Transitioning Exotic Forest to Native

Preliminary Guidelines for Transition

TĀNE'S TREE TRUST

Native Forests for our Future | Hereherea te Wao-nui-a-Tāne

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Executive Summary

Introduction

This interim report provides preliminary guidance on transitioning unharvested radiata pine plantations to permanent native forest through natural and managed ecological succession. It summarises findings to date from a five-year research programme (2022–2027) funded by MPI's Sustainable Food and Fibre Futures fund.

Why transition forestry is needed

Many radiata pine plantations on steep, erosion-prone hill country are now uneconomic or unsafe to clear-fell. Increasing frequency of severe storm events are causing destructive landslides, sediment flows, and mobilisation of woody debris, threatening downstream communities and ecosystems. Transitioning existing pine forestry on steep hill country to native forests may be an alternative option, reducing these risks to provide more resilient landscapes and a biodiverse native forest cover.

Project scope

The project aims to provide early science-based guidance for landowners and forest managers. Key components include:

- Analysis of the national LUCAS dataset to describe native understoreys within pine forests.
- National and regional bioclimatic surveys, including one focused on Tairāwhiti.
- Establishment of trial networks to test management options over the long term.
- Modelling of future carbon dynamics and successional pathways.

Although focused on radiata pine, findings may apply to other fast growing exotic species capable of acting as an initial cover of woody vegetation.

Key Findings to date

Native understorey and bioclimatic influences

Analysis of 185 LUCAS plots and a regional survey focused on Tairāwhiti shows that many older and lower-density pine stands support significant native understorey development, typically shade-tolerant shrubs, tree ferns, and subcanopy species. These communities provide a valuable base for succession, but browsing by ungulates is suppressing regeneration in many areas. There is a lack of later successional native tree species in <30-year-old pine plantation stands.

Bioclimatic conditions influence transition potential with the best outcomes typically on sites with higher rainfall, at mid-elevations, in older pine stands with thinning canopies, nearby native forest with seed, and only light animal pest browsing pressure. Older Tairāwhiti stands showed particularly strong understorey development, reflecting favourable climate.

Key constraints

Successful pine to native forest transition depends primarily on:

- Adequate native seed sources (or supplementary planting such as seed islands);

- Effective pest animal and weed control as required; and
- Timeframes, over many decades for canopy turnover from pines to natives.

These factors determine whether native species, particularly tree species, can recruit into the higher vegetation tiers and eventually form tall native forest.

Management Considerations

Transition pathways

Transition forestry can involve a range of passive to highly active approaches:

Passive ("hands-off") – Pines are left to senesce naturally while management focuses on pest control and seed enrichment where required. This avoids abrupt soil exposure and helps with suppression of light-demanding weeds but may require many decades for transition.

Active canopy manipulation – Thinning pines to increase light and accelerate understorey development, coupled with pest control and enrichment planting where required. Timing must consider weed risks, carbon goals, fire risk, and site safety.

Mixed approaches – e.g., focusing intervention by promoting natives in gullies or riparian zones as buffers for waterways while retaining a pine canopy elsewhere.

Where poisoning is undertaken, standing dead trees can aid seed dispersal as bird perches, but also create safety hazards for ongoing management or recreation until they fall.

Biodiversity and carbon

Transition forests can enhance biodiversity, but native canopy recruitment will not occur without nearby seed supply, dispersal agents (birds and wind), and protection from browsing. While the pine canopy suppresses light-demanding weeds, selective control of shade-tolerant environmental weeds may be required on some sites.

Carbon modelling shows that transition options, whether passive or active, involve an inevitable dip in total carbon stocks when pine biomass declines before native canopies mature. Management choices strongly influence the timing and depth of this dip, and the subsequent native forest type. In the long term, stands that develop tall native canopy species have the potential to recover and provide significant long-term carbon stocks.

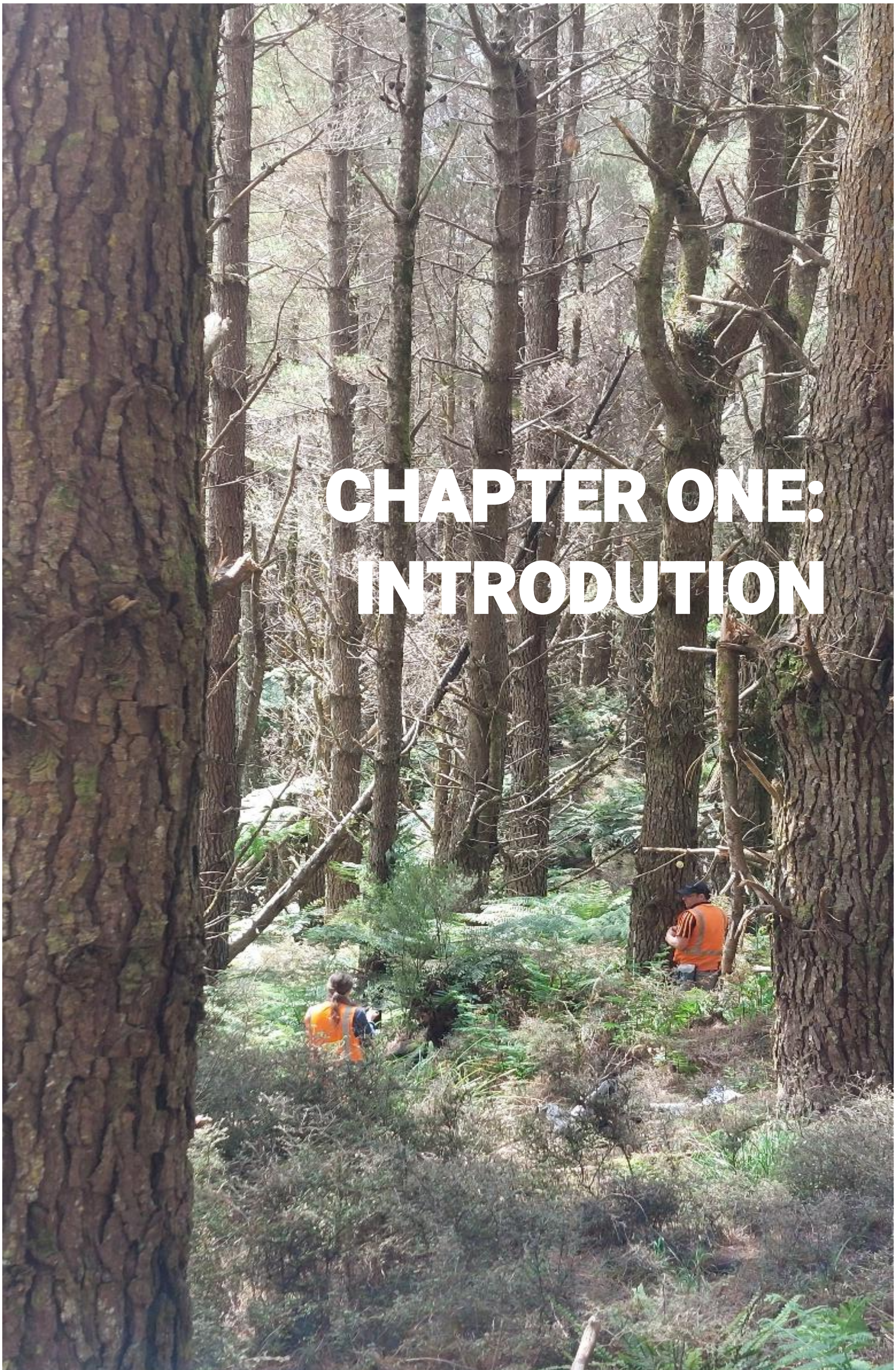
Advantages and limitations

Advantages of a well-managed transition to natives (compared with revegetation from clear-fell harvesting) will likely include reduced erosion and slash risk from exposed and destabilised slopes, reduced weed invasion, building on existing biodiversity value, and potential for longer-term carbon income from the pines. Limitations include slower initial native carbon accumulation and potentially long timeframes.

Further Research, Monitoring and Adaptive Management

Large-scale regional trials and long-term monitoring are needed to refine thresholds for canopy manipulation, landscape scale spacing of seed islands, determining adequate native seedling densities including tree species, and successional timelines. Monitoring should track pine canopy condition, native species recruitment, development of understorey structure, weed and animal pest pressures, and cultural indicators using both ground-based surveys, remote sensing and mātauranga Māori. Adaptive management involving regularly updating plans based on monitoring results is essential given the long timeframes and uncertainty.

CHAPTER ONE: INTRODUTION



1 Introduction

1.1 Project purpose and scope

The goal of the 5-year research project 'Transitioning Exotic Forest to Native' is to provide science-based information to inform forest managers, planners, researchers, regulators and policymakers, and especially to provide early guidance for active practitioners. The intention of this preliminary report is to provide early findings and insights that can guide adaptive management for this emerging transitional forestry management scenario. It is anticipated that further research, trial results, and experiences will complement and build on the outputs of this project.

The preliminary guidelines are based on several workstreams aimed at informing transitioning radiata pine to native forest, including:

- Analysing existing LUCAS (Land Use and Carbon Analysis System), a national land-use mapping and carbon-accounting framework, to assess native understorey development and forest characteristics within plantation forests and to better understand potential transitional management options.
- A national survey to examine bioclimatic influences on native understorey characteristics within pine forests in multiple regions.
- A targeted regional survey in the Tairāwhiti region to measure the understorey characteristics of pine plantations and identify the management actions required to support a pine to native forest transition.
- Modelling predicted long-term dynamics including carbon trajectories and native understorey succession, under varying disturbance and/or management scenarios.
- Synthesising the research findings and developing preliminary guidelines on managing transitions from exotic pine forest to native forest.

The preliminary guidelines will be updated and finalised at the end of the project (2027) and will include insights from the ongoing trial workstream. This workstream involves the establishment and monitoring of permanent trials to evaluate canopy manipulation, natural regeneration/planting and pest animal management aimed to help refine carbon and biodiversity models and inform empirical management practices.

Although some trial sites have involved wilding pine forest, the project has not specifically addressed wilding forest scenarios. Caution is advised when extrapolating results to other species and to areas of wilding exotic forest cover. A note of caution is also warranted when interpreting these results for situations beyond the scope of this project, which focused on transition options for established pine forests on steep, erosion-prone hill country where clear-fell harvesting has become uneconomic and poses significant downstream risks from sediment and slash mobilisations during severe storm events.

1.2 What is Transitional Forestry?

Transition forestry is a relatively recent term now being used in New Zealand forestry and primary industry sectors. But what does it mean? It has long been recognised and accepted that, through events and processes such as disturbance, natural colonisation and succession, forests can change over time in terms of their species compositions, structure, and even type (e.g. Allen et al 2013). This is usually referred to as natural succession.

The term transitional forestry, however, is generally used in relation to the practice of changing one forest type to another. In New Zealand, the term usually implies some purposeful human management intent and conceptualisation of the process. For example, a paper by Jones et al (2023) set out that: "Transitional forestry is an ongoing multi-decade process of change from current 'business-as-usual' forest management to future systems of forest management, embedded across a continuum of forest types." However, we note the term is most commonly used specifically in relation to the idea of effecting a transition from exotic forest to native forest (e.g. in the New Zealand Emissions Trading Scheme, NZ ETS). Indeed, the term is explicitly used in this way – managing exotic forests to native forest - in the recent report by the Parliamentary Commissioner for the Environment (PCE 2025).

A more specific and detailed description was used by Forbes et al 2015:

"The term 'transitional forestry' describes the concept of converting an exotic plantation forest to a native forest over time, drawing on the exotic plantation species' ability to act as a nurse plant for the regenerating native species. The plantation trees tend to be fast growing, allowing for canopy closure to be achieved in a relatively short timeframe. Fast growth also allows for the rapid sequestration of large volumes of carbon, hence why the exotic plantation species may be chosen over native early successional nurse species. The plantation trees outcompete light-demanding weed species, allowing for shade-tolerant species to establish beneath the canopy."

The term, as used above, could include plantations of various exotic species, such as *Eucalyptus* spp. However, this research project has deliberately limited its focus to the most-widely planted exotic species, Monterey, or radiata pine (*Pinus radiata*). This was to ensure both scientific robustness and relevant results are obtained within the project budget and timeframe.

1.3 Why is transitional forestry relevant?

These Guidelines will be particularly relevant to private landowners, farmers, iwi and forestry companies with production forests that are no longer economic to harvest or no longer deemed safe to harvest due to potential environmental externalities (e.g. effects of landslides).

