Achieving multiple regional goals with Carbon Forestry

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REPORT INFORMATION SHEET

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EXECUTIVE SUMMARY

The recently established NZ Emissions Trading Scheme (ETS), the Permanent Forests Sinks Initiative (PFSI) and the Afforestation Grants Scheme (AGS) are initiatives by government to mitigate green house gas emissions, encourage tree planting, and enable carbon trading. The right to secure and trade carbon credits from tree crops is a new revenue opportunity for land owners. Environment Waikato has taken the initiative to propose a regional carbon strategy that could support positive land use change and achieve a number of important economic and environmental goals.

Scion (a Crown Research Institute) and its collaborators (AgResearch and Hardwood Management Ltd) have been contracted by Environment Waikato (EW) to provide research results and knowledge that assists with the advancement of a regional carbon strategy. This work has been partitioned into the following sections; the opportunity, investment structures, and regional coordination.

1. a. The opportunity to the land owner:
   The value of the carbon forestry opportunity to land owners is likely to be specific to the owner's personal circumstances and priorities, eg livestock carrying capacity of the land and importance current cash flow.
   Several economic case studies that examine the benefits of carbon forestry indicate that the opportunity to sell carbon units (@ \$20/t CO_2 e) from forest plantations substantially improves the profitability of forestry and that positive cash returns (after 5 yrs) of over \$500/ha/yr are predicted with fast growing plantations of exotic species. However the circumstances in which this proposition is attractive is very dependent on the level of agricultural revenues foregone and the objectives of the land owner. Generally, dairy farming is much more profitable than carbon forestry and poorer land will be sought by these land owners if they wish to offset their emissions liabilities. For better sheep and beef farms, carbon prices will need to exceed \$ 20/t for carbon forestry to be more profitable than livestock production. For poorer classes of (marginal) land, particularly eroding or reverting hill country, carbon forestry offers a significant improvement in financial returns.

   b. The opportunity to Environment Waikato:
   The regional council has the opportunity to achieve multiple goals with regard to land use economics and the environmental outcomes. In addition to regional economic gains from carbon farming, , research results show that a number of environmental parameters will be improved. These are primarily; a reduction in green house gas (from sequestration of carbon dioxide), stabilisation of eroding mudstone hill country, water quality enhancement in streams and rivers by sediment reduction and nutrient reductions, and an improvement in biodiversity by providing an enhanced environment for many endangered native species of flora and fauna.

2. The investment structures for carbon forestry:
   Results from surveys of farmer perceptions of carbon forestry indicate considerable communication and education is required to succeed with a carbon forestry strategy. Farmer's attitudes to land use change are risk adverse and will take considerable facilitation to change. Numerous existing structures and incentives for tree planting are reviewed and contrasted. Most successful examples have justified the involvement of government assistance to achieve off-site environmental benefits to the nation or mitigate future remedial costs borne by the tax payer. It is recommended that

Environment Waikato take a similar role and offer financial inducements and facilitation services to ensure the carbon strategy has an impact on a regional scale.

Environment Waikato may follow the example of a business relationship of emitter/investor/land owner now in place on the west side of Lake Taupo, using Forestry Right legislation and sharing the carbon revenues.

Using its experience of the Afforestation Grants Scheme (AGS) Environment Waikato could also implement regional version of this scheme, funded from investments. There may be an element of public good in this, to further protect downstream values and hence a lower economic hurdle rate sought. In certain locations and topography there may be opportunity to consider timber harvest in the future and wood supply contracts with some of the major forest companies and fibre consumers.

The specific nature of the investment structure and incentives may best be tailored to the class of land and owners circumstances.

3. Regional Coordination and facilitation:
   Farmers have indicated they would only consider the least productive parts of a farm for carbon forestry. Facilitating the identification of these areas and the clear determination of costs and returns could be a key role for Environment Waikato. Further economic case studies, specific to the Waikato are recommended.

   Support with financial planning and investing in grant schemes seems warranted when many environmental benefits are examined. Carbon forestry is likely to bring most of the benefits of indigenous forests and communicating a better understanding of these benefits to regional rate payers would be beneficial.

The overall conclusions of this work are that the economic benefits of carbon forestry are generally very positive but can become confusing depending on the approach taken in the economic evaluation and personal circumstances of the land owner. Riparian planting along streams and rivers in intensively farmed areas, could comply with the ETS if they join woodlots of more than one hectare. Environmental benefits of this would be well aligned with the goals of the Waikato River Treaty Settlement. For the poorer steep land classes that have erosion and scrub reversion issues, this initiative is likely to be attractive and beneficial to the land owners long term sustainability. Also, those seeking improved cash flows and diversification from traditional markets may welcome a supported scheme where carbon units are stored or traded when needed to smooth out cash flows or service short term demand.

Achieving multiple regional goals with Carbon Forestry

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25 January 2010

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Introduction

The recent establishment of the NZ Emissions Trading Scheme (ETS), Afforestation Grants Scheme (AGS) and Permanent Forests Sinks Initiative (PFSI) are Government initiatives to mitigate green house gas emissions, encourage tree planting, and enable carbon trading. The opportunity to secure and trade carbon credits from tree crops is new and can potentially change land use in the Waikato region.

Environment Waikato has taken the initiative to propose a regional carbon strategy that could support positive land use change using carbon credits from forestry as a new income for landowners.

To better understand the impacts of the carbon strategy and make suggestions on its implementation Environment Waikato engaged Scion and its partners to undertake research in three major areas, namely:

1. the opportunity – the economic case for land owners to invest in tree planting for carbon and other environmental benefits;
2. investment structures – compare investment mechanisms for land owners to consider carbon forestry; and
3. regional coordination – support requirements for carbon forestry investors on a regional basis.

Waikato Environment and Economy

The Environment Waikato (EW) Region stretches from Coromandel Peninsula in the north to the slopes of Tongariro National Park and the Kaimanawa Ranges in the south (Figure 1). It includes New Zealand's largest lake (Taupo) and longest river (Waikato). Before human settlement, much of the land area was forested. Today, while 28% of the land area is in native vegetation[1], most of the lowland forests and wetlands have been converted to pasture (58% of region). There are also sizeable areas of plantation forest, some 12% of the region.

The largest industries contributing towards GDP in the Waikato region in 2006/07 were dairy farming, business services, real estate, and construction[2]. In addition, the non-monetary values of services provided by natural resources within the region have been estimated. The total value of ecosystem services was estimated in 1997 to be about the same level as regional GDP in 1997 (Patterson and Cole, 1998). Services provided by the five key regional ecosystems are indicated in Table 1.

[1] http://www.ew.govt.nz/Environmental-information/About-the-Waikato-region/Our-natural-environment/

[2] http://www.ew.govt.nz/Environmental-information/About-the-Waikato-region/Our-economy/The-hidden-economy/

Table 1: Ecosystem types and their services

Ecosystem type	Ecosystems services
Lakes and Rivers	Hydrological cycles, flow regulation and flood control, water supply, recreation and food.
Forests	Climate and erosion control, nutrient cycling, waste treatment, raw material production and carbon storage.
Agricultural/Horticultural	Commercial food production, erosion control, soil formation, waste treatment, nutrient cycling and pollination.
Freshwater Wetlands	Storm protection, flood control, habitat, nutrient recycling and waste treatment.
Estuarine	Spawning and nursery grounds for many species, habitat, waste treatment and nutrient cycling.

The multiple environmental benefits of forests are of particular interest. Soil conservation on erodible hill country and lake and river water quality are key issues within the region. The retention and expansion of forests will have a positive impact on both. Markets have now been established for two of these services - nitrogen trading for water quality and carbon trading for climate change mitigation.

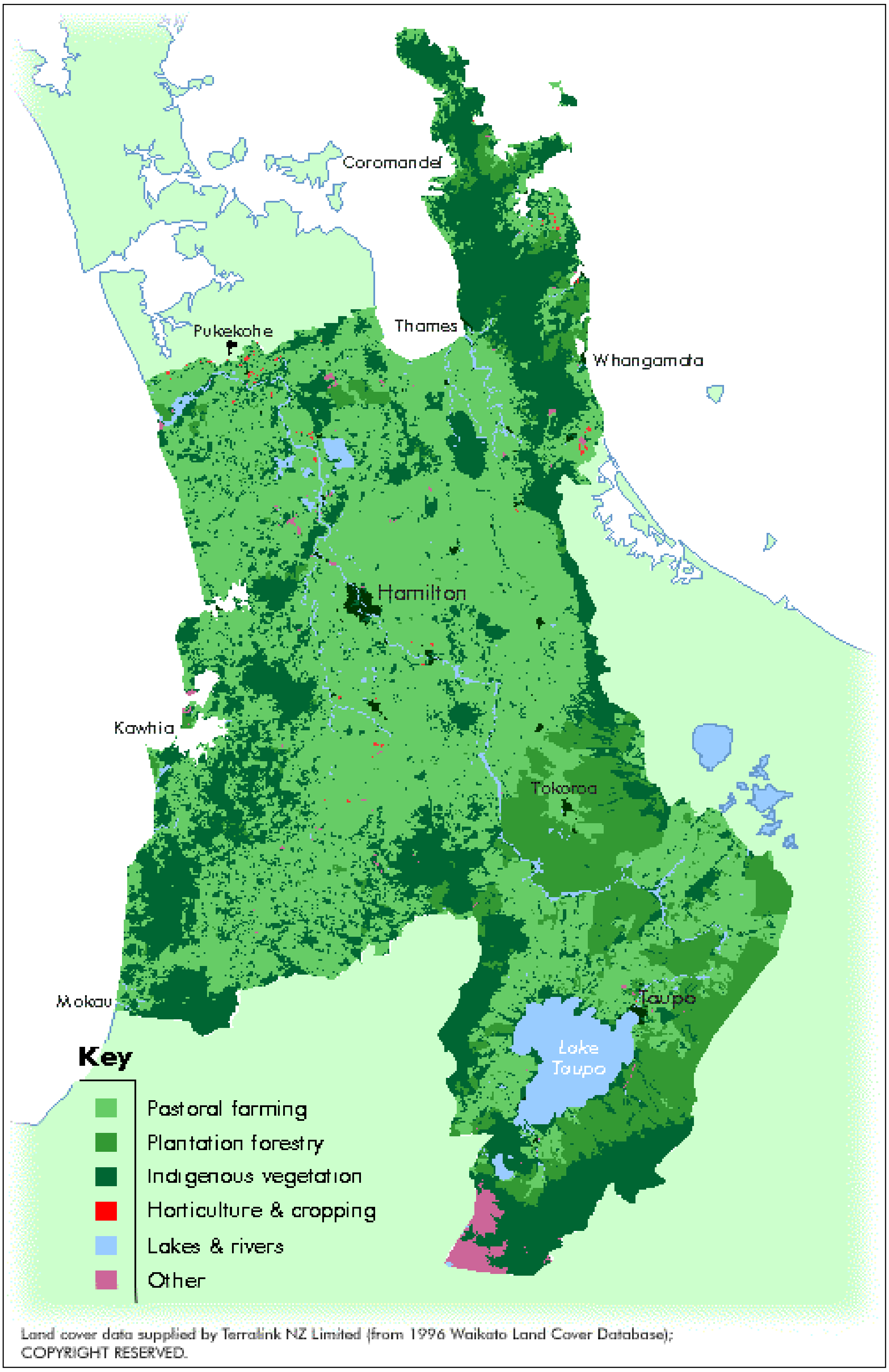

Figure 1: Environment Waikato Region.

http://www.ew.govt.nz/environmental-information/Land-and-soil/Land-use-in-the-Waikato/Regional-land-use/

Forestry

The economic and environmental benefits of forestry as a land use are well established in New Zealand and supported by 60 years of research at Crown Research Institute, Scion - formerly Forest Research Institute. The environmental benefits of a plantation forest are essentially the same as the benefits that can be derived from a natural forest, (Dyck, 2003). A comprehensive review of the environmental effects of planted forests in New Zealand has been completed by Maclaren (1996). A recent update concluded that Maclaren's findings still hold, and provided results from more recent studies (Hock *et al* 2009). The specific benefits of forests are recorded as; reducing erosion (Marden *et al*., 2005), downstream sedimentation (Piegay and Salvador, 1997; Liebault and Piegay, 2001), improving water quality, improving biodiversity (Pawson *et al*., 2006), and reducing net CO_2 emissions (Dixon *et al*., 1994).

Generally, ecosystems services from forests have been taken for granted in the past but now are better understood as essential to sustaining human life. With better understanding of climate change science and the role of Green House Gas (GHG) emissions has in climate change, Environment Waikato have correctly identified that an important environmental mitigation role for regional authorities involves carbon dioxide sequestration policies.

Section 1. The Opportunity

The economic case for tree planting

The earliest plantation forests established in the Waikato Region are among the earliest anywhere in New Zealand. Large-scale planting was initially proposed in order to create a substitute timber resource for rapidly diminishing indigenous forests. Forests established by the State in the 1920's and 1930's included Kaingaroa, Maramarua, Athenree and Tairua. Kinleith forest was established by the forerunner to NZ Forest Products in the same period. The land planted was typically scrub covered or unsuitable for farming due to stock "bush sickness", later discovered to be due to cobalt deficiency. The Forest Service also established forests to contain the spread of sand dunes, including Waiuku forest in the 1930's.

From the 1960's on, further forests were established by the Forest Service with the goal of providing export timber. The Crown also entered into joint ventures with Maori land owners - the Lake Taupo and Lake Rotoaira forest Trusts leased land to the Crown for forestry purposes in the late 1960's, and the land is gradually returning to each trust as the first rotation is harvested. Private forests were established under the Forestry Encouragement Grant Scheme.

Motivation for earlier afforestation projects included non-economic goals such as regional development, employment, as well as land rehabilitation, while the second planting boom of the 1960's and 70's was geared towards the export market, and a third boom in the 1990's saw large areas of forests established by private investors. Ownership and management of plantation forests within the region has changed, with ownership in the sector now dominated by international investment funds.

The fact that investors are still willing to buy, plant and replant forests indicates that forestry is seen as a profitable land use. However, in recent years plantation forest within the region has been converted to dairy farming.

Measures of profitability

Net Present Value (NPV)
The usual method for determining the value of alternative forestry investments is through **discounted cash flow analysis**. The projected future costs and revenues generated by a project are weighted according to when they occur, under the key assumption that money in the hand today is worth more than the same sum earned in the future. The weighting is determined by the discount rate – the higher the discount rate, the greater the premium placed on short term costs and revenues. The sum of discounted cash flows over the life of the project is the **Net Present Value (NPV)**. The project with the highest NPV for a given discount rate is selected as the best option under that criterion. More generally, any project with a positive NPV is a worthwhile investment.

The **Internal Rate of Return (IRR)**
Related to NPV, the IRR is the discount rate at which NPV is zero. In general, projects with a higher IRR are favoured over those with a lower IRR, or projects which exceed a given threshold are selected. However, the IRR does not give an indication of the scale of a project, or a direct indication of the profitability in terms of dollar returns.

Land Expectation Value (LEV)
LEV is the maximum price that one can pay for land and still earn a specified rate of return for a given project. Increasing the earning threshold lowers the price at which land can be purchased without compromising profitability. LEV applies to bare land investments and is

not equivalent to market value – a property may have a much higher market value than its value for a particular project.

Analyses in the agriculture sector tend to be focussed on **Annual Cash Flow** (or **annuities**) usually called Gross Margins or Economic Farm Surplus. Wherever possible, studies reviewed in this report that use NPV, LEV, or IRR have been **converted to an annuity** to better align with the agriculture sector. However, the above concepts can still be applied. Evison (2008) compared the profitability of rural land uses using IRR as a measure (Table 2). Agricultural data was taken from MAF farm monitoring reports. Forestry was modelled as a single age class, with a national average growth rate of 24 m3/ha/year over a 30 year rotation. Land uses were compared on an equivalent basis, by assuming that the farm would be purchased at the start of the project and sold at the end for the same dollar amount. Alternative calculations were made to examine the impact of increased real land prices on the rate of return.

Table 2: Summary of Land Use results for 2007/08 (Evison 2008b)

Model	Effective area (ha)	Net Cash Income $	Working expenses $/yr	Management costs $/yr	Cash Surplus $/yr	Cash Surplus $/ha/yr	Capital value ($/ha)	IRR (%)
Dairy (National average)	126	1,021,886	468,449	83,610	469,828	3,729	47,161	7.91
Sheep and Beef (National Average)	708	287,803	180,002	34,324	73,477	104	6,311	1.64
Sheep/Beef (Waikato BOP Intensive)	300	270,839	162,659	75,000	33,180	111	14,730	0.75
Sheep/Beef (CNI hill)	635	309,763	196,492	75,000	38,271	60	7,249	0.83
Viticulture (Marlborough)	25	907,273	288,576	75,000	543,697	21,748	362,940	5.99
Kiwifruit (BoP)	5	147,975	116,626	48,051	16,702	3,340	341,021	-0.98
Arable (Canterbury)	285	903,000	490,670	75,000	337,330	1,184	23,022	5.14
Deer (South Island)	180	227.602	109,172	58,771	59,659	331	15,428	2.15
Forestry*	500	682,023	554,825	50,006	77,193	154	5,700	2.71

* Forestry cash flows have been annualised

The results indicate that dairy, viticulture and arable farming provide the best returns under the assumptions made, while forestry, deer and sheep and beef farming (nationally) rank next. However, sheep and beef farming in the Central North Island was barely profitable. Forestry on ex-pasture sites in the Waikato Region would be expected to be more productive than the national average presented here, and the IRR could approach values for the higher-ranked alternative land uses.

Forestry prospectuses commonly advertise a return on investment of 7-9% for plantation projects, rising to 15% if real price increases for logs are assumed[3]. Analysis of the internal rate of return for a large number of forestry investments in New Zealand yielded a more modest average of 5.8%, with a range from about 3.2 - 8.2% (Liley 2010). Timber Investment Management Organisations (TIMO's) manage forests as part of a portfolio of investments, and see returns of about 5% as acceptable given the counter-cyclical trends in forestry returns and relatively low risk.

[3]Eg. http://www.franklingroupnz.com/forestry/returns.aspx

The key to discounted cash flow analyses is the choice of discount rate. Typically this is related to the cost of borrowing money for the investment or the opportunity cost of alternative investments, and may incorporate a component for project risk that is not otherwise modelled. Some analysts have advocated using different discount rates for forestry and agriculture, based on perceived riskiness of different land uses (Evison 2008). The same argument can be applied to “non-standard” siting, species and regime choices, and different discount rates could also be applied to timber and carbon revenues due to differences in perceived market risk.

