Forests and the Carbon Cycle

Emerging opportunties for native forest protection and afforestation in New Zealand

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Preface

This report has been written for the Department of Conservation by Chris Collins of Eden Resources Ltd, Wellington. The purpose of the report is to provide information to the department's senior management and strategic planners on an important emerging issue - the role of forests in the carbon cycle. In the future native forests could become highly valued as carbon sinks and reservoirs as well as for biodiversity and other well recognised reasons.

The report starts with an overview of the global carbon cycle and the role of forests. It then moves on to look at the carbon dynamics of different types of forest management options: exotic afforestation; native revegetation and native forest protection. The implications of pests, such as possums, for carbon storage in native forests are discussed. Some of the strengths and weaknesses of each type of forest management option are noted.

The report goes on to discuss three sets of circumstances that could have a bearing on the level of resources for native forest conservation work in the future. The first set of circumstances has already arrived. New Zealand is a party to the Framework Convention on Climate Change and therefore must take a close interest in the carbon status and dynamics of its native forest carbon reservoirs.

The second set of circumstances is still unfolding. The Stratford decision requires the carbon dioxide emissions from a proposed new power station be mitigated. Mitigation can include the creation of carbon sinks. The decision is subject to appeal, but if it is upheld it will create opportunities for native forest protection and a variety of land retirement and tree planning options.

The third set of circumstances is a future possibility, unlikely to arrive before the end of the decade, if at all. Nonetheless it would be prudent to take contingency measures to cover this possibility. The third set of circumstances involves mandatory tradeable absorption obligations. All emitters of carbon dioxide would have an obligation to counter, in effect, their emissions with sinks. Such a policy would have a far greater effect on native forest conservation in New Zealand than the isolated implementation of the Stratford decision.

The report's conclusions emphasise the need to improve rapidly the state of knowledge on the carbon status of native forests and the factors affecting the dynamics of carbon uptake and loss from these forests. Without this knowledge it may be difficult to seize the opportunities that are emerging.

1. Introduction

GLOBAL OVERVIEW

The global carbon cycle is not well understood, but a rough picture of what is going on has been established.The largest carbon reservoir is mineral material in ocean sediments and the lithosphere. Only a small fraction of this material (around one part in ten thousand), namely the fossil fuel reservoir, is thought to be playing a significant role in the present day carbon cycle. Figure 1 shows the main dynamic reservoirs and their fluxes. The largest dynamic reservoir is the carbon dioxide absorbed in the ocean.

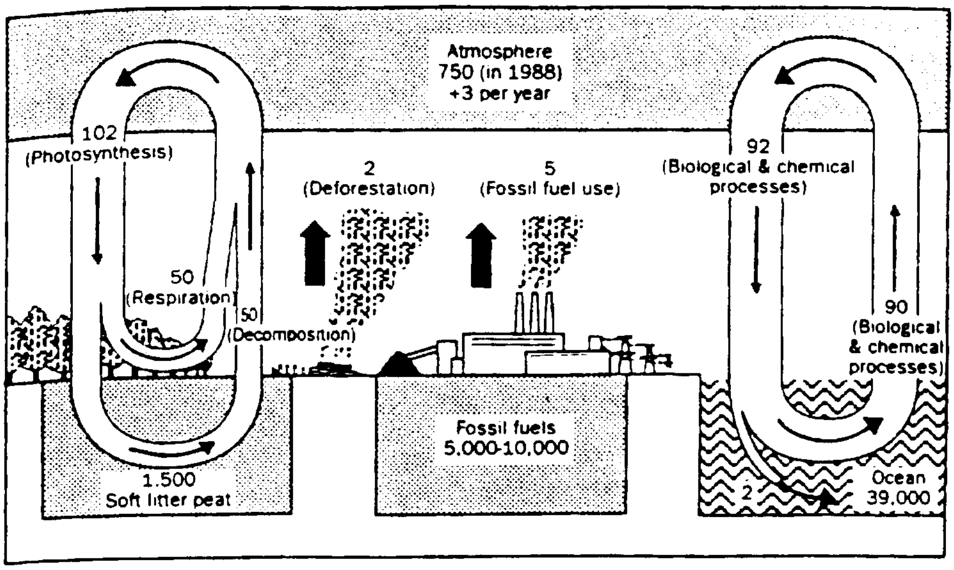
Not shown in the figure is the amount of carbon contained in living organisms.About 500 gigatonne (Gt = 10^9 tonne) is thought to be stored in terrestrial plants, mostly in forest ecosystems. A similar amount is thought to be in marine plant organisms. Perhaps 200 Gt is stored in animals, again roughly divided between terrestrial and marine environments. With the exception of forests, it is commonly assumed that the total amount of carbon in living organisms is not changing much.

The main feature of Figure 1 is two large fluxes from the terrestrial and marine ecosystems. Left to themselves these fluxes would tend to buffer, or counteract, any minor changes in atmospheric carbon dioxide levels. The use of fossil fuels and deforestation over the last two centuries has, however, created an imbalance in the carbon cycle that is not being corrected. The total emission of carbon from these human activities is currently around 7 Gt. Nature's response is a net absorption of 4 Gt leaving an imbalance of 3 Gt. This imbalance is causing an increase in atmospheric carbon dioxide levels and hence concerns over risk of climate change.

Even though some mysteries emerge when the details of the carbon cycle are examined, it is clear that it is amenable to human management. The two measures most commonly advanced to reduce the growth in atmospheric carbon dioxide levels are: to reduce fossil fuel use through energy efficiency and development of renewable energy sources; and to stop deforestation. Both measures raise serious issues of international equity and national sovereignty. The main focus of deforestation attention is tropical forest clearance. It must be remembered, however, that many countries, New Zealand being one, cleared large tracts of native forest during the crucial period, the last two hundred years, when the carbon cycle became unbalanced.

The deforestation emission in Figure 1 is the net effect of forest clearance and reforestation. At the moment there is lot of the former and not much of the latter. Movement towards restoring the carbon balance could be achieved by increasing the rate of reforestation as well as tackling the difficult issue of tropical forest clearance. New Zealand is in a special, possibly unique, position in this regard. Studies have indicated that the country has from 3 million to 5 million hectares of land which are suitable for exotic reforestation, but have negligible value for other forms of primary production and, at present, have low priority for nature conservation. Most of this land could also be reforested in native species.

FIGURE 1: GLOBAL CARBON CYCLE



Generalized portrayal of the carbon cycle, showing main reservoirs and fluxes. Quantities of carbon are in Gt (reservoirs) and Gt per annum. (fluxes). Estimates are from IPCC, Scientific Assessment of Climate Change, *fig. 1.1. and references therein. The figure is based on Stephen Schneider's drawing* in Scientific American, *Dec 1989.*

The terrestrial plant fluxes, other than deforestation, shown in Figure 1 can be considered to be the net result of two opposing natural forces. Forests are always in a state of change. At any time the amount of carbon in some forests will be increasing. Perhaps the forests have not reached maturity, perhaps they are responding to an atmospheric CO_2 fertilising effect. Forests may even be increasing their geographic extent in a few regions of the world. At the same time factors such as local climate change, or the effects of fires and pests, may be reducing the extent of other forests or lowering their carbon storage per hectare.

NEW ZEALAND SITUATION

Reducing fossil fuel use, stopping deforestation and increasing reforestation are not the only means to redress the global carbon imbalance. The notes above suggest another means: existing native forests could be enhanced for carbon storage, or some of the factors causing loss of carbon could be dealt with. Again New Zealand may be in a special position in this regard. The table on the next page shows the best available estimates of the carbon status of forest and scrubland in this country.

