Climate Change Policy and Forestry II

Review of an NZIER report entitled:

Effects of New Zealand's Climate Change Policies on the Forestry Sector - Stage II: Initial Quantification

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Executive Summary

- This review examines the New Zealand Institute of Economic Research's (NZIER) second stage report entitled *Effects of New Zealand's Climate Change Policies on the Forestry Sector*. The report's purpose is "to quantify the likely impacts on the forestry sector based on policies that are likely to emerge if the Kyoto Protocol were ratified".

- The New Zealand Government has not at this stage specified the details of its climate change policies. NZIER's work is based on the assumptions that (i) forests planted post 1990 (Kyoto forests) will earn carbon credits at their internationally traded value and (ii) pre-1990 forests (non-Kyoto forests) will pay penalties at the international carbon price if the land is not restocked following harvest. If restocked, non-Kyoto forests are assumed unaffected by credits or penalties. (Alternative policy assumptions have not yet been explored by NZIER and are to be addressed in a third stage of their work.)

- NZIER use a spreadsheet model to derive estimates of the financial effect of policy changes on the forestry industry. Two separate modeling exercises are undertaken: one for forestry and logging (which addresses the effects of the Kyoto Protocol on New Zealand forest owners), and one for the processing sub-sectors.

- We identify a number of flaws in NZIER's conceptual approach to modeling the forestry and logging sub-sector. The principal problem is the way the business as usual (BAU) projection has been specified. This defines the default commercial environment – the benchmark against which any changes resulting from new policies are compared.

- Two states of the world are considered by NZIER: "business as usual", in which no countries anywhere in the world implement the Kyoto Protocol; and "climate change policies" which comprises a world in which the Annex I countries (including New Zealand) implement the Protocol. There is no intermediate benchmark of a world in which the Protocol has been implemented by other countries and New Zealand must evaluate whether ratifying the Protocol itself is positive for forestry in that world, on the basis of the policy settings assumed and modeled by NZIER.

- With "business as usual" defined in this way, NZIER's scenarios are unable to isolate the effects of New Zealand climate change policies. Instead, they provide a comparison between a world economy exhibiting the effects of collective policy action by all those nations that ratify Kyoto, versus a benchmark of no action by any Annex 1 countries. In other words, NZIER have analysed the effects of joint international policy action – not the effects of New Zealand policy on its own.

- It is these post-Kyoto changes in the outside world – particularly the world price of logs - that dominate the model results.

- New Zealand is stated to be a price taker in the market for logs – that is, New Zealand domestic policies have no effect on the world market. Yet under the heading of examining the effects of "New Zealand's climate change policies", NZIER have treated Kyoto-induced changes in the international log price as attributable to "climate change policies". Thus they have analysed the effects of the Protocol as a whole – not New Zealand's policy response to it.

- The results from the modelling are therefore largely uninformative about the effects of New Zealand's own climate change policy. The failure to separate international from national policies means there is no separable analysis of the impact of New Zealand policy as such.

- To be useful for New Zealand policy design, the benchmark should be a world in which other Annex 1 nations have ratified the Protocol. The model would then show the consequences of New Zealand ratification and implementation in that context. In such an analysis, the world log price path (and other aspects of the international economic environment) would be set at the levels expected to prevail once a set of countries other than New Zealand have implemented the Protocol. New Zealand, as a price-taking small country, could then be modelled in policy-on (ratify) and policy-off (do not ratify) modes, to evaluate whether ratification is good or bad for New Zealand forest owners and processors, given the prior existence of the Protocol. The failure to separate the projected changes in world log prices from the effects of New Zealand's own policies is crucial because it has such a large influence on the financial outcomes reported from the model.

- Also of concern with respect to the BAU projection is the failure to specify the extent to which any conversion of land from forestry to other uses would take place in absence of climate change policies. Implicitly NZIER assume that without climate change policies, under business-as-usual all New Zealand forest land would be restocked in rotation forestry. In two of their three forestry response scenarios, they then assume complete deforestation (either immediately or after one rotation) of the non-Kyoto forest estate, as though this is attributable to climate change policy. No basis is provided for this extreme assumption, nor has any distinction has been made between the likely business-as-usual rate of land conversion away from forestry, and that projected to result specifically from climate change policy.

- In the "no-restocking" case, NZIER hypothesise in effect that the entire non-Kyoto estate represents a misallocation of land which has some (unspecified) higher-value use to which it is switched. (The gains from this higher-value use are not included in the model's accounting.) The model runs obtain their quantitative results by comparing the discounted present value of the revenue stream for an industry which is assumed to shut down at the earliest opportunity, with a benchmark revenue stream from an industry which stays in business (as usual). The massive land-use change hypothesised is not a model-

derived result of climate change policy, but an assumption introduced into the model.

- In summary, NZIER's quantitative analysis hinges on two highly contestable sets of input assumptions: the future world log price path, which is assumed to be hit in the near future by a "wall of wood"; and the proportion of non-Kyoto forest land which should optimally be deforested under various scenarios, which is set at 100% for two of the three scenarios modeled for non-Kyoto forests.

- Turning to the modelling of effects on wood processing, two significant problems arise. The first is that, as NZIER acknowledge, "international comparisons of competitiveness are fraught with difficulty, and cannot be reduced simply to production costs". Exchange rates, for example, regularly change by amounts sufficient to offset the direct domestic cost impacts that drive NZIER's results; and since exchange rate changes would be an integral part of the New Zealand economy's adjustment to climate change policies, little weight attaches to estimates of change in competitiveness at fixed exchange rates.

- The second problem is that NZIER place very heavy weight on simple bilateral comparisons between New Zealand and Chile, arguing that greenfields investment in forest products processing will shift from New Zealand to Chile in response to cost increases in New Zealand. This represents only a partial analysis, however. NZIER have accounted for one possible source of investment reallocation from New Zealand to Chile, but have failed to account for any of the countervailing forces that would be likely to operate. Chile may well be regarded as New Zealand's chief competitor at present, but since both countries are at the low-cost end of the world industry, both are likely to remain viable investment prospects. Insofar as forest-industry investors can be expected to shift from New Zealand to Chile in response to relative-cost changes, they can equally be expected to shift to New Zealand from Scandinavia, USA, Europe and Canada.

- Overall, the processing-sector modeling lacks the sophistication required to back its conclusions. Its partial-equilibrium nature precludes consideration of the effects of exchange rate changes in maintaining international competitiveness. The importance of using a comparative-advantage economy-wide framework to answer the questions being addressed here has already been discussed in detail in our review of the Stage I report. Individual firms may be able meaningfully to form business plans on the assumption that the international environment will remain constant. However, when evaluating the effects of economy-wide policy shocks on an entire sector, the partial-analysis other-things-equal approach simply lacks the necessary power to yield robust predictions.