The disadvantage of forestry as an investment has always been the upfront costs and delayed revenues. Attempts to bring forward revenues through production thinning and shorter rotations are problematical – thinning is an expensive operation with risk of damage to the final crop, and there are wood quality issues with young trees. The advent of carbon trading has changed the economics of growing trees significantly.

Forestry economics under the ETS

The Emissions Trading Scheme has been designed as a way to help New Zealand meet its international obligations with regard to climate change. The ETS aims to discourage greenhouse gas emissions and encourage sequestration of CO_2 through tree planting by creating a market for carbon trading. Forestry entered the ETS on 1 January 2008, although carbon credits from afforestation had been traded earlier on the voluntary market.

Forest owners can opt into the ETS if they own at least one hectare of forest with forest species that have or are likely to have a crown cover of over 30% and an average width of 30 metres. Forest species are those which are capable of reaching five metres in height. Owners of pre-1990 forests face obligations under the scheme if they deforest.

Forestry is New Zealand’s largest potential carbon ‘sink’. As trees grow, they absorb carbon dioxide from the atmosphere and store it in their trunks, branches, leaves and roots (above ground and below ground biomass). The amount of carbon contained within a forest depends on factors such as the species, stocking, site conditions and how long it is left to grow. When trees are harvested, carbon that is stored is released back into the atmosphere as the wood decays. At present, all harvested wood taken off site is conservatively assumed to be immediately released back into the atmosphere. Harvest residues that remain on-site are considered by MFE to decay completely over a 10-year period.

Through the ETS a grower can sell carbon units as the trees grow, but must buy them back to cover the liability at harvest. Despite this, there are two clear benefits for the forest grower.

- The first relates to the time value of money – cash flow from the units sold can be invested or spent immediately.
- Secondly, not all units earned must be repaid, as typically the minimum carbon stock on afforested pasture land will always be greater than the pre-afforestation carbon stock, due to the presence of decaying harvest residues.

MAF commissioned two recent studies into the economics of forestry under carbon trading, both of which analysed a range of species and regime options (Turner *et al* 2008; Maclaren *et al* 2008).

Species and regime choice

Radiata pine is the dominant species in plantation forestry in New Zealand. In 2009, 90% of national plantation estate was radiata pine (MAF 2010), and the proportion was probably slightly higher in the Environment Waikato region.[4] While it has been claimed that the 1990's planting boom was mainly undertaken by small private forest owners with different species preferences, the proportion of radiata pine in post-1989 forests (of owners with areas less than 1000 ha) is still 90% (MAF unpublished data).

There are many good reasons to grow radiata pine. It tolerates a wide range of sites; making is particularly suitable for large-scale afforestation in contrast to other more site-specific species. It has been well researched and trialled, so growth rates and risks are well understood, genotypes are bred for New Zealand conditions and the market for products is established. It is relatively free from pests and diseases, and limitations are generally known (such as altitude). It is also responsive to a wide range of silvicultural treatments.

On the other hand, on remote sites with difficult access and expensive harvesting, the value of radiata pine logs may not be sufficient for profitable harvesting. Without intensive and expensive silviculture it may be difficult to achieve acceptable log products. It is not considered to be a long-lived species and is unsuitable for use in continuous cover forestry, so Turner *et al* (2008) considered it to be more suited to short to medium term carbon sequestration. Other candidate species for this role include Eucalyptus species and Poplars. For longer term sequestration, candidate species include Douglas-fir (6% of the current resource), redwoods, and cypresses.

In the past, radiata pine has often been managed under a direct sawlog regime, which includes pruning to reduce the size of the knotty core and thinning to maximise clearwood growth in pruned logs. This regime deliberately sacrifices volume (and hence carbon) production to achieve greater value. Economic analyses of clearwood regimes favour short rotations. However, inclusion of carbon in the analysis favours higher stockings and longer rotations. Longer rotations generally result in improved wood properties. Higher stockings also improve many wood properties, but may reduce the amount of clearwood produced (and hence the value) and if stocking is kept too high the stand is at risk to pests, diseases and windthrow. Species such as Douglas fir and redwoods are notable for the large standing volumes they can retain at advanced ages and high stockings, making them ideal for longer term carbon sequestration.

Turner *et al* (2008) analysed the relative merits of these species, building on the work of Maclaren (2004). Modelling variations of site, species, management regime, rotation, and growth and density improvement to give a total of 96 simulations per species. These management decisions were then overlaid with economic drivers including discount rate, carbon-price, timber price, silvicultural costs, and harvesting costs. The base site selected was in the Rotorua area on ex-farmland, with altitude of 330m and latitude of 38.1°S.

While land expectation value (LEV) was the criteria used to compare options in Turner *et al.* (2008) we present the results of that study as annuities which are more easily compared with the Economic Farm Surplus reported for farming enterprises. For species with rapid carbon sequestration and/or relatively low timber values, carbon revenues lead to longer optimal rotations and less intensive silviculture (e.g. Radiata pine and *E. fastigata*). Carbon trading had less impact on species with relatively high timber values and slow rates of carbon accumulation (e.g. redwood, Douglas-fir and the cypress, *Cupressus. lusitanica*).

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[4] Based on NEFD data for the territorial regions wholly within the Environment Waikato Region, plus Waitomo (94% within Waikato), Taupo (74%) and Rotorua (38%).

Figure 2 compares annuities for the radiata pine clearwood regime for five alternative rotation lengths. Without carbon trading, forestry is barely profitable at rotation ages 25 and 30. With carbon included, forestry can afford to pay over $5000/ha for land and still make the required return (8%, or $400/ha/yr, in this case).

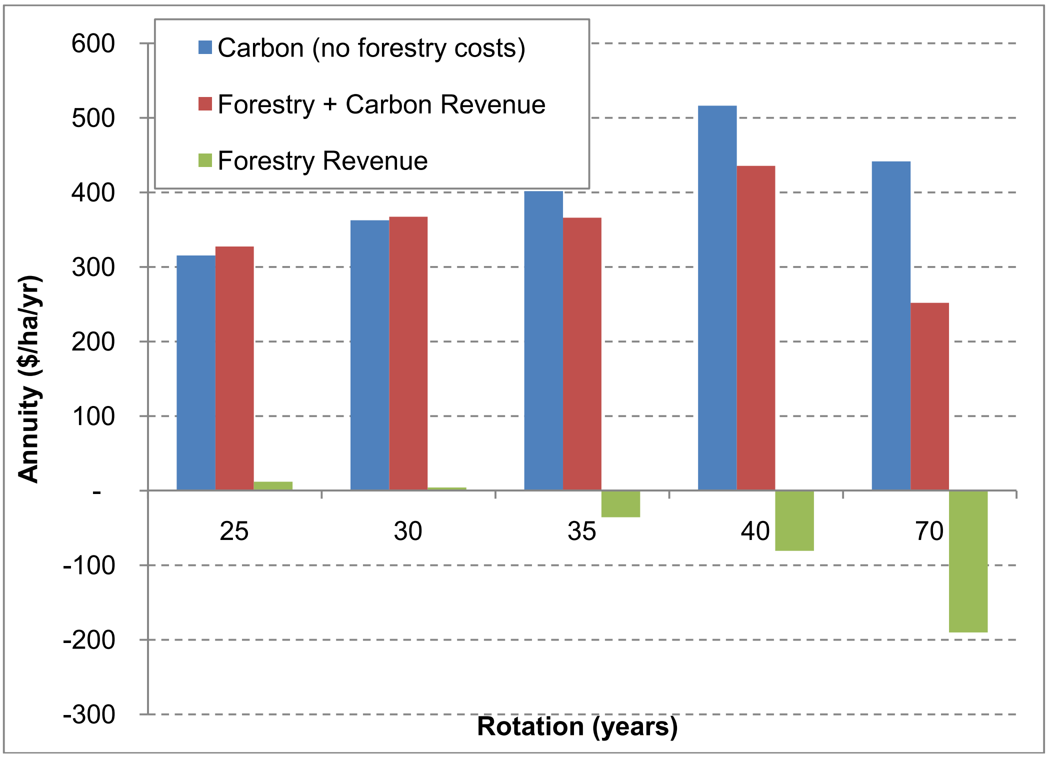

Figure 2: Contribution of carbon ($22/t CO2-e) to average annual income (annuity) value for radiata pine managed on a clearwood regime.

Figure 3 shows the influence of discount rate and carbon price on LEV for a carbon forestry radiata pine regime (plant-and-leave 800 stems/ha). With low discount rates and/or high carbon prices, forest investments can support land prices well in excess of the prices currently paid for dairy conversions.

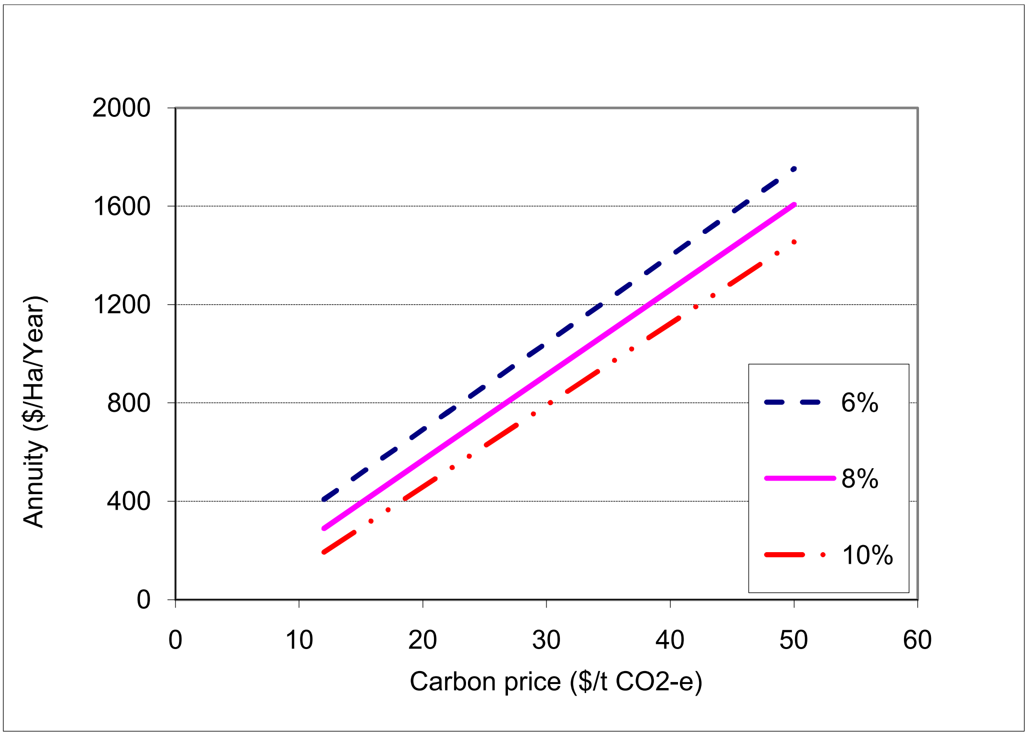

Figure 3: Influence of carbon-price and discount rate (6 to 10%) on annuities for radiata pine on a 40 year rotation plant and leave 800 stems per ha regime.

A comparison of annuities by species/regime combinations on 40-year rotations is given in Figure 4. For the plant and leave *Eucalyptus (E.) fastigata* and *C. lusitanica* regimes, a rotation length of over 80 years was slightly more profitable, but there is so much uncertainty around such long term production projections that this option was excluded. Of more interest are the potentially high returns from *E. fastigata* sawlog regimes over very short rotations (15-20 years). If sawlogs can be successfully converted to timber at these ages, the annuity would be higher than any of the alternatives presented here. *E. fastigata* also gave the highest annuities in a study on a Hawkes Bay farm (West *et al* 2008).

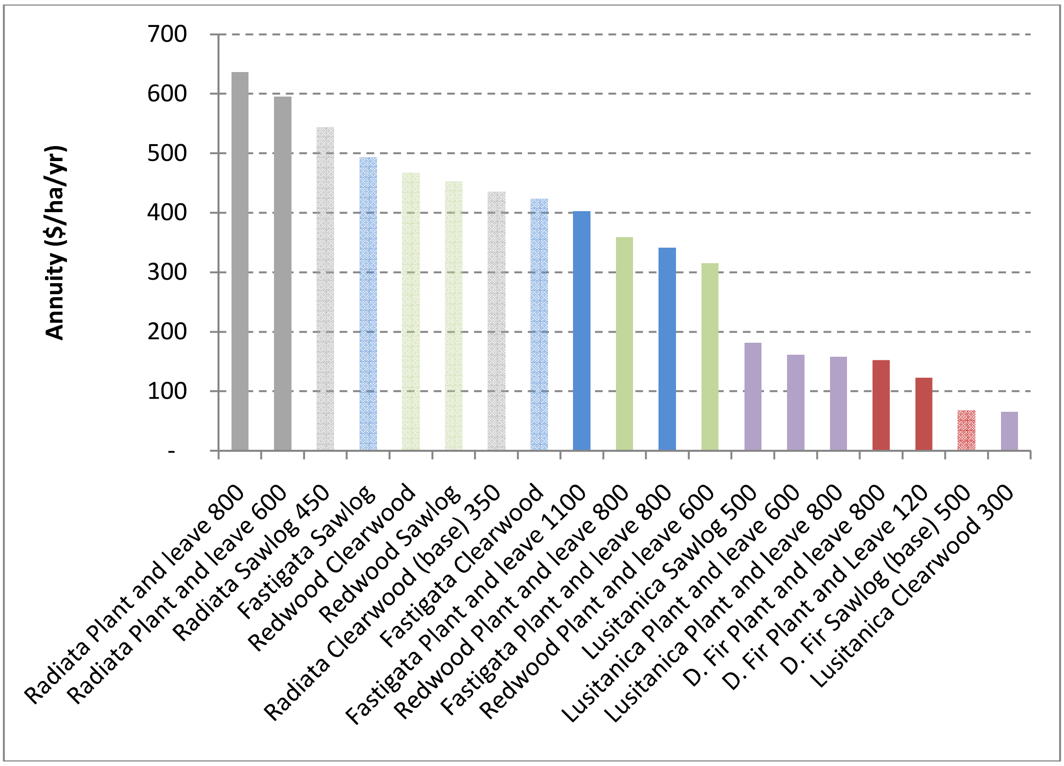

Figure 4: Annuity for species/regimes (8% pre-tax discount rate, carbon price $22/t CO2e). Species are colour coded; transparent bars indicate more intensively managed regimes with higher end product values.

Although the results suggest that the inclusion of carbon would dramatically change forest management and profitability, the authors caution that the interaction of the variables involved (e.g. site quality, species and genetics, carbon price, timber price, costs and discount rate) make it difficult to draw firm conclusions, and the lack of information on alternative species growth rates, product outturn and markets also makes comparisons difficult.

Maclaren *et al* (2008) reached similar conclusions. With a carbon price of zero, the most profitable species/regime combinations examined was radiata pine under a clearwood regime, followed by radiata pine under a framing regime (no pruning) , radiata pine under a plant-and-leave regime, Douglas-fir, *Eucalyptus nitens* and indigenous forestry. With high carbon prices, radiata pine remained the favoured option, particularly with unthinned regimes that produced greater volumes. Optimum rotation lengths increased as carbon price increased. The indigenous forestry option was based on the ETS default assumed growth rate of 3 tCO_2/ha/year, with no harvesting assumed. The LEV calculated was lower than for the plantation species, but at high carbon prices it was comparable to current forestry LEVs calculated without carbon included.

Manley and Maclaren (2010) present LEV curves for a radiata pine clearwood regime grown on an average New Zealand ex-farm site. With a discount rate of 8%, forestry without carbon would provide an annual return of $80/ha/yr, while at a $30 carbon price, returns of over $480/ha/yr could be achieved with considerable flexibility in rotation length (Figure 5), as indicated by the relatively flat peak.

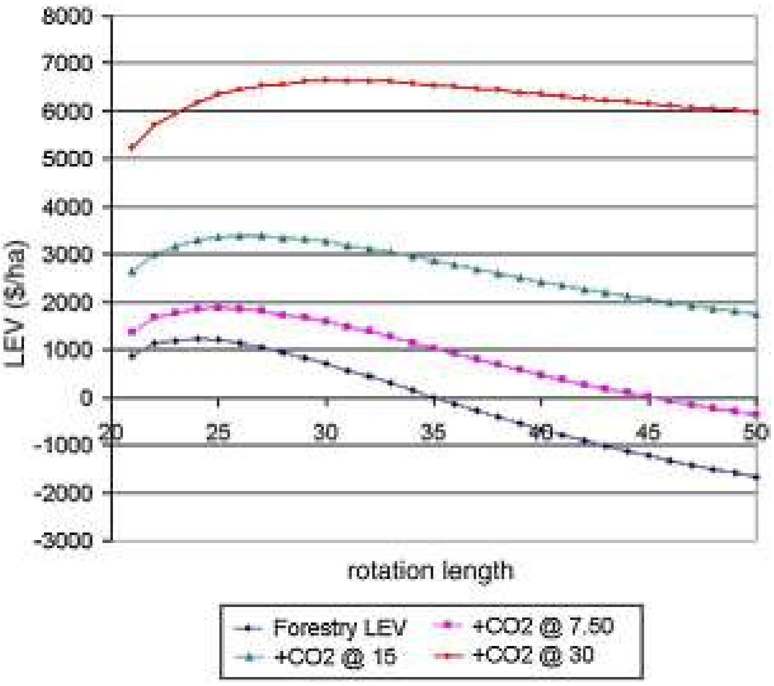

Figure 5: LEV of radiata pine clearwood regime when revenues come (i) from log sales only (Forestry LEV); and (ii) log sales and carbon trading with carbon prices of \$7.50, \$15 and \$30/t CO2.

Maclaren *et al* (2008) emphasised that little reliance should be placed on the absolute values of LEVs they calculated, as results are sensitive to the specific assumptions made. They concluded that radiata pine was still likely to be the best option under most scenarios, but apparently sub-optimal regimes and species could still have a role as a cashflow risk mitigation strategy. This is because high volume, high carbon regimes carry a risk that the stumpage value will not be high enough to offset the carbon liability at harvest. Having a proportion of the forest in longer-lived or higher value species is one way to manage that risk.

Appendix 1 provides a summary of characteristics for some of the species which may be considered for a role in carbon forestry.

