Policy to Encourage Carbon Sequestration in Plantation Forests

Suzi Kerr, Emma Brunton, Ralph Chapman

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Author contact details

Suzi Kerr
Motu Economic and Public Policy Research
PO Box 24390
Wellington
New Zealand
suzi.kerr@motu.org.nz

Emma Brunton
Motu Economic and Public Policy Research
emma.brunton@motu.org.nz

Ralph Chapman
Maarama Consulting Ltd
34 Maarama Cres
Wellington 2
New Zealand
ralph.chapman@paradise.net.nz

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Motu Economic and Public Policy Research

PO Box 24390
Wellington
New Zealand

Email info@motu.org.nz
Telephone +64-4-939-4250
Website www.motu.org.nz

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Abstract

Carbon sequestration in plantation forests provides the main means by which New Zealand will meet its international climate change obligations in the first commitment period of the Kyoto Protocol (2008–2012). However, without active policy, forests are unlikely to contribute as much in subsequent commitment periods. This research paper provides the background for examining policy measures for encouraging carbon sequestration in plantation forests in New Zealand. Part I focuses on providing factual information and positive analysis of: key domestic and international regulations; information on New Zealand forests, the forestry industry and forest profitability; discussion of land-use decision making, including the central question of what influences conversion of farmland to forestry; and forest carbon ecology. Part II moves on to normative analysis of policy design. It discusses how including considerations of the value of carbon sequestration and storage changes optimal land-use behaviour, and outlines key issues that need to be addressed when developing a policy to encourage sequestration and storage in a pragmatic way. Finally, the paper identifies a number of key areas where we need more information before we can make well-informed choices about policy design. Future work will endeavour to identify and evaluate policies that would effectively encourage sequestration.

JEL classification
Q25, Q28

Keywords
climate, forest, carbon sequestration, policy, New Zealand, Kyoto

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PART I: Context

1 Introduction

In New Zealand, climate change policy is an active area of policy debate. It is likely that it will be difficult for New Zealand to significantly reduce its energy-related emissions over the next decade. Along with this, the prospects for reducing New Zealand's agricultural emissions are dependent on research, which is at an early stage. In this context, it is important that New Zealand makes the most of its capacity to sequester carbon in growing forests, even if forest carbon sequestration only "buys time" rather than providing a long-term solution to the global climate change problem. New Zealand's capacity for sequestering carbon is large compared with that of other countries. Even with no sequestration policy, sequestration in new forests is expected to roughly offset all greenhouse gas emission increases, including those from fossil fuels and ruminant methane, during the first commitment period 2008–2012.[1]

At the global level, human responses to observed and expected climate change include two international agreements directly addressing the climate change threat. New Zealand signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and its subsidiary agreement, the Kyoto Protocol, in 1998. In December 2002 the Government ratified the Protocol. It will come into force internationally if Russia ratifies it. In late 2002 the Government announced a climate change policy package to accompany the Kyoto Protocol. Policies on carbon sequestration are an important part of New Zealand's package.

Within this context, we seek in this research paper to provide the background for examining policy measures for carbon sequestration in plantation forests in New Zealand. This paper is aimed primarily at New Zealand policy and scientific advisers reviewing and developing carbon sequestration policy in

[1] The US, which has large sinks relative to most countries, reported to the United Nations Framework Convention on Climate Change that in 2000 its sequestration from land-use change and forestry was around 1 million gigagrams of carbon dioxide, while overall net emissions were around 6 million gigagrams (United Nations Framework Convention on Climate Change, 2001).

New Zealand, stakeholders in the forestry industry, and those seeking to establish where further research needs to take place.

This paper is the first step in a broader project. Our aim is to establish firm, common ground on the basic facts, the driving forces that any policy aims to affect, and the tradeoffs involved in any policy design. We are developing this paper together with key people in industry, government officials, forestry consultants and researchers, but they are not responsible for the views or facts presented here. We do not discuss specific policy designs in this paper, since we wish to illuminate the underlying issues rather than enter policy debate. Our hope is that our process will ultimately enable policy discussion to be more productive by building understanding of different groups' concerns and interests, building a consensus to exclude policies that are likely to be ineffective or inefficient for objective technical reasons, and setting out a series of feasible policy options that might not be currently on the table but might have benefits for all Parties. This should allow the political discussion to focus on truly political issues, such as the allocation of costs and benefits.

While we develop this paper, we are also building an empirical model of New Zealand land use that includes a significant forestry component while also incorporating ruminant agriculture. This is a five-year project funded by the Foundation for Research, Science and Technology, and we are now in our second year. The modelling should provide more information on the relative importance of different factors and illustrate the likely effects of different policies. It is not intended to be an accurate model for prediction but rather a useful tool for exploring policy. When the model is functioning well, we plan to bring our "qualitative" discussion process together with the modelling process so they can complement each other and yield deeper, more robust insights into appropriate design and the likely effect of policies.

This paper is focused on the growing and harvesting of trees—i.e., it does not directly address other aspects of forestry, such as wood processing. It also excludes indigenous forest policy and conservation-oriented activities, which form important elements of the wider forestry picture. There is also considerable potential for carbon sequestration outside plantations—e.g. from reversion of grassland or scrub to indigenous "permanent protection" forest (non-harvest)—but that topic is not covered in this paper.

The structure of this paper is as follows. Part I focuses on providing factual information and analysis of: key domestic and international regulations; New Zealand forests, the forestry industry and forest profitability; land-use decision making, including the central question of what influences conversion of farmland to forestry; and forest carbon ecology. Part II moves on to normative analysis of policy design. Section 6 discusses how including considerations of the value of carbon sequestration and storage changes optimal land use behaviour. Sections 7 and 8 outline key issues that need to be addressed when developing a policy to encourage sequestration and storage in a pragmatic way. Future work will endeavour to identify and evaluate policies that would effectively encourage sequestration.

2 Existing regulations

2.1 Relevant international rules

Parties to the UNFCCC, including New Zealand, are committed to promoting conservation and enhancement of sinks and reservoirs of greenhouse gases, including forests and other terrestrial, coastal and marine ecosystems. New Zealand has also ratified the Kyoto Protocol to the UNFCCC, and this requires Parties to report on sinks and sources of greenhouse gases and meet defined emissions limitation commitments. Only a specified subset of the sinks and sources reported are accounted for in determining whether a party has met its commitments. New Zealand will be given "credit" for carbon sequestration in forests established since 1990 and is liable for any "deforestation" (transformation of forested land to a non-forest land use).

2.1.1 Article 3.3—carbon sequestered/lost through changes in forest area

Article 3.3 of the Protocol makes a distinction between forests planted before 1990 (non-Kyoto forests) and those planted after 1990 on previously unforested land (Kyoto forests).[2] Any subsequent net change in Kyoto forests from direct human-induced activities must be accounted for in each commitment period. Kyoto forests earn "credits" for carbon sequestered (the carbon stock change) during the first commitment period, and potentially during subsequent periods. If credits have been earned from a forest in one commitment period, later carbon releases from this forest (e.g. when the forest is harvested) will result in "debits".[3]

Article 3.3 also means that New Zealand is liable for deforestation of non-Kyoto forests where "deforestation" is defined as land-use conversion to a non-forestry use such as dairy production. If non-Kyoto forest is harvested and replanted within an allowed period, no debit liability will be imposed.

New Zealand is expected to generate a significant number of sequestration credits, about 105 million tonnes of carbon dioxide equivalent, under Article 3.3 in the first commitment period (2008–2012), since the land area devoted to forests in New Zealand has increased considerably since 1990.[4] These will roughly offset increases in emissions from fossil fuels and ruminant methane in the first commitment period.

2.1.2 Article 3.4—carbon sequestration through changes in forest management

New Zealand has signalled that it is unlikely to elect to include forest management under Article 3.4 of the Protocol as an eligible activity in the first commitment period. This is for two reasons. First, New Zealand does not currently have the detailed scientific information required in respect of the total forest estate, and the ability to acquire this information is also questionable.[5] Second, it is expected that accounting for this article in the first commitment

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[2] The definition of a "forest" is critical for indigenous reversion, though less so for plantation forest, which probably fits most reasonable definitions. The government has chosen to define it as an area of at least 1ha, with at least 30% canopy cover and with trees that are able to reach a height of 5m at maturity in situ (New Zealand Climate Change Project, 2002, p. 42).
[3] A fine detail in the agreement, aimed at New Zealand's special situation, ensures that Kyoto forests that are harvested during the first commitment period will not incur debits for harvesting that exceed the credits they gained during the period. This does not affect other countries because their forests will not be mature enough to harvest by 2012.
[4] New Zealand Climate Change Project (2002), p. 8.
[5] New Zealand Climate Change Programme (2001), p. 33.

period would result in a net debit for New Zealand rather than the award of additional credits.

With New Zealand's provisional decision not to elect to use Article 3.4, any changes (except deforestation) in the forests that were present in 1990 are excluded from the international accounting system, at least for the first commitment period. This does not imply that no action should be taken with respect to such forests, but that matter is beyond the scope of this paper.

2.1.3 Article 17—international trading of emissions

Article 17 of the Protocol allows for the international trading of emissions—the exchange of assigned amount units (AAUs)—between Parties to the Protocol. All removal units (RMUs) from land-use change and forestry (LUCF) activities, emission reduction units (ERUs) from Joint Implementation projects (Article 6), and certified emission reduction (CER) units from the Clean Development Mechanism (CDM) (Article 12, relevant for projects in developing countries), are in principle fully fungible (exchangeable) with AAUs.[6] They are all measured in terms of tonnes of CO_2-equivalent. This provision means, for example, that the New Zealand government, or its legally designated entities if it chooses to devolve credits, may sell RMUs created by sequestration in New Zealand to another country Party such as Japan.

The international rules for both Articles 3.3 and 3.4 have been essentially set for the first commitment period but these may change in subsequent commitment periods, or under an alternative international regime if Kyoto is replaced. This contributes to uncertainty concerning the role of land use and land-use change in the Kyoto Protocol. This uncertainty makes it more difficult to resolve issues of design and implementation of policy for carbon sequestration in New Zealand plantation forests.

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[6] There are some limitations on trading. For example, the "commitment period reserve" is the requirement that each Annex I Party must maintain in its national registry either 90% of its initial assigned amount or 100% of five times its most recently reviewed inventory, whichever is lower. The commitment period reserve is intended to guard against overselling by Annex I Parties. When this is binding, the only trading that can occur is under Article 6, Joint Implementation. This could be binding in the early years in the New Zealand case (United Nations Framework Convention on Climate Change, 2001, pp. 4–5).

2.2 Current New Zealand government policy

2.2.1 Climate change policy on plantation forests

The two key elements of current New Zealand climate change policy as it relates to carbon sequestration in plantation forests are:

- The decision that the Government will retain ownership of the sink credits for the period 2008–2012, announced in October 2002.

  The government will retain "the sink credits and associated liabilities allocated to New Zealand under the Kyoto Protocol in recognition of the carbon sink value of post-1990 forest plantings. These credits will be retained and managed by the government, at least for the first commitment period". [7]

- The development of a "Forestry Industry Framework Agreement" (FIFA).

The government also announced in 2002, "In recognition of the forest sector's role in creating the sink credits, the Government agreed to develop a 'Forestry Industry Framework Agreement' with the sector".[8] The agreement includes forestry sector investment initiatives and policy on forest sink credits.

In the 2004 Budget round, the FIFA agreement was consolidated with the announcement of a five-year package of forestry sector initiatives, further detailing of the government's forest sink credit policy, and the announcement of additional initiatives that will be considered if the Kyoto Protocol comes into force.[9]

The five-year package includes: a $12 million regional and industry market development programme; a $2.8 million bioenergy programme; a $5 million investment in industry labour and skills; and $1.4 million to assist international market access. The regional development transport funding package is a related investment, and forecasts investment of $23 million per annum until at

[7] "Sink credits," 2004.
[8] "Sink credits," 2004.
[9] Funding for the package is contingent on signing of the FIFA Memorandum of Understanding.

least 2007/8. Roading upgrades in forestry areas in Northland and Tairawhiti are a high priority of the package.

Government policy on forest sink liabilities has been further detailed to state that, for those forests where the government retains sink credits, the government will accept full liability for deforestation or harvesting of Kyoto forests. For non-Kyoto forests, the government will assume liability for deforestation up to a cap of 21 million tonnes of emission units over the period 2008–2012.[10] If Kyoto forest sink credits are devolved after commitment period one, liabilities will also be devolved in proportion.

The Wood Processing Strategy, which was established in 2001 and is closely related to the broader FIFA agreement, continues to evolve along with it. It seeks to create closer working relationships between industry and government, and to "develop and implement the strategic framework to ensure the long-term sustainability of the forestry industry through value-added processing".[11]

Initiatives under FIFA reflect increasing awareness that levels of carbon sequestration, and rates of new planting and replanting, are strongly tied with forestry industry profitability. However, with no direct mechanisms having yet been created to encourage the planting of harvestable forest, and the decision not to devolve credits to forest owners in commitment period oneclimate change policy does not provide any direct mechanisms to encourage growth in the total plantation forest estate.

