NEW ZEALAND AND THE KYOTO PROTOCOL:

Implications of Ratification for New Zealand and Rural Land Users

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EXECUTIVE SUMMARY

The objectives of this report are to examine the position of New Zealand in regard to the Kyoto Protocol and the possible impacts of the Protocol on New Zealand rural land users. The world initiatives leading to the development of the Protocol in an attempt to reduce anthroprogenic climate change, and the commitment required from New Zealand, assuming ratification, are examined.

The characteristics of New Zealand's greenhouse gas profile are discussed and our carbon sinks/emissions equation outlined to show that, due to the large-scale forest plantings since 1990, New Zealand will be able to meet its Protocol commitments in 2008-2012 with a substantial surplus available for international trading.

The possible monetary values to New Zealand and to rural carbon emitting and sink activities are outlined.

The report concludes that the application of the cost of emissions and value of carbon sinks to the causal activities via a carbon charge and an unfettered trading of carbon credits regime based on international values will best allow price signals to develop which will influence behaviour and reduce net greenhouse gas emissions.

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Objectives:

1. To provide an overview of the global initiatives being undertaken to reduce the effect of human activities on world climate.

2. To provide an understanding of the Kyoto Protocol and the obligations of New Zealand under the Protocol.

3. To investigate the implications and opportunities for New Zealand to meet its obligations under the Protocol.

4. To indicate a range of possible costs and benefits from emissions charges and credits to the pastoral farming and forestry sectors of New Zealand.

5. To provide a broad summary of the likely effects of the Kyoto Protocol in the New Zealand context for the first decade of the new century to the Kelloggs scholars of 2000 in a readily understandable form.

1.0 Greenhouse Gases & Climate Change

The Earth is surrounded by a thin film of gases forming the atmosphere. It is the composition of this atmosphere that creates some of the essential conditions for the diversity of life on the Earth's surface and in the oceans.

Water vapour and gases such as carbon dioxide and methane trap some of the solar heat the Earth radiates back to space. These gases are called "greenhouse gases" (GHG) and the greater their concentration in the atmosphere the greater the potential for a warmer planet. It is the greenhouse gases which hold the Earth at temperatures able to sustain human life - if there was no greenhouse effect temperatures would be sub-zero.

In addition to natural changes to the composition of the atmosphere, which have occurred over geological time-spans, human activity over the last 200 years has measurably changed the composition of the atmosphere through emission of GHG. The anthropogenic (human-induced) sources of GHG are shown in Appendix I. Since pre-industrial times carbon dioxide (CO_2) concentration in the atmosphere has increased by about 28%, methane (CH_4) by 145% and nitrous oxide (N_20) by 13% (*IPCC 1996*). These are the main GHG.

Some GHG produced by human activity are present naturally, for example carbon dioxide and methane. Others, such as the fluorocarbons, are the so-called "industrial gases" and, although present in very small concentrations compared to CO_2 and CH_4, have extremely long atmospheric lifetimes (for example perfluorocarbons 3,200-50,000 years versus methane 14.5 years).

Some GHG are removed naturally from the atmosphere by chemical processes or via the carbon cycle into biomass. However, GHG have been accumulating faster than these natural processes can remove them.

Since the late 19th century the global average temperature has increased by 0.3 to 0.6°C with the last years of the 20th century being the warmest since instrumental records began in 1860. The world's ten warmest years have all been since 1983 with seven since 1990. The Earth's mean surface temperature is predicted to increase by about 2°C by the year 2100 if emissions continue to increase at current rates. The most optimistic scenario is for an average global increase of about 1°C and the most pessimistic is for an increase of about 3.5°C (*IPCC 1996*). In New Zealand average annual air temperature has increased by just over 1°C since 1860 (*Salinger et.al. 1996*).

At a global level, the scientific consensus is that in addition to warming the Earth's surface, increasing atmospheric concentration of GHG will cause changes in sea level and rainfall. Any human-induced effects on the climate will be superimposed against a background of natural climate variability and change. **However, the balance of evidence suggests that there is a discernible human influence in global climate** (*IPCC 1996*). For the purpose of this report the correlation between anthropogenic GHG and climate change is accepted.

The necessity to address climatic change is because "humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequence could be second only to nuclear war" (*UNEP 1988*).

1.1 International Response to Climate Change

A key organisation established to marshal scientific information about climate change is the Intergovernmental Panel on Climate Change (*IPCC*) formed by the United Nations Environment Programme and the World Meteorological Organisation.

In 1990, the first IPCC report concluded that human-induced climate change is a real threat.

In 1992 the United Nations General Assembly adopted the United Nations Framework Convention on Climate Change (*UNFCCC*). This was signed by 155 countries ("Parties") and came into force in 1994. The ultimate objective of the UNFCCC is to achieve **stabilisation of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system** (*UNFCCC 1999*).

In 1997 developed countries and those with economies in transition agreed to legally binding emission reduction commitments under the Kyoto Protocol to the UNFCCC. (*Appendix II*).

The Protocol was agreed by all parties to the 1992 convention. By March 1999, 84 countries including New Zealand and the United States had signed the Protocol, which will become binding when at least 55 countries, representing 55% of developed countries CO_2 emissions have ratified. By October 2000 30 countries had ratified the Protocol. New Zealand has yet to do so but has signalled its intention to do so on a number of occasions, most recently by a statement by the Minister for the Environment in August 2000.

The objective of the Kyoto Protocol is to **reduce the overall emissions of GHG of the Parties to at least 5% below 1990 levels in the period 2008-2012** (*Kyoto Protocol 1992, Article 3.1*).

It must be noted that stabilising **emissions** at 5% below 1990 levels will not lead to stabilised **concentrations** (the objective of the UNFCCC) - to stabilise concentrations at 1990 levels global carbon dioxide emissions would need to be cut by more than 60%, methane by 15 to 20% and nitrous oxide by 70 to 80% (*IPCC 1996*) rather than the 5% objective of the Protocol. The Kyoto Protocol emissions reduction target of 5% will therefore only go a limited way towards the ultimate objective of stabilising atmospheric concentrations. This information can be received in two ways - as highly depressing, leading to a "why bother?" mentality and a business-as-usual approach, or as a spur to at least commence action and set targets, albeit at levels lower than required, which provide a realistic opportunity for achievement. The signatories to the Kyoto Protocol have chosen the latter and these countries, given subsequent ratification of the Protocol have embarked on a path which will provide at least a first step to mitigating and controlling the detrimental effects of humans on the Earth's climate.

1.2 Requirements of the Kyoto Protocol

The Protocol, whilst setting an aggregate objective of reducing the parties emissions of GHG by at least 5% below 1990 levels in the period 2008-2012, does not require each individual party to achieve that. Rather, it has set individual reduction commitments that will, on average, achieve the aggregate target. For instance USA as the world's biggest single-country emitter has a reduction commitment to 93% of 1990 levels whilst Australia, as a low emitter on a population and land-area basis is allowed to increase emissions to 108% of 1990 levels.

New Zealand's Kyoto target is to stabilise emissions **at 1990 levels**. This means that New Zealand's anthroprogenic production of the six main GHG in aggregate are to be stabilised at 1990 levels, on average, over the period 2008-2012 (the first "commitment period"). This corresponds to an amount of allowed emissions for this period - New Zealand's "assigned amount".

The Protocol recognises that certain anthroprogenic activities can be positive agents of removal of GHG from the atmosphere, as distinct from the activities which reduce the amount released. GHG are measured as CO_2 equivalent emissions. Each gas is measured on a scale of Global Warming Potential (GWP) using CO_2 as a base (*Appendix VI*). Methane has a GWP of 21 meaning a given weight is 21 times more damaging in a global warming sense, than carbon dioxide (GWP is related to atmospheric lifetime of the gas in the atmosphere). Any activity which removes carbon dioxide from the atmosphere (a "sink") can be counted as a net

reduction in emissions of aggregate GHG. This provision, in Article 3.3 of the Protocol, limits GHG removal by sinks to direct human-induced land use change and forestry activities of afforestation, reforestation and deforestation activities since 1990.

The provision to include removal of GHG by sinks as an integral component of the reduction commitments of the Parties to the Protocol is particularly critical to New Zealand due to the specific GHG profile of this country, and the land use changes which have occurred since 1990. A second critical component of the Protocol (Articles 3.10-3.12) is the ability of the Parties to trade the emission reduction units created by sinks within and between countries. The aim is specifically to establish an international trading market which will rapidly effect a rational price for emission units. The rationale is that carbon efficiency, like economic efficiency, will be maximised only when a free trading regime allows a transfer of the good to the party which places the highest value on it.

2.0 New Zealand Government Position and Actions

Should, and will, New Zealand ratify the Kyoto Protocol?

To choose not to ratify would be theoretically possible but quite unlikely for a number of reasons. Firstly, New Zealand has always upheld the decisions and directions of the United Nations and endeavoured to meet its international obligations. Secondly, New Zealand regards itself as a leader in environmental issues, having been at the forefront of, for example, anti-nuclear and anti-whaling campaigns.

Thirdly, our international trading "brand" increasingly relies on our reputation as a "clean and green" country. This is used to promote both our exports and our desirability as a tourist destination. This brand would be severely compromised if New Zealand failed to ratify the Protocol.

Furthermore there is the issue of ethics on a national scale. Ethical behaviour requires that we present citizens have regard to the reasonable needs of future generations. This is recognised in New Zealand by legislation in the Resource Management Act 1991 which has the purpose of "safeguarding" of the life-supporting capacities of ecosystems (*Reeves, 1996*).

Finally, as an international economic minnow New Zealand would not be in a strong position to withstand any sanctions or other actions taken by the international community should the Protocol be ratified by a majority of the parties and subsequently come into force. (The key to that is the position of the United States. As a major emitter and superpower, if the USA fails to ratify, the Protocol may fail - conversely if the USA does ratify, it is unlikely that New Zealand could withstand the subsequent pressure to do so).

There are within New Zealand, groups who argue that the Government should not be proactive in promoting ratification (*NZFIC/NZFOA 1999*). However, for the reasons outlined above and the purposes of this paper, it is assumed that New Zealand will ratify the Protocol and therefore accept, and be required to satisfy, its emissions obligations.

The Government in May 2000 agreed as a high-level objective for New Zealand's climate change programme, to show leadership on climate change **including ratification of the Kyoto Protocol** (*MFE, 2000*). A timetable was set to finalise the design of an abatement programme and to introduce legislation to Parliament to ratify the Protocol by 2002 (*Appendix III*). Cabinet agreed to the preparation of papers by October 2000 on the main policy

measures to met New Zealand's Kyoto Protocol's commitments, allocation of emission reduction responsibility across all sectors, and non-price measures for immediate implementation and further development for future implementation. Therefore this country is on a pathway leading to ratification of the Protocol. Assuming ratification does indeed occur, New Zealand will be required to show demonstrable progress under the Protocol by 2005, prior to the commencement of the first commitment period in 2008.

Government policy is that New Zealand will adopt a "least-cost" approach.

A theoretical least cost path is one where emissions abatement decisions are taken along a "merit order" of abatement cost (ie: all the cheaper actions are taken first before advancing to more expensive actions). Least cost to the economy as a whole does not mean least cost to every individual. To achieve an economy-wide least cost requires all emitters to face the same "opportunity" cost of emissions - an equal incentive to reduce emissions (*MFE 1999*). The commitment to a least-cost approach also implies the opportunity for trading between individuals to achieve least-cost to the total economy.

The range of possible actions fall into two broad categories - non-price and price measures. Non-price measures are targeted at eliciting cost-effective opportunities to reduce emissions particularly when there are market imperfections and/or a lack of information and education. Non-price measures can support the effectiveness of, and in turn be enhanced by, a price signal that makes emitters take responsibility for their actions.

Price Measures are also being examined by the New Zealand Government.

These include cross-sectional measures such as emissions trading, and carbon charges. The Government has initiated the necessary work to enable decisions on what, if any, measures it will adopt.

Ministers have already stated that a carbon charge will be considered within a review of the wider tax system. Initial design work on carbon charges and emissions trading has been undertaken (*Treasury 1997*).

Some taxes are already imposed on some emitting sectors for example, fuel excise tax and the Energy Resource Levy on open cast coal. Although their primary purpose has been to raise general revenue, changes in the tax level would have consequences for emissions. The possibility of a specific carbon tax on fossil fuel has been raised recently, although the

Government has stated no tax would be introduced until 2002 (*Hodgson 2000*). The transport sector is an obvious and easy first target as CO_2 emissions from this sector are growing the most rapidly of any sector - 32% from 1990 to 1998. However, transport has very low price elasticity in demand (responsiveness of fuel consumption decisions to a change in price) meaning that there is likely to be a large economic welfare loss if blunt measures such as a high tax, on top of existing taxes, is introduced.

A carbon charge, like some other taxes, eg: tobacco and alcohol excises is not subject to the same general principles as revenue-raising taxes. Revenue raising taxes such as GST or personal income tax are aimed at minimising their effects on people's behaviour, while taxes such as a carbon charge are aimed at changing it (*Treasury 1997*). The purpose of such taxes are to "correctly" price goods which in their use, impose otherwise unpriced costs on society - in the case of carbon the unpriced cost is human-induced climate change.

A carbon tax would send a price signal that would reinforce societal pressures to reduce carbon emissions and therefore to change citizens behaviour. However the acceptance and success of such a tax will be compromised if the funds flow into the general tax revenue without a specific boundary (an illustration is the capturing of road user charges for purposes other than roading or tobacco tax for purposes other than health spending). Any carbon tax is likely to maximise emissions-reduction efficiency only if the funds collected are made available for specific emissions-reduction or sink-increasing projects and research.

The second significant price measure is that of emissions trading. Under the Kyoto Protocol emissions would be restricted to the level of New Zealand's "assigned amount" (that is, equal to 1990 emissions) for the first commitment period. The Government would allocate units of assigned amount. Emitters would be required to ensure they have sufficient assigned amount to cover their emissions, providing a choice of purchasing additional amounts (credits) or reducing emissions, whichever is the most cost-effective to them.

