I. The Practice of Carbon Farming in New Zealand

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Abstract

In recent years, countries have begun implementing programs employing market-based instruments for delivering ecological services, rather than regulatory instruments. For governments, such policies have the potential for improving the cost-effectiveness of delivering these services, correcting market failures that lead to environmental degradation, and stimulating the development of more efficient strategies for improving environmental quality. In particular, New Zealand has been uniquely innovative with its approach to climate change policy, including a policy component, called the Permanent Forest Sinks Initiative, that is designed to allow private landowners to earn carbon credits by reforesting land. The policy holds promise to support more sustainable land use in New Zealand while delivering a new source of income to rural landowners. However, success depends on ensuring that the practical application of the policy successfully matches the theoretical conditions upon which the policy rests.

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Introduction

The advent of carbon trading around the world is changing the factors that governments, businesses, and individuals consider in their economic decisions. One policy approach being pursued in several countries, including New Zealand, is to create markets that deliver economic rewards and penalties to drive changes in land-use decisions. This chapter lays out the decision-making elements of one type of land-use change intended to mitigate climate change: establishment of new native forests. I focus here on the process a landowner must undertake in order to practice forest re-establishment in New Zealand for the purpose of earning rewards through climate policy mechanisms.

My analysis focuses on a particular group of landowners in New Zealand: indigenous Māori landowners. Māori perspectives are important in New Zealand because they own a disproportionate share of marginal and erodible land (Harmsworth, G., unpublished manuscript). As a result, Māori may stand to gain more from market incentives for reforestation than other landowners.

In order to understand the nature of the new options for landowners New Zealand climate policy creates, we must understand the new rewards the policy introduces, the conditions required for landowners to receive those rewards, and how those conditions fit in with, or require changes to, current practices. In addition, we must understand how management practices necessary to obtain climate policy rewards might also be consistent with practices that earn other rewards, including economic revenues, cultural benefits, and additional environmental enhancements. I investigate this possibility by examining the management conditions for a variety of practices and specifying how a collection of practices associated with different economic *activities* can be coordinated to form a land-use *system*, which I call "carbon farming." In the next section, I provide a rationale for a system that utilizes native forest restoration to produce the new market commodity – "carbon credits" – made possible by climate policy, and I detail the other activities that are compatible with a production system based on native reforestation in New Zealand.

Native forest restoration as a land-use system

In this work, I examine the potential for native forest regeneration to meet the conditions required by New Zealand policy. I also identify overlaps with ecological and cultural benefits not rewarded in markets. I evaluate the advantages and disadvantages of carbon sequestration through restoring native forests and its contribution to a comprehensive land-use system.

To establish a foundation for these analyses, I must first define what is meant by the land use that I call "carbon farming." The term could include any land use in which landowners receive economic benefits from carbon sequestration. However, I use it throughout this dissertation to refer to native forest restoration in combination with a suite of complementary economic activities. This land use differs in important ways from the protection of existing forests or the planting of monoculture forests, as well as the regeneration of forests for the sole purpose of harvesting trees. Instead of being based on resource extraction, this land use is rooted in the provision of a suite of ecosystem services during the process of restoration. I focus mainly on the importance of one service, climate change mitigation, but I emphasize how it can play a role in conjunction with other services. The service of climate change mitigation occurs during the forest regeneration process, through carbon sequestration, whereby sequestered carbon becomes an economic commodity that can be sold through carbon markets.

A system allowing forests to establish themselves, rather than planting trees, would seem to lose some significant accounting advantages. Planted trees are obviously a human-induced behavior, making the case for additionality easier in voluntary markets and projects under the Clean Development Mechanism. In addition, techniques for economic analyses of tree-planting for carbon sequestration are easily adapted from analysis of forest planting for timber. However, for landowners, planting trees has the disadvantage of requiring a large upfront investment to establish plantations. This cost is usually recovered when trees are harvested, but harvesting removes much of the sequestration benefit. Also, from an ecological perspective, plantation monocultures are undesirable because they fail to produce many of the ecological co-benefits associated with native forests. Therefore, with improvements in scientific information and modeling of native species, native forest restoration may well offer greater public and private benefits.

The many potential components of a carbon farming system make it difficult to estimate the impact it will have on a landscape. Important trade-offs among factors will play a role in landowners' decisions. To evaluate the potential for carbon farming to become a distinct land-use system with the potential for multiple revenue streams, I consider how the following factors influence the decisions of landowners:

1) biophysical potential – the range of what is possible for landowners to produce, through carbon credits and other compatible activities, through management;

2) economic rewards – the incentives and costs that determine what management activities are economically worthwhile for landowners;

3) institutional constraints – the legal, institutional, and cultural rules that determine what management practices are acceptable for landowners.

A. What is Carbon Farming?

Carbon farming is any land use in which landowners capture economic benefit from carbon sequestration. Carbon sequestration is the natural process by which growing plants remove carbon dioxide from the atmosphere and store it in their tissues. Each sequestered unit of carbon dioxide credits a corresponding unit of emissions elsewhere, making carbon sequestration equivalent to avoiding emissions of greenhouse gases. The unit of trade in such a system is called a *carbon credit*, which is a commodity that represents a unit of allowable greenhouse gas emissions equivalent to 1 metric ton of carbon dioxide (1 t CO_2-e). Carbon credits can function as a commodity because they have standards to define their qualities, they can be measured, and there are mechanisms for them to be traded.