Risk Management

Risk management strategies for forest owners are discussed in a report to MAF by Harkin and Hayter (2008). Risks discussed include unplanned carbon losses through fire or windthrow, regulatory changes, compliance and transaction costs, and uncertain property rights. A major concern expressed by land owners is the liability incurred when stands are harvested and the sequestered carbon is returned to the atmosphere. If the carbon price has increased substantially, the liability may be worth more than the sum of credits previously earned, and more than the returns from timber harvested.

One mitigation option is to grow a high-value crop such as a high-stocking untended planted stand which may store more carbon. Otherwise, it may be preferable to compromise some carbon sequestration in favour of a regime that produces higher value timber. With forestry there is flexibility to delay harvesting until the relative carbon and timber (or agricultural product) prices are favourable, but there are other ways that carbon price risk can be mitigated.

1. Sell only “risk-free” credits. Risk-free credits arise because it is assumed that not all carbon is returned to the atmosphere on harvest – a proportion remains in the roots, stumps and harvest residues. These residues decay over time, but there is

expected to be a minimum carbon stock in perpetuity within the forest that is greater than the pre-planting stock. In the example in Figure 6 (from Manley and Maclaren 2010) this minimum stock level is 250 t CO_2/ha. Therefore, while just over 1000 t CO_2 is sequestered up until the time of harvest at age 30, only the 250 t CO_2 sequestered in the first 12 years can be safely traded – the remaining units earned (75% of the total) must be surrendered at harvesting. There is a high opportunity cost associated with only selling the risk-free units, as almost 20 years of further carbon revenues are foregone.

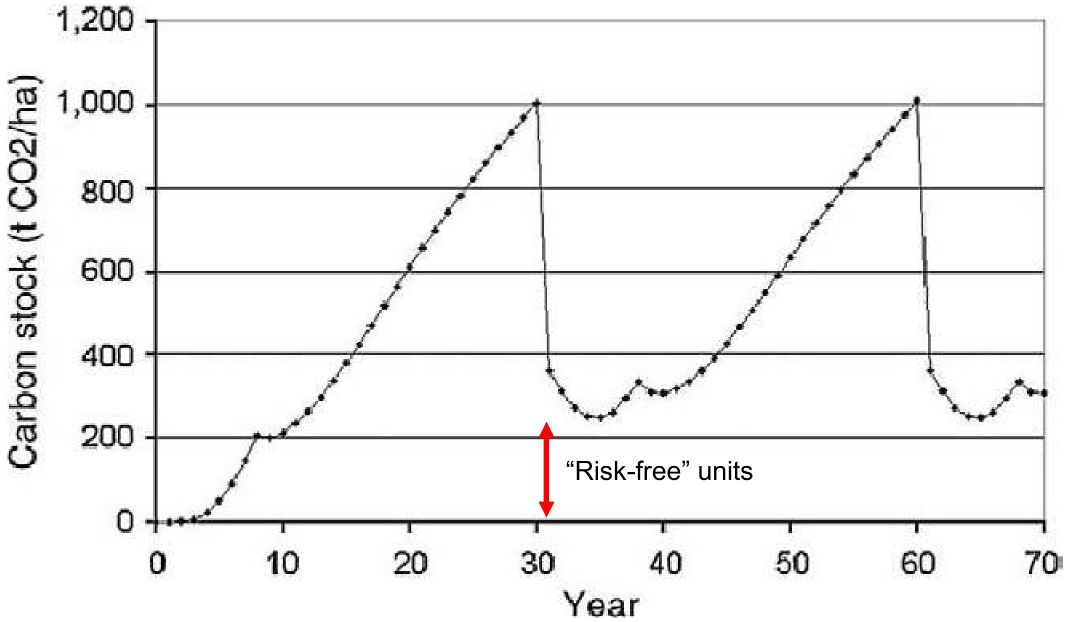

Figure 6: Carbon stock for radiata pine clearwood regime grown on a 30 year rotation (Manley and Maclaren 2010).

2. Carbon pooling. Third-parties offer to manage the trading of units from multiple stands. They are able to offer the large parcels of credits that are preferred by purchasers and possibly minimise compliance and measurement costs. Pool participants may share the risk from events such as fires and credits at harvest may be available at a pre-agreed price, so this risk is also shared.
3. Self-pooling. The idea behind self-pooling is to create a mix of age classes such that the liabilities from harvesting one area of forest are at least partially offset by growth in the remaining forest stands. The extreme example of this is a "normal forest", with an equal area in each age class up to the harvest age. In this situation, the liabilities from harvesting the oldest age class (e.g. at age 30) are exactly offset by the credits from the growth in stands aged 1 to 29. This status can be reached though planting (by planting an equal area each year for 30 years), through harvesting (by planting all area in one year, then harvesting an equal area over 30 years), or by a combination. Once a normal forest is reached there are no further credits or liabilities as the carbon stock is held constant. Manley and Maclaren (2010) present four examples for a 1200 ha forest estate. In the first ("plant 1200 harvest 1200"), the entire forest is planted and harvested in one block – this is simply a scaled-up version of the previous stand example. The three alternatives achieve a normal forest after two rotations, through harvesting, planting, or a combination:
    - *Plant 1200 harvest 40*: all 1200 ha are planted in year one, but harvesting is spread over 30 years (ages 21 to 50), with 40 ha felled each year.
    - *Plant 40 harvest 40*. 40 ha are planted each year until harvesting begins at age 30.

- *Plant 600/600 harvest 40*: 600 ha is planted in year 1 and a further 600 ha in year 16; harvesting from each block is spread over 15 years (ages 25 to 39), with 40ha felled each year.

Figure 7 shows the minimum levels in perpetuity for the four strategies and hence the level of risk-free credits. There is a trade-off between NPV and risk-free credits (or the proportion of units that must be surrendered at harvest). Planting and harvesting all 1200 ha as a single block achieves the highest NPV but has the lowest level of risk-free credits. At the other extreme, no units have to be surrendered if the forest is planted 40 ha at a time, but this option has the lowest NPV – there is a high opportunity cost associated with delaying planting if the forestry LEV exceeds the assumed land cost, as it does in this example. Achieving a normal forest through harvesting rather than planting allows a less risk-averse owner to sell additional units while keeping the proportion that must be surrendered at harvest well below the 75% level required if the forest is treated as a single block.

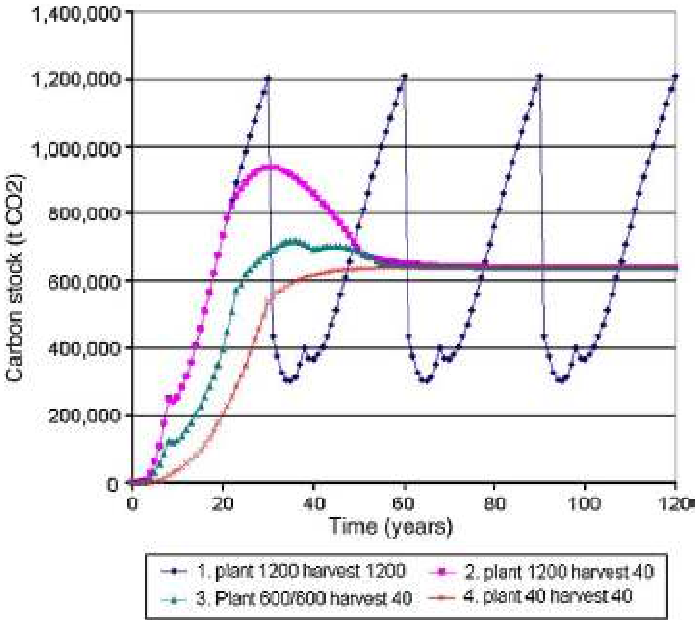

Figure 7: Carbon stocks for four estate-level strategies (from Maclaren and Manley 2010).

4. Continuous-cover forestry is an alternative self-pooling approach which may be suitable with some species. If harvesting is on a selection logging basis rather than clearfelling, the requirement for a massive surrender of units in a single year is avoided. Of course, the problem of surrendering units at the time of harvest can be eliminated altogether by eliminating harvesting.

5. Short-term hedging strategies could also be used, from the point at which "risky" credits are sold or closer to harvest date. Evison (2008a) investigated the impact of a one-off increase in carbon price in the year of harvest. With a 7 percent discount rate, 30 year rotation and carbon price of $30, the carbon price would have to increase by over 170% (to $81) before the discounted liability at harvest would exceed the sum of discounted revenues from units sold during the rotation. Hedging could be via financial markets or by holding back some units from sale.

These strategies will not all be available to all land owners. Farmers with cash flow constraints and a reluctance to seek outside investment will have to spread planting over a longer period of time. There are also forest management practicalities to consider – both in terms of economies of scale for operations and topographical constraints.

Applicability of results to Waikato Region

Potential site quality for forestry in the Waikato region varies but is generally better than the national average. Key factors influencing productivity include rainfall distribution, temperature, sunlight, soil chemical and physical properties, and exposure to adverse climatic effects (snow, wind).

Figure 8 gives the modelled productivity of radiata pine grown at 300 stems/ha as indices of how productivity varies over the region (Palmer, *et al*, 2009).

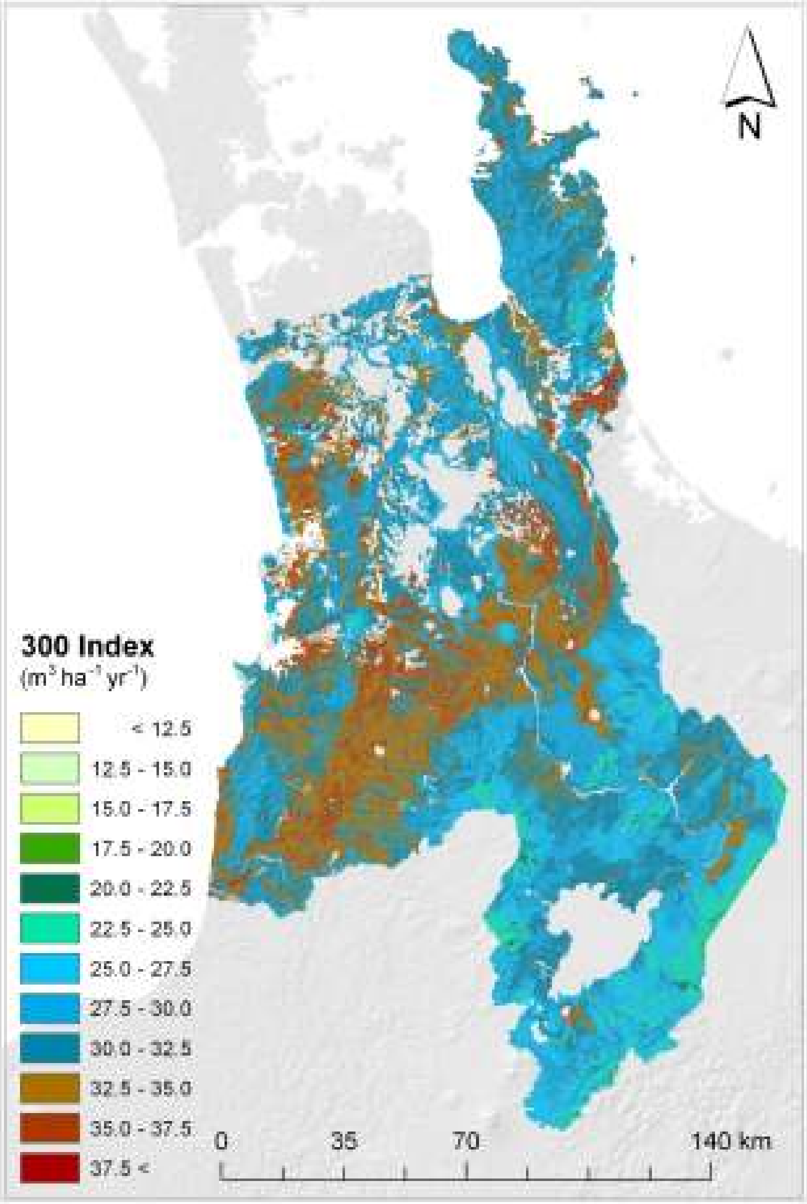

Figure 8: Radiata pine productivity map for Waikato region.

Apart from growth rates, a range of other factors influence the profitability of forestry. Discount rate, carbon price and delivered log prices are the dominant factors, but harvesting cost is also critical. This is influenced by slope, with steep erodible country more expensive for both logging and road construction. There may also be constraints on harvesting. Transport distance will also affect the returns for the grower.

Forestry costs are also important as they are incurred early in the rotation. Economies of scale make radiata pine relatively cheap to establish, but silvicultural tending costs make clearwood regimes expensive. On good ex-farm sites, growth may be such that it becomes difficult to control the knotty core size with only two or three pruning operations.

In general, investment decisions must be made at the property level, to take into account individual owner objectives, the microsites available, specific costs and tax considerations. If the objective is to supplement the existing farming operation with forestry, then comparisons of average forest productivity with average farm productivity are inappropriate, as it is likely that sites identified for planting are not "average" for either operation.

While sheep and beef farms usually have significant areas that could be put into trees, dairy farms tend to have little spare land that is not devoted to milk production. In this case, off-site investment may be the only option. The advantage of investment in forestry is that it hedges against future changes in the carbon price that will impact on the farm's emissions liabilities. Investment options are discussed in the next section, but professional advice is recommended – the management cost structures and share of risk and return can differ widely.

Financial impacts of integrating carbon forestry into farming enterprises

The previous section has presented a number of studies of the per hectare financial performance of carbon forestry alone (Maclaren et al. 2008, Turner et al. 2008, West et al. 2008, Manley & Maclaren 2010). This section presents information from past financial studies of carbon forestry, as well as a new analysis of the financial impacts of carbon forestry within the Waikato region. The analyses are based on the different financial measures used to assess the opportunity for integrating carbon forestry into farming enterprises. The section concludes with information on the key farm and forestry variables that impact on the financial opportunity from carbon forestry on farms.

Financial analyses of carbon forestry can be distinguished by the financial measures (and hence farmer financial objectives) used to assess carbon forestry. The different analyses are:

1. Comparison of per hectare Economic Farm Surplus (EFS) for land in carbon forestry with EFS for different farming enterprises
2. Comparison of whole farm cash flows (as EFS) with carbon forestry integrated into the farming enterprise.
3. Comparison of return on capital for carbon forestry on farming enterprises.

The comparison of per hectare EFS for land in carbon forestry with that for different farming enterprises highlights the potential impact of carbon forestry on average annual cash flows relative to average farming cash flows. The previous section presents this type of analysis for carbon forestry alone. This section compares those estimates with EFS for various Waikato farming enterprises.

The comparison of whole farm cash flows with carbon forestry integrated into the farming enterprise expands on the first type of analysis by assessing how carbon forestry cash flows vary from year-to-year. This is important given that cash flows from a single forestry block involve initial investment followed by a steady growth in cash flow. This section presents two case studies of whole farm cash flows with and without carbon forestry, for a Bay of Plenty sheep and beef farm and Northland dairy farm (Sinclair et al. 2010). Also presented is a per hectare cash flow analysis for a Hawkes' Bay sheep and beef farm. Other examples of this type of analysis include Praat & Wallwork (2009), Praat & Thomson (2010) and AgResearch (2010).

The comparison of return on capital for carbon forestry on farming enterprises considers the case where land purchases or rentals are part of the investment in carbon forestry. This section compares estimates of carbon forestry returns with estimates of farming returns for various Waikato farming enterprises. Examples of this type of analysis include Sinclair et al. (2010).

Per Hectare Comparisons of Economic Farm Surplus

As no specific case studies of integrating carbon forestry onto Waikato farms are available this section presents an analysis using average annual cash flows for agricultural and carbon forestry enterprises within the Waikato region. Using MAF Waikato/BOP Monitoring farms, the Beef and Lamb NZ farm survey for Northern North Island (Beef and Lamb NZ Outlook, 2010-11) and forestry returns from Turner *et al.*, 2008, per hectare average annual cash flows (Economic Farm Surplus) were calculated (Table 3). The analysis compared the existing farm enterprises and carbon forestry with a radiata pine framing regime under a \$22/t CO_2-e carbon price and a radiata pine regime under a \$50/t CO_2-e carbon price (Table 4).

Because a detailed analysis of carbon forestry returns was not possible within the scope of this study, the carbon forestry cash flows ignore variability in the productivity of land within the region for forestry. However, the assumed productivity used in Turner et al. (2008) is below the average productivity of land for forestry in the Waikato (Figure 8).

The comparison of Farm Economic Surplus for the different farm enterprises with the estimated average annual cash flow from carbon forestry at current carbon prices (\$22/t CO_2-e) indicates that carbon forestry has the potential to provide similar or better average cash flows than from sheep and beef enterprises within the region (Table 4). Carbon forestry cash flows, however, are well short of those achieved from dairying within the Waikato region. Even with a \$50/t CO_2-e carbon price and a forestry regime focused on maximising carbon sequestration (untended radiata pine) the average cash flow from carbon forestry does not approach those currently achieved from dairying.

This suggests that there is considerable potential to improve EFS from sheep and beef enterprises in the region by appropriately incorporating carbon forestry on these farms, even when the potential financial impacts of the Emissions Trading Scheme on returns from the farming enterprise are ignored. Financial opportunities for carbon forestry on dairying enterprises are much more limited, even when the potential impacts of the Emissions Trading Scheme are considered.

Table 4: Comparison of carbon forestry annuities and farming Economic Farm Surplus for "typical" enterprises by region

			Farm Economic Farm Surplus ($/ha/yr)		Carbon Forestry Annuity ($/ha/yr)	
Land Use	Region/Class[1]	Area (ha)	Without ETS	With ETS[2]	\$22/t CO_2-e[3]	\$50/t CO_2-e[4]
Sheep & beef	National	708	95	88	544	1,600
	Waikato	300	152	140	544	1,600
	CNI	635	114	105	544	1,600
	NI Class 3 - bottom	398	- 147	135	544	1,600
	NI Class 3 - middle	574	113	104	544	1,600
	NI Class 3 - top	818	211	194	544	1,600
	NI Class 3 - average	560	96	89	544	1,600
	NI Class 4 - bottom	173	- 270	249	544	1,600
	NI Class 4 - middle	335	3	3	544	1,600
	NI Class 4 - top	374	232	213	544	1,600
	NI Class 4 - average	316	64	58	544	1,600
	NI Class 5 - bottom	119	- 68	68	544	1,600
	NI Class 5 - middle	154	154	142	544	1,600
	NI Class 5 - top	384	471	434	544	1,600
	NI Class 5 - average	223	224	206	544	1,600
Dairy	National (2008)	126	3,430	2,386	544	1,600
	National (2010)	127	2,802	2,242	544	1,600
	Waikato	112	2,008	1,606	544	1,600
	National (DairyNZ)	125	2,881	2,305	544	1,600

[1] NI Class 3 = Hard Hill Country Northern North Island, NI Class 4 = Hill Country Northern North Island, and Class 5 = Intensive Finishing Northern North Island
[2] Economic Farm Surpluses were adjusted for estimated impacts of the ETS assuming an average 8.1% reduction in EFS on sheep and beef farms and 20.0% reduction on dairy farms (Sinclair et al. 2010). These estimated impacts of the ETS are illustrative only.
[3] Radiata pine managed on a framing regime
[4] Radiata pine managed on an untended (no pruning or thinning) regime

Impacts of Carbon Forestry on Whole Farm Cash Flows

The above analysis concentrates on comparison of annual average returns from carbon forestry with EFS from farming. It is important to consider the actual year-to-year variation in cash flows from carbon forestry as these vary considerably through-out the single rotation of a forest stand.