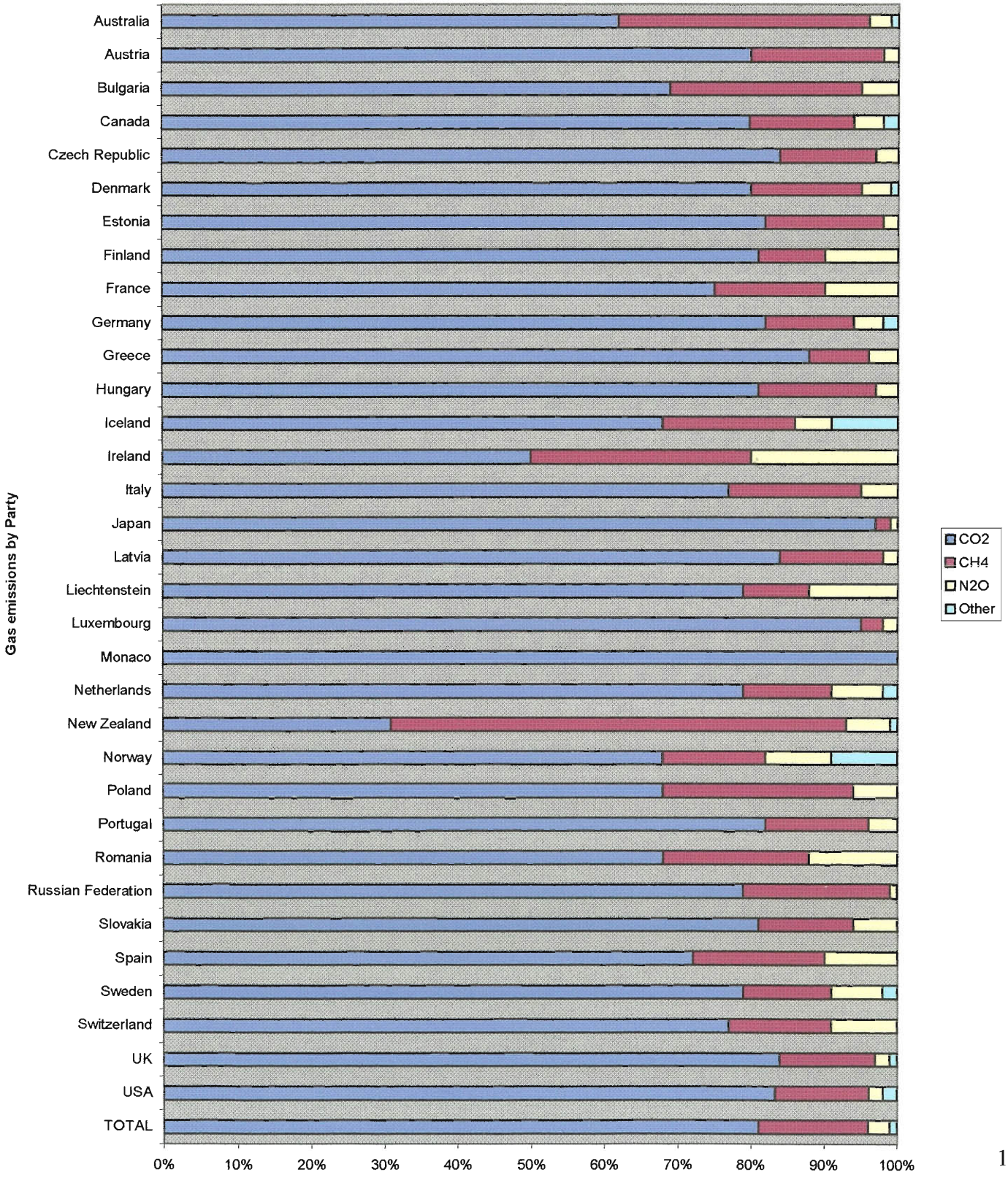
The method of allocation of initial assigned amounts has yet to be determined. There are two primary alternatives - "grandparenting" (allocation based on existing use) or "auctioning" (purchase or price allocation). There are considerable political decisions (to whom and how to allocate an assigned amount) and technical design issues (where to place the point of obligation, enforcement and collection of costs) yet to be clarified.

International emissions trading is inevitable and is expressly provided for under the Kyoto Protocol. Therefore it is highly desirable that any domestic emissions trading regime is able to interface with the eventual international regime to enable New Zealand to lower its overall cost of meeting its Kyoto Protocol targets.

3.0 New Zealand Greenhouse Gas Profile

New Zealand has a unique emissions profile compared to most of the other Parties to the Kyoto Protocol, whose predominant greenhouse gas is CO_2. This is shown in Figure 1 below.

PROPORTION OF DIFFERENT GREENHOUSE GAS EMISSIONS BY PARTY * (PERCENTAGE)



New Zealand - perhaps contrary to the belief of most of its citizens - is not a low emitter of GHG. If assessed on a "CO_2 per capita basis" in 1990 New Zealand was the 9th lowest emitter out of 33 Parties, but when assessed on an "all GHG per capita basis", New Zealand had the 4th highest emission rate (*MFE, 1998*) and in fact emits 9 times the world average of 64kg/year (*Ulyatt, 1996*).

In 1990 emissions of CO_2 in New Zealand represented only 35% of total emissions - non-CO_2 gases, especially methane (CH_4) and nitrous oxide (N_2O) account for the majority of emissions. In fact, New Zealand had the highest ratio of non-CO_2 to CO_2 GHG emissions of any of the developed country Parties to the UNFCCC. These are sourced, unsurprisingly, primarily from the agricultural sector; in particular ruminating livestock (CH_4) and agricultural soils (N_2O). The "industrial" gases, sulphur hexafluoride, perfluorocarbons, and hydrofluorocarbons are insignificant in New Zealand and predicted to remain so by 2010. Ruminant livestock in 1990 accounted for almost 90% of total methane emissions in New Zealand and nearly 60% of total GHG emissions (*MFE, 1998*).

Therefore any activity which reduces either the average methane production of ruminant animals, or the total of such animals has the potential for significant reductions in total GHG emissions. A number of technical options for reducing average methane production do exist (*Appendix IV*) and the beneficial effect of improving feed digestibility in lowering methane emissions can be significant (*Appendix V*). The efficacy of these options in the New Zealand farming environment, which is based primarily on low-intensity pastoral grazing, is highly problematic however.

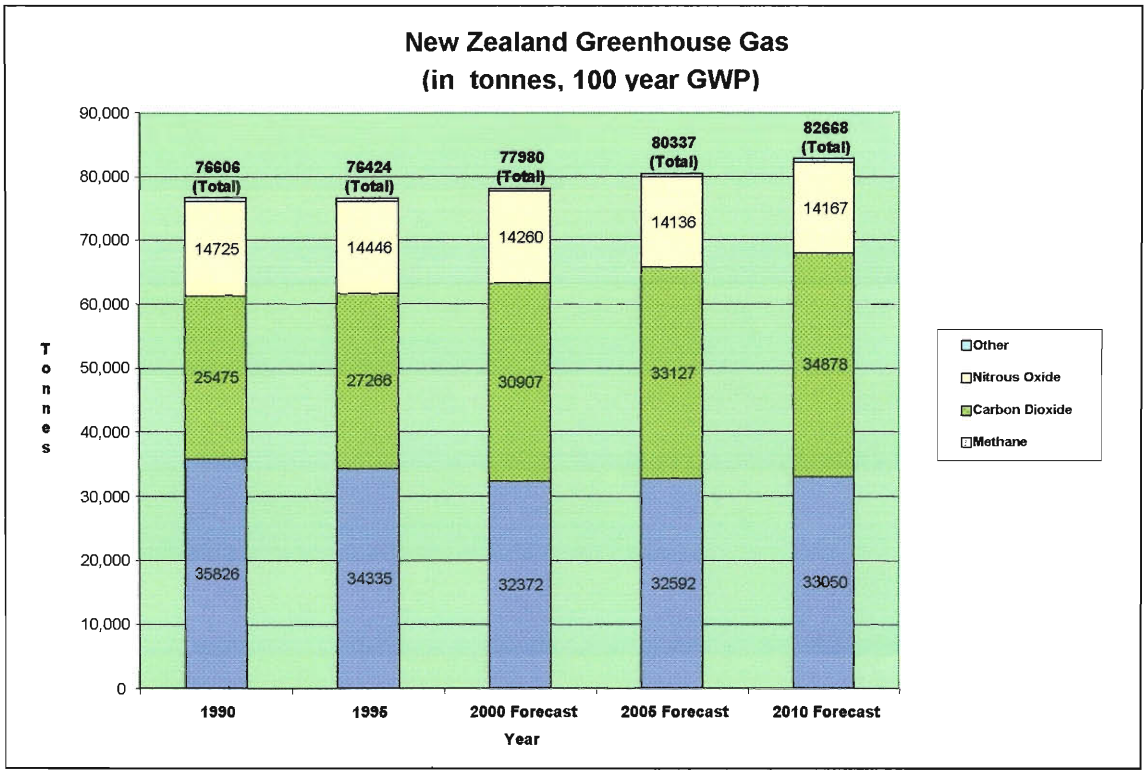
3.1 New Zealand's Projected GHG Inventory and Profile 1990 - 2010

There have been significant changes in New Zealand's GHG emissions, both in composition and quantum, since 1990. CO_2 emissions have increased, both in total volume and as a proportion of total New Zealand GHG, while non-CO_2 emissions have decreased.

From 1990 to 1995 CO_2 emissions increased 7% and are predicted to increase 37% from the 1990 base by 2010. Conversely methane decreased 4% to 1995 and is predicted to decrease 8% by 2010 (*MFE, 1998*).

Over the next decade CO_2 is likely to become the major greenhouse gas in New Zealand's inventory.

Figure 2 shows the predicted trend in New Zealand's GHG emissions, by type and in total (*from Appendix VI*).



This illustrates the most significant trends in the New Zealand GHG emissions profile from 1990 to 2010:

- ⇨ A decrease in methane emissions of 2.8 million tonnes, approximately 8%
- ⇨ An increase in carbon dioxide emissions of 9.4 million tonnes, or 37%
- ⇨ Carbon dioxide will displace methane as the major source of greenhouse gas emissions over the period
- ⇨ Methane and carbon dioxide will continue to be the major contributors to New Zealand's greenhouse gas emissions profile

⇨ Most importantly in regard to the Protocol requirements, an overall increase in emissions of approximately 6 million tonnes, 8% above the baseline 1990 position[1]

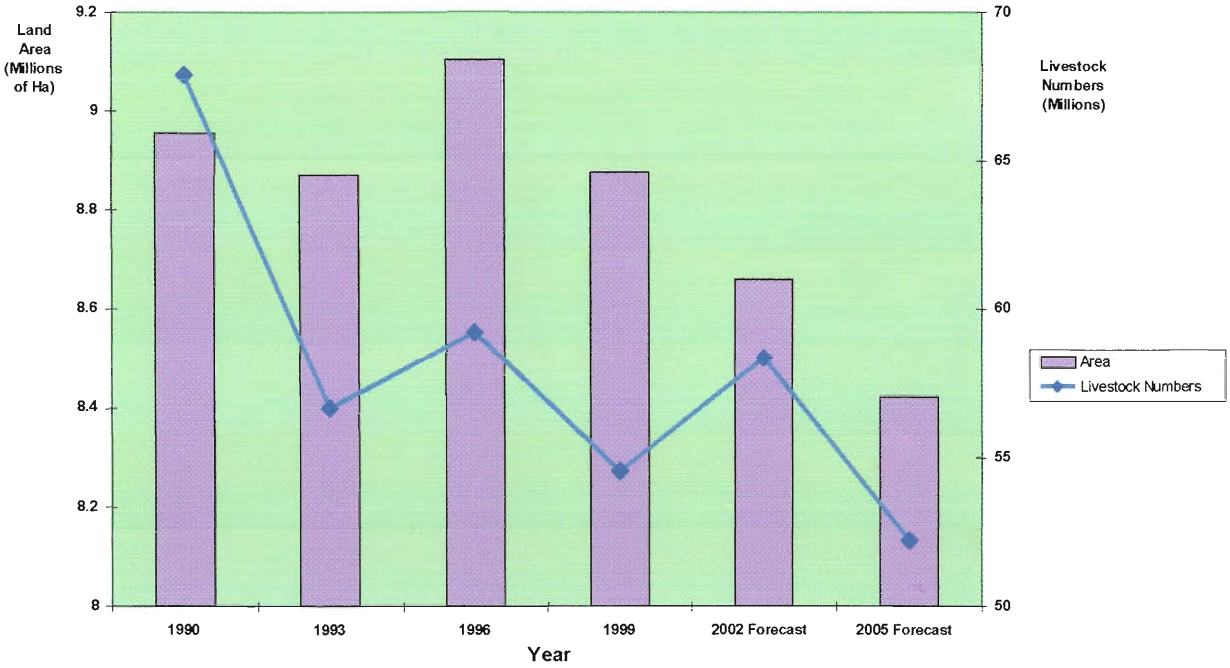
3.2 Sector Contributors to the New Zealand GHG Inventory and Opportunities for Reduction

Non-CO_2 GHG Emissions

Agriculture in 1990 contributed almost 60% of total GHG emissions through its huge contributions to **methane** (primarily ruminant livestock but also the decomposition of manure) and **nitrous oxide** (soil nitrification and de-nitrification, occurring as part of the nitrogen cycle, abetted by commercial fertilisers).

However the significance of agriculture decreased in the 1990s due to lower livestock numbers and a reduced area under pastoral grazing management. That was driven by poor commodity prices for pastoral products and relatively strong prices in the forestry sector. This is illustrated in Figure 3 below (*from Appendices VII and VIII*).

Figure 3: Livestock Numbers & Pastoral Land Area 1990 - 2005



[1] The inherent inaccuracies of predictions must be acknowledged. There are inaccuracies in both measurement and the prediction and extrapolation of land use and macroeconomic trends which affect emission production. Various publications assume different scenarios - these figures are from Ministry for the Environment, 1998

Overall, it is expected that total livestock numbers in New Zealand will continue to decrease, notwithstanding the current favourable conditions for agriculture[1].

It is predicted therefore, that **methane** emissions will continue to fall and will be well below the 1990 levels by 2008. This prediction contains a high level of uncertainty however as the driver of stock numbers is future world-wide prices for agricultural commodities. The **mix** of livestock also affects methane emissions - although both cows and sheep are ruminants, cows emit much more methane on a livestock-unit basis and the 1990's trend of replacement of sheep with dairy cows is predicted to continue, notwithstanding current dairy moratoria (*Appendices VII & VIII*).

The production of **nitrous oxide** (N_2O) is an integral part of the nitrogen cycle, although the actual biological processes involved in N_20 emission are not well understood. Increases in the amount of nitrogen added to the soil generally result in higher N_20 emissions. Grazing animals enhance emissions via urine on soils and through increasing surface damage and poor aeration in wet soils. A reduction in nitrogenous fertiliser has potential for decreasing N_20 production world-wide, however New Zealand's leguminous pastures reduce the need for such fertilisers. Consequently the potential to decrease emissions from this source is low.

The energy sector in 1990 produced 32% of non-CO_2 gases on a CO_2 equivalent basis (*MFE, 1998*). Non- CO_2 gases from this sector are virtually all methane emissions, occurring primarily during the extraction of coal and from leakage in the gas transmission and distribution system.

Coal mining decreases the pressure storing the methane produced in the formation of coal and therefore the methane is released to the atmosphere. The pressure and therefore methane levels are proportional to the coal depth underground. Most coal in New Zealand is extracted from open cast mines therefore the opportunity to trap and collect the low quantities of methane are limited.

Methane losses from gas transmissions and distribution systems, whilst only 24% of total energy-sector emissions give perhaps greater scope for reduction, although the relatively modern nature of the New Zealand distribution system implies a high cost of reduction.

[1] Strongly favourable economic conditions for pastoral farming in the 1999-2000 season are caused by a highly unusual tripartite combination of a peak in the worldwide commodity cycle, excellent climatic conditions for grass growth and an historically low-value New Zealand dollar relative to other currencies. It is the author's view that this unusual combination of favourable factors will not reverse the long-term trend.