Table 1: Carbon Status of New Zealand Forests and Scrublands

Vegetation Class	Area 10^3 ha	Carbon Reserve (Mt)
I NATIVE FORESTS		
Podocarp Forest	43	18.4
Lowland podocarp/broadleaved	1098	370.5
Highland podocarp/broadleaved	51	13.8
Broadleaved/beech	223	53.6
Subtotal - podocarp/broadleaved	1415	456.3
Lowland podocarp/broadleaved/beech	1390	486.4
Highland podocarp/broadleaved/beech	206	54.1
Beech-broadleaved forest	114	32.9
Subtotal- podocarp/broadleaved/beech	3125	1029.7
Beech Forest	2001	681.5
Subtotal Native Forests	5126	1711.2
II SCRUB AND NATIVE FOREST		
Podocarp/broadleaved/beech	814	149.9
Beech forest	317	57.4
Kauri/manuka/kanuka	50	8.6
Subalpine scrub and forest	88	13.2
Subtotal - Scrub and Native Forest	1269	229.1
Subtotal - All Native Forest and Scrublands	6395	1940.3
III EXOTIC FOREST		
Exotic forest (1992)	1290	125
Exotic forest & scrub	17	1.7
Subtotal - All Exotic Forest and Scrub	1307	126.7
TOTAL - ALL FORESTS AND SCRUBLANDS	7702	2067

Source: K Tate/Landcare

Table 1, which covers carbon in the standing vegetation, has been largely derived from a handful of total biomass studies for different forests and scrub associations. Only the data for exotic forests is based on reasonably reliable surveys. The table does not include a small amount of native forest or scrub on predominantly pasture or grasslands (these ecosystems total approximately 180 Mt of carbon). The table does not include soil carbon - in simple terms this is typically one half of the carbon in the standing biomass.

Even allowing for uncertainties, it is clear that native vegetation represents a very important carbon reservoir in New Zealand. The country has over 6 million hectares of native forest and scrubland that are suffering detriment, to various degrees, from introduced weeds and pests. Forest and scrub containing vulnerable podocarp and broadleaved species are thought to contain around 57% (1179 Mt) of New Zealand's total forest and scrub carbon reserves (2067 Mt) or nearly 50% of the total vegetative carbon reserves (2419 Mt). Exotic forests in 1992 contained just over 6% of the forest and scrub reserves. It could be that protecting New Zealand's native forests for carbon reasons (as well as nature conservation) is more important than planting exotic forests to create new carbon sinks.

2. Forest Management -Carbon Implications

This section provides a brief overview of the carbon implications of different forest management regimes. It ends with a short comparison of the relative advantages of production and conservation forests.

CONSERVATION FORESTS

A mature forest that is not harvested is in quasi carbon equilibrium. There may be a substantial short term turnover of carbon in the biomass from growth, browsing and decay. Each year some of the forest productivity translates into carbon going into long term storage as woody material. Meanwhile some of the existing woody material (branches or whole trees) falls and decays.The net uptake of carbon in the above ground biomass may be close to zero. The forest is a carbon reservoir. Most New Zealand native forests contain between 200 tonnes and 450 tonnes of carbon per hectare (tC/ha) in their living biomass and standing stock of litter.

Some of the carbon in the forest litter is incorporated via a range of biological processes into the soil profile.At the same time there is a flux of carbon from the soil. A typical native forest might contain 200t to 300t of mineral carbon per ha in the top 1 metre of the soil profile. Historically the soil uptake of carbon must have exceeded the outgoing flux for the soil carbon reservoir to have been built up. It is quite possible that in mature forest the soil carbon reservoir continues to increase, albeit slowly.

NATIVE SCRUBLAND

Mixed indigenous scrub may contain up to 100 tC/ha. Reasonably mature manuka and kanuka on average could contain 50 tC/ha, a similar amount to gorse scrub. These scrublands are serial in nature and natural succession could see them progress to tall native forest on many sites. There may be opportunities to accelerate this process through better pest and fire control, and enrichment with nursery material. In many cases loss of native scrubland to other land uses could mean a carbon opportunity cost of 200 to 300 tC/ha (less the carbon content of the alternative ecosystem). If scrub is converted to rotation managed exotic forest, the net opportunity costs could be 100 to 200 tC/ha.

REFORESTATION

Grasslands can be very productive but the amount of carbon stored in the living biomass and litter at any time will be much less than a forest. Improved pasture in New Zealand may contain 3 tC/ha. On the other hand, snow tussock grassland, an ecosystem subject to low grazing rates, may contain over 30 tC/ha.

In New Zealand, exotic forestry is the main landuse change. If scrub is cleared for tree planting then initially up to 100 tC/ha may be lost. The growth of the new trees will recapture this amount and more.After 20 to 30 years a radiata plantation will contain around 250 tC/ha. Allowing for rotational management (explained below) the average amount of carbon in an exotic plantation will be around 100 tC/ha.

Direct reforestation with native tree species is difficult. Kauri and beech are two species with potential for plantation type establishment. Growth rates tend to be slower than radiata so that a level of 250 tC/ha may take 60 years, or more, to achieve. Accelerated native forest succession is a possibility with enrichment of scrubland (planting suitable natives in very small clearings). Scrubland appears to grow very rapidly for a short time, perhaps 10 years, and then slow down. Over a 25 year period the average carbon uptake rate of manuka appears to be half that of radiata (ie similar to kauri or beech).

The soil carbon implications of reforestation are not well understood. In the time frames relevant here, namely 25 to 100 years, the potential increase in soil carbon from reforestation is likely to be overshadowed by the increase in the forest biomass. Soil carbon loss, however, may be an important issue with deforestation.

FOREST HARVESTING

When exotic plantations are harvested the amount of in-situ forest carbon drops markedly. The typical merchantable log removed from an exotic forest contains about half the carbon in the original tree. Due to the low durability of radiata, the rest of the biomass carbon (roots and branches) is quickly lost over five years or so, through decay. Burning the harvest slash accelerates this loss.

When the forest is replanted the new trees will take up carbon and the cycle is repeated. Over several rotations the average amount of carbon stored in the forest biomass will be between one third and one half the maximum at the time of harvest. The exact proportion depends on the growth-time profile for the species, the site conditions during the rotation (eg whether there was a drought) and the age at harvest. The swings in carbon storage caused by the harvest-replanting cycle can be smoothed out by careful management of a large forest. A plantation of 100,000 ha, for example, managed on a 20 year rotation basis so that only 5,000 ha are cleared and replanted each year, will constitute a fairly stable carbon sink.

Forest establishment and harvesting requires fossil fuel inputs for machinery, transport, fertilisers, weed sprays and other chemicals. On each rotation these inputs amount to about 5% of the average carbon content of the forest. In other words after about 20 rotations the same amount of carbon is released from fossil reservoirs as has been stored in the forest sink; the net storage is zero. Using renewable energy sources will mitigate this problem. The forest management problem is minor, however, compared with the very large fossil fuel inputs to off-site forest processing.

FORESTRY PROCESSING

Forests are harvest for a reason - to provide fuel or raw material for artifacts. Converting harvest logs to kiln dried timber or pulp and paper is a very energy intensive process. In New Zealand the sum of carbon emissions from fossil fuel inputs to forest processing can equal the average in-situ forest biomass storage after 2 to 3 rotations. This issue is being tackled, coincidentally, by the processing industry on a variety of fronts, such as increased energy efficiency, greater use of renewable biomass fuels leg waste wood) and the development of easily processed tree varieties. Carbon-balanced forestry systems have been developed overseas. Modern chemical pulp mills in Sweden and Finland, for example, are virtually self-sufficient in energy, require negligible fossil fuel inputs and, in some cases, even produce a heat surplus.

Production is only part of the total lifecycle for artifacts. Recycling and ultimate disposal can have significant carbon cycle implications. Landfill disposal of wastepaper, for example, can lead to methane emissions; methane is a powerful carbon based greenhouse gas. On the other hand, a landfill site could be managed to provide long term storage for some of the carbon materials placed there. Burning wastepaper with energy recovery can displace fossil fuel use. Recycling wastepaper may reduce or increase fossil fuel use depending on the source of alternative virgin paper, the transport distances involved, etc.