2.2.2 Other forestry-related climate change policies

"Negotiated Greenhouse Agreements" (NGAs) for competitiveness-at-risk firms are another government climate change policy initiative. Under an NGA, a firm would reduce its emissions intensity to World's Best Practice levels in exchange for either a partial or full exemption from the emissions charge. As of June 2004, one NGA has been concluded, and a further 12 applications to

[10] Hodgson (2004a), p. 3.
[11] Industry New Zealand (2002), p. 3.

negotiate have been received, with six currently under negotiation.[12] Two of the six applications under negotiation are from forestry processing companies.[13]

The "permanent forest sink mechanism" may also have an effect on plantation forestry. The permanent forest sink mechanism will award Kyoto forest landowners for carbon sequestration, subject to the landowner covenanting the forest for permanent protection. Under the mechanism, landowners will be allocated tradable emission units equal to the amount of increased carbon stored in the forest over commitment period one. Entry into the scheme requires a contract to be signed between the landowner and the Crown. Contracts will be registered against land titles and run with the land, and bind all future landowners. The initial proposed mechanism (as at October 2002) required a commitment not to harvest for commercial gain. However, in the May 2004 budget this rule was revised to allow landowners some harvest of the forest after 35 years, subject to the constraint that continuous canopy cover is maintained, and landowners are responsible for any carbon emission liabilities that may arise.[14, 15]

Penalties will be incurred for deliberate breaching of harvesting allowances. These will require the landowner to “replace all credits received plus additional units calculated on the basis of an annual compounding rate of 10 percent, applied to each year’s sequestration, commencing from the earliest year in which the forest sequestered carbon in respect of which units were generated”.[16] Arrangements for "replacing" units are to be agreed upon during contract negotiation. The penalty will apply to any deliberate harvesting before the 35-year period, and to any over-harvest after the 35 years. If carbon is lost through non-deliberate harvest, e.g. fire, disease, or windthrow, landowners will incur liabilities in proportion to the amount of carbon released, but with no additional penalty payment.

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[12] “Negotiated Greenhouse Agreements,” 2004.
[13] As at March 2004, the government is in negotiation with Carter Holt Harvey's key manufacturing operations and Norse Skog Tasman (“Negotiated Greenhouse Agreements,” 2004).
[14] Hodgson, 2004b.
[15] The definition of "continuous canopy cover" is under development as at June 2004, but will generally require a continuous canopy cover over the ground at any point in time. Implicitly there is a disincentive to over-harvest to avoid incurring liabilities.
[16] The Chair, Cabinet Policy Committee (2003), p. 4.

The mechanism does allow for the possibility of exiting the scheme through negotiation under the contract. Exit will require the mutual consent of the Parties and full repayment of carbon credits earned, and penalties will be incurred if harvesting is carried out. The mechanism also allows for land-use change out of forestry. Landowners will be able to change land use at any time, with the requirement that trees cut down (that exceed the allowable harvest) will not be able to be sold for commercial gain. Landowners will also be required to replace emission units for re-released carbon.[17]

The proposed Permanent Forest Sink Mechanism is probably not directly relevant to the forestry industry. It is unlikely to compete with growing forest for harvest, unless the price of carbon relative to wood rises, and is most likely to affect marginal land.

A further government climate change mechanism, the Projects to Reduce Emissions Mechanism, has the potential to affect forestry e.g. through funding of bioenergy projects. However, forest sink projects have been excluded from it at this stage. The mechanism is designed to provide incentives to generate emission reductions that go beyond business-as-usual.

Other forestry protection mechanisms, such as the QEII National Trust and Nga Whenua Rahui, continue to operate. However, these mechanisms do not affect commercial forestry.

2.2.3 Resource Management Act (RMA)

The RMA is a key part of New Zealand's regulatory framework affecting land-use decisions, both nationally and at a local government level. Under the RMA, councils are required to promote the sustainable management of natural and physical resources, including water and soil. Interpretations of the implications of this objective vary by local authority, as do relevant ecological considerations such as the resilience of land resources (e.g. erodibility) and conditions such as climate variability. Whether a forester can get consent to harvest on steep land is often discretionary. In some regions, local conditions are

[17] Indigenous Forestry Unit (2004).

judged to necessitate fairly strict regulation of forestry activity, or restrictions on putting land into forestry. For example, Environment Canterbury's draft Natural Resources Regional Plan 2003 proposes to restrict change from pasture to plantation forest, in view of concerns about afforestation reducing stream flows.[18] In addition, how local authorities implement the RMA affects the speed and cost for forest owners of gaining consents for forest planting and harvest. Uncertainty as to conditions surrounding consents can influence investment decisions. It is widely commented in the forestry industry that the RMA is an impediment to investment in the sector.

Amendments have recently been made to the RMA, and it remains under review. Amendments in the Resource Management (Energy and Climate Change) Amendment Act 2004 (which came into effect on 2 March 2004) require exercisers of the Act to have particular regard to the effects of climate change, and require local authorities "to plan for the effects of climate change, but not to consider the effects on climate change of discharges into air of greenhouse gases".[19] The amended Act aims for a national management approach on controlling greenhouse gas emissions. It also recognises the need to consider climate change and energy matters when planning and making decisions on resource management issues. These amendments tend to focus on methods to adapt to climate change.

The current review is focused on achieving an effective balance between national and local interests within the Act, streamlining the design and process of local policy formulation, and improving the consent decision-making process.[20] This involves consideration of the extent to which central government should, and is able to, give national direction on resource management matters that affect climate change.

The recent amendment to, and current review of, the RMA recognise the potential for inconsistent treatment of climate change across local and regional

[18] Environment Canterbury (2003).
[19] New Zealand 2004, No. 2, Part 1, Section 3.
[20] "Focus of the 2004 RMA review programme," 2004.

councils, current lack of certainty on climate change issues within the RMA, and the transboundary nature of climate change impacts.

2.2.4 Taxation rules affecting forestry

Forest planting costs can be deducted from and thus "shelter" other income, and this can be attractive to farmers wishing to smooth their tax payments. However, while the cost incurred in investing in a new forest *can* be deducted for tax purposes, the cost incurred in the purchase of an existing but immature forest *cannot* be deducted against other income—it is held in a "cost of bush" account until income is earned from harvest. Whether or not the former is "advantageous" in tax terms, it is clear that the regime is not neutral between buying a forest and planting one—it favours planting over purchase.

3 New Zealand's forestry industry

In this section we highlight key plantation forestry trends, with an eye to forestry's sequestration potential. In particular we want to understand what types of actors are likely to be able to effectively and efficiently sequester more carbon (or protect existing carbon stores) and what drives their behaviour. Policy needs to be directed at these groups in effective ways. We also want to establish the magnitudes of the key variables: levels and changes in forest, and amounts of carbon sequestered in New Zealand forests. Also, for distributional and equity reasons, we want to understand who is likely to be affected by any policy aimed at carbon sequestration. This section of the paper provides initial discussion of these points. The ongoing five-year programme aims to provide a more thorough, empirically-based analysis.

3.1 Basic forest facts: Areas, trends, ages

Plantation forest covers around 7% (1.83 Mha) of New Zealand's total land area of 27.1 Mha.[21] This compares with 44% in pastoral land and 23% in indigenous forest.[22] The National Exotic Forest Description (NEFD), which

[21] Ministry of Agriculture and Forestry (2004), p. 2.
[22] Pastoral land area was sourced from Ministry of Agriculture and Forestry (2003b) and indigenous forest land area was sourced from "Land cover database, land cover for New Zealand" (1997).

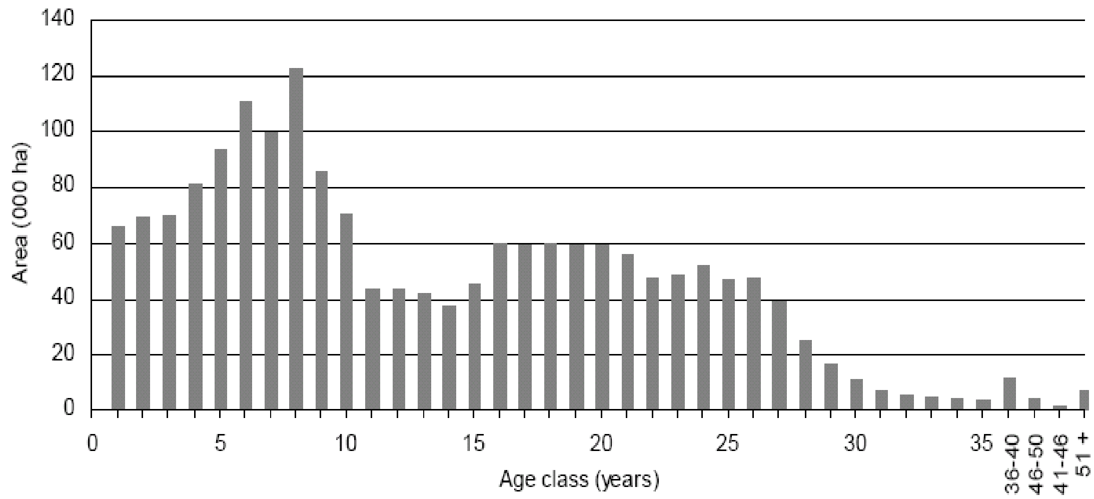
provides a profile of age classes, shows that planting has been unusually high since 1990. These are forests under 12 years in age in Figure 1 (this includes both restocking and planting newly established forests). If radiata forests are on average harvested at around 27 years in age, a large area will be harvested over the next 12 years (termed the "wall of wood"), but the harvesting demands in around 20 years will be higher still. As forest is harvested, owners need to make the decision about whether to replant. If this land has alternative uses, these are key decision points for potential deforestation.

Forest owners have considerable flexibility to adjust the age at harvest depending on market conditions, subject to some constraints from cash flow requirements. However, the annual increment in wood quantity gradually falls as rotation length is extended, and owners are likely to weigh the increment in wood value from another year's physical growth, together with the likelihood of an increase/decrease in wood prices, against prevailing market interest rates.[23] The area-weighted average clear-fell age for radiata pine (which is 89% of plantation forest area) was 27 years at April 2001, and 27.4 years in 2002.[24] With Douglas fir (6% of plantation forest area), other exotic softwoods (2%) and exotic hardwoods (3%), rotation length is typically longer (e.g. for Douglas fir usually ranging between 40 and 60 years), with more variation emerging in harvesting age.

[23] Current annual increment of volume peaks at about 21–23 years for radiata pine under typical NZ conditions and remains at very high levels for another 10–15 years (personal communication, Piers Maclaren).

[24] New Zealand Forest Owners Association, Ministry of Agriculture and Forestry, and the New Zealand Forest Industries Council (2003), pp. 1 and 3.

Figure 1: Total estimated planted production forest area, by age class (as at 1 April 2002)



Source: Ministry of Agriculture and Forestry (2003a).

3.1.1 How much new forest has been planted since 1990?

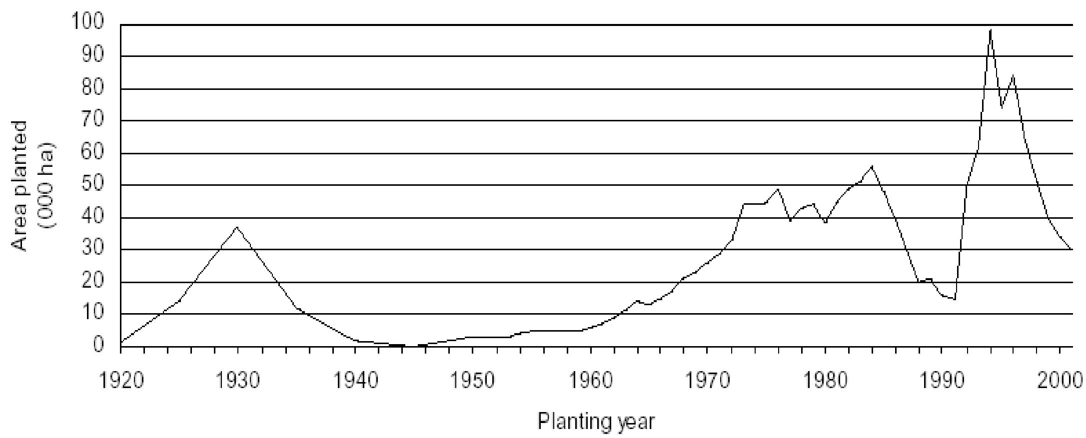
To gain an estimate of Kyoto forest, i.e. forest planted on unforested land (in other words, excluding restocking) since 1990, new planting data are used. Figure 2 (New land planted in production forest in New Zealand) shows that new planting rates in the early 1990s were at historic highs. It also shows that new planting rates have fallen since the early 1990s peak. New planting rates were at 30,100ha in 2001, 22,100 in 2002, and 14,900 (provisionally) in 2003; these are well below the average afforestation rate for the last 30 years of 44,900 ha/yr.[25] Because permanent deforestation rates are anecdotally said to be very low, the new planting rates also indicate the growth in the total forest estate.

However, a problem with NEFD numbers is that new planting and restocking numbers are estimates rather than solid numbers. The new planting estimate is calculated from the total numbers of seedlings sold by commercial forest nurseries, as reported to the Ministry of Agriculture and Forestry (MAF). Restocking estimates are based on data collected from forest owners but, to the extent that some farm foresters do not respond to the survey, the estimate's

[25] Ministry of Agriculture and Forestry (2004), p. 2.

reliability is limited.[26] Without as yet a map of New Zealand land cover in 1990, afforestation since that date cannot be accurately estimated.