- In conclusion, the NZIER Stage II results in their present form provide very limited information about the effects of potential New Zealand climate change policies. The financial results for forestry and logging can not be cited as due to domestic policy changes. The results and assumptions have not been

sufficiently clearly qualified in the text of the report to inform the reader of the limitations of NZIER's analysis. The study would benefit from substantial effort being put into reviewing the key assumptions made, given that these effectively determine the results.

1. Introduction

The New Zealand Institute of Economic Research (NZIER) has prepared, for the Wood Processing Strategy Climate Change Group, two reports addressing the likely impacts on forest-based industries of policy measures expected to be implemented following ratification by New Zealand of the Kyoto Protocol.

The first report set out the conceptual framework adopted by the NZIER analysts in approaching their task. The second report, reviewed below, quantifies various effects, using partial-equilibrium spreadsheet models developed in-house by NZIER.

The Ministry of Agriculture and Forestry (MAF) has asked Simon Terry Associates Ltd (STA) to review both reports. This is the second of our two review reports, and addresses NZIER's modeling exercise and the quantitative results obtained from it.

2. The Models[1]

For the purposes of quantitative analysis, NZIER has undertaken two separate modeling exercises: one for forestry and logging, which addresses the effects of the Kyoto Protocol on New Zealand forest owners; and one for the processing sub-sectors, which addresses the competitiveness of New Zealand-located wood processing and pulp and paper manufacturing. The methodological approaches of the two are substantially different, and the results are best reviewed separately.

2.1 The Forestry Model

This is described by NZIER (Stage II Report p.11) as "a sophisticated model of the New Zealand forest estate", and consists of a large Microsoft Excel workbook containing an expertly-constructed financial model. There are no price-response routines of the usual elasticity-based economic variety; but by searching out wealth-maximising silvicultural and harvesting options for each age cohort of trees in the estate, the model does simulate quantitative changes in harvested timber volumes in response to exogenously-imposed price shocks, tracing out in the process a simulated timber supply curve.

There is no explicit demand side, and hence no market-clearing routine. Implicitly in the model, and explicitly in the Stage II report (p.48), NZIER has proceeded on the assumption that "New Zealand is a price taker" so that "changes in its [log] supplies will not impact on world prices". Sales of harvested logs out of the forest estate, and purchases of logs as inputs by the processing sub-sectors both in New Zealand and elsewhere in the world, are assumed to take place without quantity restrictions at the same exogenously-imposed world price - or more accurately, at the same percentage deviations from a RISI[2] world price projection shown as

Figure 4, p.9, of the NZIER report. This "business-as-usual" price projection appears to have been drawn from RISI's fully-specified world timber supply and demand model, but there is no other use of RISI's world market modelling work or capabilities in the NZIER study.

The NZIER model simulates the response of forest owners to three sets of price shocks:

- the direct impacts of Kyoto-derived policies on the prices received and paid by forest owners for the carbon sequestered by growing trees and that released at harvest;
- NZIER's hypothesised "likely" changes in the world log price, relative to business as usual, due to implementation by other countries of the Kyoto Protocol;
- changes in the price of diesel fuel and electricity utilized in the growing and harvesting of trees (these are of second-order importance only, as energy accounts for only a small fraction of the total costs of growing and harvesting trees).

Having responded to these shocks, each group of forest owners in the model ends up with an estimated gain or loss, relative to business-as-usual expectations, in the form of a change in the Net Present Value of each age cohort of trees in each category of forest[3]. The model aggregates these age-specific NPV changes up to an overall change in the NPV of each category of forests measured at 2001.

The level of detail, and hence the size, of the spreadsheets is very substantial, and a large amount of technical information on silvicultural practices and costs has been built in for the purpose of modeling forest owners' responses. Each annual age cohort of trees planted from the early 1920s to the present is treated and valued separately. The investment of time and expertise in assembling this information into a consistent set of spreadsheets has been correspondingly large, and the quality of this technical implementation work appears to be high.

It is important, however, not to confuse detail and complexity in a financial model with economic sophistication. The modeling approach chosen by NZIER is very data-intensive on a narrow front (planting dates and volumes, rates of increment of growing trees, silvicultural costs at particular stages of growth, harvest costs and returns). However, the methodology itself is in effect a large-scale calculation, the results from which are dependent on the key input assumptions made rather than on the internal routines of the spreadsheet itself.

In presenting the results from this model for various scenarios, NZIER has unfortunately adopted a graphical technique which is extremely difficult to interpret both for lay readers and for specialists not familiar with the model and the data. The box on the next page discusses this in more detail.

Before describing the model itself, it may be useful to formulate the question the model was designed to answer. The issue as framed by NZIER is the following:

The background situation:

At the year 2001, there is in existence a non-Kyoto forest estate (land planted in forestry prior to 1990) and a Kyoto forest estate (land newly planted from 1990 on). The total estate comprises over 70 annual age cohorts of trees of various species each of which will have its own current log size, current and projected rate of volume increment, age-specific future silvicultural and harvesting costs, and some expected log price when harvested. The value of this estate at 2001 is the Discounted Present Value of the future cashflows available from management and harvest of the estate, including any rewards and penalties accruing due to implementation of climate change policies. (Under business as usual these are set to zero.)

The value of the estate must be calculated purely on its future earning potential, without regard for past expectations, expenditures, and mistakes. Some forest is no doubt on unsuitable land, or may have been established using high-cost techniques, and will never realize a commercial return on the owners' sunk costs of planting and silviculture to date. Some will be on extremely productive forestry land or may have been established very cheaply, and will in due course earn very high returns on past establishment costs. The relationship of future returns to sunk costs is irrelevant to the current valuation, which rests entirely on the going-forward costs and revenues.

