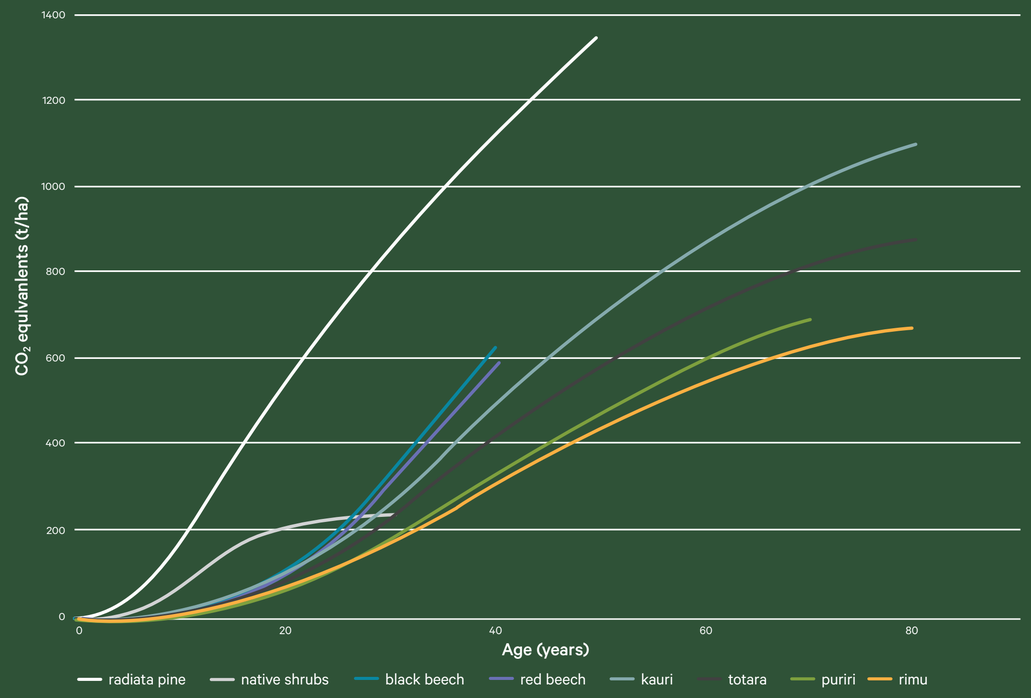


Variation between species and forest age:

Research by Tāne's Tree Trust shows significant variation in surveyed trees of the same species, which are planted in different regions. A 48-year-old Kauri surveyed in Hawkes Bay had estimated carbon stocks of 966 (t/ha), almost three times higher than a 36-year-old Kauri in Northland, which had estimated carbon stocks of 393 (t/ha). There is also significant variation for Kauri at different ages. Kauri are storing significant amounts of carbon after 50 years of growth. 71-year-old Kauri trees' carbon stocks were estimated to be 47% higher than 51-year-old Kauri trees in the same location.[27]

Figure 4: Illustrative graph based on Tāne's Tree Trust graph of predicted carbon sequestration rates on average sites for several native tree species, mixed species shrub planting, and a typical radiata pine stand.[28]

Note, pine sequestration rates for this figure were sourced from the ETS carbon sequestration look-up tables which only cover the first 50 years of a forest's lifecycle.



2. Establishment and maintenance costs

Assuming a planting density between 2x2m and 4x4m, the estimated costs to establish a native forest on a grass site ranges between $3,438 and $13,750 per hectare. The ongoing inspection and control of weeds in the first five years post planting is estimated to be $300 per hectare per annum.[29] Control of pest animals also needs to be considered when establishing or regenerating forest areas, the cost of which varies considerably depending on methods used.

Table 1: Establishment and maintenance costs of native forests on grass sites ($ per ha)

	Planting density	
Cost	**4x4 (625 stems per ha)**	**2x2 (2500 stems per ha)**
Site preparation (including herbicide spraying of grass, some woody weed vegetation clearance)	$313	$1,250
Seedling cost @ $4 per seedling	$2,500	$10,000
Planting cost @ $1 per seeding	$625	$2,500
Total establishment costs	**$3,438**	**$13,750**

Direct grants and top-ups to help with the costs of fencing, land preparation, and planting on erosion prone land are available under the 1BT programme for:

- **Native Planting:** $4,000 per hectare to plant a native forest.
- **Native Reversion:** $1,000 per hectare to assist the reversion of land to permanent native forest cover.
- **Mānuka/Kānuka Planting:** $1,800 per hectare to plant only mānuka or kānuka.
- **Exotic Planting:** $1,500 per hectare to plant an exotic forest.

However these are currently not sufficient to drive native planting at scale, nor do they support or incentive planting of marginalised land areas.