Figure 2: New land planted in production forest in New Zealand



Source: Ministry of Agriculture and Forestry (2003a). Existing baseline predictions of forest area.

The rates of new plantation forest planting in New Zealand are highly variable, and consequently prediction is difficult. Current rates of new planting are estimated to range from 0–25,000ha/yr, with NEFD's provisional estimate for 2003 being 14,900 hectares. Farm forestry planting rates seem to have slowed down substantially in the last few years.[27] One farmer commented recently that "new plantings have declined steadily since 1996, as has membership of the NZ Farm Forestry Association, and there seems to be a widespread belief that forestry has little commercial value for farmers."[28] Some forestry industry commentators consider current planting rates to be close to zero.

Three of the range of possible explanations that have been offered to explain the drop in new planting rates are that existing forestry investors are concentrating on pruning and maintaining existing stands; that future returns to planting, as crudely indicated by current wood prices, are not sufficiently encouraging; and that new investors who might have established new forests have

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[26] The 2002 NEFD surveyed all forest owners and managers with at least 1000 hectares of planted production forest, and received a 100% response rate. Owners with less than 1000 hectares are surveyed every other year. Small-scale forest owners (1 to 39 ha) were last surveyed in the 1995 Statistics New Zealand small forest grower survey. All of these areas are still present in the 2002 NEFD database (Ministry of Agriculture and Forestry, 2003a, p. 8).
[27] Mike Halliday, personal communication, May 2003.
[28] Denis Hocking, personal communication, May 2003.

been scared off by negative press about the forestry industry and New Zealand's policies in relation to the Kyoto Protocol. A few foreign investors appear willing to plant despite the prospect of current relatively low rates of return because, it has been suggested, they see forestry investment as "green" and a risk management option.[29] A model of the mix of influences on new forest planting rates is presented in Section 4 below.

In contrast to current estimates of new planting, the Forest Industries Council's vision is for the planted area to expand from 1.8Mha to between 3.5 and 4Mha by 2025.[30] The expansion realised will depend on the investment decisions of a range of public and private forestry companies and individuals. Discussion with forestry industry stakeholders indicates that while this vision remains achievable, it is strongly dependent on future investment levels, forestry profitability and the level of confidence in the industry.

3.2 NZ forestry industry structure

3.2.1 Forest ownership

3.2.1.a Who owns current forests?

The New Zealand plantation forest industry is more concentrated than dairy or sheep production, but less concentrated than forest processing. The largest six companies (Carter Holt Harvey, Harvard Management Company (who bought Central North Island Forest Partnership in October 2003), Weyerhauser New Zealand, Juken Nissho, and Ernslaw One) together own around 655,000ha, which is 36% of the total planted area.[31] All six are foreign-owned. Seventy-five forest owners have blocks that exceed 1,000ha, and together these companies and individuals owned 1.285Mha in 2003, or 70% of the total planted area. Put another way, small blocks (less than 1,000ha) comprised 30% of the total planted area.[32]

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[29] Peter Clark, CE of P F Olsen, personal communication, May 2003.

[30] New Zealand Forest Owners Association, Ministry of Agriculture and Forestry, and the New Zealand Forest Industries Council (2003), p. 22.

[31] Tenon Ltd (previously Fletcher Challenge Forests) sold its entire forest estate to three buyers in 2004.

[32] Ministry of Agriculture and Forestry (2003a), p 20–21.

Table 1 gives a breakdown of planted production forest ownership in five broad categories.

Table 1: New Zealand forest ownership, as at 1 April 2003

Ownership category [1]	Estimated total area (ha)	Percentage of estimated total
Registered public company	828 930	45%
Privately owned [2]	852 418	47%
State-owned enterprise	42 415	2%
Local government	58 161	3%
Central government [3]	45 415	3%
New Zealand total	**1 827 339**	**100%**

Notes:

1. Ownership is based solely on the ownership of the forest irrespective of the ownership of the land.

2. “Privately owned” includes all privately owned forests. The legal entities included in this category are private companies, partnerships, individuals and trusts, which include Māori trusts and incorporations.

3. “Central government" forests are predominantly Crown owned forests on Māori lease hold land. These forests are managed by Ministry of Agriculture and Forestry.

Source: Ministry of Agriculture and Forestry (2004).

3.2.1.b Who owns Kyoto Forests?

The picture of who owns Kyoto forests (as opposed to plantation forests in general) is not a clear one. MAF reports that between 1990 and 2002 “it is estimated that 640,000 hectares of forest have been established. New entrants to forestry have carried out much of this new planting. Accurate details of the ownership composition of these new entrants are not available. Anecdotal evidence suggests that the majority of these new owners are either private landowners or syndicate investors and that most of the forests established by these owners are small in size.”[33] While some anecdotal evidence collected in the writing of this paper supports MAF’s assessment of Kyoto forest ownership—i.e.

[33] Ministry of Agriculture and Forestry (2004), p. 2.

that in the last decade, most planting has been carried out by farmers reforesting marginal blocks of land—other commentators perceive new planting to be roughly equally distributed between farm foresters, investment partnerships and small to medium-size companies.

3.2.1.c Land ownership vs. forest ownership

Existing ownership arrangements, e.g. leases, forestry rights, and Crown Forest Licenses, allow the ownership of the forest to be legally separated from the ownership of the land. Where the forest owner and landowner are separate entities, as is true for a large amount of the plantation forest estate, complexities in policy design are introduced. Our incomplete data collection on land ownership and forest ownership of the plantation forest estate shows that for at least 37% of forested land, the landowner and forest owner are separate entities. And, for at least 21% of forested land, the landowner and forest owner are the same entity. For the remaining 42% of forested land, the relationship between the landowner and the forest owner is unknown.[34]

3.3 Forest prices and profitability

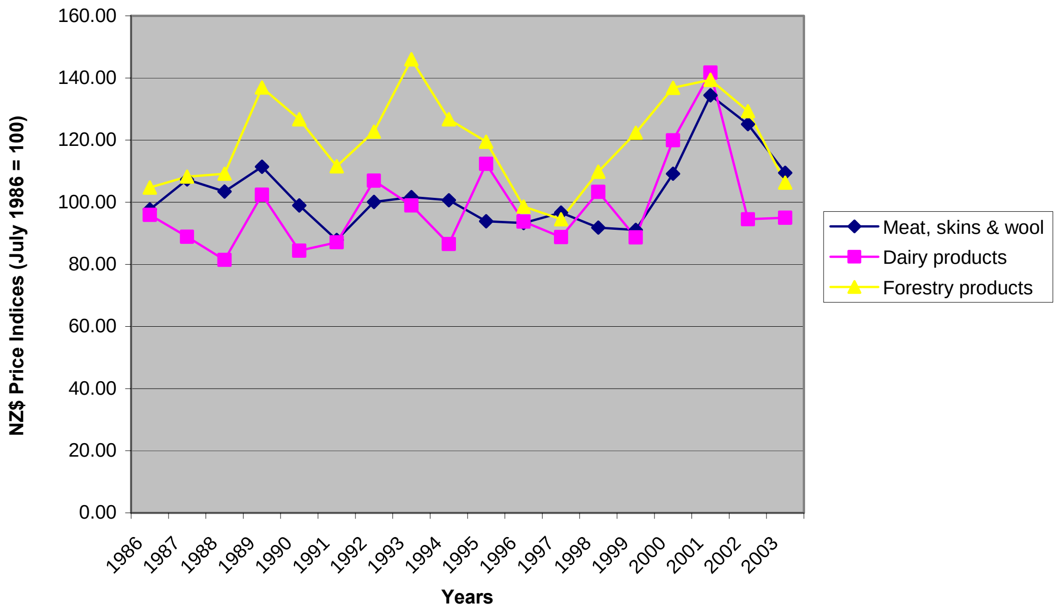
To anticipate a key element of the model of land-use decision making provided in Section 4, the returns from forestry (especially relative to agricultural returns) are clearly an important influence on land use in New Zealand. Figure 3 shows agricultural price indices from 1988 through 1995. In this period, the price index for forestry diverged from the other agricultural products' indices. It rose as high as 40% above its 1986 level while the other prices remained near their 1986 levels. Assuming no comparative change in costs, this suggests that forestry profitability rose relative to farm profitability during this period. From around 1995, the forestry index converged with the other indices and has since followed a similar path, indicating that changes in forestry output prices have become more comparable to changes in prices in the other main agricultural sectors.

[34] In these cases we may have information on either the landowner or the forest owner, but not both. Therefore for these pieces of forested land we cannot connect the forest owner with the landowner.

Little time series data is available on forestry production costs. This data would enable a fuller picture of forestry profitability to be developed. However, forestry and logging production input price data for 1994 to 2000 indicates that input prices were relatively steady over this period.[35]

[35] New Zealand Forestry Statistics (2000).

Figure 3: Meat, skins and wool, dairy products and forestry products—relative output price trends, 1986–2003



Notes:

Data is derived by taking an annual average of monthly data.

The 2003 average is based on four months of data, January–April.

"Meat, skins and wool" includes lamb, beef, wool, skins, and venison.

"Dairy products" includes whole milk powder, skim milk powder, butter, cheese and casein.

"Forestry products" includes sawn timber, logs, and wood pulp.

Source: ANZ commodity price index—historical series and component indices.

New Zealand is a small player in internationally traded forest products (at 1.1% of world forest products trade),[36] and is largely a price taker in the international forest product market. Major competitors in the pine wood market are Chile, Australia, Brazil and South Africa; our position is open to competition and is price sensitive. The profitability of the planted forest industry is thus substantially "exogenous" to the New Zealand industry's actions, other than to its cost structure. Profitability movements are driven largely by international macroeconomic factors such as economic demand in the key markets of Australia,

[36] New Zealand Forest Owners Association, Ministry of Agriculture and Forestry, and the New Zealand Forest Industries Council (2003), p. 4.

Japan, the US and South Korea. The parts of the New Zealand forestry industry that were producing and exporting unprocessed, unpruned logs were seriously affected by the Asian crisis, reducing prices in 1998. However, prices for pruned logs remained buoyant until somewhat later (early 1999).[37]

Costs of substitute material products such as steel, aluminium and concrete, and the costs of fossil fuel alternatives to wood, affect the demand for wood in the international market. Costs of product installation further influence costs. Evolving attitudes towards fossil fuel use and its effects on climate change are also of significance. In the longer term, concerns about climate change may mean that fossil fuel use will turn down in favour of demand for wood both as a fuel source and as a solid wood product. However, even if this does not eventuate, growing population and incomes are likely to increase wood demand over time.[38]

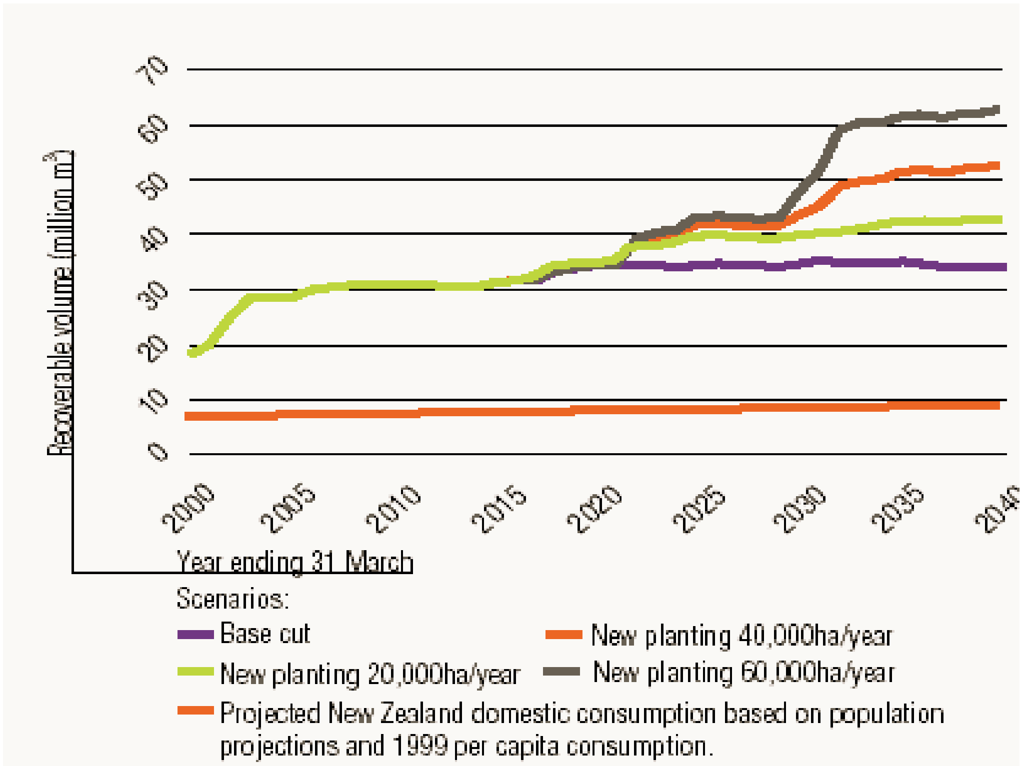
To maintain its market position and minimise future demand-side risks, New Zealand forestry operations have been moving to consolidate market credibility through Forest Stewardship Council (FSC) certification. Of New Zealand's 1.8Mha, some 42% is now FSC-certified.[39] Forestry plantation profitability is also affected by future investment both directly in forestry production and by capital infrastructure building. These aspects are discussed in Section 3.3.1 to 3.3.2 below.

