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Carbon forestry with regenerating natives

Carbon farming by allowing marginal pasture or agricultural land to revert to indigenous forest can be practical and inexpensive, especially for large areas.

Around 1.55 million ha of marginal grasslands in New Zealand are potentially available and could revert to shrubland and eventually indigenous forest, especially where there are nearby seed sources. The majority of that land is in private ownership, including Māori freehold.

New Zealand has laws and regulations that enable carbon forestry on private land within international guidelines. The forestry-related schemes are Permanent Forest Sink Initiative (PFSI) and the New Zealand Emissions Trading Scheme (ETS).

A forest under the ETS

Naturally regenerating forests are only eligible under the ETS if they have become 'forest' after 1989. They must meet the requirements for size and width as well as potential canopy cover of tree species capable of reaching 5 m in height. Local land-use practices and environment affect whether or not land cover has the potential to qualify as a forest. For example, mānuka easily attains 5 m in some parts of the country, but in other areas it barely reaches 3 or 4 m.

An uneven process

Natural or near-natural forest regeneration is controlled by environmental conditions, colonisation potential and land management practises. Plant dispersal, establishment, growth and survival vary between species and across uneven physical conditions, resulting in patchy landscapes involving numerous species, tree ages, varying stem densities and different successional trajectories and growth rates.

Why natural regeneration? Planting indigenous tree seedlings is not usually cost-effective (or carbon efficient) for carbon sequestration. Exceptions occur when another crop can be co-produced (e.g., mānuka plantings for honey) or if biodiversity considerations outweigh the economics of carbon farming.

In many situations, natural regeneration can involve high rates of recruitment and seedling densities. The greater the numbers of existing shrubs and available tree seed sources at the time of pasture retirement, the faster the progression to native forest.

Areas favouring natural forest regeneration. Sufficient annual rainfall, reasonably fertile soils, moderate temperatures and other local woody cover favour natural regeneration and significant rates of growth. Figure 1 shows where in New Zealand regeneration is likely to occur. In places, environmental limits to tree establishment and growth, e.g. exposure, drought, cold, wind, elevation and low soil fertility, means trees will struggle to revert to forest in any sensible time period. Native regeneration also occurs in gorse or broom stands, especially in older, taller stands, on steeper slopes where the gorse/broom canopy tends to form openings, at warmer, wetter sites and in places where higher wind speeds may help seed dispersal.

To promote grasslands to native forest succession[1]

- Keep domestic stock out by fencing
- Control pest animals such as hares, goats, pigs, etc
- Use weeds such as gorse and broom as a nurse crop
- Control noxious and smothering weeds such as old man's beard (*Clematis vitalba*), particularly around edges or in canopy openings
- Prevent fires

How much carbon will be sequestered? Carbon capture or sequestration rates represent the net above-ground and below-ground carbon that is stored in vegetation over time as forests grow. Carbon accumulation is slow initially, then ramps up once the canopy closes and eventually declines in older stands, but tends to remain positive even after some centuries, provided that forests remain undisturbed. The national average carbon stocks of natural forest (including live above- and below-ground biomass, dead wood and litter) in New Zealand is 840 t CO_2e per hectare (Holdaway et al (2017).

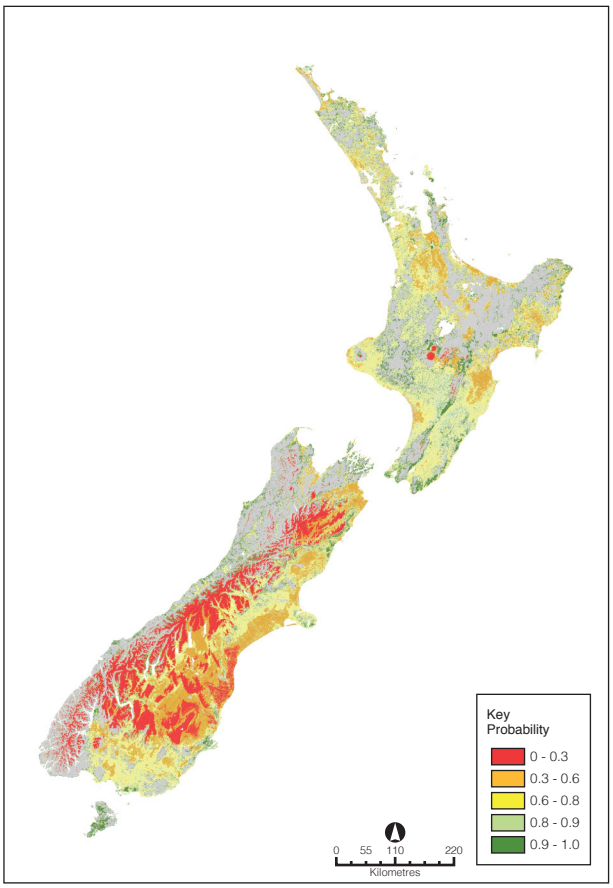

Figure 1: *Areas where reversion is likely to occur. Grey areas are already covered by indigenous or planted forest. (reproduced from Mason et al. 2013, doi: 10.1371/journal.pone.0075219.g003)*

MPI (2015) look-up tables are used to estimate emission returns for ETS/PFSI participants with more than 100 ha of post-1989 forest under current regulations. From the tables, the mean rates of carbon sequestration over the initial 50 years of stand development are around 6.5 t CO_2e per hectare per year, depending on region and species.

Costs and returns

If costs are controlled and sequestration and market values are high (Fig 2), carbon farming can be economically viable (Table 1) and comparable with hill sheep farming. Hill country sheep farming returned a net profit of \$28 $ha^{-1}yr^{-1}$ for South Island high country and marginal hill farms in 2012 and \$268 $ha^{-1}yr^{-1}$ for more intensively farmed North Island hill sheep blocks.