Comparatively, the cost of establishing a Pine forest (for the purposes of harvesting) is estimated at $3,925 per hectare.[30]

Table 2: Establishment and maintenance costs of pine forests intended for harvest ($ per ha)

Cost	**$ per ha**
Establishment (year 1)	1,140
Establishment (year 2)	235
Establishment (year 3)	225
Thinning (year 7)	140
Landings	80
Harvest roading	1,035
Management	1,070
	3,925

3. ETS eligibility criteria

Under the Climate Change Response Act 2002, forest land:

a. is an area of land of at least 1 hectare that has, or is likely to have, tree crown cover from forest species of more than 30% in each hectare; and

b. includes an area of land that temporarily does not meet the requirements specified in paragraph (a) because of human intervention or natural causes but that is likely to revert to land that meets the requirements specified in paragraph (a); but

c. does not include:

   i. a shelter belt of forest species, where the tree crown cover has, or is likely to have, an average width of less than 30 metres; or

   ii. an area of land where the forest species have, or are likely to have, a tree crown cover of an average width of less than 30 metres, unless the area is contiguous with land that meets the requirements specified in paragraph (a) or (b)

Criteria and limitations within the ETS which disincentive natives include:

- The criteria centre around an area being in forest prior to 31/12/1989 (pre-1990) or after 1/01/1990 (Post 1989). Only post-1989 land is eligible to register in the ETS and claim NZUs. Under the current ETS settings, there is no practical way of delineating pre-1990 regenerating scrub from post-1989 regenerating forest. When land undergoes regeneration there is a point at which shrubs will be intermingled with young forest species which means it is more difficult to satisfy the regulators that the land did not have potential forest at 31/12/1989, particularly for low producing areas such as marginal farmland. This can lead to exclusion of some land areas which are undesirable for exotic plantations or other productive use, yet have potential to support native forests.
- The current 'term' under the Permanent Forest Sink Initiative (PFSI) is 50 years, with the option for landowners to continue with a new 25 year covenant after the first 50 years. This creates a disadvantage for natives given that they have slower maturity rates, significantly longer life spans, and many scientific studies posit that the carbon sequestration potential of natives outweighs that of exotics over a longer term – see appendix 2 for further detail. (Note, the PSFI will be replaced with the new Permanent post-1989 activity in the ETS from 2023).

Opportunities exist to revisit some of these criteria with a view to broadening the parameters of ETS eligible land, creating additional carbon sequestration revenue opportunities, while also contributing to New Zealand's emissions reduction targets, native biodiversity goals and other goals relating to soil quality, erosion and waterways.

05 – Recommendations to incentivise native planting at scale

The critical need to accelerate the regeneration of New Zealand's native biodiversity is not up for debate: The reasons for doing so are very clear. The challenge that exists is driving forward the changes that will incentivise action at pace and at scale.

The research, debate and investigations of the Aotearoa Circle's Biodiversity working group has concluded that there are a range of policy levers, financial incentives and updates to the ETS, which separately or in combination, will narrow the financial gap currently causing monoculture exotic forests to be favoured over biodiverse native forests.

The following page covers a series of recommendations which we believe require urgent and serious consideration.

In aligning with the concepts explored by the Aotearoa Circle's Sustainable Finance Forum, the Biodiversity Domain believes that any form of Government funding relating to investing in nature should use an outcome-based, or 'payment by results' approach. Funding could be linked to biodiversity or other outcomes. For example, instead of 'funding planting' the Government could 'purchase a successful transition from an exotic-dominated ecosystem to a native-dominated ecosystem'.

This way, the Government is not carrying the political risk of project failure, but creating a system change where investors can be paid for success while also carrying the risk for achieving it.

Another alternative to paying for biodiversity outcomes is funding allocated to developing a workforce that delivers these outcomes. This way, expertise is built and career paths are forged which in turn support longevity of the outcomes funded.

> *"ANZ supports the establishment of biodiversity credits and payment for outcomes contracts in helping develop financing products that mobilise capital in support of improving biodiversity in Aotearoa."*
>
> ANZ