NATIVE FOREST PROTECTION

Existing native forests and forest-scrub ecosystems constitute a very important carbon reservoir. In New Zealand this reservoir amounts to around 1900 million tonnes (Mt) of carbon. To put this in perspective the total emission of fossil fuel sourced carbon in this country is currently around 7 Mt. As mentioned earlier, a forest can be in carbon expansion or decline due to natural processes. It is quite conceivable that in New Zealand, pests and weeds are creating a negative trend that overlays any natural shift in native forest carbon status. A number of studies have shown a decline in forest biomass.

Increased browsing by possums and goats, for example, is likely to lower the carbon content of palatable forest vegetation. Canopy browsing by pests can reduce the vigour of tall trees and bring about their early demise. Meanwhile understorey destruction means that there are fewer replacement saplings. Secondary impacts on bird species can also adversely affect forest reproduction via such mechanisms as reducing the number of seed dispersal agents. Cases of native forest canopy collapse have already been noted, and it is thought that further significant areas are at risk of complete collapse within 50 years as a result of pests.

The loss of litter in forests has been noted, and attributed principally to goats and deer. This could be due in part to lower leaf drop (due to possum browsing); but the main reason is probably the removal of litter off-site by wind and runoff as a consequence of low densities of seedlings and other forest floor plants from deer and goat browsing. For some tree species less litter means a degradation of seed bed conditions, which feeds back to further forest decline.

Some of the carbon lost when litter is washed or blown off-site may end up stored in deep lake or marine sediments. A real concern, though, is whether the soil carbon dynamics are adversely affected by litter loss. While carbon accumulation after reforestation may be slow this may not be the case with forest degradation. Loss of litter may reduce the carbon flow into forest soils without a commensurate reduction in the outgoing carbon flux.

Native forests are also subject to damage from weeds and fire, and possibly secondary effects such as soil erosion. While there are rough estimates of the carbon status of native forests and scrub - that is the amount of carbon they might contain - there is scant knowledge of the carbon dynamics of these ecosystems - that is the relationship between key factors, such as pest levels and control measures and the resulting carbon effects. In terms of New Zealand's climate change mitigation responsibilities, it is crucial to quantify the forest carbon impacts of pests, weeds and fire etc. It could be more important to take steps to retain or enhance the carbon content of native forests than it is to maintain expansion of the exotic plantation estate.

STRENGTHS AND WEAKNESSES OF CARBON MITIGATION OPTIONS

In the future competition could emerge between native forest protection, native reforestation and exotic reforestation, as greenhouse forestry options. This competition could take place both in the public policy arena and the commercial marketplace (see later sections on the Stratford decision and tradeable absorption obligations). Some of the carbon cycle strengths and weaknesses of each approach are listed below. The lists are not exhaustive - the entries are intended as a prompt for strategic planners and policy analysts:

Exotic Forestry - Strengths

- wide range of suitable sites including elevated localities;
- proven establishment methods and support infrastructure;
- carbon dynamics reasonably understood;
- fast carbon uptake, possibly as much as 10 tC/ha/year.

Exotic Forestry - Weaknesses

- low carbon storage due to rotational harvest;

- forest processing causes fossil fuel emissions;
- conflict between sawlog and carbon production;
- monoculture - future pests or disease?

Other strengths and weaknesses, less directly connected to the carbon cycle, can also be identified. Commercial motives for planting radiata are a strength in that they could reduce the cost of creating forests for carbon storage. A weakness is the low conservation value of plantations. This can be mitigated by extending the rotation period to allow the development of a rich native species understorey. Longer rotations also lead to increased average carbon storage.

Native Forest Establishment - Strengths

- long term carbon storage quite high;
- low cost if simply fencing reverting scrub;
- secure - genetically diverse.

Native Forest Establishment - Weaknesses

- carbon uptake rates uncertain, sometimes low;
- ongoing commitment to pest and weed control;
- lack of techniques for bare sites (grassland)?

Native Forest Protection - Strengths

- high potential to increase storage by reversing degradation;
- avoided future carbon losses could be very high;
- off-site carbon benefits (to non-protected sites);
- low fire risk cf exotics?

Native Forest Protection - Weaknesses

- dearth of knowledge on carbon dynamics;
- ongoing commitment to pest and weed control.

Native forest protection and afforestation could play an important role in future climate change mitigation measures, providing the poor state of knowledge of the carbon uptake of native afforestation and the carbon dynamics of existing native forests is rectified.

3. Framework Convention

This section outlines the key point of the Framework Convention on Climate Change (FCCC) relevant to forest management and the New Zealand Government's interpretation of its obligations as a party to the convention.

INTERNATIONAL SITUATION

The Framework Convention on Climate Change was open for signature at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. It was supported by 160 countries at the conference. Not all of these countries have subsequently ratified the treaty. New Zealand was the 34th nation to ratify. After the 50th state or regional union (eg EEC) ratified the FCCC it came into force. This occurred in 1994.

The overall objective of the FCCC is stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human caused interference with the climate system. As a first step the FCCC places a general obligation on developed countries, such as New Zealand, to return emissions to earlier levels and to protect and enhance greenhouse gas sinks, such as forests.This obligation derives from Article 4, subparagraph 2 (a) and (b) of the FCCC, which is paraphrased below. Key phrases are highlighted in bold:

"2. The developed country Parties and other Parties included in Annex 1 commit themselves specifically as provided for in the following:

(a) Each of these Parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and **protecting and enhancing its greenhouse gas sinks and reservoirs**. These policies and measures will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention, **recognising that the return by the end of the present decade to earlier levels of anthropogenic emissions of carbon dioxide** and other greenhouse gases . . . would contribute to such a modification [followed by text recognising the need to maintain economic growth and acknowledging the differing circumstances of each Party].

(b) . . . Parties shall communicate, within six months of the entry into force of the Convention . . . and periodically thereafter, . . . detailed information on its policies and measures referred to in subparagraph (a) above, as well as on its resulting projected anthropogenic emissions by sources and removals by sinks of greenhouse gases . . ., **with the aim of returning individually or jointly to their 1990 levels these anthropogenic emissions** . . ."

The FCCC is a dynamic document that makes provision for future clarification, refinement and strengthening. For example the Berlin Conference of the Parties held in March-April 1995, one year after the treaty came into force, was foreshadowed in the FCCC. The Berlin Conference established a process which (inter alia) aims, in the process of strengthening the commitments in Article 4.2 (a) and (b) of the FCCC for developed nations (such as New Zealand), to:

- set quantified limitation and reduction objectives within specified time-frames, such as 2005, 2010, and 2020, for developed countries' anthropogenic emissions by sources and removals by sinks.

COMMENTARY

The interpretation of FCCC has been the subject of much debate and controversy. The FCCC contains a dispute settlement process, but in the early stages of the treaty this process is not likely to be used. Countries will try to satisfy FCCC obligations in a manner consistent with wider national interests. In so doing they will also try to avoid vigorous diplomatic censure from the other Parties. The following commentary is intended to provide background to the New Zealand Government's policy position, rather than debate the merits of the position.

The FCCC calls for the protection of sinks and reservoirs. The thrust of the FCCC is dealing with anthropogenic impacts. If a forest is losing carbon naturally it might be argued that this does not fall within the ambit of the FCCC. Is pest and weed damage in New Zealand natural? The fact that the pest and weeds in question were introduced by humans in modern times, and have been recognised and managed as a problem in the past, probably means that the current level of effort is open to scrutiny to determine whether it constitutes protection of the forest carbon reservoir. In the circumstances, if native forests are losing carbon then it can be argued that New Zealand is failing in its FCCC obligations.

The New Zealand Government has adopted a net approach to its FCCC obligations. This will be elaborated shortly, but a corollary of the approach could be an argument that FCCC obligations are satisfied as long as the nation's forests are not losing carbon overall. This corollary has not been advocated yet, possibly because little attention has been paid to the carbon status of native forests. The net sinks approach would mean that any loss from native forests could be offset by gains from exotic forest. Without endorsing this interpretation it is worth looking at whether this is likely in New Zealand.