The waste sector contributes only 4% of non-CO_2 emissions. This is methane from landfills and wastewater. Landfill gas comprises by volume approximately 55% methane and 40% carbon dioxide (with small amounts of many other gases). Emissions continue for around 30 years after the closure of the landfill. High biodegradable organic content is a primary factor in the production of landfill gas and there is considerable potential to reduce that via waste minimisation, composting and recycling. There is also potential to reduce landfill gas emissions by trapping and flaming off the methane converting the release to water and carbon dioxide which has a much lower GWP. This is likely to be economic only at large central landfills (some, such as that at Silverstream in the Hutt Valley, are already collecting gas). The trend towards closing small landfills and consolidation to large facilities will assist this.

Methane from wastewater is derived primarily from industrial sources, the anaerobic degradation of wastes such as abattoir and dairy processing. Wastewater in New Zealand is generally handled biologically, using aerobic oxidation ponds but when industry discharges to the anaerobic sewerage system the methane emissions increase significantly. There is certainly scope to reduce emissions if wastewater treatment options which avoid methane generation or collect emissions are chosen, noting however that this sector is a very small proportion - approximately 3% of the waste sector and 0.01% of the total methane production on a 1990 basis (*MFE, 1998*).

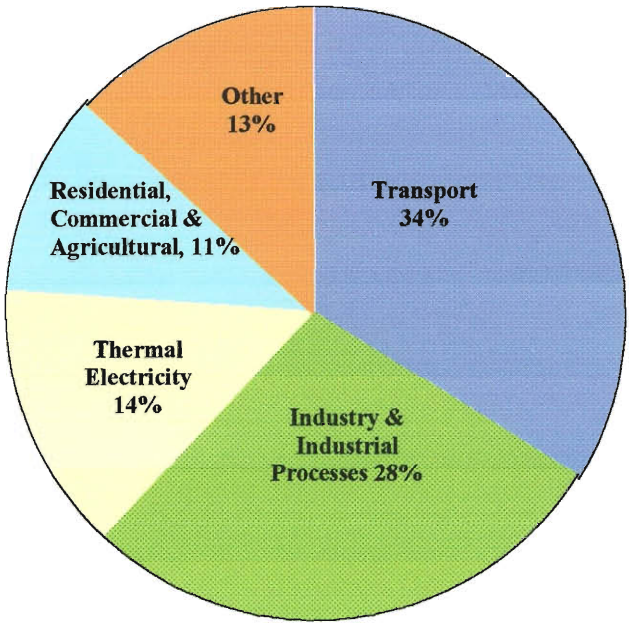
Total methane emissions from waste have fallen since 1990 because of the increased collection of landfill gas, and are expected to remain below 1990 levels by 2010.

Finally, the industrial sector makes a relatively minor contribution to the non- CO_2 GHG inventory in New Zealand. This was some 4% in 1990. The industrial gases include the fluorinated hydrocarbons (HFCs) and sulphur hexafluoride (SF_6). These are extremely potent GHG (for example SF_6 has a GWP of 23900!) however in New Zealand the potential for decreased use is limited.

CO_2 Emissions

The transport, energy and industrial sectors contribute the majority of CO_2 emissions in New Zealand, as illustrated by Figure 4 below.

Figure 4: 1990 Carbon Dioxide Emissions by Sector



The CO_2 emissions of a nation tend to increase with increasing GDP growth as the level of economic activity and personal wealth and consumption increases. Therefore predictions of New Zealand emissions in the period 2008-2012 contain inherent uncertainty since the underlying macro-economic and activity data, such as GDP growth and livestock numbers requires making long-range assumptions which are inherently judgmental and uncertain (*MFE, 1999*).

The most recent prediction of annual CO_2 emissions in the period 2008-2012 from the Ministry for the Environment is for emissions to increase about **37% above 1990 levels** (*Appendix VI*).

The combustion of fossil fuels is by far the major source of CO_2 emissions, representing 96.5% in 1995 (*Treasury, 1997*). (Cement manufacture and the release of CO_2 as part of steam from geothermal fields comprise the bulk of the remainder). Therefore the greatest opportunity to reduce CO_2 emissions is to reduce the use of fossil fuels. There is a range of

non-price and price measures which can be used by Government to assist a reduction. An obvious and convenient price measure is a carbon charge - tax - on fossil fuels and the principles of design and implementation of such a charge have been the subject of considerable research and discussion (*Treasury, 1997*).

3.3 Summary of New Zealand Greenhouse Gas Profiles

Non-CO_2 GHG emissions are currently more significant than CO_2 in New Zealand's total GHG profile, although both the proportion and the absolute volumes have declined since 1990, and are expected to continue to do so. Of the non-CO_2 gases, by far the most significant are methane and nitrous oxide - 99% of the total in 1990 with a similar proportion predicted in 2010 (*Appendix VI*).

As discussed the main contributor to these two gases is agriculture and therefore only changes to the emissions from this sector have the potential for reductions of any significance in the non-CO_2 component of GHG in New Zealand. Given the difficulties in limiting or capturing methane emissions from New Zealand's widely dispersed ruminant animals and their wastes, land use changes away from pastoral grazing represents the best opportunity for further reductions. In the New Zealand context, this is the conversion of pastoral land to forestry.

The increase in the CO_2 component of New Zealand's greenhouse gas emissions, both actual through the last decade of the 20^{th} century and predicted for the first decade of the new century, is significant. The extremely high proportion of total CO_2 emissions caused by the burning of fossil fuels suggest that any action taken should focus strongly on achieving reductions in this area, for maximum effectiveness.

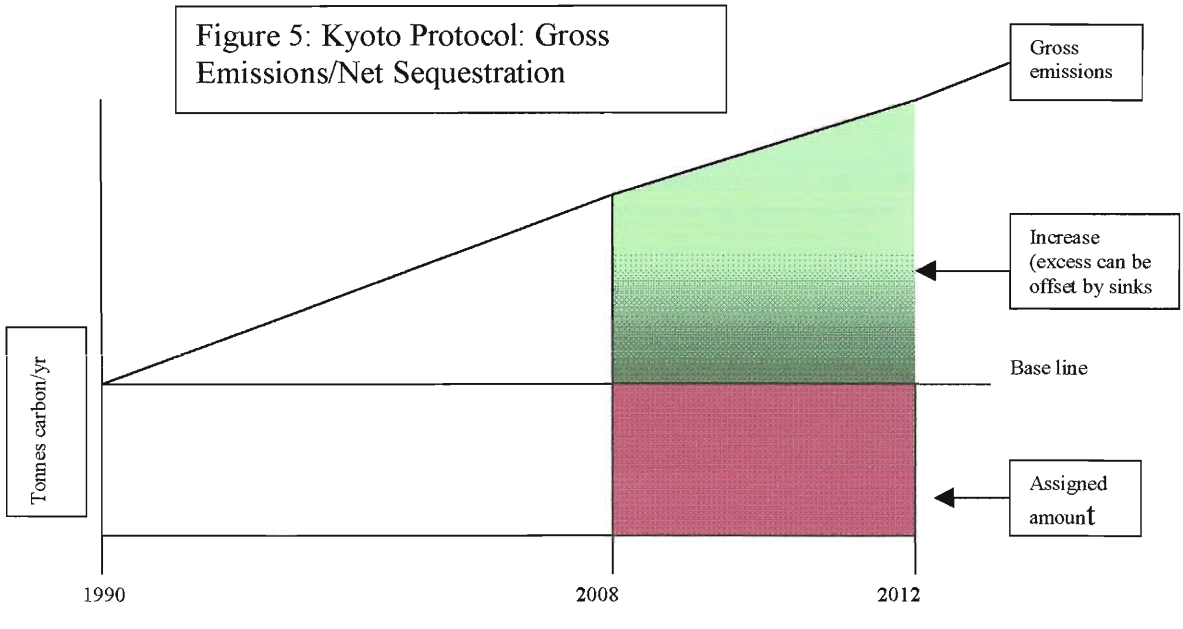
4.0 Carbon Sinks

A carbon sink is defined in the UNFCCC as "any process, activity, or mechanism which removes a GHG, an aerosol or a precursor of a GHG from the atmosphere" (*Ford-Robertson, 2000*). Protecting and enhancing sinks is recognised as valuable to the objective of stabilising atmospheric conditions of the GHG.

The Kyoto Protocol supports this position and allows "verifiable changes" in [carbon] stocks" to be used to meet reduction commitments. The Protocol limits GHG removal by sinks to human-induced land use change and forestry activities (*Appendix II*). As stated previously in the New Zealand context carbon sinks are essentially exotic forest plantations.

The role of carbon sinks in meeting commitments is illustrated in Figure 5 below (*Ford-Robertson, 2000*).

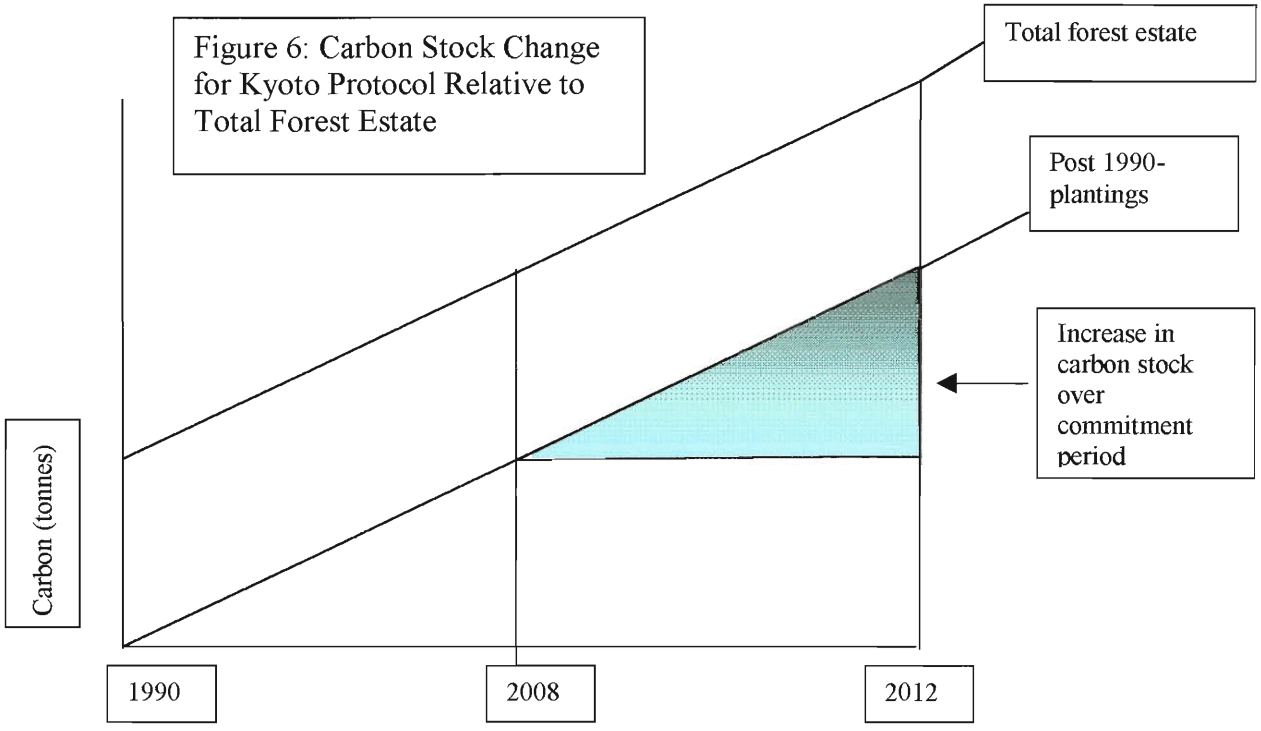
Figure 5: Kyoto Protocol: Gross Emissions/Net Sequestration



The lower shaded area represents the allowable emissions and the upper shaded area represents the additional carbon that is emitted, which therefore must be offset.

In calculating the forest sinks that could offset the increase in emissions, the total forest estate is not considered, even if it is accumulating carbon. Only the "Kyoto forest" is included, meaning only the **"verifiable changes** in stocks" of carbon in forests "resulting from **direct**

human induced land use change and **forestry activities since 1990**"[1]. This is illustrated by Figure 6 below



This shows the carbon stock change in "Kyoto forest" that may be used as an offset to emissions. Under current Article 3.4, the forest must have been planted since 1990 (and the significant majority of New Zealand plantation forests were not) and the carbon stock change is only that which occurs in the five year commitment period. The carbon sequestered prior to 2008 does not form part of the allowable offset. Indigenous forests (which are not human induced) are also excluded, but scrub reversion on abandoned agricultural land may be included.

4.1 Verification of Carbon Sequestration

The Kyoto Protocol requires that carbon sequestration must be "verifiable". This does not mean "verified" - it introduces the potential of models to predict what cannot be seen and easily measured (*Ford Robertson, 2000*). In New Zealand forestry, volumetric models such as "STANDPAK" which predict stem biomass have been developed and are widely accepted.

[1] Although there remains a possibility that this limitation, in Article 3.4 of the Protocol, will be expanded to include pre-1990 forest plantings under some options for additional activities. Certainly such an expansion would be in New Zealand's best interests. Conversely, some human-induced land use changes may not be eligible.

The carbon contained in the trees is estimated using the C-CHANGE module of STANDPAK. The model estimates carbon contained in live trees, roots, forest floor, litter and understorey. The stem growth data which can be measured regularly are used to tailor C-CHANGE to each specific site.

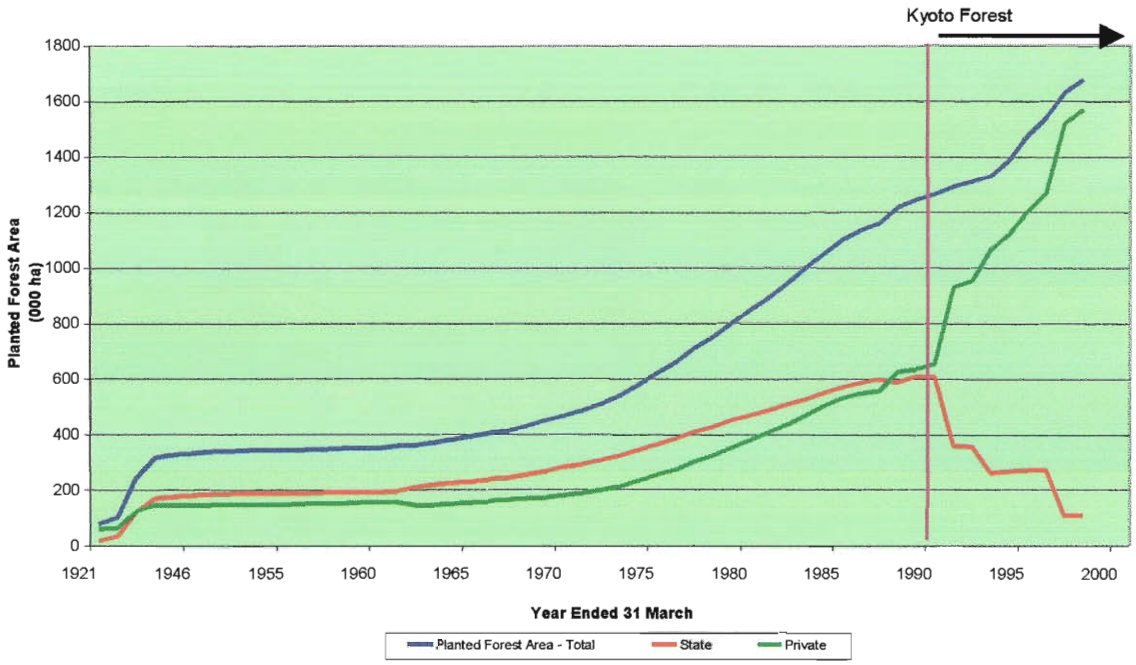
New Zealand scientists are confident that our forest inventory models can be adapted to give a verifiable calculation of carbon sequestration. Indeed, the New Zealand modelling, at least of aboveground biomass, is highly developed on a world scale. The accuracy of such modelling will depend on the intensity of sampling, and that will, in turn, be dependant on the value placed on the carbon sequestration. That is, a very high value will make worthwhile the sampling intensity necessary to ensure a high level of statistical confidence - carbon will only be traded within the level of confidence of the sampling methodology.