Price effects on the timing of harvest

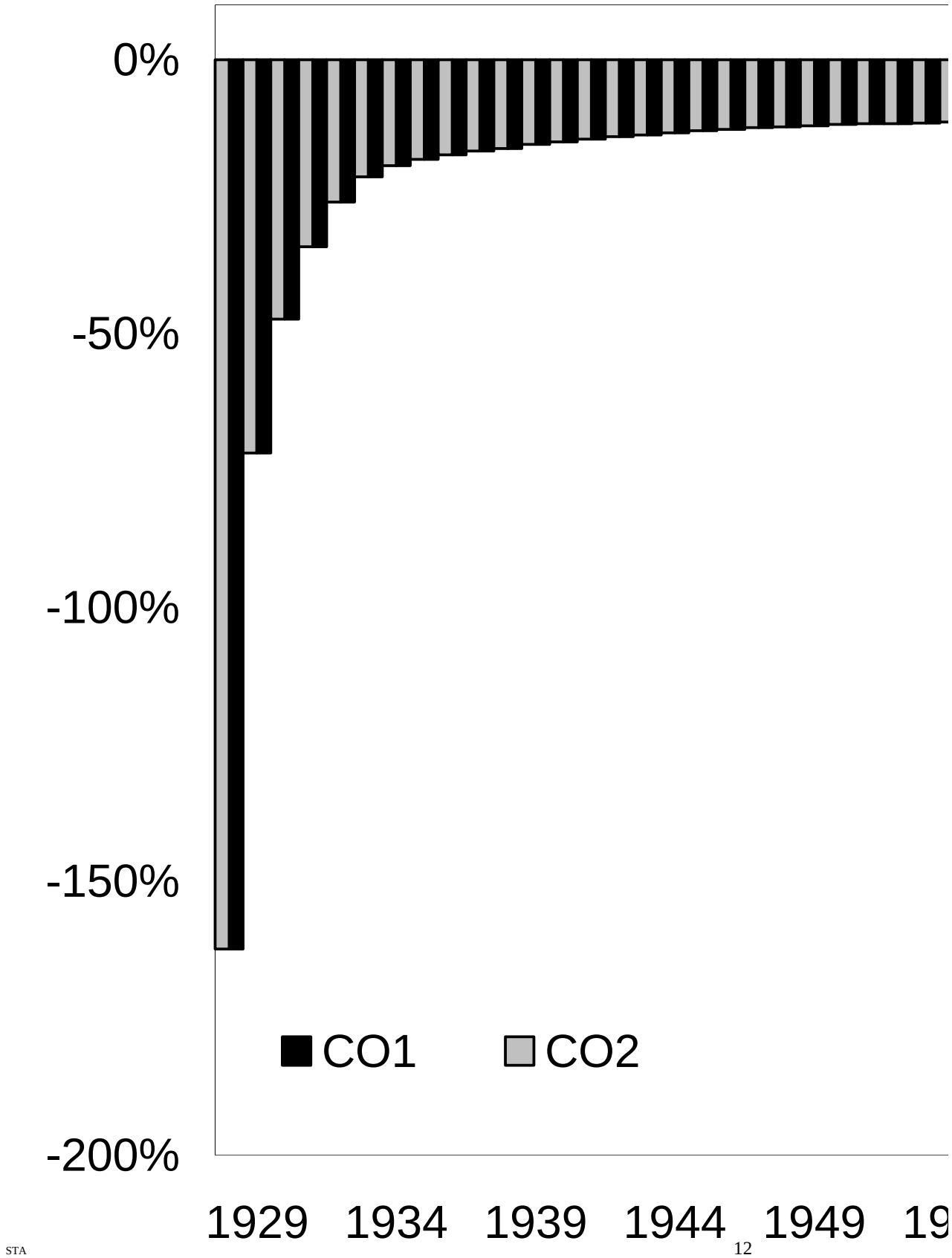
New Zealand exotic forests are generally logged at between 28 and 36 years of age, and a considerable portion of the standing forest estate is mature and ready for harvest over the next decade. The issue with these trees is basically to choose the time of harvest to take advantage of expected future price trends. Insofar as prices are expected to rise in the near future, there will be commercial incentives to hold trees back for a few years to realize the higher price. Insofar as prices are expected to fall, the opposite is true: immediate harvest may catch the market at its peak.

Presentation of NZIER Model Results: Comment

We reproduce below the bottom right-hand panel of NZIER's Figure 7 p.17, showing simulated changes in the 2001 present-value, by annual age cohort, of non-Kyoto forests under the NZIER "worst case" scenario with so-called "continuous restocking":

NZIER's Figure 7

Worst case, continuous restocking


0%
-50%
-100%
-150%
-200%
CO1
CO2
1929
1934
1939
1944
1949
19

Each pair of bars in this chart corresponds to the trees planted in the year shown along the horizontal axis. Negative values denote losses from climate change policies; positive values denote gains. The dark shaded bar of each pair is for a low-carbon-charge scenario (NZ$48 per tonne of C)[4] and the light shaded bars are for a high carbon charge (NZ$120 per tonne of C). The immediate visual impression is of large negative outcomes for most of the forest estate and very small positive outcomes for only a tiny fraction of the population. To obtain the true picture it is necessary to put the axes in context. The vertical axis is measured not in dollars but in percentage changes (it is not, incidentally, entirely clear how a financial value change of negative 150% ought to be interpreted). Large bars on the chart may represent substantial proportional changes in very small actual magnitude, whereas apparently small bars may represent very large sums of money. It is noticeable that the most dramatically negative percentage impacts are shown for trees planted prior to 1930.

The horizontal axis scale is planting years, with no weighting to reflect the share of each annual cohort in the total estate. Reference to Table 9 p.27 of the Ministry of Agriculture and Forestry's *A National Exotic Forest Description as at 1 April 2000* shows that only 2,516 ha (0.21%) of the estimated non-Kyoto forest estate of 1,198,600 ha[5] contains trees aged 70 years or more (i.e. planted prior to 1930), yet this tiny minority of forests visually dominates the chart. The four years 1985-1989, for which modest percentage gains are shown in NZIER's chart above, account for 184,769 ha (15.4%) of the non-Kyoto estate. A further 21% of the non-Kyoto forest estate contains trees planted since 1989, which do not seem to feature in Figure 7 at all, but which one might expect to share the same (positive) impacts as late-1980s plantings, given the importance of increased log prices post-2008 for the NZIER model results (see below).

The charts in NZIER's Figure 7, in short, do not provide a transparent summary of the numerical results, and are potentially misleading in the visual impression which they convey of overwhelmingly negative outcomes. Straightforward tables of the quantitative results, matching gains and losses with age cohort volumes, would have been more useful and would have enabled readers to evaluate for themselves what proportion of the non-Kyoto estate is estimated to win, and what proportion to lose, under the continuous-restocking model runs. The absence of such tables showing the detail of model results is a major shortcoming of the report.

Trees which are not yet fully mature could be harvested prematurely if an expected future fall in price would outweigh the gain in timber volume from growing them to full maturity. Otherwise, the usual optimal harvest decisions would apply.

What the model is set up to do

Under business as usual, the owners of the existing estate are assumed to have a management and harvesting plan for each age cohort of trees which maximizes the present value of those trees. Aggregated across the entire estate this gives an overall management and harvesting plan. The model is asked to identify this plan (on the assumption that there is a unique equilibrium), calculate the corresponding NPV, and set this NPV up as the benchmark relative to which any effects of climate change policies are to be measured.