In 1990 exotic forests were taking around 4.5 Mt of carbon out of the atmosphere. By the year 2000 the figure could be close to 7 Mt of carbon (additional fossil use to achieve this uptake, or as a consequence of increased wood processing, will appear on the emissions side of the New Zealand ledger - see table 2 and the related discussion on page 13).

To counter the exotic forest gain in the year 2000, New Zealand's native forests carbon reservoir would need to lose around 7 MtC/yr or 0.35% of its stored carbon per annum. This sort of decline could be expected if forests were being uniformly and steadily degraded to scrub over approximately a 250 year timeframe. In one sense this is hard to imagine, but on the other hand, as mentioned earlier, over half the native forest carbon reservoir is held in "at risk" podocarp broadleaved forest. Significant areas of this forest are being so degraded that canopy collapse within 50 years is a possibility. With a net sinks approach to FCCC protection obligations, there is a prima facie case for concern that the carbon loss from native forests exceeds the uptake by exotic forests.

A forest losing carbon could be taken as an anthropogenic emission source. In that case the FCCC seems to be calling for the situation to be returned to its 1990 status by the year 2000. The New Zealand Government has interpreted its FCCC obligations as meaning net CO_2 emissions must be returned to 1990 levels by the year 2000. It might be argued that the phrase "individually or jointly" in Article 4.2 (b) lends weight to this position, although some commentators see this phrase as referring to the possibility of joint implementation between Parties. Under the New Zealand position, net emissions are derived by taking the net carbon absorbed in a given year by forests and subtracting this from fossil fuel and industrial process emissions.

Under this net emissions approach it could be argued that native forests, as an emission source, would not need to be singled out for remedy (ie to return emissions to 1990 levels). As long as the arithmetic indicated that the overall net emissions were no greater in the year 2000 than in 1990, then FCCC obligations are satisfied. Counter-intuitively, even if the carbon loss from native forests at any time exceeds that taken up by exotic forests, the net approach may still mean no action is required to protect native forests. This is due to the special accounting rules explained in the next section. Before dealing with these rules further elaboration of the New Zealand Government policy on FCCC obligation is needed.

NEW ZEALAND POLICY

In responding to climate change, the Government's objectives are to:

- reduce net CO_2 emissions to 1990 levels by the year 2000 and keep them at that level beyond then. A three pronged approach is envisaged:
    - energy efficiency measures and incentives;
    - afforestation as a temporary measure; and,
    - investigation of renewable energy options.
- seek ways of reducing net CO_2 emissions levels to 20% below their 1990 levels by the year 2000, conditional on the measures to achieve this:
    - being the most cost effective;

    - providing the greatest range of benefits regardless of whether climate change occurs;
    - not reducing New Zealand's competitive advantage in international trade; and
    - having a net benefit to New Zealand society.
- have as a long term goal a reduction in all greenhouse gas emissions and ensure the country can adapt to the impacts of climate change.

The ratio of forest sink absorption to the sum of energy and industrial process emission reductions, in order to stabilise net emissions, has been set at 80:20. The growth in forestry between 1990 and 1995 has already been large enough to counter the expected increase in energy sector carbon dioxide emissions from 1990 to the year 2000. Consequently the ratio is only important for setting the public policy target for energy sector carbon dioxide emission reduction by the year 2000 (that is the reduction from the levels likely to occur if no public policies were adopted).

4. Greenhouse Gas Accounting

Under the FCCC, Parties are required to report a national inventory of anthropogenic emissions by sources, and removals by sinks, using comparable and agreed methodologies. Parties are also obliged to report on climate change policies and measures and the expected effect of these on emissions and sinks. This section outlines the key points in New Zealand's First National Communication under the FCCC which sets out this country's situation.

NATIONAL COMMUNICATION

The net emissions ledger in new Zealand's National Communication has two sides. The first is the carbon dioxide emissions from fossil fuel use and industrial processes (these processes, which make up around 10% of this side of the ledger, are the result of carbon anode consumption in aluminium smelting, calcination of limestone in the cement industry, and the reduction of iron ore). The other side of the ledger is the removal of carbon by sinks or its loss from reservoirs.This side of the ledger is limited in scope; the only landuse source or sink that is quantified is exotic forestry.

Table 2 shows the sinks and sources information reported in New Zealand's First National Communication under the FCCC, together with some extra columns. The second column (headed *Energy Emissions)* is the business-as-usual forecasts for anthropogenic CO_2 emissions. Most of these come from the use of fossil fuels (90%). Current Government policies are expected to reduce the actual emissions in the year 2000. The third column shows the expected result. The next column shows the expected uptake of carbon by exotic forests, net of harvesting, fires etc. The uptake will increase over the decade due to new planting.

Table 2 Carbon Accounting - 1990 and Year 2000

Year	Energy Emissions	Ex Policy Measures	Exotic Forests	Net Emissions	Native forests	True Net Emissions
1990	6.95 Mt	6.95 Mt	-4.55 Mt	+2.40 Mt	X Mt?	2.4 + X
2000	8.45 Mt	8.05 Mt	-6.95 Mt	+1.10 Mt	X + Y Mt	1.1 + X + Y

According to the Government's interpretation of its FCCC obligations, net emissions only have to be the same in the year 2000 as in 1990. As it turns out, net emissions are expected to fall over the decade from 2.4 Mt to 1.1 Mt. More trees are being planted than the Government needs for its 80:20 sinks/ emission reduction policy. It, however, appears that one of the reasons the Government has adopted a modest policy target for emission reductions via energy efficiency and renewables, as opposed to no target at all, is to satisfy concerns of other Parties that afforestation is a soft option.

New Zealand's first FCCC Communication does not, however, quantify the uptake or loss of carbon from native forests. Instead it contains a short note (section 6.6.3 of the Communication) on indigenous forests. This note refers to the role of the Forest Heritage Fund and Nga Whenua Rahui in protecting private forests; and the need under the amended Forests Act to ensure logging of native forests is sustainable from July 1996 onwards. It acknowledges the problem of possums and reports that "the control of possums in 700,000 ha of indigenous forest is expected to preserve or enhance these natural reservoirs of carbon and prevent them from becoming a carbon source". No mention is made of what will happen to the carbon status of the rest of the country's native forests. (There are over nearly 4 million hectares of podocarp/ broadleaved forest and scrub.)

Section 5.4 of the Communication reports that carbon lost through the clearance of scrubland for forest planting is accounted for in the estimate of the net carbon uptake by exotic forests. No estimates are available for the effect of vegetation clearance for landuse other than exotic forestry. A suggestion is made, which is credible, that it is likely that more land is reverting to scrubland cover than is being cleared of such vegetation for non-forestry purposes. Annex 1 to the Communication provides a general discussion of the soil carbon implication of landuse changes, but this is fairly inconclusive.

ACCOUNTING FOR NATIVE FORESTS

Is it conceivable that allowing for any carbon loss from native forests would cause a problem in terms of FCCC obligations and the net approach? The adopted accounting methodology has 1990 as the starting point. Nobody knows how much carbon was being lost from native forest in that year, but let it be +X Mt (positive because it is assumed to be an emission). It could be a large amount, even more than is being taken up by exotic forests, but in the accounting what matters is the change over the decade,Y Mt. The total emission from native forests in the year 200 is X +Y Mt. The fifth column in Table 2 headed *Net Emissions* shows that exotic forests are expected to cause net emissions to fall by 1.3 Mt (2.4-1.1) over this decade. Now the X Mt occurs in the *True Net Emissions* column for both 1990 and year 2000, and the two entries simply cancel each other. The question therefore, in this context, is whether Y Mt is greater than 1.3 Mt. If it is, then the *True Net Emission* will have risen over the decade. An increase in emissions of 1.3 Mt is conceivable as the following scenario indicates.