While this project focuses on existing plantations of radiata pine, results may be relevant to other exotic species following the timeframes and processes of natural forest succession, supported by various levels of active management interventions. Central to this is the potential of exotic species, either planted or regenerated, to act as a beneficial nurse cover for regenerating native forest. It may also be relevant to exotic plantation forest established for the purpose of carbon sequestration rather than timber production.

Large-scale afforestation of New Zealand has proponents for many reasons, including the many non-timber values that forests can provide. Forest restoration is one of the most promising and powerful approaches to tackle the grand challenges of climate change and biodiversity loss (Brancalion et al 2025). The Climate Change Commission (CCC 2021) discussed the establishment of 300,000 hectares of new native forest complemented by 380,000 hectares of new exotic forest, by 2035, as part of a national response to climate change. And, since 2008, the NZ ETS has encouraged significant afforestation, predominantly with radiata pine, often with carbon sequestration rather than timber production being the primary purpose for many of those forests.

Exotic plantation forestry for either timber production or for carbon-farming, has suffered losses of 'social license to operate' (MFE 2023) and public backlashes. Recent extreme weather events (e.g. Cyclone Gabrielle) have heightened public awareness of the impacts of plantation exotic forestry, particularly on steep hill country, where erosion and forestry debris caused widespread damage, affecting the wellbeing and livelihoods of downstream communities and other land users. In contrast, expressions of strong public support and preference for native reforestation are common (as reflected in public submissions to government policies such as the One Billion Trees programme, and by NGO initiatives such as Recloaking Papatuanuku). This is based on the recognised multiple values associated with native forests (NZIER 2024, Aimers et al 2021), including cultural values, especially to tāngata whenua.

However, the high costs of planting and establishing new native forests (Bergin & Kimberley 2014), makes large-scale native reforestation by planting, simply unrealistic – at least in the short term. Furthermore, despite some public disdain for exotic pine, there is research to indicate that plantations of exotic species can harbour indigenous species and may facilitate native regeneration, albeit more likely as novel communities instead of exact restorations of previously existing native forests. (e.g. Brockerhoff et al 2003, Forbes et al, 2019, Marshall et al 2023). However, due to the long timeframes involved, and lack of examples, this is not a certainty.

Developing ways to appropriately manage forest areas where clear-fell harvesting is either uneconomic, environmentally unacceptable, or because the forests are in the Permanent Forest category of the NZ ETS, will be important to avoid leaving problematic forest legacies for future generations to deal with. Transitional forestry may offer a pragmatic long-term (and intergenerational) management approach in some circumstances.

Although Māori have particular connections to native forest (through whakapapa), and many aspire to transition their exotic forest estates back to native forest (Lausberg & Slade 2025), they are often reliant on exotic forestry for income and may lack the financial means to affect an abrupt conversion to native forest (such as by planting). Transitional forestry is potentially a pragmatic response to that conundrum.

The probability that novel ecological communities will emerge through such transitional processes should not undermine their value. In many cases, this may represent the most feasible outcome, especially given that past disturbances, species invasions, and ongoing climate change make restoring pre-human native forest types both highly unlikely and impractical (e.g. Hobbs et al 2013, Coomes 2003, Marris 2011). Instead, the priority should be on establishing resilient, self-sustaining native forests, appropriate for each site, that provide the multiple benefits associated permanent native forest cover.

While the drivers and relevance of transitional forestry in New Zealand are clear, significant questions remain concerning its feasibility.

1.4 Existing knowledge, information, and resources

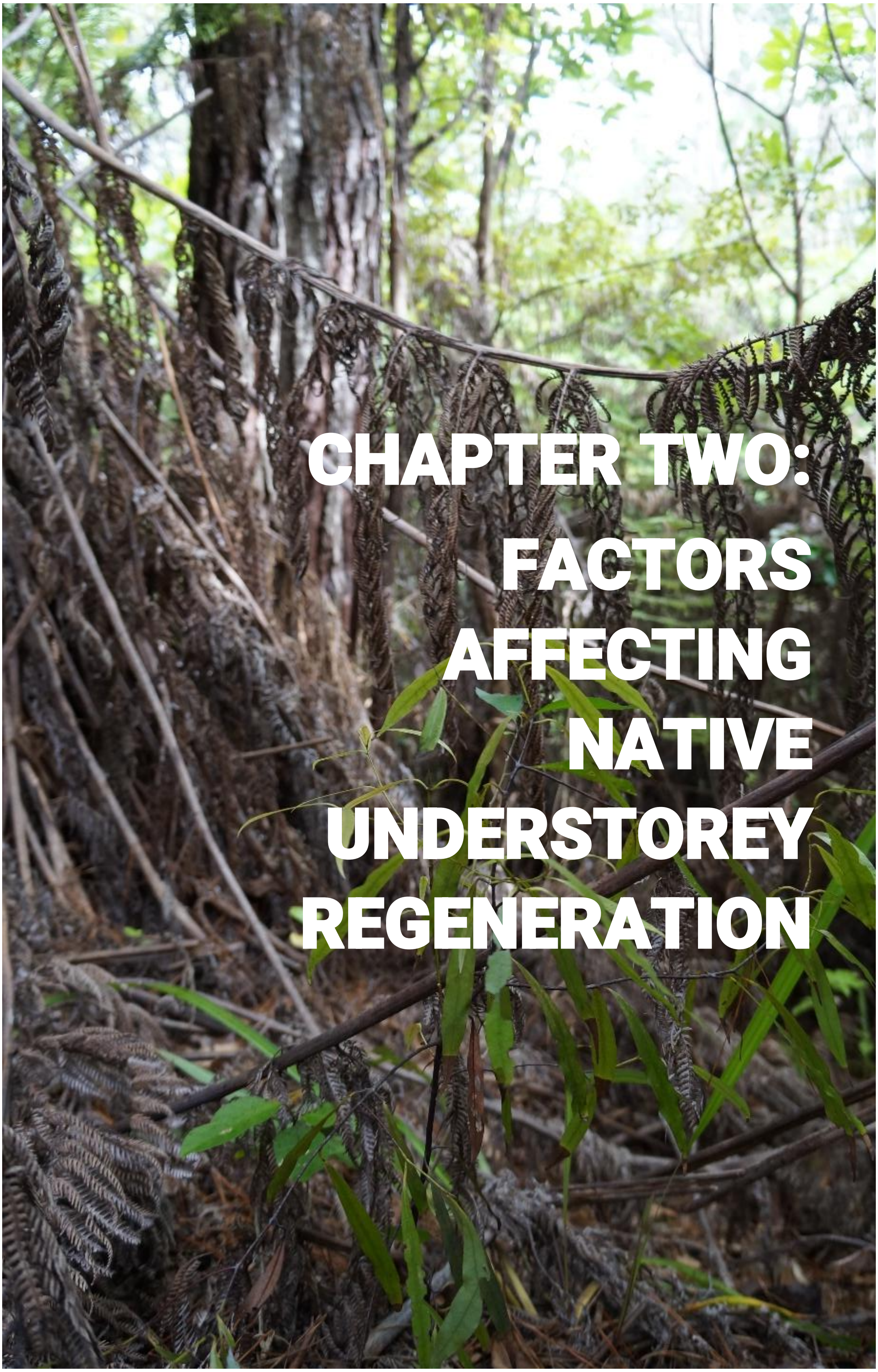
In 2016, the Marlborough District Council, Department of Conservation, and the Marlborough Sounds Restoration Trust prepared guidelines based on experiences and information relating to the conversion of pine plantations back to native vegetation in the Marlborough Sounds. This largely involved experiences in dealing with wilding pines, including dense stands, especially regeneration post-harvest, and the effective poisoning and control of them.

In 2021, MPI commissioned a report on the then current state of knowledge on the topic of transitioning exotic plantations to native forest. (Forbes & Norton, 2021This report made recommendations for a programme of research including national-scale surveys conducted along important biotic and abiotic gradients and forestry experiments such as canopy manipulation. It also highlights the need for better carbon modelling.

While case studies and examples exist to indicate that transitional forestry might be tenable in specific situations, more research is needed to isolate and understand the multiple influencing factors and to enable general guidelines to be developed. This includes understanding the bioclimatic factors as well as the complexities of ecological management such as weed and animal pest management, what type of intervention might be required in each situation, and native forest recruitment and succession timelines under a pine canopy. As the PCE points out, “Almost all research into biodiversity in pine plantations in New Zealand has occurred in forests managed for timber production. It is unclear to what extent this research could apply to carbon forests. The absence of periodic clear-fell harvesting could support long-term biodiversity values. However, planting and maintaining forests at higher stocking rates to maximise carbon sequestration could reduce sub-canopy light levels and restrict development of a native understorey until the forest naturally self-thins.” (PCE 2025 p.28).

With few clear examples and little research, considerable uncertainty remains.

Key questions include: where, geographically, are exotic to native transitions more likely to be successful, is supplementary planting required, is manipulation of the pine canopy necessary, what level of pest control is required, what stocking level of native canopy tree species is needed to achieve succession, what is the carbon storage profile, and how to assess and monitor progress towards an ecological succession?



CHAPTER TWO: FACTORS AFFECTING NATIVE UNDERSTOREY REGENERATION

2 Factors affecting native understorey regeneration

It is predicted that if left unharvested, radiata pine forests can eventually transition into permanent, native-dominant forests through natural forest succession processes (Meurk & Hall 2006). However, the transition from exotic to native forest is a relatively new area of research, and the long-term outcomes of allowing radiata pine forests to mature and decline naturally remain uncertain (Forbes & Norton, 2021).

Evidence suggests that diverse understoreys of native trees and shrubs often establish beneath radiata pine plantations (Allen et al 1995, Brockerhoff et al 2003, Ogden et al 1997). However, more research is needed to determine whether, and under what conditions, these native understoreys can develop into substantial native forests capable of replacing the exotic canopy as pine trees age and die. The timescales over which such transitions might occur are also largely unknown. Additionally, it is unclear whether actively managing the pine canopy could help facilitate or accelerate this process.

A crucial first step in understanding this transition is to study the composition and development of understoreys in existing exotic plantations. As part of Tāne's Tree Trust's *Transitioning Exotic Forest to Native* project, we undertook three studies focused on the understorey of existing radiata pine forests:

LUCAS National Forest Study – We analysed understorey measurements from 185 forest inventory plots across New Zealand's exotic planted forests, established as part of New Zealand's Land Use and Carbon Analysis System (LUCAS) to assess understorey carbon stocks and biodiversity (Kimberley et al 2025).

Bioclimatic Study – We established 80 plots in mature radiata pine plantations across eight regions in New Zealand to investigate regional variation in native understorey regeneration. The analysis focused on identifying biotic and abiotic drivers of this variation and determining ecological thresholds to inform potential transitional forestry strategies (Forbes 2025).

Tairāwhiti Study – We collected data from 45 plots in older radiata pine stands in the Tairāwhiti region to examine how factors such as stand age, pine stem density, and proximity to native seed sources affect native forest development beneath exotic canopies (Graeme et al 2025).

2.1 LUCAS national forest study

Introduction

This study analysed data from New Zealand's national inventory of exotic planted forests to assess the carbon stocks and biodiversity in the understorey of existing exotic plantations. The research aimed to:

- Quantify the carbon and biodiversity present in understorey vegetation.
- Understand how understorey carbon and species diversity change as the forest ages.
- Evaluate how crop tree density influences these understorey characteristics.

The analysis used data from 185 plots across New Zealand's exotic forest estate (LUCAS system), mostly planted in radiata pine, but with some Douglas-fir and other species. In each plot, all stems >2.5 cm DBH were identified and measured for diameter, and a sample measured for height. Stems were classified into crop trees, exotic non-crop, and native non-crop. Carbon calculations were performed using allometric equations, wood density values, and biomass-to-carbon conversion factors, and converted to CO_2 equivalents. Shannon diversity index and species richness were used to assess native biodiversity.

Results

- The majority of carbon (95.6%) was stored in planted exotic crop trees (average 419 tCO_2/ha), with smaller amounts in pre-existing mostly native forest fragments within the plantation forest boundaries (2.4%), native understorey species (1.2%), and exotic understorey species (0.8%).
- Although naturally regenerating radiata pine was a significant component of the understorey in second rotation stands, it declined markedly in importance with stand age.
- Apart from regenerating radiata pine, most understorey carbon was stored in native species. Native vegetation occurred in 68% of plots, averaging 2 species per plot.
- More than 50% of native understorey carbon was in subcanopy tree species followed equally by tree fern and shrub species, with less than 10% in tall canopy tree species.
- Carbon and biodiversity in native understorey species increased steadily with stand age. Compared with younger radiata pine stands (≤15 years), older stands (>15 years) had higher native carbon (5.4 vs. 2.9 tCO_2/ha), more species per plot (2.8 vs. 1.7), and lower exotic carbon (mostly radiata pine) (1.1 vs. 4.0 tCO_2/ha).
- Carbon in understorey natives was higher in lower density (≤250 stems/ha) compared with higher density (>250 stems/ha) radiata pine stands (8.4 vs. 3.0 tCO_2/ha).
- The study reveals that the carbon stored in the native understorey of radiata pine stands is only a small fraction of what is projected for native forests regenerating without a pine canopy at a similar age. For example, at 30 years, LUCAS plots contained an average of only 7 tCO_2/ha. In contrast, naturally regenerating native shrubland with no radiata pine canopy is predicted to store an average of 258 tCO_2/ha at the same age.

