The active forest management regime of New Zealand Carbon Farming's permanent forest estate

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Figure 1: 42-year-old *Pinus radiata* with podocarp regeneration on the East Coast with no active forest management

Abstract

This paper explores New Zealand Carbon Farming's (NZCF's) approach to transitioning exotic forests to resilient, biodiverse native forests. The organisation's approach combines ecological principles with practical management techniques to transition exotic forests into native ecosystems, while simultaneously mitigating climate change and enhancing biodiversity.

NZCF's management regime is underpinned by a robust scientific foundation, including data-driven decision-making and long-term planning. The organisation's interventions, such as site selection, nurse crop establishment, pest control, canopy manipulation and enrichment planting, are designed to align commercial imperatives with long-term specific ecological objectives. NZCF's approach to forest management aligns with emerging trends in international forestry. There is a growing recognition of the need to move beyond the traditional dichotomy between industrial plantation forestry and conservation towards more integrated and sustainable approaches that combine economic objectives with ecological restoration.

Results demonstrate the effectiveness of NZCF's regime in achieving desired ecological outcomes, such as increased biodiversity and improved forest health. The paper highlights how active forest management offers valuable insights for forest owners and managers seeking to implement sustainable practices and address pressing environmental challenges.

New Zealand Carbon Farming

New Zealand Carbon Farming (NZCF) is a private company established in 2010. The focus of the business is to concurrently: sequester carbon to make a real

difference in climate change; and provide a long-term lasting legacy of resilient and biodiverse native forest in its permanent forest estate. Through its active forest management regime, NZCF has successfully sequestered over 30 million tonnes of carbon to date, making a significant contribution to New Zealand's climate change mitigation efforts.

The organisation is now the largest New Zealand owner of planted managed forests, actively managing 78,000 ha of forest lands across 118 forests throughout the country. Seven of these are in the South Island and the balance in the North Island. The bulk of the NZCF forests managed are permanent, but there are also 12 forests (5,300 ha) established by NZCF and managed for other landowners for timberland outcomes.

In terms of carbon management, NZCF has 114,000 ha, including 36,000 ha of forest under carbon management for other forest owners for a timber outcome. The organisation has 70 full-time staff involved in this management programme, as well as an extensive contractor workforce.

The forest ecology and science

NZCF's forest management regime is underpinned by a deep understanding of forest ecology. With a team of four experienced trained ecologists, seven professional foresters and seven GIS specialists, NZCF employs a data-driven, science-based approach to forest management. Also, for the last seven years the organisation has been assisted by an Independent Advisory Group of professors, researchers and people with significant experience in native forests. This group has provided rigour and third party review on the continued enhancement of the organisation's forest management regime. This collaborative approach ensures that NZCF's practices are informed by the latest scientific research and best practices.

Climate change is significantly impacting forest ecosystems, leading to changes in species distribution, altered growth patterns and increased vulnerability to pests and diseases (Bravo et al., 2017). The organisation's commitment to sustainable forests is embedded in its long-term planning, which focuses on achieving desired future forest structures through carefully targeted interventions. As part of its planning, NZCF are very focused on the climax forest structure required. This focus provides confidence, underpinned by its management actions, to ensure that the forest is on a pathway to deliver the required climax state for permanent forests. This approach ensures that NZCF's forest management efforts are aligned with both short-term and long-term goals.

Trends in best practice international forest management

New Zealand's forestry history has been significantly influenced by its past land use practices, including large-scale native deforestation. In the early 20th century the country experienced a surge in exotic plantation forestry, particularly *Pinus radiata*, following the Royal Commission of Forestry recommending in 1913 to expand exotic forestry to meet New Zealand's growing timber needs.

By the 1950s, the depletion of native timber resources became increasingly apparent. Exotic timber, particularly *Pinus radiata*, rapidly gained market dominance, accounting for over 80% of total production by the late 1960s. By the late 1980s, public pressure led to a virtual cessation of native logging. This approach created a polarised landscape, with limited integration between industrial plantation management and conservation forest management.

This historical context has shaped New Zealand's forestry landscape and continues to influence contemporary discussions about sustainable land use and forest management. This pathway of large-scale exotic forestry has presented challenges and opportunities for balancing economic development with environmental protection.

Forest management regimes and systems spanning this great divide in New Zealand are few and far between. This is highlighted in the Scion 2023 paper 'Transitional Forestry in New Zealand: Re-evaluating the Design and Management of Forest Systems Through the Lens of Forest Purpose' (Jones et al., 2023). The paper commented, 'forestry within New Zealand is an ongoing process of change from an existing bimodal philosophy of land management, where industrial plantation forestry and conservation forestry sit in apparent opposition, to future sets of forestry systems that blend multiple uses, landscapes and forest types.' Also, 'There is a clear and growing international recognition of a multitude of environmental, economic and cultural benefits from afforestation with mixed stocks of native and non-native tree species, when working within more adaptive forestry paradigms' (Figure 1).