Assuming only the podocarp/broadleaved forests are affected by pests and are losing carbon, then the increment of 1.3 Mt over a decade equates to about 0.4tC/ha/10 years for these forests. Imagine that this decade is part of a period when a pest problem, or its effects are still growing. For the sake of a simple model assume this problem is part of a 50 year build-up, the end result of which will be a point where annual carbon storage is halved. A healthy forest in complete carbon equilibrium might store 4 tC/ha/yr in new growth and lose an equivalent amount through decay. If the new growth was halved, due to pests, but the decay continued at the earlier rate then a loss of 2 tC/ha/yr might result. If the pest problem grew gradually so that it took 50 years before forest growth was halved, then the average increment in carbon loss per decade would be 0ACt/ha - the amount that would neutralise the uptake by exotic forests (ie the per hectare equivalent of value Y in Table 2).

In reality the carbon status and especially the dynamics of native forest is unclear. The point of scenarios, such as the one just painted, is to gain a feeling for the likely significance of an issue; is the outcome from worst case scenario trivial? Does a plausible case indicate a worrying possibility? (Yes, as indicated in the scenario above.) Given the short time within which possums have got out of hand, and the manifest damage observed to some forests, it is conceivable that the average increment in carbon loss per decade is of the order of 1 to 2 MtC, ie large enough to be a concern in terms of the net emissions approach. Raising the native forest carbon loss issue is not likely to be a case of crying wolf.

Clearly allocating resources to research the carbon status and dynamics of native forests is justified and should be a priority. This has been recognised by the Royal Society National Science Strategy Committee on Climate Change (NSS CCC), which advises Government on climate change research priorities. The NSS CCC has identified native forest - carbon research as vital and a priority for PGSF funding. The Committee has also identified the need to increase operational research by government departments to (inter alia) properly monitor carbon changes for FCCC National Communication purposes.

5. Stratford Decision

This section moves away from the FCCC to the Resource Management Act and the decision by the Minister for the Environment concerning a proposed power station at Stratford. The Minister approved the air discharge permit for a 400 megawatt natural gas combined cycle power station subject to a requirement that any increase in CO_2 emissions from the electricity generation sector, as a consequence of the new power station, be mitigated. This decision has been appealed to the Planning Tribunal. The notes that follow cover the situation that would apply, should the decision be upheld.

While New Zealand's obligations under the FCCC were raised at the resource consent hearing and in the subsequent recommendations and decision, the pivotal point was that the increase in CO_2 emissions as a result of the proposed power station were significant, in amount, and would probably have an incremental adverse effect on the global environment. It was decided that the emissions could not be avoided, but they should be mitigated (to the point where they are in effect remedied).

A flexible approach to mitigation has been adopted. Mitigation could take the form of CO_2 reductions outside the electricity generation system (via energy efficiency for example) or such sink activities as new forest plantings (or additional protection of potential or established native forests). The administrative arrangements are that each year the resource holder (ECNZ until the right are sold) shall provide to the Taranaki Regional Council, a report on the amount of additional emissions expected, and a plan setting out how these emissions will be mitigated. Subsequently a report on implementation of the plan must also be provided each year.

The Board of Enquiry that heard the application became aware of the problems created by dealing with CO_2 matters on a case by case basis. The Board recommended to the Minister that a national policy statement on climate change under the Resource Management Act be initiated. The Minister decided that the need for such a statement would be clearer once a study of the effects of the Stratford decision on the Government's climate change policy had been completed. This study is still underway.

The decision gives little guidance as to the rules that might govern the use of sinks as a mitigation measure. Sinks can be provided by third parties under contract to the consent holder (referred to as ECNZ from here on). The methodologies used to estimate absorption by sinks have to be compatible with the Intergovernmental Panel on Climate Change's Guidelines for Greenhouse Gas Inventories.

The resource consent for the power station does not make the timetable for sink mitigation clear. If only sinks were used as mitigation the overall objective would be (it seems) to eventually store in forests the same amount of carbon emitted over the station life. The time limit within which this result has to be achieved is not set out. It could be argued that perfect mitigation would see the requisite amount of carbon stored by the end of the station's life.

It could be further argued that carbon uptake in sinks has to occur in the same year as the emissions to be mitigated (as well as being equivalent in amount). In reality there is likely to be some trade-offs in terms of timetable and uptake rates. The nature of these trade-offs could have a bearing on the relative merits of different forestry mitigation regimes.The prospects for different regimes are discussed below.

EXOTIC PLANTATION FORESTRY

There is an argument that to constitute mitigation, sinks should be expressly established for that purpose. In other words mitigation should not come along on the coat-tails of normal commercial forestry. This argument was not accepted by the Board or the Minister (there are practical difficulties in differentiating forests on the basis of motive of planting). The result is that in order to establish new exotic plantings as mitigation, ECNZ need only demonstrate that it has a contract which will ensure the replanting of the forest, each time it is harvested. With new plantings of around 100,000 ha/yr it should be possible to create some sort of market for such in-perputity contracts.

From a carbon balance perspective, the Stratford approach to using exotic forests to provide mitigation will provide little real benefit. It is quite possible that not one single tree will be planted extra to what would have been planted without the Stratford decision. Nonetheless, from ECNZ's perspective, exotic reforestation is likely to be a cost effective solution and consequently play a major role in its mitigation plans. There may still be room, however, for native forest options.

From a commercial viewpoint one indicator of the efficiency of a sink option is the cost per tonne of carbon stored. ECNZ could invest in exotic forestry in the expectation that the venture will be commercially viable.While investment funds would need to be found, it is quite likely that from ECNZ's viewpoint the cost per tonne of carbon is negative. ECNZ, however, may not want to have exotic forest investment as part of its business. Considering the long investment time frame and hence future uncertainties of forestry, ECNZ may consider there are more secure uses for the finance it can raise. It may seek instead to obtain covenants or other instruments over existing forests to ensure they remain in forest cover or are replanted if harvested.

It costs $20/tC to $30/tC to establish a radiata forest sink (including land purchase). These costs would be roughly doubled if the forest was subsequently harvested and managed on a rotation basis. The revenues from the first harvest should (many people hope) cover the initial establishment costs. An existing forest owner may be concerned about future timber markets and whether the harvest revenues would also be able to cover the cost of replanting. ECNZ may be able to obtain a replanting obligation by paying enough now (after allowing for up to 25 years of interest, tax issues, and a risk premium) to cover future replanting. On this basis the cost of replanting obligations would probably not exceed $5 to $10 per tonne of carbon. These figures could be used as a benchmark to assess native forestry alternatives.

NATIVE REFORESTATION

Reading into the Stratford decision it appears that native revegetation could constitute mitigation. ECNZ could purchase and retire scrubland, or negotiate covenants or other legal instruments with landowners to ensure that parcels of land revert to native forest. The Taranaki Regional Council may require evidence that adequate levels of pest and weed control will be available to protect the resulting forest in perpetuity. ECNZ could establish a trust fund for this purpose.

There is little date on the potential carbon uptake rate for native scrub. Some biomass figures for young manuka/kanuka indicate that over 15 to 20 years the uptake rate could be 2 to 3 tonnes of carbon per hectare per year. Pricing the exotic forest alternative at $5/tC indicates that native afforestation could be competitive if costs can be kept below $10 to $15/ha per year. Pest control for non broadleaved scrub would be fairly low, so a role for land retirement and scrub reversion, in a mitigation plan, looks promising. It should be noted that including land in a mitigation plan that was probably going to revert to bush does little for the global carbon balance (just like the exotic forest option). Accelerating the succession and providing pest control are positive actions, however. Furthermore if the scrub was under threat of clearance, then protecting it represents a real gain.

Even though native reforestation or scrub enrichment with nursery material would be expensive, it could also play a role. Active revegetation (and land retirement) could fit in well with a mitigation plan even if they have trouble competing with exotic reforestation on commercial grounds. There are three reasons for this:

- exotic and native carbon uptake and storage considerations;
- issues relating to real benefit and scientific standards;
- corporate image and public relations benefits.