There have been no case studies of the potential impact on whole farm cash flows of integrating carbon forestry into Waikato farming enterprises. Instead this section presents examples for a drought-prone Bay of Plenty sheep and beef farm, and a Northland low production rolling dairy farm from Sinclair et al. (2010). The section begins with an example of the per hectare cash flows from a forestry block, which demonstrates the impact of tree species and management regime on forestry cash flows over the rotation period. The case studies from Sinclair et al. (2010) put those forestry cash flows into the context of the whole farm cash flow.

Hawkes Bay Sheep and Beef

Cash flows for the first 28 of the 60 years of tree growth for forest blocks established on the McRae Trust farm at Wairoa (West et al 2008) are shown in Figure 9. For the sake of clarity, data for the three plantation regimes with the lowest estimated carbon sequestration potential have been omitted.

At age 30 (not shown) there is no doubt that revenue from timber sales will exceed that from carbon credits and will dwarf initial costs. Because of this, all data shown (except for the radiata pine 350 stems/ha clearwood regime) include carbon credit revenue in the 28 year period. The net income for the radiata pine 350 stems/ha clearwood regime at age 30 was estimated to be $30,589/ha/yr, ie revenue from clearfelling one hectare of tended radiata pine.

In most cases positive net cash flows are expected by tree age 5-7years. Exceptions are the two native stands and the two radiata pine clearwood stands.

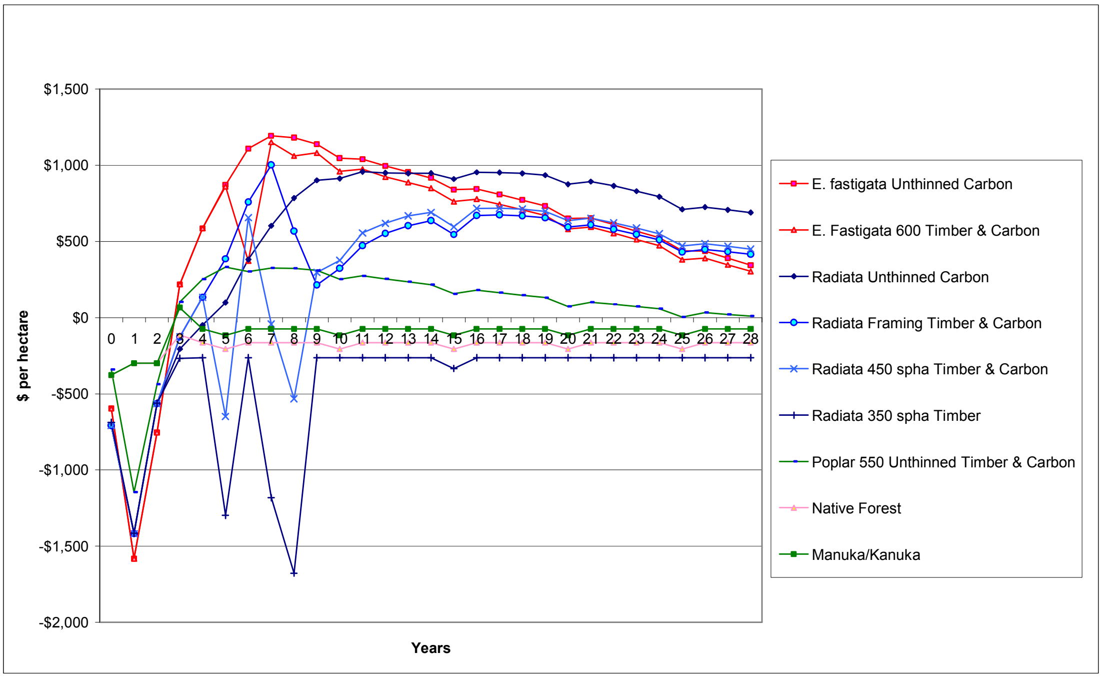

Figure 9: Predicted annual per hectare cashflow for nine tree-based scenarios in northern Hawke's Bay.

Estimates shown in Figure 9 reflect the high costs of planting and releasing in all exotic tree scenarios during the first two years; also the fact that income from carbon credits is not received until year three.

Cash flows from eucalypt plantations was predicted to be high at first and declining as growth rates slows with age. Radiata pine has slower initial growth than E. fastigata and therefore early cashflow is lower. Later in the rotation radiata pine cashflow exceeds that for eucalyptus species.

Stands grown for timber production show a reduction in cashflow when trees are thinned (eucalypts Year 6; radiata pine Year 8) or pruned (radiata pine Years 4, 6 and 7). Small reductions in cashflow at five-year intervals reflect costs associated with carbon auditing. All scenarios including timber production show a reduction in cashflow at age 15 due to the cost of a mid-rotation inventory.

Negative values for native tree stands indicate that income from sequestered carbon is not sufficient to offset rent and other costs. The scenario representing timber production only (no carbon credits) will not generate revenue until age 30 and therefore shows poor economic performance up to that time.

Bay of Plenty Intensive Sheep and Beef

This case study was for a 1,167 ha sheep and beef farm situated in the Eastern Bay of Plenty on ash to pumice soil. The farm is in a moderately high rainfall area, although the summers can be hot and dry, occasionally requiring destocking. The farm contour ranges from flat to steep with most of the property on a rolling contour, with 350 ha of intensive land and 813 ha of extensive land. The farm has recently been intensified and has a stocking rate of 14.2 SU/ha. The property runs breeding ewes and finishing cattle (beef steers and Friesian bulls). There are 4,474 ewes and mated hoggets on the farm weaning 4,600 lambs (103%). A high percentage of the surplus lambs are finished on the property, as are the cattle, which are generally purchased as weaners.

The case study farm was consider a high site quality for radiata pine, with medium establishment costs, average harvesting costs and slightly above average roading costs. An important advantage of the farm is its close proximity to markets for logs. The farm owners have had previous experience with forestry on adjacent grazing land and so see trees as providing a potential GHG offset on certain properties. The owners expressed a preference for planting on the steepest, erosion prone, and most unproductive land, provided these areas formed a large enough block to make harvesting financially viable. The owners were also interested in the option of allowing the unsuitable, steep areas to revert to native bush.

The carbon forestry scenario modelled was to consider planting the least productive land, which made up almost half of the farm, in carbon forestry; 236 ha of the slightly better class land for forestry was planted in thinned radiata pine on a 32 year rotation, and 253 ha was planted in untended radiata pine on a 33 to 35 year rotation.

The modelled impact of integrating carbon forestry (with an average carbon price of \$20/t CO_2-e) into the sheep and beef enterprise on farm cash flows from 2007 to 2070 is shown in Figure 10[5]. Total farm EFS with carbon forestry was below the EFS without carbon forestry at establishment and reestablishment, and while the forest carbon sequestration rate increased. Once the trees were about 10 years old total farm EFS was higher with

[5] The analysis undertaken by Sinclair et al. (2010) considered risk in agricultural and forestry commodity prices, by allowing year-to-year variability in prices. This variability leads to the year-to-year fluctuations in Economic Farm Surplus.

carbon forestry than without. Average annual EFS was $540/ha with carbon forestry, compared with $440/ha without.

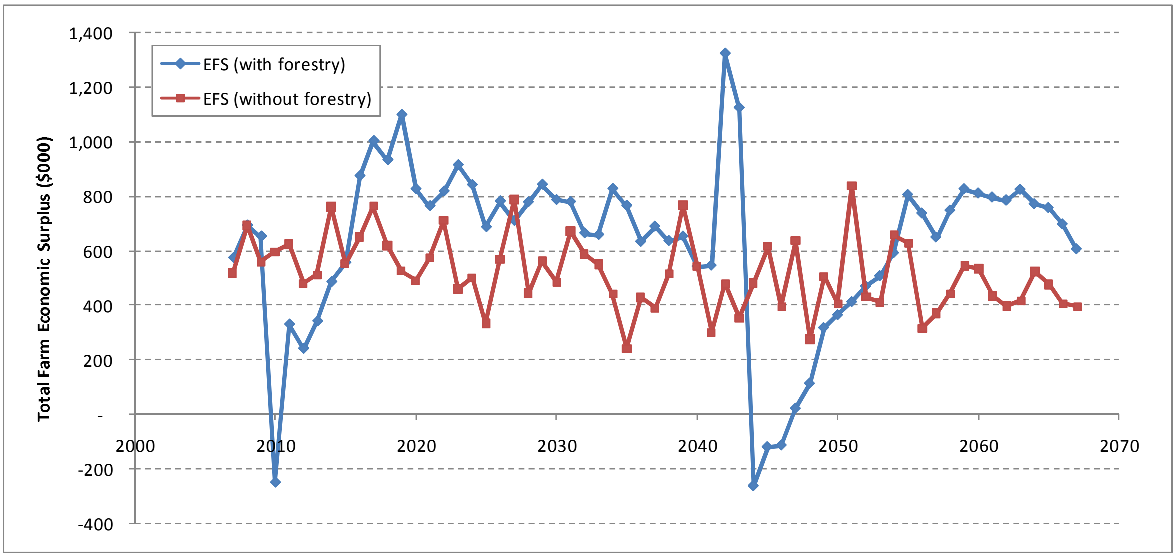

Figure 10: Modelled total farm Economic Farm Surplus for the case study sheep and beef farm from 2007 to 2070, with and without carbon forestry integrated into the farm.

Northland Dairy Farm

This case study was for a farm comprising of a System 1 (minimal imported feed) dairy platform (220 ha effective) and dry stock support block (220 ha effective). The former is on a rolling contour with ryegrass/white clover being the dominant vegetative cover. The latter is on a rolling to steep contour with some areas of developed ryegrass/white clover and other areas kikuyu pasture. The support block also includes two small forestry blocks; 15 ha of 14 year old thinned radiata pine and 4 ha of 11 year old thinned radiata pine, both managed on a 29 year rotation. The farm runs a split calving system with 280 cows calved in the spring and 210 calved in the autumn. All young and dry stock are grazed off the milking platform. Production is typical for the area with 780 kg MS/ha/yr production and 330 kg MS/cow and 370 kg MS/cow for the spring and autumn herds, respectively.

The farm owner expressed an interest in exploring carbon forestry as an option for offsetting GHG emissions if the government continues with the Emissions Trading Scheme. The carbon forestry scenario modelled was to retain the dairy platform and convert half of the 220 ha support block, along with the existing forestry, to 112 ha of thinned radiata pine managed on a 35-year rotation. The farmer considered planting of trees on the milking platform to be a potential nuisance, especially if plantings were in small plots, and preferred to plant the steepest, most erosion prone, and least productive land on the support block.

The modelled impact of integrating carbon forestry (for a $20/t CO_2-e carbon price) into the support block on total farm Economic Farm Surplus is shown in Figure 11. Incorporating carbon forestry into the farming enterprise improved the overall profitability of the whole farm. Total farm Economic Farm Surplus with carbon forestry was similar to or slightly above the EFS without carbon forestry. Average annual EFS was $834/ha with carbon forestry, compared with $612/ha without.

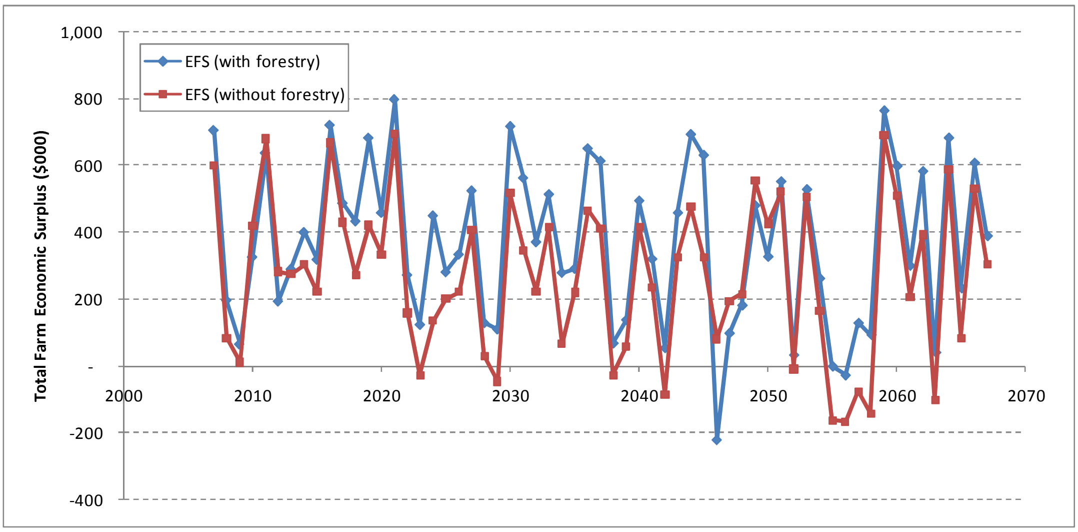

Figure 11: Modelled total farm Economic Farm Surplus for the case study dairy farm from 2007 to 2070, with and without carbon forestry integrated into the farm.

The case study shows the advantages of having existing post-1989 forestry on the run-off, with carbon revenues from the two small forestry blocks offsetting the initial costs of establishing the new forestry block. This avoided an initial negative cash flow.

Comparison of Returns from Investment in Carbon Forestry in the Waikato region

The comparison of returns from investment in carbon forestry in the Waikato region used the same data as for the comparison of average Economic Farm Surplus. Investment returns were estimated used data from MAF Waikato/BOP Monitoring farms, the Beef and Lamb NZ farm survey for Northern North Island (Beef and Lamb NZ Outlook, 2010-11) and forestry returns from Turner *et al.*, 2008, in whole farm discounted cash flows for 30 years (Table 5). The analysis compared the existing farm enterprises and carbon forestry with a radiata pine framing regime under a \$22/t CO_2-e carbon price and a radiata pine regime under a \$50/t CO_2-e carbon price (Table 4).

The benefits of carbon forestry are very dependent on farm asset value, which as presented here includes buildings and farming stock. Generally there has not been an improvement in IRR where asset value exceeds \$7000/ha. Figure 12 illustrates this relationship.

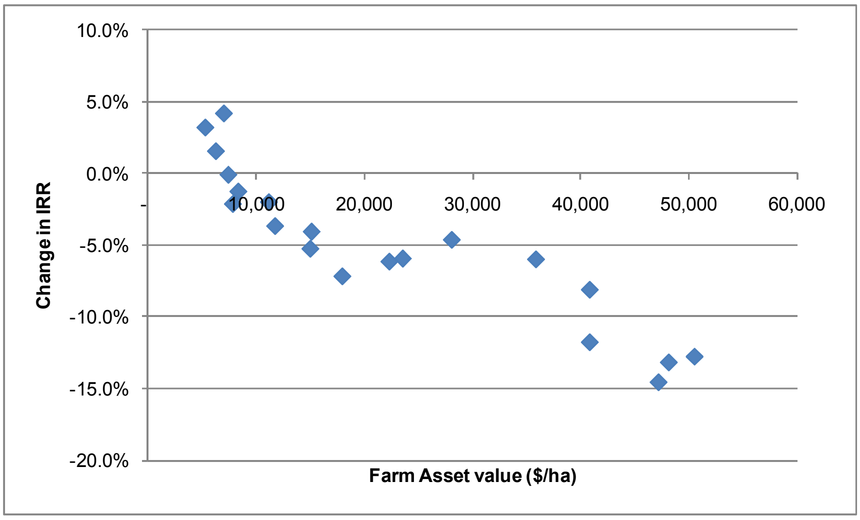

Figure 12: Change in IRR when Carbon Forestry replaces a range of land use classes indicated by average asset value.

Table 5: Comparison of carbon forestry and farming enterprise returns for “typical” enterprises by region.