Conclusions and Implications for Forest Transition

Understorey vegetation, while a small component of total plantation carbon, plays a vital role in increasing the native biodiversity value of a plantation stand.

Older and lower density stands foster higher native plant richness, diversity and carbon accumulation, making them potentially valuable for biodiversity co-benefits.

In general, the conditions in the understorey of radiata pine forests strongly favour the development of secondary colonising shade-tolerant native understorey subcanopy tree, tree fern and shrub species.

Although thinning radiata pine stands will encourage understorey growth, even in low-density radiata pine stands the carbon stored in the understorey will still be only a small fraction of the pine canopy carbon.

A naturally regenerating native forest without a radiata pine canopy stores more carbon than the carbon found in equivalent aged native understorey of a pine plantation but has a fraction of the overall carbon found in mixed pine/native forest.

2.2 Bioclimatic study

Introduction

This workstream aimed to examine whether the understorey vegetation composition and structure of mature stands of plantation radiata pine vary spatially, and if so, what are the drivers of variation?

The aims of the work were threefold:

1. Undertake a nationwide survey of representative exotic conifer plantation forests to assess and understand key biotic and abiotic factors and regional variations that affect regeneration of native species within such forests.
2. Examine spatial gradients and patterns at a landscape scale (e.g., relationships between regeneration and proximity to existing native forest seed sources, etc.) and stand level variables (e.g., stand structure, canopy density).
3. Empirically define management thresholds regarding levels of regeneration to understand where and why adequate regeneration is attained without specific interventions.

The survey sampled 80 plots distributed across eight political regions of New Zealand. The forests surveyed were all commercially owned and rotationally managed for timber by a total of four different forestry companies. All compartments surveyed were 20-30 years old. Sampling was conducted along elevation gradients coinciding with areas of climate gradients to capture variability in climate, native seed source proximity, and a variety of other site factors. A range of climatic, biotic and abiotic explanatory variables were relied upon and these yielded data relating to the composition and structure of plantation understoreys.

Results

- All response variables representing native forest development responded positively to increases in total annual precipitation between approximately 1,200 and 1,500 mm, after which there was no additional influence of increasing precipitation on the response variables.
- Response variables responded positively to increasing elevation between approximately 200 and 500 masl, with optimum conditions ≥500 masl
- Slope aspects ranging southeast through southwest were most favourable for all response variables. Response variables were least favourable on slope aspects west through north, and flat sites.
- All response variables increased with increasing stand top height between heights of c. 25 and 35 m tall, with no additional influence of top height at heights above 35 m.

- The native woody *S* and PCA1 response variables showed positive associations with increasing native cover in the landscape up to approximately 2,500 ha within a 5 km radius (7,854 ha area), which equates to increases in these response variables in landscapes ranging up to 32% native cover.
- Native woody stem densities declined when wind speed exceeded c. 3 m/s.
- Native woody species richness responded positively to increases in July mean solar radiation and July mean temperature from 6.5 to 7℃ and 6 to 8℃, respectively.
- Native woody stem densities were highest where browse was no more than light and lowest when subjected to heavy levels of browse.
- The PCA1 response indicated a negative association with January mean solar radiation at values approximately >22.5 Watts/m^2.

Conclusions and Implications for Forest Transition

Based on these results, sites most conducive to transitional forestry are indicated to be those with the following combination of attributes:

- Elevated annual rainfall,
- Mid-elevation,
- Older stands with opening structure,
- Significant native cover (>30% area) within 5 km of the transition stand,
- Warm sites sheltered from strong winds and not affected strongly by high summer temperatures,
- No more than light occurrence of browse by introduced mammalian browsers.

2.3 Tairāwhiti study

Introduction

This study focused on older radiata pine stands across Tairāwhiti. Data were collected from 45 plots from February 2023 to August 2024. The surveyed stands averaged 37 years in age (range 21-63 years) with pine density averaging 310 stems/ha and mean top height 42 m.

Circular plots (0.06 ha) were established and all stems≥2.5 cm DBH were measured for diameter, and a sample measured for height. Subplots were installed for measuring smaller saplings and seedlings. Proximity to native seed sources was assessed using mapping, aerial imagery, and local observation. Carbon calculations were performed using allometric equations, wood density values, and biomass-to-carbon conversion factors, and converted to CO_2 equivalents. Shannon diversity index and species richness were used to assess native biodiversity. Relationships between understorey characteristics and stand variables were analysed using correlation analysis and Generalised Additive Mixed Models.

Results

- Radiata pine crop trees stored an average of 1,353 t CO_2/ha with only 1.3% of total carbon (averaging 22 t CO_2/ha) stored in the understorey.
- The understorey was overwhelmingly native, with natives comprising 98–99% of both stem counts and carbon. Mean species richness was 11 for all stems and average 4 species for stems ≥ 2.5 cm DBH.
- Shrubs made up over 75% of stems, but contributed only 20% of carbon, whereas subcanopy trees and tree ferns stored 42% and 30% of carbon, respectively.
- Stand age was positively correlated with understorey carbon, stem density, and species richness.
- Crop stand density was negatively correlated with understorey carbon, Shannon diversity, and species richness.
- While older and lower-density pine stands support greater understorey carbon and species richness, late-successional canopy species were only beginning to establish in sapling and tree tiers.
- Distance to native seed sources and elevation had minimal effects, except for slight reductions in sapling diversity with increasing distance from native forest.
- Exotic weeds were minimal, with small, localized infestations near human infrastructure (roads, housing).
- Exotic browsing pressure from deer, goats and/or cattle was widespread.

Conclusions and Implications for Forest Transition

The Tairāwhiti radiata pine understorey aligns with national findings in that they are predominantly composed of secondary-colonising native species that are mostly shade tolerant.

Browsing pressure and closed pine canopies limit regeneration of understorey plants.

Management interventions such as thinning, controlling browsers, and promoting seedling recruitment from nearby native forest, increase the carbon and biodiversity of the understorey.

The Tairāwhiti understorey vegetation had higher species richness and diversity, as well as carbon than the national LUCAS metrics. This likely reflects the older age of the Tairāwhiti stands. The Tairāwhiti sites also generally have suitable biotic and abiotic conditions for understorey growth, with the exception of widespread browsing influence. This implies that an exotic forest to native transition, given time, may be more easily achievable here than in some other regions around NZ.

2.4 Other work

Trials

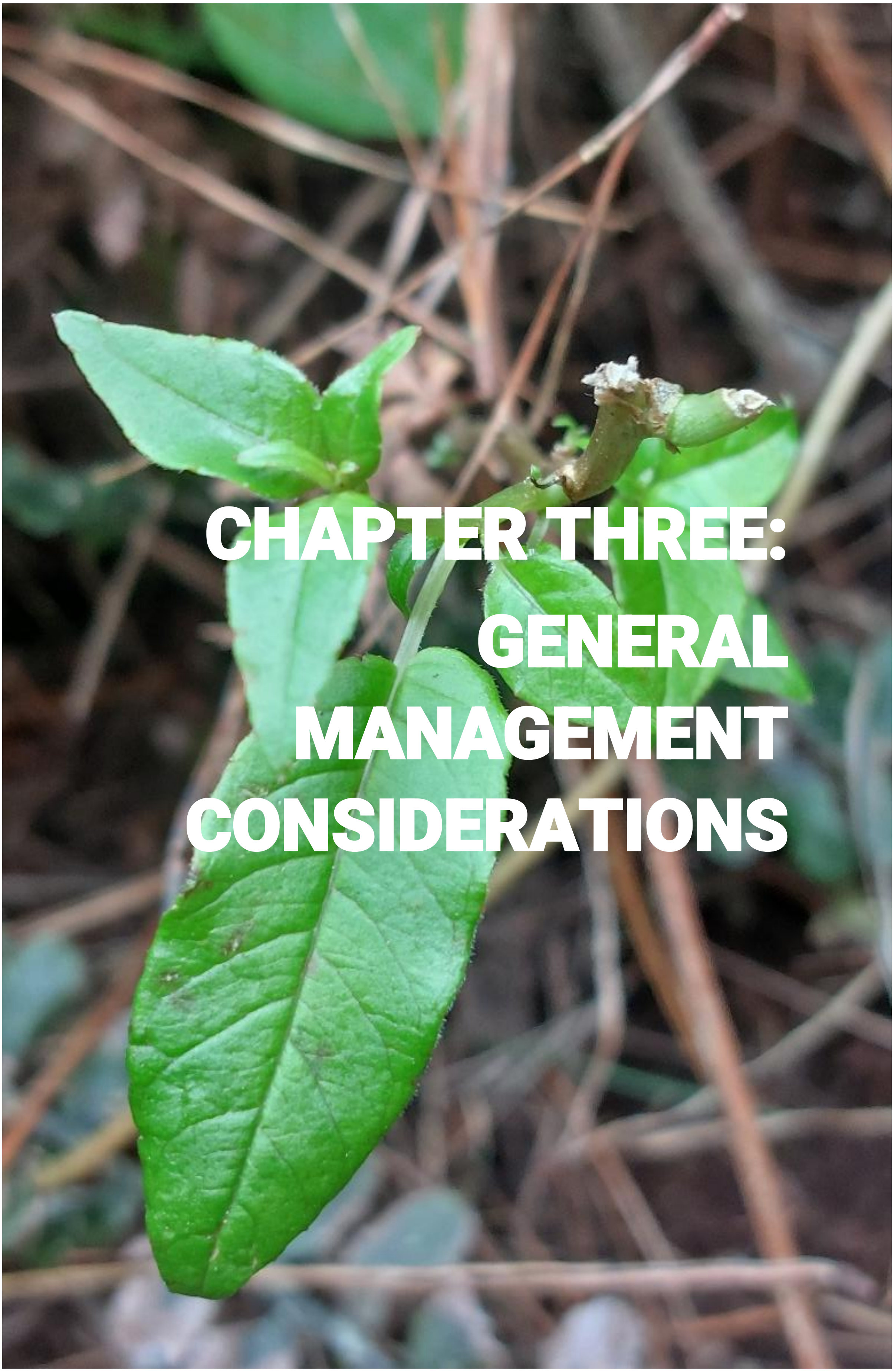
A further study forming part of Tāne's Tree Trust's *Transitioning Exotic Forest to Native* project involves the establishment and monitoring of permanent trials to evaluate canopy manipulation, natural regeneration/planting and pest animal management to help refine carbon and biodiversity models and inform empirical management practices (see Appendix C). Early indications are that planting survival is variable; some planted species survive and grow better in gaps, while others do better under the pine canopy; and palatable species have low survival without effective browser control e.g. kohekohe. The establishment and growth of weed species has been recorded in poisoned gaps where seed sources are nearby. Full results from this study will not be available until the end of the project and will be reported in the final guidelines.

Other small-scale case studies are available e.g. Forbes 2021b, and Tāne's Tree Trust's Adaptive Management of Coastal Forestry Buffers series mentioned below.

Difficult revegetation sites

Where conditions are harsh (very dry or very cold) such as found at Lake Pukaki, shelter from wilding pines is providing to be essential to initiate native planting establishment (Zachary Marion, pers. com.). This has also been shown in coastal dune situations where transition of degrading pine buffers to native forest can assist with the re-establishment of dune forest. Dune forest restoration has the double outcome of helping restore a threatened ecosystem as well as provide a more resilient and permanent buffer for inland pine plantation stands (see the Coastal Buffers case study in Appendix A).

CHAPTER THREE: GENERAL MANAGEMENT CONSIDERATIONS



3 General management considerations

Implications from the research above raise a number of management considerations.

This section highlights and discusses some general principles and considerations relevant to transitional forestry and for the development of a Transitional Forestry Management Plan.

Transitional forestry presents a complex management challenge. There are risks with any land use change and transiting an unharvested plantation to native forest is one land use change method to consider alongside other methods.