5.0 The New Zealand Plantation Forest Estate

New Zealand plantation forestry is based on the ubiquitous Pinus *Radiata,* a native of California which has proven particularly suitable for New Zealand conditions. The exotic forest estate in New Zealand has been continually expanded since the first significant plantings in the 1930s as illustrated in Figure 7 below.

Figure 7

Expansion of Planted Production Forest in New Zealand (MAF 1998)



Plantings accelerated considerably in the 1990s, driven by economic factors and expectations favourable to forestry and unfavourable to pastoral agriculture. A period of low commodity prices for beef and sheep products coincided with favourable prices for forestry products, including a spectacular price peak in 1993.

The area of 'Kyoto forest' in New Zealand was approximately 514,000 hectares by 1 January 2000, with plantings since 1990 averaging around 50,000 hectares/yr (*MAF 1998*). Kyoto forest is only new plantings and does not include replanting of pre-1990 forests harvested in the period.

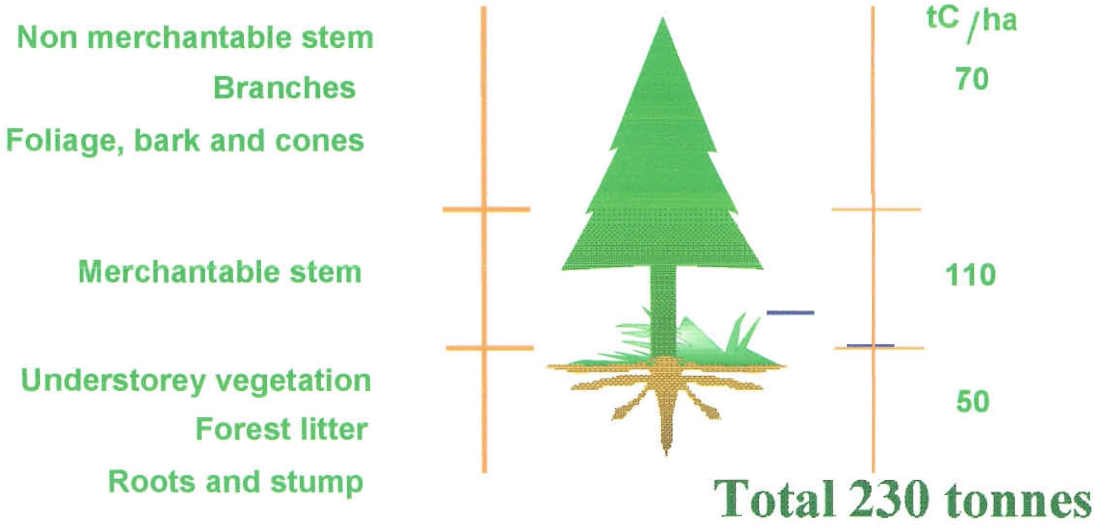
Since the 1980's when conversion of indigenous forestry was virtually halted (due primarily to conservationist pressures) the rate of new plantings has been determined by both the economics of plantation forestry and pastoral farming and their relativity since new planting could only be derived from conversion of grazing land.

The current forest estate at 1.7 million hectares comprises only 6% of New Zealand total land area, whilst pasture and arable land is in excess of 13 million hectares (*MAF 2000*). It has been estimated however that only 5 million hectares can be maintained in pasture without significant erosion controls (*Eyles 1993*).

Whilst not all of the land that may be retired from pastoral use will necessarily be suitable or available for plantation forestry, it can be assumed that land availability *per se* will not be a limiting factor to the expansion of forestry in New Zealand at current rates of planting over the next 50 years. If the average rate of new plantings in the boom years of 1990-1998 continued, approximately 3 million new hectares would be planted by 2050. This represents much more than a short-term solution.

5.1 Carbon Sequestration from New Zealand "Kyoto Forest"

A "standard" 30 year old stand of Radiata pine contains the following carbon:



(=844 tonnes CO2 equivalent)

The carbon sequestration volume is expected to increase as new-generation forests mature. The estimate of 230 tonnes/hectare is based on the average present-day forest, but new plantings over the past decade have been on better land (ex-farmland) and of trees with superior genetic quality than in the past. There have also been changes to silvicultural practices which may affect sequestration volumes. Latest estimates are for new forests to be in the range of 250-300 tonnes C/ha (*Ford-Robertson 2000*). Carbon sequestration is not

however, constant over the life of a forest, with the rate increasing significantly after the first 10 years, in line with total biomass.

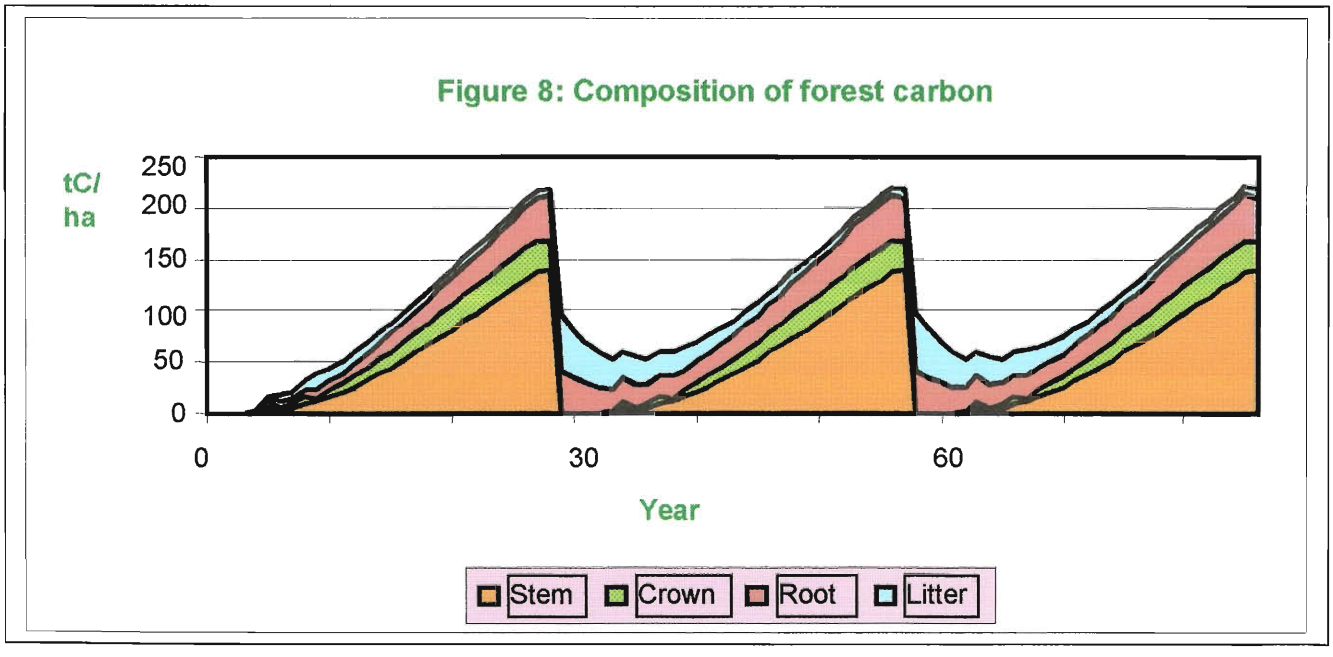
Forest planted from 1990-1997 will be 11 to 18 years old by 2008 and is predicted to sequester 2.7 million tonnes of carbon/year during the first commitment period (13.5 MtC total). A "medium" planting scenario - 55,000 ha/year from 2000 onwards gives a total predicted sequestration from Kyoto forests of 7.5 million tonnes of carbon per year during the commitment period, or 37.5 million tonnes in total from a predicted area of 1,295,000 hectares of Kyoto forest planted 1990 to 2012 (*Ford-Robertson et al 1999*)

This volume, expressed in carbon dioxide equivalents (CO_2-equivalents in 100 year GWP's is a common measure of emissions) is 27.5 million tonnes/year[1] or 137 million tonnes over the 5-year period.

That is the extent of New Zealand's projected sink in 2008-2012.

5.2 Possible Value of Carbon to New Zealand Forest

The carbon storage by a stand of forest is, as noted, not constant over the life of a forest. Carbon is progressively built up, and stocks peak at harvest time at which much, but by no means all, is removed from the site. This is illustrated in Figure 8.



[1] One kg carbon = 3.67kg CO2-equivalent

The long-run average stock over a number of forest rotations is approximately 100 tonnes carbon/ha (367 tonnes CO_2-equivalent).

There are a number of technical issues in regard to the implementation of the Kyoto Protocol still to be resolved which will affect the ability of the forest owner to convert the carbon sequestered in the forest to cash. Different carbon accounting systems, eg: land-based versus activity-based, give different values. There is also no international certainty over what constitutes a "forest" and what activities may be included as sinks.

The costs of measurement, brokerage and maintaining carbon pools is also unknown.

However, if a long-run average stock of 100 tonnes of carbon (367 tonnes of CO_2-equivalent) per hectare is assumed and a world price of US$10/tonne of CO_2-equivalent was established (the validity of this is discussed in Section 5) that suggests a price over a 30-year rotation, of around NZ$8,000/hectare. That is very significant additional income since income from the wood products of a typical forest planted in 1999 is projected to be around $40,000 per hectare (in present-day values). Assuming the carbon could be sold on a "mean-annual increment" basis (by no means assured) this could give an equivalent income of NZ$250-300 per hectare per year. This will not all be captured by the forest owner as the cost of measurement, brokerage etc is likely to be significant. Nonetheless it suggests a significant enhancement of forestry returns, encouraging further conversion of pastoral land.

6.0 Methane Emissions from Pastoral Farming & Possible Costs

Methane is produced as part of the normal digestive processes of ruminant animals. Microbial action in the rumen converts feed into products which can be further digested and used by the animal - the fermentation process enables ruminates to utilise coarse forages which animals with a single stomach cannot. Methane is released from this process by belching. (Contrary to popular perception 98% of methane comes from the front end of New Zealand animals).

Ruminants typically lose 4 to 7 percent of gross energy intake from feed at methane. Estimates of methane emissions (*Ulyatt, 1996*) are:

Sheep - 30 grams per day

Cow - 250 grams per day

Conversion to carbon equivalents gives an emission of 61kg carbon/year for a sheep and 522kg/year for a cow. (*Appendix VII*). In CO_2 equivalents that is 224kg/year (sheep) and 1,916kg/year (cow).

From these figures an emission rate per pastoral hectare can be calculated. High productivity dairy pastures, supporting 3 cows per hectare creates an emission of 1.57 tonnes of carbon per year or 5.7 tonnes of CO_2 equivalent. Low productivity pasture carrying 7 sheep per hectare creates an emission of 0.4 tonnes of carbon per year or 1.57 tonnes of CO_2 equivalent. This is the land type most likely to be afforested.

Therefore, when low productivity pasture is converted to forest there is a benefit of 30 years of methane emissions avoided by removing the ruminants. That is 12 tonnes of carbon per hectare **in addition to** the 230 tonnes sunk by carbon sequestration of the forest biomass.

Conversely, maintaining pastoral farming carries a carbon-cost. If a carbon tax of US$10/tonne of CO_2 equivalent was applied, pastoral farmers could be liable for an annual tax in the order of (using an exchange rate of NZ$1 = US$0.45)

	Cost per Ha	**Cost per LSU**
Low intensity sheep (7 LSU/ha)	$35	$5
High intensity cows (21 LSU/ha)	$126	$6

6.1 Conversion of Sheep to Cattle Pasture

The trend in New Zealand agriculture since 1980 has been a decline in sheep numbers and an increase in cattle numbers, especially dairy cows (*Appendix VIII*). This trend, which is predicted to continue past 2000, has implications for the level of methane emissions. On a livestock unit basis a cow emits approximately 20% more methane than a sheep (*Appendix IX*). That is due to the much higher feed intake relative to maintenance requirements, with a dairy cow's intake about four times maintenance compared to a sheep's intake of two times at most (*Ulyatt 2000*). The methane-emission cost of dairy **products** is actually considerably less than of sheep products (*Appendix X*) but on a per hectare basis the higher productivity available from conversion of sheep pastures to dairy, (which has been a consistent trend, especially in the South Island) results in a greater per hectare emission of methane.

Therefore the **composition** of New Zealand's livestock numbers has implications for the long-term projections of methane production and should be considered in assessing the accuracy of long-term methane and emission projections. This is an area that appears to have had little recognition in any discussion, research, or projections. Further research to examine the effect of current trends, especially if the present moratoria on conversion of land to dairying are lifted, is required.

7.0 Carbon Sequestration by Forest Sinks Relative to Additional Emissions

Estimates of New Zealand's total GHG emissions by 2008 vary. However, Ministry of the Environment figures (1999) indicate an increase of 1.63 million tonnes carbon per annum from the 1990 base-line and this is confirmed by more recent work (*Ford-Robertson et al 1999*) predicting 1.60 million tonnes. Any estimate is subject to the inaccuracies discussed earlier (Section 3.2) however it can be concluded that, despite the inherent inaccuracies and other adjustments to land-use changes (eg: burning of existing scrub and gorse before planting forests) New Zealand will be able to comfortably meet its emissions obligations for the first commitment period. The carbon sequestered by our Kyoto forests, 7.5 million tonnes/year, will exceed our additional emissions of 1.6 million tonnes per year by 5.9 million tonnes, a factor of 4 to 5. Even if no new forest is planted from 2000 onwards, sequestration by sinks will be twice as much as additional emissions (assuming of course that sink credits are not all sold).

