Transitioning Exotic Forest to Native

Draft Preliminary Guidelines for Transitional Forestry

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TĀNE'S TREE TRUST
Native Forests for our Future
Hereherea te Wao-nui-a-Tāne

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Executive Summary

Exotic to native transitional forestry is a method to consider for changing clear-fell plantation land use to permanent native forest. Permanent diverse native forest, particularly on steeplands, can provide many benefits such as reduced erosion, downstream flood protection, aquatic and terrestrial species habitat, and carbon sequestration. The method to reestablish diverse native forest from clearfell production land can be either via management following harvesting or transitioning unharvested plantations.

This is an interim report offering early or preliminary guidelines on the topic of transitioning existing plantations of exotic forest to native forest via processes of ecological succession, as opposed to clear-felling and planting and/or relying on natural regeneration following a clear-fell harvest operation. It is based on the findings to date from a 5-year research project funded by the Te Uru Rākau, The New Zealand Forest Service.

Definition

The results of this project are specific to plantations of radiata pine. However, we use the term ‘transitional forestry’ more generally, as the concept and management intent to transition plantations of exotic trees species to native forest, using the timeframes and processes of natural forest succession and various levels of active management interventions. This relies on the potential of exotic plantation species to act as a nurse cover for regenerating native species.

Relevance

Transition forestry is particularly relevant for existing exotic forests established steep marginal and remote hill country. Many of these pine plantations were originally planted for erosion control but have become uneconomic to harvest or too risky to clear-fell due to the potential downstream impacts of severe storm events. In such area, transitioning towards permanent native forest offers a safer and more sustainable option where the multiple values and benefits associated with native forest are sought in the long term. It will also be relevant to exotic plantation forest established for the purpose of carbon sequestration rather than timber production.

Evidence and confidence

While research, case studies and examples exist to indicate that transitional forestry is possible, more research is needed to isolate and understand the multiple influencing factors and to inform management. While a transition may be possible, necessary management costs may make it unviable.

Adaptive management approach

Transitional forestry is complex and will involve managing dynamic ecologies in flux with changing pressures. Best practice requires a comprehensive intergenerational forest management plan. A thorough understanding of the site, forest, ecological processes, along with financial and human resources and capacities is also essential. However, initial management will, by necessity, commence based on our current level of knowledge, yet need

to be flexible enough to cope with evolving issues and new understanding. Therefore, a 'learn by doing' adaptive management approach, based on regular monitoring, trials, and reviews, is recommended.

A content outline for a Transitional Forestry Management Plan is provided in this report.

Conducive site factors

Abiotic conditions such as temperature, rainfall and soil affect the type of vegetation that can be sustained at a site (refs). Some site conditions do not support tall forest growth e.g. alpine elevations, wetlands such as marshes or fens.

Sites that historically supported tall forest that have good rainfall, mild temperatures … will be the most conducive to transitioning back to native forest. However, there are also sites the loss of the protective forest cover has resulted in sites now exposed to harsh conditions (e.g. open dunelands, or sub-alpine tussock lands). These sites will be more difficult to transition but utilising the hardy nature of pine can potentially boost native forest re-establishment through providing a tall protective cover relatively efficiently.

Apart from biotic factors, other factors influencing whether a transition will be successful or not include proximity of native seed sources, exotic browser pressure and time. Time is required for seed to naturally disperse and plant communities to develop.

Management options continuum

Transitions to native forest on less conducive sites, and/or where quicker transitions are desired, may require more active and costly management interventions and inputs (such as thinning, extensive weed and ungulate control, and supplementary planting). On more favourable sites, and if transitions over longer timeframes are acceptable, then relatively more passive management approaches such as relying on browser/predator control and natural regeneration and succession, may be possible.

Our modelling suggests that without active canopy manipulation, Radiata pine forests may take 80 - 170 years to naturally transition from being predominantly exotic to predominantly native forests1. In contrast, active manipulation of the pine canopy could expedite a transition point to around 50 years.

Potential advantages of transitional forestry

Slowly transitioning an existing exotic forest may be an alternative option to an abrupt transition by felling and or poisoning all of the exotics. The potential advantages include; utilising an existing tall forest 'nurse' cover, avoiding damage to existing native understory, managing light-tolerant weed species and erosion risks. There may be potential to earn carbon credits from the exotic nurse in the short and mid-term and perhaps in the future from biodiversity credits from the developing native forest.