Carbon farming, then, is a production system for carbon credits. However, carbon farming is broader than the carbon credit production system alone, because it can include other activities along with carbon sequestration, as long as they do not conflict with the rules for production of carbon credits. This gives landowners the flexibility to diversify and add supplemental revenue streams within a single land use.

In New Zealand, landowners utilizing this system of management can earn revenues from several environmentally sustainable sources, such as public subsides for the provision of soil stabilization, water regulation, nutrient cycling, or recreation. These are examples of four identified types of ecosystem services: provisioning, regulating, supporting, and cultural (Millennium Ecosystem Assessment 2005). Landowners can also earn revenue from private markets for non-timber forest products.

"Bundling" these services and revenue streams in a single land use serves important conceptual and practical purposes. Conceptually, it allows analysis of carbon farming as one of a discrete choice of land uses available to landowners, but one that can incorporate multiple sources of revenue. Analyzing carbon farming as a discrete land use choice allows me to investigate the contribution of each activity to the overall profitability and competitiveness of the land use, not just the activity itself. Being able to estimate which activities are worthwhile for landowners is useful for understanding what other ecosystem services will be provided. When these provisioning activities can be bundled into a single land use, the private incentive to implement the land use is increased. Treating carbon farming as a coherent land use also has the practical benefit of being easier to communicate to landowners and decision-makers.

B. Where do the rewards for carbon sequestration come from?

Why do we want to reward carbon sequestration?

The scientific rationale for carbon sequestration in forests comes from an understanding of the Earth's climate system, especially the interaction of atmospheric and terrestrial processes (Nabuurs et al. 2007). Emissions of greenhouse gases are expected to cause changes in the climate at a global scale, potentially resulting in dramatic shifts in weather patterns and average temperatures that could impact the systems that support human livelihoods and well-being (IPCC 2007). If current trends continue, our activities will continue to increase GHG concentrations in the atmosphere, increasing the likelihood and severity of negative impacts (Mastrandrea and Schneider 2004).

As a result of these conditions, scientists have recommended that governments create policies to stimulate changes in behavior that will reduce the concentration of GHGs. Some governments have responded by adopting a "cap" on their national emissions and developing market-based policies designed to meet this cap by shifting decisions in favor of lower-emission activities. In New Zealand, policy rewards apply to land-use activities, in addition to other sectors of the economy (Ministry for the Environment 2007).

<u>What are the economic mechanisms behind carbon farming?</u>

National accounting of greenhouse gas emissions

As a signatory country to the United Nations Framework Convention on Climate Change (UNFCCC), New Zealand has agreed to limit or reduce its net GHG emissions to 1990 levels by 2013. This agreement was codified in the Kyoto Protocol, which was signed in 1997 and entered into force in 2005. The UNFCCC process requires that New Zealand account for human-induced emissions of GHGs. To meet its commitment, New Zealand has developed policies to make emissions more costly and to reward carbon sequestration.

The policy, when implemented, will establish an emissions trading system as a mechanism to trade credits. The policy creates elements that markets require for efficient use of resources: scarcity, commodification, and mechanisms for trade (Montgomery 1972).

One element of the program, called the Permanent Forest Sinks Initiative (PFSI), allows landowners to receive the credits earned through their management of private lands. The PFSI was proposed in the Climate Change Amendment Response Bill (Parliament Bill Number 258-3) and received Royal assent on 13 November 2006. This initiative created a mechanism whereby landowners can register the eligible land they have set aside for permanent succession to native forest. In exchange, the government will devolve the credits to these projects, delivering them to the landowners after the government receives its allocation at the end of each commitment period. Landowners can sell the credits to entities seeking to offset emissions, such as businesses or national governments.

The New Zealand Emissions Unit Register (NZEUR) is the system New Zealand uses to account for the balance of its emissions relative to its emissions cap. The PFSI provides the mechanism for removing credits from the government register and delivering them to landowners who provide forest sequestration. Landowners can then sell these credits in the emissions trading system. The buyers can submit the credits to offset their emissions. Although the removal of credits reduces the credits in the NZEUR available for the government to use to meet its cap, in the long run the incentive of the credits should induce landowners to increase the amount of forest, generating new credits for New Zealand as a whole. The increase in forest area will be detected in the New Zealand Greenhouse Gas Inventory (hereafter "the Inventory"; Ministry for the Environment 2009) and sequestration by the new forest will add to the balance of credits in the Inventory. Thus, the credits removed from the register will be compensated by an overall increase in sequestration (and a reduction in net emissions noted in the Inventory).

Accounting at the landowner level

Currently proposed rules require individual landowners to periodically measure the sequestration in registered forests, using forest mensuration techniques performed by a certified forest consultant. However, other monitoring approaches are possible, including a measurement program conducted by the government, the use of remote sensing techniques (Brown 2002; DeFries et al. 2006), or a model estimation with a documented level of certainty, coupled with the registration of a land-use change by a landowner with the government. The New Zealand government has used remote sensing and analysis to conduct two previous national land cover inventories, in 1996 and 2001-2002, resulting in the Land Cover DataBase (LCDB). The LCDB was used in the estimate of the land-use contribution to the NZ Greenhouse Gas Inventory, and the same approach could be used in the future to verify registered land cover changes and bring the land-use inventory into balance with the credits delivered to landowners from the national register.