3.3.1 Forestry infrastructure and processing needs

Figure 4 illustrates the impacts of different planting scenarios on wood availability in later periods and hence implicitly the demand for harvesting and processing infrastructure in each scenario. Key questions are: Will our ability to harvest, transport and process a much increased wood supply limit the further expansion of New Zealand forests? Could we continue to profitably grow forests in New Zealand even if we only export logs?

[37] "New Zealand forest industries log pricing," accessed on 10 February 2004.
[38] Sutton (1999), p. 8.
[39] New Zealand Forest Owners Association, Ministry of Agriculture and Forestry, and the New Zealand Forest Industries Council (2003), pp. 21.

Figure 4: Effect of different planting rates on wood availability



Source: New Zealand Forest Owners Association, Ministry of Agriculture and Forestry, and the New Zealand Forest Industries Council (2003).

At harvest, the costs of transporting timber to mills, processing plants and ports is significant.[40] New Zealand has over 400 sawmills, and a dozen significant ports for log or chip exports.[41] Road condition is also important, especially for commercially marginal growing regions such as the East Coast of the North Island. Some forestry companies use a working circle rule of thumb for forest planting or acquisition decisions (particularly for pulp and other lower

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[40] The New Zealand Forest Owners Association, Ministry of Agriculture and Forestry, and the New Zealand Forest Industries Council (2003) estimate of the cost to transport 1 cubic metre of wood for 1 kilometre is 15–20 cents (p. 25). Loading costs, plus the cost of the initial 10–20 km, are the largest cost element. An estimate of fixed costs is $3 per cubic metre, with 11–12 cents per cubic metre kilometre on top of that (David Paul, personal communication, May 2003). On occasion, harvesting and transport costs mean that growers leave trees standing at maturity rather than harvesting.

[41] "Exports of logs and wood chips by port September 2003 quarter and September 2003 year (provisional)," 2003.

grade products); the "working circle" distance from processing plants is heavily influenced by transport costs.

With around a third of a growing supply of logs now being exported in log form, substantially up from the 1980s, port facilities are also increasingly significant.[42] Access to adequate facilities, and cost levels, at the major ports (Tauranga, Whangarei, Nelson, Napier and Gisborne) are important. As infrastructure can have a significant impact on costs, it is important to the industry that infrastructure does not constrain industry growth. Roading and the Gisborne port are identified by the industry as key areas needing upgrading.

3.3.2 How are growing and processing of forests linked?

The majority of wood processing in New Zealand takes place in the central North Island. The major forest owners are also the main wood processors, with their processing plants located near or within their forests.

Approximately 70% of the annual pine harvest is processed in New Zealand, with the remaining 30% exported as unprocessed logs.[43] Wood supply volumes are expected to reach around 30 million cubic metres by 2010 and, given current planting rates, we can expect a longer-term supply of around or above 40 million cubic metres (see Figure 4). In order to process the increasing wood supply there is pressure on the forestry industry to both upgrade existing facilities and invest in green-field plants. The industry has spent over NZ$1.6 billion on enhancing capacity over the 10 years to July 2002, and it expects to spend a further $445 million over the period 2003–2009.[44]

Because forest growers always have the backstop alternative of exporting logs, it is likely that local processing capacity will have only a limited impact, if any, on prices received for timber. However, in areas where port facilities are congested, an increment in processing capacity could temporarily have a modest impact in lifting otherwise sub-marginal log prices.

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[42] Ministry of Agriculture and Forestry (2003b).
[43] Ministry of Agriculture and Forestry (2003b).
[44] New Zealand Forest Owners Association, Ministry of Agriculture and Forestry, and the New Zealand Forest Industries Council (2003), p. 18.

Similarly, expected energy costs are unlikely to have any significant impact on forest returns, except through the indirect path of influencing processing plant investment decisions. A reliable supply of low-cost electricity and process heat is an important factor in processing returns, especially for more energy-intensive processing. If energy costs rise with climate change regulation, gas scarcity, and other factors this is likely to reduce or at least limit the expansion of throughput and hence input demand from processing mills, adversely affecting forestry returns from sales within New Zealand and diverting wood to export markets.

In the longer term, if processing infrastructure is better developed in New Zealand, allowing a move away from log sales on commodity markets, the industry may be better equipped to withstand commodity price fluctuations. Domestic timber prices may also become less anchored to international timber log export prices.

3.4 Specific Māori issues

Māori have a considerable stake in forest resources: MAF estimates that about 240,000ha, or 14% of New Zealand's plantation forests, are on Māori land,[45] and Māori are estimated to own around 35,000ha of this forest.[46,47]

Harmsworth's recent work has found that an estimated 300,000–400,000ha of Māori land is marginal.[48] Of this marginal land 255,000–345,000ha is under indigenous forest or mature scrub, and 40,000–50,000ha is in pasture (and was in pasture at 1990).[49]

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[45] This was estimated for the year 2000 (Ministry of Agriculture and Forestry, 2001).
[46] Figure supplied by Crown Forestry (personal communication).
[47] Harmsworth (2003) estimates that about 12.1% of total Māori land in New Zealand is in plantation forest.
[48] Marginal land has been generally identified as land falling in Land-use capability classes 6–8. Land-use capability is an ecological measure that rates land for 1–8 on its ability to sustain agriculture, taking into consideration ecological characteristics, climate, and the potential for erosion.
[49] Harmsworth (2004). Māori land in Harmsworth (2003) refers to Māori freehold land (from Māori Land Court records), which is largely Māori multiple owned land.

With, as yet, no map of New Zealand land cover at 1990 it is not possible to accurately quantify the amount of Māori land that has an opportunity to gain credits for reforestation or regeneration to scrub under Article 3.3 Kyoto rules. Clearly, the 40,000–50,000ha in pasture has this potential. Also, a portion of the 255,000–345,000ha currently under indigenous forest or mature scrub may have been in immature scrub at 1990 and not have met the Kyoto definition of forest. However, this portion is likely to be a few percent at most.[50]

Harmsworth has identified that Kyoto-eligible marginal Māori land is likely to be favoured for afforestation into exotics (rather than regeneration to scrub) due to the perceived higher economic returns of plantation forest among Māori.[51] In the absence of policy to deter deforestation, further Māori land in mature non-Kyoto scrub or indigenous forest may also be targeted for clearing and reforestation into plantations.[52]

4 Land-use decision-making

In this section we discuss the factors affecting land-use decisions by New Zealand landowners (or land-use decision makers acting on behalf of owners)—for example, the decision whether to plant a forest or retain land as pasture. These influences will vary among groups and across individuals, but there are some regularities and common factors affecting decisions, as well as factors that may be particularly important for specific groups.

The essential issues can be set out with a fairly simple standard economic model. We then take into account additional factors such as tax, risk, social factors and lifestyle choices and discuss who is likely to expand forest land and the likely scale of such expansion.

[50] Craig Trotter, personal communication, 31 May 2004.
[51] Garth Harmsworth, personal communication, 12 February 2004.
[52] Some district councils place restrictions on the clearing of mature scrub.

Much of the background information supporting the discussion in this section has been based on consultations with a variety of industry groups. If a source is not explicitly mentioned in the text, the information has been derived from these meetings.

4.1 A simple model

Simple economic models of land use propose that land-use decisions depend primarily on expected returns from competing alternative uses. Consider a landowner facing a choice between retaining land in agriculture and converting it to forest.[53] This standard model is derived from Stavins and Jaffe (1990), who have tested the model in the United States. In their model, the landowner will convert agricultural land to forest only in the following circumstances:

$$(F - K - A.q + M) > 0$$

where F is the present value of forest net revenue, taking into account delay until harvest; K is the present value of the cost associated with establishing and managing a forest (site preparation, planting, pruning etc.), A is the present value of the expected future stream of agricultural revenues; q is a parcel-specific index of feasibility of agricultural production, including effects of soil quality and moisture; and M is the expected cost of agricultural production. Another way of viewing this is:

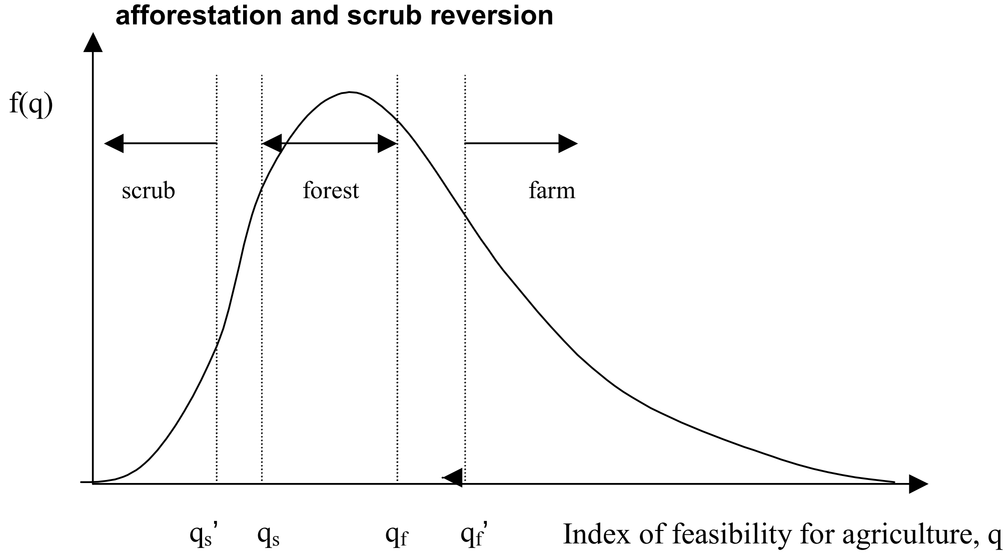
$$q_f = [F + M - K]/A$$

where q_f is the threshold value of land quality below which there is an incentive to convert to forestry (and above which it stays in agricultural use). We create a similar threshold for the distinction between forestry and scrub, q_s. Very low quality land will not yield a positive return in forest. A possible frequency distribution of land types is shown in Figure 5.

[53] Another alternative in some contexts is setting it aside for biodiversity protection. However, biodiversity protection can be viewed as a special case of (non-harvest) forestry.

If land quality of a particular parcel is below q_f, the land will be converted to forestry. This threshold q_f is represented by a vertical line in the diagram below, which has "q", the land quality index, on the horizontal axis. If the land quality is above q_f' it will remain in agricultural uses. The gap between them results from the fixed costs of converting from one use to another. In this range, the land will stay in its current use. The positions of the thresholds will move with changes in output prices, productivity and costs.

Figure 5: The distribution of land quality, and economic thresholds for afforestation and scrub reversion



Source: After Newell and Stavins, 2000.

We can expect q (the parcel-specific index of feasibility of agricultural production) to be a function of:

- soil quality—including soil moisture and factors such as acidity
- slope (topography) and erodibility
- accessibility
- local climate.

In general, poor soil quality and steep country tends to be converted to forestry, sometimes with the assistance of regional councils concerned to minimise flooding in vulnerable river catchments.

The net return to forestry, F – K, has various components, principal ones being:

- the price of logs received by the forester after harvest, at the port or processing site
- the volume of timber of different grades produced (e.g. pruned logs; saw logs; industrial logs)
- the cost of planting, growing and harvesting the trees
- transport costs (a function of distance and trucking cost structures) to a port or processing site.

Given that forest rotations are so long, a key factor, the price of logs at the harvest point, is highly uncertain. While industry participants commonly cite current log prices as an indicator of future prices, there is major uncertainty over this element of the return; many in the industry note there is no strong reason to expect that current log prices will be a good predictor of log prices at the point of harvest.

4.1.1 How much land is marginal for agriculture and could be used for forestry?

PA Consulting have estimated that land suitable for forestry is over 9.4 million hectares in area, although it is important to note that this is not a prediction of actual likely conversion.[54] The Forest Industry Council's vision for planted area by 2025 is 4 million hectares.[55] Given that the current forested area is around 1.8 million hectares, under either "scenario", potential conversion of farmland to planted forest would be very substantial. At present, it can only be said that most industry commentators do not see *current* confidence levels as sufficient to generate planting rates that would achieve conversion of such large areas.

[54] PA Consulting Group (2001), Chapter 10, p. 3.

[55] New Zealand Forest Owners Association, Ministry of Agriculture and Forestry, and the New Zealand Forest Industries Council (2003), p. 22.

4.1.2 How much land that is in forestry might not be in future?

On the other hand, little reconversion is currently taking place. The model in Section 4.1 suggests that there needs to be a significant increase in returns to farming before conversion from forestry to farming is likely to take place—in effect there is a "buffer" damping conversion. This buffer arises partly because reconversion involves costs of removing stumps, roots etc., which may be around $4000 per hectare. Some industry commentators note a few reconversions from forestry to dairy but the land quality (q in the model) has to be exceptionally good (perhaps valued at around $12,000 per hectare) to justify such action. [56]

4.2 Other factors that affect land-use decisions

Expected returns may explain a significant portion of overall variance in land use, but many other factors affect specific decisions and can provide additional explanatory power. Different land uses have different risk profiles and different agents respond differently to these risks. Tax treatment, particularly of forestry, has changed over time. Governance (e.g. government, private, Māori, foreign) affects the way the landowner makes decisions. Non-economic factors such as environmental and social considerations can also have a significant impact on land-use decisions. These could be reflected in individual preferences or in the constraints imposed by regulation such as the RMA.