3.1 Objectives and long-term goals/outcomes

Responsible land stewardship or kaitiakitanga requires some form of active management for all forests, whether native or exotic. Forests typically have multiple values and threating pressures. Management will often be unique to a site reflecting the natural features and characteristics of a place, its management history, ownership, and other wider contextual considerations.

Transitional forestry is a concept likely to be of particular interest to managers of existing pine plantations where the values and benefits of native forest are sought in the long term. Generally, these may include enhancing catchment health and indigenous biodiversity, but may also include other cultural and recreational values, and potentially timber and/or non-timber forest products (including carbon sequestration).

Ecologically diverse indigenous ecosystems are more resilient to impacts from a changing climate and other pressures such as invasive species (e.g., Schnabel et al 2025, Zhai et al 2025, Billing et al 2022, Zhang et al 2022, McCann 2000, Loreau and de Mazancourt 2013).

Restoring resilient and healthy native forest is often the implicit long-term goal. Transitional forestry may present a pragmatic pathway or option, especially where clear-felling an existing forest would be associated with significant adverse effects such as erosion or problem weed invasions (e.g., climbing vines, light-demanding weed species).

A key requirement in developing a permanent resilient native forest is to ensure that the forest is developing a structure that supports all plant habits and high species diversity. This will mean that the forest can support palatable species and tall canopy species as well as diverse ground cover. Such a forest will be more likely to self-regenerate following natural disturbances. It will also provide high rainfall interception and absorption and soil strength through diverse plant root structures.

Transitions will not be quick, clean, or absolute. Achieving long-term outcomes may require the balancing of many competing short and mid-term values and constraints (e.g., financial resources and capacity). Establishing native forest takes intergenerational timeframes, and transitions will be non-linear, indirect routes to native forest restoration. A forest following a successful transition trajectory will gradually increase the indigenous biodiversity values within a local landscape and complement other existing areas of native forest and plantings. Like any restoration activity, an end-goal of an ideal historic reference state is unlikely to be achieved due to the developing forest facing new environmental pressures (Marris 2011, Hobbs et al 2013).

3.2 General considerations relevant to transitional forestry

Some general matters and aspects relevant to transitional forestry are discussed in more detail below.

Site conditions

This research project and other research (e.g. Brockerhoff et al 2003) have found many environmental factors and conditions to be correlated with understorey forest characteristics beneath radiata pine canopies (see Section 2). It is important to consider whether supportive site bioclimatic conditions are present as this will determine the likelihood of achieving a transition. Extra caution is needed when considering sites without supportive bioclimatic conditions (e.g. low rainfall, high summer temperatures, lacking seed sources) that could require unsustainable management inputs.

Level of intervention required

Transitions to native forest on less conducive sites may require more active and costly management intervention and inputs, such as canopy manipulations, extensive and ongoing weed and browser control, and supplementary planting and maintenance. In contrast, relying on possum and predator control together with natural regeneration and succession only, may be sufficient at more favourable sites (e.g. the Whangapoua Forest trial site – Appendix C, Fernandes et al 2025). Yet some level of active management is always required. This may be conceptualised as a continuum; at one end, intensive management, associated with higher costs and time pressures, and at the other end, less intensive, lower cost management strategies. All transitions (as with any native forest) will need to be managed over long timeframes. Understanding the minimum management requirements to affect a transition for each site will be important for setting the appropriate strategic approach of any management plan.

Economic circumstances are also relevant to this consideration. The relative need and capacity to finance and maintain necessary management inputs needs to be well understood.

Tensions and trade-offs

There are likely to be some general tensions or trade-offs involved with transitional forestry. For example, not undertaking active management such as canopy thinning or underplanting may save on costs, but require a longer timeframe to affect a transition. Maximising pine density for carbon income will slow the development of a native understorey. And many decisions will be associated with corresponding risks – some financial with implications for carbon income and liabilities, or environmental (such as weed invasion, fire risk, slope instability). Presently, there is limited research-based guidance to help forest managers understand the pros and cons of various management actions or options. In many cases, the management decisions will need to be made with incomplete knowledge and uncertainty concerning the outcomes. This highlights the need to involve the local community in discussions so that risks are well understood for each potential management direction.

Fire

Fire risk is predicted to increase in many areas of NZ (Fire Emergency NZ 2023). Species-diverse native forest is generally less flammable than monocultures of pine or regenerating kānuka or tōtara (Gross et al 2024, Gross & Clifford 2025, Depietri & Orenstein 2019). However, stress and disturbance to a forest changes the hazard and wildfire potential (Gross et al 2024). Minimising fire risk for transition forests will be similar to plantation forests. Ultimately, a succession to diverse native forest should reduce the risk but interim measures might include targeted control of pines in gullies to boost revegetation and increase diversity of less flammable native species. This could create 'green fire breaks' that may help impede the spread of a fire (Depietri & Orenstein 2019, Aimers et al 2021). Such areas can also function as 'seed islands' to enhance the native diversity developing under the remaining pine canopy (see Seed Island discussion in Section 4). Further discussion and advice about developing a resilient native forest and reducing fire risk is presented in the Tāne's Tree Trust factsheet 'Resilient native forest in an era of climate change' (https://docs.tanestrees.org.nz/resilient-native-forest-in-an-era-of-climate-change).

Overhead forest hazards

Overhead hazards are a risk in all tall forests. This risk can increase if large areas of tall trees are senescing (as can happen in an aging monospecific pine stand or where trees have been poisoned). The timing and duration of the increased risk period will be influenced by the management approach. Health and safety may affect management activities such as the ability to undertake pest and weed control, monitoring, and recreational activities while elevated risks from forest hazards exist.

Native forest canopy development

Generally, native understorey under pine timber plantations is slow to develop, has low volumes of carbon, and comprises only relatively few and sparsely stocked native canopy species. Exotic browsers can significantly reduce the density of understorey stems and potentially eliminate palatable species. This can affect the trajectory of the forest development. Dense native understoreys of tree ferns and shrubs can also inhibit the regeneration of native seedlings, especially the less shade-tolerant species (Forbes et al., 2016).

To allow for mortality and ensure natural succession, the pine understorey will need to support a high density of native seedlings (including tall canopy species). Like native forest understorey, seedling numbers will reduce through natural attrition and falling debris. However, at this stage the minimum stocking of native canopy tree seedlings, saplings, and small trees to ensure a successful transition to tall native forest is not known. Ensuring adequate native understorey will be a significant issue for management to ensure a transition via natural succession. It will also have implications for the carbon stocks of the forest (see Section 4).

Inevitable dip in carbon stocks

In all scenarios modelled, a significant dip in total forest carbon stock appears to be inevitable as forests transition from radiata pine to native. This occurs when the carbon stock of the pine component of the forest is significantly reduced (either by thinning, disturbance events such as windthrow, or through natural stand mortality), and where the carbon within the native forest understorey is insufficient to immediately offset the loss from the pines. This issue was noted by the Parliamentary Commissioner for the Environment (PCE 2025) and has been confirmed by our modelling (Kimberley et al 2025 – see Section 4.2).

While a dip in carbon stocks during a transition cannot be avoided, there appears to be significant scope for management choices to influence the timing and severity of the dip. For example, through deliberate thinning of the pines to promote the early development and recruitment of native tree species into the canopy, the dip may occur within the first half century. In contrast, without any thinning or manipulation of the pine canopy the dip could be extended out to between 80 and 170 years. Moreover, retaining the pines longer is likely to achieve a higher peak of carbon sequestered before the inevitable dip occurs. A gradual thinning out of the pines over an extended period progressively creating gaps in the pine canopy will give native understorey species more opportunity to move into higher tiers with correspondingly increased carbon content. This may lessen the dip compared with a shorter transition period.

Following the dip, the potential to regain total carbon stocks will depend on the type of native forest that succeeds. Native forests without tall canopy tree species may not regain the carbon stocks previously held in the pine forest. However, a forest of tall native canopy trees species may eventually sequester more carbon than was held in the original pine forest.

Management plans need to anticipate these inevitable and significant dips in total standing carbon stocks. There may be implications for revenue or liabilities linked to the dip in the forest's standing carbon stock for stands registered with the NZ ETS. This could be important for financial planning and management.

It is important to note that native understoreys developing within pine forests sequester less carbon and at a slower rate than planted or naturally regenerated native forests in open conditions. This is important to consider for sites where native regeneration will naturally occur following logging with little input (low weed and browser pressure), soil stability risk from harvesting is acceptable and maximising carbon sequestration (particularly over the next few decades) is not an important goal.

Carbon market considerations

Land and forest owners considering transitional forestry should seek specialist advice concerning the New Zealand Emissions Trading Scheme (NZ ETS) or any other carbon market or scheme. Certain factors such as whether the forest was established before 1990 will affect its status in respect to the NZ ETS.

Potential complementary land uses

It is important to have a clear understanding of what the objectives and long-term goals are for the transitional land. The impetuous for transitioning exotic forest to native has been centred around the need to stabilise steep erosion-prone land. A resilient native forest is one that is species-diverse which enhances its ability to withstand biological and climatic pressures. These pressures include disease, weeds, animal pests, disturbances such as drought, storms and fire, all of which are increasing with the changing climate.

Aside from establishing a permanent resilient native forest, landowners may have additional goals such as small-scale native timber extraction using continuous cover forestry methods (Barton 2008, Wardle 2016), or developing recreational opportunities in appropriate locations. Care needs to be taken around increasing edge effects (Burns 2006). Increased disturbance of forest canopies can affect weed communities, change litter decomposition and nutrient cycling, increase wind throw and drying/fire risk within a forest (Gross 2025, Harper et al 2005, Jo et al 2025, Laurance et al 2007, Norton 2002, Wyse et al 2018). Tracks, while providing necessary access networks to undertaken pest control etc, can be vectors for weeds, animal pests or disease. Therefore, consideration of other land uses within the transition forest area will need to be assessed as to whether they can be complementary with establishing and maintaining a resilient native forest matched to suitable land.

Community perceptions and social license to operate

Pine forests can be negatively perceived as an environmental and social problem by some landowners and communities. Often there are few or no feasible alternative land use options other than changing the land use to permanent native forest cover. In such instances developing an active management plan incorporating intergenerational timeframes, inherent risks and uncertainties, to transition a forest (or parts of a forest) to native may enable landowners and local communities to perceive the existing exotic forests more positively. Building and maintaining support from the local community (sometimes referred to as a 'social license to operate') is important. It will be essential for communities to have confidence that, while acknowledging that any land use change will involve risk, a transition is tenable and that necessary long-term active and adaptive management to ensure a successful transition will be undertaken.

Transitional Forest Management Plans

Appropriate management plans are an essential part of responsible land stewardship. These plans will need to be sophisticated enough to deal with the inherent uncertainty, complexities, and the intergenerational timeframes involved. General considerations need to start with an assessment of the site's values, risks and how feasible managing a transition is for a particular site. It is appropriate to include mana whenua and local community participation in considering the long-term vision and management challenges.

In terms of process and structure, a transitional forest management plan should evolve from a reflexive interplay between the vision and goals, a rigorous understanding of the site's features, conditions, opportunities, restraints and risks, identified through detailed survey and mapping. A realistic understanding of the required financial and human resources and capacities that are available is also essential. A detailed management plan will respond to an analysis and synthesis of these matters.

Surveying, mapping and inventory is a common approach to understanding the forest's features. This may result in a forest map with a mosaic-like pattern of various management units or areas, each with specific management actions proposed.

A Transitional Forest Management (TFM) Plan may be useful as a check list to ensure many of the important topics are addressed. Refer to Appendix B for a general framework to assist in developing a TFM plan.

Adaptive management

Ecological restoration is inherently complex and unpredictable, and transition forestry will be no exception—particularly when management objectives are to achieve a diverse native forest over the long term. Selecting the most effective management actions to guide this transition requires a flexible, adaptive approach, where success depends on learning and adjusting as work progresses. This does not, however, remove the need for a robust initial forest transition management plan.

Adaptive management should include clearly specified and scheduled methods to monitor and assess changes in forest structure and the effectiveness of interventions. Periodic reviews at appropriate intervals allow results and new research findings to feed back into the detailed management plan. This is a reflexive, iterative process that continues through the life of the forest.

CHAPTER FOUR: ACTIVE MANAGEMENT OPTIONS

4 Active management options (interventions)

This chapter discusses in more detail particular management actions that will affect the long-term trajectory and end goal of an exotic to native forest transition.

There is a continuum between more active and passive management approaches to affect a transition from pine to native. More active management is relevant to sites that are less conducive to a natural transition, and where speeding up the transition to native forest is desired. This involves more human interventions to influence and accelerate the processes of forest succession, such as thinning the pine canopy, and supplementary planting etc. In contrast, more passive approaches will rely more on the natural processes and timeframes of natural regeneration and forest succession. However, some active management, such as pest animal and weed control to assist natural regeneration of native shrubs and trees, reducing the pine canopy, supplementary planting of natives where required, and monitoring, will likely be required right across that continuum even if a relatively passive management approach is taken.