Carbon uptake from radiata is fast, but the eventual storage for a commercial plantation is modest, perhaps one third of that in a mature native conservation forest. A radiata forest will remove a given amount of carbon in say 25 years. A newly established native forest may take 60 years to store the same amount of carbon, but unlike the harvested radiata, the native trees will keep growing, taking several hundred years to reach maturity.

It may be possible for ECNZ to seek a mitigation time extension - perhaps out to 50 years instead of the power station life of 25 years - in return for an amount of native afforestation which will provide the bonus of extra sink storage in future. In that case ECNZ may find it useful to present a mitigation plan with a mix of exotic and native reforestation.

As mentioned earlier, knowledge on the carbon uptake rate of scrub and regenerating native forest is poor. This may not be a serious barrier to native reforestation. An argument can be made for relaxing the scientific standards for the time being. It is clear that the exotic forestry option need not result in extra tree planting and hence more carbon absorption by sinks than was going to happen anyway. Revegetation and pest control sponsored by ECNZ would be new, an additional to the business-as-usual future, and therefore provide a carbon benefit.While there would be uncertainty as to the level of benefit, at least it would not be zero, and this factor may favour a role for native reforestation in a mitigation plan.

Covenanting activities by the Queen Elizabeth II National Trust could be supported by ECNZ. Revegetation by such organisations as the RFBPS could also be part of mitigation plans. Even *landcare* activities by the farming community, such as establishment of riparian strips, could be sponsored by ECNZ. The opportunity exists for ECNZ to use native reforestation, especially in collaboration with community groups, iwi, environmental organisations, etc, to build local goodwill, gain broader public relations kudos and raise its profile as a good corporate citizen in political circles. These benefits could help to offset the extra financial costs of native reforestation compared with using exotic plantations as mitigation.

NATIVE FOREST PROTECTION

Many of the indirect commercial and other considerations that apply to native forest reforestation also apply to native forest protection measures.

Comprehensive pest control for native forests is likely to range from $5 to $10 per hectare depending on site and pest levels. The carbon benefits could be around 2 to 3 tC/ha/yr, on the basis of increased uptake, in which case the costs could be of the order of $2 to $5/tC. For forests under threat of collapse over the next 50 to 100 years the benefit, arguably, could be the prevented loss of 2 to 4 tonnes per annum plus the increased uptake of 2 to 3 tC/ha/yr. In this case the cost could be between $1 and $3/tC. This is competitive with exotic forestry if a replanting obligation is the mitigation option adopted by ECNZ (bear in mind that the cost could even be negative if exotic forestry is treated as a commercially viable investment).

It is conceivable that ECNZ may find it useful to partly fund some of the research needed to create input-output relationships for native forest protection (funding input, type of control activity and carbon storage output), useful because it would help ECNZ identify an appropriate level of investment in native forest protection, and/or because a reward was available. One reward for this effort (other than public relations etc) might be first option to enter an agreement with the Government to undertake carbon oriented protection measures on selected parts of the conservation estate.

If a relationship between pest numbers and carbon decline is established for different forest types and localities, then ECNZ may find it efficacious to fund research into control methods rather control activities per se. A breakthrough in biological control of possums, for example, could create a very large carbon credit.

There are a couple of concerns with pest control as a mitigation measure under the Stratford decision. Pest control is already publicly funded. There is a possibility that entry of a new agent on the scene could see current funding or future increases in public funding reduced. The result would be no real benefit. This would put native forest protection in the same boat as exotic reforestation.

The other related concern, in the absence of a permanent solution to the pest problem, is ensuring that gains made are not subsequently lost. As noted earlier, this concern also occurs with native reforestation. The creation of a trust fund with sufficient capital to generate enough interest (net of inflation) to fund ongoing maintenance control, may be needed.

CONSERVATION PORTFOLIO

The Stratford decision creates a number of opportunities for additional resourcing for conservation activities in New Zealand. It will not create a large windfall, however. The proposed power station will emit up to 400,000 tonnes of carbon (as carbon dioxide) each year. If the cost of mitigation is $10/tC the total mitigation budget would be $4M per year. Much of this is likely to go to exotic forestry options. The balance, though, could make a useful contribution to conservation objectives, especially if a reasonable proportion was spent on research into forest pest control.

The Department in collaboration with other interested parties could take the initiative and put together a portfolio of potential investments of ECNZ to consider when developing its first mitigation plan. A wide range of situations could qualify as candidates for this portfolio. Some of these situations are outlined below. A common feature of each of these is the marrying of the carbon storage objective with core or secondary conservation goals. Whether any one of the suggestions could actually form part of a mitigation plan will depend on the Taranaki Regional Council.

QEII COVENANTS

The QEII prioritises applications for convenanting. Not all proposals are accepted. There is often a waiting list for those accepted and meanwhile stock damage, etc, continues. There is a risk that some prospects will drop off the bottom end of the list due to the delays.

ECNZ could be offered (ie invited to pay for covenanting costs) the bottom 50 approved applications on the waiting list at any time, together with those rejected (which usually have some useful native vegetation). It can be argued that this approach leads to some carbon storage that might not have happened otherwise.

ACTIVE REVEGETATION

A private landowner, DOC and RFBPS could put together a revegetation package for a pasture site in an area short of native forest (eg Hawkes Bay). RFBPS provides some of the labour and ECNZ pays for fencing and initial plant material (perhaps cutting and transport of manuka slash). Five years later nursery material is planted. DOC is contracted to prepare the revegetation plan and supervise the work. The land is either purchased or covenanted (possibly with some reward to the landowner leg create a stock watering dam with pump and troughs, downstream of the revegetated catchment). Purchased land could be transferred to a suitable trust for in-perpetuity management (or transferred to the Crown or a local authority as a reserve).

PASSIVE AFFORESTATION

Roller crushing of manuka is going on in a region leg Marlborough) as part of land preparation for exotic forestry. ECNZ buys a block of scrub that has access and terrain making it clearly suitable for exotic forestry and therefore at risk to conversion. Fencing is improved and a degree of pest and weed control is undertaken. As part of its mitigation plan ECNZ claims a carbon credit equal to the likely carbon storage in say 50 to 100 years (when the block will have some tall forest species) less the carbon storage had the land been converted to exotic forestry (net effect probably 100 to 150 tC/ha).

CONSERVATION ADVOCACY

This is a similar situation to passive afforestation, except that ECNZ finances Resource Management Act advocacy (assuming a land use consent is needed for the scrub conversion). Each time a ECNZ funded effort is "successful" a carbon credit is claimed for the mitigation plan.

Note that the logic of the Stratford decision suggests that all net carbon emissions should now be mitigated, irrespective of whether the source is fossil fuel or land clearance. In reality though, where scrub clearance is not a prohibited activity, a bundle of landscape, nature conservation, soil and water conservation and climate change arguments would be needed to be presented to persuade a local authority to decline land use consents.

PEST CONTROL - LOW PRIORITY AREAS

ECNZ funds comprehensive pest control in a system of areas with low priority for conservation values (and away from farmland in TB endemic areas) and hence little prospect of pest control otherwise.The aim of control would be to arrest forest decline and then to increase carbon uptake. In this case it could be argued that the carbon benefit is the potential loss of carbon that might have occurred had forest degradation continued - perhaps 200 to 250 tC - plus any carbon new resulting uptake - perhaps 2 tC/yr. To ensure in perpetuity carbon storage, ECNZ establishes a trust fund with an initial cash grant, or builds up a fund over ten years, out of power station revenues.

PEST CONTROL - PRIORITY AREAS

ECNZ funds comprehensive pest control in a system of areas with very high conservation values. Since these areas probably would have been subject to pest control anyway, it might be more difficult to claim any potential long term loss as part of the carbon benefits. Carbon uptake beyond maintenance of the present situation could be reasonably claimed, however. As well as the carbon benefits, ECNZ could be permitted to market its involvement much as Mainland Cheese does with hoiho or Comalco with kakapo.This would help offset the lower carbon benefits compared with the situation above.