Other authors also mention this dichotomy between the two main forest types – the benefits of enhancing existing forest's functions through active management (Payn, 2021) as well as afforestation on lower productivity land classes (Watt et al., 2011) – giving opportunity to create a mosaic of land uses integrating more forest types to the landscape.

The NZCF forest management regime sits within this trend, which has alternative ways of monetising non-timber aspects of forestry to ensure long-term sound forest management and prudent stewardship. It should be noted that in other parts of the world, particularly in Europe, there have been active forest management systems for many centuries. There are a broad range of forest management approaches, especially for mixed-species forests and forest transition regimes (Pretzsch et al., 2017), where NZCF's regime would look quite at home.

The NZCF regime

Within a transition forestry management regime, regeneration is a naturally occurring ecological process of forest succession. Fast-growing pioneer trees provide the right conditions for a slower-growing and more complex forest, allowing a range of species to become established as part of a biodiverse ecosystem.

To accelerate and support the natural regeneration process, NZCF uses an initial crop of exotic trees supplemented by native seed sources. It also undertakes careful management and planned interventions to create the ongoing environment for the transition to a biodiverse native forest.

Site selection

Our site selection for afforestation has targeted low-productivity land, Land Use Capability 6 and above that is often steep, erosion-prone and has more difficult access. We also seek sites with existing native seed sources. These sorts of sites enhance our start point for our overall regime for the ongoing regeneration process and forest succession process. We undertake detailed site due diligence, to understand well what the nature and scope of future interventions may be specific to the site, and to achieve our long-term objectives.

Establishment

Good site-specific planning, up front, is key. Understanding the site well ensures that we are able to best leverage the opportunities to obtain optimal carbon sequestration, and ensure our long-term objectives of well-structured, productive and resilient permanent native forests. We establish at a stocking of 1,200 stems/ha to get early canopy closure, suppress competing weeds, and get the process of forming a good forest environment underway as soon as possible.

Pest control

For new afforestation, pest animal control starts well before any new seedling goes into the ground. NZCF has a comprehensive pest animal control programme. This programme protects exotic nurse crop and (also critically) the growth and development of native species. A comprehensive and professionally managed pest management programme is vital to the success of a regenerating native forest.

NZCF currently invests more than $2 million p.a. on the largest private pest management operation in New Zealand. Since 2019 we have removed over 127,000 animals. Over the last two years we have removed over 28,000 animals p.a. The mix of animal species includes 50% goats, 20% deer and 13% possums.

One element of our pest animal control programme is buffer zones. This is a management tool we have across our estate where we work with neighbours to put in place formal legal agreements

Figure 2: AT220 in action – possum removals

that give us the ability to remove animals off their land. This is done in a very structured manner, with Health and Safety considerations a top priority.

When we started our pest animal control programme it included a traditional possum trap line programme. Now, the use of the Auto Trap AT220 has moved us to a new level of efficiency and effectiveness in our possum (and other pest species) control programme (Figure 2). The AT 220 has: automatic re-setting and re-luring; up to 100 resets resulting in a huge labour-saving cost reduction; fresh lure dispensed automatically every night, with the lure trail created over time attracting more pests; and a monitoring app using Bluetooth.

NZ Auto Traps (which last year NZCF became a half-owner of) have just released the AT520 AI; AI standing for Artificial Intelligence. This new trap has AI-enabled technology with a camera for real-time species identification and precision targeting. This allows species selective arming, protecting native species and targeting non-native species. It has auto re-setting and fresh lure dispensing for continuous pest control as with the AT220.

Of particular note is the feature of Advanced Remote Monitoring with Yarn Mesh, which is a wireless mesh communications technology providing extensive, reliable connectivity across vast and complex landscapes. Therefore, you have real-time updates and comprehensive monitoring through a self-forming, self-healing network. It has a solar-powered design with remote alerts for lure replacement and maintenance needs. We initially saw the Auto Trap products as a possum control tool, but there is a much broader application on a wider range of pest species. We continue to complement our use of Auto Traps with a wider range of trapping systems (e.g. targeting of mustelids and other pest species).

Ungulates (deer and goats) across New Zealand are at very high levels. For us, the re-invasion of our forests is a real issue. Deer can and will travel long distances very quickly to seek new food sources. As detailed earlier, over half of our animal removals are goats. With a more rapid breeding cycle than deer their long-term control requires ongoing focus.

Canopy manipulation

Forest thinning is part of our regime to manage forest health, wind firmness, forest productivity and fire risk. We use a chemical thinning treatment process, which we refer as Variable Density Thinning (VDT). This phase of thinning targets a stocking of 650–750 stems/ha (Figure 3). To support the regeneration process, VDT is also used to manipulate the forest canopy further as one of the keys to native regeneration is the role and also, where required, the management of the forest canopy and introduction of light to the forest floor (Figure 4).

For our VDT canopy manipulation planning we use high resolution aerial imagery and have trained an AI tool 'Picterra' to count every tree in our forest to determine an initial site-specific assessment of stocking. The actual thinning operation is tracked via GPS to ensure the contractor treats the required area in the correct location and to the prescribed standard.

