Carbon financed conservation forestry

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Figure 1: Native understorey in mixed exotic and indigenous forest at Milnthorpe Reserve, Golden Bay

Abstract

The arrival of the forest carbon sector over a decade ago heralded a new era in forest conservation financing. In New Zealand, the restorative reforestation of erosion-prone rural landscapes and native forest habitats would be limited only by the appetite for carbon credits among carbon buyers and a return on investment for investors. However, a native forest carbon industry has not yet materialised apart from a relatively small collection of projects on the margins, in spite of a carbon price that is (at the time of writing) just shy of $40/tCO_2e$. For forest conservation to be carbon financed at scale it needs to be commercially viable without the help of grants. The commercial viability of native forest carbon is challenged, however, by high costs and low revenues.

A remedy that does not require blunt government intervention in the carbon market is a middle path that combines native and exotic carbon forestry, to deliver an economic performance profile sufficient to cross the stop/go threshold. This paper looks at the economics of this middle path and recognises it as an emerging sub-sector poised to take off in the coming decade.

Restorative afforestation benefits

Restorative afforestation of permanent forest delivers a range of ecosystem services including, but not limited to: soil conservation, watershed protection, soil moisture retention, cooling and regulation of micro-climates (Chen et al., 1999), stream water quality enhancement, carbon sequestration and enhanced biodiversity outcomes. Subject to appropriate site selection, all of these ecosystem services can be delivered by 'ecological infrastructure' in the form of exotic tree species in a permanent forest setting.

The conceptual framework of production forestry and non-production indigenous forestry in New Zealand has tended to exist along a polarised spectrum (e.g. the public backlash against whole farm conversions to plantation forestry include the campaign by the group '50 Shades of Green'), with exotic monocultures managed under a clear-fell regime at one end and 100% native forest at the other. A middle path beckons, with mixed species approaches that deliver ecosystem service benefits while providing ongoing investment returns for the landowner/investor.

Native forest economics

Small-scale native afforestation is common with riparian and habitat restoration projects. These are often funded by grants and/or rely on voluntary labour, but some are supplemented with carbon income. However, native afforestation at a landscape scale is beyond the reach of grants and voluntary labour inputs, and to be successful the economics must be self-sustaining.

At first glance, the carbon market may appear the obvious solution where native afforestation costs are offset by carbon income. The economic realities of self-funding native carbon forestry, though, are challenging for two main reasons: the native 'carbon credit factory' is expensive to build; and native carbon credits accrue at a relatively slow pace.

Both of these realities combine to deliver internal rates of return (IRRs) typically close to or below zero. To gain access to private capital the IRR typically needs to be both above zero and compete with alternative sustainable investment offerings. In the forestry space, these alternatives include the afforestation of eligible farmland with pure exotic forests where the Emissions Trading Scheme (ETS) allows carbon (New Zealand Units or NZUs) to be generated at a cheaper and faster rate.

Cost-benefit analysis

The cost-benefit of native carbon afforestation varies, depending on the forest establishment method adopted. These range from full restorative planting of potted indigenous tree species at high densities and with high species diversity at one end, to minimalist regenerative methods employing pest management and limited indigenous enrichment (if any, using low-cost indigenous species) at the other.

Table 1 shows the cost-benefit analysis of a hypothetical 50 ha project under three planting approaches where the key variable is stem density per hectare. Also included are two alternative methods for natural regeneration, one where the regeneration starts today and the other where the regeneration commences 20 years prior.

Cost-benefit analysis assumptions

Net present value is calculated using a 6% discount rate under three carbon price projections (as below, in real terms) and land costed at an annual rental at 3% of land value:

- CP1 $39/NZU rising at $1.50 p.a.
- CP2 $39/NZU rising at $4.75 p.a. (average of CP1 and CP3), and
- CP3 $39/NZU rising at $8 p.a.

The rationale for applying these carbon price projections is as follows:

- The Year 1 carbon price is slightly lower than the NZU spot price at the time of writing
- CP1 models a conservative, but plausible, average annual carbon price increment
- CP3 models an aggressive, but plausible, average carbon price increment (being similar to NZ Productivity Commission (2018) recommendations for carbon pricing of $75–$200/tCO_2e in the coming few decades)
- CP2 is an average of CP1 and CP3 and aligns broadly with the rate of carbon price increase in recent years.

Project development costs include project initiation costs, forest establishment, contracting and associated management. For the natural regeneration projects, the project development costs include initial inventory work to determine ETS eligibility, tree age and opening carbon stock.