Implementation of climate change policies by the international community is hypothesised to change future log prices. Costs of silviculture and harvest which involve the use of energy are hypothesised to increase due to carbon charges. Possible changes in log prices and costs are fed into the model to generate new scenarios, each with a new optimal management and harvest plan on the basis of which the model recalculates the present-value of the forest estate. Comparing this new value with the business-as-usual

benchmark gives the estimated effect of the changes for the scenario specified.

The above outline describes a standard modeling problem suited to the tools of financial analysis – basically, discounted cashflow calculations for alternative future scenarios with key parameters imposed from outside the model by the analyst. Everything is held constant except those variables which the analyst opts to change. (This is known as "partial" analysis because it abstracts from wider changes in the economy that might be triggered by, for example, implementation of Kyoto.)

In the Stage II scenarios, the exchange rate and the costs of land, labour and capital are held unchanged, while the prices of energy and carbon storage are raised (relative to business-as-usual), and the world price of logs is moved initially down, then up, relative to business as usual. Outputs from the model are the quantity changes as forest owners respond to these three price shocks, along with a new net present value of the forest estate for each scenario tested.

Once such a computer model has been built, only a small amount of time and effort are required to run multiple scenarios on it. Wide-ranging exploration of the implications of alternative price assumptions is possible and is a good way to explore the model's properties. Within the constraint of its structure the model should be able, for example, to identify threshold values of the three exogenously-varying prices (energy, carbon and logs) at which key outcomes change in sign. Examples could be the switch between rotation forestry and permanent retention of forest as a carbon store, modeled in NZIER's Figure 9 p.22; the switch from aggregate losses to aggregate gains for non-Kyoto forests, not explored at all in the Stage II report; and a possible switch from premature harvesting to late harvesting on average across the estate.

Since the ability to conduct such sensitivity tests around preferred or "likely" scenarios is a key payoff on the costs of building computer spreadsheet models of this sort, it has to be assumed that NZIER has conducted such tests in the course of preparing the Stage II report. It is regrettable that the results have not been more fully reported in accessible form.

Converting the general prescription for a financial model into detailed design involves some difficult choices amongst alternative possible computation routines, which can potentially affect the final results. The NZIER model setup imagines the owner of each age-cohort of trees standing at the planting data (e.g. at 1930 for trees planted in that year) and forming forward-looking expectations of costs and benefits over the life of the trees in order to value the forest as at the planting date. On the cost side of the cashflow stream to be discounted are the silvicultural costs, entered into the model on the basis of 2001 technology and costs incurred at appropriate stages in the lifecycle of the trees. All these costs up to 2001 are treated as fixed costs, outside the control of the forest owner. Costs after 2001 are discretionary for the forest owner, who adjusts the post-2001 management plan to maximize the trees' discounted present value at planting date.

On the benefit side, the revenue expected to be received at harvest is calculated from log size and the assumed market price path. The discounted value of benefits at planting date depends on the timing of harvest (other things being equal, deferring harvest reduces NPV and vice versa). The forest owner's simulated management plan at planting date maximises the NPV by fine-tuning the projected post-2001 silviculture and harvest date.

The model's future time horizon is truncated at the point where all trees currently in the ground have been harvested. As each piece of land is harvested, a terminal value equal to the current sale price of land is entered to capture fully all cashflows from that point forward. This land value is held invariant across all the scenarios, a procedure which renders the model "blind" to all effects of climate change policies beyond the current harvesting round.

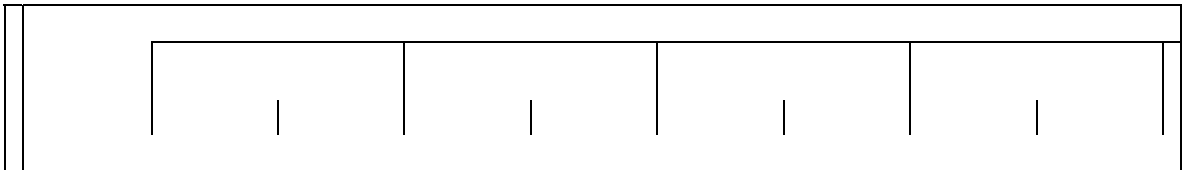
When the three scenarios for non-Kyoto forests are constructed, the same log price paths, energy price changes, and terminal land values are entered. Hence the only real difference among the three is the "exit cost" falling on the forest owner at the time of harvest. In the "non-restocking" case the full carbon charge on deforestation is incurred at harvest for all trees felled from 2008 forward. In the "one-restocking" case this exit charge is deferred by one rotation cycle (i.e. the exit charge is the discounted value of a future tax rather than an immediate tax). In the "continuous-restocking" case the exit charge is set at zero – but there is no accounting for the cashflows from subsequent harvests at the new projected world price for logs.

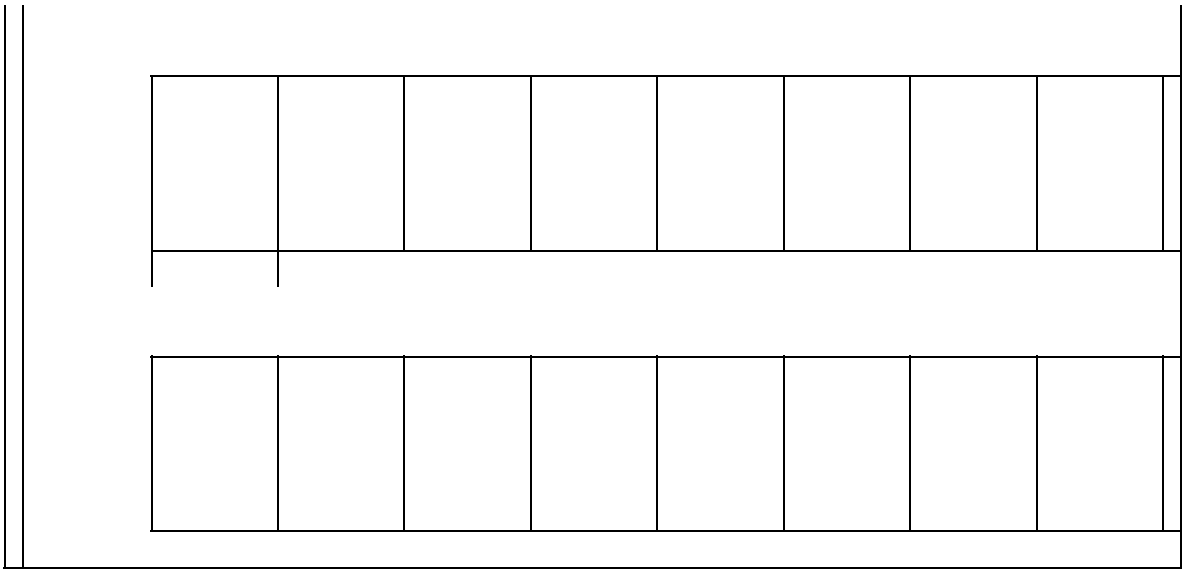
This truncated horizon, and the absence of any accounting for climate-change-policy-induced impacts on the profitability of future rotation cycles, needs to be borne in mind when interpreting the model results.