As part of our canopy manipulation programme, in 2021 we established gap optimisation trials in the King Country and East Coast. These trials looked at various gap sizes, waste chainsaw thinning vs chemical thinning, and enrichment native planting and no native planting.

Other canopy manipulation investigations we have progressed include:

Figure 3: Variable Density Thinning (VDT) forest treatment in a 12-year-old *Pinus radiata* stand

- Coupe harvesting with replanting in native species that aligns with our targeted longer-term forest structure
- A pilot to determine what forest sites may be amenable to production thinning vs chemical thinning, and what is the full suite of operational and other considerations required.

Enrichment planting

Targeted spatial enrichment native planting to support and accelerate the natural forest succession process is a key tool (as required) to provide confidence that the pathway forward to the long-term forest structure is on track. Our focus on the spatial structure over time of the future forest sees us plan targeted spatial intervention, where needed, on areas of most value. This is based on the distance of our nurse crop exotics species from existing native forest and what the specific species requirements are.

The need to intervene can arise if existing native seed sources are too far away and/or are not the right species. Then targeted enrichment planting, which includes seed islands, can be timed and sequenced if required for the specific forest site (Figure 5). This process may also be in tandem with our VDT as required (managing light levels with VDT). Different native species at different altitudes, aspect and site conditions in the same forest may also be required.

Fire mitigation and forest health

Like any prudent forest owner, we put real effort into fire mitigation measures across our estate. This includes:

- Commencing a green break programme where we are in corridors of high risk (i.e. power line corridor), where we plant more fire tolerant natives and then thin our pines out over time. This uses the VDT technique already described
- Having our fire plans online with Fire and Emergency NZ (FENZ). Water point locations are part of our fire plans. Our weather stations are connected to the FENZ network for input to Fire Index reporting
- Having a comprehensive Powerline Corridor Management work programme, working actively with lines companies. As part of our fuel reduction initiatives, we undertake roadside pruning and targeted grazing.

Forest health is a high priority for us. Our business model is an annual cashflow business. We only need to get one more carbon credit per hectare to pay for, as an example, our dothistroma programme. So, for us comprehensive annual monitoring timely treatment of dothistroma infections is a good investment. We also actively monitor for other health issues.

Figure 4: Gap optimisation trial

Figure 5: Native enrichment planting in age three and four *Pinus radiata* forests

Research and monitoring

Optimising the carbon increment of the nurse crop and simultaneously providing adequate conditions for native regeneration of varied species presents challenges from microsite to regional variability that span the scale of the NZCF estate. To determine more specific forest management interventions a series of monitoring plots, trials and sites have been put in place. We also continue exploring novel ways to collect and analyse data, particularly spatial data, and use it as a tool for decision-making of complex ecological relations at large-scale.

The development and continual evaluation of such sites, model calibration and iterative updates to match operational and efficiency demands are a core process to obtain successful and effective interventions.

Summary

The active management approach used by NZCF involves a sequence of targeted interventions and ongoing management over the long term to support the forest through progressive stages of growth and transition. Growing conditions also vary from region-to-region, and even across individual sites, meaning a targeted programme needs to be developed suited to each forest.

Our forest management regime for our permanent forest estate is a long-term endeavour with significant changes occurring over several decades. Transitioning an exotic nurse crop to a resilient, productive and biodiverse native forest requires us to deliver a regime underpinned by good forest management and forest ecology principles. This will also require significant operational and professional capability and capacity.

As the largest New Zealand owner of planted managed forests, we are proud of how we are leading the way in moving forward. This is bridging the divide between the polarised silos of intensive exotic plantation forest management (centred around *Pinus radiata*) and a conservation-centric focus with limited resources for essential active management on our native forests.

References

Bravo, F., LeMay, V. and Jandl, R. (Eds). 2017. *Managing Forest Ecosystems: The Challenge of Climate Change*. Switzerland: Springer International Publishing.

Jones, A.G., Cridge, A., Fraser, S., Holt, L., Klinger, S., McGregor, K.F., Paul, T., Payn, T., Scott, M.B., Yao, R.T. and Dickinson, Y. 2023. Transitional Forestry in New Zealand: Re-evaluating the Design and Management of Forest Systems Through the Lens of Forest Purpose. *Biological Reviews*, 98: 1003–1015.

Payn, T. 2021. Putting Purpose First – 10 Functional Forest Types for New Zealand. *New Zealand Journal of Forestry*, 66(1): 3–11.

Pretzsch, H., Forrester, D. and Bauhus, J. (Eds). 2017. *Mixed-Species Forests: Ecology and Management*. Berlin, Heidelberg: Springer.

Watt, M., Palmer, D. and Hock, B. 2011. Spatial Description of Potential Areas Suitable for Afforestation Within New Zealand and Quantification of Their Productivity Under *Pinus radiata*. *New Zealand Journal of Forestry Science*, 41: 115–129.

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