Potential disadvantages of transitional forestry

Notwithstanding the potential benefits, disadvantages and risks include; the longer timeframes required, extended period of hazardous forest conditions, and our research

[1] Based on relative proportions of standing volume of carbon

indicates that, as long as radiata pine dominates, the rate of carbon sequestration of the native forest component is slower than planted or regenerating native forest in open conditions.

Inevitable dips in carbon stocks during transitions

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 natural stand mortality), and where the residual carbon stocks within the native forest understories is insufficient to immediately offset the loss from the pines. Long-term, total carbon stocks are predicted to increase again depending on the type of succeeding forest.

There appears to be significant scope for management choices to influence the timing and severity of the carbon dip or dips. Through deliberate thinning of the pines or disturbance events, the dip may occur within the first half century. In contrast, without any thinning or disturbances, the dip could be extended out to 80+ years.

Delaying the dip is likely to achieve a much higher peak of carbon sequestered before the inevitable dip.

Carbon markets

Forest owners are advised to obtain expert advice regarding the potential implications, opportunities and/or liabilities and risks associated with the New Zealand Emissions Trading Scheme, and/or other regulations and carbon markets.

Policy and regulation

Well managed transitional forests have the potential to provide a pathway forward from past land use decisions and provide significant environmental values over time. However, currently there is no policy or financial stimulus that recognises the value of forests demonstrating they are on a successful transitionary trajectory towards diverse native forest.

Policy analysts might consider the implications of these preliminary research findings in relation to the existing regulatory mechanisms. A number of potential roadblocks and incentives are discussed.

1. Introduction

1.1 What is Transitional Forestry?

Transitional forestry is a relative 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. Forbes et al 2015 and 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[2] 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." (Forbes et al 2015)

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 limited project budget and short timeframe.

While the results of this project are specific to plantations of radiata pine, we also use the term 'transitional forestry' more generally, as the concept and management intent to transition plantations of exotic trees species to (predominantly) native forest, using the timeframes and processes of natural forest succession and various levels of active management interventions.

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[2] Alt-F Reset: Examining the drivers of forestry in New Zealand. April 2025. PCE.

1.2 Why is transitional forestry relevant?

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 certainly encouraged significant afforestation, predominantly with radiata pine, often with carbon sequestration rather than timber production being the primary purpose for many of those forests. This has not been without controversy.

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 carbon-farming, there is some international research to indicate that plantations of exotic species can harbour indigenous species and facilitate native regeneration, albeit more likely as novel communities instead of exact restorations of previously existing native forests. (e.g. Brockerhoff et al 2003, Marshall et al 2023). Although still unproven in New Zealand, there are also indications that, in some circumstances, such transitions might also be viable here (Forbes et al, 2019). However, due to the long timeframes involved, and lack of examples, this is not a certainty.

The NZ ETS has incentivised afforestation with exotic species, including extensive areas of exotic plantation forest established for the purpose of carbon sequestration rather than timber production. These are often referred to as carbon forests or for carbon-farming. There are also significant areas where clear-fell harvesting is either uneconomic, environmentally unacceptable, or because the forests are in the Permanent Forest category of the NZ ETS. Developing ways to appropriately manage such forest areas 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 & Norton 1996, 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.

1.3 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, Forbes Ecology prepared two reports for MPI, one on the then current state of knowledge on the topic of transitioning exotic plantations to native forest; and a following one on the existing data and research approaches for addressing knowledge gaps for forest carbon aspects of transitioning plantations. The latter 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?

1.4 Project purpose and scope

The goal of this 5-year project was to conduct research to provide science-based information to inform forest managers, planners, researchers, regulators and policymakers, and especially to provide early guidance for active practitioners. Of course, this will not constitute complete or final guidelines on the matter, rather just relate early findings and indications to support an adaptive management approach in relation to managing this developing type of forest management. It is anticipated that further research, trial results, and experiences will complement and build on the outputs of this project.