Once a landowner registers an area of reforestation or afforestation and the sequestration in the forest has been measured and verified, the PFSI delivers credits to the landowner. The landowner can then sell these credits to buyers who may use them to offset their emissions. Through this process, the landowner converts the service of sequestration into a marketable commodity (credits) and then into revenue.

C. What conditions affect the value of carbon farming?

Conditions for land-use activities to meet standards for credit production

New Zealand's emissions trading system is designed for free exchange of New Zealand credits with internationally traded credits. The PFSI criteria provide an interpretation of the rules established under Articles 3.3 and 3.4 of the Kyoto Protocol. Articles 3.3 and 3.4 stipulate the conditions for land-use activities that result in removal of greenhouse gases from the atmosphere to be considered valid for the New Zealand government to use them for international compliance. By designing its domestic rules to be as consistent as possible with international rules, New Zealand ensures that any discrepancy between the credits it devolves and the credits from new forests noted in its inventory will be minimal.

Activities under Articles 3.3 and 3.4 must be:

1) Eligible – requiring "direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990."

2) Measurable—"measured as verifiable changes in carbon stocks in each commitment period."

3) Verifiable—"reported in a transparent and verifiable manner."

While the New Zealand government has flexibility in making domestic rules and rewarding domestic projects, it is in New Zealand's interest to take steps to ensure that the activities rewarded actually reduce net emissions. Notably, the policies to reward these activities need not follow the same rules as the CDM, for instance, because CDM projects must demonstrate that they meet criteria like additionality *at the project level*. New Zealand may implement a comprehensive policy (Sohngen et al. 2008), in which compliance with the terms of the Kyoto Protocol is met *at the national level*, removing the need for projects to individually demonstrate additionality. The obligations to Kyoto create a fiscal incentive for New Zealand to frame its policies to reward emissions reductions efficiently, but do not *require* New Zealand (or any Annex 1 country) to set up rules identical to the CDM for transferring credits. Put differently, credits are an asset that New Zealand can use to reward any behavior it deems beneficial to the country, as it does with other wealth transfers.

This difference is extremely important, because it allows flexibility in domestic policy to overcome some of the difficulties inherent to stand-alone projects conducted in isolation, as they are in the CDM. With a comprehensive program at the national scale, the government can take advantage of economies of scale in monitoring activities and can support market infrastructure to reduce transaction costs. All land management activity can still happen on private land at the project scale, but by removing some of the transactional difficulties present at that scale, the domestic policy can improve the relative attractiveness of activities that produce carbon credits. For example, costs of measurement, which impinge heavily upon the profits of a native forest system, can be reduced by using limited measurements or modeled values, improving the profitability of native forests relative to other practices (PFSI Carbon Accounting Design Team 2007). Policymakers may consider other unpriced benefits of native forests worthy of social investment that reduces barriers to native forest establishment. Used judiciously, such investments could create incentives that deliver other valuable environmental services (Plantinga and Wu 2003). The policy can also incorporate rules to simplify administrative costs. The PFSI, for example, reduces the administrative burden of determining additionality by ruling that all land that was not forest in 1990 is eligible. This rule probably includes some new forests that would not be considered "additional" under CDM rules and it probably excludes forests that existed in 1990, but would add "additional" credits if judged by the CDM. However, the benefits of accounting for the net effect of these forests probably do not outweigh the costs of determining their additionality.

The PFSI sets rules of land management that meet these objectives, allowing New Zealand to devolve internationally tradable emissions credits[2] to participating landowners.

[2] Landowners receive credits in the form of NZUs, which can be sold into the New Zealand ETS or can be exchanged for AAUs at a rate of 1:1 and sold internationally.

The carbon commodity

A program to reward afforestation and reforestation, such as the PFSI, is intended to stimulate efficient use of land and emissions reductions by rewarding landowners with a quantity of commodity equal to their production of carbon credits. We expect landowners to adopt this production system where it is more profitable than other land uses. Ecosystem services like carbon sequestration have a unique advantage over other commodity production systems because they incur virtually no transportation costs to deliver the product to the consumer. Carbon credits are produced and "consumed" *in situ*. Consequently, the main production costs are the opportunity cost of the land and transaction costs related to quantification, certification, and monitoring. This factor gives carbon farming a comparative advantage over other land uses in inaccessible areas.

Although native reforestation as a management activity is relatively simple, the activities needed to establish the "production" of carbon credits are complex. Landowners need to know the rules governing the production of the carbon commodity, particularly the requirements for certifying that the activities and quantifying production. In other policies, such as Costa Rica's Payment for Ecosystem Services program, the government offers subsidies for maintaining a land use and takes on the responsibility of certification itself (Malavasi and Kellenberg 2002). In contrast, New Zealand policy places the burden of certification on landowners. Landowners also are responsible for marketing and capturing the revenue from their product – they receive revenue from selling carbon credits on a market, not from a government subsidy.

For landowners, the revenues from carbon sequestration are a function of the following factors:

1) whether their activities meet the eligibility conditions for producing credits,
2) the quantity of credits produced, and
3) the price of carbon credits when they are sold.

The profitability of the carbon credit production system depends upon these three factors, which determine the value of carbon sequestration, the ease of carbon credit transactions, and the restrictions on land use imposed by carbon farming.

Conditions for participation

To earn credits in the PFSI, land management practices must meet several conditions: eligibility, verifiability, measurability, and permanence (Ministry of Agriculture and Forestry 2007). These conditions have been written into regulations under the proposed PFSI. Landowners who enroll in the program and demonstrate their eligibility will receive credits at the end of each commitment period. Landowners may then sell credits at their discretion.