Land Use	Region/Class[1]	Area (ha)	Farm Asset Value ($/ha)	Farm Internal Rate of Return (%/yr) Without ETS	Farm Internal Rate of Return (%/yr) With ETS[2]	Carbon Forestry IRR (%/yr) Sawlog[3]	Carbon Forestry IRR (%/yr) Untended[4]
Sheep & beef	National	708	6,311	1.64%	1.52%	1.45%	3.23%
	Waikato	300	11,771	1.40%	1.29%	-3.12%	-2.24%
	CNI	635	5,334	2.33%	2.15%	3.37%	5.56%
	NI Class 3 - bottom	398	7,047	-2.27%	-2.09%	0.39%	1.95%
	NI Class 3 - middle	574	8,388	1.47%	1.36%	-1.03%	0.24%
	NI Class 3 - top	818	7,882	2.91%	2.69%	-0.56%	0.81%
	NI Class 3 - average	560	7,463	1.41%	1.30%	-0.11%	1.35%
	NI Class 4 - bottom	173	28,072	-1.05%	-0.97%	-5.99%	-5.64%
	NI Class 4 - middle	335	11,201	0.03%	0.03%	-2.86%	-1.94%
	NI Class 4 - top	374	15,036	1.67%	1.54%	-4.21%	-3.54%
	NI Class 4 - average	316	15,152	0.46%	0.42%	-4.24%	-3.57%
	NI Class 5 - bottom	119	35,852	-0.21%	-0.21%	-6.43%	-6.16%
	NI Class 5 - middle	154	23,569	0.71%	0.66%	-5.60%	-5.19%
	NI Class 5 - top	384	17,991	2.85%	2.62%	-4.84%	-4.29%
	NI Class 5 - average	223	22,318	1.09%	1.00%	-5.47%	-5.03%
Dairy	National (2008)	126	47,161	7.91%	6.34%	-6.81%	-6.61%
	National (2010)	127	50,489	6.03%	5.56%	-6.89%	-6.70%
	Waikato	112	40,819	5.35%	4.93%	-6.62%	-6.39%
	National (DairyNZ)	125	48,099	6.51%	6.00%	-6.83%	-6.63%

[1] NI Class 3 = Hard Hill Country Northern North Island, NI Class 4 = Hill Country Northern North Island, and Class 5 = Intensive Finishing Northern North Island
[2] Economic Farm Surpluses were adjusted for estimated impacts of the ETS assuming an average 8.1% reduction in EFS on sheep and beef farms and 20.0% reduction on dairy farms (Sinclair et al. 2010). These estimated impacts of the ETS are illustrative only.
[3] Radiata pine managed on a framing regime for a $22/t CO_2-e carbon price
[4] Radiata pine managed on an untended (no pruning or thinning) regime for a $22/t CO_2-e carbon price

Key Influences on the Financial Impact of Carbon Forestry on Farms

The whole farm financial impacts of incorporating carbon forestry into dairy or sheep and beef farm enterprises depend critically on the particular characteristics of the farm (Sinclair *et al*. 2010; Praat and Thomson 2010; AgResearch 2010):

- The high agricultural revenue foregone from converting dairy land to forestry does not make forestry revenue a cost-effective option for offsetting farm GHG emissions, even up to carbon prices of \$50/ t CO_2-e on high production dairy enterprises. Forestry plantings on dry stock areas (e.g. dairy farm run-off), however, are profitable when the carbon price is greater than \$30/ t CO_2-e.
- On sheep and beef farms, adding carbon forestry for ETS cost abatement was marginal at \$20/ t CO_2-e, but quickly becomes profitable above this value with returns more than double at a carbon price of \$50/ t CO_2-e.
- The profitability of carbon forestry on these farms depended on:
    - Land use classes planted and region. The ability to plant sizeable areas of poorer land use classes reduced any negative impact of forestry on overall farm profitability
    - Forestry species and management regime
    - The presence of existing post-1989 forestry which reduced the upfront costs of carbon forestry, and reduces the risk of future increases in carbon price.
    - The capital tied up in livestock production which will be rendered obsolete (fencing, water, stockyards, shearing shed)

The agricultural revenue foregone of moving land from agricultural production to forestry relative to the revenue earned from carbon forestry is influenced by a number of farm specific factors, including the cost of agricultural emissions. These costs are critically dependent on:

- carbon price, Sinclair *et al*. (2010) found that a carbon price greater than \$30/ t CO_2-e significantly increased the profitability of carbon forestry on farm, as above this price there was a simultaneously strong increase in returns to forestry and reduction in agricultural returns;
- the ETS rules; and
- farm emissions, which can vary considerably depending upon the efficiency with which a farming enterprise converts available feed into meat, wool, or milk solids (AgResearch 2010).

Estimates of the reduction in farm profitability in 2015 of the proposed ETS range from 2% to 12% for sheep, beef and deer enterprises (Sinclair *et al*. 2010; AgResearch 2010).

Regional Environmental Benefits

The benefits of a plantation forest are essentially the same as the benefits that can be derived from a natural forest (Dyck, 2003), namely the way the forest is managed determines which benefits are given precedence. For example, a short rotation pulpwood forest is typically managed to maximise economic benefits while a forest in a nature reserve is managed for social values. However, a short rotation forest can also provide environmental benefits as part of an effluent management strategy and forests of all types can provide opportunities for recreation.

Maclaren (1996) gives a comprehensive review of the environmental effects of planted forests in New Zealand. A recent update (Hock *et al* 2009) concluded that Maclaren's findings still hold, and provided results from more recent studies. Table 6 describes some of the environmental benefits of forests identified by these authors.

Table 6: Benefits of Forests (after Dyck 2003 and Hock *et al* 2009).

Ecological – Regulation		
Climate	Temperature Humidity Atmospheric composition Rainfall Wind	Moderating role Moderating role Buffering role – carbon absorption etc Fog condensation Protection against wind action
Climate Change		CO_2 sequestration
Air Quality	Refinement Purification	Fixes pollutants, recycling Diffuses volatile compounds
Water Systems	Controlling rising water levels Maintenance of low levels	Reduces surface runoff (peak flows reduced by up to 50%) Infiltration of excessive rainfall
Water Quality	Purification Protection of water supply areas Reduction of sediment content	Fixes pollutants, recycling Reduction of sources of pollution (Lowest N and P leaching potential) (sediment load reduced by 50-90% if whole catchment afforested)
Soil Maintenance	Reduction of diffuse erosion Reduction of erosion in fragile areas Soil reconstitution	Protects from the impact of rain Soil stabilisation Physical protection Reduces surface runoff
Ecological – Protection		
Against Natural Risk		Torrential and sudden rises in water levels, avalanches, landslides and falling rock
Against Noise		Filtering effect
Ecological – Preservation		
Biological Diversity	Maintenance of current diversity Preservation of future diversity at local level Preservation of future diversity in land-use planning	Provides conservation at all levels Preserves evolution potential Maintains liaisons and corridors Provides dynamic conservation by linking up forest areas into a network

Trees on Farms

Trees can be incorporated into farming in many ways, including:

- retention of existing forest fragments, riparian planting;
- retirement from grazing and reversion to indigenous forest;
- Agroforestry - woodlots, stock havens, widely-spaced trees, timberbelts, effluent management plantings, and
- Whole catchment or whole farm afforestation.

Mead (2009) provides a review of recent trends in agroforestry in New Zealand. Interest was greatest in the 1990s but the annual afforestation rate has since fallen to low levels for various reasons:

- Declining returns for forestry, in part due to high shipping costs.
- Declining returns for sheep and beef farming (hence farmers lacked discretionary spending to invest in trees).
- Conversion to dairy farms, with removal of existing trees and shelterbelts to install irrigation.
- The realisation that widely-spaced radiata pine results in poor pasture and poor wood properties, and widely-spaced poplars lack a market.
- A growing awareness of the environmental benefits from preserving existing native forest and scrub remnants.
- Forest policy uncertainty, with land owners not wanting to be "locked in" to a forestry land use.

In contrast, it was believed that the future for trees in the rural landscape to be much healthier, due to converging drivers:

- "Green economics" (market–driven certification, eco-agriculture, animal welfare etc)
- Soil conservation
- Bio-fuels based on woody crops
- Carbon and nitrogen trading
- Developing markets for other environmental services.

Positive direct or indirect financial returns from growing trees were still seen to be crucial for encouraging afforestation (Mead, 2010).

Biodiversity

Until relatively recently, little research attention had been paid to biodiversity on New Zealand's production land base, despite the fact that plantation forests and farmland make up about half of New Zealand's land area. MacLeod *et al* (2010) speculate that this is because of:

- a research focus on understanding the causes of the drastic decline in New Zealand's endemic species;
- a prevailing "preservation" rather than "conservation through sustainable use" paradigm; and
- an historical view of production landscapes being devoid of biodiversity.

Traditionally forest management had been holistic in nature but the separation of forest management into "preservation" (Department of Conservation) and "Production" (Forestry Corporations) components following the disestablishment of the NZ Forest Service lead to plantation forest management being increasingly regarded as "tree farming", with the same emphasis on production and profit as in conventional agriculture. However, thanks largely to third-party certification of forest operations (especially the Forest Stewardship Council), conservation of biodiversity within plantations is now a mainstream activity (Brockerhoff 2010).

Pawson *et al* (2010) list 118 threatened indigenous species that previous surveys have found within plantation forests, including fish, mammals, birds, invertebrates, lizards, frogs and plants. Well known case studies include orchids at Iwatahi in Kaingaroa forest, kiwi in Waitangi forest, falcons in Kaingaroa forest and the ground beetle *Holcaspis brevicula*, where the only known population is in Eyrewell Forest on the Canterbury Plains. This plantation forest also contains more remnant Kanuka forest (as an understory) than the rest of the Plains combined, but the forest is ear-marked for dairy conversion. The authors suggest that plantation forests could play a role in restoration ecology. For example, the North Island robin, pied tit, and whitehead (common in plantations in the central North Island) could recolonise indigenous remnants through introductions to adjacent plantation forests.

The threatened species list includes 44 species that have only been observed in non-planted land contained within the plantation boundaries, including indigenous forest remnants, wetlands and frost flats. The plantation forest still provides indirect benefits in these cases, through;

- providing extended foraging habitat;
- buffering effect to maintain microclimate;
- protection of stream environments;
- monitoring biodiversity and forest health;
- exclusion of stock;
- periodic pest control (Pawson *et al* 2010).

While Pawson *et al* (2010) express concern at the lack of adequate data on biodiversity within plantations, the situation is probably worse for agricultural land. Improved pasture supports little indigenous biodiversity, but farmland also includes a mosaic of indigenous forest remnants, shelterbelts, wetlands and woodlots. Blackwell *et al* (2005) found significantly more birds and more species on kiwifruit orchards and sheep and beef farms than had been reported for native bush, pine plantations and scrub on public land. Sheep/beef farms mainly supported introduced and native open-habitat species such as skylark, spur-wing plover, redpoll, starling, pied oystercatcher and southern black-backed gull. Overall it was concluded that the majority of farms do not currently sustain a high diversity of native bird species, but that a wide range of introduced species is supported with high levels of abundance. It is unknown whether habitat availability or predation is the main factor controlling populations, but it is thought that the increasing intensification of agriculture will have a negative effect, as it has had overseas.

In general, research and management is best conducted at a landscape scale (Norton and Miller, 2000; MacLeod *et al* 2008; Pawson *et al* 2010). Diverse landscapes will have higher conservation values – in the case of plantation forests, this diversity includes the proportion of native forest habitats, as well as the spatial juxtaposition of different-aged plantation stands and their proximity to native forest. The restoration of native bird species on farmland will require both an increase in the area and quality of native vegetation on farms and the adoption of suitable farming practices (Blackwell *et al* 2005). However, widespread adoption of biodiversity – or other environmental - goals on farmland is unlikely unless farmers see a commercial return, either directly or indirectly (Table 7).

Table 7: Biodiversity benefits (from Anon 2003)

Commercial production benefits	
Direct:	• Species are used and harvested to produce food, medicine, clothing and timber • Payment for environmental services (C and N trading; biodiversity credits)
Indirect:	• Pollination • Biological control of pests, weeds and diseases • Shelter • Weed suppression • Erosion management, nutrient retention • Improving soil microbial and earthworm activity • The maintenance of clean air and water
Other economic benefits	
	• Enhanced land values • Supporting a 'clean green image' – potentially important for retaining overseas market access • Tourism • The potential for payments for enhancing or protecting biodiversity (especially in Europe).
Aesthetic benefits	
	• People enjoy seeing species, landscapes and the ecosystems in which they live.
Existence benefits	
	• The value we place on knowing species and ecosystems remain in existence, e.g., New Zealand would be culturally diminished if, for example, one or more of our kiwi species, or the bellbird became extinct.
Cultural benefits	
	• The Maori concept of kaitiakitanga.
Conservation benefits	
	• Providing habitat for threatened or endangered species of flora and fauna
Recreation benefits	

Horizons Regional Council considers that both regulatory and non-regulatory (assistance to landowners) methods are essential for effective biodiversity protection (Maseyk, 2010). Some commentators are sceptical that the agro-industry can "use natural resources and at the same time facilitate persistence of indigenous biodiversity components at scales that contribute to national biodiversity goals" – without regulation (Lee *et al.*, 2008).

The best outcome for biodiversity would be increased indigenous forest cover on lowland areas which have been most heavily modified in New Zealand (just 6% of the conservation estate is below 100m elevation). Riparian planting is extremely important, as it provides both terrestrial and aquatic habitat, as well as improving water quality. The benefits of planted exotic trees are less widely recognised, and the un-thinned regimes favoured by carbon farming typically provide a less diverse habitat supporting fewer indigenous species. In contrast, the second rotation at Puruki (15km Nth of Taupo) research catchment (originally planted onto exotic pasture and managed on a sawlog regime) contained 17 vascular plant species in the understorey (Brockerhoff, *et al*; 2002). Larger plantation forests which contain a patchwork of age classes are more suitable habitats for many species than small fragmented woodlots, as clearfelled areas will usually have suitable areas in close proximity for displaced species to move into. It may also be more effective to protect existing remnants than to establish new forests.

The choice of role taken by Environment Waikato in establishing carbon forests will affect biodiversity outcomes if the nature of the forests established differs. For example, publicity surrounding the financial benefits of carbon farming may attract investors who purchase and afforest entire farms, while farmers who wish to stay on the land lack the cashflow to establish forest on sensitive areas. However, in general any increase in indigenous and/or forest habitat will be a biodiversity gain and a wealth of information is available to those who want to maximise the biodiversity gains from their carbon forests

Water protection

A similar situation applies to the enhancement and maintenance of water quality – the optimal solution for this purpose may not be optimal for carbon farming. For example, dense stands of very fast growing species can be used to extract pollutants from the groundwater and fix it into tree biomass. This approach relies on the trees then being felled and the biomass taken off-site, with a new crop being established. From a carbon trading point of view, the harvest results in a liability and the long-term average carbon stored is relatively low. Another example is riparian planting. 'Best practice' does not generally involve planting woody tree species right up to the banks (EW 2006) -although best practice is in itself a compromise between what is best for the waterways and what is best for farm profitability.

Water quality will be improved by converted whole catchments from pasture to forest, and this will also lower peak flood rates. The benefits come from displacing stock and ending fertiliser inputs, as well as filtering sediments and regulating stream temperature. Forests that are either not harvested or are managed on a continuous cover basis will be most beneficial, but plantations with unharvested riparian zones would be almost as good.

If farming is to remain the dominant land use, then carbon trading may allow financial hurdles to riparian planting to be overcome. Care needs to be taken to ensure that such planting is appropriate and not simply aimed at maximising financial returns from timber and carbon.

Soil conservation

The ability of trees to hold soil on slopes and thus perform an erosion prevention function depends on a number of factors:

- Species –growth rate, depth of root penetration, tensile strength of roots
- Soil –characteristics –clay content, underlaying bedrock, friability
- Site – slope steepness, rainfall pattern and intensity, land use.

For *P.radiata* and poplars, there has been work done by a number of scientists to calculate the tonnage of roots required to provide an effective root holding capacity (McElwee, 1998).

Poplars are well known for their deep root system and their ability to grow from poles. This makes it much easier for the farmer to stabilize soils on slopes and not lose the grazing potential of the pasture by planting poplar poles and protecting the poplar stem with a plastic, expanding sleeve.

However to become effective, calculations suggest that 14 tonnes of root biomass for poplars is required to hold soil on slopes and this occurs at different ages for different stockings of poplar plantings. For *P.radiata* the threshold has been calculated at 30 tonnes of root biomass per hectare. Further work is needed to validate these thresholds but they are useful in giving indicative comparisons.

Figure 13 shows root biomass for the species where data is available (West, *et al*, 2008).

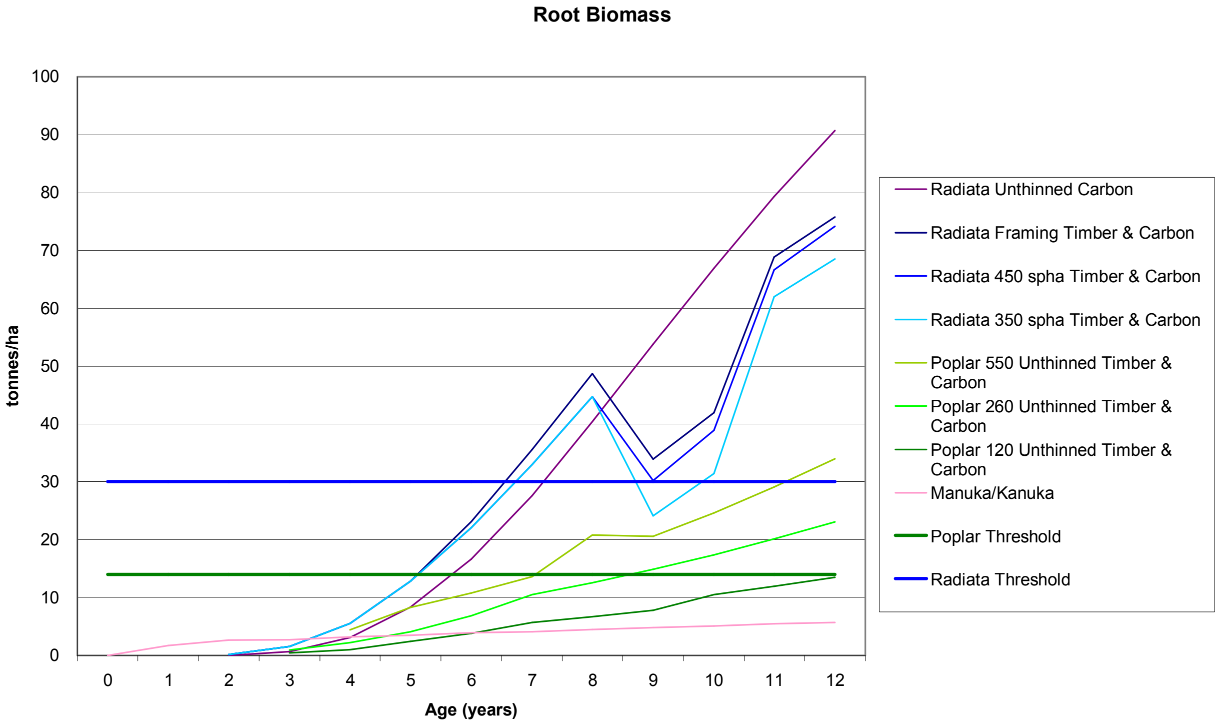

Figure 13: Tree crop root biomass for a range of species, tree ages, and stockings.

For poplars, one can see that root holding capacity occurs at

- age 7 for 550 sph.
- age 9 for 260 sph
- age 12 for 120 sph.

If the slope is already showing signs of erosion, then 12 years is a long risk period before root holding capacity becomes truly effective. However many spaced plantings of Poplar only occur where land has slipped, ie not continuous, and therefore at lower overall per hectare stocking than 120.

In *P.radiata*.the root holding capacity threshold is denoted at 30 tonnes of root biomass and this occurs about Age 7 yrs for the thinned regimes.

P.radiata has a shallower root system and lower tensile strength than *Poplar sp.* hence the greater tonnage required to reach root holding capacity.

To date we have not located any data on eucalypt species but given the tensile strength of eucalypts vs poplars and pines, we suspect that eucalypts will fall between the other two species in terms of tonnage/ha. as soil holding capacity.

From a soil stabilisation, soil holding capacity, there is merit in capturing the site as quickly as possible while also capturing carbon credits quickly (McLaren, P. 1996).

Fast growth equates to better soil stability adding to improvement in water quality by reducing erosion and reducing the amount of water available for runoff.