4.2.1 Risk and uncertainty

With forestry's long horizon, uncertainty is greater than in many other land uses. Forestry investors need to make an assumption about the price of wood 20–30 years in advance. Their expectations about profitability may be based on historical and current prices. Policy uncertainty is a major factor because policy can change considerably over the period of their investment. Although other farmers (e.g. sheep and beef farmers) need to make investments that will last long periods, their flow of returns begins very quickly, so they are less vulnerable. Forestry investors may be more sensitive than other agricultural investors to signals about long term future trends in either prices or policy. Where prices or policy seem particularly uncertain, decisions may be deferred until more

[56] Peter Clark, personal communication, May 2003.

information is available. Some commentators have suggested that forestry investors are very sensitive to perceptions of the industry's future. Thus small foresters reacted severely to the Asian crisis even though it did not directly affect the market they would be producing for.

Different investor groups' attitudes to risk and uncertainty will influence forestry investment decisions. Empirically, it is clear that the investment behaviour of the different investor groups varies—with little corporate investment in forestry over the last five years, while some (diminishing) farmer investment has continued. This may in part be because corporates, small investors and farmers differ in their risk management strategies, as well as concerns about cashflow.

Larger agents (such as corporates) are likely to be less affected by risk. Agents who have diversified activity may also be less affected by forestry risk. In particular, farmers investing in forestry often point to the risk diversification advantages of forestry—they engage in forestry while maintaining a viable level of livestock to spread and manage risk. They can maintain some cashflow in the short term while investing for significant expected returns in the longer term. Estate planning is another frequently mentioned driver for farm foresters, with forests being viewed as an asset to be inherited by the next generation.

It has been commented that farmers often meet lumpy cashflow requirements by selling forest blocks at times of need, something that corporates may be less able to do if they need to provide a steady supply of wood input to processing plants. Farmers can also spread risk by engaging in joint ventures with investment companies.[57] Farmers retain the land in many such ventures, with investors contributing capital for planting; at harvest, proceeds are split.

[57] "Warren Forestry—how we operate" (2003).

4.2.2 Governance: Foreign ownership

Approximately 50% of New Zealand's planted forest estate is owned or controlled by foreign investors.[58] There are factors involved in foreign investors' decisions that may lead them to make different decisions than local investors. Foreign investors tend to be more mobile in their options, and larger in size, than local investors. Their interest in the New Zealand forest industry is largely focussed on gaining access to raw materials, thereby securing supply, and will be affected by constraints on raw material access internationally. Local decision-making on land use tends to be influenced by the level of investment interest shown by offshore entities; for example, an increase in foreign investment in New Zealand forestry would likely increase future forest replanting and planting rates.

4.2.3 Environmental considerations

Most farmers are conscious of environmental concerns such as soil erosion and the arguments for retiring steeper hill country into forestry. For farm foresters in particular, environmental factors are "high on the list" of considerations affecting planting decisions on a particular block of land. While their key concern is erosion control—limiting water run-off, especially after heavy rain—other location-specific concerns such as protecting a streambed or wetland can be important. Farm foresters may respond directly to these environmental concerns.

They might also be affected by regional planning constraints, especially where the environmental impact affects a much wider area. Catchment and water quality protection is especially significant in some areas, such as surrounding North Island lakes, where nitrogen export rates are higher under grass than forests. In the case of Lake Taupo, the regional council is moving to vary the regional plan to protect water quality. And, as noted above, in drier areas such as Canterbury and Nelson, concerns about the impact of forestry in reducing water run-off, in the context of heavy demands on water for irrigation, can influence regional council regulatory decisions under the Resource Management Act.

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[58] PA Consulting Group (2001), Chapter 10, p. 5.

These decisions may affect small and large forestry investments differently. Hock et al (2001) note the potential social as well as economic impacts of forestry in the Mackenzie Basin. They find a definite long-term economic benefit of switching from pastoral farming to forestry. However, little land has in fact been planted—influenced, it seems, among other things, by the fact that larger-scale plantings require notified resource consents, which were not granted due to environmental reasons.[59]

The East Coast Forestry Project set up by MAF in 1992 is an example where environmental considerations have been implicitly taken into account in the creation of a government-aided forestry initiative. It is managed by the MAF Forest Management Group and aims to plant at least 60,000ha of commercial forest over 28 years on severely eroding and potentially erodible land on the East Coast of the North Island. Government grants are available to landholders through a tender process, with this financial assistance providing means to offset the additional costs and risks associated with afforestation on erodible land. [60]

4.2.4 Social considerations

Changes in land use have implications for the levels and types of employment in rural areas. Forestry may employ fewer people per hectare than sheep/beef farming, and particularly, may employ few people who live locally. Often specialised teams are brought in for specific jobs such as planting, pruning or harvesting. The types of people who are employed in forestry may also be different than those in dairy or sheep/beef farming. They have different skills and often a different "culture". This has impacts on local communities that may or may not be welcome. Changes in land use may require in- and out-migration and gradual community adjustment. Resistance to forest planting in some areas may reflect both reservations about environmental impacts of forestry (e.g. concerns about reduced water run-off or the aesthetic impacts of pine plantations) and about its social impacts. Some concerns arise because forestry is unfamiliar.[61] These

[59] Barbara Hock, personal communication,.May 2003.
[60] “East Coast Forestry Project,” 2003.
[61] Ministry of Agriculture and Forestry (1993).

factors can affect decisions directly or through difficulty in obtaining resource consents.

One Forest Research commentator suggests that where one or two farmers introduce forestry to an area, other (often older) farmers may over time take up planting as familiarity with forestry practice increases.[62] Older farmers may have longer time horizons and may plan to provide the forest to their children as a bequest. The average age of farmers in an area may be an indicator of openness to converting farms or parts of farms to forestry, and the occupational change involved.

4.2.5 Issues on Māori-owned land

As well as the above considerations, Māori land-use choices are likely to be influenced by additional factors including existing governance structures, aspirations about land control, non-timber-related economic opportunities (e.g. the production of honey and medicines from manuka and kanuka), and biodiversity values. Social factors—including concerns about loss of local employment opportunities in an area; a desire to keep communities intact; intergenerational equity considerations; stewardship of culturally significant areas; and whether other possible income sources are compatible with afforestation—can also be important.[63]

4.2.6 Timing of adjustment in land use

Figure 2 and Figure 3 suggest that an increase in relative forestry product prices may be followed by increases in new forest planting. But land-use change involves investment and is not instantly reversible. Thus we would not expect instantaneous responses to changes in prices or costs. Farmers may regard price or policy changes as temporary, so may wait to see if they become permanent. They may also have short-run cash flow issues that make a rapid response difficult.

[62] Barbara Hock, personal communication, 2003.
[63] Harmsworth (2003), p. 6.

The land conversion process in New Zealand appears often to be "lumpy"—there may be key points in time when a land-use decision needs to be made, perhaps for financial or family reasons, and at these times land use has a higher probability of changing. Also, the optimal size of a farm for agricultural purposes may be rising over time (assuming that a larger operation allows economising on farm management overheads). The farmer has various options. One is to sell off a block for forestry, and buy a neighbouring pasture block of good quality to reach optimal (or at least viable) farm size. Another is to sell off the whole farm—either to another farmer (leading again to aggregation) or to forestry investor interests. Because of the transaction costs of purchase/sale/leasing, the blocks in question are often sizeable—for example, 200 or 500 hectares. Similarly, conversion out of forestry can only happen at specific times—when the forest is harvested—and may occur in large blocks to make alternative land uses viable.

Some landowners may be slow to move to an "optimal" land use. Adjustment is costly where new knowledge has to be acquired and, as with the adoption of new technology, a change of land ownership associated with migration of people with different skills or generational change may sometimes be required. A non-forestry example of this is the movement of Waikato dairy farmers to Southland, which was associated with the dairy boom in Southland.

4.3 Who might expand forest area in future?

The recent pattern of forest planting suggests that larger corporate players will retain their current level of forest and are unlikely to expand their forest area—unless there are increases in forestry profitability and industry confidence. This means that smaller agents are likely to be the key players in purely commercial forest expansion in the short term.

In the longer term, plantation forestry may become an option for a wide variety of players as environmental concerns increase, even without active climate policy to encourage it. When forests are planted for environmental reasons they are likely to be planted on marginal land, and particularly on steep hill slopes and riparian areas.

5 Basic carbon ecology

5.1 Basic ecology: How much carbon in forests

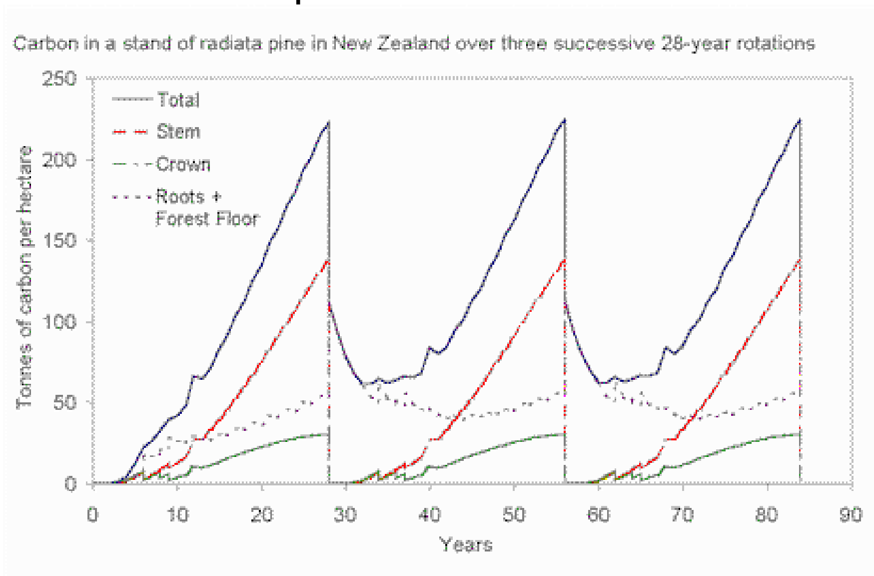
At the *stand* level, the carbon stock in a New Zealand plantation forest depends primarily on the silvicultural regime of the particular stand. Stands vary in the age classes of trees they contain, and the way the stand is managed. Relevant factors include:

- species used
- initial stocking
- fertilisation
- pruning/thinning regime
- rotation length.

These factors can be affected by forest management but will be significant for reporting under Article 3.3 only where they affect Kyoto forests. They will have a much bigger impact if New Zealand decides to report under Article 3.4, where management of the entire forest estate will be relevant.

An example of the time profile of the carbon stock for a stand is shown below—it includes pruning at age six, eight and nine years, and thinning, to waste, at age six and nine years, with log extraction from the site at clearfell, age 28. This example is not on previously farmed land so may not be directly applicable to many of the Kyoto and potential Kyoto forests. Modelling of stand carbon stocks for New Zealand pine plantations is now well established (e.g. through Forest Research's stand management modelling system STANDPAK and C_Change module).

Figure 6: Carbon in a radiata pine stand



Source: Forest Research (2002).

A forest combines a large number of different stands of different ages. Thus the sequestration pattern in a forest is likely to be much smoother than that in a stand.

5.2 Aggregate carbon sequestration estimates

MAF estimates carbon sequestration in the New Zealand plantation forest estate on an annual basis, both for the entire forest estate and for forests that have been planted since 1990.[64] They also model the variability of aggregate projected carbon sequestration under different new land planting rates, with recent new planting rates based on the latest NEFD estimates of annual new planting.

The results for carbon sequestration for only those stands established since 1990 show that "the size of the carbon reservoir in these stands collectively increases under all scenarios modelled until harvesting begins in 2019. The onset of harvesting results in a decline in average stand age (and therefore carbon

[64] MAF's separate estimates for post-1990 forests are not aligned with the Kyoto Protocol/Marrakesh Accord carbon accounting rules (Paul Lane, personal communication, December 2003).

stored) which can only be compensated for by a high new planting rate."[65] In other words, if New Zealand does not resume high planting rates (of about 40,000ha/yr) in the near future, the post-1990 carbon pool will become a net source rather than a net sink by the period 2018–2022.

Our project aims to forecast land-use change and hence new forest planting so that we can say what scenarios are likely rather than simply looking at the range. We will also model the effect of different policy scenarios on the projected levels of aggregate carbon sequestration.

5.2.1 Stocks of soil carbon

Stocks of soil carbon are large, but usually change more slowly than above-ground biomass, and there are more uncertainties in soil carbon estimation, partly associated with spatial variability.[66] Plantation forestry can have counteracting effects on soil carbon stocks. First, consistent evidence shows that soil carbon stocks fall as land transitions from pasture to pine but the fall in soil carbon stocks is estimated to be small in comparison to the gain in above-ground carbon stocks. Further soil carbon loss may arise from forest harvest effects.[67] On the other hand, afforestation of marginal land can prevent soil carbon being lost in erosion events. Also, the accumulation of pine leaf litter on the forest floor (which contains carbon) is likely to offset below-ground soil carbon losses over the longer term.