Standards in New Zealand's policy require that landowners demonstrate the following:

Eligibility. Land is eligible if its use in 1990 did not meet the definition of "forest." The guidelines of the PFSI (Ministry of Agriculture and Forestry 2007) give the following definition of "forest":

> "Forest" is a minimum area of land of 1.0 hectare with tree crown cover (or equivalent stocking level) of more than 30 per cent with trees with the potential to reach a minimum height of 5 metres at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 30 per cent or tree height of 5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest.

The guidelines include an important footnote, relevant to my definition of carbon farming:

> Where land is managed as a farm, the presumption is that the land is grassland (eligible) except where land has been retired from grazing or where the forest definition is (or will be) clearly met. So, for example, kanuka/manuka scrub may be regularly cleared and therefore not be considered a forest because the forest definition will not be met.

Verifiability. Projects under the PFSI may be verified in two ways. First, the definition of "forest" is written so as to allow forests to be verified by remote sensing, using the same technology adopted for developing the Inventory. This is sufficient to detect changes in forest cover, but remote sensing alone is not sufficient to know if landowners are managing the land in accordance with PFSI requirements. Therefore, a third party must verify the condition of the forest before credits are issued (PFSI Carbon Accounting Design Team 2007).

Measurability. Measurement of forest sequestration allows the climate benefits of forest establishment to be quantified, and therefore gives markets confidence that each ton of forest sequestration is equivalent to (and fungible with) a ton of avoided emissions. At the project level, measurement creates tradeoffs between costs and accuracy. Increasing the level of confidence in the quantification is costly to landowners, but could potentially yield a higher number of credits. The proposed rules for quantification of forest credits explicitly uses the lower bound of a 90% confidence interval for the number of tons delivered to each project (PFSI Carbon Accounting Design Team 2007). Such a rule allows landowners to make cost-effective decision about the measurement methods they undertake (within bounds) and giving an incentive for improving the accuracy of information. PFSI rules require at least some direct measurement, but a combination of measurement and modeling could be equally accurate at lower cost (Chomitz 2006). The EBEX21 Program (Carswell et al. 2003), for example, used a model-based estimate of sequestration to determine the expected number of credits in a project, then used on-the-ground sample measurements in each project to improve the accuracy of the overall model.

Permanence. Forest sequestration credits, unlike emissions reductions, are not necessarily permanent (Kerr 2001, Chomitz 2006). Landowners who lose the forest through accident or intent may be held liable for replacing credits. Liability ensures that emissions reductions will be permanent, because whenever credits are lost, the seller is required to replace them. A loss of credits would thus result in a cost to landowners.

According to draft regulations released in April 2007, landowners will be required to sign a covenant agreeing to maintain continuous canopy forest (PFSI Carbon Accounting Design Team 2007). When a landowner signs this agreement, he is legally bound to meet the conditions. In exchange, he is entitled to the carbon credits generated by his land during the Kyoto commitment periods (2008-2017) and beyond, as long as a market for credits continues to exist and he continues to comply with the covenant. Upon breach or termination of the covenant, or a reduction in the carbon stock in the forest area (unless the reduction is due to a *force majeure*), the landowner is required to submit the equivalent number of units (credits) to the government (PFSI Carbon Accounting Design Team 2007).

***Additionality*.** Additionality is a condition for projects outside of capped markets, such as the CDM, but landowners are not explicitly required to demonstrate additionality in the PFSI, as they are in the CDM. Additionality is the difference in emissions between a "business as usual" scenario and a scenario with an emissions reduction policy or project. The eligibility rules of the PFSI are framed in a way that guarantees a certain kind of additionality: a forest established since the baseline year of 1990 is considered to be additional. New Zealand's national emissions baseline is based on 1990, so changes to forest area since the baseline are measured the national Inventory. The incentives for afforestation and reforestation are balanced by disincentives for deforestation under the NZETS system, in which landowners must pay a penalty for emissions from deforesting land. The assumption implicit in this system is that 1990 represents the "business as usual" area of forest and level of carbon stock for New Zealand.

Pricing and payments

A landowner who enrolls in the PFSI and complies with the rules above can expect to receive the quantity of credits accrued during each commitment period. To convert these credits into income, the landowner will enter into an agreement with a buyer to sell the credits and transfer them at the time they are received from the Crown. Landowners have the flexibility to arrange forward contracts for credits, or to wait until they are delivered to begin selling them. A forward contract has the benefit of providing certainty: the price could be set at the beginning of the contract, or it could be indexed to a specified market. The forward contract also can improve liquidity, if payments to sellers are made before the landowner receives credits, even if credits are not delivered to buyers until the end of a commitment period. On the other hand, landowners who can afford to hold credits after they have received them will have the advantage of potentially selling at a higher price if the market price rises. Regardless of payment structure, landowners may be able to sell their credits at "premium" prices by marketing the special qualities of forest sequestration credits, particularly the social co-benefits they can provide.

D. What are the complementary opportunities for carbon farming?

Carbon farming is a management system that can integrate carbon sequestration with other management activities to generate multiple revenue streams from a single set of management practices. The financial and socio-cultural rewards that are available for other services, where they can overlap with the rewards from selling carbon credits, will influence landowners' decisions about adopting carbon farming. The range of activities is limited by the constraints of the New Zealand policy and other national laws, but they still allow a wide array of practices that can improve the environment and landowners' livelihoods. These activities make carbon farming worthwhile in more places.