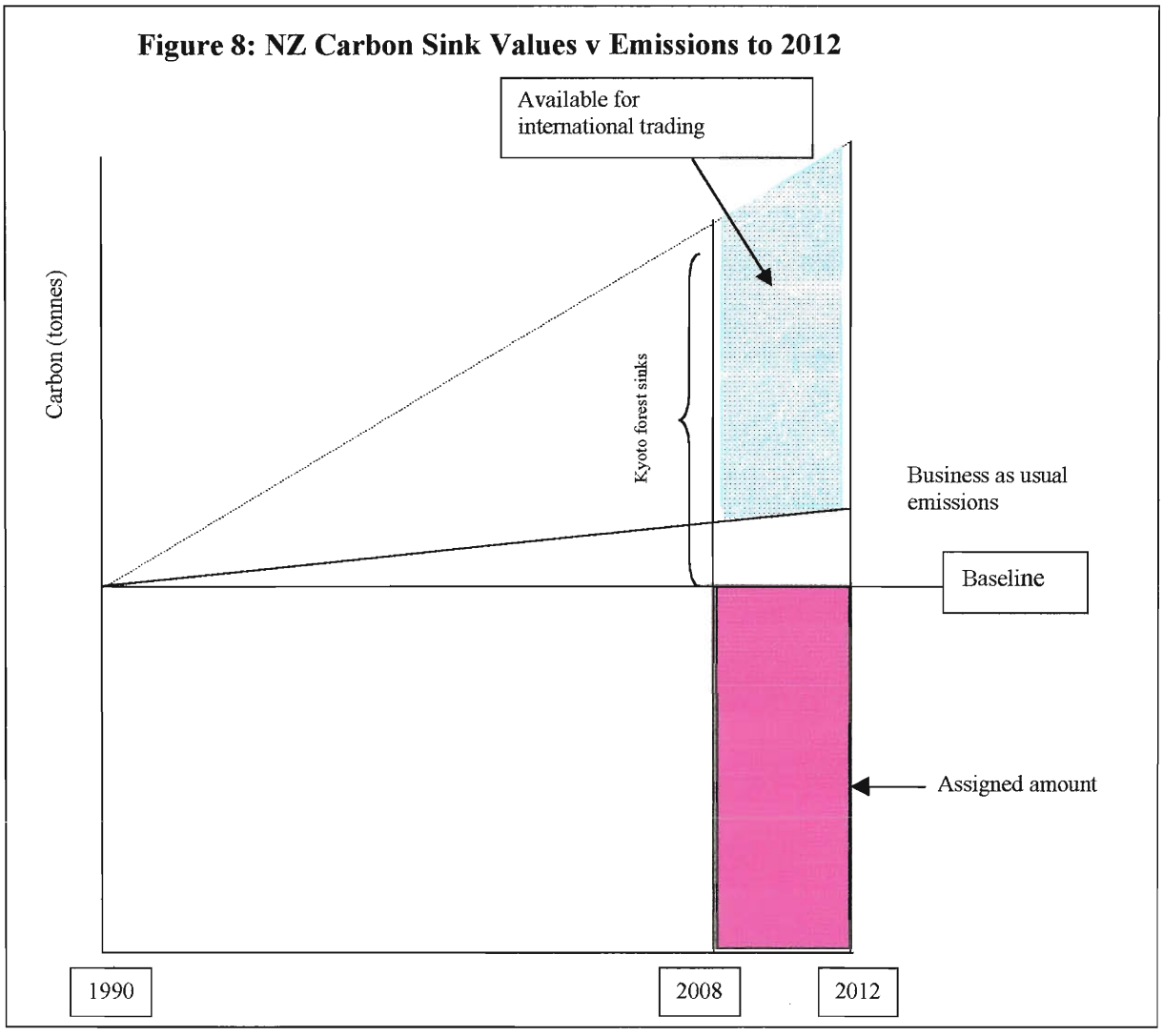
However New Zealand needs to consider the longer term implications of its position, since the possibility of the first commitment period of the Protocol being followed by continuous further commitments is high. Continuous commitment periods have implications as New Zealand's Kyoto forest matures and is harvested. If there are no new plantings from 2000 onwards the total plantation estate carbon reservoir continues to increase until about 2020 (*Marshall 2000*). After this time a steady state carbon reservoir is reached with the increase in carbon sequestration by forest growth being offset by emissions through harvesting.

Even though New Zealand has an apparent large area of plantable land, its conversion to forestry will be dependent on the returns from forest-based products. It would be imprudent for New Zealand not to take steps to reduce its gross emissions of GHG, in particular to slow the rate of CO_2 emissions. Reliance on ever-increasing areas of forest to offset ever-increasing emissions is not a viable long-term policy, relying as it does on the economics of New Zealand forestry to be always significantly attractive to stimulate new plantings, as the primary means of meeting our Kyoto Protocol commitments.

7.1 Emissions Trading and Some Possible Values

Carbon secured by sinks in excess of that required to offset additional emissions is available for international trading. This is illustrated by Figure 8 below.

Figure 8: NZ Carbon Sink Values v Emissions to 2012



The lower shaded area represents New Zealand's allowable emissions. There is an excess of emissions predicted if the business as usual pathway is followed, due to the increase in CO_2 emissions. However, this excess is not only offset by the forest sinks, there is a considerable surplus represented by the upper shaded area.

As outlined, the proportion of New Zealand's net carbon sink credits available for international trading (ie: in excess of what is required to offset additional emissions) after

2008 is expected to be around 5.9 million tonnes carbon per year, or 21.6 million tonnes CO_2 equivalent.

This carbon 'credit' will have a significant international value.

It is beyond the scope of this paper to discuss the models and methodologies used to predict international carbon prices in the future. As long as an unfettered trading environment is able to develop (and trading is implicitly provided for in the Protocol), prices will ultimately be determined by the marginal cost of emissions-abatement measures.

For the purposes of providing a guide to New Zealand's possible gross earnings however, a range of US$5-US$30 is proposed[1]. An exchange rate of NZ$1 = US$0.45 and a net annual carbon surplus of 4-7 million tonnes (14.7 to 25.7 million tonnes of CO_2) suggests annual earnings in the range shown below:

Figure 9: Possible Earnings from International Sale of Sink Credits (NZ$ millions/year)

			Price per tonne of CO_2 (NZ$)				
Millions of Tonnes	**Carbon**	**CO_2 equivalent**	**10**	**20**	**30**	**40**	**50**
	4	14.7	147	299	441	588	735
	5	18.4	184	368	552	736	920
	6	22.0	220	440	660	880	1100
	7	25.7	257	514	771	1028	1285

These values, whilst theoretical, illustrate the potential importance of any international trading regime arising from the Kyoto Protocol, to the New Zealand economy. Such values also provide a focus for the ownership of carbon emissions and sinks.

[1] Econometric models which attempt to predict the value of carbon are highly technical and theoretical. The eventual price will depend on a number of factors including the cost of emissions reduction, the cost of measurement and verification of sinks and the impact of brokerage and Governmental dead-weight costs. A recent workshop to discuss sinks (MFE 2000) suggest a possible value of NZ$10-30/tonne CO2-equivalent.

8.0 Ownership of Carbon Sinks & Emissions

The objective of the Kyoto Protocol, to reduce net world emissions of greenhouse gases, is unlikely to be achieved unless a price measure is attached to the emission and sequestration of carbon. Cajolery and appeals to the social/environmental conscience of world citizens are unlikely to succeed in the absence of price signals which recognise the climate-change cost of carbon.

In the New Zealand context, there are rural land uses which clearly contribute to GHG emissions (primarily pastoral farming with ruminants) and which soak up such emissions (forestry). Therefore the aim of a carbon price would be to include the environmental cost of the carbon released or sunk by each activity. In doing so the price will effect an economic transfer from one land user to another, probably via a carbon tax - to emitters - and an opportunity to sell carbon credits - to sinks. The presence of a tax implies the inevitable involvement of the Government and indeed, the commitment to the Protocol and the acceptance of New Zealand's obligations is a Governmental one.

There is a real concern amongst foresters that the New Zealand Government may choose to appropriate for itself the credits arising from sequestration without compensation, whilst simultaneously taxing emitters. In the case of the forest industry and forest-farmers, these are the same entity.

Cabinet policy papers presented at a recent Rotorua workshop on forest sinks centred on the concept of what **proportion** of the carbon credit should be retained by foresters. This raised the ire of participants as this was perceived to be a nationalisation of an existing property right (*Hayes 2000*).

New Zealand is in the fortunate situation of its national forest plantings, which have since 1990 been driven by the private sector, compensating for its national growth in GHG emissions, particularly of carbon dioxide. This has not been a Governmental initiative, but a result of private capital, with 97% of new plantings since 1990 a result of non-Government investment (*MAF 1998*).

Expropriation or nationalisation of carbon property rights (and since it is the activities of specific individuals which created the sinks then the carbon contained in the forests is no less a property right than the wood fibre) by Government would be highly undesirable, sending a signal to both New Zealand and overseas investors that capital investment in this country is at

risk. Furthermore if the Government assumes any proportion of carbon credits for itself a number of complications arise if the forest is lost through fire or harvest. The carbon contained in the forest is indivisible from the actual timber - if the Government attempts to claim ownership it will be interfering with the forest-owners control of the wood in the forest and could expect to face compensation claims. If such expropriation was coupled with a tax then the concept of carbon-costs would lose credibility and have a negative impact on further forestry investment - the reverse of the signal intended by the Kyoto Protocol. There would be a similar loss of credibility if emitting activities such as pastoral farming of ruminants were exempted from any carbon tax for reasons of political expediency. It is the author's firm view that any future carbon credits must, for maximum efficiency and effectiveness, be recognised as a private property right within New Zealand and be able to pass to New Zealand and world carbon markets with a minimum of third-party and Governmental interference.

The Government has already claimed, by default, the carbon credits arising from the reduction in methane caused by the conversion of farmland to forest, and that is significant in terms of New Zealand's overall obligations under the Protocol.

If a carbon tax is implemented, it should be charged to **all** emitters on a CO_2-equivalent basis. There are technical issues of measurement and tax collection issues to be resolved in addition to the issues associated with the allocation of New Zealand's existing assigned amount. However, any exemptions granted will immediately dilute the economic signal being created to achieve an environmental effect. For New Zealand to exempt, for example methane-producing farmers, when methane is such a major proportion of its total emissions profile, would be to undermine the credibility of carbon charges in all other sections of the community and business, and to create a favoured sector given special rules of treatment.

The success of a carbon tax is also likely to be enhanced if the revenues are identified as a distinct fund, available to facilitate projects which lower both gross and net emissions (Examples would be funding of research into greater electrical efficiency of appliances, increasing pastoral feed quality to lower methane production, ensuring insulation of all public buildings, etc).

Allocation of the costs and benefits of carbon emissions and sinks is unlikely to be enhanced by any interference in a free-trade mechanism.

The Kyoto Protocol arose as an attempt to influence the behaviour of modern societies to reduce the negative effects of their activities on the Earth's climate. Modern society relies on the influence of price mechanisms as well as social conscience. A free-trade environment allows the true cost of carbon to be recognised by all users, and human behaviour to be influenced accordingly. The target of the Kyoto Protocol in relation to the extent of change in emissions behaviour required, is a modest one - free trade mechanisms which allow the greatest chance of success should be encouraged.

SUMMARY AND CONCLUSIONS

1. New Zealand Gross greenhouse gas emissions are likely to exceed its 1990 baseline position by around 6 million tonnes per annum, or 8%, by the first Kyoto Protocol commitment period, 2008-2012.

2. That increase is due to much greater emissions of carbon dioxide, offset by a predicted decrease in methane levels.

3. The combustion of fossil fuels is the major source of New Zealand's CO_2 emissions and is therefore a likely target for a carbon tax. Whilst such a tax will not necessarily significantly reduce fuel use in the short term, it will provide a signal to influence behavioural change. A carbon tax will be more effective in assisting New Zealand to lower its gross emissions if it is applied to a specific fund available for assisting in emission-reduction research projects and other measures aimed at reducing both gross and net emissions.

4. Pastoral agriculture is the biggest contributor to non- CO_2 gas emissions. The best opportunity for reductions in non- CO_2 emissions is the continuation of land-use change from pastoral to forestry use.

5. The extent of land-use change that occurred from 1990 to 1998 (the conversion of pastoral land to forestry) was, alone, sufficient to offset New Zealand's predicted increase in emissions during the first commitment period of the Kyoto Protocol. Additional plantings have increased further the excess of carbon sequestration versus emissions and this excess is available for international trading.

6. Reductions in emissions of methane, New Zealand's predominant greenhouse gas, have been achieved by reduction in livestock numbers. However this trend is vulnerable to a continuance of existing trends in the **composition** of livestock types, specifically the change to dairy stock from sheep since this increases methane produced per hectare.

7. Notwithstanding the current comfortable position in regard to the first commitment period of the Kyoto Protocol, New Zealand should be taking steps to reduce its gross emissions of GHG, in particular CO_2 emissions. Long term we cannot rely on ever-increasing areas of forest to offset ever-increasing emissions.

8. International trading of carbon credits could earn New Zealand significant income, in the range $200 million to $1.3 billion per year, in the first commitment period. A clear definition of ownership rights is required to ensure investment signals - both costs and earnings from carbon - are available.

9. The efficiency of price signals to modify behaviour will be weakened if any New Zealand Government actions are made either to assume the rights to carbon sequestration credits which have arisen through the actions of private investors or to exempt any section of the community from the costs of its emissions.

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Lastly, my thanks to my wife Trish, who has been a constant source of encouragement and a valuable advisor.

APPENDICES

Appendix I: Anthroprogenic Sources of Greenhouse Gases

Gas Type	Chemical	Main Source
Carbon dioxide	CO_2	Fossil fuel combustion, biomass burning, industrial processes, including steel, cement and aluminium manufacture, natural gas venting and fugitive emissions from geothermal energy use
Methane	CH4	Rice cultivation, ruminant livestock, biomass burning, coal mining, natural gas venting and leakages, and landfills and other waste management systems.
Nitrous oxide	N2O	Fossil fuel combustion, biomass burning, agricultural soils, nitrogenous fertiliser, and industrial processes including nylon manufacture.
Sulphur hexafluoride	SF6	Electrical switchgear, magnesium and aluminium smelting, fire suppression, other industrial applications.
Perfluorocarbons	PFC's	Aluminium smelting, and other industrial applications (usually as replacements for ozone-depleting substances).
Hydrofluorocarbons	HFC's	A range of industrial applications (usually as replacements for ozone-depleting substances).

Source: Ministry for the Environment 1999: Climate Change Domestic Policy Options Statement

APPENDIX II

KYOTO PROTOCOL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The Parties to this Protocol,

Being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as "the Convention",

In pursuit of the ultimate objective of the Convention as stated in its Article 2,

Recalling the provisions of the Convention,

Being guided by Article 3 of the Convention,

Pursuant to the Berlin Mandate adopted by decision 1/CP.1 of the Conference of the Parties to the Convention at its first session,

Have agreed as follows:

Article 1

For the purposes of this Protocol, the definitions contained in Article 1 of the Convention shall apply. In addition:

1. "Conference of the Parties" means the Conference of the Parties to the Convention.

2. "Convention" means the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992.

3. "Intergovernmental Panel on Climate Change" means the Intergovernmental Panel on Climate Change established in 1988 jointly by the World Meteorological Organization and the United Nations Environment Programme.

4. "Montreal Protocol" means the Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in Montreal on 16 September 1987 and as subsequently adjusted and amended.

5. "Parties present and voting" means Parties present and casting an affirmative or negative vote.

6. "Party" means, unless the context otherwise indicates, a Party to this Protocol.

7. "Party included in Annex I" means a Party included in Annex I to the Convention, as may be amended, or a Party which has made a notification under Article 4, paragraph 2(g), of the Convention.