Financial incentives and subsidies

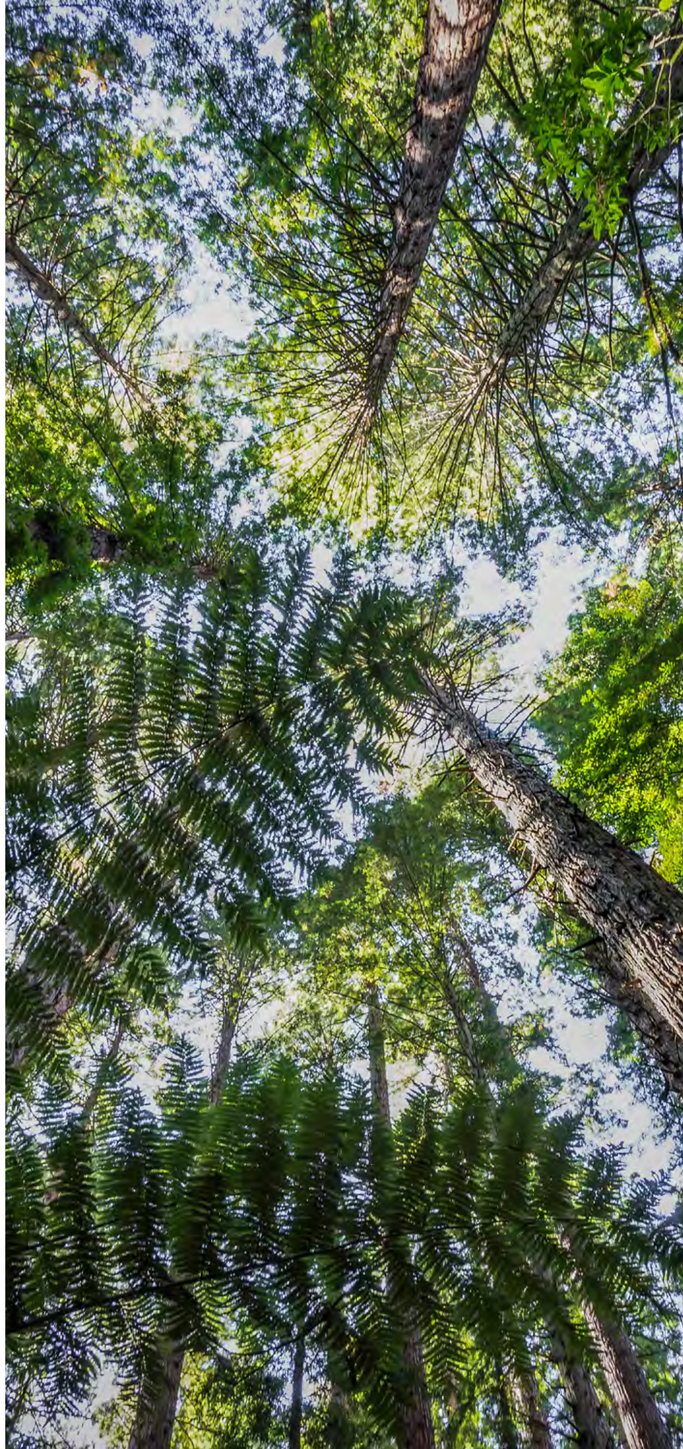
- Extend (beyond 2020) and review the funding and grants available for native planting under the 1 Billion Tree Programme. Options to consider:
  - Increase the grants associated for natives
  - Introduce grants which incentivise/lower the cost for native planting on scrub land (e.g. classify scrub land as priority land, eligible for a top-up grant)
  - Make this funding exclusive to natives
  - Introduce a stand alone fencing grant to support natural regeneration in suitable areas
- Provide or subsidise native seedlings required for the establishment on native forests.
- Provide low-interest loans for establishment costs of native forests.
- Provide funding to support field measurement of native forests.
- Explore the opportunity to apply an outcomes-based approach to funding provided for the purposes of biodiversity regeneration (including the above recommendations).
- Introduce a biodiversity payment or credit which places a monetary value on biodiversity outcomes. For more detail on how this concept could work, see Appendix 3.

ETS changes

- Revisit the ETS eligibility criteria for scrubland to remove current barriers in assessing this land's eligibility for the scheme.
- Review legislation and regulations surrounding public conservation land within the ETS to support the inclusion of new native forests on DOC land within the scheme. Although the Crown cannot participate in the ETS (and therefore cannot claim NZUs), the NZUs could be passed on to and benefit community or local government initiatives, such as native restoration groups or trusts.
- Invest in updating the sequestration look-up tables for natives to more accurately reflect the range of sequestration for different native species and geographic locations.
- Extend the sequestration look-up tables beyond 50 years.
- Explore options to require mandatory ETS participants to invest in a minimum proportion of NZUs associated with native forests.

Other Recommendations

- Consider opportunities to support biodiversity regeneration at scale within the Resource Management Act (or potential substitute). For example, making 'carbon farming' a notifiable activity to enforce criteria requiring defined levels of climate resilience and native biodiversity.
- Consider mechanisms such as defined-period incentives to 'kickstart' the market, particularly incentives or initiatives which encourage the long term sustainability of the native seedling industry (i.e. to drive scale and cost-efficiencies).
- Consider initiatives which would address current market inefficiencies limiting the scale and sophistication of the native seedling industry.
- Consider mechanisms to leverage recent initiatives such as Jobs for Nature to build a skilled and engaged 'biodiversity workforce'. Skills such as seed collection, propagation, nursery management and carbon field measurement could be developed to support biodiversity regeneration beyond the immediate funding period of these initiatives.



Key considerations

Any solutions introduced should ensure the following as a priority:

- Forests must be ‘permanent’ (as per the ETS definition of permanent)
- Forests must be biodiverse (i.e. not monoculture). Native plantation can still be biodiverse depending on the diversity of plant age and species
- Forest owners must ensure appropriate pest plant and animal management is undertaken

Our recommendations do not necessarily intend to exclude native plantations or alternatives such as using exotic pines as nursery plants for eventual transition to native forests. Such alternatives should, however, meet defined biodiversity requirements in line with the above considerations.

Easing the ‘remaining gap’

While financial return is a key driver of participation in the ETS (from a forestry perspective), there are other benefits of natives which mean that the ‘financial gap’ does not necessarily need to be completely closed to drive parity between exotics and natives, and increase the attractiveness of native planting.

- Native planting could attract a premium from New Zealand companies wanting to invest in offsetting their emissions with projects that are aligned to their values
- Biodiverse forests are more resilient to plant pathogens, fire risk and climate change compared to monoculture forests and therefore carry less risk as an investment
- The incentives, changes and recommendations proposed in this report are specifically intended to incentivise native planting within the ETS. However there are also a range of subsidies, grants and funding available from central or local governments in response to other key issues such as conservation, erosion management, pest control and water quality, that could, in combination or alone, level the playing field between exotics and natives.