This project focused on transitioning radiata pine to native forest, and included:

- Analysis of existing LUCAS (Land Use and Carbon Analysis System), a national land-use mapping and carbon-accounting framework, to assess native understory development and forest characteristics within plantation forests to better understand these forests and potential management options to encourage a transition.
- Plot surveys to gain information about bioclimatic effects on native understorey characteristics within pine forests in multiple regions.
- Targeted plot surveys to measure the understorey characteristics of plantations in the Tairāwhiti region and determine what management actions are required to support a pine to native forest transition.
- Establish a network of permanent trials to inform carbon and biodiversity forestry models and to empirically refine management practices.
- Model predicted long-term dynamics of transitional forest carbon and native understorey development, including successional change, with varying disturbance and/or management scenarios.
- Collating a summary of the above research results (in this report), highlighting the key findings, and develop preliminary guidelines on managing transitions from exotic pine forest to native forest.

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.

This report and the summary guidelines will be made freely and widely available via the Ministry of Primary Industries forestry and land management advisory services and networks, and from Tāne's Tree Trust website.

2. General 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 understories 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 understories 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 understories 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 understory of existing radiata pine forests:

LUCAS National Forest Study – We analysed understory 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 understory 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 understory 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 understory of existing exotic plantations. The research aimed to:

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

The analysis used data from 196 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 understory species (1.2%), and exotic understory species (0.8%).
- Although naturally regenerating radiata pine was a significant component of the understory in second rotation stands, it declined markedly in importance with stand age.
- Apart from regenerating radiata pine, most understory carbon was stored in native species. Native vegetation occurred in 68% of plots, averaging 2 species per plot.
- More than 50% of native understory 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 understory 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 understory 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 understory 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

Understory 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 understory of radiata pine forests strongly favour the development of secondary colonising shade-tolerant native understory subcanopy tree, tree fern and shrub species.

Although thinning radiata pine stands will encourage understory growth, even in low-density radiata pine stands the carbon stored in the understory 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 understory 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-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 understories.

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 m.a.s.l, with optimum conditions ≥500 m.a.s.l.

- 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,
- Areas with >30% native cover within 5 km,
- 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 Tairawhiti 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 understory 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.
- The understory was overwhelmingly native, with natives comprising 98-99% of both stem counts and carbon, although this understory stored only 1.3% of total carbon (averaging 22 t CO_2/ha).
- 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 understory carbon, stem density, and species richness.
- Crop stand density was negatively correlated with understory carbon, Shannon diversity, and species richness.
- While older and lower-density pine stands support greater understory 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).

Conclusions and Implications for Forest Transition

The study indicates that the native understory in Tairāwhiti radiata pine plantations is predominantly composed of secondary colonising, mostly shade-tolerant, native species with a mean species richness of 11 for all stems and average 4 species for stems ≥ 2.5 cm DBH.

Browsing pressure (deer, goats and/or cattle) and closed pine canopies limit regeneration of understory plants.

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

The abundance of native species in the understory of old radiata pine stands suggests that, if left unharvested, these stands will eventually transition back to native forest. However, the carbon stored in the native understorey, even in low-density pine stands, is only a small fraction of that stored in the pine trees. Therefore, as the forest transitions there will be a significant and unavoidable drop in the total carbon stored in the ecosystem.

The Tairāwhiti understory carbon and density/diversity metrics were higher than the national LUCAS metrics, likely reflecting the older age of the Tairāwhiti stands. The Tairāwhiti sites also generally has suitable biotic and abiotic conditions for understorey growth, apart from 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 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 restoration of pine buffers can assist with the re-establishment of threatened dune forest which will help restore a threatened ecosystem as well as provide a more resilient and permanent buffer for inland plantation stands (see the Coastal Buffers case study in Appendix A).

3. General management considerations

Transitional forestry presents a complex management challenge. There are contentious issues associated with transitional forestry with fears of creating long lasting environmental problems for future generations.

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.

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 long, 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.

This section highlights and discusses some general principles and considerations relevant to transitional forestry. It then outlines the process and content required to create a Transitional Forestry Management (TFM) Plan.

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 attributes, and the potential to be managed for multiple purposes. These will often be unique combinations 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).