Article 2

1. Each Party included in Annex I, in achieving its quantified emission limitation and reduction commitments under Article 3, in order to promote sustainable development, shall:

(a) Implement and/or further elaborate policies and measures in accordance with its national circumstances, such as:

(i) Enhancement of energy efficiency in relevant sectors of the national economy;

(ii) Protection and enhancement of sinks and reservoirs of greenhouse gases not controlled by the Montreal Protocol, taking into account its commitments under relevant international environmental agreements; promotion of sustainable forest management practices, afforestation and reforestation;

(iii) Promotion of sustainable forms of agriculture in light of climate change considerations;

(iv) Research on, and promotion, development and increased use of, new and renewable forms of energy, of carbon dioxide sequestration technologies and of advanced and innovative environmentally sound technologies;

(v) Progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors that run counter to the objective of the Convention and application of market instruments;

(vi) Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures which limit or reduce emissions of greenhouse gases not controlled by the Montreal Protocol;

(vii) Measures to limit and/or reduce emissions of greenhouse gases not controlled by the Montreal Protocol in the transport sector;

(viii) Limitation and/or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy;

(b) Cooperate with other such Parties to enhance the individual and combined effectiveness of their policies and measures adopted under this Article, pursuant to Article 4, paragraph 2(e)(i), of the Convention. To this end, these Parties shall take steps to share their experience and exchange information on such policies and measures, including developing ways of improving their comparability, transparency and effectiveness. The Conference of

Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, consider ways to facilitate such cooperation, taking into account all relevant information.

2. The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively.

3. The Parties included in Annex I shall strive to implement policies and measures under this Article in such a way as to minimize adverse effects, including the adverse effects of climate change, effects on international trade, and social, environmental and economic impacts on other Parties, especially developing country Parties and in particular those identified in Article 4, paragraphs 8 and 9, of the Convention, taking into account Article 3 of the Convention. The Conference of the Parties serving as the meeting of the Parties to this Protocol may take further action, as appropriate, to promote the implementation of the provisions of this paragraph.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol, if it decides that it would be beneficial to coordinate any of the policies and measures in paragraph 1(a) above, taking into account different national circumstances and potential effects, shall consider ways and means to elaborate the coordination of such policies and measures.

Article 3

1. The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.

2. Each Party included in Annex I shall, by 2005, have made demonstrable progress in achieving its commitments under this Protocol.

3. The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I. The greenhouse gas emissions by sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8.

4. Prior to the first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol, each Party included in Annex I shall provide, for consideration by the Subsidiary Body for Scientific and Technological Advice, data to establish its level of carbon

stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how, and which, additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to, or subtracted from, the assigned amounts for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of the Intergovernmental Panel on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice in accordance with Article 5 and the decisions of the Conference of the Parties. Such a decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period, provided that these activities have taken place since 1990.

5. The Parties included in Annex I undergoing the process of transition to a market economy whose base year or period was established pursuant to decision 9/CP.2 of the Conference of the Parties at its second session shall use that base year or period for the implementation of their commitments under this Article. Any other Party included in Annex I undergoing the process of transition to a market economy which has not yet submitted its first national communication under Article 12 of the Convention may also notify the Conference of the Parties serving as the meeting of the Parties to this Protocol that it intends to use an historical base year or period other than 1990 for the implementation of its commitments under this Article. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall decide on the acceptance of such notification.

6. Taking into account Article 4, paragraph 6, of the Convention, in the implementation of their commitments under this Protocol other than those under this Article, a certain degree of flexibility shall be allowed by the Conference of the Parties serving as the meeting of the Parties to this Protocol to the Parties included in Annex I undergoing the process of transition to a market economy.

7. In the first quantified emission limitation and reduction commitment period, from 2008 to 2012, the assigned amount for each Party included in Annex I shall be equal to the percentage inscribed for it in Annex B of its aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A in 1990, or the base year or period determined in accordance with paragraph 5 above, multiplied by five. Those Parties included in Annex I for whom land-use change and forestry constituted a net source of greenhouse gas emissions in 1990 shall include in their 1990 emissions base year or period the aggregate anthropogenic carbon dioxide equivalent emissions by sources minus removals by sinks in 1990 from land-use change for the purposes of calculating their assigned amount.

8. Any Party included in Annex I may use 1995 as its base year for hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, for the purposes of the calculation referred to in paragraph 7 above.

9. Commitments for subsequent periods for Parties included in Annex I shall be established in amendments to Annex B to this Protocol, which shall be adopted in accordance

with the provisions of Article 21, paragraph 7. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall initiate the consideration of such commitments at least seven years before the end of the first commitment period referred to in paragraph 1 above.

10. Any emission reduction units, or any part of an assigned amount, which a Party acquires from another Party in accordance with the provisions of Article 6 or of Article 17 shall be added to the assigned amount for the acquiring Party.

11. Any emission reduction units, or any part of an assigned amount, which a Party transfers to another Party in accordance with the provisions of Article 6 or of Article 17 shall be subtracted from the assigned amount for the transferring Party.

12. Any certified emission reductions which a Party acquires from another Party in accordance with the provisions of Article 12 shall be added to the assigned amount for the acquiring Party.

13. If the emissions of a Party included in Annex I in a commitment period are less than its assigned amount under this Article, this difference shall, on request of that Party, be added to the assigned amount for that Party for subsequent commitment periods.

14. Each Party included in Annex I shall strive to implement the commitments mentioned in paragraph 1 above in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention. In line with relevant decisions of the Conference of the Parties on the implementation of those paragraphs, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, consider what actions are necessary to minimize the adverse effects of climate change and/or the impacts of response measures on Parties referred to in those paragraphs. Among the issues to be considered shall be the establishment of funding, insurance and transfer of technology.

Article 4

1. Any Parties included in Annex I that have reached an agreement to fulfil their commitments under Article 3 jointly, shall be deemed to have met those commitments provided that their total combined aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of Article 3. The respective emission level allocated to each of the Parties to the agreement shall be set out in that agreement.

2. The Parties to any such agreement shall notify the secretariat of the terms of the agreement on the date of deposit of their instruments of ratification, acceptance or approval of this Protocol, or accession thereto. The secretariat shall in turn inform the Parties and signatories to the Convention of the terms of the agreement.

3. Any such agreement shall remain in operation for the duration of the commitment period specified in Article 3, paragraph 7.

4. If Parties acting jointly do so in the framework of, and together with, a regional economic integration organization, any alteration in the composition of the organization after adoption of this Protocol shall not affect existing commitments under this Protocol. Any alteration in the composition of the organization shall only apply for the purposes of those commitments under Article 3 that are adopted subsequent to that alteration.

5. In the event of failure by the Parties to such an agreement to achieve their total combined level of emission reductions, each Party to that agreement shall be responsible for its own level of emissions set out in the agreement.

6. If Parties acting jointly do so in the framework of, and together with, a regional economic integration organization which is itself a Party to this Protocol, each member State of that regional economic integration organization individually, and together with the regional economic integration organization acting in accordance with Article 24, shall, in the event of failure to achieve the total combined level of emission reductions, be responsible for its level of emissions as notified in accordance with this Article.

Article 5

1. Each Party included in Annex I shall have in place, no later than one year prior to the start of the first commitment period, a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. Guidelines for such national systems, which shall incorporate the methodologies specified in paragraph 2 below, shall be decided upon by the Conference of the Parties serving as the meeting of the Parties to this Protocol at its first session.

2. Methodologies for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol shall be those accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties at its third session. Where such methodologies are not used, appropriate adjustments shall be applied according to methodologies agreed upon by the Conference of the Parties serving as the meeting of the Parties to this Protocol at its first session. Based on the work of, *inter alia*, the Intergovernmental Panel on Climate Change and advice provided by the Subsidiary Body for Scientific and Technological Advice, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall regularly review and, as appropriate, revise such methodologies and adjustments, taking fully into account any relevant decisions by the Conference of the Parties. Any revision to methodologies or adjustments shall be used only for the purposes of ascertaining compliance with commitments under Article 3 in respect of any commitment period adopted subsequent to that revision.

3. The global warming potentials used to calculate the carbon dioxide equivalence of anthropogenic emissions by sources and removals by sinks of greenhouse gases listed in Annex A shall be those accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties at its third session. Based on the work of, *inter*

alia, the Intergovernmental Panel on Climate Change and advice provided by the Subsidiary Body for Scientific and Technological Advice, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall regularly review and, as appropriate, revise the global warming potential of each such greenhouse gas, taking fully into account any relevant decisions by the Conference of the Parties. Any revision to a global warming potential shall apply only to commitments under Article 3 in respect of any commitment period adopted subsequent to that revision.

Article 6

1. For the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy, provided that:

(a) Any such project has the approval of the Parties involved;

(b) Any such project provides a reduction in emissions by sources, or an enhancement of removals by sinks, that is additional to any that would otherwise occur;

(c) It does not acquire any emission reduction units if it is not in compliance with its obligations under Articles 5 and 7; and

(d) The acquisition of emission reduction units shall be supplemental to domestic actions for the purposes of meeting commitments under Article 3.

2. The Conference of the Parties serving as the meeting of the Parties to this Protocol may, at its first session or as soon as practicable thereafter, further elaborate guidelines for the implementation of this Article, including for verification and reporting.

3. A Party included in Annex I may authorize legal entities to participate, under its responsibility, in actions leading to the generation, transfer or acquisition under this Article of emission reduction units.

4. If a question of implementation by a Party included in Annex I of the requirements referred to in this Article is identified in accordance with the relevant provisions of Article 8, transfers and acquisitions of emission reduction units may continue to be made after the question has been identified, provided that any such units may not be used by a Party to meet its commitments under Article 3 until any issue of compliance is resolved.

Article 7

1. Each Party included in Annex I shall incorporate in its annual inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, submitted in accordance with the relevant decisions of the Conference of the Parties, the necessary supplementary information for the purposes of

ensuring compliance with Article 3, to be determined in accordance with paragraph 4 below.

2. Each Party included in Annex I shall incorporate in its national communication, submitted under Article 12 of the Convention, the supplementary information necessary to demonstrate compliance with its commitments under this Protocol, to be determined in accordance with paragraph 4 below.

3. Each Party included in Annex I shall submit the information required under paragraph 1 above annually, beginning with the first inventory due under the Convention for the first year of the commitment period after this Protocol has entered into force for that Party. Each such Party shall submit the information required under paragraph 2 above as part of the first national communication due under the Convention after this Protocol has entered into force for it and after the adoption of guidelines as provided for in paragraph 4 below. The frequency of subsequent submission of information required under this Article shall be determined by the Conference of the Parties serving as the meeting of the Parties to this Protocol, taking into account any timetable for the submission of national communications decided upon by the Conference of the Parties.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall adopt at its first session, and review periodically thereafter, guidelines for the preparation of the information required under this Article, taking into account guidelines for the preparation of national communications by Parties included in Annex I adopted by the Conference of the Parties. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall also, prior to the first commitment period, decide upon modalities for the accounting of assigned amounts.

Article 8

1. The information submitted under Article 7 by each Party included in Annex I shall be reviewed by expert review teams pursuant to the relevant decisions of the Conference of the Parties and in accordance with guidelines adopted for this purpose by the Conference of the Parties serving as the meeting of the Parties to this Protocol under paragraph 4 below. The information submitted under Article 7, paragraph 1, by each Party included in Annex I shall be reviewed as part of the annual compilation and accounting of emissions inventories and assigned amounts. Additionally, the information submitted under Article 7, paragraph 2, by each Party included in Annex I shall be reviewed as part of the review of communications.

2. Expert review teams shall be coordinated by the secretariat and shall be composed of experts selected from those nominated by Parties to the Convention and, as appropriate, by intergovernmental organizations, in accordance with guidance provided for this purpose by the Conference of the Parties.

3. The review process shall provide a thorough and comprehensive technical assessment of all aspects of the implementation by a Party of this Protocol. The expert review teams shall prepare a report to the Conference of the Parties serving as the meeting of the Parties to this Protocol, assessing the implementation of the commitments of the Party and identifying any potential problems in, and factors influencing, the fulfilment of commitments. Such

reports shall be circulated by the secretariat to all Parties to the Convention. The secretariat shall list those questions of implementation indicated in such reports for further consideration by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall adopt at its first session, and review periodically thereafter, guidelines for the review of implementation of this Protocol by expert review teams taking into account the relevant decisions of the Conference of the Parties.

5. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, with the assistance of the Subsidiary Body for Implementation and, as appropriate, the Subsidiary Body for Scientific and Technological Advice, consider:

(a) The information submitted by Parties under Article 7 and the reports of the expert reviews thereon conducted under this Article; and

(b) Those questions of implementation listed by the secretariat under paragraph 3 above, as well as any questions raised by Parties.

6. Pursuant to its consideration of the information referred to in paragraph 5 above, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall take decisions on any matter required for the implementation of this Protocol.

Article 9

1. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall periodically review this Protocol in the light of the best available scientific information and assessments on climate change and its impacts, as well as relevant technical, social and economic information. Such reviews shall be coordinated with pertinent reviews under the Convention, in particular those required by Article 4, paragraph 2(d), and Article 7, paragraph 2(a), of the Convention. Based on these reviews, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall take appropriate action.

2. The first review shall take place at the second session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. Further reviews shall take place at regular intervals and in a timely manner.

Article 10

All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, without introducing any new commitments for Parties not included in Annex I, but reaffirming existing commitments under Article 4, paragraph 1, of the Convention, and continuing to advance the implementation of these commitments in order to achieve sustainable development, taking into account Article 4, paragraphs 3, 5 and 7, of the Convention, shall:

(a) Formulate, where relevant and to the extent possible, cost-effective national and, where appropriate, regional programmes to improve the quality of local emission factors, activity data and/or models which reflect the socio-economic conditions of each Party for the preparation and periodic updating of national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties, and consistent with the guidelines for the preparation of national communications adopted by the Conference of the Parties;

(b) Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change and measures to facilitate adequate adaptation to climate change:

(i) Such programmes would, *inter alia*, concern the energy, transport and industry sectors as well as agriculture, forestry and waste management. Furthermore, adaptation technologies and methods for improving spatial planning would improve adaptation to climate change; and

(ii) Parties included in Annex I shall submit information on action under this Protocol, including national programmes, in accordance with Article 7; and other Parties shall seek to include in their national communications, as appropriate, information on programmes which contain measures that the Party believes contribute to addressing climate change and its adverse impacts, including the abatement of increases in greenhouse gas emissions, and enhancement of and removals by sinks, capacity building and adaptation measures;

(c) Cooperate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries, including the formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain and the creation of an enabling environment for the private sector, to promote and enhance the transfer of, and access to, environmentally sound technologies;

(d) Cooperate in scientific and technical research and promote the maintenance and the development of systematic observation systems and development of data archives to reduce uncertainties related to the climate system, the adverse impacts of climate change and the economic and social consequences of various response strategies, and promote the development and strengthening of endogenous capacities and capabilities to participate in international and intergovernmental efforts, programmes and networks on research and systematic observation, taking into account Article 5 of the Convention;

(e) Cooperate in and promote at the international level, and, where appropriate, using existing bodies, the development and implementation of education and training programmes, including the strengthening of national capacity building, in particular human and institutional capacities and the exchange or secondment of personnel to train experts in this field, in particular for developing countries, and facilitate at the national level public awareness of, and public access to information on, climate change. Suitable modalities should be developed to implement these activities through the relevant bodies of the Convention, taking into account Article 6 of the Convention;

(f) Include in their national communications information on programmes and activities undertaken pursuant to this Article in accordance with relevant decisions of the Conference of the Parties; and

(g) Give full consideration, in implementing the commitments under this Article, to Article 4, paragraph 8, of the Convention.