06 – Conclusion

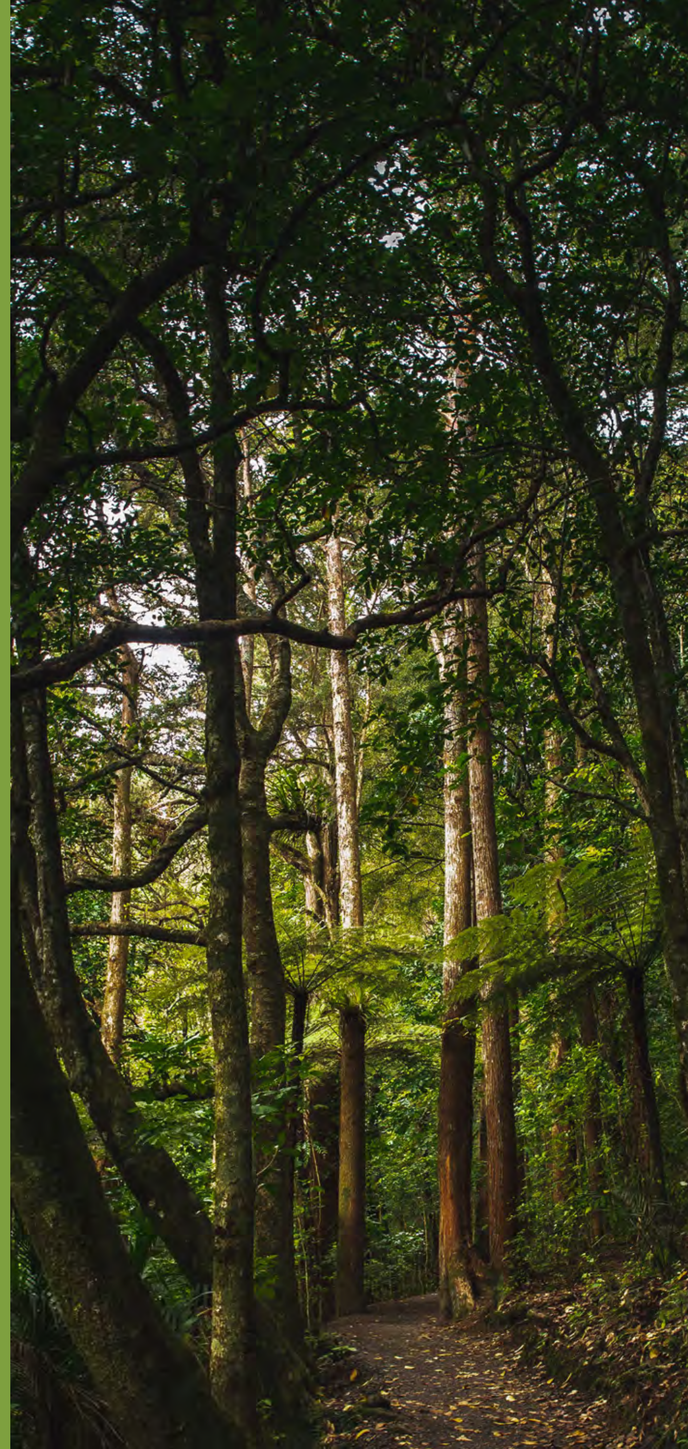
If New Zealand is to respond to its biodiversity crisis, accelerating native planting at scale must be a priority.

As a mechanism to help New Zealand reduce its greenhouse gases, the ETS presents an opportunity to be part of the solution, however, incentives and changes are required to make native planting at scale more commercially attractive.

We urge the Government to prioritise funding, actions and initiatives which will level the playing field for natives within the carbon market and ultimately enable more private investment into the regeneration of New Zealand's native biodiversity.

Leveraging the ETS, New Zealand has an opportunity to:

- accelerate the regeneration of New Zealand's native biodiversity
- address other environmental issues such as soil erosion and water quality to support healthy ecosystems
- establish additional carbon sinks which will help New Zealand reduce its emissions
- optimise the use of marginalised land which has no other productive use
- develop new revenue streams for land owners



APPENDIX 1:

Analysis of land suitable for regeneration of native forests – analysis provided by Manaaki Whenua, Landcare Research

If we consider only private land parcels of over 5 hectares in total size that are not already in forest and can be marginal for pastoral agriculture (i.e., Land Use Classes 6, 7 & 8) we estimate there are approximately 2.8 million hectares of land that appear able to support tree species. This is split between 1.2 million hectares in the North Island and 1.6 million hectares in the South Island. 1.2 million hectares of the total land area are not suitable for production exotic forests.

Further sub-dividing the total land area that could be incentivised for afforestation, according to how easily it may naturally regenerate tall forest, suggests the following:

- North Island land area that excludes areas suitable for commercially-grown exotic forests, excludes ecologically sensitive areas, extreme slopes (i.e., greater than 40°) and areas with environmental factors that limit tree growth (e.g., frost flats, ultramafic soils) and could potentially regenerate native forests with forest tree species is 260,000 ha. The majority of the North Island could naturally regenerate (including the areas suitable for exotic production forests).
- South Island land area that could potentially regenerate native forests with forest tree species (and the same restrictions described above) is 480,000 ha. Of the total South Island land area that could support tree species, only 1 million hectares appear suitable for natural regeneration.