Depending on the location of the project, carbon farming system can include the following activities:

1) providing carbon sequestration in regenerating native forests,

2) regulating erosion,

3) supporting biodiversity,

4) providing non-timber products like honey, and

5) serving as a venue for recreation, learning, and traditional cultural practices.

Each component brings its own distinct rewards, but in some cases these rewards can become additive, or even multiplicative, on a single piece of land. For instance, controlling pests to promote biodiversity can also promote better forest health. Healthier and more diverse forests grow more quickly, increasing their effectiveness for soil stabilization. What makes carbon farming work as a land-use alternative is that the ecological functions can be transformed into economic benefits, either directly through government subsidies and private markets for services and products, or indirectly through enhancements to production and well-being in other areas.

In some cases, the economic rewards from public initiatives and private markets will outweigh the rewards from carbon sequestration. These cases still meet the definition of carbon farming because the economic revenue from carbon credits still plays a role in the landowner's decision. Below, I catalog the complementary incentives currently available in New Zealand.

1. Public Subsidies

In NZ, several policy initiatives offer subsidies for activities on private land that yield public benefits. In the East Cape area, these include:

1) Property tax reduction.
2) Erosion control subsidies.
3) Biodiversity protection subsidies.

Each of these initiatives offers compensation to landowners as a stimulus to induce changes in land management. Each one applies only to certain eligible areas.

Property tax reduction

The Gisborne District Council offers property tax (rates) reduction or forgiveness for several situations. Areas of significant biological diversity, identified in the District Plan as Significant Natural Areas, Protection Management Areas, or Department of Conservation (DoC) Protected Natural Areas, are eligible for rates forgiveness if the land is set aside under a covenant in one of the DoC programs listed below. In addition, Māori land that is economically unproductive and demands no services is eligible for land tax reduction under a program called Whenua Rahui (not to be confused with the DoC program called Nga Whenua Rahui).

Erosion control

The East Coast Forestry Program (ECFP) is administered by the Indigenous Forestry Unit in the Ministry of Agriculture and Forestry (MAF). Since 1992, the ECFP has been a contestable grant program that subsidizes the afforestation of highly erodible land in the East Cape region. The land targeted by the program is defined by the Land Use Capability class index, an 8-level classification ranging from land suitable for all purposes (class 1) to land not suitable for any productive purpose (class

8) (See Box 1: Land use capability). Land targeted under the ECFP includes erodible land in LUC unit VIIe18 and higher, as well as all of class VIII land.

An independent review of the program in 2005 recommended that the existing tender system be abandoned in favor of a grant system, with a consistent payment for each hectare enrolled (Ministry of Agriculture and Forestry 2006). The report cited landowner comments and other submissions, which stressed that the tender process was complicated and uncertain. Notably, the program budget has never been fully spent in any year and only 30,000 ha of the original 200,000 ha of target land have been treated. In 2006, the target was reduced to the "most erodible" 80,000 ha and a regulation by the Gisborne District Council called the Sustainable Hill Country Program (SHC) came into force, requiring landowners to treat highly erodible land. The criteria for determining target land are the same as for the ECFP, but the extent of target land for the SHC was determined by a using fine-scale satellite imagery (scale: 1:10,000) rather than the coarser imagery used by the ECFP (1:50,000) (Fantham, P., Gisborne District Council, personal communication, 2007). Because of the SHC regulation, landowners will be required to treat target land with the set of approved options designated by the GDC. Depending on the severity of erodibility, this can include poplar pole plantings, afforestation with native or exotic trees, or native forest succession.

Box 1. Land use capability.

Land use capability (LUC) is a classification of land suitability for different purposes due to its characteristics. According to the New Zealand Land Resource Inventory (NZLRI) described in Jessen et al. (1999):

> The following mapped physical factors are considered when making LUC assessments: rock type, soil, slope, and the present type and severity of erosion. Climate and the potential for erosion are equally important. The effects of past land use may also influence LUC assessments. LUC assessments are made in a three-part hierarchy: LUC class, LUC subclass, and LUC unit.

- the LUC class is the first and broadest category of the LUC classification system. It expresses the total degree of limitation to sustained use. There are eight LUC classes used in New Zealand, from class I (negligible limitation) to VIII (extreme limitation).
- the LUC subclass is the second category and expresses the major kind of limitation. The NZLRI uses four LUC subclass limitations: erosion (e), wetness (w), soil (s), and climate (c). There are only 30 LUC subclasses in New Zealand.
- the LUC unit is the third and most detailed category. Each LUC unit is defined by its unique assemblage of physical factors. A LUC unit groups uniform land types together. Specifically, a LUC unit will group map polygons which 'respond similarly to the same management; are adapted to the same kinds of crops, pasture or forest species; have about the same potential yield, and require the same kind and intensity of soil conservation and other land management measures'. There are over 700 different LUC units in the NZLRI.

Figure 1

The shift to a grant process, among other changes, was announced jointly by the Minister for Agriculture and the Gisborne District Council in June 2007 (Ministry of Agriculture and Forestry 2007). Under these rules, all of these treatments could earn carbon credits on Kyoto eligible land. One-time payments per hectare amount to 70% of the cost of poplar plantings, \$1342-\$2886 per ha for forestry plantings (prorated according to distance from Gisborne), and \$1375 per ha for reversion. However, the projects are not completely separate. A special provision in the ECFP allows the program to reduce the level of the grant for landowners who receive revenue from carbon sequestration under the PFSI, the NZ ETS, or other programs

(Ministry of Agriculture and Forestry 2007). On the other hand, harvests of trees planted under the ECFP would incur liabilities if they violated the rules of the PFSI (see above).