To obtain the total valuation of the forest estate at 2001, the planting-year Net Present Values are compounded up to 2001, using a discount rate consistent with that used for the DCF calculation (8% in the NZIER modeling, the modellers have informed us), and the results are added together.

This entire procedure is repeated for each scenario specified by the modellers, and the results are recorded as overall gains or losses for the relevant forest category, relative to the business as usual benchmark. All scenarios reported in the Stage II report show negative impacts for non-Kyoto forests and positive ones for Kyoto forests. Totals across the entire forest estate are not shown in the report but can be obtained by adding the Kyoto and non-Kyoto results, as in the table below.

Table 1
Reported Results from NZIER Model Scenarios: $million change from Business as Usual





The most favourable of the reported NZIER scenarios (continuous rotation forestry, "best case" price path plus high carbon charge) yields net gains for the entire forest estate of $1.9 billion. The least favourable (complete deforestation of the entire New Zealand forest estate, both Kyoto and non-Kyoto, as the current growing crop reaches harvest, with logs sold under the "worst case" price path, and a low carbon price on the credits secured as the Kyoto crop grows) predicts a loss of $1.3 billion.

The assumptions underpinning the latter result are so extreme as to lie entirely outside any reasonable bounds, and NZIER's claim in the Executive Summary, p.iv, that its scenarios span "a variety of feasible assumptions" stretches interpretation of the word "feasible" to the limit. While it may well be true that some part of the existing non-Kyoto forests will be optimally deforested with the land transferred to alternative uses following the next harvest, no evidence in the NZIER reports or elsewhere establishes that the entire non-Kyoto forest estate is likely to come under this heading. Imposing 100% deforestation by assumption, and reproducing the resulting scenario output as falling within the "likely" range, is not good modelling practice.

In the case of the Kyoto estate it is clear that continuous rotation forestry dominates non-restocking, and the reported outcome under 100% deforestation is therefore of little economic interest unless there are really major gains from reallocating this land to other uses, which ought then to be included in the model's accounting procedure. Reviewing Table 1 it can be seen that even under NZIER's assumptions, the climate-change-policy gains from rotation management of Kyoto forests suffice to outweigh most of the losses to non-Kyoto forests even under the extreme assumption that the latter are 100% deforested.

There are a number of other areas in which the scenario results reported in the Stage II report are attributable entirely to the input assumptions made, as distinct from the internal routines of the model itself. Of particular concern is the crucial assumption, imposed on all NZIER scenario runs, that the world log price will slump in the next six years if the Kyoto Protocol is implemented. Without this

short-run price dip, the negative results shown in Table 1 would disappear, because they are driven primarily by the revenue losses for those owners of non-Kyoto forests whose trees are ready for harvest and cannot be held back to secure higher expected prices post-2008. These price effects, it must be emphasized, are driven entirely by events outside New Zealand, and outside the New Zealand Government's control. They are predicted by NZIER to occur irrespective of whether NZ ratifies the Protocol or not, and are not to be confused with "effects of climate change policy" if by "policy" one means "New Zealand policy".

In the Stage I report (cf our previous review) NZIER appeared to accept as necessarily true the proposition that the prospect of incurring carbon charges for deforestation post-2008 would induce Annex I forest owners to glut the world market with a "wall of wood" from prematurely-harvested trees, thereby driving the world log price down. In the Stage II report, this mechanism is presented in the following terms (p.11):

> From our modeling of the log supply implications in New Zealand (refer next chapter) we know*[emphasis added]* that if New Zealand signs the Kyoto Protocol tomorrow log supply will increase relative to business as usual in the short run until 2008, when climate change policies take effect. This is because forest owners/manager bring forward the harvest of their forests in order to avoid the liability of purchasing carbon permits to cover their emissions.

This hypothesis is absolutely central to NZIER's results. Not accepting the wall-of-wood prediction would overturn most or all of the negative signs reported for nom-Kyoto forest outcomes from the international community's adoption of climate change policy.

2.2 The Processing Sectors Model

The discussion of the manufacturing stage of forest-based industries in the Stage II report relies heavily on verbal argument, partly because of the importance assigned to background information on the market and technological contexts within which the New Zealand industry operates, and partly because of the importance, for NZIER's results, of qualitative judgments about the outcomes of inherently uncertain policy and market processes.

There is nevertheless a quantitative side to the analysis, comprising a set of cost data, broken down by five operating-cost categories (fibre, energy, labour, freight and materials/other), for New Zealand producers compared to competitors operating in the same industries in other countries.

Country-specific costs are converted to US dollars (evidently at current exchange rates) to make them directly comparable with each other. The modeling exercise consists of adjusting each country's production costs for changes in the world price of wood fibre (as per the log price projections used also for the forestry and logging model), and the local prices for energy and freight (linked to energy price changes). Holding the individual-country exchange rates unchanged with respect

to the US dollar, the analysis then compares relative operating costs after the policy shock with those prior to the shock, and derives a change which is reported as the "change in international competitiveness".

Cost data has been collected and presented for a range of countries: four for packaging lumber (Figure 11 p.27); five for laminated veneer lumber (LVL) (Figure 13 p.29); five for medium density fibreboard (MDF)(Figure 15 p.30); and seven for chemical pulp (Figure 17 p.32). (Numerical data on mechanical pulp costs by country is not presented, though analytical results are presented (Figure 20 p.33).)

A striking feature of the operating-cost data is that, at the exchange rates used to convert to US dollars, New Zealand is consistently among the low-cost suppliers in the world market. For packaging lumber New Zealand, Australia and Chile have a clear cost advantage vis-a-vis China. For LVL New Zealand is slightly higher-cost than Chile and China, roughly equal to Indonesia, and well below Australia. For MDF China is the low-cost supplier with New Zealand in second place; Chile, Malaysia and Australia rank well behind. Finally for chemical pulp, South America is lowest-cost, followed by Africa; then New Zealand comes close behind, with Canada, the USA, Europe and Scandinavia all much higher-cost.

Having plotted relative variable-cost data NZIER observes that Chile is similarly placed to New Zealand in terms of cost-competitiveness (at the exchange rate utilised to construct the charts), and they then conjecture that relative operating cost is the primary determinant of the location of investments in new processing capacity. Anything that increases New Zealand's costs, other things equal, is then claimed to cause investment to flee New Zealand for Chile, leading to a decline in the rate of capital formation in New Zealand wood processing industries.