Cost-benefit analysis results

Six different establishment methods were analysed against the three CP1, CP2 and CP3 carbon price projections. The results are presented in Table 1.

Interpretation

The full native afforestation method established at 8,333 stems/ha (N8333) is perhaps the ideal from the perspective of maximising near-term biodiversity outcomes on each hectare treated. The challenge is that this method is cost prohibitive at capital expenditure of $78,000/ha. In a capital constrained market, this severely limits the area of land that can be treated and therefore dilutes the overall delivery of ecosystem services. The IRR for this scenario ranges from –10.5% for CP1 to –4.9% for CP3. This high-intensity afforestation approach is the least financially viable option.

This contrasts with mānuka planted at 1,000 stems/ha (M1000). Here, capital expenditure is of the order of $10,750/ha. At scale, mānuka honey rental (priced here at $200/ha/year) may add to revenues. Including the honey rental, this establishment method delivers an IRR of 0.7% for CP1 and 6.7% for CP3. The establishment of mānuka at 1,000 stems/ha is the highest financially performing establishment method where the objective is pure native afforestation. A mānuka honey rental placeholder of $200/ha/year is used here to provide an indication of what might be possible and is consistent with Clarke (2020).

Table 1: Cost-benefit analysis of establishment methods (ranked by projected IRR)

Establishment Method	Cash Capex	Cash Capex/ha	IRR CP1	IRR CP2	IRR CP3	NPV per ha CP1	NPV per ha CP2	NPV per ha CP3
N8333	$3,901,194	$78,024	–10.5%	–6.9%	–4.9%	($69,969)	($66,697)	($63,424)
N2500	$1,232,268	$24,645	–5.6%	–1.6%	0.7%	($20,464)	($17,192)	($13,920)
N1000	$545,934	$10,919	–1.7%	2.7%	5.3%	($7,733)	($4,461)	($1,189)
M1000	$537,596	$10,752	0.7%	4.3%	6.7%	($5,462)	($2,189)	$1,083
NRY0	$57,713	$1,154	2.9%	7.6%	10.2%	($1,067)	$842	$2,750
NRY-20	$57,713	$1,154	15.6%	24.6%	31.2%	$1,250	$3,684	$6,119

Key:

N8333	Native afforestation planted at 8,333 stems/ha
N2500	Native afforestation planted at 2,500 stems/ha
N1000	Native afforestation planted at 1,000 stems/ha
M1000	Mānuka afforestation planted at 1,000 stems/ha
NRY0	Natural regeneration commencing in Year 0 (via retirement of grazing and pest control)
NRY-20	Natural regeneration commencing in Year 20 (20 years prior)

The challenge is that mānuka honey rentals vary greatly, depending on a range of factors determined by honey contractors, and will only last for the period when mānuka forest remains productive. Mānuka is a seral tree species that forms a natural nursery and will typically be succeeded by taller tree species after 50 years, and mānuka honey productivity reduces through time as trees mature and market prices vary season to season. Moreover, this model does not maximise near-term biodiversity outcomes, but has the advantage that limited capital can be used to treat a larger area and generates positive IRRs at all three carbon price projections.

High stem densities (such as 4,000 to 8,000 stems/ha) result in interplant competition and natural mortality within the first 20 years. In contrast, lower stem densities reduce the likelihood of natural mortality, and instead provide an environment conducive to promoting natural regeneration of broadleaf species, depending on the availability of resident seed sources. Here, nature contributes to the capital stock and biodiversity outcomes and in addition increases project returns.

Both natural regeneration methods (NRY0 and NRY-20) deliver positive IRRs, which is because the capital expenditure burden is low. For establishment method NRY0, it is assumed that it will take 12 years following the retirement of grazing for natural regeneration to meet the forest land definition in the ETS. This creates a lengthy delay in the receipt of carbon income to offset the opportunity cost of retiring the land from grazing.

The most economically viable option modelled is where the natural regeneration is both well established and the land meets the post-1989 forest land definition under the ETS. This permits the ETS registration at a time when carbon sequestration rates are more favourable.

Mixed forest economics

The above analysis demonstrates that native afforestation of bare land is economically challenging and is unlikely to be adopted voluntarily at scale by investors and rural communities. Gaining access to capital at scale requires an afforestation method that delivers appropriate cashflow and financial returns.