Biodiversity protection

Several programs offer subsidies for setting aside land of moderate to high conservation value. These include:

1) Queen Elizabeth II Trust (QE2)

2) Nga Whenua Rahui (NWR)

3) Biodiversity Condition Fund

4) Natural Heritage Fund

Each of these programs has different conditions and payments. All four programs are administered by the Department of Conservation (DoC).

The QE2 is targeted at high-value conservation areas on private land. When enrolled in the program, landowners receive cash payments for financial assistance with protecting land, which amount to up to half the proposed costs of fencing, pest control, and management to encourage a diversity of species. QE2 functions as an easement and is registered permanently on the land title. DoC assumes all management activities, unless landowners request another arrangement (such as providing pest control themselves).

NWR is a program targeted at land of similar conservation quality on Māori land. NWR requires that landowners sign a *kawenata*, or covenant, in which they agree to set aside the land for 25 years.

Most Kyoto-eligible land is not attractive to these programs because any land that was not forest in 1990 has not yet reached the high quality, diverse state which these programs seek to protect. However, blocks set aside for carbon farming which contain areas of high-quality forest can receive revenues from both activities. Importantly, conservation programs often help offset costs of fencing, the main capital investment required to establish carbon farming.

The Biodiversity Condition Fund provides grants for landowners to protect areas outside public land with high ecological value. Applications are accepted twice each year, and fund projects for enhancing biodiversity, including "areas of native vegetation, wetlands, and the habitats of native fish, birds and other species" (Ministry of Agriculture and Forestry website, n.d.). The fund targets projects under $60,000 per year and a maximum term of three years, though these guidelines may be violated in certain special cases. Landowners can use this program to apply for fencing or pest control funding, though applications are unlikely to be accepted for young forests.

The Natural Heritage Fund is a contestable fund for protecting areas of New Zealand habitat that meet one or more of the following criteria: representativeness of natural ecosystems, sustainability of protection, contribution to the original integrity of the landscape, and the maintenance of amenity and utility values. Applications are accepted on a continuous basis, and the Fund has protected over 230,000 hectares of indigenous ecosystems since 1990 (Department of Conservation 2007). The Natural Heritage Fund is unlikely to fund beginning reforestation projects because of the nature of the targets for the fund. However, landowners may see the Natural Heritage Fund as a potential source of revenue in the future, once the forest has reached maturity.

2. Market opportunities

Manuka honey and oil

Manuka honey is a burgeoning product in the Gisborne District. The medicinal properties of manuka, New Zealand's tea tree, are retained and concentrated in the honey, and can be measured by a standardized laboratory procedure. The region is large enough to support a small bee-keeping industry, with farms owning their own hives or leasing space to beekeepers. Beekeepers, in turn, sell wholesale honey which is later retailed domestically and overseas. Prices for the highest quality honey have risen 300-400% in the past five years, as demand has surged in new markets, retailers have standardized their products, and operators have invested in processing infrastructure (Satchell, H., personal communication, 2006). The high value of manuka honey has made beekeeping sustainable year-round, even though the manuka flowering season only lasts about 8 weeks each year. It is difficult to quantify the revenue from honey on a per-hectare basis, because quality varies by year (usually due to weather conditions) and by location (due to the terrain and the maturity, genetic strains, and density of manuka). However, the harvest of manuka honey appears to be completely compatible with carbon farming. The only possible conflicts might occur if honey production results in leakage of greenhouse gas emissions or if landowners cut mature manuka to maintain honey production as forest succession begins to occur.

Manuka oil is extracted from the foliage of the manuka plant, and also has medicinal properties as a skin treatment and disinfectant. The author knows of one facility that manufactures manuka oil in the East Cape using a patented extraction process. In the manuka scrub, harvesters use hedge clippers to remove the manuka foliage (not the woody stems) and collect it in bags. The bags are transported to the processing plant and the leaves are shredded by a mulcher and deposited in large pressure kettles. A process using pressurized steam extracts the oil, which is collected and used in several different products. The used foliage is stockpiled, dried, and used as biofuel or sold locally for mulch (Kerr, M., personal communication, 2006).

These manufacturers lease rights to harvest manuka foliage from local farmers. Young manuka is ideal for the process, but manuka can only be harvested for a few years before it becomes too large to be harvested economically (it has limited capacity for pruning). Additionally, the highest-quality oil production is limited to genetic strains of manuka found in a limited location. Because of these factors, once again it is difficult to generalize about the per-hectare value of manuka oil, but its economic importance is increasing in the region. If harvests are limited to particular age classes, seasons, and areas, the impact on manuka growth – and the deviation from modeled growth – may be small, and the areas harvested may still meet the conditions for carbon farming. Harvest of these products can add revenues in the early years of forest establishment, when carbon sequestration rates are low.