4.1 Possible transition scenarios

Our modelling (Kimberley et al 2025) indicates that interventions or natural disturbances that reduce the pine canopy before its natural lifespan could significantly bring forward a transition from being a predominantly exotic forest to being predominantly a native forest. For example, a transition relying on natural succession may take well over 100 years. In contrast, the models indicate that active manipulation of the pine canopy, (e.g., by stand thinning) could result in a transition to native dominance as early as 50 years. Reducing the pine component of the forest may have implications for income derived from carbon stored in the forest (see Section 3.2).

This modelling also presents different native forest outcomes based on different forest types and browsing pressure. This will be relevant to landowners who have exotic browsers such as deer or goats in their landscape. The type of native forest that can develop will depend on the site locality and the level of browse pressure.

The modelling presented in Figure 1 shows three different pine thinning scenarios, together with long-term projections for four different modelled forest types. These four forest types are used as representatives of the likely ecological character of the native forest ultimately replacing the radiata pine:

1. Mānuka/kānuka – represents sites without management to address limited seed sources and/or high levels of browsing pressure. This forest type represents a worst-case scenario for natives as it assumes they remain indefinitely as a treeland with limited successional ability and therefore capacity to store carbon. However, with appropriate management, most mānuka/kānuka forests are likely to slowly develop into a diverse forest type containing tall canopy species with good potential to store high levels of carbon. The data is from Tairāwhiti (Gisborne Region) and browse pressure included deer, goats, cattle and possums (Graeme et al 2025).
2. Tōtara – represents compromised sites with good seed sources of tall-tree species such as tōtara but with high browsing pressure (no pest management), favouring the dominance of

unpalatable plant species. These forests can also develop into a diverse forest type with appropriate management. The data is from Northland and browse pressure included goats, cattle and possums (unpublished TTT data).

3. Coastal broadleaf – represents lowland North Island and upper South Island sites with good seed sources and limited browsing pressure. The data is from Marlborough Sounds sites with active pest control (Carswell et al 2012).
4. Kānuka/red beech – represents sites in lowland southern New Zealand with good seed sources and limited browsing. The data is from a Bank's Peninsula site with active pest control (Carswell et al 2012).

Forest types 3 and 4 represent diverse natural forest. Requirements for active pest management to achieve a healthy diverse forest will vary according to site specific conditions. Possible actions are discussed below.

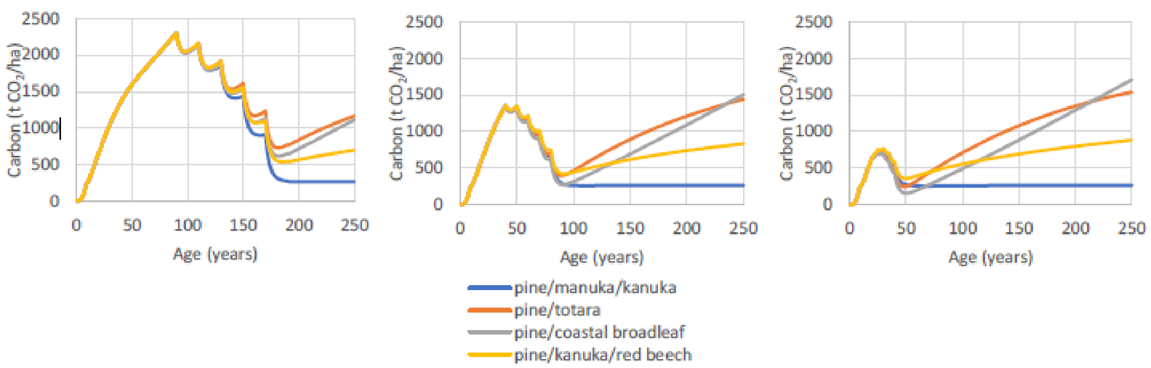


Figure 1: Transition scenarios with varying native forest types - 1. Coupe thinned between 90-170 years (left); 2. Coupe thinned/disturbance events between 40-80 years; 3. Coupe thinned 20-40 years (right). Note pine carbon storage is based on the national average for Radiata pine.

Should a forest manager want to transition to native forest as quickly as possible, they may decide to manipulate the pine canopy and undertake native planting additional to any necessary 'seed island' planting. Alternatively, a land manager may not want to expose the land to any sudden removal of pine canopy and manage the pine canopy to naturally thin and senesce, gradually falling over with time. This will free up resources for necessary pest control and also ensure a 'tree' cover for ETS purposes. Reclassifying production exotic forest as permanent forest may provide the opportunity for an ongoing income via carbon credits.

Any transition that aims for a diverse high-carbon native forest (e.g. coastal broadleaf for kānuka/beech forest type) will require browser and predator control relative to the catchment pest pressure.

4.2 Animal pest control

Exotic browsers and predators of seed-dispersing birds can affect the trajectory of a native forest transition (Wardle et al 2001). This in turn can affect the biodiversity and carbon sequestration value of the developing forest. Pest control methods utilised will depend on individual situations but can involve poisoning, trapping and shooting (ground and aerial). Fencing is only useful at a small scale.

Even where ungulates are not present, possum control is required to ensure favoured species such as kohekohe are not eliminated from the forest community via preferential browsing. The long-term trials set up as part of this transition project (see Appendix C) have found palatable species such as kohekohe are browsed out of plantings very quickly where possums are present. While the trial fencing does not exclude possums, they do exclude pigs. Therefore, given enough time, we may be able to infer the level of pig pressure on natural regeneration.

Undertaking animal pest control involves ongoing costs. The benefits include improved biodiversity and long-term carbon growth (biodiversity/carbon credits) and other economically unvalued ecosystem services.

Most Regional Councils have animal pest control advice and resources. Other resources can be found at Predator Free 2050 (www.predatorfreenz.org) and the Department of Conservation (www.doc.govt.nz/nature/pests-and-threats/).

4.3 Weed control

Environmental weed species can also affect the trajectory of a native forest transition (PCE 2021). Weed species of particular concern are those that are shade-tolerant and therefore persist under a tall canopy (e.g. tree privet, wild ginger) and/or vines such Old Man's beard or climbing asparagus that can cause canopy collapse or smoother the understorey.

Weed control is best undertaken during it's early stage of establishment when it can be more easily managed before it becomes a wide-spread issue. Weeds can be more common around areas of human activity (e.g. housing or roadsides). These are sites to monitor more closely than the middle of a forest where weeds are less likely to invade. Keeping the forest canopy intact helps reduce the diversity of weed species than can survive under the shade of the pine canopy and developing native understorey. Openings in the pine canopy can provide light levels that encourage weed growth so should be managed carefully (Forbes & Norton 2021).

Weed control involves ongoing monitoring and reactive management with varying costs.

Most Regional Councils have weed control advice and resources. Other resources can be found at Weedbusters (www.weedbusters.org.nz/) and the Department of Conservation (www.doc.govt.nz/nature/pests-and-threats/weeds/).

4.4 Supplementary native planting

Establishing native forest at a large scale through intensive blanket planting is often prohibitively costly often $20,000-$50,000 per hectare including fencing, planting and early weed control (Bergin & Gea 2007; Parliamentary Commissioner for the Environment 2022; Ministry for Primary Industries 2024) and, as with any planting programme, carries significant risks such as drought, weed invasion, and browsing damage. The level of post-planting maintenance required, particularly weed control to prevent suppression of newly planted natives and control of browsing animals can be significant. In large-scale blanket planting projects, post-planting care is frequently underestimated, commonly due to insufficient resources or a limited appreciation of the ongoing commitment required, which often leads to substantial losses in plant survival. The need for weed control for plantings within pine transitions is reduced or avoided by the suppression provided by the pine shade.

Regardless, large-scale blanket planting as part of a pine-to-native forest transitions is unlikely to be appropriate. Establishment of native species will generally be most effective in gaps within the pine stand (such as clear-felled gaps or coups) or beneath a tall sparse pine canopy where light levels are higher than found under dense young pine stands.

Native regeneration under a pine canopy may also be constrained by a lack of nearby seed sources (e.g., McAlpine et al. 2016; Moles & Drake 1999, Marshall et al 2025a). Supplementary planting of key native species, including canopy-forming trees within gaps or a thinned pine canopy may therefore be required to overcome this limitation.

One option for supplementary planting is the establishment of 'seed islands' - clusters of native shrubs and trees planted within the pines (see box below, Marshall et al 2025a). The aim is to establish patches of enhanced native diversity. This can be an effective and efficient method to increase the diversity and distribution of native seed sources throughout a transition forest and complement existing natural regeneration by adding missing forest diversity.

Targeted control of pines in gullies may also be an effective strategy to boost native revegetation as part of a network of 'seed islands' across the landscape. Regenerating low-to-moderate flammability native species within these gullies not only contributes to habitat diversity but can also function as natural fire breaks and stabilise gully systems. Over time, as the native gully buffer matures, it will potentially also serve as a 'slash trap', intercepting debris from windthrown pines on upper slopes. This reduces the risk of mobilised slash being washed downslope during storm events or heavy rain, further enhancing slope stability and downstream resilience.

Seed islands therefore offer a practical tool for accelerating transition within exotic forests: utilising protected microsites for establishment, boosting native seed production, and promoting succession towards a resilient, self-sustaining native forest ecosystem.

THE CONCEPT OF SEED ISLANDS

Introduction

Establishing 'seed islands' across landscapes involves creating small, intensively planted areas of native species to assist natural processes in developing diverse native forests at scale. This is a pragmatic and cost-effective approach, especially given the high cost of native planting (often exceeding $20,000/ ha) and the impracticality of intensive blanket planting across large areas.

The principle is to create small, intensively managed groves of native trees that that serve as nuclei for regeneration to enhance the diversity of wind- and bird-dispersed seed across wider regenerating or sparsely planted landscapes. By concentrating effort at small scale using tall, well-conditioned seedlings, providing shelter species where required, reducing browsing by pest animals, maintaining timely weed control, and, where practical, controlling predators of seed-dispersing birds, this approach is likely to ensure higher survival and faster early growth rates.

A Pragmatic Approach

There is no single prescription for seed islands. They represent a flexible and adaptive tool for encouraging establishment of native revegetation working with nature where the cost or logistics of blanket planting are prohibitive. The strategy is simply to create a network of small, diverse groves that act as hot spots of biodiversity across a landscape where there is interest in establishing native forest at scale. While seed islands are targeted at assisting reversion of marginal farmland, the concept is equally relevant to transitioning exotic plantation forests to native forest over time.

Role of Seed Islands in Transitioning Exotic to Native Forest

Strategically located seed islands within exotic pine forests can serve as nuclei for native forest development. These small, intensively planted groves act as local seed sources that stimulate wider natural regeneration as the exotic canopy ages, thins, or is progressively removed, helping establish a more diverse native high forest over time.

By incorporating later-successional canopy tree species, often missing from the typically shade-tolerant, shrub-dominated native understorey of pine forests, seed islands help accelerate succession toward a diverse, tall native forest. They are best established in canopy gaps or where thinning or poisoning of pines increases light availability, while still benefiting from the shelter provided by surrounding trees.

As the exotic canopy opens naturally or through active management, native seedlings from these islands spread outward through wind and bird dispersal. Over time, this expansion helps shift the forest composition toward native dominance without the need for large-scale planting.

See further information at –
https://docs.tanestrees.org.nz/how-to-establish-seed-islands-of-natives/

4.5 Reducing the pine canopy

Reducing the shade and competition from the pine forest can enhance the growth of a native understorey, particularly native species that are less tolerant to shady environments. Research has shown that opening gaps in wilding conifer canopies can increase native seed germination, but this is species dependent (McAlpine & Drake 2003, Forbes et al 2016). However, gap creation may also provide more opportunities for exotic weeds to establish and increase animal pest browsing (McAlpine & Drake 2003, Dickie et al 2022, Forbes et al 2016, Marshall et al 2025b), thereby also increasing maintenance requirements.

Erosion risks are associated with both killing the pines early and with leaving them to grow on. Clear-fell plantation forests experience a 'window of vulnerability' from when the tree cover is lost until the replacement fast-growing pines have developed a protective tree cover and root growth to intercept rainfall and help stabilise the slopes again. Replacement of the protective cover may be slower for native regeneration, resulting in an even longer 'window of vulnerability'. Alternatively, if the pine trees are left to stabilise the land for longer and die naturally, they may thin gradually or blow over *en mass* in a weather event. Therefore, the relative pros and cons of manipulating the pine canopy need very careful consideration along with the scale and timing of interventions. A targeted staged example is given above of early control of pines in gullies to boost native growth before the land stabilisation from uphill pines is reduced either through human intervention or natural senescence.