There are two major problems with this analysis. The first is that, as NZIER themselves acknowledge (Stage II report p.25) "international comparisons of competitiveness are fraught with difficulty, and cannot be reduced simply to production costs". Exchange rates, for example, regularly change by amounts sufficient to offset the direct cost impacts that drive NZIER's results; and since exchange rate changes would be an integral part of the New Zealand economy's adjustment to international climate change policies, little weight attaches to estimates of change in competitiveness at fixed exchange rates, especially when combined with the assumption of zero flexibility in production technology (NZIER makes no allowance for substitution away from inputs whose costs have increased).

The second problem is the lack of a well-specified model of global forest-industry investment allocation. NZIER places very heavy weight on bilateral comparisons between New Zealand and Chile, arguing that greenfields investment in forest products processing must shift from New Zealand to Chile in response to any cost increases in New Zealand that are not matched in Chile (as a non-Annex I country). While not developed explicitly, the implicit argument appears to be that this process would significantly reduce new investment in these industries in New Zealand, because

(i) "relative profitability" correlates directly with "international competitiveness" which correlates directly with relative operating costs measured in local currency (this is the implicit consequence of working with a fixed US dollar exchange rate throughout NZIER's analysis); and

(ii) investment is completely footloose internationally with no locational drivers other than raw local-currency costs so that only the lowest-cost destination can attract investment.

The first of these, as already noted, fails to take account of the exchange rate changes and other real-world economic adjustments that can be expected to follow implementation of Kyoto. The second flies in the face of the observation that new processing investment has been proceeding in all forestry countries, including those which the NZIER charts show to be far less "cost-competitive" than New Zealand at current exchange rates. The same incentives that NZIER suggests ought to lead forest-industry investors to shift from New Zealand to Chile would equally be expected to shift investment flows towards New Zealand from Scandinavia, the USA, Europe and Canada.

There is, in other words, a major gap in the NZIER modeling of the international allocation of investment flows. They have accounted for one possible source of reallocation from New Zealand to Chile, but failed to account for any of the countervailing forces that would be likely to operate, including reallocation to New Zealand from other Annex I countries.

Obviously one would not expect all the world's forest-processing investment to flow exclusively to whichever country happens to be at the low-cost end of the international merit order. The reality is that investment takes place in high-cost as well as low cost countries in the NZIER charts, reflecting the facts that (i) cost is not everything; (ii) processing is efficiently located close to forestry resources, which makes New Zealand a natural processing location so long as logs continue to be produced here; and (iii) given the uncertainties (including exchange rate uncertainty) overhanging post-Kyoto world markets, wise investors will maintain a diversified portfolio of interests in various wood-producing countries including New Zealand.

The NZIER cost calculations, in short, neither establish that New Zealand processing industries would actually be less competitive post-Kyoto than pre-Kyoto (this requires general-equilibrium modeling including exchange rate adjustments), nor that investment flows into New Zealand processing industries would necessarily be lower post-Kyoto than under business-as-usual, given that New Zealand will still be strongly placed in the international merit order in terms of relative costs.

In summary, the main shortcoming of the processing-sector modeling is its lack of sophisticated analysis to back a conclusion which unavoidably requires sophisticated analysis. For individual firms forming business plans in an international environment which can be assumed to remain constant, the sort of analysis presented could be adequate. But to evaluate the sector-wide effects of

international policy shocks, a partial-analysis other-things-equal approach simply lacks the necessary power to yield robust predictions. The data collected by NZIER is useful input for a full analysis, but no more than that.

Post-Kyoto, Annex I countries will probably have increased processing costs relative to non-Annex I countries, if all other things remain equal, exchange rates do not change, and no technical substitution possibilities exist to mitigate increased energy prices. This point is intuitively straightforward and requires no quantitative modeling. Since all other things will not remain equal, however, the actual quantitative outcomes will not match those obtained by the NZIER technique. Since the nature of market feedbacks is usually to reduce disequilibrium, it would be wise to expect that in practice the economic situation facing processors will turn out less severe than the NZIER projections.

3. Methodological Points

The counterfactuals used in the NZIER analysis are poorly specified, which leads to a lack of clarity in the conclusions reached. Two states of the world are compared in the modelling: "business as usual", in which no countries anywhere in the world implement the Kyoto Protocol; and "climate change policies" which comprises a world in which the Annex I countries including New Zealand implement the Protocol. There is no intermediate benchmark of a world in which the Protocol has been implemented and New Zealand must evaluate whether, and how, to implementing the Protocol itself.

The point here is that the price shocks which drive NZIER's results consist of two quite separate sets of changes: log prices and carbon charges. The world log price is assumed to change as a result of international implementation of Kyoto, and the hypothesised response of world supply and demand to the new international policy environment. This shock, in other words, is entirely outside the control of the New Zealand Government and is projected to occur regardless of what policy stance New Zealand adopts. Ratification or non-ratification of Kyoto by New Zealand has no impact on NZIER's world log price path, and there are correspondingly no domestic policy conclusions to be drawn from their results in the present form. (New Zealand has no significant influence on whether other countries ratify the Protocol.)

The NZIER modelling approach could have been used to explore the effects on forest owners of New Zealand's own climate change policy decisions, but the Stage II study does not offer any such analysis because it fails to draw the essential distinction between those effects on New Zealand forestry which flow from the actions of other Annex I countries, and those which flow from climate change policies implemented by the New Zealand Government.

To isolate the effects of New Zealand policy, NZIER would have had to specify a second business-as-usual benchmark: "business as usual in a post-Kyoto world". In this analysis the world log price path, and potentially other aspects of the economic environment, would have been set at the levels expected to prevail once countries other than New Zealand have implemented the Protocol. New Zealand,

as a price-taking small country, could then be modelled in policy-on (ratify) and policy-off (do not ratify) modes, to evaluate how New Zealand ratification, and subsequent implementation of climate change policies, would affect New Zealand forest owners and processors.

In a state of the world where no other countries have taken action, New Zealand is unlikely to ratify the Protocol or implement climate change policies. Such a world is not, therefore, the most relevant or interesting counterfactual benchmark for the policy-related analysis foreshadowed by the terms of reference, and the title[6], of the NZIER study.

A second problem with NZIER's counterfactuals is more technical, but underlies the results which they obtain in two of their three "options" for land use (p.16), namely "non-restocking" and "restocking once only". (In passing, it may be observed that there is no distinction of any economic interest between these two options, and the derivation and inclusion of results for the second involves redundancy[7] in a report which elsewhere is extremely thin in its coverage of far more important areas of sensitivity.)