Ecologists generally agree that ecologically diverse indigenous ecosystems are more resilient to impacts from a changing climate and other pressures such as invasive species (e.g., Scnabel 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 and 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, 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, and 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 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 D, 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 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 understory. 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), or human safety risks from creating hazardous forest conditions. 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 around much of NZ (NIWA 2016). Species-diverse native forest is generally less flammable than monocultures of pine or regenerating kānuka or tōtara (Depietri and Orenstein 2019). However, stress and disturbance to a forest changes the hazard and wildfire potential (Gross et al 2024). Minimising fire risk for transitioning forests will be similar to plantation forestry. 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 of less flammable native species. This could create 'green fire breaks' that may help impede the spread of a fire (Depietri and Orenstein 2019, Aimers et al 2021). Such areas can also function as 'seed islands' to enhance the diversity of understory tiers developing under the remaining pine canopy (see Seed Island discussion in Section 4).

See: https://www.ruralfireresearch.co.nz/__data/assets/pdf_file/0005/63932/14553-FlammabilityGuide.pdf

Creating overhead forest hazards

Hazardous forest conditions – namely the increased risk of falling trees and branch debris, will likely be created at some stage during a transition. The timing and duration of the increased risk period will be influenced by the management approach. Active interventions such as poisoning pines to reduce their stocking could intensify the risks but shorten the period of risk. In contrast, leaving the pines to self-thin through natural disturbance events and/or to die out naturally, will prolong the risk over many decades – probably over half a century or more. Health and safety may significantly affect management activities such as the ability to undertake pest and weed control, monitoring, and recreational activities while elevated risks from forest hazards exist. Safety and health concerns will be a serious issue for planning and managing transitional forests, noting that all forests have overhead risks associated with tall canopy.

Native forest canopy development

Generally, native understories under pine timber stands are slow to develop, have low volumes of carbon, and comprise only relatively few and sparsely stocked native canopy species. If browsers are present, then the stocking of palatable tall canopy species will be significantly reduced or absent. Dense native understories of tree ferns and shrubs can also inhibit the regeneration of native canopy tree species, especially the less shade-tolerant species Forbes et al., (2016). Furthermore, mortality amongst the native seedlings, saplings and young trees developing in the understory and substories should also be anticipated due to damage from falling debris, trees and heaving root-plates from the failing pines. Yet the successful transition to a tall native forest will require sufficient recruitment of native trees species through the sub-canopy tiers to form a new canopy.

To allow for mortality and ensure natural succession, the pine understorey will need to support a high density of seedlings (including tall canopy species). Like native forest understories, seedling numbers will reduce through natural attrition and falling debris. However, at this stage the minimum stockings of native canopy tree seedlings, saplings, and small trees, is not known. This 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 residual carbon stocks within the native forest understories is insufficient to immediately offset the loss from the pines. This issue was noted by the PCE (2025) and has been confirmed by our modelling.

In no scenario modelled were we able to avoid a significant dip in carbon stocks during a transition. However, there appears to be significant scope for management choices to influence the timing and severity of the dip or dips. 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, delaying the dip is likely to achieve a higher peak of carbon sequestered before the inevitable dip.

Following the dip the potential to regain and build 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 also 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 understories developing within pine forests sequester less carbon and at a slower rate than planted native forests in open conditions. Such understandings may be important when considering ultimate management objectives – especially if native forest restoration rather than carbon income is the primary goal. A general observation is that carbon sequestration rates of the native understories are low as long as the pines are present.

NZ ETS considerations

[to be reviewed by MPI]

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, and its size (i.e., if it is under or over 100ha) will potentially affect its status in respect to the NZ ETS.

For forests over 100 ha in size and/or needing to account for carbon stocks using the Field Measurement Approach (FMA), our modelling does not suggest any financial advantage in managing to facilitate an early transition to native forest. However, at present, for forests less than 100 ha in size, and accounting for carbon stocks using the Ministry for Primary Industries' Carbon Look-up Tables, there is no financial penalty for inducing a dip in total carbon stocks while a forest is still classed as predominantly an exotic forest (determined by total basal area at breast height, of tree stems per hectare) and the greater than 30% canopy cover threshold is maintained. A transitioning forest with a canopy comprised of a low density spread of pine trees over a developing native understory (that includes native canopy tree species), is likely to meet those criteria for a considerable period. This suggests that carbon accounting using the look-up tables, may be preferrable for forest owners wishing to manage an early transition from pine to native forest.