It may be wise to trial areas first to see how the forest responds, and to stage interventions to ensure the evolving situation can be realistically managed.

The stocking of pines can be reduced in a uniform way across an area, such as by evenly thinning stems throughout the forest to certain density (stems/ha), or through concentrated control of groups of trees, often referred to as coupes. These contrasting methods may variably suit the regeneration of different native tree species – potentially influencing the species composition of the future native forest (Forbes et al 2015, Roschak 2017). The size of a coupe may also be determined by practical considerations (e.g., matched to a tree length if manual felling is used), or by regulatory criteria e.g. carbon markets. However, both even or coupe thinning operations may elevate the risk of further canopy disturbances by wind and storm events.

Pines can be thinned by felling or killed standing by ringbarking or poisoning. The latter is probably the most cost effective and widely applicable method. Standing dead trees can provide perching opportunities for birds, which can help spread seed to promote natural regeneration. However, as outlined in Section 3, dead standing trees create a forest hazard. This risk has health and safety implications for public recreation and operational forest management activities until the trees have fallen.

Best practice methodology and efficacy for controlling pine density is outlined in de Lange et al (2022), Environment Canterbury (2025), Wilding Pine Network (2022), National Wilding Conifer Control Programme (n.d.-a,b). Most conifer control information is associated with wilding conifer work, however forestry companies will have good data around plantation thinning costs and new/favoured techniques. Control methods include both hand and chemical options. Table 1 provides a general comparison of estimated cost by tree size and density of pine stems.

Table 1: Estimated general cost by tree size and density of stems for pine control

Tree size	Likely cost per tree or per hectare	Time per tree	Key cost drivers / caveats
Small seedlings / saplings	Low per-tree cost (labour + small herbicide)	Seconds to a few minutes	High densities increase labour; re-emergence must be tracked
Medium trees (fell + stump treat)	Moderate cost (crew, chainsaws, herbicide)	Minutes per tree	Access, slope, vegetation obstacles, crew skill all matter
Large trees (drill & fill, or felled)	Higher cost (drill time, more herbicide, safety, handling fallen biomass)	Tens of minutes, possibly more	Safety, tree fall risk, site complexity
Dense stands / inaccessible terrain	Cost per hectare can be relatively high (due to helicopter, machinery, complex logistics)	Aerial methods treat many trees per hour	Regulatory consents, helicopter hours, drift management, terrain

Appendix C outlines the paired-plot trials set up as part of this research project to investigate the effect of pine canopy manipulation and ungulate/pig fencing on the survival of under plantings and natural regeneration. These trials will provide a baseline to track the influence of pine canopy density and browsing pressure on the natural regeneration of the understorey and trial plantings. Results from the trials will be included in the final project guidance report due 2027.

CHAPTER FIVE: MONITORING

5 Monitoring

Native forest establishment and successional processes involve many phases and very long timeframes (e.g Wyse et al 2018). It may take centuries for a tall, species diverse, native forest to fully develop. And, as the PCE (2025), pointed out "*In some places it may become increasingly challenging to re-establish forests in a way that resembles their former character.*"

Transition forests are unlikely to be the same as the historic forests, yet they may still develop into resilient, diverse, and self-sustaining native forest communities. Many of these native forest values will start to build even while the pines dominate and especially as the canopy thins out, either naturally long term, or by management shorter term. Monitoring, during the interim stages, towards the end goal is essential to measure progress. Such monitoring will also help detect any evolving risks and threats and identify the effectiveness of management interventions.

Forest structure, species diversity, and species composition are fundamental indicators for assessing ecological restoration success (Oliveira et al 2021). Monitoring needs to be an intrinsic part of adaptive management and is essential to inform forest management.

Ecological monitoring to measure progress towards transitional goals will need to objectively measure indicators such as forest composition and structure, threats, and trial outcomes including pine canopy manipulation. Key standard ecological monitoring metrics include:

Status of the pine canopy

- Density, age and other stand characteristics influencing light penetration and effect on the understorey development of existing pines.
- Consideration of various management regimes aimed at opening up the pine canopy.

Developing native-dominant forest composition and structure

- Species richness over time, ideally benchmarked against a nearby mature native forest.
- The presence and persistence of palatable species in the understorey and sapling layers.
- Evidence of canopy tree seedling regeneration and recruitment into the canopy.
- Development of forest tiers depending on the forest type (ground, shrub, sub-canopy, canopy).
- Presence of appropriate biota, such as groups of species fulfilling a particular ecosystem role (e.g. important seed dispersers) to allow for natural ecosystem functioning.

Threats and Pressures

- Weed surveys and mapping, with emphasis on vulnerable entry points such as roadsides and tracks.

- Animal pest monitoring, ideally linked to national datasets to define threshold browsing levels that allow regeneration.
- Impacts of ongoing land use, such as grazing or adjacent forestry operations.

Trial outcomes including canopy manipulation

- Operational trials to compare pine canopy manipulation methods and effect on understorey regeneration or planting to guide short-term management.
- Long-term experiments to evaluate the efficacy and cost-effectiveness of interventions such as poisoning the pine canopy or enrichment planting with natives.

5.1 Monitoring methods

A variety of ground-based methods are available to support systematic, repeatable ecological monitoring:

- Permanent Sample Plots (PSPs): Provide robust, long-term data on survival, growth, and forest structure. PSPs generally involve establishing bounded plots (up to 400m^2) for mature pine or native forest to provide accurate stand densities by species. Plot measurements of tree diameters and heights and sapling and seedling heights by species provide stand level metrics such as mean diameter, mean height, basal area, volume and carbon. Although developed originally for radiata pine stands, the procedures for establishing standard PSPs are described by Ellis and Hayes (1997).
- Reece Plots: A semi-quantitative method to determine changes in species composition and abundance within tiers over time, both exotic and native. Reconnaissance plot descriptions (RECCEs) are a versatile technique used for inventory and monitoring in a wide range of vegetation types (Hurst et al. 2022). Field measurement of bounded plots of various sizes depending on the height of the canopy but generally up to 400m2, including recording mean top height of the vegetation, and then estimated percentage canopy cover of species within 6 defined height tiers and assigning a Braun–Blanquet cover abundance scores for each species within each tier.
- Paired-Plot Methodology: Comparing treated and untreated pine canopy areas to measure effects of differences to native understorey development over time. Monitoring methods for research trials will be customised to the objectives, forest type and scale as required but is likely to follow the standardised monitoring methods of either PSPs or Recce systems along with ensuring plots are established in representative areas and follow statistically robust procedures for randomisation and replication.

Monitoring planted natives: A practical, low-cost system has been developed by Tāne's Tree Trust to measure the success of nursery-raised native plantings, both with and without pine intervention. The Native Planting Monitoring Tool (https://monitoring.tanestrees.org.nz) provides a simple, quantitative, plot-based method for assessing early survival and growth of planted natives. It allows systematic sampling of planting sites to generate statistically robust data on early performance. The results help identify key risks to newly planted trees, inform management priorities such as pest animal control, and highlight species best suited to local site conditions.

Remote sensing is likely to become a practical monitoring method complementing ground-based monitoring. Drone imagery and aerial surveys provide potentially scalable ways to monitor canopy cover, potential species change, and site conditions.

The inclusion of **matauranga Māori** incorporates traditional monitoring methods and can encompass wider wellbeing/health indicators than just ecological.

Monitoring techniques are always evolving. Examples of additional techniques that are starting to become more widely used include:

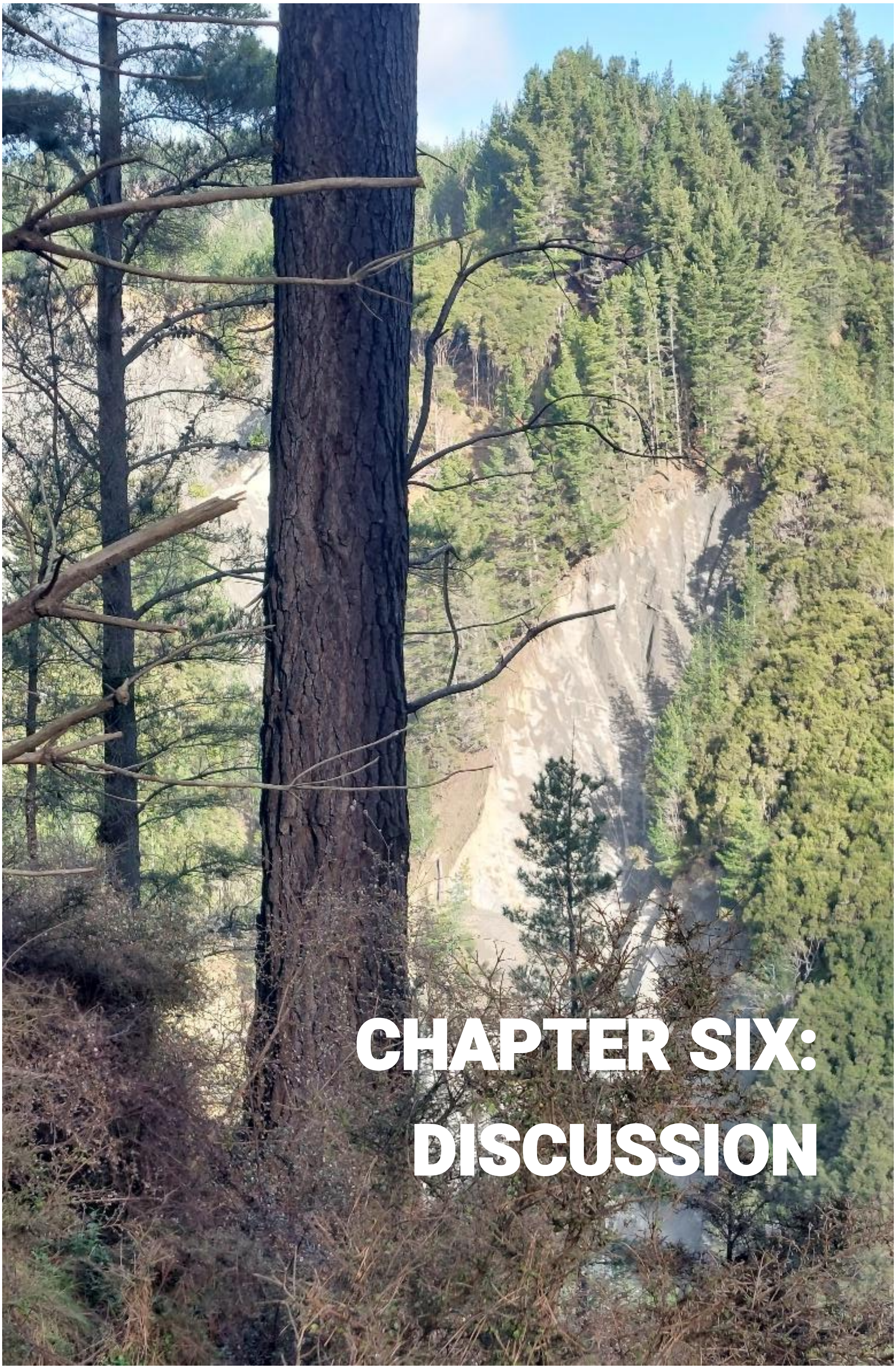
- eDNA (eDNA For Environmental Monitoring – Biological Heritage NZ)
- Bioacoustics (see Listening to Nature: The Emerging Field of Bioacoustics - Yale E360, (PDF) Good practice guidelines for long-term ecoacoustic monitoring in the UK, Bioacoustic monitoring of lower North Island bird communities before and after aerial application of 1080 | NZES)

Tāne's Tree Trust Database Upgrade

Tāne's Tree Trust (TTT) is expanding its role as a hub of publicly accessible information, tools, and data to support native forest establishment and management, and also Close-to-Nature continuous cover forestry, and transitional forestry nationwide. A key step is upgrading its national database of plot-based measurements in planted and regenerating native forests. This will help fill critical knowledge gaps, as identified by the Parliamentary Commissioner for the Environment, by consolidating scattered datasets and making them more widely usable for land managers, researchers, and agencies.

Purpose and Scope

The new upgraded TTT Database will allow easy entry, processing, and secure storage of data on both planted and naturally regenerating forests, including mixed species/mixed age forests, native–exotic stands, (e.g., transitional pine to native forestry, and continuous cover forestry). Users will be able to use this system as a repository for their forest inventories, compare performance across species, sites, and management practices, drawing on a diverse set of trials, surveys, and operational programmes nationwide.