Figure 2: Community planting of native seedlings in mixed exotic and native planting, Manapouri

Impact investors tend to preferentially support high co-benefit initiatives, but still require a commercial or semi-commercial return. Either way, an indicative return of 0.7% at CP1 is unlikely to be sufficient to trigger a decision to invest, particularly at a scale needed to change the course of landscape history. Note that impact investing is an investment strategy designed to deliver beneficial social or environmental impact alongside a financial return (Chen, 2021).

Ultimately, the IRR will need to march northwards to enable any investment at scale to proceed, irrespective of the capital structure and security arrangements. This necessitates lifting the financial performance of restorative carbon projects above those delivered by the least cost, highest performing pure native reforestation scenarios.

One way to do this is to introduce exotic tree species to the restorative afforestation strategy. Figure 1 shows the native understorey of natural regrowth beneath an exotic nursery crop canopy 40 years after the exotics were planted (Golden Bay). Figure 2 depicts the native reforestation element of a mixed exotic and native forest carbon project undertaken as a community planting day at a site in Southland. Figure 6 shows contour ripping for the adjacent exotic hardwood element at the same site in Southland.

Where the strategic focus is to maximise biodiversity and sustainable land management co-benefits, exotics can be introduced at a scale sufficient to nudge the financial performance above the required rate of return. This can include exotic woodlots in a portfolio focused primarily on native forest restoration. Here, the purpose of the exotic species is to fund the natives. Furthermore, the hectares planted in exotic species can be managed to transition to a pure native forest in the long term through adaptive management and continuous canopy forestry.

Mixed native/exotic afforestation methods

Two alternative mixed native/exotic afforestation methods are considered:

- **Method 1: Mixed afforestation where natives initially dominant (Mix N Dom)**

  This afforestation method applies the same assumptions as for native afforestation, including the same 50 ha area, but with exotic hardwood stands introduced into the initial planting area until the IRR at CP1 delivers a 4% return. [Exotic hardwoods (angiosperms) were used in this analysis because they deliver the highest carbon sequestration rates in the ETS. Exotic softwoods deliver similar financial results to those of exotic hardwoods and are also compatible with this mixed model approach.] This resulted in planting 33 ha of natives (mānuka and tōtara) and 17 ha of exotic hardwoods. The exotic hardwood stands involve planting hardwoods at 833 stems/ha, thinning and then harvesting 10% of the total exotic area and replacing with natives (mānuka and tōtara), repeated in a five-yearly cycle until all exotics are removed. The afforestation method conservatively assumes that the exotic hardwood crop will generate a net stumpage of $10 per cubic metre (similar to firewood returns), although higher valued returns for higher valued exotic hardwoods are certainly possible.

- **Method 2: Mixed afforestation where exotics initially dominant (Mix E Dom)**

  This afforestation method applies the same assumptions as Method 1 (Mix N Dom), but with only 10% of the total area initially planted in natives and the remaining 90% of the area planted in exotic hardwoods. Here, the exotic hardwood element is harvested and replaced with natives in the same manner as Method 1 and is designed to transition to pure native forest by year 57.

Cost-benefit analysis results

The economic returns of the two mixed native/exotic afforestation methods are presented in Table 2.

Interpretation

As illustrated in Table 2, the IRRs are consistently higher than those for the pure native plantings presented in Table 1. There is an infinite variety of different proportions of stand areas allocated to native and exotic species. These results are therefore only indicative of the range of possible scenarios. In both cases, the long-term outcome is the managed transition to a pure native forest but where the short-term forest establishment strategy delivers financial returns more likely to enable access to private capital investment at scale.

Summary of afforestation methods considered

Table 3 below combines the results of Tables 1 and 2. Figures 3–5 provide a graphical interpretation of these results.

Interpretation

As can be seen, the economic pathways to native forest restoration and the provision of ecosystem services at scale reflect varying degrees of financial viability, with high planting density ecological restoration at one end and mixed exotic and native forestry and natural regeneration at the other. The afforestation method employing the initial establishment of exotic species and the managed transition to a pure native forest is an effective means of financing the delivery of permanent native forests at scale.

Discussion

Having a dream to heal and re-cloak entire landscapes is commendable. However, if we cannot finance our dream, then dream is all we get to do. Financing this dream necessitates the strategic design of an afforestation programme capable of delivering the sustainable land management outcomes and attracting finance for the task at the scale required.