The issue is as follows. The "business-as-usual" benchmark used in all the NZIER model runs involves a world in which log prices follow the RISI forecast and New Zealand retains, under rotational management, its entire existing forest estate, selling optimally-timed harvests from that estate at the projected prices. This business-as-usual projection embodies the implicit assumption that all land currently under rotation forest is optimally so allocated[8], and there is no adjustment for any landuse changes. The present value calculated for the non-Kyoto forest estate thus implicitly includes the future stream of net cashflows from permanent rotation forestry.

When NZIER introduce their "no-restocking" case, they hypothesize in effect that the entire non-Kyoto estate represents a misallocation of land which has some (unspecified) higher-value use to which it is switched[9]. The model "does not compare forestry land use with the available alternatives"(p.23) – but NZIER's "no-restocking" scenario results are obtained by comparing the discounted present value of the revenue stream for an industry which is assumed to shut down at the earliest opportunity with a benchmark revenue stream from an industry which stays in business (as usual). This is not really a comparison of like with like.

This is only one of a series of problems that arise in the specification of NZIER's "non-restocking" option and its offshoot, the "restock-once-only" variant. As discussed in section 4 below, failure to partition the non-Kyoto estate between some proportion which is optimally deforested and the remainder which is optimally retained in forestry is a weakness of the model. In addition, the model does not allow non-restocking non-Kyoto forest owners to walk off their land leaving the trees in place ("due to time constraints, this option is not examined in any detail" p.16), which means that forest owners are compelled, by assumption, to harvest even if doing so incurs a loss. (The report does not state whether this situation actually occurs in any of the model runs. In a fully-specified model there would be a routine to abort any age-cohort harvest for which revenue fell short of

avoidable cost; we have not at this stage checked whether NZIER have included such a routine.)

1. Detailed Review of the Quantitative Results for Forestry and Logging

The results of NZIER's model runs are presented in two parts: Kyoto forests (pp.19-21) and non-Kyoto forests (pp.16-19).

For **Kyoto forests** the Stage II scenarios find an unequivocal gain from implementation of the Protocol. The model scenarios analysed give projected gains of the order of $1 billion to $2 billion of additional present value added to the wealth of the forest owners as measured at 2001 (pp.v, 21). The prospect that high carbon permit prices might induce a switch from rotation to permanent forest cover, which was an important plank in NZIER's Stage I report, has receded considerably in the Stage II report whose model runs (p.22) show rotation forestry generally more profitable than permanent forestry over all the assumptions explored, with only a few of the very young age cohorts of trees switching even at high carbon prices. (Clearly, however, the model could have been driven to make this landuse switch by imposing lower long-run log prices and higher carbon prices than those explored.)

There is no immediate reason to suppose that the positive results for Kyoto forests are anything other than robust, although it would have been helpful to have sensitivity runs conducted with lower log prices after 2008, to explore the offsetting of carbon-credit income against lower log revenues.

For **non-Kyoto forests**, the Stage II report at first sight finds unambiguously negative outcomes, which are given considerable prominence in the Executive Summary (p.iv). Having canvassed a range of assumptions which they describe as "polar ranges of losses" (p.iv, note 1 to Table 2), NZIER present no case in which this sector as a whole does not face substantial losses of present value (pp.iv-v, 17-19). This overall result, however, has been obtained by aggregating across a mixed range of outcomes in some of which one set of non-Kyoto forest owners gain while others lose (Figure 7). Since losses appear to be directly related to age of trees at 2001, it is likely that the choice of discount rate has had major importance in driving some of the aggregated results. (With rotations of the order of three decades for radiata, harvest timing issues are likely to bulk large. NZIER's sensitivity testing will no doubt have involved varying the discount rate used, and results from this exercise ought to have been provided in an appendix.)

The finding that climate change policies are damaging to non-Kyoto forests even under the most favourable "likely" assumptions is a dramatic one which must attract close scrutiny, especially given that the modeling strategy used is a partial-equilibrium spreadsheet in which only a very limited range of input assumptions have been changed to derive the results (see section 2 above).

To see why the numerical results are intuitively surprising, consider the "best case" scenario results for the "continuous restocking" option. In this scenario, non-

Kyoto forest owners never deforest their land, and hence never pay carbon charges nor receive carbon credits. They are, in other words, entirely insulated from any direct impacts of climate change policies. Consequently, given the structure of the NZIER model, the balance of gains and losses for these forest owners is determined virtually entirely by the assumed changes in the log price, with only minor second-order effects from higher diesel prices affecting harvesting costs. As NZIER summarise the scenario (p.19) "no carbon liability is incurred. The losses are due entirely to the hypothesized log price reductions occurring before 2008".

The log price, under the "best case" assumption, falls 1% below business-as-usual up to 2007 and then rises to 4% above business-as-usual into perpetuity. Thus logs harvested and sold before the first commitment period realize lower profits, while logs from all subsequent harvests reap increased profits. The second of these two effects obviously raises the present value of the forests, while the first lowers it. The mathematics of discounting determine the net effect.

The reported model outcome for this case (p.19) is a loss of net present value of between $86 million and $95 million, depending on the carbon price (a higher carbon prices marginally raises harvesting costs, and hence increases the present-valued loss).

To anyone familiar with DCF calculations there is something odd about the confidence with which NZIER has attached a negative sign to the outcome of this scenario, given that nothing has happened to the forest owner apart from an early fall in the log price followed by a permanent increase. A simple financial present-value model would predict a positive, not negative, impact on net present value from the assumed price changes taken in isolation.

Suppose we start in 2001 with a (hypothetical) $1 million forest estate, valued at the NPV of its business-as-usual cashflow stream. At an 8% discount rate, the implied annual revenue is $1 million*0.08=$80,000.

Now from 2008 forward the price (hence the annual revenue on a constant harvest volume) rises by 4%, so annual revenue from 2008 to perpetuity is $83,200 with a present value in 2008 of $1,040,000, i.e. a $40,000 gain. Discounting this back to 2001 at 8%, we get a present-valued gain of $23,340 on our starting $1 million.

For the six years 2002-2007, annual revenue falls by 1% of $80,000 – that is, by $800 per year, a discounted present-valued loss at 2001 of $4,165.

Subtracting the six-year loss from the subsequent gain, we are left with a present-value gain on the revenue side of the calculation of $19,175. This leads to the intuitive expectation that the sign on the DCF change ought to be positive, not negative, for the hypothesized changes in log price.

The effect of carbon charges on harvesting costs does not seem likely to reverse this positive sign. On page 19 NZIER report that nearly trebling the carbon price, from $48 to $120 per tonne of carbon, changes the all-up loss to non-Kyoto forests by only $9 million on a forest estate valued in billions (cf Table 1 above). Scaled

down to match our hypothetical $1 million forest, this seems unlikely to be sufficient to reverse the sign on the outcome.