CHAPTER SIX: DISCUSSION

6 Discussion

Why transition

This project evaluates the characteristics of established radiata pine plantations on steep hill country that are too risky or uneconomic to clear-fell. It seeks to identify options for transitioning unharvested radiata pine stands on these erosion-prone landscapes toward permanent native forest. Increasing severe storms resulting in destructive landslides that wash sediment and woody debris from steeplands are a huge threat to the health and wellbeing of downstream communities, waterways and the coastal environment. The situation is expected to worsen with climate change predictions.

Identifying alternatives to conventional clear-fell forestry is therefore essential to address this growing risk. Approaches that guide exotic to native forest transitions can help reduce these wider landscape hazards while contributing to large-scale re-establishment of permanent native forest, long-term carbon absorption and biodiversity gains.

Factors influencing transition

Our research has highlighted that many established radiata pine plantations, particularly older and lower density stands, support significant native understorey biodiversity. The analysis of the LUCAS national database and the regional survey of pine stands undertaken in Tairāwhiti indicates these understoreys are dominated by shade-tolerant native shrubs and subcanopy tree species, and tree ferns. Research and observations indicate that widescale browsing and seed predation by ungulates, possums and rats is having a significant impact on regeneration. Retaining and enhancing this existing regeneration avoids the inevitable reset caused by clear-felling and reduces the risk of mobilising sediment and slash during storm events and establishment of light-demanding weeds. However, successful succession to a mature diverse native forest depends on several key factors:

- Recruitment of later successional native canopy tree species supported by adequate local seed sources and seed dispersers;
- Protection from browsing animals and shade-tolerant environmental weeds; and
- Allowing time (multi-decadal) for a natural or managed turnover of the pine canopy to enable the transition to tall native forest.

This research shows that the first two biotic factors - seed supply and animal pest pressure - are the most significant constraints and will require a landscape scale approach. Existing remnant native forest can be mapped and complimented with actively planted 'seed islands' (where needed) throughout the landscape. Control of animal pests and weeds will be an ongoing activity, and the level of management will be determined by the threat intensity in the landscape e.g. type and density of weed sources, exotic browsers and predators of seeds and native animals including seed dispersing birds. Pest animal and weed control undertaken at a small scale is less efficient and effective that large scale landscape control.

Monitoring will also be needed to record the change in structure and diversity of the developing native forest over time.

The bioclimatic study shows that native regeneration within mature radiata pine plantations is strongly shaped by climate, stand structure, and landscape context. Native plant richness and stem density were highest in areas with elevated rainfall, mid-elevations, older stands with more open canopies, and landscapes containing >30% native forest within 5 km, highlighting the importance of nearby seed sources. Warm, sheltered sites with moderate summer temperatures performed best, while high wind exposure and heavy browsing greatly suppressed regeneration.

These findings identify the conditions under which transitional forestry is most feasible and may provide practical thresholds for prioritising large-scale sites where natural succession toward native forest is most likely to succeed.

Management options

Pines can be thinned by felling or by killing them standing through ringbarking or poisoning, the latter generally being the most cost-effective option. Standing dead trees provide bird perches that aid natural seed dispersal, but they also create forest hazards, with health and safety implications for public access and operational management until the trees eventually fall.

Depending on a forest owner's objectives, transitional forestry can range from passive management to highly active intervention:

- Hands off approach – Pines are left to age, thin and collapse naturally but will require ongoing animal pest control. Depending on the location, the forest will also benefit from weed control and planting of native seed islands where required. This option avoids abrupt soil exposure and will likely maintain high carbon uptake for many decades, however the transition to native tree dominance will be delayed.
- Active canopy manipulation – Thinning or creating gaps can accelerate understorey development if paired with pest control as required with the 'hands off approach'. There are pros and cons of speeding up the pine canopy collapse which need to be considered and will vary for each site. If there are environmental threatening weeds it can be beneficial keeping a shaded pine canopy as long as possible, or at least until there is a dense native understorey. Another reason to keep the pine canopy standing may be to enhance carbon sequestration by the pines for as long as possible.
- A mixed approach – For example, where gully stability is an issue, it may be beneficial to control the pines within the riparian zone to allow faster native tree establishment while leaving the rest of the catchment pines standing to help stabilise the upper slopes. The native riparian zone will provide a developing native seed source and green fire buffer and by the time the catchment pines begin to die naturally the maturing riparian buffer will be better able to trap any collapsing trees that might be mobilised by storm events.

Demonstration trial sites

Three permanent trial sites were established as part of Tāne's Tree Trust's *Transitioning Exotic Forest to Native* project to evaluate the effect of canopy manipulation and pest animal management on natural regeneration and plantings. Trial results will be analysed at the end of the project and incorporated into the final guidelines. Ongoing surveys of these long-term trials will help refine carbon and biodiversity models and inform empirical management practices.

Further research

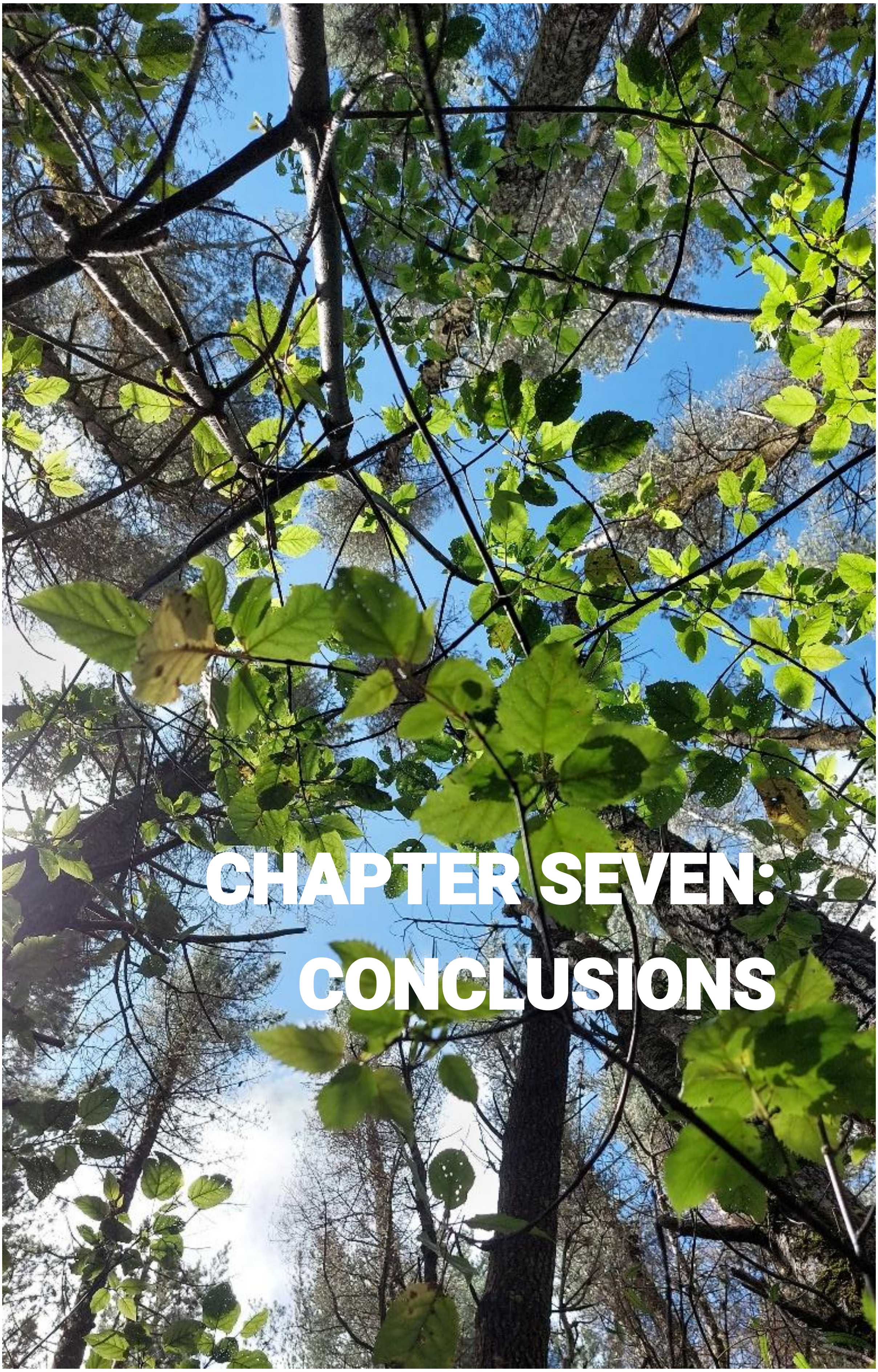
Further research is required to guide effective transitions from exotic plantations to native forest. Priority needs include:

- Extending permanent regional trials to understand how different sites respond to canopy manipulation, pest animal control and natural regeneration.
- Continuing monitoring of established long-term trials and enhance with new surveys of revegetation in pine canopy gaps to identify which species are dominating higher light environments and compare how quickly they develop compared to natural regeneration under closed pine canopy.
- Identifying minimum native stem densities and optimum pine canopy densities over time needed to support successful succession including the recruitment of tall native canopy species.
- Determining effective spacing of native seed sources across a landscape and an understanding of seed dispersal distances and timeframes for viable seed production to act as a network of stepping stones for bird and wind dispersal.

Monitoring and adaptive management

Transitions from radiata pine to native forest take many decades and include many uncertainties. This does not mean that transitions cannot be established but highlights that regular monitoring and adaptive management are essential. Monitoring will allow tracking of transition stand condition under different management regimes including native species recruitment (especially palatable vs canopy species), structural understorey development, and threats such as weeds and browsing. Tools such as Permanent Sample Plots, RECCE plots, paired-plot comparisons, TTT's Native Planting Monitoring Tool, and new technologies like drones, eDNA and bioacoustics can all support consistent, repeatable assessments. Mātauranga Māori can also guide monitoring by incorporating cultural and wellbeing indicators.

A practical adaptive management approach that involves long-term monitoring will allow adjustments and learnings as work progresses. Because transitions are long-term and uncertain, management plans must be flexible and updated as new information from trials and monitoring becomes available.



CHAPTER SEVEN: CONCLUSIONS

7 Conclusions

Overall, the research highlights that transition forestry involves a complex set of management decisions shaped by site conditions, ecological constraints, economic considerations, and long-term objectives. Successful transitions require clear goals, an understanding of local bioclimatic pressures, and a realistic assessment of how much intervention is needed—ranging from intensive canopy manipulation, pest control and seed island planting to more passive, gradual succession only with pest control.

Transitions also involve navigating trade-offs. Faster, more intervention-heavy approaches can accelerate native forest development but may come with higher financial and environmental costs and risks. Slower, low-intervention approaches preserve canopy stability and carbon stocks for longer but may delay the full ecological benefits of mature native forest establishment. Fire risk, overhead hazards from senescing or poisoned pines, and uncertainty around the recruitment of native canopy species all require careful consideration. Carbon modelling indicates that a dip in total carbon is unavoidable during transition, with timing and severity strongly influenced by management choices and with potential implications for ETS participation.

The feasibility and acceptability of transition forestry are also shaped by social licence, community expectations, and compatibility with other land uses. Ultimately, successful transitions depend on robust, site-specific management plans, long-term commitment to addressing pest and weed pressures, and a willingness to adapt management as conditions and knowledge evolve. When these elements are in place, transition forestry can stabilise vulnerable landscapes, support biodiversity, and set in motion the development of resilient native forests for future generations.

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APPENDICES

APPENDIX A: CASE STUDY - Adaptive management of coastal forestry buffers

This study provides an example of whether pine stands can assist a pine to native transition in a situation where the bioclimatic conditions are not favourable to forest establishment.

Introduction

The Adaptive Management of Coastal Forestry Buffers project explored methods for transitioning failing aged exotic coastal pine buffers in the upper North Island into diverse native forests. Unlike the even-aged pine stands currently protecting production forests, native duneland ecosystems are expected to be more sustainable and resilient to climate change.

The Problem

Historic duneland forests across New Zealand have largely disappeared due to clearance, fire, and browsing animals, surviving today only in a few South Island locations. Sand dunes are among the most difficult habitats for native plants to re-establish, with challenges including wind, salt, drought, nutrient-poor soils, and invasive species.

To stabilise dunes, foresters planted exotic buffers, mainly radiata pine. These were intended as sacrificial forests that protected inland production forestry by reducing sand movement.

The Need for Change

Many pine buffers are now over-mature and failing, creating vulnerability for production forestry. Climate change, with its likely increases in droughts and storms, adds further pressure.