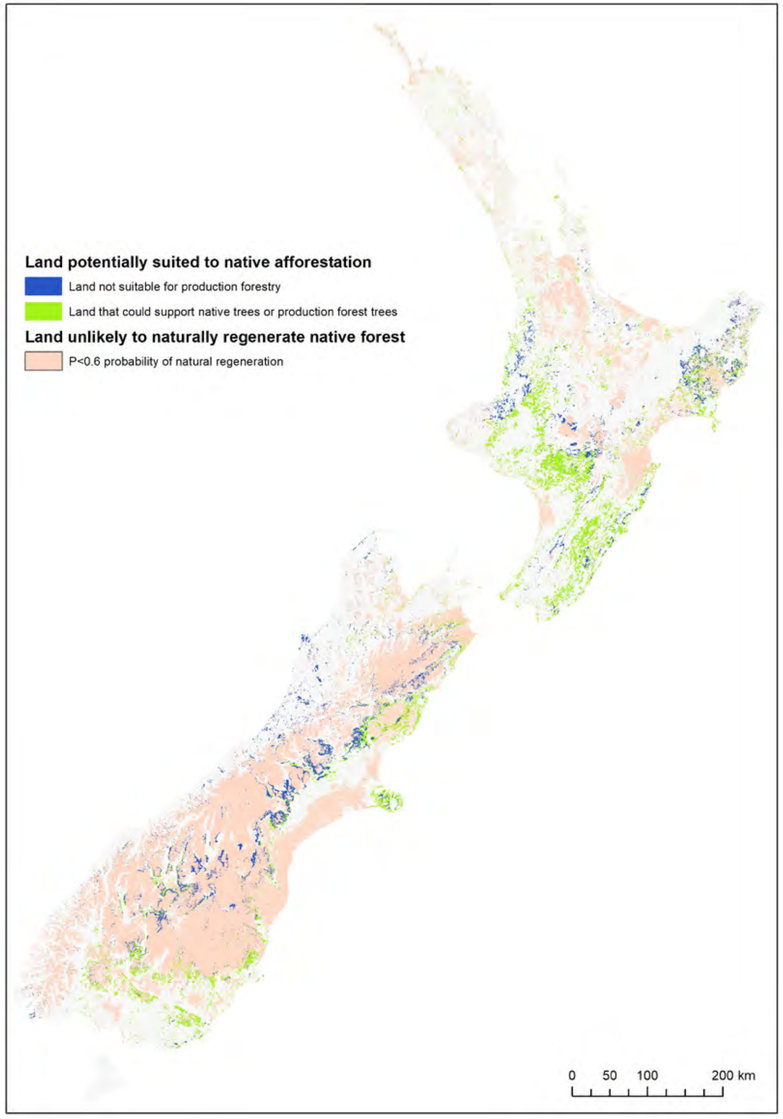
Areas of land in private ownership that can support forest tree species are shown in Figure 5 on the following page. Only the land areas that could naturally regenerate have been mapped – these are shown in either green or blue, depending on whether they are also suitable for exotic plantation forestry or not.

It is recommended that a conservative approach is taken to natural regeneration and that only the most likely areas (i.e., those with > 0.8 probability of regenerating into forest land within 30 years) should use natural regeneration. Other areas may require more intensive treatments such as planting – the best areas still lie within the total that can naturally regenerate (conditions are more amenable to tree growth here).

Probabilities of natural regeneration are taken from Mason et al (2013)[31] and only land parcels with a natural regeneration potential > 0.6 are included in this analysis. Likelihood of natural regeneration is shown in Figure 5 on the following page.

APPENDIX 1:

Figure 5: Total land area that could potentially support native forests through the use of natural regeneration that is not already classed as forest land. Only private land > 5 ha parcel size is included and adjustments have been made for environmental conditions that preclude forest growth. Green parcels indicate areas that could potentially support production forests versus blue areas that are not considered suitable (from MPI). It should be noted that this map uses national scale data so will not be accurate for any individual land-holding or for small land areas.