Article 11

1. In the implementation of Article 10, Parties shall take into account the provisions of Article 4, paragraphs 4, 5, 7, 8 and 9, of the Convention.

2. In the context of the implementation of Article 4, paragraph 1, of the Convention, in accordance with the provisions of Article 4, paragraph 3, and Article 11 of the Convention, and through the entity or entities entrusted with the operation of the financial mechanism of the Convention, the developed country Parties and other developed Parties included in Annex II to the Convention shall:

(a) Provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in advancing the implementation of existing commitments under Article 4, paragraph 1(a), of the Convention that are covered in Article 10, subparagraph (a); and

(b) Also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of advancing the implementation of existing commitments under Article 4, paragraph 1, of the Convention that are covered by Article 10 and that are agreed between a developing country Party and the international entity or entities referred to in Article 11 of the Convention, in accordance with that Article.

The implementation of these existing commitments shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among developed country Parties. The guidance to the entity or entities entrusted with the operation of the financial mechanism of the Convention in relevant decisions of the Conference of the Parties, including those agreed before the adoption of this Protocol, shall apply *mutatis mutandis* to the provisions of this paragraph.

3. The developed country Parties and other developed Parties in Annex II to the Convention may also provide, and developing country Parties avail themselves of, financial resources for the implementation of Article 10, through bilateral, regional and other multilateral channels.

Article 12

1. A clean development mechanism is hereby defined.

2. The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.

3. Under the clean development mechanism:

(a) Parties not included in Annex I will benefit from project activities resulting in certified emission reductions; and

(b) Parties included in Annex I may use the certified emission reductions accruing from such project activities to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3, as determined by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

4. The clean development mechanism shall be subject to the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to this Protocol and be supervised by an executive board of the clean development mechanism.

5. Emission reductions resulting from each project activity shall be certified by operational entities to be designated by the Conference of the Parties serving as the meeting of the Parties to this Protocol, on the basis of:

(a) Voluntary participation approved by each Party involved;

(b) Real, measurable, and long-term benefits related to the mitigation of climate change; and

(c) Reductions in emissions that are additional to any that would occur in the absence of the certified project activity.

6. The clean development mechanism shall assist in arranging funding of certified project activities as necessary.

7. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, elaborate modalities and procedures with the objective of ensuring transparency, efficiency and accountability through independent auditing and verification of project activities.

8. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall ensure that a share of the proceeds from certified project activities is used to cover administrative expenses as well as to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation.

9. Participation under the clean development mechanism, including in activities mentioned in paragraph 3(a) above and in the acquisition of certified emission reductions, may involve private and/or public entities, and is to be subject to whatever guidance may be provided by the executive board of the clean development mechanism.

10. Certified emission reductions obtained during the period from the year 2000 up to the beginning of the first commitment period can be used to assist in achieving compliance in the first commitment period.

Article 13

1. The Conference of the Parties, the supreme body of the Convention, shall serve as the meeting of the Parties to this Protocol.

2. Parties to the Convention that are not Parties to this Protocol may participate as observers in the proceedings of any session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. When the Conference of the Parties serves as the meeting of the Parties to this Protocol, decisions under this Protocol shall be taken only by those that are Parties to this Protocol.

3. When the Conference of the Parties serves as the meeting of the Parties to this Protocol, any member of the Bureau of the Conference of the Parties representing a Party to the Convention but, at that time, not a Party to this Protocol, shall be replaced by an additional member to be elected by and from amongst the Parties to this Protocol.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall keep under regular review the implementation of this Protocol and shall make, within its mandate, the decisions necessary to promote its effective implementation. It shall perform the functions assigned to it by this Protocol and shall:

(a) Assess, on the basis of all information made available to it in accordance with the provisions of this Protocol, the implementation of this Protocol by the Parties, the overall effects of the measures taken pursuant to this Protocol, in particular environmental, economic and social effects as well as their cumulative impacts and the extent to which progress towards the objective of the Convention is being achieved;

(b) Periodically examine the obligations of the Parties under this Protocol, giving due consideration to any reviews required by Article 4, paragraph 2(d), and Article 7, paragraph 2, of the Convention, in the light of the objective of the Convention, the experience gained in its implementation and the evolution of scientific and technological knowledge, and in this respect consider and adopt regular reports on the implementation of this Protocol;

(c) Promote and facilitate the exchange of information on measures adopted by the Parties to address climate change and its effects, taking into account the differing circumstances, responsibilities and capabilities of the Parties and their respective commitments under this Protocol;

(d) Facilitate, at the request of two or more Parties, the coordination of measures adopted by them to address climate change and its effects, taking into account the differing circumstances, responsibilities and capabilities of the Parties and their respective commitments under this Protocol;

(e) Promote and guide, in accordance with the objective of the Convention and the provisions of this Protocol, and taking fully into account the relevant decisions by the Conference of the Parties, the development and periodic refinement of comparable methodologies for the effective implementation of this Protocol, to be agreed on by the Conference of the Parties serving as the meeting of the Parties to this Protocol;

(f) Make recommendations on any matters necessary for the implementation of this Protocol;

(g) Seek to mobilize additional financial resources in accordance with Article 11, paragraph 2;

(h) Establish such subsidiary bodies as are deemed necessary for the implementation of this Protocol;

(i) Seek and utilize, where appropriate, the services and cooperation of, and information provided by, competent international organizations and intergovernmental and non-governmental bodies; and

(j) Exercise such other functions as may be required for the implementation of this Protocol, and consider any assignment resulting from a decision by the Conference of the Parties.

5. The rules of procedure of the Conference of the Parties and financial procedures applied under the Convention shall be applied *mutatis mutandis* under this Protocol, except as may be otherwise decided by consensus by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

6. The first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol shall be convened by the secretariat in conjunction with the first session of the Conference of the Parties that is scheduled after the date of the entry into force of this

Protocol. Subsequent ordinary sessions of the Conference of the Parties serving as the meeting of the Parties to this Protocol shall be held every year and in conjunction with ordinary sessions of the Conference of the Parties, unless otherwise decided by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

7. Extraordinary sessions of the Conference of the Parties serving as the meeting of the Parties to this Protocol shall be held at such other times as may be deemed necessary by the Conference of the Parties serving as the meeting of the Parties to this Protocol, or at the written request of any Party, provided that, within six months of the request being communicated to the Parties by the secretariat, it is supported by at least one third of the Parties.

8. The United Nations, its specialized agencies and the International Atomic Energy Agency, as well as any State member thereof or observers thereto not party to the Convention, may be represented at sessions of the Conference of the Parties serving as the meeting of the Parties to this Protocol as observers. Any body or agency, whether national or international, governmental or non-governmental, which is qualified in matters covered by this Protocol and which has informed the secretariat of its wish to be represented at a session of the Conference of the Parties serving as the meeting of the Parties to this Protocol as an observer, may be so admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure, as referred to in paragraph 5 above.

Article 14

1. The secretariat established by Article 8 of the Convention shall serve as the secretariat of this Protocol.

2. Article 8, paragraph 2, of the Convention on the functions of the secretariat, and Article 8, paragraph 3, of the Convention on arrangements made for the functioning of the secretariat, shall apply *mutatis mutandis* to this Protocol. The secretariat shall, in addition, exercise the functions assigned to it under this Protocol.

Article 15

1. The Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation established by Articles 9 and 10 of the Convention shall serve as, respectively, the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of this Protocol. The provisions relating to the functioning of these two bodies under the Convention shall apply *mutatis mutandis* to this Protocol. Sessions of the meetings of the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of this Protocol shall be held in conjunction with the meetings of, respectively, the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of the Convention.

2. Parties to the Convention that are not Parties to this Protocol may participate as observers in the proceedings of any session of the subsidiary bodies. When the subsidiary

bodies serve as the subsidiary bodies of this Protocol, decisions under this Protocol shall be taken only by those that are Parties to this Protocol.

3. When the subsidiary bodies established by Articles 9 and 10 of the Convention exercise their functions with regard to matters concerning this Protocol, any member of the Bureaux of those subsidiary bodies representing a Party to the Convention but, at that time, not a party to this Protocol, shall be replaced by an additional member to be elected by and from amongst the Parties to this Protocol.

Article 16

The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, as soon as practicable, consider the application to this Protocol of, and modify as appropriate, the multilateral consultative process referred to in Article 13 of the Convention, in the light of any relevant decisions that may be taken by the Conference of the Parties. Any multilateral consultative process that may be applied to this Protocol shall operate without prejudice to the procedures and mechanisms established in accordance with Article 18.

Article 17

The Conference of the Parties shall define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading. The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article.

Article 18

The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, approve appropriate and effective procedures and mechanisms to determine and to address cases of non-compliance with the provisions of this Protocol, including through the development of an indicative list of consequences, taking into account the cause, type, degree and frequency of non-compliance. Any procedures and mechanisms under this Article entailing binding consequences shall be adopted by means of an amendment to this Protocol.

Article 19

The provisions of Article 14 of the Convention on settlement of disputes shall apply *mutatis mutandis* to this Protocol.

Article 20

1. Any Party may propose amendments to this Protocol.

2. Amendments to this Protocol shall be adopted at an ordinary session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. The text of

any proposed amendment to this Protocol shall be communicated to the Parties by the secretariat at least six months before the meeting at which it is proposed for adoption. The secretariat shall also communicate the text of any proposed amendments to the Parties and signatories to the Convention and, for information, to the Depositary.

3. The Parties shall make every effort to reach agreement on any proposed amendment to this Protocol by consensus. If all efforts at consensus have been exhausted, and no agreement reached, the amendment shall as a last resort be adopted by a three-fourths majority vote of the Parties present and voting at the meeting. The adopted amendment shall be communicated by the secretariat to the Depositary, who shall circulate it to all Parties for their acceptance.

4. Instruments of acceptance in respect of an amendment shall be deposited with the Depositary. An amendment adopted in accordance with paragraph 3 above shall enter into force for those Parties having accepted it on the ninetieth day after the date of receipt by the Depositary of an instrument of acceptance by at least three fourths of the Parties to this Protocol.

5. The amendment shall enter into force for any other Party on the ninetieth day after the date on which that Party deposits with the Depositary its instrument of acceptance of the said amendment.

Article 21

1. Annexes to this Protocol shall form an integral part thereof and, unless otherwise expressly provided, a reference to this Protocol constitutes at the same time a reference to any annexes thereto. Any annexes adopted after the entry into force of this Protocol shall be restricted to lists, forms and any other material of a descriptive nature that is of a scientific, technical, procedural or administrative character.

2. Any Party may make proposals for an annex to this Protocol and may propose amendments to annexes to this Protocol.

3. Annexes to this Protocol and amendments to annexes to this Protocol shall be adopted at an ordinary session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. The text of any proposed annex or amendment to an annex shall be communicated to the Parties by the secretariat at least six months before the meeting at which it is proposed for adoption. The secretariat shall also communicate the text of any proposed annex or amendment to an annex to the Parties and signatories to the Convention and, for information, to the Depositary.

4. The Parties shall make every effort to reach agreement on any proposed annex or amendment to an annex by consensus. If all efforts at consensus have been exhausted, and no agreement reached, the annex or amendment to an annex shall as a last resort be adopted by a three-fourths majority vote of the Parties present and voting at the meeting. The adopted annex or amendment to an annex shall be communicated by the secretariat to the Depositary, who shall circulate it to all Parties for their acceptance.

5. An annex, or amendment to an annex other than Annex A or B, that has been adopted in accordance with paragraphs 3 and 4 above shall enter into force for all Parties to this Protocol six months after the date of the communication by the Depositary to such Parties of the adoption of the annex or adoption of the amendment to the annex, except for those Parties that have notified the Depositary, in writing, within that period of their non-acceptance of the annex or amendment to the annex. The annex or amendment to an annex shall enter into force for Parties which withdraw their notification of non-acceptance on the ninetieth day after the date on which withdrawal of such notification has been received by the Depositary.

6. If the adoption of an annex or an amendment to an annex involves an amendment to this Protocol, that annex or amendment to an annex shall not enter into force until such time as the amendment to this Protocol enters into force.

7. Amendments to Annexes A and B to this Protocol shall be adopted and enter into force in accordance with the procedure set out in Article 20, provided that any amendment to Annex B shall be adopted only with the written consent of the Party concerned.

Article 22

1. Each Party shall have one vote, except as provided for in paragraph 2 below.

2. Regional economic integration organizations, in matters within their competence, shall exercise their right to vote with a number of votes equal to the number of their member States that are Parties to this Protocol. Such an organization shall not exercise its right to vote if any of its member States exercises its right, and vice versa.

Article 23

The Secretary-General of the United Nations shall be the Depositary of this Protocol.

Article 24

1. This Protocol shall be open for signature and subject to ratification, acceptance or approval by States and regional economic integration organizations which are Parties to the Convention. It shall be open for signature at United Nations Headquarters in New York from 16 March 1998 to 15 March 1999. This Protocol shall be open for accession from the day after the date on which it is closed for signature. Instruments of ratification, acceptance, approval or accession shall be deposited with the Depositary.

2. Any regional economic integration organization which becomes a Party to this Protocol without any of its member States being a Party shall be bound by all the obligations under this Protocol. In the case of such organizations, one or more of whose member States is a Party to this Protocol, the organization and its member States shall decide on their respective responsibilities for the performance of their obligations under this Protocol. In such cases, the organization and the member States shall not be entitled to exercise rights under this Protocol concurrently.

3. In their instruments of ratification, acceptance, approval or accession, regional economic integration organizations shall declare the extent of their competence with respect to the matters governed by this Protocol. These organizations shall also inform the Depositary, who shall in turn inform the Parties, of any substantial modification in the extent of their competence.

Article 25

1. This Protocol shall enter into force on the ninetieth day after the date on which not less than 55 Parties to the Convention, incorporating Parties included in Annex I which accounted in total for at least 55 per cent of the total carbon dioxide emissions for 1990 of the Parties included in Annex I, have deposited their instruments of ratification, acceptance, approval or accession.

2. For the purposes of this Article, "the total carbon dioxide emissions for 1990 of the Parties included in Annex I" means the amount communicated on or before the date of adoption of this Protocol by the Parties included in Annex I in their first national communications submitted in accordance with Article 12 of the Convention.

3. For each State or regional economic integration organization that ratifies, accepts or approves this Protocol or accedes thereto after the conditions set out in paragraph 1 above for entry into force have been fulfilled, this Protocol shall enter into force on the ninetieth day following the date of deposit of its instrument of ratification, acceptance, approval or accession.

4. For the purposes of this Article, any instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by States members of the organization.

Article 26

No reservations may be made to this Protocol.

Article 27

1. At any time after three years from the date on which this Protocol has entered into force for a Party, that Party may withdraw from this Protocol by giving written notification to the Depositary.

2. Any such withdrawal shall take effect upon expiry of one year from the date of receipt by the Depositary of the notification of withdrawal, or on such later date as may be specified in the notification of withdrawal.

3. Any Party that withdraws from the Convention shall be considered as also having withdrawn from this Protocol.

Article 28

The original of this Protocol, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

DONE at Kyoto this eleventh day of December one thousand nine hundred and ninety-seven.