Other considerations may include the risk that potential future income from carbon credits may fluctuate according to the value of the units, and/or regulatory changes to the NZ ETS (Exempting/limiting forestry etc.).

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. Increased disturbance of forest canopies can affect weed communities of natural forest understories and changes in litter decomposition and nutrient cycling (Jo et al 2025) and disturbance can lead to increased wind throw and drying within a forest (Harper et al 2005, Laurance et al 2007, Norton 2002) and fire risk (Gross 2025). 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 are complementary or conflicting with establishing and maintaining a resilient native forest.

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 forest cover. In such instances developing an active management plan to transition a forest (or parts of a forest) to native – even if it involves intergenerational timeframes, inherent risks and uncertainties, 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 a transition is both tenable and that the necessary long-term active and adaptive management required to ensure a successful transition will be undertaken.

Transitional Forest Management Plans

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 transitional 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 management plan.

4. Active management options (interventions)

4.1 Introduction

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.

4.2 Modelling transition scenarios

Our modelling (Kimberley et al 2025) indicates that interventions or natural disturbances that significantly 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 coupe thinning or other significant disturbances) could result in a transition to native dominance as early as 50 years. Of course, reducing the pine component of the forest may have implications for income derived from the total stocks of carbon stored in the forest. This is discussed in Section 3. However, forest owners may wish to expedite an early transition to native for various reasons such as establishing a native cover earlier.

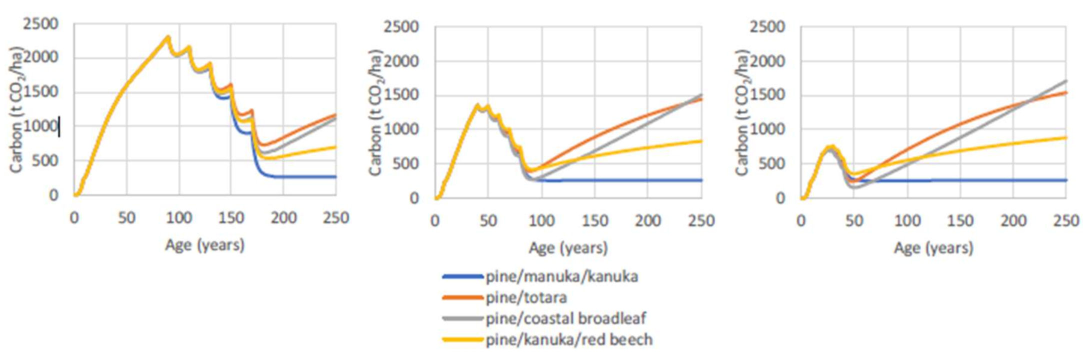

Figure …: Transition scenarios with varying native forest types - 1. Coupe thinned between 90-170 years (left); 2. Coupe thinned/disturbance events between 40-80 years; 3. Coupe thinned 20-40 years (right).

For these three scenarios, the long-term projection following pine thinning/disturbance is then modelled on different forest types. These four forest types are used as representatives of the following situations regarding the likely ecological character of the native forest ultimately replacing the radiata pine:

1. Mānuka/kānuka - represents sites with 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. Without limitations, most mānuka/kānuka forest is likely to develop into a diverse forest containing tall canopy species with good potential to store high levels of carbon.
2. Tōtara - represents sites with good seed sources of tall-tree species such as tōtara but with high browsing
3. Coastal broadleaf - represents sites in central - northern New Zealand with good seed sources and limited browsing
4. Kānuka/red beech - represents sites in lowland southern New Zealand with good seed sources and limited browsing. Options for active management will vary according to site specific conditions. Possible actions are discussed below.

4.3 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 D) 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/).

4.4 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 understory.

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/).

4.5 Supplementary native planting

Establishing native forest at a large scale through intensive blanket planting is often prohibitively costly (Bergin & Gea 2007) 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 canopy that has been thinned or poisoned to increase light levels.