Replacing exotic buffers with native coastal forests offers environmental benefits. Native ecosystems are more resilient, permanent, and culturally valued, and their restoration aligns with the New Zealand Coastal Policy Statement and national biodiversity priorities. Social drivers are also important: forestry companies increasingly seek a “social licence to operate” by incorporating cultural, community, and conservation values, consistent with Forest Stewardship Council standards.

Challenges in transitioning exotic buffers to native

Re-establishing diverse native duneland forests is a long-term project requiring careful management in harsh coastal conditions. Transitioning strategies must balance protection of inland production forestry with cost-effective restoration. Success depends on three main factors:

- Shelter
- Seed sources
- Control of exotic browsers

- Additional considerations include pine canopy density, planting density, and buffer width.
- Shelter and Shade

Pines tolerate harsh coastal conditions and provide shelter essential for native establishment. Their canopy replicates the role of early pioneer species, creating shade, reducing drought stress, and enriching soil. Field trials showed higher survival rates for native plantings under pine canopies than in exposed dunes.

Using pine as a temporary pioneer canopy can potentially accelerate forest succession by decades compared with relying solely on hardy native pioneers. Pines also suppress weeds, lowering management costs. However, canopy management is crucial: if too dense, it restricts light; if too open, weeds proliferate.

Native Seed Supply

Because many dunelands lack remnant native forest, natural seed dispersal is often limited. Birds and wind generally only disperse seeds short distances. Where local seed sources are scarce, “seed islands” can be planted within pine buffers. These groves act as stepping stones for birds, gradually spreading seed throughout the buffer.

Seed islands can also function as green firebreaks, using low-flammability native species such as ngaio, karamu, hangehange, karaka, and kawakawa. Establishing seed islands with large plants, fencing, or pest control increases their survival, particularly where broad pest control is not yet feasible.

Exotic Animal Control

Browsing by rabbits, hares, possums, goats, deer, and pigs can devastate young plantings and suppress regeneration. Effective pest management must precede and continue throughout restoration. Rodents and mustelids also reduce seed supply and bird populations, so large-scale pest control is often required.

Pine Manipulation

Dense pine canopies initially protect natives and suppress weeds. but naturally thin and senesce over decades. This introduces canopy gaps where natives, including light-demanding species, can start to dominate.

Where faster or more controlled transition is needed, foresters can selectively fell or poison pines. Poisoning allows trees to die standing, reducing damage to undergrowth while still providing bird perches. However, canopy openings must be monitored to prevent weed invasion.

Long-Term Resilience

Sustainable coastal buffers must be designed to withstand climate change impacts such as sea-level rise, drought, fire, and storms. Key factors include:

- Buffer width: allowing for inland migration and reduced edge effects.
- Forest diversity and maturity: reducing risks from fire, disease, and pests.

Historical pollen records show that forest composition naturally shifts with climate change. This underscores the need for diverse, adaptive ecosystems rather than monocultures. Transitioning to native buffers is therefore both an ecological and economic investment in long-term resilience.

Conclusion

The transition from exotic pine to native duneland forest is complex, requiring innovation, long-term vision, and ongoing management. Key strategies include using pines as shelter, supplementing native seed supply, implementing strong pest control, and managing pine canopy density.

Replacing failing pine buffers with diverse native forests will:

- Enhance ecological resilience and biodiversity.
- Provide more permanent protection for inland production forestry.
- Align with national biodiversity priorities and climate change adaptation needs.
- Support forestry companies' social and cultural responsibilities.

A shift to native coastal forests represents a sustainable pathway forward, ensuring both ecological and economic resilience for New Zealand's duneland landscapes.

Further information: Tāne's Trees – Adaptive Management of Coastal Forestry Buffers.

APPENDIX B: Transitional Forest Management Plan

The following sets out a general framework for a Transitional Forest Management (TFM) Plan for transitional forestry. These include:

1. **Land ownership details**
   - Set out relevant ownership details, land titles and interests (e.g., if freehold, leasehold, Māori owned, an Incorporated Society, or subject to forestry rights etc.).
2. **Catchment communities**
   - Outline the relevant communities and their values/interests (mana whenua, rural land users, residential, interest groups).
3. **Detailed inventories and mapping of forest features and values**

   Land description:

   - Spatial mapping of geographic features (e.g., topography, soils, roading, waterbodies/courses, and wider local landscape context/connections -especially proximity to other areas of native forest).
   - Bioclimatic data (e.g., rainfall, mean temperature, elevation etc.).
   - Historic land cover, land use, and management history.
   - Current land use, features, and values including cultural values (e.g., Waahi tapu, significant landforms, archaeological sites, recreational and landscape values, and visual catchments etc.)

   Forest description:

   - Forest inventory (e.g., map forest types, describes existing plantation stand/compartment age, stand stocking, height, volume etc., also understorey composition, characteristics, and development).
   - Ecological and natural features and values (e.g., presence of rare flora and fauna or values, presence of pests and weeds, relative capacity for natural regeneration).
4. **Zones and regulations**
   - Applicable District Plan zones, rules and mapped notations.
   - Other policy and regulatory documents (e.g., NES-CF).
5. **Objectives and goals**
   - Outline short, mid, and long-term goals and desired outcomes, relevant to forest owners, the local community, and the environment. (N.B. – these should include economic, environmental, social, cultural, recreational, landscape values).

6. **Capacity, resources, and sustainability**

- Identify financial and human resources available for long-term, intergeneration management investment (e.g., forecasts of carbon returns).
- Structures for long-term management continuity.
- Risks to income security, and management/governance capacity.

7. **Proposed Forest Management details**

- Identify forest management units and prescribe their detailed management including:
- Silviculture (e.g., canopy thinning, underplanting etc.).
- Forest protection measures (e.g., livestock exclusion, windthrow avoidance, fire risk mitigation etc.)
- Animal pest, weed, biosecurity and disease control (e.g., browsers, predators, wildings, and weed invasions, access policies and protocols for plant and machinery etc.)
- A works/implementation budget and programme.
- Risk management, insurance and mitigation (e.g., carbon liabilities, health and safety risks from dying trees).
- Contingencies for regeneration/transition failure and/or disturbance events.

8. **Monitoring and review**

- Set up forest monitoring systems (e.g., Forest Reconnaissance (Recce) plots Permanent Sample Plots) to monitor native regeneration, changes in forest composition, successional structure, growth and carbon.
- Set up animal pest and weed monitoring (with a focus around disturbance areas such as roads).
- Schedule and budget for appropriate periodic re-assessments.
- Schedule reviews of the TFM Plan to respond to results from monitoring and/or new research – i.e. to effect adaptive management.
- Consider how to report on progress/trends towards an ecological transition and how to model or predict future trajectories.

APPENDIX C: CASE STUDY - Transition Management trials

Introduction

This case study documents early results and design of forestry management trials undertaken as part of Tāne's Tree Trust's (TTT) 5-year *Transitioning Exotic Forest to Native* programme, supported by a Ministry for Primary Industries (MPI) Sustainable Food and Fibre Futures (SFFF) grant (2022–2027).

The overarching aim of the project is to investigate practical methods for transitioning exotic plantation forests (primarily *Pinus radiata*) into self-sustaining native forests. The trials test canopy manipulation and under-planting techniques in partnership with iwi, local councils, the Department of Conservation (DOC), and forest industry companies. These efforts will generate long-term datasets on forest dynamics that can inform landowners, managers, and policymakers seeking alternatives to clear-felling on erosion-prone or environmentally sensitive land.

Trial Sites

Omahuta Forest (Northland)

In 2023, Tāne's Tree Trust, the Department of Conservation, and local hapū established paired experimental plots in Omahuta Forest.

Site description: ~20 ha of naturally re-established *Pinus radiata* originating c.2003.

Surroundings: Seed sources of broadleaf, kauri, and podocarp species are located within ~150 m, increasing the likelihood of natural regeneration.

Management approach: Paired plots compare intact pine canopy with 100% poisoned pine canopy (via drill-and-fill technique). Fencing is used in selected plots to exclude browsing animals and selected fenced/unfenced plots have planting to supplement natural regeneration.

This site is particularly valuable for testing transitions from relatively young, naturally regenerated pine into mixed kauri–podocarp systems.

Whangapoua Forest (Coromandel)

In 2023, Summit Forestry Ltd partnered with TTT to establish trials in Whangapoua Forest.

Site description: ~2.3 ha of 1976-planted *Pinus radiata*.

Surroundings: Broadleaf–podocarp seed sources present in riparian margins within ~70 m.

Management approach: Paired canopy treatments (retained vs poisoned), under-planting, and fencing.

Whangapoua represents a mature exotic stand, making it an ideal test site for canopy-retention and transition strategies instead of clear-felling.

Upper Maitai (Nelson)

In 2024, Nelson City Council and TTT established paired plots in the upper Maitai catchment.

Site description: ~3 ha of 1992 *Pinus radiata*.

Surroundings: Mixed beech–podocarp native forest within ~100 m of plots, providing diverse native seed sources.

Management approach: Paired canopy treatments (retained vs poisoned), under-planting, and fencing.

This site links directly to Nelson's water supply catchment management, testing how transitioning pine to native can simultaneously support biodiversity, water quality, and resilience against slope failure.

Objectives of the Trials

The forestry management trials are designed to:

1. Compare natural regeneration and under-planting success under intact pine canopy versus fully poisoned canopy.
2. Measure canopy effects: assess how light availability affects planted and natural understorey regeneration and weed establishment under different treatments.
3. Assess browsing pressure by comparing fenced and unfenced treatments.
4. Develop long-term datasets (beyond the 5-year SFFF timeframe) to understand successional dynamics over decades.

By the end of 2027, these trials aim to provide early insights into which combinations of treatments (poisoning, under-planting, fencing) most effectively establish self-sustaining native trajectories across different ecological contexts.

Trial Layout and Methods

Each site is structured around paired plots:

- Retained pine canopy.
- % poisoned pine canopy (via drill-and-fill).

Within each treatment:

- Natural regeneration is monitored by counting, identifying, and measuring spontaneous native seedlings.
- Under-planting involves introducing selected native canopy species (e.g., tōtara, kahikatea, taraire, pūriri, hard beech) to accelerate succession.
- Fencing treatments test the effect of browsing exclusion on seedling recruitment and survival.

Annual re-measurement includes monitoring stem density, growth rates, species composition, canopy openness, soil conditions, and browsing damage.

Ecological Context and Background Knowledge

Previous ecological studies inform the trials:

Canopy influences on succession: Cameron (1960) noted that dense mānuka or kānuka canopy can suppress podocarp regeneration. By comparison, dense pine canopy may similarly restrict establishment of light-demanding conifers.

Gap dynamics: McGlone et al. (2017) reviewed evidence that conifer establishment in New Zealand forests typically requires light gaps and canopy openings. Thus, canopy manipulation (selective poisoning, thinning) may be essential for enabling podocarp recruitment.

Species shade tolerances: Canopy trees vary—tawa is highly shade tolerant; miro tolerates moderate shade; rimu is relatively shade intolerant. These traits suggest different species will succeed under retained pine canopy vs poisoned canopy.

Successional opportunities: Heenan et al. (2024) argue that if podocarp seedlings establish in pine understoreys, they may capitalize on canopy gaps as pines die and potentially outcompete faster-growing broadleaf, setting forests on long-term conifer-dominated trajectories.

Anticipated Outcomes and Long-Term Value

The trials are expected to yield:

- Comparative growth and survival data for native species under pine canopies versus poisoned canopies.
- Evidence-based recommendations on canopy manipulation strategies (e.g., when and how to poison pines, when to retain for microclimate or weed suppression).
- Understanding of seed source and dispersal limitations, highlighting when targeted under-planting is essential.
- Indications of browser effect on vegetation composition, highlighting which browser species require control to help achieve a diverse native forest.
- Practical guidance for councils, iwi, and landowners managing aging or hard-to-harvest pine stands.
- Long-term monitoring datasets that continue beyond 2027, offering insight into transitional forestry.

Conclusion

The forestry management trials in Omahuta, Whangapoua, and the Upper Maitai catchment are pioneering demonstrations of how New Zealand's exotic forests can be guided toward native forest futures. By systematically testing canopy retention versus canopy removal, and layering in under-planting and browsing control, these trials will provide the practical prescriptions urgently needed by land managers.

The collaborative model—linking iwi, DOC, councils, and forestry companies with TTT—ensures that results will be locally grounded and nationally relevant. Over time, these sites may stand as living examples of how New Zealand can meet its biodiversity, climate, and cultural aspirations by weaving native forest back into landscapes currently dominated by exotic pines.