Eco-tourism

The Gisborne District is not as popular a tourist destination as other areas of New Zealand (Statistics NZ 2007), but it does support several tourism businesses, which market its isolated wildness, pastoral setting, and Māori culture as attractions. Some of these tourism operators offer horse trekking, bush walks, and guided hunting for their clients. The revenues from these activities are difficult to assign on a per hectare basis to the forest, as they rely on factors like the overall aesthetics of the landscape, the abundance and health of game, reputation of the tourism operator, effectiveness of advertising, and demand for the activities among the pool of tourists visiting the region. Nevertheless, tourism activities are compatible with carbon farming, potentially enhancing its profitability. In fact, activities like hunting, when targeted at pest species (such as possums, deer, and pigs) can actually enhance the ecological condition of the forest and improve the rates of forest growth and carbon sequestration.

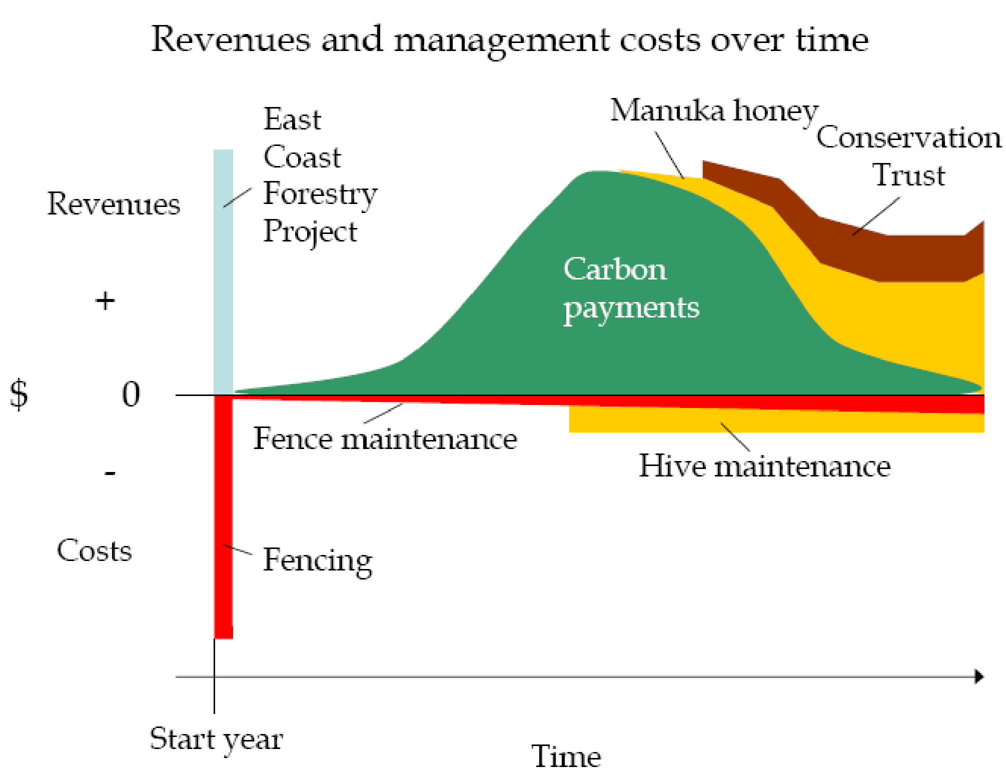

Figure 1. Conceptual illustration of several revenue streams assembled over time in single carbon farming project.

E. How does the carbon market work and who are the players?

Landowners who successfully implement their own management system receive credits, but how do they convert these into payments? With whom do they make contracts? How and when do they engage them?

To address these questions, we need to define a few roles in the carbon market. These are functions that must be fulfilled in existing or anticipated carbon markets.

An individual can fulfill several of these roles simultaneously (avoiding conflicts of interest), but for ease of reference, I define six separate roles:

Seller: the landowners are the sellers of credits, unless the landowner enters a contract to have credits allocated to another party, such as a project developer providing financing.

Buyer: buyers seek to purchase offsets for their emissions. They may include national governments, private individuals or businesses, or any interested group or organization.

Broker: a broker facilitates the transaction between a buyer and a seller. At times, a broker may act either as a buyer or seller to smooth the disjuncture when there is a gap between buyers and sellers.

Certifier: the certifier carries out the activities to guarantee that a project plan and initial set-up meet the conditions of the PFSI. The certifier may also help the seller develop a management plan, complete an application, and convey the information to the regulator. The role of certifier ends when the application is approved. Under PFSI rules, certifiers must be NZ Certified Forest Consultants.

Monitor: the monitor carries out activities to verify that the project continues to meet the conditions of the PFSI on an on-going basis. Monitoring continues as long as the project exists, and plans for monitoring must be included in the PFSI application. Monitoring may be conducted by a certifier, the regulator, or both.

Regulator: the policy managers at the Ministry of Agriculture and Forestry are the regulators. They process and approve applications from potential sellers, certify and collect information from certifiers and monitors, monitor existing projects, and register changes in sellers' accounts when notified by sellers, buyers, and brokers.

Under the rules of the PFSI, the costs to government for maintaining market mechanisms must be recovered (Ministry of Agriculture and Forestry 2007).

Therefore, the regulator will charge fees for processing applications, monitoring projects, and registering transactions. The proposed costs were released to the public in the PFSI Consultation Document (Ministry of Agriculture and Forestry 2007). In addition, sellers may incur costs from insurers, brokers, certifiers, and monitors, in addition to project costs. These costs may be recovered through sales of credits to buyers. Forward-selling credits can smooth the flow of revenue for sellers, but the landowner incurs risk when the amount or price of credits is uncertain.