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 2025). Some 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 2025). The aim is to create seed islands placed within canopy gaps or areas where active thinning of the pine canopy is underway. This can be an effective and efficient method to increase the diversity and distribution of native seed sources throughout a transitioning 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 landscape scale transitional forestry. Any 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/

4.6 Reducing the pine canopy

Reducing the shade and competition from the pine forest can enable the regeneration and/or quicker growth of a native understory, including native species that are less tolerant to shady environments. Opening gaps in wilding conifer canopies can increase native seed germination , but this is species dependent (McAlpine & Drake 2003, Forbes et al 2016). It 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), 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 plantings have developed a protective tree cover and root growth to intercept rainfall and help stabilise the slopes again. Alternatively, if the pine trees are left to die naturally, they may thin gradually or blow over in a weather event in a mass. Therefore, the relative pros and cons of manipulating the pine canopy need very careful consideration along with the scale and timing of interventions. 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 concentrated to small 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 (refs). 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 if the forest is in the NZ ETS (e.g., to ensure minimum forest cover requirements are maintained). 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 significant 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 for controlling pine density is provided in Appendix C.

Appendix D 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.

5. Monitoring

Native forest establishment and successional processes involve many phases and very long timeframes. 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.*" Transitional 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 probably start to build even while the pines dominate and especially if the canopy thins out, either naturally long term, or by management shorter term. However, during the interim stages, progress towards such goals is essential to measure progress including any evolving risks and threats and to identify and 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 which ideally also needs to be an intrinsic part of adaptive management is essential to inform forest management.

Ecological monitoring is required to measure progress towards transitional goals and will need to objectively measure indicators such as forest composition and structure, threats, and trial outcomes including pine canopy manipulation and the developing native components:

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 understory 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).

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.

Monitoring methods

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

- Permanent Sample Plots (PSPs): Provide robust, long-term data on survival, growth, and forest structure. PSPs generally involve establishing bounded plots each up to 400m^2 in area for mature pine or native forest to provide accurate stand densities by species, and field measurements of tree diameters and heights by species to provide various 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.

Additional monitoring techniques:

- 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.

6. Policy and regulation

Policy and regulation designed for certain outcomes can sometime cause unintended impacts on activities not initially considered in the policy or regulation drafting. It is important to consider in drafting how existing land uses can adapt to increasing knowledge and expectations around sustainable land use. This will help avoid roadblocks to transitioning to a new land use that can provide important ecological and community benefits. Even so, unexpected effects can arise and need to be addressed if we are to improve how we utilise and protect natural resources. Such issues have arisen around policy and regulations that hinder the transition of a pine stand to a highly underrepresented ecosystem (e.g. potential carbon liabilities associated with transitioning a pine stand back toward native duneland forest - see Appendix A). Similarly, forest owners can potentially be liable for carbon liabilities if they want to transition larger more sustainable riparian margins back to native forest.

Incentives are also important to consider. In respect to income related to carbon sequestration, there is no financial incentive to manage an early transition from Pinus radiata to native forest. Nor is there presently any effective financial stimulus to incentivise the biodiversity gains and other potential environmental benefits from transitioning exotic plantation forests to diverse native forests. The potential development of Biodiversity credits could be a useful tool to help fund large-scale and on-going pest control where it can be shown that an exotic forest is following a trajectory towards a diverse native forest ecosystem. Averaging of carbon credit payments over the long-term of a transitional forest (as for production forests) could also help smooth large up-front payments and ensure ongoing funds for continuous maintenance costs.

Some sites may lend themselves to transitioning to a continuous cover forestry (CCF) regime that allows for long-term timber production potential. Low intensity and low impact harvesting may be possible, and timber could be one of many values such forests provide. However, there is presently no suitable provision under Part 3A of the Forests Act, to enable the legal milling of naturally regenerated (as opposed to planted) native species from within exotic forests that were established prior to 1990. This may disincentives management to increase the native component within exotic forests where the option for some long-term timber production may still be desired.