PEST CONTROL RESEARCH

Pest control costs per ha could be reduced through research into such matters as improved baits, or biological controls. If pest control can be related to carbon gains, then research can also be related to carbon gains. Let us say that $1/ha of control buys Y tC/ha. If research halves pest control costs and the budget for control was held constant, then for each control dollar spent the carbon benefit of the research would be Y tC/ha. Well designed research typically has high cost benefit ratios (and moderately high risks). DOC in conjunction with CRIB could identify some specific avenues of research for ECNZ to fund. If ECNZ chose well it could end up with some very cost effective mitigation measures.

WILDLIFE HABITAT/RIPARIAN STRIPS

A stream suitable for blue duck habitat, except for lack of riparian vegetation is identified (eg Central Volcanic Plateau). With the agreement of the landowner and facilitation by the regional council, a riparian strip is fenced and planted using native trees, shrubs etc. ECNZ meets the costs, claims a carbon benefit and could see public relations advantages - it may also be able to use this action as mitigation when seeking renewal of Tongariro Power Development water permits.

In another situation, riparian strips may be desirable to filter sediment and nutrients from farmland (eg around Lake Rotorua). A mixture of exotic trees (eg poplars) and a native understorey (eg flax, hebe) may be used. Downstream water quality and hence fisheries are enhanced, and a wildlife habitat/ corridor established.

FARM FORESTRY

A rich native plant understorey is just forming under a poorly pruned five hectare farm forestry block, which is about to be cleared. There are few native habitats in the area. A cash grant from ECNZ to the landowner could defer harvest for five years or more. Furthermore subsequent harvest could be on a selective/occasional logging basis for a local sawmill. The carbon storage of the woodlot increases (both radiata and native component) and a useful wildlife habitat is established. The woodlot could also be selectively replanted in exotics to maintain a wood supply to the sawmill and occasional income to the landowner.

SOIL CONSERVATION

In places like the East Cape conventional soil conservation forestry on eroding pasture involves planting radiata, undertaking minimal silviculture, and clearing the forest after 25 to 30 years to avoid soil and land stability loss via windfalls, and then replanting. The resulting timber is often not worth a lot, but revenues usually cover harvest and replanting costs. An alternative approach with greater carbon and conservation benefits involves wide spaced radiate planting to get a quick result, followed by the use of manuka slash, forest duff and then some native nursery material. When the radiata is around 20 years old it can be cut to waste as an adequate native understorey will be in place and replanting with exotics will not be necessary. The result is less soil disturbance and the establishment of a more permanent solution.

The cost of this integrated radiata/native regime may only be slightly higher than an all exotic approach. Working with regional councils, the landowner, DOC and possibly local conservation groups, ECNZ could make up this difference and claim the 50 to 100 year carbon storage.

The Taranaki Regional Council would be wise not to try and get into great detail over every suggested component of a mitigation plan. Instead the Council could establish a set of rules of thumb for assessing different activity classes X tC per kilometre for riparian strips:Y tC/ha for pest control in podocarp forest; Z tC/ha for "at threat" regenerating scrub, etc. DOC could work with the Regional Council and ECNZ on establishing these rules of thumb.

6. Tradeable Absorption Obligations

This short section provides an overview of the concept of tradeable absorption obligations and their counterpart tradeable emission permits. These economic instruments have been promoted as a means to mitigate and reduce emissions.They could form part of an international system that could help to optimise the overall global response to climate change. The notes below only deal with the application of tradeable systems to New Zealand.

Tradeable economic instruments are often put forward as an alternative to a carbon tax. Within New Zealand environmental circles opinion on tradeable economic instruments varies. The Maruia Society appears to be the main advocate for establishing a system of tradeable absorption obligations.

The system would involve emitters of CO_2 having an obligation to absorb an equivalent amount of carbon in a sink.The emitters would not have to establish and manage the sink, as this could be contracted to third parties. A tradeable system might see sink owners creating absorption certificates according to the carbon uptake of their forests. Every emitter would need to hold enough certificates to cover their emissions. They would buy these from the sink owners.

If a firm went out of business then it could sell unused certificates to others. If a business wanted to expand and increase its emissions then it could buy certificates from sink owners or other businesses. Various property rights and administrative arrangements are conceivable, but this simple outline conveys the basic idea. All emissions would be covered by the system, including carbon released when existing forests are harvested, burnt or otherwise lose carbon. A certificate would be created by carbon uptake, but loss of carbon already in forests when the system was implemented, would have to be avoided or covered by a certificate generated by forestry on another site.

If the absorption system is confined to New Zealand, there may be concerns that with a large area suitable for afforestation, emissions would continue to grow for a long time. Landuse competition may not push up prices enough to create an adequate incentive for emitters to become more energy efficient or use renewables. For this, and other reasons, a quicker way of reducing emissions to sustainable levels may be considered necessary.

With more forest cover the planet will probably be able to assimilate CO_2 emissions from fossil fuels providing they are around 50% of current levels. Tradeable absorption obligations would provide an incentive to reduce emissions as long as there were energy efficiency or renewable energy options available to businesses that were cheaper than obtaining absorption certificates. Once that point is reached, or even to accelerate its arrival, tradeable emission permits could be introduced.

Tradeable emission permits would augment absorption obligations. All emitters would need to have an emission permit as well as a set of absorption certificates. Again various property right and administrative arrangements could apply. Permits can be introduced initially by grandparenting existing emitters or via competitive tender. At first the sum of permits could equal existing emissions. Permits would be tradeable like absorption certificates so that individual businesses can adjust their emission levels, but the overall total of permitted emissions would be fixed.

The decline in emissions could be achieved by assigning permits a limited life. When they expire a reduced quantum could be reissued. Alternatively the permits could have a decay function built in so that their emission value falls over time. As the quantum of permits (or their emission value) falls over time, the monetary value of a permit rises. This make previously non commercial energy efficiency and renewable options more viable. The stronger market for these alternative energy options spurs on R&D, leading to lower costs, and mitigation of adverse economic impacts. The ever reducing level of available permits means that interest in reducing or avoiding emissions is maintained until the national emission target is achieved.

There are some similarities between the Stratford decision and the pair of economic instruments just described, but also some major differences. In the forestry context the main point to note is the extensive market for absorption certificates that would be created. If all of New Zealand's CO_2 emissions had to be covered by absorption certificates then the market would be over 8 MtC in the year 2000 instead of the 0.4 MtC from the proposed ECNZ power station.As the total exotic forest carbon uptake in the year 2000 is forecast to be just less than 7 MtC, a strong seller's market would develop. This would push up prices closer to the full cost ($/tC/ha) of establishing an exotic forest. The range of native reforestation and protection options that would be commercially attractive would also expand.

The system of economic instruments outlined above requires a strong property rights basis resting on firm science to avoid cheating. Consequently the input-output relationships and related rules connecting native forestry measures to absorption certificates would need to be well defined, compared to the bit of soft science that might suffice for the ECNZ Stratford mitigation plans. Knowledge on native forest carbon status and dynamics would have to improve markedly for native reforestation and protection to play a role in a widespread absorption obligation regime.

It should be noted that some parties that have thought about tradeable absorption obligations do not favour a completely free market approach to sinks (or favour an obligation system at all). Greenpeace New Zealand, for example, has argued for a public policy on the mix of sinks, if some form of carbon emission - forest offset system is implemented. Targets could be set for the proportion of emissions that has to be covered by native forest absorption, establishment of riparian strips and other conservation or environmental tree planting or protection.

There is merit in the Greenpeace suggestion from both a conservation perspective and a carbon sink viewpoint. The marketplace may not produce a mixed sink portfolio even if the consequences of a wide range of risks were placed on the players. Having a mix of sinks would avoid the problems that can arise from having all your eggs in one basket - such as vulnerability of genetically similar forests to a new and destructive pest. Public policy on a sink mix may be desirable, but it would not diminish the need to improve the science of the native forest - carbon connection.