Strategic design

The perfect is the enemy of the good. The only way to deliver permanent native afforestation at scale is to deliver an economically viable solution without the need to rely on grant funding. This analysis has shown that the forest establishment methods that meet this criterion are: a) natural regeneration of existing (ETS eligible) stands of native forest; and b) planting a mix of native and exotic trees. Given that the registration of existing and eligible native forests (already protected under district plans) does not create additional ecosystem services, the dream of healing the landscape and providing additional ecosystem services requires the realisation that planting exotic species is a means to the end goal. Despite this, the registration of eligible naturally regenerating forest land in the ETS can provide seed capital to invest in mixed native/exotic afforestation.

However, the sustainable land management challenge requires active afforestation at scale if it is to have a meaningful impact on meeting New Zealand's Paris Agreement obligations, i.e. this country's aspiration to be a net zero carbon economy by 2050 and help build

Table 2: Cost-benefit analysis of two mixed native/exotic afforestation methods

Establishment Method	Cash Capex	Cash Capex/ha	IRR CP1	IRR CP2	IRR CP3	NPV per ha CP1	NPV per ha CP2	NPV per ha CP3
Mix N Dom	$466,069	$9,321	4.0%	8.7%	11.8%	($1,875)	$3,288	$8,451
Mix E Dom	$338,734	$6,775	11.2%	17.1%	21.2%	$85	$12,546	$20,824

Table 3: Cost-benefit analysis summary of all establishment methods considered in this paper

Establishment Method	Cash Capex	Cash Capex/ha	IRR CP1	IRR CP2	IRR CP3	NPV per ha CP1	NPV per ha CP2	NPV per ha CP3
N8333	$3,901,194	$78,024	−10.5%	−6.9%	−4.9%	($69,969)	($66,697)	($63,424)
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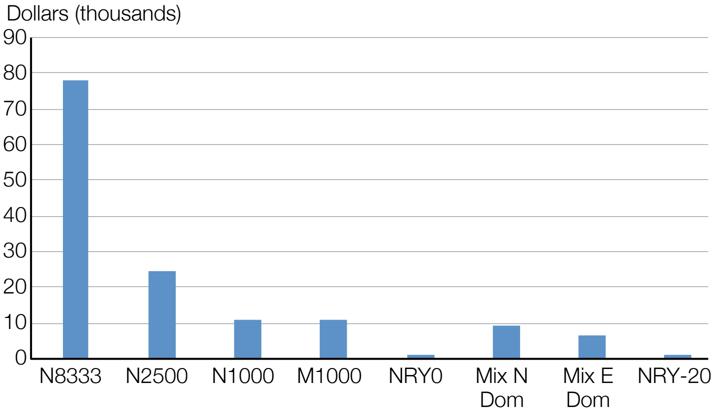

Figure 3: Capital expenditure per ha across afforestation methods discussed

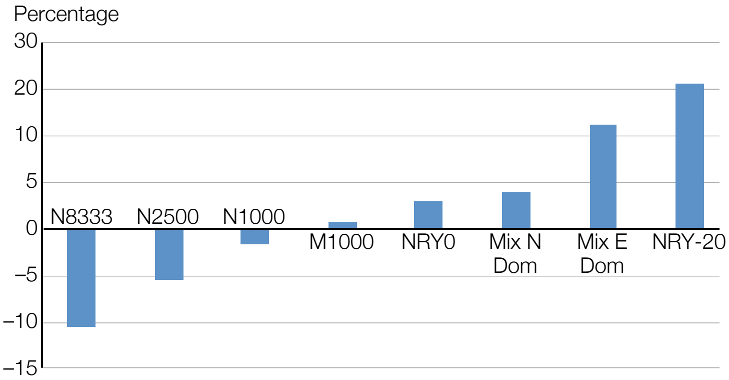

Figure 4: IRRs for carbon pricing model CP1 across afforestation methods

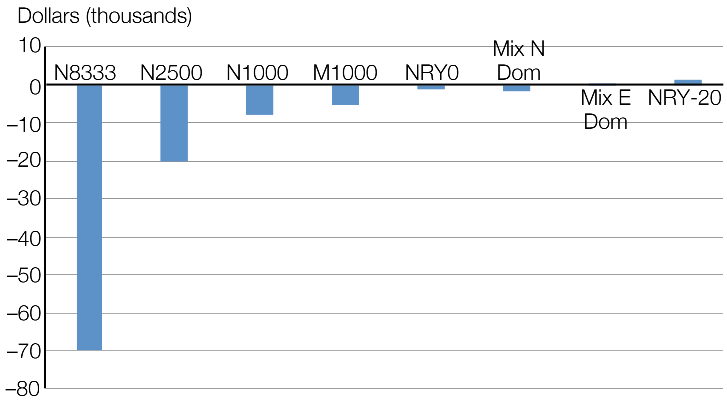

Figure 5: Net present value per ha for carbon pricing model CP1 across all afforestation methods

climate resilient landscapes. According to Bloomberg (2020), small-scale indigenous reforestation is unlikely to sequester enough carbon to meet this challenge.