5.3 Risks associated with carbon in plantation forests

Fire is often seen as a key risk. However, the probability of fire is low in New Zealand.[68] Wind is a more significant risk.[69] Other uncontrollable risks include storm events such as Cyclone Bola, which had major effects on forests. No land user could have totally prevented those risks to forests. If an area of forest

[65] Te Morenga, Wakelin and Forest Research (2003), p. ii.
[66] Baisden et al (2001), p. 12.
[67] Baisden et al (2001), p. 13.
[68] The probability of any given hectare of plantation being burnt in any year is about 0.06% (Maclaren, 1996, p. 168).
[69] On average about 12% of net stocked area is lost over a 28-year rotation through wind damage (Maclaren, 2000, p. 99).

is destroyed by wind and consequently cleared, New Zealand would lose the accumulated credits under Kyoto rules.

In New Zealand forests pests are an important issue, and an adequate investment in border biosecurity remains the best defence. However, New Zealand already makes a major investment in forest biosecurity on the basis of the economic and environmental significance of our forest resources—so that even an enhanced awareness of the value of carbon sequestered in forests is unlikely to alter the level of that investment.

PART II: Policy design issues

Having established the basic context for carbon sequestration policies, we move on to analysis of policy design issues. We begin by considering the potential value of additional sequestration. Is it likely to be large enough to justify the costs of designing and implementing a policy to achieve optimal sequestration? We then consider issues relating to different types of policy approach.

Section 6 explores the potential impact that including the value of carbon sequestration in land-use decisions could have on forest area. Section 7 discusses types of incentives and reasons why current forest area may be below its potential, even excluding any possible carbon policies. Are there opportunities to simply improve the efficiency of the forest growing sector and increase forest area? This analysis suggests ways in which government might indirectly encourage new forest planting by increasing the profitability of the forest sector. Section 8 moves on to discuss policies that directly aim to increase sequestration by devolving incentives to landowners and/or forest owners. It outlines key issues that need to be addressed when developing a policy design to encourage sequestration and storage in a pragmatic way.

6 The potential impact of rewards on carbon sequestration

Here we discuss how including considerations of the value of carbon sequestration and storage changes optimal land-use behaviour. This is to provide an indication of the maximum that policy could potentially achieve.

A simple policy of providing annual payments for the additional carbon sequestered (possibly in the form of carbon credits that can be held or exchanged for cash) and liability for all carbon released at the time of harvesting would perfectly internalise the benefits of carbon sequestration. If there were no administrative costs this would simply change forest net revenue. The present value of net revenue would rise as long as carbon prices are not rising too fast relative to the investor's discount rate (so the carbon payments received while the stand grows offset the liability on harvest) and/or there is no intention to convert the land to non-forest uses (so a higher cost of liability on harvest is always offset by higher carbon payments in the next rotation). If there is a risk that net revenue could fall, the forest investor can always opt to insure against carbon price changes, or provide for the desire to clear land, by holding carbon credits instead of taking the cash and bearing the liability to buy credits later. In our simple policy investors are never liable for more credits than they earned while the forest grew. Thus they can guarantee that they do not lose from the policy.

The quantity of carbon sequestered will depend on the carbon "yield curve" for the land and forest type in question, and this yield curve enables the landowner to adjust the land-use decision for the carbon return. One possible carbon yield curve for a stand of radiata pine was given in Figure 6.

With higher levels of forestry profitability, land that would have been marginal for forestry will now be profitable and we would expect conversion of land from agriculture to forestry. The higher the carbon yield and carbon price, the more land will be converted. We would also expect that rotation lengths would become longer, so that average carbon stocks are higher, and that in some cases land will not be harvested when the net revenue is too low (e.g. land with poor access and poor quality timber).

By comparing the amount of new forest and total carbon sequestered during the commitment period when there is no revenue from carbon with the amounts sequestered with varying levels of carbon price, we can generate a "supply curve" for carbon. This supply curve slopes upward as usual—i.e. as the marginal incentive applied increases, the amount of carbon sequestered also rises. However, the shape is non-linear: with an increasing price ($ per tonne) the supply curve gets increasingly steep, as more and more of the land in an area is converted and the quantity of marginally convertible land diminishes. This is a curve that the empirical modelling in our wider project is estimating.

Any real policy will fall short of the optimal reward system because of monitoring costs and difficulties, and other compliance costs. In addition, if forestry investors do not trust government, they may respond differently to a revenue stream that comes from a government policy than to one that comes from selling a product on the market. Even if the carbon sequestration policy were known to be stable for a long time, because international carbon prices are still highly uncertain, revenue from the policy would still be very uncertain. Thus forestry investors may not respond to it in the same way as to a rise in timber prices or a fall in pruning costs, which may be more stable or which they may feel they understand better.

In the perfect world of our model, a carbon sequestration policy is unambiguously beneficial to foresters. In the real world, where compliance costs are high and carbon prices may be low, there is a risk that the net benefit to foresters required to participate could be negative. This legitimate fear necessitates careful policy design to maximise benefit and minimise cost.

6.1 Effects of forestry carbon sequestration policy outside of plantations

The same factor—increased plantation profitability—that leads marginal agricultural land to be converted to forests, also creates pressure to convert scrub and regenerating native forest land to plantation forest if only plantation forests are eligible for credits. In Figure 5, providing a reward for carbon sequestered in plantation forest would move q_f to the right, leading to conversion of farm land to forest, but would also move q_s to the left, leading to the conversion of scrub to forest. This could have negative implications for overall carbon sequestration if it involves deforestation, or if the long-run level of carbon sequestration in indigenous forests is higher. This has been a concern of environmental groups. In New Zealand this has been partially addressed with a Forestry Accord, where plantation forest owners have agreed not to clear reverting scrub in order to establish new forests. Another solution is to offer carbon sequestration rewards to indigenous forest as well. To a certain extent this is already happening through the development of policy to reward permanent (non-harvest) forests.

In the New Zealand context, an important dynamic is the likely displacement of other greenhouse gases (ruminant methane and nitrous oxide) due to reduction in livestock numbers with conversion from livestock agriculture to forestry. This is an extra bonus. However, it cannot be assumed that land conversion will lead to a proportionate reduction in livestock numbers (with associated methane and nitrous oxide reductions), partly because the land that is converted will tend to be the lowest quality with low stocking rates. In addition it is possible that livestock number reductions in one area may be partially offset by increases elsewhere, perhaps through more intensive stocking, so that apparent methane/nitrous oxide reductions are partially offset.

7 Central control versus devolution of incentives

7.1 Value of devolution

Devolving credit for sequestration allows market processes to discover the lowest cost opportunities for carbon sequestration, and will lead to a higher overall level of sequestration for any given "reward" level, i.e. for any given level of funding of rewards for carbon. Devolving credit will increase the supply by lowering the marginal cost of New Zealand standing timber relative to that from developing countries unless they manage to claim credits through the CDM. In theory they can claim such credits from 2000 forward. In reality, the costs of setting up and carrying out CDM projects is likely to be high, depending on the stringency of assessment of baselines, additionality etc. CDM use for forestry may thus be relatively limited.

Devolving credit has two components. Devolving credit for changes in behaviour from here on, avoiding deforesting existing forest or planting new forest, has real incentive effects that will alter the overall levels of sequestration and storage. Devolving credit for behaviour before now (e.g. planting Kyoto forests during the 1990s) has large distributional and equity implications but probably does not have major efficiency implications. Here we focus on devolution of responsibility for future behaviour. We assume that devolution implies that Kyoto forest owners gain all credits for sequestration from here on together with liability for carbon released during harvesting, and that all forest owners bear full liability for deforestation (change to a non-forest land use). Thus foresters gain the full carbon benefit of their actions from now on and bear the full costs. We do not advocate this as the ideal system, but we need to have a system in mind as we assess other aspects of policy. Later in this part we discuss possible alterations to this system and some of their benefits and disadvantages.

A devolved credit system lowers the marginal opportunity cost of planting or replanting a forest for both Kyoto and non-Kyoto forests. If a non-Kyoto forest owner were considering converting a hectare rather than replanting, in a fully devolved system he would have to bear the liability for deforestation. This makes replanting more attractive. This does not mean that the non-Kyoto forest owner is better off or faces lower dollar costs of timber production. Essentially the liability lowers the return to the forester from conversion to agriculture and means that he will continue to produce timber even at a lower timber price. The forester's land is less valuable because it now carries a potential liability. This is a loss of asset value. This only has a real effect on his wealth if his land is of a type which he would have wanted to convert to agriculture without the liability. Land that cannot realistically be used for non-forest purposes is unaffected. The non-Kyoto forest owner loses some wealth because he bears the potential liability but gains no credit. These are equity issues that need to be considered in allocation of credits for historical action or some other form of compensation, to make the policy fair and acceptable.

If a Kyoto forest owner is thinking of converting a hectare away from forestry after harvesting, he will take into account the credits he would have received as the forest grew back. These lost credits are roughly equal to the deforestation liability, so in the same way as for non-Kyoto forest owners, they make replanting more profitable relative to agriculture. For both, this lowers the cost of continuing forestry relative to other options. The land is more valuable in forestry than in other uses.

This increased incentive to produce standing timber does not mean that processed timber costs fall with comprehensive climate regulation—overall effects on costs are indeterminate because the lower supply cost of timber will be offset to an unknown extent by a rise in cost of the fossil-fuel energy use involved in transportation and processing.

7.2 Direct interventions by government

It is unlikely that government can send an effective price signal to efficiently reward sequestration and deter deforestation if it maintains control of all credit revenue. Nevertheless, there are some "central control" policy options available to the government that do not entail devolving incentives directly to foresters.

The government can influence sequestration by, for example, improving infrastructure, providing information to facilitate forestry, or adjusting the tax regime.[70] Central government could strengthen incentives or provide resources for local government to improve planning and consent performance, and use policy statements or plans under the RMA to influence local land use towards forestry where appropriate. Some of these may be relatively crude poorly targeted instruments. Much of their effect may be to simply improve returns on existing forestry investments without any behavioural change. This general policy domain is where FIFA is pitched. Some of those policies—for example those oriented more towards wood processing—may not be the most cost-effective means of optimising planting. They may act more as a mechanism for compensation/gain sharing in the context of the government claiming the vast majority of the carbon sequestration credits. They should be assessed as such.

If existing problems limit the forest-growing sector now, policies that address these problems could increase simple economic efficiency while also having carbon sequestration benefits. Policies to address non-carbon-related issues are likely to be those discussed above. Using them for carbon as well would simply be expanding their use beyond the otherwise optimal level. How effective this would be in inducing sequestration is a key question.

[70] One possibility, for example, is to make immature forest acquisition deductible, like planting.

7.2.1 Public infrastructure: Roads, ports

Road transport costs have a significant influence on planting decisions. Aside from privately financed forestry roads, investment in relevant roads is largely the responsibility of local government, and appropriately so, as the benefits accrue mainly locally. National benefits flowing from regional development and services to downstream industries not in the area also justify a central government contribution. A similar argument applies to ports, which in some cases are substitutes for roads (although in most cases they are complementary). Moreover, benefits accrue not just to forestry investors but also to the wider community, including farmers and other rural producers and town populations. The critical policy question is the optimal level, location and timing of road and port investment, taking into account the overall benefit to New Zealand from enhanced carbon sequestration and the need to signal to forestry investors that planting decisions will be complemented by appropriately timed and located future investment in roads. The desire to encourage carbon sequestration might lead to slightly faster or more extensive road and port development.

7.2.2 Information

The discussion in Section 4.2 noted a fairly common pattern in New Zealand in which forestry takes time to "catch on" among farmers and investors in some areas. This suggests both that social patterns, such as farmer age and social/aesthetic preferences, are significant in influencing the spread of forestry, and also that there may sometimes be an information gap—a lack of local models and information sources—in some localities. This might justify coordinated provision of information on the costs and benefits of forestry simply to reach optimal levels of forest in the absence of carbon policy. This could be of value even without devolved credits.

If credits are devolved, provision of high quality information to landowners about carbon sequestration calculation, possible future returns from carbon credits (beyond 2012), the range of land-use choices that can increase carbon sequestration, land capability, climatic variability, etc. may complement the incentives provided by credit devolution. There is a case for such information provision to be funded by central government and provided through regional councils or commercial providers. Examples of government supported commercial provision of this sort of information have emerged recently, e.g. Topoclimate-South.

An expansion in forest planting also increases the demand for people with the skills associated with planting, managing and harvesting forestry. Government has an important role here as the major education provider.

7.2.3 Regulatory barriers—e.g. RMA

Local authorities will always have to take into account distinctive local environmental and other conditions in their policies, plans and resource consent decisions. Unnecessary local variation in policies and practice under the RMA may, however, be minimised by better coordination and information sharing. Timeliness of decision-making is also an issue that needs to be addressed. Local authority staff may need better training. Stronger, more consistent performance of local authorities is likely to require encouragement and resources from central government. More consistent approaches and performance across local authorities are likely to most assist corporates operating in a number of regions and districts, and is less likely to be important to farm forestry investors.

8 Design and policy evaluation issues for devolved policies

8.1 Compliance costs: Monitoring

Administrative compliance costs are a key issue in policy design. Monitoring both land use and carbon and tracking large numbers of agents could be costly both to government and the agents themselves. Many small landowners are likely to have an aversion to dealing with government agencies concerning issues of land use and may fear a "slippery slope" of compliance requirements if they engage with government. They fear that any benefits they gain from a policy may be swamped by the administrative costs of compliance.