Is all the above academic, or of any practical import? Some commentators consider that the post Berlin FCCC process will, by as early as 1997, lead to New Zealand receiving performance targets for the period 2000 to 2010 much tougher than at present lie maintaining net emissions at 1990 levels). Some of these commentators consider that emission/absorption economic instruments are an efficient mechanism to reduce emissions and counter those that do take place.

As a contingency measure the science of the native forest-carbon connection needs to be rapidly improved. The potential for future widespread absorption policies reinforces the need to improve the science for the other reasons mentioned earlier: the issue of sink protection under Article 4.2 (a) of the FCCC; the National Communication reporting requirements under the FCCC and the New Zealand reliance on sinks under a net emissions policy; and the opportunities for native forestry initiatives in terms of the Stratford decision.

7. Conclusions

7.1 Rough estimates of the size of the New Zealand native forest carbon reservoir are available from previous biomass studies, but an accurate assessment of the current carbon status is not available. Knowledge of the carbon dynamics of native forests, including the effect of pests, is very limited. Little is known about the rate of carbon uptake by land reverting to native forest, or land managed so that it eventually ends up back in native forest.

7.2 Native forests and scrub constitute over 80% of New Zealand's vegetative carbon reservoir. They hold about 1900 Mt of carbon in their biomass and litter. Forests and scrublands containing vulnerable podocarp and broadleaved species are thought to contain around 57% (1200 Mt) of New Zealand's total forest and scrub carbon reserves (2100 Mt) or 50% of the total vegetative carbon reserves (2400 Mt). Exotic forests in 1992 contained around 127 Mt of carbon, or just over 6% of the forest and scrub carbon reserves. The soils under native forests are also an important carbon reservoir; they contain an additional 1000 Mt of carbon.

7.3 Improving the state of knowledge on carbon aspects of native forest management is vitally important in order for New Zealand to show that it is discharging its obligations under the Framework Convention on Climate Change. It may also be important if opportunities for additional resources for native forest protection and reforestation are to be realised. These opportunities include the Stratford decision (subject to appeal) that has created a need to mitigate carbon dioxide emissions caused by a new power station, and the potential for future climate change policies, such as tradeable absorption obligations.

7.4 Under the FCCC, New Zealand appears to have an obligation to protect and enhance native forest carbon reservoirs. The Government has adopted a net emissions approach to its FCCC obligations. It may wish to have a net sinks policy as well, whereby uptake by exotic forests is placed alongside losses from native forests, to see whether there is a net loss. If there is no net loss then an argument might be advanced that *overall* sinks and reservoirs are being enhanced.

7.5 There is a prima facie case that native forests are losing carbon. Arguments that the loss is natural and therefore does not count (in terms of FCCC obligations), are not credible. In 1990 exotic forests absorbed about 4.5 Mt and this amount is increasing each year. It is quite conceivable that native forests are losing more carbon each year than exotic forests are absorbing. In that case, even with a net sinks approach, New Zealand will be obliged to take measures to reduce the carbon loss from native forests (or increase the uptake by exotic forests).

7.6 The FCCC requires countries, such as New Zealand, to return emissions of CO_2 to 1990 levels by the year 2000. This country has adopted a net emissions approach, whereby absorption by forest sinks can be used to offset emissions, for the purposes of satisfying FCCC obligations. The first official New Zealand Communication under the FCCC reports on year 1990 and expected year 2000 emissions and sinks, but does not quantify native forest carbon changes. The increase in carbon uptake by exotic plantations between 1990 and year 2000 is shown to exceed the increase in emissions, mainly from fossil fuel use, over the same period by 1.3 Mt.

7.7 If carbon losses from native forest grow by more than 1.3 Mt over this decade then the ability of New Zealand to keep its net emissions at 1990 levels will be compromised. This is more than a remote possibil ity given the growing problem with possums and goats, and the loss of seed dispersing birds in native forests. New Zealand has a lot at stake with the net emissions approach to its FCCC obligations and needs to know quickly whether it is likely to have a problem.

7.8 Even if the growth in carbon loss from native forests this decade is less than 1.3 Mt there is no room for complacency. New and more stringent targets are being developed under the FCCC for implementation from the year 2000 onwards. These new targets may elevate the significance of native forest carbon loss.

7.9 The Stratford decision by the Minister for the Environment will create a small competitive market for carbon sinks. The details of the decision mean that no extra trees need be planted beyond what would have been anyway. To satisfy the mitigation requirement the power station operator will only need to show that enough land is permanently committed to forestry. To count third party exotic plantations, ECNZ (or whoever manages the power station) will need to obtain some form of replanting agreement. The rules that will apply to native forest-carbon sink options are not yet clear.

7.10 ECNZ could see exotic forestry as a commercially viable investment in which case the cost of mitigation via sinks would be zero. For various reasons the third party replanting contracts option may be preferred. In this case the costs (expressed in terms of $s per tonne of carbon mitigated) will probably be similar to the most cost effective native forest protection or afforestation options.

7.11 A moderate amount of relatively expensive native forest options may also find their way into a mitigation portfolio for several reasons: obtaining recognition for the long term carbon benefits of native forestry options could lower costs; and involvement in protection and tree planting could provide public relations benefits to the power station operator. Funding pest control research could be a particularly cost effective mitigation measure. The total cost of mitigating emissions from the proposed power station is likely to be less than $4M/yr. This sum represents around 40% of the total existing pest control budget for the Department of Conservation.

7.12 To take advantage of the opportunity presented by the Stratford decision, DOC together with other interested parties leg certain regional councils and environmental groups) should work up a portfolio of con servation investment opportunities for ECNZ. This portfolio would consist of a series of costed proposals for different types of native forest-carbon sink activities together with an estimate of the carbon benefits. A precursor to development of the portfolio would be discussions with ECNZ to identify the general types of activities that might be attractive to the power station manager.

7.13 Lack of data may make it difficult to be definitive about the real cost-benefits of each proposal. The key factor for each proposal is the amount of carbon storage that is accepted as being likely by the Taranaki Re gional Council which manages the resource consent conditions. For a variety of reasons, such as the public good nature of forest protection and afforestation, the regional council, in the early stages, may not demand a high standard of proof for carbon storage claims made in a conservation portfolio.

7.14 In the longer term adoption of such economic instruments as tradeable absorption obligations may be deemed necessary for New Zealand to meet more stringent FCCC targets. Tradeable absorption obligations would represent an extension of the Stratford decision. An absorption obligation will have two major impacts on native forestry. Firstly they are likely to give sink owners the upper hand in the marketplace. In the year 2000 emissions from fossil fuel use and industrial processes will be around 8 Mt of carbon while absorption by exotic forest may only be 7 MtC. Sink demand will push up prices so that more native forest options become commercially viable.

7.15 The second effect of an absorption obligation is that it may place an onus on landowners to maintain the carbon status of their forest - both native or exotic - or compensate for carbon loss by obtaining *absorp tion certificates* generated from carbon uptake by forestry on other sites. This outcome would reinforce the FCCC call to protect and enhance sinks and reservoirs.

7.16 To effectively realise the opportunities that are emerging the Department of Conservation needs to improve the level of knowledge on the carbon status and dynamics of native forests and regenerating forests. Eventually the aim should be to develop reliable input-output models so that the Department can advise the Government on the carbon consequences per unit of dollar investment in various management interventions. This information is likely to become increasingly important in the future, not only for public expenditure reasons, but also to enable the Department to present potential private carbon mitigation partners with well quantified investment options.

7.17 As a first step to this end the Department should commission a state of the art report that pulls together all available information related to the native forestry carbon issue: any information on biomass increase rates for regenerating scrub; rate of biomass increase after possum control; the cost of different revegetation regimes, etc. It would also be helpful if the Department identified suitable trial or monitoring sites to help obtain biomass/time/management methods relationships. The Department could work with other parties to present proposals for Public Good Science Fund research.

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