Property size and registered area have the largest effect on costs. If the registered area is less than 100 ha, the MPI look-up tables can be used to estimate rates of carbon sequestration and administrative costs are greatly reduced.

For properties of 100 ha or more, it is compulsory to carry out field measurements under the Forest Measurement Approach (FMA). The total costs of measurement by specialist consultants will amount to several thousand dollars once every five years. It should also be noted that mensuration costs will be more noticeable and difficult to outweigh by returns for sites with slow rates of forest growth.

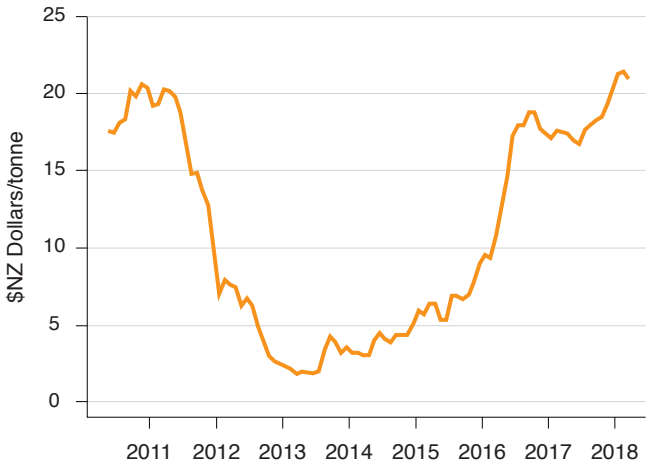

Figure 2: *New Zealand Unit Prices 2010 - 2018. Data: 'NZU monthly prices' https://github.com/theecanmole/nzu*

Table 1: *Generalised annual costs and net returns from reverting indigenous forests on a nominal land parcel of 200 ha for a first commitment period of 5 years.*

	Costs (range)	Notes
Start up costs	\$1500–3,500	Legal, registration, specialist advice[2]
Yearly costs	\$2,500	Insurance, fence maintenance, pest control, etc
1–5 yearly	\$88.89	Applications for emissions return (MPI fee)
5 yearly	\$9,000–12,000	Mensuration including data entry
Total costs per annum	\$4,377–5,377	Above values averaged across five years; bottom and top of ranges given.
Annual Returns:		
Sequestration at age 20	3–10 t CO2e $ha^{-1}yr^{-1}$	Indicative sequestration rates
Total C units sequestered	600–2000	
Sale of units	\$6,000–40,000	Indicative price range \$10–20
Net return per year (For a 200 ha site)	**\$1,423 to \$34,423 (\$7 to \$172 $ha^{-1}yr^{-1}$)**	

GST, the cost of marginal land, control of invading wilding conifers or other noxious weeds, nor commission on sales of credit units are not accounted for.

[1] http://www.doc.govt.nz/about-us/science-publications/conservation-publications/protecting-and-restoring-our-natural-heritage-a-practical-guide/site-preparation/

[2] Extensive information is available on the Ministry for Primary Industry's website and this is the best source of up-to-date information. Nevertheless, MPI documentation carries an important disclaimer: "*Individuals should seek advice from a qualified professional/expert where they require more detailed advice for their individual specific situation or, where relevant, seek formal legal advice*".

Conclusions

Large expanses of land with marginal pastoral or agricultural use in New Zealand are suitable for forest revegetation. Natural forest regeneration is feasible where favourable tree establishment environments exist and seed sources are not too distant. Fencing out livestock and pest control will be necessary.

It will be difficult for areas less than about 30 hectares to make an economic return due to the fixed costs and relatively small sequestration potential.

From 30 to 100 hectares, it is possible to take advantage of look-up sequestration tables and save on mensuration costs. In fact, for areas up to ~200 hectares it is recommended to only register the best 99 hectares.

Over ~200 hectares, increasing size will result in increasingly economic offset as the proportional cost of mensuration declines.

Afforestation schemes do not fetch the highest prices for carbon alone. Initiatives that commit to best practise permanent carbon sinks and promote other environmental and biodiversity or conservation values achieve a premium above the market price for these offsets.

Funder

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Key references and links

Holdaway RJ, Easdale TA, Carswell FE, Richardson SJ, Peltzer DA, Mason NW, Brandon AM, Coomes DA 2017. Nationally representative plot network reveals contrasting drivers of net biomass change in secondary and old-growth forests. Ecosystems 20: 944–59.

Ministry for Primary Industries 2015. Look-up tables for post-1989 forest land in the emissions trading scheme: https://www.mpi.govt.nz/dmsdocument/6979-look-up-tables-for-post-1989-forest-land-in-the-ets.

A recent report by MOTU outlines some of the current context for obtaining credits via carbon sequestration by native forestry: https://motu.nz/our-work/environment-and-resources/emission-mitigation/emissions-trading/facilitating-carbon-offsets-from-native-forests/

QEII National Trust is an independent charitable trust that partners with private landowners to protect natural and cultural heritage sites on their land with covenants: https://qeiinationaltrust.org.nz/managing-your-covenant/restoration/

Regional guides for planting native trees: https://www.treesthatcount.co.nz/resources/regional-guides-for-planting-natives/

Tāne's Tree Trust supports and promotes the sustainable management of indigenous trees and has produced a series of publications with practical information. http://www.tanestrees.org.nz/resource-centre/publications/

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About Scion

Scion is the Crown research institute that specialises in research, science and technology development for forestry, wood and wood-derived materials, and other bio-material sectors.

Scion's purpose is to create economic value across the entire forestry value chain, and contribute to beneficial environmental and social outcomes for New Zealand.

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