IN WITNESS WHEREOF the undersigned, being duly authorized to that effect, have affixed their signatures to this Protocol on the dates indicated.

Annex A

Greenhouse gases

Carbon dioxide (CO_2)
Methane (CH_4)
Nitrous oxide (N_2O)
Hydrofluorocarbons (HFCs)
Perfluorocarbons (PFCs)
Sulphur hexafluoride (SF_6)

Sectors/source categories

Energy
- Fuel combustion
  - Energy industries
  - Manufacturing industries and construction
  - Transport
  - Other sectors
  - Other
- Fugitive emissions from fuels
  - Solid fuels
  - Oil and natural gas
  - Other

Industrial processes
- Mineral products
- Chemical industry
- Metal production
- Other production
- Production of halocarbons and sulphur hexafluoride
- Consumption of halocarbons and sulphur hexafluoride
- Other

Solvent and other product use

Agriculture
- Enteric fermentation
- Manure management
- Rice cultivation
- Agricultural soils
- Prescribed burning of savannas
- Field burning of agricultural residues
- Other

Waste

- Solid waste disposal on land
- Wastewater handling
- Waste incineration
- Other

Annex B

Party	Quantified emission limitation or reduction commitment (percentage of base year or period)
Australia	108
Austria	92
Belgium	92
Bulgaria*	92
Canada	94
Croatia*	95
Czech Republic*	92
Denmark	92
Estonia*	92
European Community	92
Finland	92
France	92
Germany	92
Greece	92
Hungary*	94
Iceland	110
Ireland	92
Italy	92
Japan	94
Latvia*	92
Liechtenstein	92
Lithuania*	92
Luxembourg	92
Monaco	92
Netherlands	92
New Zealand	100
Norway	101
Poland*	94
Portugal	92
Romania*	92
Russian Federation*	100
Slovakia*	92
Slovenia*	92
Spain	92
Sweden	92
Switzerland	92
Ukraine*	100
United Kingdom of Great Britain and Northern Ireland	92
United States of America	93

* Countries that are undergoing the process of transition to a market economy.

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Appendix III: Timetable for Ratification of the Kyoto Protocol by NZ

Timing	Milestone	Comment
July 2000	Cabinet decisions	Consideration of 1st tranche of sectoral (non-price) measures and directions for further work by officials on non-price and cross-sectoral price measures, including consultation on industry agreements, trading and sinks
August 2000	Cabinet decisions	Papers on resourcing and international issues
October 2000	Cabinet decisions	Further non-price measures for implementation and in principle decisions on cross-sectoral and price measures for detailed design and further consultation
November 2000	COP 6	Clarification of key aspects of the rules for international trading and sinks expected
Early 2001	2001 budget round	Proposals for climate change resourcing for 2001/02 and outyears
March 2001	Cabinet decisions	Further decisions on detailed design issues for measures and report backs
April 2001	Draft NEECS	Statutory deadline for publishing draft National Energy Efficiency and Conservation Strategy (NEECS)
mid 2001	Cabinet decisions	Detailed implementation decisions on sectoral and cross-sectoral measures and drafting of legislation
November 2001	COP 7	Further development of detailed international rules and requirements
November 2001	Third National Communication under the UNFCCC	NZ's substantive international report on our response to our commitments under the UNFCCC and progress on implementation of the Protocol
Late 2001/early 2002?	Government legislation	Introduction of Kyoto Protocol ratification and implementation legislation to Parliament
June 2002	Rio +10	Government has announced ratification by Rio +10
By 2002	Commitment to show demonstrable progress under the Protocol	
1 January 2008	First commitment period	Beginning of first 5 year target period

Source: Ministry for the Environment 2000: "*Climate Change: Early Decisions and Directions*" (referring to Cabinet Papers CAB(00)M15/12A)

Appendix IV: Technical Options for Reduction of Methane Emissions from Livestock

Improved nutrition through chemical and mechanical treatment of feed

Improved nutritional quality through chemical and mechanical treatment of feed involves the dosing or immersing roughages from crop by-products (eg: straw) in a mixture of sodium hydroxide, urea and water, and storing it for several days. This increases the digestibility of the roughage from about 50 percent to as much as 75 percent. Chopping crop residues also increase digestibility.

Improved nutrition through strategic supplementation

Nutrition can be improved through strategic dietary supplementation. A deficiency of nutrients, eg: ammonia (although this is rarely a problem in New Zealand), will affect the composition and mass of the complex micro-organism population that inhabits the rumen, thereby affecting the ability to digest cellulose. This can be corrected by supplying stock with multi-nutrient lick blocks, or by defaunation. Defaunation is the process of dosing an animal to remove protozoa in the rumen which are thought to decrease digestion efficiency. (Protozoa derive a portion of their energy by ingesting bacteria, thereby reducing the outflow of bacteria from the rumen to the intestine that provides animals (grazing on poor pasture in particular) with a source of protein needed to maximise digestive efficiency. Defaunation, which can be achieved by at least one type of natural foliage, may increase microbial cell outflow by 25-50 percent on poor pasture, and thus reduce methane emissions per unit of carbohydrate fermented by approximately 25 percent). Defaunation agents, however, are not yet commercially available.

Targeted mineral and protein supplements are applicable for specific dietary deficiencies, some of which may be seasonal.

Dosing with methane-inhibiting compounds

Animals may be dosed with methane-inhibiting compounds, but most methane-inhibiting compounds are too volatile to be used as feed additives. Recent research in Australia has shown preliminary evidence that a new, more stable compound, used under commercial conditions, can cause a sustained reduction in methane production, a changed pattern of rumen fermentation, and improved feed efficiency in cattle fed with the compound once a day.

Modification of rumen bacteria via genetic engineering

Over the long term, it may be possible to select or bioengineer specific microbes that improve feed utilisation or suppress methane production directly. Some microbial feed additives that improve rumen fermentation are commercially available. Currently these products contain naturally-occurring microbes. In the future, specifically engineered microbes may further enhance efficiency. Further research would be needed in several areas, including:

- ⇨ Correlation of methane-producing species and other rumen environmental factors with levels of methane production

- ⇨ Identification of techniques to inhibit specifically targeted methane-producing bacteria without adversely affecting animal performance. Such techniques might include

developing hydrogen-using microbes that out-compete the methane-producing bacteria, or microbes that produce an antibiotic that selectively inhibits their growth.

Production enhancing agents

Production enhancing agents reduce the emission of methane per unit of production. They include naturally occurring and synthetic hormones. Bovine somatotrophin (bST and the synthesised version rbST, using recombinant DNA techniques) is used particularly with lactating cows. Dose size correlates with productivity increase, until a threshold is reached. Dosing can increase milk production by 20 percent or more and, although feed intake will also increase, emissions per unit of production are decreased. RbST is believed to be safe to humans; research continues on the effect to the animal and on the environment. The technique is likely to be cost-effective for herds that are intensively managed, that receive high quality feed and that have high genetic value.

Anabolic steroids are effective in increasing the rate of weight gain and improving feed conversion efficiency amongst beef cattle, by redirecting the energy used to deposit fat in the animal to the deposition of protein. Hormones used include:

- Progesterone for steers and bulls grown for beef
- Testosterone used in steers, but most frequently in heifers
- Zeranol or trenbolone for steers and heifers
- Estradiol benzate, used in combination with progesterone and testosterone

The preferred method is to implant a small pellet under the skin of the animal's ear. The pellet releases a defined dose of hormone into the animal's bloodstream, which will reach the appropriate sites throughout the body. The hormones typically increase daily growth by 5 to 15 percent, and improve feed efficiency by 5 to 10 percent.

Because of public concerns for consumer health, the European Community has banned the use of hormones in the production of food for humans, and food cannot be imported that was produced using hormone implants.

Other production-enhancing agents being investigated include isoproterenol, clenbuterol and cimaterol.

New Zealand has licensed hormonally based growth promotant implants for use in cattle only. Current usage is estimated at approximately 10 percent of the national cattle herd. No somatotrophin (eg: bST) is currently licensed in New Zealand. Growth promotants are not used on sheep or deer.

Improved production through improved genetic characteristics

Improved production, which reduces methane emissions per unit of output, is possible through improved genetic characteristics. This can be achieved by cross-breeding, continued genetic improvement through breeding programmes, or possibly by transgenic manipulation. Adequate management conditions, such as adequate feed and disease control, are necessary for genetic potential to be realised. Transgenic manipulation involves the transfer of genetic material from one species to another and, although preliminary results are available (eg: in mice), a considerable amount of research is needed before transgenic manipulation could be used commercially in food-producing animals. Research has also identified that some animals emit less methane than other animals of the same species. It may therefore be possible to selectively breed animals with this low methane characteristic.

Improved production efficiency through improved reproduction

Improved production efficiency per given emission of methane is also possible through improved reproduction, such as twinning, embryo transplants and artificial insemination. Twinning allows fewer breeding animals to be kept to produce a given number of offspring. Techniques to inhibit hormones that suppress twinning have been developed. (There are some down-sides of twinning which may have to be addressed alongside this, for example heifers born twin with a bull are often sterile). Adequate nutrition also needs to be available to enable twins to grow and mature as quickly as offspring from single births.

Embryo transplants may be used to increase the proportion of stock that become pregnant, and can assist in increasing the rate at which the genetic potential of stock is improved.

Artificial insemination (AI) is a reasonably well-established practice. Advantages include eliminating the need to maintain sires, thereby reducing cost, and allowing the superior genetic potential of a single sire to be spread among many progeny. Oestrus synchronisation can be used alongside AI and embryo transplants to increase reproductive performance and reduce costs.

Source: Ministry for the Environment 1998: "*Climate Change: More than just carbon dioxide. Significance, sources and solutions for non-* CO_2 *greenhouse gases in NZ*".

Appendix V: Effect of feed quality on methane emission of cows with the same level of milk production

DM digestibility (%)	55	65	75
Milk production (kg/d)	20	20	20
Feed intake (kg DM/d)	21.6	17.5	14.6
CH_4 emission (g/d)	499	386	306
G CH_4/kg milk	24.9	19.3	15.3

Source: Ulyatt 1996: *"Is Emission Control Technology Advanced Enough to Control or Monitor Emissions Other than Carbon Dioxide?"* Ag Research, Palmerston North

Appendix VI: Emission of New Zealand Greenhouse Gases for 1990 and 1995 and Projections from 2000 to 2010 (*for thousands of tonnes, 100 year GWP*)

thousands of tonnes, 100 year GWP)

	1990[a]	1995[a]	2000	2005	2010
Non-CO_2 Gases					
CH_4	35,826	34,335	32,372	32,592	33,050
N_20[b]	14,725	14,446	14,260	14,136	14,167
SF_6	4.78	4.78	7.17	7.17	9.56
HFCs	n e g	183.3	213.2	247	286
PFCs	575.5	188.5	221	227.5	227.5
Total Non-CO_2	51,134.3	49,157.6	47,073.4	47,209.7	47,740
CO_2	25,475	27,266	30,907	33,127	34,878
Total GHG	76,609.3	76,423.6	77,980.4	80,336.7	82,618

Notes a) Actual emissions. Emissions from 2000-2010 are projections.

b) Projections for nitrous oxide from agricultural sources (the largest contributor) are projected from 2000 levels as the data from this source are too uncertain to do otherwise.

c) IPCC 1995 Global Warming Potentials are $CO_2 = 1$
$CH_4 = 21$
$N_2O = 310$
$HFC_{134a} = 1300$
PFCs (CF_4) = 6500
$SF_6 = 23900$

Source: Ministry of Environment 1998 : "*Climate Change: More Than Just Carbon Dioxide. Significance, sources and solutions for non- CO_2 greenhouse gases in New Zealand*"

Appendix VII: Farm Types in Pasture, Actual and Forecast 1990-2005

June Year	Dairy	Sheep	Beef	Deer	Total
	(Millions of HA)				
1990	1.448	5.227	2.089	0.191	8.955
1991	1.459	5.149	2.161	0.188	8.957
1992	1.511	5.059	2.276	0.211	9.057
1993	1.579	4.822	2.276	0.194	8.871
1994	1.759	4.680	2.388	0.212	9.039
1995	1.795	4.522	2.377	0.231	8.925
1996	1.919	4.764	2.112	0.308	9.103
1997(e)	1.932	4.656	2.086	0.332	9.006
1998(e)	1.950	4.569	2.057	0.352	8.928
1999(f)	1.961	4.507	2.034	0.373	8.875
2000(f)	1.969	4.436	2.008	0.405	8.818
2001(f)	1.982	4.355	1.980	0.434	8.751
2002(f)	2.009	4.253	1.938	0.459	8.659
2003(f)	2.035	4.157	1.898	0.483	8.573
2004(f)	2.060	4.069	1.861	0.504	8.494
2005(f)	2.083	3.990	1.827	0.520	8.420

(e) estimate
(f) forecast

Source: MAF Policy 2000

Appendix VIII: Livestock Numbers, Actual & Forecast 1990-2005

Year	Dairy	Sheep	Beef	Deer	Total
	(Millions of HA)				
1990	3.44	57.85	4.59	2.00	67.88
1991	3.43	55.16	4.67	2.39	65.65
1992	3.47	52.57	4.68	2.65	63.37
1993	3.55	50.30	4.76	2.52	61.13
1994	3.84	49.47	5.05	2.67	61.03
1995	4.09	48.82	5.18	2.66	60.75
1996	4.17	47.39	4.85	2.81	59.22
1997(e)	4.24	47.00	4.81	3.16	59.21
1998(e)	4.37	45.15	4.42	3.50	57.44
1999(p)	4.43	45.68	4.62	3.82	58.55
2000(f)	4.48	45.51	4.63	4.32	58.94
2001(f)	4.56	45.15	4.70	4.77	59.18
2002(f)	4.72	43.72	4.73	5.17	58.34
2003(f)	4.88	42.21	4.71	5.55	57.35
2004(f)	5.03	40.83	4.76	5.88	56.50
2005(f)	5.16	39.47	4.92	6.14	55.69

(e) estimate
(p) provisional
(f) forecast

Sources: Statistics New Zealand and MAF

Appendix IX: Calculation of CO_2-equivalent Emissions from Sheep & Cows

1. Sheep

Methane emission: 30g/day/sheep

Converted to CO_2 equivalents GWP (x 21) = 224kg/yr/sheep

Per livestock unit (1 sheep = 1 LSU) = 224kg CO_2-equivalent/yr/LSU

Converted to carbon (÷ 3.67) = 61kg/carbon/yr/sheep

2. Cows

Methane emission 250g/day/cow

Converted to CO_2 equivalents (x 21) = 1916kg/yr

Per livestock unit (1 cow = 7 LSU) = 273.7kg CO_2-equivalent/yr/LSU

Converted to carbon (÷ 3.67) = 522kg C/year/cow

Appendix X: Relative Gross Economic Efficiency of the Major Animal Industries with Respect to Methane Emissions in 1995

	$(M)FOB	**Methane produced (000's tonnes)**	**Efficiency ($gCH_4/$FOB)**
Sheep	3177	848	267
Beef	1573	329	209
Dairy	3308	286	86

Source: Ulyatt 1996: *"Is Emission Control Technology Advanced Enough to Control or Monitor Emissions Other than Carbon Dioxide?"* Ag Research, Palmerston North