7. Further research

There is a need for ongoing research around adaptive management and monitoring of transitioning exotic forests. Other areas that require further research include -

- Survey revegetation in pine canopy gaps to get a clearer idea of what species are dominating light gaps and how fast are they growing.
- Determine the minimum native stem density per hectare required for successful gap succession to occur. [also of relevance to native forest establishment]
- Determine the minimum canopy species stem density per hectare for a successful transition to mature tall forest to occur.
- Practical distance between seed islands across a landscape to act as a network of stepping stones for birds to frequent and spread seed.

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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: Summary of control of conifer trees (pines) relevant to transitional forestry operations

Introduction

Methods for controlling exotics, particularly pines, are provided by tree size and scale of the number of pines, either planted or regenerated as wildings are summarised. Information is based on research and operational wilding pine programmes (refer to references for more details). Control methods include both hand and chemical options.

Small seedlings – hand pulling

For seedling pines less than 1m high and preferably less that 2cm basal diameter can generally be hand pulled. It is best to ensure the root systems are left elevated above bare soil and exposed to fully dry out.

Depending on the existing vegetation cover, particularly height, small seedlings may be difficult to locate if hidden within a canopy of shrubs. Timing of operations may be best left until seedlings appear above the existing vegetation cover for crews to quickly locate establishing pines.

Saplings – stump cutting

Pine saplings 1-2m or greater in height and with basal diameters greater than 3-4cm basal diameter are likely to be too difficult to readily hand pull. Manual removal will require hand-sawing or cutting with loppers care is required to ensure the cuts are clean, low to the ground and the stumps have no green foliage remaining.

It is essential that stems are cut as close to ground level as possible to ensure all green foliage is removed otherwise stumps are likely to resprout. In many cases herbicide treatment of small seedlings cut at ground level may not be required if the cut is done cleanly.

This method is suited for sparse to moderate densities on accessible ground.

For larger saplings and small trees, a combination of hand cutting and application of herbicide can be considered. This involves cutting the tree as close to the ground as possible with a light chainsaw or other hand tools, and immediately applying a herbicide gel to the cut stump to prevent regrowth. Timing is important as the herbicide must be applied soon after cutting while the stump is live. This method is efficient and widely used in ground control where access allows.

Small-to-medium size trees

For larger stems with a basal diameter ranging from about 10-30cm, options include felling and treating stumps with herbicide or herbicide treatment of base.

Cut stump and herbicide – Medium-sized trees are often felled with chainsaws (or handsaws where small and it is practical) and stump herbicide treatment applied. This method is practical in accessible terrain and moderate densities.

Ground-based basal bark application (GBBA) – This method involves spraying a low-volume herbicide (often oil-carrier + active ingredient) around the base of the stem encircling the lower bark so that it is absorbed into the tree. It is effective for small to medium stems with some sources indicating up to approximately 30 cm diameter trees can be treated in suitable conditions. This method is particularly useful in ground control operations where many stems can be treated without cutting or drilling holes for inserting chemical.

According to Briden et al. (2014), this method enabled contractors to treat trees in less than 20 seconds per tree, a big improvement over the older 1-5 minutes per tree with more manual methods.

Large trees

For large trees often greater than 30cm in diameter and up to over 1m in diameter, the "drill & fill" method is often used.

Drill & fill (injection It is preferred where felling is dangerous such as on steep slopes or where there is a substantial understorey of native vegetation with the potential to develop as the poisoned pine canopy gradually opens up. It involves drilling holes at up to 10cm intervals around the trunk and injecting herbicide into the sapwood to kill the tree.

Aerial basal bark application (ABBA) – Applied from helicopters, this is essentially a targeted spray (via wand) of herbicide to the lower stem bark of scattered small to medium trees in difficult-access or steep terrain. It avoids felling in hazardous terrain and allows remote access.

Aerial foliar spray (AFSA / boom spraying) – For dense, closed-canopy infestations, aerial spraying of tree foliage from a helicopter (or plane) is often preferred. This applies herbicide to needles (foliar uptake) across many trees. It's efficient over large areas, but requires careful application (droplet size, wind conditions, drift control, buffer zones near waterways) and regulatory consents.

Briden et al. (2014) note that aerial boom spray is a newer method that offers efficiency gains over traditional felling in dense stands.