F. What are the steps involved in establishing a carbon farming system?

To meet the conditions necessary for making carbon farming a profitable management system, several steps are necessary. They are listed below in an order that would avoid committing resources prematurely; however, it is not necessary that every step occurs in this order. I have grouped the steps into stages, according to the type of activities involved.

Stage One: Engagement and information gathering

1) Engage and make decisions. Engage in the process of deciding land-use allocation.

2) Determine eligibility. Identify eligible areas of land.

3) Estimate opportunity cost. Assess the current and future returns on those lands in their current use.

4) Quantify initial conditions. Form an estimate of the amount of sequestration that will occur over time.

5) Estimate carbon revenue. Form an estimate of the revenue from carbon sequestration on eligible land, based on the amount of sequestration and expectations about the price of carbon credits.

6) Consider liability. Account for liabilities in the assessment, using the expectation of the replacement price of credits for future deforestation.

Stage Two: Decision, land allocation, and project initiation

7) Ensure legal approval. If the project is on Māori land, any decision intended to create a long-term obligation on the land will require approval of the Māori Land Court, and the terms of any contract (in Stage Four) must be reviewed by the Court. Recording decisions in meeting minutes can help establish a legitimate decision-making process for the Court's review. The covenant template for the PFSI requires signatures of every person with a material interest in the project area: a burdensome requirement for multiply owned Maori land.

8) Determine spatial allocation. Identify potential areas to set aside, weighing expectations of cash flow and returns from carbon farming relative to other uses.

9) Establish initial conditions. Once specific areas have been chosen, measure or estimate the stocks of carbon on designated area at the beginning of the process.

10) Commit the chosen land to the project. Indicate the decision to commit land resources to carbon farming.

11) Register the project. If necessary, register or apply to a government program such as the Permanent Forest Sinks Initiative.

12) Land conversion. If the project is approved to receive credits, convert current land uses into carbon farming by building necessary fences, removing stock, and eliminating pests that may restrict tree growth.

Stage Three: On-going project management

13) Address permanence. If permanence is desired, take steps to ensure permanence of the carbon stock, including all reasonable efforts at physical protection, such as establishing fire breaks, and legal protection, such as registering the set aside areas on the land title.

14) Maintenance. Maintain continuous management of the carbon stock and make provisions for assigning appropriate resources in the future.

15) Quantify conditions in the future. At the end of each commitment period, quantify the current stock of carbon, either through sampling or modeling. The

carbon that has accumulated since the beginning of the commitment period is the number of credits reported to and received from the government.

Stage Four: Market engagement and sale of credits

16) Find and engage a buyer. Engage markets directly or through a broker to sell credits. The government may decide to engage with registered landowners through the program, as a buyer of credits.

17) Negotiate a contract. When a buyer has been found, negotiate a contract to sell credits.

18) Complete the sale. Receive payments and deliver credits.

G. What might carbon farming mean for rural development?

Carbon farming represents a new type of land use that can compete with, replace, integrate with, or work alongside existing land uses. It has the potential to bring new sources of revenue to rural areas. At the same time, it can improve the provision and maintenance of ecosystem services. For example, in the Gisborne District, the extreme erodibility of much of the land puts it at risk for landslides, flooding, and destruction of downstream infrastructure. When a greater fraction of this erodible land is in forest cover, particularly native forest cover, erosion is reduced (Liebault et al. 2005), runoff is slowed, and risks to downstream infrastructure may be reduced . Owens and others (Owens et al. 2005) suggest reforestation can reduce the risk of flood damage. Cyclone Bola, an extreme weather event, caused extensive damage in 1988. Certainly this damage would not have been prevented by afforestation of the district; nor would it make sense economically to give up the revenues from all productive land in the region simply to prevent the risk of damages. Instead, I note that reforestation provides wider benefits than the income to the farmer; it also provides services to those downstream, those who travel on the roads or transport goods, those who access power and communications, and those who rely on clean surface water supplies.

Conclusion

The introduction of climate policies like the PFSI have created the potential for landowners to "farm" carbon credits in a new land management system. For some parts of New Zealand, carbon farming may provide competitive revenues, especially on inaccessible, marginally productive land. These revenues might come from outside the region, bringing new investment into the area, or they might come from the New Zealand government itself, as an investment to help meet New Zealand's international commitments. The government may have good reasons for purchasing these domestic credits back from landowners. Given the option of buying foreign or domestically-produced credits at an equal price, New Zealand would benefit by buying domestic credits because of the secondary benefits that will flow from these new forests. Such purchases would encourage more efficient land use and generate a stream of co-benefits.

Carbon farming also has consequences that may be seen as negative by many. For instance, converting marginal land into permanent forests will remove it from other kinds of production and reduce the potential for development of farm or forestry production in rural areas and districts with a high proportion of marginal land. Districts like Gisborne, already strained to provide services from its limited tax base, will find increasing difficulties if native forest reserves are exempted from taxes. If increased revenues from other activities like tourism do not compensate for these lost revenues, districts could find themselves in a worse position, and carbon farming could be blamed.

Carbon farming through native forest restoration requires little investment, but the process of decision-making and implementation is complex. Many points of uncertainty remain, and they are likely to have a discouraging effect on landowners. Overcoming these sources of uncertainty will require new syntheses of information, new vehicles for delivering information to landowners, and new legal instruments for ensuring management conditions and project impacts actually deliver policy goals.

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