There will be tradeoffs between accuracy in assessing sequestered carbon with comprehensive coverage on the one hand and costs of administering the regulation on the other. Strategic choice of the point of assessment, use of existing information (such as forest inventories), use of models, and voluntary participation of small players could reduce administrative/compliance costs with relatively small efficiency costs. Given perceptions among some landowners, limiting engagement to a voluntary basis may also be the only feasible course in the short term.

8.1.1 How accurate should monitoring be?

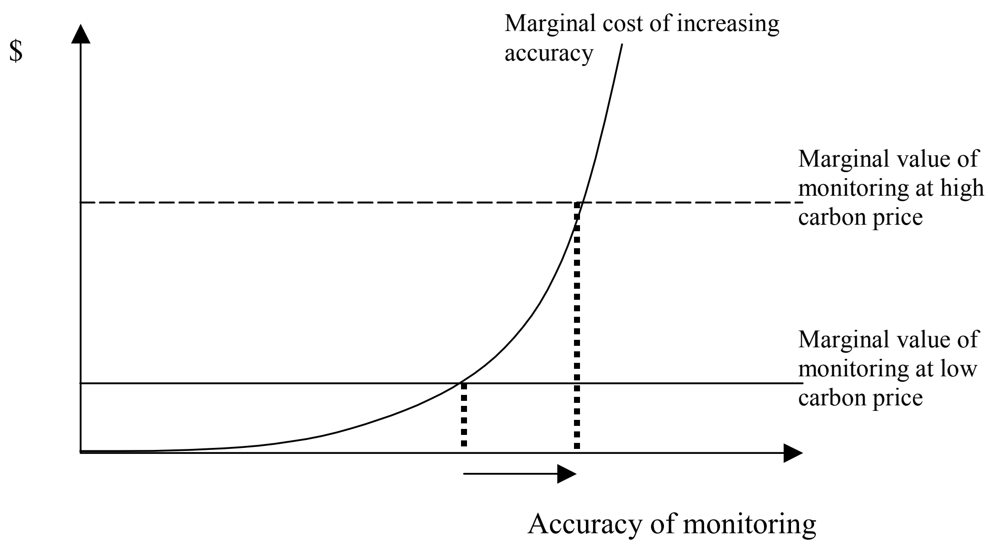
The basis for environmental integrity is accurate measurement of the carbon stored or added to sinks. Monitoring is a requirement of credit creation and maintenance because otherwise compliance cannot be established. Because sinks can be destroyed, monitoring must be ongoing, though it need not be frequent. As long as no carbon release occurs and monitoring continues, the credits would remain valid.

At a global scale what is important is that measurement is unbiased so that the amount credited globally is accurate. Large errors in specific places are not important as long as they go in both directions and do not lead to global bias and too many (or too few) credits being created. Overall bias will lead atmospheric concentrations to be different from those envisaged in the Kyoto agreement.

Ensuring fairness across countries requires more accurate measurement so that each country's total sink credits accurately reflect the real sinks created. Again, as long as the national total is accurate, it does not matter to other countries if the methodology used to generate this is not accurate for each specific area within a particular country. Current inventory methodologies are designed in this way. Errors are made but they average out over large areas so the national total is reasonably accurate. These inventories are currently taken using a combination of remotely sensed and aerial imagery, plot sampling, and models of carbon accumulation with limited differentiation of carbon storage across space.

The problem becomes more challenging if we want to measure carbon more accurately at a local level. Simply put, the smaller the area where we require accuracy, the more costly and difficult it is. The gains from accurate measurement are obvious: more equity across landowners and more accurately focused incentives to enhance carbon stocks. The costs of more accurate measurement are higher costs of monitoring and compliance. These have to be traded off against each other. When the carbon price is relatively low, the compliance costs are likely to dominate and less accurate methods are probably preferred. As carbon prices rise, more accurate methods will become worthwhile.[71]

Figure 7: More accurate monitoring is justified by a higher price on carbon



8.1.2 Who monitors and how?

One monitoring option, the lowest-cost one, would be for government to combine remotely-sensed maps of land use and cadastral maps of property boundaries to determine changes in land use and then use their carbon models, based on a random sample of audited sites, to estimate net carbon sequestration. This would be consistent with national-level reporting, and would be relatively unbiased. The disadvantage would be that it would be quite inaccurate, particularly for small areas and areas with unusual sequestration patterns (e.g. if the land is extremely fertile or the landowner has enhanced the forest).

[71] In Figure 7 we define accuracy as the reduction of social costs from errors, so accuracy's marginal value is constant.

A way to address this would be to allow landowners to choose to have their carbon levels audited if they think it will provide a higher payment. They could then trade off the cost of the audit against the value of extra payments. Accepting audited estimates from landowners would, however, create a bias in total carbon credits claimed nationally because only those who have higher than average modelled sequestration would opt to provide alternative figures. Those with lower than average sequestration would stay silent. Therefore, those who opted to provide their own estimates would always claim more credits than the government would have given them. The average credits provided on all other land may need to be adjusted downward to keep the domestic total and the internationally reported totals consistent. Land where landowners did not opt to provide their own carbon sequestration numbers will tend to be lower carbon producing land, but might also include small land parcels. Owners of small parcels will not choose to provide alternative figures because the cost would outweigh any gains. Thus this system would create some inequity for such small parcel owners.

A second monitoring option would be for landowners to report their own changes in land use. This could be randomly audited with remote sensing or ground-truthing. If the total were inconsistent with the national-level reporting, adjustments could be made to all domestic credits (e.g. increasing or decreasing the quantity to account for bias). These reports of land-use change could be translated into sequestration using government models, or landowners could pay for more accurate, certified audits if they chose.

8.1.3 Point of assessment

The "point of assessment" to account for carbon stock changes (sequestration or emissions associated with harvesting) could be either the land user (forest owner) or the landowner. The appropriate choice may well be different for indigenous forest (not covered here) than for plantation forest and may vary by block size. As far as possible it is desirable that the assessment includes those people/legal entities that jointly cover all sequestration and deforestation (i.e. all forest and potential forest) in New Zealand and can influence sequestration on the land, either directly or through contracts with the land user.

At the same time it will be important to minimise the number of agents required to report, and choose those who can report with least cost (possibly because they already collect inventory information).

The current land user (e.g. a forest concession holder, or "forest owner") usually has substantive control of land-use choices in the short run, but it may be difficult to track users through time as contracts change. They may also have limited long-term control of the land or their control may be contractually limited to a finite period of land use. Landowners have control of land use in the long term as their existing contracts with land users roll over.

Wherever the point of assessment is placed, positive carbon price signals encouraging more planting and more use of sustainably harvested wood will be passed up and down the supply chain. This may be hindered by high transaction costs in some cases. A more comprehensive system with a greater percentage of the assessment obligation placed on those who control land use will lead to more efficient price signals.[72] Because of the long-term nature of forestry, liability of deforestation depends on past actions and contracts. The choice of the point of assessment could have significant distributional effects.

8.1.4 Reporting costs and cash flow

There may be a trade-off between cash flow and reporting costs. Any sink credits need to be verified at regular intervals, but these intervals need not be short. Verification could involve varying degrees of accuracy. It may be that only the existence of the forest is monitored in some periods, rather than auditing the carbon content of those forests. For example, it may be adequate to verify initial establishment of a block and then only monitor in 5 and 15 years time, and verify the time of harvest if it is claimed to be surprisingly late. The need to monitor between planting and harvest depends on the incentives for early harvest—for some forests there may be strong commercial reasons not to harvest before the trees mature.

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[72] This can be compared with the case of fossil CO_2 emissions where many potential alternative points of assessment/obligation are available: fossil fuel importers and producers, large energy users, consumers of energy-intensive products, or consumers of retail gasoline. This is because fossil-fuel use is a near-perfect proxy for CO_2 emissions.

It is also not necessary that monitoring occur every time a payment is made. Land users could be asked to report only if their level of forest falls between periods of formal monitoring. Payments could then be based on previous information combined with these self-reports. This would minimise compliance costs while putting a small amount of enforcement risk on government.

8.2 Liability

Either the government or the land user can bear the liability for deforestation. If the government bears the liability, the government is essentially "renting" the credits from the landowner and must give them back when the land is cleared (the land user then uses the returned credits to meet the liability).[73] As in any rental contract, the price paid will be a fraction of the capital value of the credits (e.g. as with a residential rental). The value the government should pay the landowner and hence land user depends on how the government thinks their liability for repayment is changing over time. (To continue the residential rental analogy it is as though when they stop renting they are forced to buy.) If they expect that carbon credit prices will fall in future, the government will be willing to pay a higher rental because they think the extra liability they are taking on is smaller. If in contrast they think credit prices might rise, they will want to pay a low rental and may simply prefer to back out of the contract and its associated payments unless the land user is willing to bear or share the liability.

Landowners may want to retain the ability to change their mind about their land use. A permanent commitment to a carbon sink/reservoir is a severe land-use limitation: forever is a long time. If crop prices or technology changes so that profitable alternative land-use options emerge, or if the cultural values of successive owners have a different emphasis, the landowner might desire to change the land use. They may want this to be possible without breaching a contract or making a large cash payment.

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[73] For discussion of the value of different contract forms see Kerr (2003).

There are also issues about trust. If the government is unable to commit to a long-term policy, land users might fear that they will be held liable for deforestation in the long term even if that were not in the current agreement. They may also fear that the government will stop making or reduce payments when they have already committed to a project and are unable to back out. These perceptions of regulatory risk would affect the optimal policy design.

A credit in the form of a tax break aimed at land users who sequester carbon is unlikely to impose any liability on the land user. Thus it is similar to a rental payment. The levels of payment to the land user should therefore be similar to the rental payments. A tax policy may also create different perceptions about the stability of government policies. It is an instrument that governments have, in recent years at least, been cautious about using or varying, so this might create a more positive perception. It is not clear that it would reduce the probability that the government would decide to impose liability at a later date, however.

8.2.1 Cash flow and liability

Different policies have different cash flow implications for land users and also impose different risks. Carbon sequestration is inherently risky because it is reversible. Liability for deforestation imposes risk because carbon prices and returns to competing non-forest land uses are uncertain and affect both the probability of incurring the liability and the cost of it if it is incurred. Even while making policy consistent with New Zealand's international commitments (i.e. rewarding only for net sequestration within each commitment period) there are options for meeting different concerns about cash flow and allocation of the risks and costs that arise from liability for deforestation.

A series of policies have the same overall present value if both land user and government have the same concerns about the timing of cash flow (i.e. same discount rate) and about risk. When these conditions do not hold, the policy choice is critical. Essentially there are tradeoffs between the level of cash flow to land users and both the risk they bear and the overall expected value of the carbon rewards on a given piece of land.

8.2.2 Timing of payments, risk bearing and liability

In any policy, the earlier the payments are made, the lower the total nominal value of the payments should be. The land user prefers to have their money up front. The government prefers not make payments earlier. If the land user has a higher discount rate than government, however, it might be better overall for the land user to get the money early and accept that in exchange the total nominal amount the government has to pay out is lower.

A policy where payments up front are greater than the value of credits already created can lead to an enforcement issue. If government pays for credits and they are not created, they have to get money or credits back from the land user. Enforcement relies on deterrence and legal action. In contrast, if payments occur only as carbon is sequestered and monitored, enforcement is largely by prevention—no payments occur if no carbon is sequestered. Liability would still need to be enforced if the land user bears it. A rental contract imposes the most liability risk on the government but avoids nearly all enforcement problems.

The contract form chosen has implications for the risks land users and government bear. The "rental" policy imposes all the deforestation liability risk on the government. The government will need to be compensated by having to make lower payments overall.

If government chooses to bear all the liability, they can charge for this risk bearing only on the basis of observable characteristics. Some land users might feel that because they can control the deforestation liability to a certain extent, for example because they have cultural or personal environmental reasons for protecting forest more than others, they prefer a higher payment in exchange for bearing liability. Unfortunately if two contracts were offered—one in which government bears the liability and one where the landowner bears it—the highest risk landowners would choose the first contract and the government might be left with only the risky part of the portfolio. This would have to be anticipated and would affect the generosity of the contract they could offer.

8.3 Effects of making participation voluntary

One option to reduce monitoring costs and avoid the risk that some participants in the programme lose would be to make the system voluntary or, alternatively, make it compulsory for large landowners or land users but voluntary for smaller ones. Government would maintain the residual rights and obligations. This approach is commonly used in pollution control where there are some large sources and then a large number of very small sources. Rules are set for opt-in to the system. Landowners or land users who choose to include their pieces of land would need to meet monitoring requirements. They would be able to claim credits and would also be liable for emissions from deforestation.

A baseline level of storage and sequestration would need to be established—this could be as simple as the levels of carbon in existing forests (possibly proxied for by the age class and planting density) and the area of forest at a given date. Baseline deforestation liability would either need to be generous enough (e.g. not hold them fully liable for harvesting/deforestation of existing forest) that it does not deter entry, or compulsory on all landowners or land users so that it did not affect the economics of their choice about whether to participate in the credit programme.[74]

If involvement in the domestic program was voluntary and monitoring stopped on a piece of land for any reason, for example the carbon price dropped and the sequestration wasn't worth continuing, the buyer would have to pay all net accrued credits back because their permanence could not be guaranteed.