Adverse effects of plantations

It should be recognised that there may be negative impacts from tree planting depending on how it is planned and undertaken. Past planting booms that resulted in whole farms being planted "boundary–to-boundary" have had a negative backlash from rural and urban stakeholders. A more considered approach with some consideration of aesthetics and neighbours is needed.

Brockerhoff et al (2008) argued that establishing plantations on marginal farmland represented a lost opportunity to re-establish indigenous forests that could provide greater long-term conservation benefits. Since the plantation represents an improvement over pasture in environmental terms, this is perhaps a negative result only if the “business as usual” process involved natural reversion. Some exotic plantation species may be replaced by native forest through natural succession if left unharvested. Wildling spread (especially shade tolerant species such as Douglas fir which can establish within native forest) was also seen as a potential problem. The theoretical risk of “population sinks” or “ecological traps” was also noted, which refers to species moving to a habitat that cannot support a self-sustainable population, to the detriment of the existing population. This has yet to be demonstrated for New Zealand species.

Other potential issues include forest areas providing a refuge for pest and weed species and the impact of commercial forest harvesting and roading on erosion and water quality. Existing regulations and careful planning and execution of operations will minimise any negative environmental impacts.

Niche planting on dairy farms

Dairy farmers consistently report a lack of available land on their farms for tree planting, as land use is maximised for milk production. A range of opportunities for “niche” plantings have been suggested, including woodlots for spray-irrigation of effluent, short-rotation woody bioenergy crops (eg. willow), ETS-compliant riparian forest, and shade/shelter plantings.

HortResearch has carried out research[6] on the use of coppiced willows and poplars in effluent irrigation systems. Stands can be directly irrigated or used as riparian buffer zones to remove nitrogen. A major advantage of these species is that they can be coppiced and the foliage can also be fed to stock. Growth rates were highly variable over the three year study and affected by drought, pests and disease, but more nitrogen was removed than would be the case in irrigated and grazed pasture. However, with annual coppicing the woodlot would never meet the definition of forest under the ETS and even if the trees were allowed to reach 5m in height before harvest, the short rotation and low average carbon storage would make this an unlikely candidate for carbon forestry. The same applies to short rotation bioenergy crops, which tends to be grown in the same way. Regimes for effluent management and bioenergy production could be modified to allow the forest definition threshold to be met, although this would cause other difficulties (eg. in harvesting, handling, and feeding out) and the carbon income may not be enough to compensate for compromising the other objectives.

There are proven benefits from fencing and planting riparian zones on dairy farms and a wealth of experience and guidance on how this can be best achieved. Farmers are generally supportive although there are still some issues to be resolved. A review for the Auckland Regional Council on riparian widths (Parkyn et al 2000) concluded that while relative small grass buffers were effective at filtering sediment and associated nutrients, buffers of at least 10-20m were required to support self-sustaining native vegetation and protect most aquatic functions. Moderation of stream temperature requires 400m of continuous planting and shade. Forested stream channels tend to be wider than those through pasture, so there would be an initial increase in sediment loads until the stream banks reach a new equilibrium.

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[6] http://www.hortresearch.co.nz/files/projects/poplarandwillow/archive/dairy-effluent.pdf

Riparian planting can qualify for the ETS without meeting the 30m width requirement as long as the planting involves forest species capable of reaching 5m in height, and the planting is contiguous with an area that itself meets the forest definition. In practice this means that new riparian planting will need to be adjacent to a new woodlot or new area of regenerating forest of at least 1 ha. The cost of fencing and planting is significant and has often been subsidised. Farmers are generally concerned with loss of productive land and the cost, including on-going maintenance (eg. control of pests and weeds). Under the ETS there are also risks with flooding events that lead to unplanned carbon liabilities.

Shelterbelts less than 30m in width can qualify under the ETS on the same basis as riparian planting. Again, there are already good reasons to plant shelter for pasture and stock production and animal welfare reasons. There is also a wealth of guidance on the establishment of shelter using exotic or indigenous species, and other environmental and economic benefits may accrue. Farm management issues still need to be considered, including shelter maintenance and interference with irrigation, machinery and line-of-sight. Whether the carbon benefits obtained through registering what may be small areas of shelter belts or riparian plantings will outweigh the costs and risks will need to be assessed on a case by case basis.

Agroforestry regimes that mix stock and trees on the same land are less likely to be successful. Even with a high value tree species at a low stocking, both the pasture and tree performance is likely to be compromised. Trees would need to be protected from stock to prevent damage so ETS-compliant agroforestry on dairy land would not find favour with farmers. It should also be noted that tree species grown primarily for the production of fruit and nut crops do not qualify under the ETS. The retention and expansion of existing native forest remnants on dairy farms may be a better opportunity. A survey found that Waikato dairy farmers were generally positive towards native forest, but few had sought to actively conserve their forest remnants (Jay 2005).

Section 2. Investment Structures

Introduction

The introduction of the PFSI, AGS and ETS schemes has created new land use options and considerable compliance complexity for land owners to assimilate. For many land owners, especially farmers, the concept of forfeiting potential agricultural land into a long term occupation by tree plantations and gaining little or no revenue until tree harvest, has not been a favoured land use option. However, the prospect of gaining an early revenue stream from carbon units and having an alternative to revenues from a fluctuating agriculture sector, has renewed interest and improved the possible economic outcome for many farming enterprises.

A major issue confronting most land owners considering carbon forestry is how to finance a long term investment. Also, what business structure best suits their personal circumstances. Fortunately there are a number of possible investment vehicles that might be employed and these are discussed below.

Investment vehicles With Government assistance

Afforestation Grants Scheme (AGS)

This scheme was promoted by the Government with assistance from Regional Councils to encourage more investment (and land use change) in Kyoto compliant forests. As such land owners with land not in tree cover as at 31/12/1989 could apply for a grant to establish new forests.

The grant recipient owns the land and trees but the Government owns the carbon credits (and liabilities) for the first 10 years of plantation life. Thereafter the land owner would be responsible for liabilities but also receive carbon credits.

Essentially the full cost of establishment (~$2000 /ha.) is paid by the Crown to a successful applicant and he/she is responsible for establishing and maintaining the new forest. Grants are available for high yielding forest (>15m3/ha/yr.) and lower yielding species for conservation /riparian type plantings.

A secondary objective of the scheme was to address the environmental effects of farming. viz; erosion control , reduce nutrient leaching, mitigate flood peaks etc.

The scheme is administered by MAF and the Regional Councils (50% funding to each) and to date has been oversubscribed. If awareness of climate change and the need to effect land use change in the higher LUC's was part of the scheme's intent, then it has been very successful.

The current Government has announced a withdrawal of funding post 2012 which suggests they no longer think a subsidy for carbon farming is required.

East Coast Forestry Project (ECFP)

This scheme was initiated in the wake of floods and damage caused by Cyclone Bola in March 1998.

Much of the East Coast infrastructure north of Gisborne was severely damaged and there were numerous slips and loss of topsoils. Thus the government of the day set up this scheme to address these severe erosion problems e.g the Waiapu river near Ruatoria discharges **38 million tonnes of soil per year into the sea.**

The ECFP commenced in 1992 and is aimed at repatriating land that is likely to erode or more likely, is already eroding. The implication is that with topsoil and fertility down, growth of the resulting crop will be reduced and the expectation of economic return is not the priority.

The so-called “target land” is generally eroding land, but increasingly the ECFP staff are offering grants to plant land adjacent to the target land, in order to stabilise valley systems, soils and mitigate flood water peaks.

At the district level, the Gisborne District Council has identified land requiring erosion prevention treatment as **Overlay 3A.** This mapping effort identifies vulnerable catchments and watersheds and specifies that owners need to have a plan in place by 2013 and effective tree cover by 2021.

Unfortunately there is very little quantitative economic data, to indicate the benefits tree planting brings to erosion prone lands. However, previous studies indicate that tree plantings reduced soil slippage by 95% (Douglas, 2009). Also gully erosion is reduced by 50%, stream bank collapse by 24%, mass movement of foot slopes by 67% and mass movement of hill faces by 71% (DSIR 1992).

Naturally there is some dissent amongst land users over areas and extent of the need to retire land from grazing and convert to tree cover but some of the photos the ECFP staff have are compelling evidence in favour of a land use change.

The ECFP is still very much a timber utilisation scheme and as such operates a distance factor from Gisborne port. There is also an incentive to invest in silviculture and rules around initial stocking and thinning. (i.e. carbon sequestration was not part of the rationale in setting up the scheme.)

There is also a covenant requirement on the land which is eligible for grant monies. It is a 50 year covenant and effectively locks in the tree plantation land use for that period with restrictions on harvesting.

The pros of the scheme are that erosion prone land is going into tree plantations and stabilising hillsides which would otherwise end up in the sea. In the words of an ECFP staffer, “the money spent on creating 34,000ha over 18yrs (approx. $90million NZD) is considerably less than the damage costs from another Cyclone Bola (~$150million).

One could argue to the contrary; ie that money could be spent elsewhere for the same effect, or more compulsion should be applied to land owners to change from a non-sustainable land use. The Gisborne District Council Combined Regional Land and District Plan (CRLDP) requires that areas of land in Overlay 3A be treated with effective tree planting or reserve fencing. Overlay 3A is a directive to land owners to make changes and stop soil loss.

There is a human reluctance to admit that a known land use is unsustainable, perhaps best summed by an old kuia from Ngati Porou – “Why should we put the land into trees when my husband spent his whole life clearing bush to create farmland?”

Aspects of the timber end use from remote, steep and erosion prone land also needs review. There is a case to suggest that parts of this land should be “retired” into trees with no intent to harvest. Carbon sequestration may be an economic way of achieving this.

Permanent Forest Sink Initiative (PFSI)

This Government initiative was seen as a way of improving carbon sequestration, increasing permanent forest sinks and also gaining a number of other objectives – reducing soil erosion, reducing nutrient runoff, improving biodiversity and improving water qualities.

Though no grant monies was offered, the promise of AAU's (Assigned Amount Units) as the carbon credit was seen as international tender, as opposed to the NZU's (New Zealand units –carbon credits issued by the NZ Government).

The harvesting limitations –restricted for 99 years (later amended) and the land covenant required –restricted land use for at least 50years, have reduced attractiveness of the PFSI versus the more flexible ETS. The scheme is now seen as a way land owners can register riparian strips or small areas of planted native forest on their land and gain carbon credits.

Whilst there is a lot of emotion around the planting of NZ native species, the cost per plant, weed control costs and relative growth of native trees vs exotic trees, all summate to suggest a poorer economic return compared with fast growing exotics. There may be a case for the Council to consider funding assistance of native species plantings for riparian strip exclusion zones, on account of improved biodiversity reduced nutrient loss into waterways and retaining of soil rather than economic return. The only possible exception to this is manuka, which is discussed later.

Lake Taupo Protection Trust initiative. (LTPT)

This Trust was set up in Feb 2007 to administer a fund to encourage land use change and also help protect water quality in Lake Taupo by reducing the amount of nitrogen flowing into the lake.

Various land uses "leak" varying amounts of nitrogen leachates (as modelled by "Overseer"- a computer model which measures inputs and outputs of farm production.) Dairy farming excretes 30-40 units of nitrogen/ha / year; sheep and cattle farming excretes 13-17 units of nitrogen /ha /yr. and a plantation forest excretes approximately 3 units of N /ha/yr.

By changing from sheep and cattle farming to planted forest, 10-14 units of N can be claimed by the land owner from the land use change. At ~$400/ unit, this cash incentive can be used by the land owner to plant forest or farm elsewhere outside the Lake Taupo catchment area. The Trust is charged with spending some $80 million NZD on this land use change and a number of land conversions are now proceeding in the Taupo basin. The LTPT requires a covenant on the land in return for the nitrogen credit and this covenant lasts for 999 years.

Investment vehicles without Government assistance

Carbon Emitter; Investor; Land Owner

The nitrogen reduction initiative has promoted some innovative arrangements in terms of investment vehicles. In one such example, there is an arrangement between a power producer (the emitter) who has a need to buy carbon credits, an investor who wants to invest in the carbon sequestration space and the land owner who is interested in farming on parts of his land but happy to forfeit poorer parts of the farm to tree plantations, in return for nitrogen credit monies.

The revenue from the carbon is shared between the investor and the land owner according to their assessed contributions. Given the uncertainty over how the carbon market will develop, the introduction of a buyer for future carbon credits has made the whole development much less risky.

It also allows farming to proceed on the better parts of the farm whilst reducing overall nutrient runoff –in other words promotion of better and more sustainable land use. At a time when revenues from sheep and cattle farming have been marginal, this land use diversification is seen as positive by most authorities.

Carbon Emitter; Investor; Maori Trust

This is just a variation on the same theme but often Maori Trusts do not have the development monies to change land use. A large portion of the Lake Taupo catchment area is owned by various Maori iwi. The nitrogen credits from LTPT and the carbon emitter wanting to help protect water quality and water availability for downstream power generation has made this land use change possible.

Quite often the Forestry Right legislation is enacted for this sort of investment vehicle and this gives safeguards to all parties involved. For most parts the Forestry Right involves a lease of land for a specified time (with regular rent reviews) but there may be some carbon sharing or share of timber revenues if timber production is planned for the plantation estate.

Farm Plans

Whilst an indirect form of Government assistance, farm plans as employed by Horizons Regional Council and in a small way by the Hawkes Bay Regional Council, (Wairoa Sediment Reduction Initiative) have helped promote land use change also. The original objective was to reduce erosion and mitigate flood damage, but the development of a carbon trading scheme is changing the way some of these joint ventures are being written. Recent JV's by Horizons Council have involved a sharing of the potential carbon revenues according to the relative inputs from the parties. The farm plan itself also helps focus attention on the farming enterprise, the land capabilities and what parts of the farm business, and which land uses are profitable.

Horizons have written some 300 farm plans covering approximately 15,000 ha of erosion prone land in the Manawatu region in the last 5 years. Council staff see the farm plan investment as the best way of gaining farmer involvement in land use decisions.

Joint ventures in forestry with forestry companies

These schemes were in vogue in 1980s, with large forestry companies such as NZ Forest Products; Carter Holt Harvey and Fletcher Challenge Forests. Their forestry successors (Harvard, Rayonier; Taumata) have kept these JV's going but many partnerships are just starting to grapple with the implications of carbon revenues and liabilities. Most of these JV's were developed before carbon sequestration and carbon trading became a reality.

Under the ETS legislation, the land owner has rights to both carbon credits and also the carbon liabilities should anything happen to the forest (windblow, fire, disease) or the forest is harvested. If the forest is only one age class (all established in the one year) then the liabilities cannot be easily mitigated by spreading risk and revenue over a number of age classes. Maori Trusts who have a long term view of land assets are fearful of what this liability might mean for future generations. Again uncertainties around carbon markets and their future are not helping in this regard.

In time there will be an arrangement of carbon sharing worked out between the forestry companies and land owners, in order for joint venture partnerships to persist. The investment model of a land owner diversifying his /her income from the land, whilst the forestry company gains volume for the processing plant without having to buy land still has merit. Many of the forestry companies have large plantation holdings in addition to the joint venture forests and could fashion an insurance or acceptance of the liabilities whilst mitigating against the growing estate.

Managed Investment Funds

Once the carbon market gains more acceptance both locally and globally, there will be investment funds looking for land to buy or rent via joint ventures with land owners. A fore runner of this sort of investment vehicle was Sustainable Forest Management (SFM) which sought to address some 30,000 hectares of erosion prone land owned by Ngati Porou Forest Corporation on the East Coast.

The scheme suffered from poor finance arrangements, overseas investment issues and did not last, but the model of an investor developing a joint venture with a land owner (in this case, a Maori tribe) and using Forestry Right legislation whilst promoting better land use and local employment is quite an attractive one.

Investment by land owner

Within New Zealand, there is a thriving Farm Forestry Association and by the NZFFA's own estimates over 100,000 ha. of plantations in farm forester ownership. There is considerably more area employed through partnership, syndicates etc. and much of it dated from a period of high wood prices in the mid 1990's. All this plantation investment was conducted because individuals assessed investment in forestry to be useful diversification and profitable.

Whilst the carbon market remains poorly developed or uncertain, investors are reluctant to engage. But if perceptions improve, then individuals or groups will again seek land for afforestation. It may be for carbon, timber, environmental values or a mixture of all of these.

Whilst sheep and cattle farming returns are not very good at present and certainly not allowing farmers the luxury of diverting excess income into plantations, some dairy farmers are considering carbon emission offset plantings.

Kyoto rules do not allow for the removal of forest for another land use (say dairy farming) and re-establishment of new forests on another site (offsets). However this is being discussed in global forums on climate change and there may be changes in regulations to allow this in the future. Some of the larger dairy farmers are looking for property which could double as run-off grazing land and also for afforestation to offset their farm carbon emissions. This direct investment vehicle by the land owner (s) will remain a large part of future plantation development, with carbon sequestration as part of the investment consideration.

Investment in compatible land uses

Carbon sequestration can be achieved as a by-product of a number of other tree crop ventures**.**

Manuka (*Leptospermum scoparium*)

Most attempts to promote native forest species for carbon have been thwarted when the investor discovers that most NZ native species grow very slowly compared to some of the exotic plantation species (<8m3/ha/yr. vs 25-30m3/ha/yr). At $20/tonne of carbon this translates to considerable revenue difference.

However manuka honey has been determined to have superior antibacterial properties and certain strains of manuka have high UMF. (UMF =Unique Manuka Factor). This is a proxy measure for antibacterial potency and the market for wound dressings is such that a premium is paid for high UMF honey.

On certain sites in NZ it is possible to gain revenue of approx. $1000 /ha/yr from manuka honey collection and this compares favourably with MAF figures for Waikato hill country sheep and beef farm returns.

At present there is action to form a cooperative company that would involve farmers/land owners; beekeepers; honey marketing companies, such as Comvita. Once this cooperative is formed and improved returns flow back to the land owner, then the potential for expanding the manuka estate by planting will improve significantly.

Some farmers and foresters will find irony in this development with manuka, as the predominant species on reverting land is often manuka.

Truffles
Certain varieties of subterranean fungi (mushrooms) grow in symbiosis with certain tree roots, often in mycorrhizal association. With the right set of environmental conditions; soils, climate, tree species and fungal symbiont, the amount of fungal growth is enhanced.

These fungi are harvested using specially trained dogs or pigs that sniff out the underground fungal growths which are sold as food additives. Most local growers are trying to grow highly prized truffles e.g. *Tuber magnatum* which grows best on hardwood roots (oak,birch,hazel) and in neutral to alkaline soils.