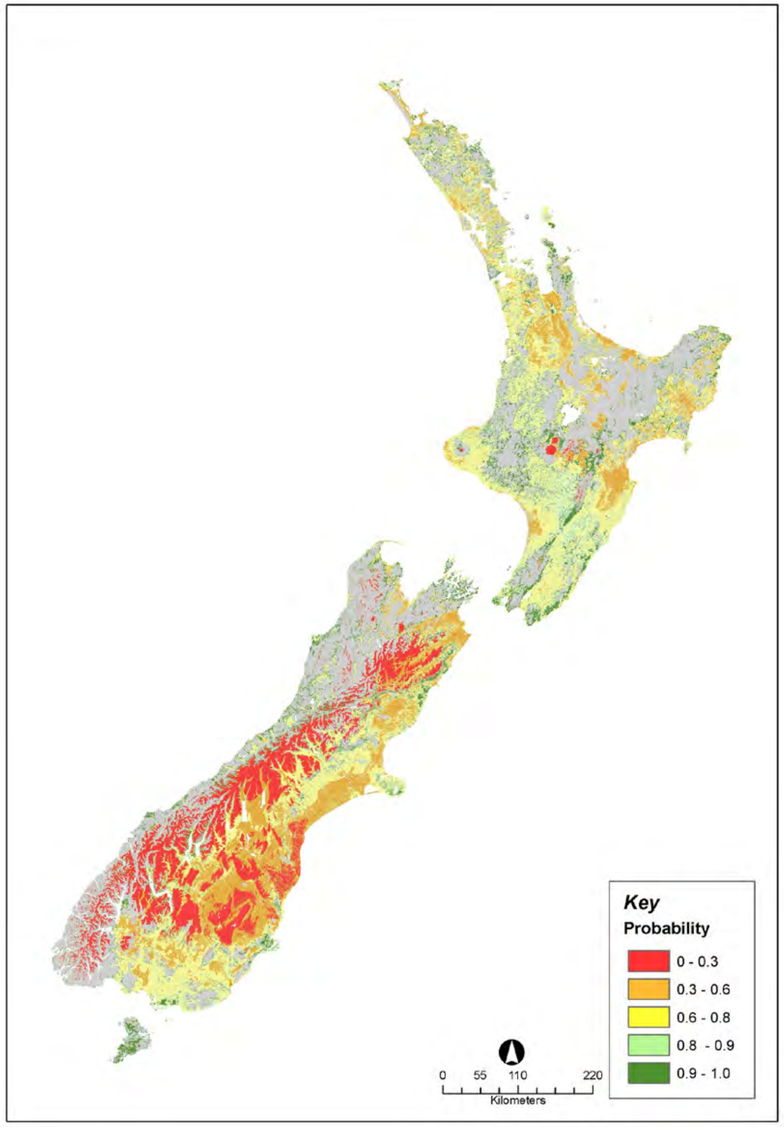


Figure 6: Probability that non-forest land can natural regenerate native "forest" species. Only areas with a P ≥ 0.6 should be considered suitable for natural regeneration of native forests. This map does not indicate time taken for species to achieve 30% crown cover per hectare. Note that land covers are taken from LCDB – greyed areas are those already in forest. Figure reprinted from Mason et al. (2013).

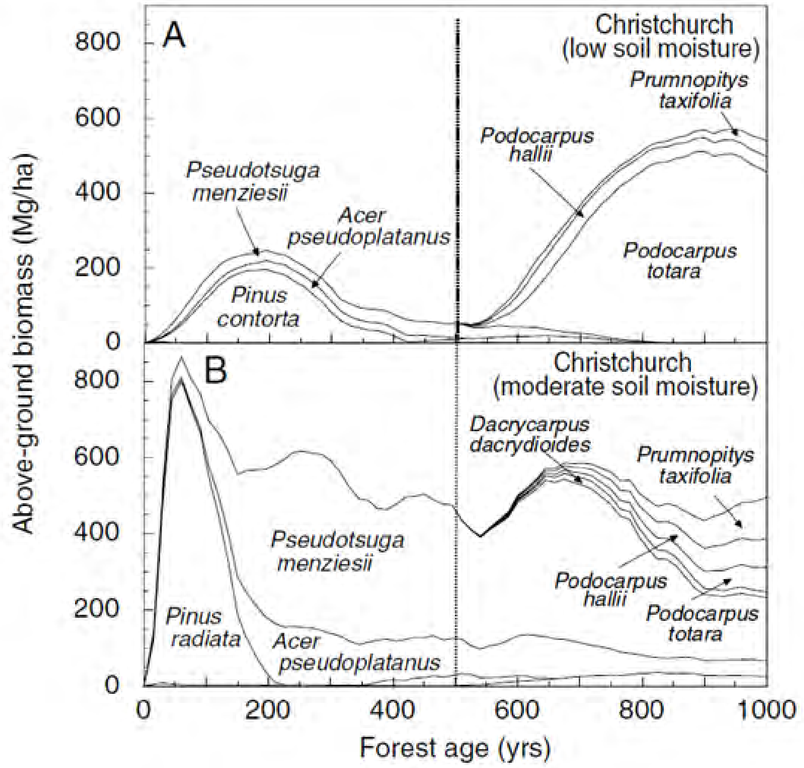
APPENDIX 2:

Native carbon sequestration past the lifespan of pine

Average total carbon stock (excluding soil) of mature natural forest is approximately 950 tCO_2e,[32] but different forest types will attain different maximum stocks. The national Land Use Carbon Analysis System (LUCAS) shows beech/podocarp-broadleaved forests to contain the highest stocks per hectare. Because the forests are comprised of cohorts of ages spanning centuries, it is difficult to construct a detailed sequestration curve for old-growth forests. Space-for-time studies suggest at least 100 years is required to achieve maximum biomass after a succession has been established.[33] Approximately half of 'biomass' is carbon.