The mixed exotic/native method to afforestation is a middle path that is considerably more beneficial than business-as-usual pastoralism on erosion-prone land. It avoids the sedimentation impacts of clear-cut plantation forestry on this land type and is much more affordable than a pure native approach. Research into mixed exotic and native forestry is limited in New Zealand (e.g. Forbes et al., 2019), and recent work on the notion of 'right tree right place' has highlighted a number of factors necessary for durable afforestation solutions (Clarke, 2020).

A mixed exotic/native method also needs ongoing management and the adoption of a reliable strategy to ensure the successful transition from an exotic to a native canopy. One possibility is a continuous canopy approach. The method originally considered (and since discarded by the author) involved interplanting natives and exotics in the same stand through either single tree removal, a single tree narrow corridor, or small coup removal and replacement. The logistics of exotic extraction and replacement with a subsequent generation of trees without damaging the originally planted native element can prove challenging.

Planting discrete (adjacent) exotic and native stands, followed by exotic corridor creation wide enough to enable machinery harvesting and replacement, mitigates both the logistics and the capital expenditure problem. This approach also enables adaptive management in the replacement of corridors of harvested exotics with either natives or a subsequent generation of exotics in a shelterwood setting, particularly if the native element proves to require a longer timeframe to transition to site dominance.

The nature of pioneering is living with higher uncertainty. If we are to respond to a climate emergency with an outlook that recognises the emergency we will need to take risks – because the risk of non-action or business-as-usual pastoralism on erosion lands is also unacceptable. Furthermore, this approach is not proposed as the only approach to climate action in the rural landscape. Instead, it comprises a complementary measure to commercial plantation forestry, particularly in landscapes that are too erosion-prone to be suitable for large-scale clear-cut forestry practices (see Bloomberg et al., 2019) or pastoralism.

Financing the dream

Landscape-scale, permanent restoration forestry for the combined purpose of sustainable land management, biodiversity conservation and community economic development will need to gain access to capital in proportion to the task. The order of magnitude of capital required for the afforestation of 200,000 ha (as is needed in regions like Hawke's Bay, Gisborne District and the Central North Island) is well over a billion dollars for each region. If not deployed in a market-based mechanism, this funding would need to be provided as a grant or subsidised. There is not enough money available in the grant sector for this level of financial commitment.

Partnership approach

Impact investment at scale will require a capital structure capable of unlocking money at the volume required, and at a cost of capital capable of delivering the range of co-benefits that are possible within a profitable business model. Clean development the world over often struggles to gain access to private capital, which is partly because clean development is a new thing, and any new thing comes with greater uncertainty. Accordingly, the investment community tends to look at new things as higher risk investments than old things that are more predictable.

Figure 6: Contour ripping for exotic element of mixed exotic and native planting, Manapouri

Higher risk profiles require higher returns on investment to cover that risk. This drives up the cost of capital, often to levels beyond the reach of social enterprise solutions designed to maximise social good whilst delivering a profit, rather than maximising financial return on investment (Weaver, 2015). More conservative investors like pension funds can provide large volumes of money at a relatively low cost of capital, but typically require financial risk mitigation to guarantee the more modest returns (Ward, 2010).

Financial risk mitigation to enable large-scale private capital investment in 'look after the place' enterprise solutions is a key strategic piece of the 'save world' puzzle. Indeed, if we are to realise the sixth industrial revolution and deliver a climate-resilient, low-carbon, sustainable future, we will need someone to underwrite private sector financial risk. An ideal person for this role is the Government (investing using taxpayers' money on behalf of all New Zealanders) – whose discount rates are lower, whose time horizons are longer, and who can socialise this risk for a common purpose – as happens in war, COVID and other crisis economies.

Conclusion

The Government has created the ETS to change behaviour and encourage investment in reducing emissions and sequestering carbon. The ETS provides an opportunity to change the course of history in rural New Zealand and heal our erosion lands. Most of the key ingredients are already in place for land management systems change capable of healing our broken hillsides nationwide. The last piece of investment readiness is a nation willing to walk a middle path, and an underwriter who can unlock private capital at scale to enable sustainability entrepreneurs, landowners, investors and communities to get on with it.

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