Ginseng
Ginseng is a root of a Panax plant (*Panax ginseng* or *Panax quinquefolius*) favoured by a number of Asian societies (particularly Korea) as a food additive and health tonic.

The root portion is harvested and powdered for inclusion in drinks and tonics. Ginseng grows under forest trees in filtered light and can be managed as another crop under pine plantations.

Key drivers in investment decisions

The major drivers vary according to the organisation and type of land being considered for plantation forestry. A public entity such as Environment Waikato seeks environmental benefits from land use where it can, eg clean water. It is worth noting that most of the public funded afforestation schemes have arisen from a major weather event –such as Cyclone Bola. Thus you could say the ECFP is mainly about public good –trying to avoid another cyclonic event causing major damage. The general rationale is that the 34,000 ha created during the life of the ECFP (18yrs) is money well spent as insurance /mitigation against future damage.

An investor interested in carbon forestry has an economic return objective as the major driver and wishes to maximise IRR / LEV or NPV whilst enjoying the environmental benefits that come from increasing afforestation on marginal hill country lands. Even farm foresters who may have quite small forest areas on their farms are interested in economic returns and market acceptance, which may affect their species choice for planting.

Since NZ plantations are > 90% *P.radiata*, you get both reactions amongst small growers or intending growers of plantations; those that opt for *P.radiata* as it represents less market risk. Those that have an aversion to *P.radiata,* seek species diversity and different landscape values to their farm.

In a Hawkes Bay study by West, *et al*, (2008) the most profitable species to grow for carbon was *E.fastigata* (see section 1). Paul, *et al* (2008), found similar results where eucalypt species gave improved returns for carbon against *P.radiata* on account of fast initial growth and higher wood density.

As the carbon market develops, this may alter the mix of species being planted for carbon objectives, as investors chase better economic returns and more biodiversity in the landscape.

One of the emerging major drivers for sheep and cattle farmers is the desire for a land use that offers better economic returns and some buffer against the variable returns from sheep and beef farming. The advent of the carbon market and potential returns from quite early in the rotation has heightened interest amongst farmers to land use change.

Land owner attitudes have been researched and reviewed by a number of studies, these are summarised in appendix 2.

Section 3. Coordination and Support

Range of possible roles for Environment Waikato

Section 2 has discussed the results from farmer surveys and made suggestions on roles that arise from the results.

In addition, potential roles identified by Environment Waikato include:

- a passive role where information is provided to landowners, but no economic stimulus or help is provided to support land use change,
- a fully active role where Environment Waikato seeks to form a collaborative or joint venture style relationship with the land owner and directly supports afforestation of marginal land,
- a governing/risk management function where Environment Waikato provides a regional or inter-regional carbon aggregation service to small land owners to minimise risk through carbon pooling.
- a regulatory role where Environment Waikato achieves its environmental objectives through policy and regulation.

Environment Waikato has an investment portfolio and a number of environmental objectives as part of its core purpose. Thus it has the potential to take the role of financial facilitator for land use change, whilst gaining improvement in some of the environment parameters. Several of these roles fit with the business structures that are discussed in Section 2.

Information sharing

Currently, Environment Waikato is taking a passive role by making information available to landowners and encouraging debate, and this is supported by local initiatives such as nitrogen trading and central government initiatives such as the ETS, AGS and PFSI. However, progress toward environmental targets could be improved. A more targeted information campaign may help but there is growing evidence that landowner attitudes and cash flow constraints are strong barriers to establishing tree cover on farmland.

Funding for planting

A more active, collaborative approach could take the following form. For example, a farmer has a portion of his land that is prone to erosion and any soil loss could add sediment to one of the Waikato's river systems. Because of poor returns from the farming enterprise, there are insufficient funds to change land use and establish plantations on the identified land. Environment Waikato could offer to fund establishment of the trees in return for a share of the carbon and timber that might result from the tree growth. The AGS provides a potential model for this type of approach. There may be a time period specified, like the AGS or a rotation period chosen.

Even if this more active role is undertaken, there will still be a need to take a facilitation role with farmers and land owners, advertising the benefits from carbon sequestration to the farm, the region, and sustainability of the farming enterprise, so that there is more acceptance of land use change and its positive economic and environmental benefits. This could involve detailed "Whole Farm Plans" for representative farms. The Council could also have a role in bringing investors and land owners together for land use change.

Regional coordination

The third “regional coordination” role may be required if Environment Waikato has a financial stake in carbon forests, but could be adopted regardless. This role would require Environment Waikato to use its resources and networks to help mitigate liabilities and bring more certainty to the carbon market by helping with insurance, carbon pooling amongst smaller forest owners and using some of its land use planning resources to help improve plantation siting on farms so that both environmental and commercial objectives are considered.

Carbon pooling would involve putting together groups of small forest owners so that the collective tonnage makes sense for sale by a carbon trader. The Council may be able to facilitate insurance cover and carbon liability mitigation by its local government buying power and providing seed capital to get this sort of business started initially.

Mechanisms for regional coordination

The market theorists hypothesise that the environmental problems in New Zealand are due to market failure, ie the value of environmental services and cost of environmental damage is not captured by conventional markets, so correct signals are not delivered to those responsible for land use and land use change. Cap-and-trade schemes are one way to capture these externalities and involve setting a upper limit for existing practice and beyond that participants must buy units to mitigate going above the cap. While cap-and-trade schemes (eg Lake Taupo nitrates) are good initial steps to adjust perceptions, the level of the cap first negotiated is generally too high to rectify the problem and only creates a holding pattern until there is political acceptance for a second round. Also, there is no guarantee that these markets will not also experience failures – some existing forests within the region was undoubtedly cleared ahead of the 2008 deadline as a perverse outcome of the upcoming ETS introduction. An alternative would be to calculate values for these environmental services and offer some of this value as an inducement to the land owner to change land use.

As discussed in Business Structures in Section 2, a key mechanism for coordination of the carbon strategy is likely to be direct financial incentives.

The investment portfolio of Environment Waikato will have a target minimum return on investment to be achieved over time and part of the council’s role will be to ensure this hurdle rate so that rate increases are minimised over time. The difficulty for Council will be to arrive at a rate of return deemed satisfactory, if environmental values are considered an important part of the investment decision. It may be that a lower rate of return is acceptable if good environmental returns are achieved from the investment, but these environmental benefits are difficult enough to quantify - in terms of soil retention, improved water quality, lower flood peaks, biodiversity etc – let alone monetary value.

Advocacy in Councils

Environment Waikato already has Land Management Offices who advise and inform land owners to consider their environmental footprint, the sustainability of their farming operations and best practices. Environment Waikato could possibly establish “champions” within the District Councils in the region who advocate for the above objectives and suggest ways and means they can be achieved.

It may start from a desire to reduce nutrient or turbidity in the Waikato River and work back to what that means in land use change or it may start with the land owner’s pocket. The farm interviews cited in this report suggest that antipathy to land use change is often based on inertia to change and ignorance of alternatives.

Section 4. Conclusions

This report presents;

(i) the on-farm financial and environmental opportunity and off-farm environmental opportunity from integration of carbon forestry into farming enterprises within the Waikato region;

(ii) the barriers to realising these opportunities; and

(iii) the various roles that Environment Waikato could play in overcoming these barriers to realise the on-farm and regional opportunities.

This report takes a broad view of forestry considering a variety of species such as radiata pine, *Eucalyptus fastigata*, and redwoods, management regimes, and purposes (timber and carbon, riparian, permanent forests).

Economics

The New Zealand Emissions Trading Scheme provides land owners with the opportunity to realise a cash flow from carbon forestry through the sale of NZUs earned from carbon sequestered in their forests. This significantly improves the financial aspects of traditional forestry by addressing three historical barriers to integrating forestry within farming enterprises.

Firstly, carbon forestry overcomes the typically 30-year delay in realising revenue from the initial investment in establishment by providing the opportunity for annual revenue from the sale of carbon credits. While initial cash flows from carbon forestry are negative ($500/ha/yr to $1500/ha/yr in the first five to seven years depending on tree species and management), beyond age five, cash flows increase to between $500/ and $1000/ha/yr by age 10.

Secondly, carbon forestry provides significantly higher returns than traditional timber forestry alone. For radiata pine managed to produce clearwood from pruning and thinning, timber returns are around $90/ha/yr[7]. Combining timber returns with revenue from carbon sequestration can increase returns more than five-fold to between $160-$520/ha/yr for carbon prices of $7.50/t CO_2-e to $30/t CO_2-e. Carbon forestry returns at the current carbon price of $20/t $C0_2$-e are approximately $400/ha/yr to $600/ha/yr, which exceeds the Economic Farm Surplus for most sheep and beef enterprises and is comparable with returns for the top performing intensive finishing sheep and beef farms in the Northern North Island. This comparison ignores the potential negative impact of the Emissions Trading Scheme on farm returns under livestock production, which would further favour carbon forestry. However, even under ideal circumstances for carbon forestry, with a $50/t CO_2-e carbon price and radiata pine managed purely for carbon, returns of $1,600/ha/yr are unlikely to exceed returns from a typical Waikato dairy farm.

Thirdly, carbon forestry provides more certainty of annual revenue from forestry by not being reliant on future timber returns. An additional benefit of carbon forestry within the context of the on-farm impacts of the Emissions Trading Scheme is that it provides protection against the impact of fluctuations in the price of carbon on farm enterprise liabilities from GHG emissions; when emission costs are high, carbon forestry revenues are also high so offsetting the higher emissions costs.

These improvements in the financial aspects of forestry enhance the traditional on- and off-farm benefits of appropriately integrating forestry within farming enterprises. When financially viable forestry options (based on the sound choice of tree species, management, block size, mix of tree ages) are correctly sited on the poorer producing

[7] Estimated for a 25 year rotation and an 8%/yr discount rate (Turner et al. 2008)

land on a farm, several on-farm benefits can be realised. Firstly, forestry provides an alternative source of revenue from timber to counter periods of poor returns from agricultural products or provide funds for investment elsewhere in the farming enterprise, e.g. resowing, farm equipment, roading, fencing, etc. Secondly, moving less productive areas of the farm out of pasture, and into forestry, enables resources to be concentrated on the most productive areas of the farm to enhance production of the remainder. Thirdly, forests can be used to increase animal welfare (and hence production) by providing shelter during hot periods in the summer and cold periods in the winter. Fourthly, forests can provide on-farm environmental benefits such as controlling rising water levels, reduction of erosion, and maintenance of biodiversity. This report has presented findings from a number of farm case studies that demonstrate these multiple benefits from appropriately integrating carbon forestry in farming enterprises, especially sheep and beef enterprises.

The off-farm benefits of carbon forestry are predominantly environmental, and are strongly influenced by where carbon forestry occurs (within a catchment or range for an endangered species for example) and the forest species and management applied. A number of studies have identified numerous environmental benefits from forestry including control of rising water levels during high rainfall, improved water quality, reduced sedimentation in waterways, reduced diffuse erosion, and maintenance of biodiversity. The impacts on the regional economy and employment of integrating forestry within farms are significantly influenced by the extent to which agricultural and forest products are processed within the region. As there are a number of major wood processors within the Waikato (Kinleith pulp and paper mill, one MDF mill and approximately 10 sawmills) economic impacts may at least be neutral, though direct estimation of these impacts was beyond the scope of the current study.

Attitudes of Land Owners

While farmer interviews indicate that sheep and beef farmer perceptions of carbon forestry are neutral to positive, and dairy farmers' perceptions are negative to neutral, there are a number of barriers to integrating carbon forestry on farming enterprises in the Waikato region. These barriers are predominantly related to farmer attitudes towards carbon forestry and their perceptions of the relative benefits and costs.

Firstly, carbon forestry is seen as directly competing with pastoral-livestock production, so preference is given to developing forestry on the least productive land on the farm. Most dairy farmers characterised their farms as having little or no land suitable for carbon forestry, reflecting the high returns from dairying. Where dairy farmers did consider forestry as an option they identified small and/ or fragmented areas of potential for planting, or preferred investing in forestry off-farm.

Secondly, sheep and beef farmers often identified a lack of cash operating surplus as a significant barrier to being able to invest in the establishment of carbon forests.

Thirdly, many farmers admitted that they lacked knowledge of the Emissions Trading Scheme, other afforestation schemes (e.g. PFSI, East Coast Forestry Project), the costs of establishing and maintaining forestry blocks, forest management, and the appropriate sitting of forestry on their farms.

Fourthly, farmers perceived carbon forestry as risky due to uncertain changes in future carbon prices, especially due to policy uncertainty, a low expected future value of timber, and the obligation to surrender carbon credits at harvest.

Roles for Environment Waikato

The barriers identified above suggest a variety of roles for Environment Waikato in overcoming these barriers to realise the on and off-farm benefits of carbon forestry within the Waikato region. These roles include:

1. Providing farmers with extension support and locally relevant information on the Emissions Trading Scheme and forest management., Addressing information gaps, demonstrating the relative merits of forestry and pasture, and addressing constraints to land use change
2. Working with farmers to develop farm plans incorporating carbon forestry where this enables farmers to increase the financial and environmental performance of their whole farm system. An important aspect of this will be helping farmers to identify the size and location of less productive areas of their farm and how to optimise the remaining agricultural component of their farm. Appendix 3 reviews new tools and technologies that may help with this.
3. Either direct financial support to cover upfront establishment costs, e.g. the Afforestation Grant Scheme, or matching purchasers with sellers to enter into joint ventures
4. Provision of mechanisms that increase the certainty of future carbon price, particularly at harvest. Mechanisms include facilitating:
    - carbon pooling amongst a group of farmers so that harvest liabilities for some are offset by sequestration in others forests, and upfront payment for carbon sequestered over the rotation
    - management plans that enable individual farmers to pool their credits by creating a mix of forest ages on their farm and recommending forest management regimes that also provide timber revenue to offset carbon liabilities at harvest
    - short-term hedging at the time of harvest

The specific nature of the investment structure and incentives may best be tailored to the class of land and owners circumstances. For illustration purposes, a matrix of options are suggested below that have simplified the complex variety of land ownership circumstances. The areas given for subsidisation and limits for qualifying are only indicative and not recommendations.

Range of options by land productivity class

Option	Average 5-10 LSU/ha	Average 11-15 LSU/ha	Average 16-20 LSU/ha
Plant the lowest producing 75% of property	All steep and eroding land classes planted, some retirement, subsidisation of planting by EW. Possible sale of property to investor. House and sheds retained as lifestyle farm, land use planning assisted by EW.	Not applicable	Not applicable
Plant the lowest producing 25% of property	Significant economic improvement, full subsidisation of planting by EW	Moderate economic improvement, some subsidisation needed by EW.	Not applicable
Plant the lowest producing 10% of property	Improves cash flow, moderate subsidisation of planting by EW.	Improves cash flow, little subsidisation by EW.	Small economic impact if agriculture joins ETS, mitigates effluent pollution risk EW assists with planning.
Plant Riparian zones only	Not applicable	Small economic impact, but mitigates sedimentation risk, EW assists with planning.	Some economic impact but mitigates effluent pollution risk, EW assists with planning.

Recommended next steps for Environment Waikato

1. Further scope the regional opportunity for carbon forestry to identify areas where forestry under the ETS is a financially viable option and how the extent of forestry would be influenced by different mechanisms of additional support. This information can then be used to:
   - Estimate the regional economic and environmental benefits, including the sectors within the region that would potentially gain or lose from a Waikato Regional Carbon Strategy
   - Identify the extent to which the strategy would enable forestry to address areas of environmental concern within the region, i.e. are forests likely to be planted in the areas of the region with the greatest environmental issues
   - Identify the most cost effective opportunities for providing environmental benefits, i.e. areas where there are significant environmental issues that could be addressed by forestry and the financial benefits from forestry are greatest

2. Undertake an examination of landowner attitudes to tree planting within the Waikato region to identify the characteristics, goals and barriers for different farmers adopting carbon forestry

3. Undertake at least three in-depth on-farm case studies for different farm enterprises. These can then be used to demonstrate the financial and environmental benefits of appropriate integration of carbon forestry within typical farming enterprises within the Waikato region. These case studies should also explore the farmer decision-making process, roles Environment Waikato could take in overcoming barriers to adopting carbon forestry, and suitable investment vehicles for supporting carbon forestry. Key to the success of the case studies will be (i) that the case study participants are relevant to and trusted within the farming community, and (ii) the integration of carbon forestry within the farming enterprise meets the farmer's goals..

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Appendix 1. Summary of species options

Species	Site selection	Climate Risk	Pests/Disease Risk	Market Risk	Advantages cf *P. radiata*
Radiata pine	Very site tolerant. Best on warmer latitudes, lower altitudes, on sloping and well-drained ex-farmland. Rainfall above 500 mm and preferably above 1000 mm.	Low - very resistant to drought and moderately resistant to frost; easily damaged by strong winds or wet snow.	Low – although pine pitch canker and Western gall rust could be very serious if introduced	Low – versatile, widely traded.	
Douglas-fir	Best with moderately high rainfall (1000 to 1500 mm annually), moist, free-draining, uncompacted soils. Avoid cold flat sites with no air drainage. Out-performs radiata pine at higher altitudes.	Low – susceptible to drought before canopy closure.	Medium - Swiss needle-cast fungus causes productivity loss	Low – established world structural timber market	Much more wind and snow-stable. High long-term carbon storage; potential for continuous cover management.
Coastal redwood	Prefers sheltered inland localities such as valley floors, gully bottoms and river flats with deep, fertile, moist but well-drained soils, relatively high humidity, and reasonably high, well-distributed rainfall	Medium - vulnerable to out-of-season frost, drought and wind.	Low	Medium – single market (California); possible durability issue with NZ-grown wood	High long-term carbon storage; potential for continuous cover management.
C. lusitanica	Prefers mild areas away from the immediate coast. Relatively demanding in respect of shelter, fertility, and moisture supply, especially during summer. 1000-3000 mm rainfall, constant humidity. Key productivity drivers include potential root depth, fertility, average minimum temperature, and number of ground frost days in summer.	Medium, or low if sheltered from wind and rainfall is adequate.	Medium - cypress canker a serious problem, particularly in *C. macrocarpa.* Soft bark is highly palatable to sheep, cattle, hares, rabbits and possums.	Very low - market demand in New Zealand is not satisfied.	Naturally durable wood, potentially higher value.
Eucalytptus fastigata	Prefers free draining soils and frost free areas*. Relatively slow initial growth, so	Climate – medium	High for eucalyptus spp in general – lower for E. fastigata.	Medium -sawlog conversion issues	Huge economic advantage if production

	weed control needed.			and small resource scale	of high quality sawlogs from young stands can be routinely achieved.
Poplars	Best in moist valley bottoms and lower hill slopes.	Medium – not drought resistant, out-of-season frosts, wind	High - rust, possums	High – no intrinsic quality advantage cf radiata	Very cold tolerant in winter; can use for stock feed; no winter shading of pasture.