Where carbon sequestration is forward-projected, based on known demographic patterns, it has been hypothesised that native carbon storage will out-perform that of planted exotic forests at the scale of centuries. This is illustrated using the modelling approach of Meurk and Hall (2006)[34] for a dry eastern location (to the right), where it was assumed that native species would naturally invade around 500 years and eventually dominate. (To convert to tCO2e biomass must be halved and then multiplied by 44/12).

Figure 7: Modelled above-ground biomass at Christchurch under low soil moisture conditions (A), and moderate soil moisture conditions (B), beginning with exotic *Pseudotsuga menziesii, Acer pseudoplatanus, Pinus radiata,* and *Pinus contorta*. Indigenous species were introduced at year 500.



APPENDIX 3:

Exploring the concept of a biodiversity payment or credit

Much like the revenue stream created through the ETS for the carbon sequestered by forests, an opportunity exists to place a monetary value on the benefits of native biodiversity through the development of a biodiversity credit.

Similar models exist internationally, for example, the Burren Programme in Ireland where farmers receive a results-based payment for biodiversity improvements, scored on a ten-level ranking that covers multiple variables.

The 'product'

- A time-bound payment for example, over the first ten years which pays for the successful transition of an exotics-dominated ecosystem to a natives-dominated ecosystem.
- The objective of the payment would be to compensate for the 'financial gap' between the establishment of native forests and exotic forests until carbon revenue becomes more steady (though not equivalent to pine).
- The impact of the payment would be measured as the shift from exotic grasslands or scrub (e.g, gorse or broom) to native shrubs and forest species.
- Using the same logic, a biodiversity payment could also be used to finance the transition of exotic forest (i.e. abandoned pine forest) to native forest through interplanting and assisted succession
- In future, the credit could potentially be adapted for other types of ecosystem restoration – i.e. riparian margins, wetlands, mangroves etc. – to provide a source of revenue for restoration activities that are not eligible for the ETS.

Market supply of biodiversity units

Market supply of biodiversity units would come from:

- **Entrepreneurs involved in restoration projects.** For example, producers of small-scale restoration who are looking to complement future carbon revenue with short-term opportunities for cashflow through the sale of biodiversity units.
- **Large emitters in the ETS** who want to create long-term carbon sinks, especially to hedge against future carbon liabilities, but can't justify the long-term return on investment for natives. In the case of emitters, the biodiversity payment would create a short-term financial return, not in the form of carbon credits for immediate offsetting, but rather as cash payments for the sale of biodiversity units. Thus, the business model for native forest sinks would start out with biodiversity payments, succeeded by NZUs over time. Such companies would also benefit from the positive branding and reputation associated with supporting native biodiversity.

Market demand of biodiversity units

Market demand of biodiversity units could come from:

- **Non-ETS participants,** who already pay a carbon price through the price of fuel etc., but nevertheless want to signal to the market that they are supporting positive environmental outcomes. In this case, rather than buying into carbon-neutrality through offsetting, businesses (and potentially individuals) are instead investing into the climate resilience of New Zealand, by purchasing biodiversity units that finance the transition of exotics-dominated ecosystems to natives-dominated ecosystems.
- **Parties involved in assisted regeneration:** (e.g. PredatorFreeNZ) to pay for the pest control that enables native birds to successfully disperse seeds and accelerate regrowth.
- **Parties with a legal requirement to deliver biodiversity outcomes.** Such obligations have the potential to be mandated under any future Resource Management Act (or equivalent).

The role of the Government

The Government could play two roles in a market for biodiversity credits:

- **A co-purchaser of successful outcomes,** e.g. by matching the purchase of units on a dollar-for-dollar basis. Thus the biodiversity payment could be a blended public/private payment.
- **Verification or auditing the biodiversity improvements,** by building this into its environmental monitoring. Potentially this job could be undertaken by councils, hopefully underpinned by the post-RMA legislation.