8.3.1 Bias in outcomes

Voluntary participation by small players reduces compliance costs and encourages broadening of the system but also creates bias because opting in is a strategic act. Those who opt in will tend to be those who expect to gain from the system.[75] For example, people who know they have already done actions that will lead to sequestration that goes beyond their baseline will want to participate to

[74] The programme must ensure that there are no incentives to clear existing forest and plant new forest to claim credits. This is discussed below under in Section 8.3.2..

[75] Opt-in was allowed in the US Acid Rain program for controlling SO_2 emissions from electric utilities. Montero (1999) discusses the effect this had on environmental outcomes.

gain this windfall. If the monitoring system is simple, for example gives the same carbon credits per hectare on good and poor land even though the good land really yields more, a farmer on poor land is more likely to opt in than a farmer on good land because the agricultural returns on the poor land are artificially low relative to the carbon return. Thus the sequestration that is rewarded is likely to be greater than the actual additional sequestration. This is a risk for government, as it still needs to meet its national targets.

A system that allows opt-out creates additional complexity. Allowing opt-out can exacerbate the bias problem, particularly if land users can anticipate whether they will benefit from staying in. They might simply opt in for years where it is advantageous and opt out for bad years.

8.3.2 Leakage

Leakage arises when sequestration in one project is offset by increased deforestation in another area that is not included in the programme. If, for example, there was a fixed amount of investment for forest planting in New Zealand and there were rewards for planting new areas but no liability for deforestation, some resources would be redirected from replanting on existing forest area toward planting new forests. Deforestation liabilities are much higher than the new sequestration on new forests because almost the entire carbon stock is lost in one period with deforestation, while growth happens gradually. If land users are offered credits for new forests but face no liability for existing forests, leakage could be extremely costly. In the extreme, negative additional sequestration would result and the government would simply be giving away resources.

The only way to avoid leakage completely is to have a comprehensive compulsory system (or no system at all). The likely scale of leakage depends partly on the elasticity of forestry investment. To what extent would a credit system for new planting lead to higher overall levels of forestry investment? It also depends on how easily new land can be substituted for existing forest land. Will investment in new forests crowd out investment in replanting? These are partly empirical questions. Some types of land might be more responsive than others, as might be some types of investors.

8.4 Risks arising from economic factors

The economic risks in a devolved carbon sequestration system have two sources: the returns for any carbon credits earned and the costs of creating and maintaining the resource that earns the credit. On the return side, the carbon price, the possibility of price differentiation, and risks around whether the Kyoto Protocol will come into force are key sources of uncertainty. Current price estimates range anywhere from NZ$0.55 per tonne of CO_2 to over NZ$55 for the first commitment period (with recent prices appearing to gravitate to around NZ$10).[76] These prices affect the value of sink credits directly. Interest rates and expectations about changes in prices affect the value now of future carbon credits, or promissory notes for credits. This uncertainty is likely to fall gradually as 2008 comes closer and more dramatically after 2008, when a real market is operating.

There is some risk of price differentiation among carbon units, to the disadvantage of RMUs. The Marrakesh accords state that all RMUs from LUCF activities are in principle fully fungible (exchangeable) with ERUs from Joint Implementation projects, CERs from the Clean Development Mechanism, and AAUs, all being measured in terms of tonnes of CO_2-equivalent. But already, RMUs are distinguished from other units by not being "bankable",[77] and it is possible that European countries will discriminate against RMUs in their emission unit purchasing preferences and even the rules for their trading programme.

On the cost side, the largest cost is often that relating to the use of the land itself. If there is no viable alternative land use, the economic cost of using the land is zero. If some new opportunity arises, however, or the profitability of existing alternatives rises, the project cost rises correspondingly. This is a key source of economic uncertainty. From a risk viewpoint, the issue is the landowner's possible future desire to change the use of land away from forestry after harvest, in which case the landowner may face a deforestation liability.

Luckily the liability risk and the risk that people will desire to change land use because of carbon price changes are likely to be negatively correlated, so

[76] "Landfill gas scheme wins carbon credits" (2004).
[77] Page (2002), p. 5.

the overall risk is less than it appears at first sight as long as land users have the ability to deforest and either stop receiving credit (a "rental" contract) or pay the deforestation liability. If the land user wants to change land use because returns to alternative uses have risen or returns to forestry have fallen, they may bear a higher liability if credit prices happen to be high. If credit prices are too high, the land user will choose not to make the change. If the return to the alternative use is very high, the liability may not seem so important. Land users will be least likely to clear their land and therefore have make payments for deforestation liability at the time when those payments would be very high.

When credit prices are low, and hence the return to maintaining the forest is low relative to the return to other uses, so land users want to change land use, liability is also low and land users face relatively little penalty.

In the case where forestry returns fall, if the land is not valuable for other uses, there is no liability; even if forestry activities cease, indigenous reversion is likely to occur, so there is no "deforestation". If, however, forestry has become very unprofitable and reversion to pasture is just possible, the liability might seem an extra burden in an already bad situation.

A contract that requires permanent storage in a fixed piece of forest imposes more risk on land users because it restricts their responses to economic conditions. They risk losing valuable alternative returns.

8.5 Baseline—i.e. what are rewards provided relative to?

The international rules set one baseline—all credits from post-1990 forests belong to New Zealand. All liability from deforestation is borne by New Zealand. The domestic baseline does not need to be the same. The internal allocation of credits within New Zealand has no environmental impact—total international credits and hence total net emissions will be the same however they are allocated domestically.

Figure 8: Baseline efficiency and equity tradeoffs

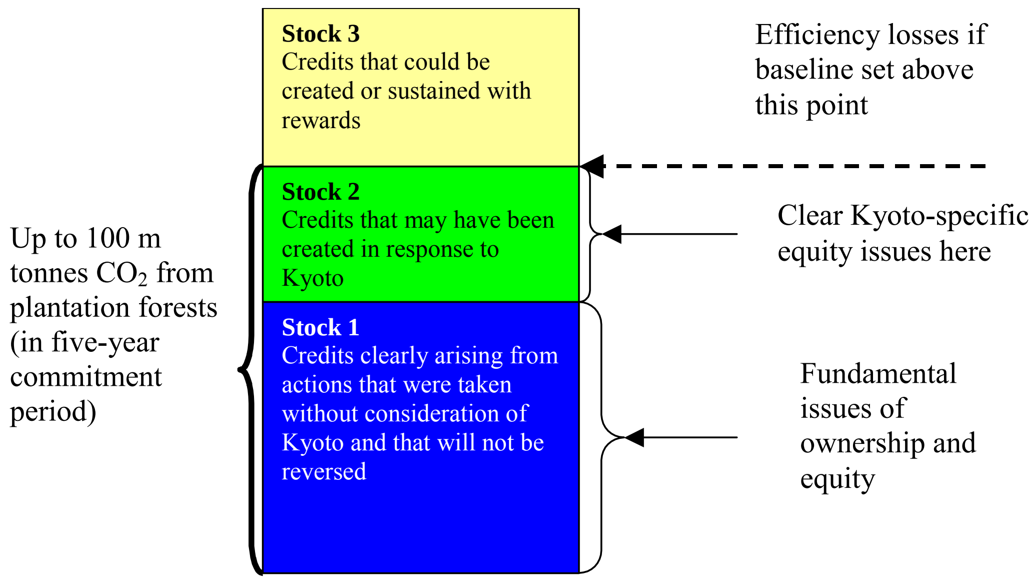

Figure 8 breaks the total amount of carbon credits into three stocks. The total of stocks 1 and 2 is estimated at around 100m tonnes CO_2. Within the lowest stock, Stock 1, the issue is simply about who should benefit from this windfall gain to New Zealand. We do not discuss this here. Within Stock 2, the equity issues are complex because landowners may have planted forest in response to expectations about Kyoto and might feel they have a strong argument for being rewarded even though there are no direct incentive effects from allocating credits to them. For Stock 3 there are clear efficiency arguments. Against both equity and efficiency criteria, Stock 3 credits should belong to those who control the land. The greatest challenge is to identify where the line falls between Stocks 2 and 3. We discuss the issues relating to ownership of Stocks 2 and 3 below.

8.6 Stock 2—rewards for early action

Some landowners and forest owners might have in good faith invested in forests with the idea that they will contribute not only profit but also carbon sequestration, which will have environmental benefits. This was relatively unlikely in 1990 but became more likely in more recent years. It is hard to separate Stocks 1 and 2, but errors have primarily distributional implications. If the government wants to reward this essentially altruistic (or optimistic) behaviour to encourage these people to do more in future, it could find it compelling to give them some share of credits even if that share is based on historical activities. There are no direct efficiency effects here. There may be indirect incentive effects through building trust that government will at lease partially reward those who create benefit for New Zealand.

8.7 Stock 3—ownership of "additional" carbon credits.

Even if government were to claim ownership for Stocks 1 and 2, this does not mean that they should claim all credits. In particular, if land or forest owners create additional forests they should be rewarded for this by receiving any extra credits. The regulation should be designed to reward any activities that sequester carbon and that would not have happened otherwise. We would expect that with this regulatory system more forests would be planted. Ownership of these credits is an efficiency issue central to regulatory design.

The real gain for New Zealand from here on will come if land and forest owners plant and protect more forest than they would have without Kyoto. Forest areas may be expanding anyway but if they expand even more because of appropriate incentives, that will bring extra gains to New Zealand. The additional gain to New Zealand only comes from landowners and forest owners doing things from now to 2012 (and possibly into later commitment periods) that they wouldn't have done otherwise. The ideal system would ensure that the person making decisions about forestry faces the same reward (incentive) as New Zealand as a whole.

If the government is to claim Stocks 1 and 2, it must face the difficult problem of setting a baseline that will encourage additional carbon sequestration but not reward sequestration that would have happened anyway. If the baseline is set too low, land and/or forest owners will receive a windfall and be rewarded for actions they have already taken and the government loses potential revenue.

In contrast, if the baseline is set too high, people could actively protect and regenerate forest and receive no reward. This would decrease their incentive to do so and demotivate those acting from a mixture of good will and self interest. An opportunity for an efficient reduction in greenhouse gas concentrations would be lost.

With plantation forests, once they are planted they are unlikely to be harvested before maturity, so we can predict sequestration between 2008 and 2012 fairly accurately. New forests planted between now and 2012 will have a low sequestration rate during the period—so new forests will not be large contributors. A baseline where forests planted after 2000 (as opposed to 1990) are rewarded would be one approximation to a baseline that only rewards additional sequestration. It would create relatively small windfall gains and be unlikely to lead to any perverse incentive problems. As long as forests planted in the 1990s never face a liability greater than the credits they receive during the commitment period, owners will have no perverse incentive to harvest before 2008. As this is guaranteed at the international level, it should be incorporated in a domestic system as well.

In no case does the setting of the domestic baseline affect international greenhouse gas environmental integrity. The international rules that define the carbon credits New Zealand receives are fixed. On the other hand, if New Zealand adopts policies that are seen to effectively increase sequestration in line with the intent of the UNFCCC, this will enhance New Zealand's reputation and bargaining position for the second commitment period.

9 Key empirical issues raised

This paper has summarised the current state of policy and the forestry industry. It has also canvassed the range of policy questions that must be addressed to design an effective carbon sequestration policy for plantation forests. It has deliberately not provided even a straw man for a potential policy. Instead it has identified a number of key areas where we need more information before we can make well-informed choices about policy design. Some of these choices involve political judgements (e.g. the appropriate allocation of credits for historical action). Some choices will be affected by our existing institutions or scientific knowledge (e.g. monitoring and allowing for voluntary participation of some groups). Another group of choices is of particular interest to Motu because policy makers need empirical information on economic factors and human behaviour to make good choices. The following questions are central:

1. Who owns New Zealand forests and the land under them?

2. How much new forest has been planted since 1990, who planted it and who owns it?

3. How much new forest is likely to be planted without incentives?

4. How much would price incentives affect forest planting?

5. How large are New Zealand's deforestation liabilities likely to be?

6. Who is likely to deforest existing forest? Why? How might they be influenced by price incentives?

7. How will policies affecting the forest processing sector influence plantations?

8. What non-price factors drive new planting and responses to incentives? How important are these, and where are they most important?

9. What social effects is any potential policy likely to have?

10. What non-climate environmental effects is any policy likely to have?

11. How can price-based policies be designed most effectively?

12. How can price-based policies be effectively complemented by non-price policies?

This paper has been a first step in clarifying the questions and providing basic information to start answering them. Motu and others, particularly Landcare Research and Forest Research, have ongoing research programmes to address these questions. See

- www.motu.org.nz/land_use_nz.htm
- www.landcareresearch.co.nz/research/greenhouse/index_800x600.asp
- "climate change and energy" under research at www.forestresearch.cri.nz.

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Acronyms

Acronym	Page first mentioned	Definition from text—note missing definitions, changes, and corrections (definition must *always* precede first use of acronym). Example: Human resources (HR)
AAU	13	Assigned amount unit
CDM	13	Clean Development Mechanism
CER	13	Certified emission reduction
ERU	13	Emission reduction unit
FIFA	14	Forestry Industry Framework Agreement
FSC	27	Forest Stewardship Council
LUCF	13	Land-use change and forestry
MAF	21	Ministry of Agriculture and Forestry
NEFD	19	National Exotic Forest Description
NGA	15	Negotiated Greenhouse Agreement
RMA	17	Resource Management Act
RMU	13	Removal unit
UNFCCC	9	United Nations Framework Convention on Climate Change

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