*Experience of authors indicate *E. fastigata* is more robust than this and can tolerate moderately heavy soils and frosts as demonstrated by extensive planting in New Zealand and its natural range in Australia

Other species:

Blackwood (*Acacia melanoxylon*) and Black Walnut (*Juglans nigra*) have potentially high log values, but low stand volume (and carbon) growth and are very site specific. Kauri and totara have relatively slow growth rates

Appendix 2. Land owner attitudes

The purpose of the ETS is to give land managers an economic incentive to change their management practices. However, individual land owners differ in their situations and farming objectives, perceive information in different ways and therefore make different land use decisions. Several studies have examined the factors that influence decision-making related to farm management changes in general (e.g. Morris et al 1996), tree planting (e.g. Fairweather 1992) and the ETS in particular (e.g. Rosin et al 2008). Some of these studies have examined the policy implications of land owner attitudes, including the factors that are likely to make an intervention successful.

A common theme is the very different demographics of sheep/beef farmers and dairy farmers. The latter tend to be much younger, have much less farming experience and have higher qualifications. The two industries are also structured differently and there is greater diversity in sheep/beef farm management. Sheep and beef farming has been much less profitable. These factors affect the attitudes and goals of farmers. For example, Morris et al (1996) expressed the primary aim of the sheep/beef farmers in their survey as:

> ”*to be able to remain farming and to obtain returns for their labour and investment that allow them a reasonable standard of living, based on increasing the profitability of the farming operation.”*

These farmers emphasised profitability and the need to “farm safely” (ie. a conservative, risk-minimisation approach). They had sought to increase profitability by reducing labour requirements or increasing efficiency. Maintaining flexibility and conservative management were seen as the best way to minimise risk. It was noted that during the downturn with the removal of SMP’s and prolonged drought, many innovative, progressive farmers lost their farms as they were over-extended financially. This conservatism included a preference to trial innovations at a small scale before adopting them.

Dairy farmers in the survey were mainly production-oriented; their goal was:

> ”*to get the farm up to potential production and increase profit”*

These farmers emphasised increasing production, increasing efficiency and control by monitoring production. New practices were adopted if they lead to more efficient use of labour and capital, including greater use of consultants and contractors. A separate, smaller group of dairy farmers were described as having a “self-sufficiency” orientation – these tended to be older, established farmers with smaller farms and from family farming backgrounds. Generally they had lower stocking rates, were self-sufficient in terms of supplementary feeds, used fewer contractors, and did not employ farm advisers or attend discussion groups. They often had other farming interests including pigs, cattle and pedigree breeding.

Morris et al (1996) went on to discuss the experiences and attitudes of these farmers in the context of technology transfer, noting that farmers:

- distrusted any agency which “pushes” technology;
- perceived a lack of accountability in people giving advice;
- believed that they could seek information themselves rather than receive directive advice;
- had a preference for information derived from local trials rather than the implementation of national programmes.

Holloway (1999) also highlighted the way farmers differentiate between ‘distant’ and ‘local’ forms of scientific knowledge – in the context of the relevance global warming to agriculture this was seen as a barrier to a shared understanding between scientists and farmers. Rhodes et al (2001) conducted 35 interviews and six focus groups involving a further 100 North Island hill country farmers. They found that efforts by farmers to improve the environment were often in response to a perceived problem such as erosion, while principles of sustainability - in particular the interdependence of economic, social, institutional and environmental conditions - were not fully accepted:

> *“Physical evidence backed by established agricultural science promotes a response and has a credibility among farmers, which the ecological sciences lack.”*

As one consequence, it was noted that farmers readily identify with visible environmental issues, such as soil erosion, weeds and pests, but have less awareness of “invisible” issues such as water quality (and by inference, greenhouse gas emissions). The importance of the local was again stressed. Survey participants were described as passionate about where they lived, and it was suggested that harnessing this pride and passion about the local environment and community may offer the key to seeking land use change. Time was noted as at least as big a constraint as money.

With respect to tree planting by farmers, past research has found that farmers are generally reluctant to replace pasture with trees and give a variety of reasons for planting. Fairweather (1992) reviewed nine studies ranging from small case studies to national random samples of land owners. Direct financial benefit from timber ranked behind shelter, ‘best land use’, and aesthetic considerations. However, the author observed that the low ranking for timber returns probably reflected the relative economics of agriculture and forestry in the past.

Fairweather (1992) went on to develop decision trees in an attempt to determine which factors were most important in decision making. Separate decision trees were developed depending on the type of planting considered: woodlots, shelter, agroforestry and poplars/willow. In each tree a number of ‘elimination factors’ removed farmers from reaching the decision point of whether to plant that year or not. The elimination factors for all planting types were:

- belief that trees would not grow
- previous experience of low forestry returns
- belief that stock do not need shelter
- already have shelter from other trees
- have never heard of agroforestry
- are uncertain about agroforestry
- belief that poplars and willows do not give benefits
- have no need for benefits from poplars or willows
- already have sufficient trees (of each type).

Farmers not eliminated then go on to make the key planting decision based on their perceptions of the relative merits of forestry and the current land use, as restricted by three constraints: commitments to some other form of tree planting, lack of time due to other farming operations and lack of cashflow. This made it possible to identify four basic groups within the case study when faced with the decision to plant a woodlot:

- those who do not even consider planting woodlot trees because they believe trees will not grow, they have been put off by past experience or they already have enough woodlots;
- those who can find no reason to plant;
- those who plant woodlots typically because they are a better land use on the worst of their land;

- those who see forestry as providing better return than grazing, with the financial returns being the main factor in their decision to plant.

The decision trees therefore assist with the development of strategies to promote land use change. The first is to address the ‘elimination factors’ by which farmers exclude themselves from the possibility of tree planting. Often these reflect an information gap (although it should be remembered that information may need to be local to be trusted). The second relates to the relative merits of forestry and pasture as economic land uses. Case studies which address both the economic performance of the trees and the real performance of the specific piece of land planted may help here. A third strategy addresses the constraints – the lack of time and money for planting. Finally there were technical issues that could be tackled, such as the lack of knowledge of forestry operations and their labour and cost requirements. Implementation details of carbon forestry and carbon trading would be included here.

The general approach used in the decision trees remains valid, although there is clearly a need to re-examine landowner attitudes to tree planting in the light of the subsequent planting boom, subsequent decline and introduction of government initiatives such as the PFSI, AGS and ETS. A University of Canterbury PhD student is currently surveying 2500 land owners to investigate how landowner characteristics and preferences influence decisions to plant forests.

More recent studies have looked specifically at attitudes toward efforts to curb greenhouse gas emissions including the ETS. In his Masters thesis, Fowles (2009) interviewed 23 Taranaki dairy farmers, investigating their attitudes towards global warming and emissions reductions in general, and specific barriers to the use of nitrogen inhibitors and riparian planting. Half did not believe in the concept of climate change, while others thought there might be change but that it was cyclical and would right itself, or that the change would have positive consequences. Unsurprisingly, they overwhelmingly saw the introduction of the ETS in negative terms. In contrast, there was a high level of riparian management (fencing and planting) and a positive attitude towards the regional council’s riparian programme. Few farmers were keen to plant more of their land, although some considered the need was inevitable or would consider it as a last resort. Most believed that they either had enough forest already or would plant off-farm if necessary. One considered that it was ethically wrong to take land out of food production.

It is clear that future uptake of carbon forestry will be strongly dependent on farmer attitudes towards having commercial or conservation plantings on their farms and also their perceived costs and benefits. Both Rosin *et al*. (2008) and Sinclair *et al*. (2010) interviewed farmers to determine their perceptions of carbon forestry as a potential new enterprise to help offset livestock green house gas (GHG) emissions liabilities. In total, 13 North Island dairy farmers, one South Island dairy farmer, three North Island sheep and beef farmers and 17 South Island sheep and beef farmers were interviewed. The dairy and sheep and beef farms ranged in size from 70 to 220 ha and 141 to 3000 ha, respectively. The farms also varied widely in stocking rate, enterprise configuration, and ownership structure (Rosin *et al*. 2008; Sinclair *et al*. 2010). While the small number of farmers interviewed is not sufficient to make general conclusions for each agricultural sector as a whole, they do provide a sample of some very relevant current farmer perspectives relating to issues affecting the potential future uptake of carbon forestry.

Rosin *et al*. (2008) found almost all of the farmers interviewed considered keeping the most productive land areas of their farms in pastoral use was essential for maintaining the economic viability of their current livestock enterprises. It was perceived developing carbon forestry blocks would compete directly with these pastoral based enterprises. As a result, when they were asked to identify suitable areas for carbon forestry on their farms they selected locations that were least valued for livestock production. This also caused wide disparities in the ability of farmers to identify areas for afforestation that would make a substantial difference in offsetting potential GHG emissions liabilities from their livestock.

Sheep and beef farmers were able to identify larger land areas suitable for afforestation than were dairy farmers. This likely reflected the differences in farm size and type of land class that is generally used by the two sectors. However, few sheep and beef farmers were able to envision afforestation sufficient to offset more than half of the GHG emissions liabilities generated by their current livestock policies, owing to the perceived negative effect on their current pastoral based enterprises. A significant constraint identified by sheep and beef farmers for developing carbon forestry blocks was the current lack of cash operating surplus in their businesses. Many of the dairy farmers characterised their farms as having little land available for carbon forestry. In general, there were few areas on the farm that were not considered indispensible for livestock grazing. Areas that were identified as being suitable for carbon forestry were usually small and often fragmented across the farm (Rosin *et al*. 2008).

Several issues potentially affecting the uptake of carbon forestry were revealed in an exercise where the interviewed farmers were asked to identify where on their farms carbon forestry could potentially be integrated. These issues included:

- farmers were uncertain of the land use change options available to them, caused by a limited awareness of the New Zealand ETS and afforestation initiative policies (including their requirements);
- many farmers lacked general knowledge around the cost of establishing and maintaining forest blocks; and
- there was often limited insight into the appropriate positioning of forest blocks on the farm to allow multiple indirect benefits to be realised.

Farmers reluctant to engage in carbon forestry also often claimed little knowledge of silvicultural practices (Rosin *et al*. 2008).
Most of the interviewed farmers perceived that forest blocks were a risky investment. Uncertainties negatively impacting on the decision whether or not to invest in carbon forestry included:

- large up-front cost of establishing new forests;
- long time-frame before there is a return on investment from logging;
- changes in future carbon prices;
- future policy changes;
- low expectation of future log values; and
- concerns about compliance costs (Rosin *et al*. 2008).

In the study by Sinclair *et al*. (2010), dairy farmers were also reported to have a greater aversion to adding carbon forestry to their farms, compared to the sheep and beef farmers, especially if it impinged on the lands productive capacity as a dairy unit. While they considered tree planting was an option in the future for offsetting any potential GHG emission liabilities, and generally had no aversion to planting trees, they did not want forestry added to the property where it negatively affected the productive capacity of the dairy farm or became a hindrance to daily farm management. If forestry was to be added it would be targeted on the least productive areas of the farm to minimise any negative impact on milk production as the primary enterprise. Dairy farmers were open to planting forestry if the economics were favourable. However, it was perceived that planting even a relatively small proportion of the farm or runoff in trees would have a significant negative impact on milk production and investment in external forestry to offset emissions was generally considered a more appropriate strategy, if needed.

The interviewed sheep and beef farmer perceptions of adding forestry to their properties ranged from being neutral to positive. Similar to dairy farmers, they envisioned any new tree plantings would be targeted on poorer producing areas of the farm. They were unsure of how such new forestry blocks would impact on the productivity of their current pastoral based enterprises, but were generally more optimistic that concentrating resources on the most productive areas of the farm would enable productivity to be maintained (Sinclair *et al*. 2010).

The farmers viewed the obligation to surrender NZU at harvest as the main risk concern if carbon forestry was to be added to their business. They were also concernd about their ability to select the correct planting and management regime to maximise the economic returns from the forest.

The general, principles that EW will need to take into account in a regional carbon forestry strategy will be the same as those that apply in other regional initiatives concerning farmers. For example, the dairy sector is clearly different from the sheep/beef sector but farmers are ultimately diverse – a 'one size fits all' approach is unlikely to succeed. Farmers will resist losing control over their own properties and decisions, and resent outside interference from parties with a vested interest who are not accountable for the impact of land management changes. There are also hurdles to overcome that are specific to carbon forestry, including scepticism towards the whole concept of global warming and "trading in hot air".

A key requirement is local case studies of real farms - quantitative information on the size, position and productive capacity of the different landscape units on a farm is needed when analysing the potential for integrating forestry into an existing farm system (Dodd *et al*. 2008a,b; Praat and Thomson 2010). Local demonstrations will always be more compelling than computer model outputs.

The costs and benefits of carbon forestry are not well understood by farmers. Several studies on sheep and beef farms have reported lower than expected reductions in livestock carrying capacity with the addition of forestry (Praat and Wallwork 2009). Even increases in livestock carrying capacity have been reported for some erosion control plantings (Hicks 1995). However, little information is currently available for dairy farms, especially in relation to the biophysical and economic impacts associated with the types and size of forestry plantings required for profitable carbon forestry.

Roles that EW could play in overcoming resistance to tree planting are in Table 8.

Table 8: Possible EW roles in overcoming resistance to tree planting.

Information gaps	EW Role
Doubts about tree survival and growth rates	Collate data from successful tree planting in the region, covering the full range of sites and species.
Previous experience of poor forestry returns	Collate 'worst case' case studies to stress what not to do.
Benefits of shelter for stock	Collate information on pasture and stock benefits across the range of farms in the region. Include trends in animal welfare/green marketing etc.
Agroforestry potential	Collate information requirements for successful grazing within forests within the region.
Benefits of poplars/willows	Collate information on relative merits of spaced poplars/willows over conventional forestry.
Environmental benefits	Collate information from case studies of proven environmental benefits from tree planting, emphasising concrete, easily-visualised changes rather than abstract metrics.

ETS, AGS, PFSI and their requirements – implications for agriculture in 2015 and abatement options.	Facilitate information dissemination. Collate local case studies.

Relative merits of forestry and pasture	
Economic viability of farm requires retaining the most productive land as pasture – carbon forestry would compete directly with this goal.	Case studies which address both the economic performance of the planted trees and can separately identify costs and returns for the same piece of land planted if left under pasture.
Impact of forestry blocks on the productivity of their current pastoral based enterprises	Case studies.
Little knowledge of silvicultural practices or optimal planting schedule and regime.	Collate information from local case studies, forestry experts etc.
Farmers lacked general knowledge around the cost of establishing and maintaining forest blocks	Collate information from local case studies, forestry experts etc.
Farmers perceived forest blocks were a risky investment. - large up-front cost of establishing new forests, - long time-frame before there is a return on investment from logging, changes in future carbon prices, future policy changes, low expectation of future log values, and concerns about compliance costs.	Promote different options for risk sharing.
Obligation to surrender NZU at harvest seen as the main risk.	Case studies with risk minimisation strategies.
Appropriate positioning of forest blocks to allow multiple indirect benefits to be realised	Local case studies – good and bad examples

Constraints	
Least productive farm areas seen as suitable for planting are small and scattered.	Provide information based on the Land Use Inventory system or more detailed individual Farm Plans, identifying the most suitable landscape units on farms for carbon forestry.
Lack of cash operating surplus	Direct investment or facilitate investors
Lack of time	Provide 'package' of contractors
Hindrance to daily farm management (e.g. machinery, line-of-sight).	

Appendix 3. New tools and technologies

A range of new developments are continuing to arise from research that will help with land use decision making. The following concentrates on those related to land use , particularly from Scion and AgResearch.

ACRES: Land Use decision Tool

Produced by Scion, AgResearch, MAF – prototype stage, still in development

ACRES is a DSS tool for assessing the financial and environmental benefits of integrated land management by providing:

- A strategic view of land management (30+yrs)
- Integration of multiple land uses at the paddock level
- Financial and environmental impacts
- Easy to use, web-based, map interface
- Access to information from many existing models

Land management decisions affect financial, social and environmental outcomes therefore land owners need to take a holistic view and to make informed strategic decisions. ACRES is currently in development by Scion and AgResearch with funding from the Ministry of Agriculture and Forestry.

Forecaster: maximising forest investment

Produced by Future Forest Research Ltd- mature product used by forest industry

Forecaster is a software framework used to maximise tree crop returns based on predicted log product out-turns. It works by modelling the impacts of site, silviculture and genetics on tree growth, branching and wood properties. Forecaster is suitable for all plantation species. Currently it is used to:

- Support the correct scheduling of silvicultural operations such as pruning and thinning, and is especially useful for scheduling intensively pruned regimes.
- Develop yield tables to report the predicted volume availability by log grade at each age;
- Predicted CO2 sequestration for two rotations
- Compare easily the potential impacts of adopting different, sites genetics, and management regimes.

Forest Calculators - Radiata pine, Douglas fir, Cypresses, Redwood, Eucalyptus

Produced by Future Forest Research Ltd - mature product, used by forest industry

These are species based calculators that are easy to use with Excel like interfaces aimed at the farm forester. They primarily use a single page interface to predict the outcome of site and management regimes scenarios in terms of per hectare wood production as log grades, carbon dioxide sequestration, and give economic results from discounted cash flow. Carbon is calculated using the C-Change model.

Geomaster: land use records in space and time

Produced by Scion – mature product, used by forest industry

Geomaster is a forest and land information system, and is designed to record large quantities of information on where the land is and what is its use through time, e.g. forest areas, tree crop and stand treatment, and track any operation or event. GeoMaster interfaces with a GIS system and forms the basis for many forestry management functions. It can interface with business systems to be used for operational control.

OCTOPUS: Optimal Catchment Tradeoffs, Production, Utilities and Services

Produced by Scion – research tool, still in development

Octopus is an optimisation framework that takes outputs from multiple scenarios for land use and production systems and solves large combinatorial problems across space and time. This involves the integration of data from multiple sources and the application of mathematical algorithms that will find optimal solutions given multiple objectives and constraints.

For example, an objective may be a sustainable business over 50 years with an acceptable cash flow. Another objective may be an acceptable environmental impact. Another may be a minimum level of livestock numbers. This is achieved through land use options and management strategies. The key is property management as an investment in time and space