Skid-hopping or aerial crew drop-off – In remote or rugged terrain with sparse clusters of large trees, helicopters may drop in crews who then undertake ground control (e.g., cut-stump or drill & fill) on the spot. This is known as "skid-hopping" or crew drop-off. This method reduces walking access costs but is expensive due to helicopter time.

Harvesting for timber or as biofuel – Where trees are large enough and access allows, conventional forestry harvesting may be an option. This can offset costs from the sale of logs for timber or providing wood chip as a fuel source, but such clear-felling of stands must be balanced with ecological and erosion risks. Logging is typically viable only in dense stands of commercial-size trees on accessible terrain.

Herbicide

Type of herbicide – Metsulfuron-methyl is the most common and versatile type of herbicide used to control most conifer species when undertaking the drill and fill operation however there are other herbicides that can be used as a substitute.

- Metsulfuron-methyl (600g/kg) – Metsulfuron-methyl is a sulfonylurea herbicide that inhibits plant growth by stopping cell division in roots and shoots, primarily targeting broadleaf weeds and some woody plants such as gorse, blackberry, and broom. Suitable for all wilding conifer species except for Pinus contorta and Pinus pinaster.
- Glyphosate (510g/l or stronger) – Glyphosate is the world's most common herbicide used to kill weeds in farms, orchards, gardens, and public areas by inhibiting their ability to absorb nutrients. Suitable for Pinus pinaster and all other wilding conifer species, except Pinus contorta, when metsulfuron methyl is not available.
- Triclopyr amine (360g/l) and Aminopyralid - Triclopyr amine is a systemic, auxinic herbicide used to control broadleaf and woody plants by mimicking plant growth hormones, causing abnormal and twisted growth that leads to plant death. Only for control of Pinus contorta.

Mixing rate (herbicide mixing rate with water or additives) – when using herbicide follow the recommended rates with mixing with water, other herbicides or adjuvants. The following rates suitable for conifer control have been recommended by the National Wilding Conifer Control Programmes in the publication, Gound-based Herbicide Injection – Drill and Fill, Version 3: October 2021:

- Metsulfuron-methyl (600g/kg) – Mix 50g of metsulfuron-methyl (600g/kg) per litre of clean water. Ensure the water has a pH > 7.
- Glyphosate (510g/l or stronger) -Use a neat (no dilution with water or any additives) solution of glyphosate (510g/l or stronger).
- Triclopyr amine (600g/l) and Aminopyralid – Mix a neat (no dilution with water or any additives) solution of triclopyr amine (360g/l) + 30 ml/L aminopyralid.

Costs of different control methods

Estimating costs and times is challenging because they vary substantially with terrain, density of the exotic trees being targeted, accessibility, species, crew experience, permitting requirements, and follow-up requirements. Nevertheless, some indicative figures and published data help give a ballpark for planning.

Per-tree or area cost and timeframe

Research and observations from experienced operators involved in controlling exotics provide insights in costs at the tree or area level and estimates of timeframes involved. Examples include:

- Briden et al. (2014) compared old methods (hand removal, cutting, scrub-bars) vs newer basal bark and aerial bark methods. They note that traditional physical methods took 1-5 minutes per tree, whereas the newer basal bark method reduced that to less than 20 seconds per tree in good conditions.
- In one operational setting near Twizel, using basal bark spraying over 30 ha, contractors took 2.5 days to complete; the same area with older methods was estimated to take over 10 days.
- The initial removal phase tends to be the most expensive per hectare due to the initial density of regenerating exotics. However, each subsequent maintenance sweep is cheaper since fewer and smaller trees remain.
- Timing of control operations can affect cost and timeframes for control including the season and growth phase of the trees (e.g., spring growth vs winter dormancy), and ease of access (e.g., slippery wet ground vs dry conditions).
- Some mechanical or aerial approaches may scale better per hectare than manual tree-by-tree treatment, particularly in dense infestations or remote terrain.
- A comparison of estimated cost by tree size and density of stems is provided below.

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

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APPENDIX D: 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 Forest 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 understory 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 understories, 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.

References (placeholders for now):

Cameron, R.J. (1960).

McGlone, M.S. et al. (2017).

Heenan, P.B. et al. (2024).

Tāne's Tree Trust project updates (2023–2024).

MPI Sustainable Food and Fibre Futures project brief.