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References

1. Department of Conservation (2020). Biodiversity in Aotearoa – an overview of state, trends and pressures 2020. https://www.doc.govt.nz/globalassets/documents/conservation/biodiversity/anzbs-2020-biodiversity-report.pdf
2. Department of Conservation (2000). The New Zealand Biodiversity Strategy 2000-2020. https://www.doc.govt.nz/globalassets/documents/conservation/new-zealand-biodiversity-strategy-2000.pdf
3. Norton, B.G. (1987). Why Preserve Natural Variety, Princeton University Press.
4. Ministry for the Environment (2019). Environment Aotearoa 2019. https://www.mfe.govt.nz/environment-aotearoa-2019-overview
5. Ibid.
6. Ministry for the Environment (2001). Our Clean Green Image: What's it Worth? https://www.mfe.govt.nz/sites/default/files/clean-green-aug01-final.pdf
7. Department of Conservation (2020). Te Mana O Te Taiao, Aotearoa New Zealand Biodiversity Strategy 2020. https://www.doc.govt.nz/globalassets/documents/conservation/biodiversity/anzbs-2020.pdf
8. Daigneault, A.J., Eppink, F.V. and Lee, W.G. (2017). A National Riparian Restoration Programme in New Zealand: Is it Value for Money?, Journal of Environmental Management. doi: 10.1016/j.jenvman.2016.11.013
9. Waller, L.P., Allen, W.J., Barratt, B.I.P., Condron, L.M., França, F.M., Hunt, J.E., Koele, N., Orwin, K.H., Steel, G.S., Tylianakis, J.M., Wakelin, S.A. and Dickie, I.A. (2020). Biotic interactions drive ecosystem responses to exotic plant invaders, Science 338 (6494). doi: 10.1126/science.aba2225
10. Perry, G.L.W., Wilmshurst, J.M., Ogden, J. and Enright, N.J.(2015). Exotic mammals and invasive plants alter fire-related thresholds in southern temperate forested landscapes. Ecosystems 18.
11. Yao, R. and Velarde, S. (2014). Ecosystem Services in the Ōhiwa Catchment. Report prepared for Bay of Plenty Regional Council. doi: 10.13140/RG.2.1.3127.8808
12. Ibid.
13. Ministry for Primary Industries (2020).
14. Environmental Protection Authority (2018). 2018 New Zealand Emissions Trading Scheme Report.
15. Market research carried out by Air New Zealand
16. Ministry for Primary Industries (2020).
17. Tuahine, H. (2018). Supporting native plantation forestry in the NZ ETS: Combining revenue from carbon, native timber, and co-benefits,Report for Tāne's Tree Trust Motu Economic and Public Policy Research. https://motu.nz/assets/Documents/our-work/environment-and-agriculture/climate-change-mitigation/emissions-trading/Supporting-native-plantation-forestry-in-the-NZ-ETS-final-report.pdf
18. Norton, D. and Pannell, J. (2018). Desk-top assessment of native vegetation on New Zealand sheep and beef farms.
19. Norton, D.A., Suryaningrum, F., Buckley, H.L., Case B.S., Cochrane, C.H., Forbes, A.S., Harcombe, M. (2020) Achieving win-win outcomes for pastoral farming and biodiversity conservation in New Zealand, New Zealand Journal of Ecology (2020) 44(2). doi: https://dx.doi.org/10.20417/nzjecol.44.1
20. Norton, D.A., Buckley, H.L., Case, B.S., Pannell, J. (2019). The NZ sheep & beef sector's contribution to biodiversity and carbon sequestration. doi: 10.3390/proceedings2019008048
21. Stephens, J.M.C., Molan, P.C., Clarkson, B.D. (2005). A review of Leptospermum scoparium (Mytaceae) in New Zealand, New Zealand Journal of Botany 43 (2). https://doi.org/10.1080/0028825X.2005.9512966
22. Hēnare, M. (2014), Iwi Signal End to Pine Plantations. http://www.uabsknowledge.ac.nz/en/research-and-comment/research-and-analysis/iwi-signal-end-to-pine-plantations.html
23. Farah Hancock (2019). 'Crisis' in native plant industry, Newsroom. https://www.newsroom.co.nz/2019/02/10/432776/chaos-and-crisis-in-native-plant-industry
24. Ngati Hine Forestry Trust (2019). Ngati Hine Forestry Trust Annual Report 2019.
25. New Zealand Plant Producers Incorporated (2019). Growing New Zealand, Native Nurseries Survey Insights. https://growingnz.co.nz/filescust10/CMS/Insights.pdf
26. Ministry for Primary Industries (2017). Carbon Look-up tables for Forestry in the Emissions Trading Scheme. https://www.mpi.govt.nz/dmsdocument/31695/send
27. Ibid no. 17
28. Tāne's Tree Trust (2014). Carbon Sequestration by Planted Native Trees and Shrubs, Planting and Managing Native Trees.
29. Bergin, D.O., and Gea, L. (2007). Native Trees – Planting and Early Management for Wood Production (Revised ed.): New Zealand Forest Research Institute, New Zealand Indigenous Tree Bulletin No. 3. https://cdm20044.contentdm.oclc.org/digital/api/collection/p20044coll6/id/0/download
30. Hock, B., Heaphy, M., Harrison, D. and Payn, T. (2014). Nga Aho Rangahau o Maniapoto Forest Opportunities.
31. Mason, N.W.H., Wiser, S.K., Richardson, S.J., Thorsen, M.J., Holdaway, R.J., Dray, S., Thomson, F.J. and Carswell, F.E. (2013). Functional Traits Reveal Processes Driving Natural Afforestation At Large Spatial Scales. PLOS One 8 (9), e75219: http://dx.doi.org/10.1371/journal.pone.0075219.
32. Holdaway R.J., Easdale T.A., Carswell F.E., Richardson S.J., Peltzer D.A., Mason N.W.H., Brandon A.M. and Coomes D.A.(2017). Nationally Representative Plot Network Reveals Contrasting Drivers of Net Biomass Change in Secondary and Old-Growth Forests. Ecosystems 20. doi:https://doi.org/10.1007/s10021-016-0084-x
33. Carswell, F.E., Burrows, L.E., Hall, G.M.J., Mason, N.W.H. and Allen, R.B. (2012). Carbon And Plant Diversity Gain During 200 Years of Woody Succession in Lowland New Zealand,New Zealand Journal of Ecology 36.
34. Meurk C.D. and Hall G.M.J. (2006). Options for Enhancing Forest Biodiversity Across New Zealand's Managed Landscapes Based on Ecosystem Modelling and Spatial Design, New Zealand Journal of Ecology 30.

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