NZIER's contrary result appears to be an artefact of the model structure. Recall that the model's time horizon is truncated at the first harvest. This may well have had the effect of reversing the sign on the present-value. Experimentation with the simple present-value calculation set out above shows that if the $4 price increase disappears about 2050 (that is, before the second post-2008 harvest cycle is completed) then the sector's projected gains from the higher price are cut back to less, in present-value terms, than the up-front costs from the 1% price fall.

The problem thus may be simply that NZIER has incorrectly reported the assumptions of the scenario being modeled: instead of a permanent log price increase after 2008, the assumption may be a price increase for the first post-implementation rotation, and business-as-usual prices thereafter, captured by the unchanged BAU land value entered as the terminal exit revenue item.

Apart from limitations of the model structure, NZIER's negative outcome from the so-called "best case" scenario is still overhung by the question of whether the hypothesized log-price path has credibility. All the NZIER results for non-Kyoto forests depend very heavily on the assumption that the world log price will fall below business-as-usual as soon as Kyoto ratification occurs, and will recover only from 2008 on. An hypothesized short-run 1% - 5% price drop may not seem much for a commodity whose normal price volatility exceeds this range, but in the carefully controlled environment of a financial model the effects can appear devastating.

Considering that the entire NZIER result for forestry hinges on the log price path prior to 2008, it is remarkable that so little explanation or justification is provided for imposing this assumption on the model. A brief paragraph at the bottom of page 11 contains the entire analytical foundation for the model results:

> The same dynamics *[early harvesting to avoid deforestation charges]* would be experienced in all Annex I countries. However, rotational forestry would continue to be profitable in non-Annex I countries as no liability is incurred for harvesting trees and new plantings may still earn the forest grower credits under the CDM. The net effect in the period until 2008 is likely to be some downwards pressure on log prices as Annex I countries, such as New Zealand and Australia, try to sell more of there *[sic]* logs in shared markets….

There are, in other words, major uncertainties about the short-run reactions of harvest volumes and world prices following international implementation of Kyoto. NZIER does not give sufficient grounds to be certain that the world log price will fall, relative to business as usual, prior to 2008; on the contrary, the fact that this prospect is being openly discussed ought to contribute, via expectations, to preventing the slump, as most forest owners have the opportunity to hold back trees for later harvest. The underlying assumption which NZIER appear to be making is that very large areas of non-Kyoto forest somewhere in the world are already destined for deforestation, and hence face Kyoto penalties which create an

incentive to deforest early. Insofar as the world's non-Kyoto forests are to remain in rotation forestry, there is no incentive to advance the next harvest simply to avoid the Kyoto implementation date, because these forest owners face no penalty.

Turning to another area of concern in the forestry scenarios, in the "no-restocking" and "restock once only" scenarios for non-Kyoto forests NZIER conduct no sensitivity tests of their assumption that 100% (as distinct from some smaller proportion) of the existing non-Kyoto forest estate is destined for deforestation. This assumption is so extreme and so unrealistic that any quantitative estimate which hinges on it has to be viewed with the greatest caution. What it implies is that the entire forest estate planted in New Zealand before 1990 is assumed to be occupying land which has a higher-value use – in other words, that the New Zealand economy's entire pre-1990 investment in the forest industries has turned out to be either a mistake (misallocation of land) or a response to a temporary comparative advantage which New Zealand possessed in the twentieth century but which has disappeared in the twenty-first.

It is important to be clear what NZIER are saying with this assumption. As already noted in section 2, the assumptions of non-restocking (and its minor variant, "restocking once only") which are input to NZIER's first two scenarios are entirely unrelated to climate change per se. Whereas the assumption of a pre-2008 log glut is hypothesized as a response to Kyoto, the non-restocking hypothesis relates to the highest and best use of forestry land with or without climate change policies. NZIER have not modelled, and have not built into their model any capability to model, any effect of climate change policies on the decision whether or not to restock.

With a diverse portfolio of forests in the non-Kyoto estate, it would be most surprising if the entire estate were headed for deforestation. A far more likely situation, which would have provided the basis for potentially credible model results, would be that part of the estate is likely to switch to alternative use while most of it will remain in continuous restocking. The NZIER model would be capable of refinement to model this situation by varying, for experimental purposes, the proportion of the non-Kyoto estate that is hypothesized to be on headed for deforestation, as well as the age-composition of the trees in deforestation-prone forest.

5. Conclusions

In summary the main shortcomings of NZIER's Stage II study are:

- For forestry and logging, NZIER use a model which in effect assumes its results rather than deriving them from in-depth economic analysis. The remedy is not to abandon the model, but to put substantial effort into reviewing the key assumptions made and into sensitivity testing of variations in those assumptions.

- There are two crucial input assumptions on which NZIER's entire quantitative analysis hinges: the future log price path, and the proportion of non-Kyoto forest land which should optimally be deforested. When assumptions such as these are critical, it is good practice to defend them in depth, and to report sensitivity tests which vary them within reasonable bounds to establish how robust the model results are.

- The bounds within which NZIER vary their log price assumption are too narrow, because of the importance of the first six years in any discounted-cash-flow calculation. In particular, NZIER conduct no sensitivity test to see what would happen if their assumed short-term temporary world log glut fails to materialise - for example, as a result of (i) developments from ongoing consultations among the Kyoto parties to fine-tune the implementation of section 3.3 to mitigate or eliminate perverse incentives for Annex I forest owners to harvest prematurely); or (ii) rational response by the owners of forests which are to remain under rotation, and who are able to defer harvest in response to a temporary glut which is expected to be reversed within a few years.

- NZIER acknowledge (bottom p.22) that the issue of whether the world timber harvest will be brought forward or deferred in response to Kyoto is "finely balanced". This ought to have led them to be more tentative about their maintained hypothesis that the aggregate worldwide harvest will be brought forward in response to Kyoto. In addition it would be reasonable to provide readers of the report with a more in-depth analysis of the finely-balanced economics of world harvest timing. The strong impression, both from our inspection of the model itself and from the Stage II report, is that NZIER's quantitative finding of a negative impact from climate change policies on non-Kyoto forests under continuous restocking is extremely fragile because of the centrality of log price outcomes from uncertain future market developments. Since this is the central result of the analysis, the failure to test it rigorously leaves a major gap.

- The log price analysis has not been buttressed by use of a fully-specified world demand and supply model for forestry despite the existence of such a model (RISI) which has the capability to conduct experiments regarding the impact of climate change policies. While constraints of budget and timing have ruled out such modelling work for the present stage of analysis, the terms of reference for the study did require use of world model results where available, and it would probably be good value for money for MAF to commission some work on this front, if indeed RISI have not yet published any Kyoto model runs. (We have not had time to review RISI's published model output to date.)

- The assumption in two of NZIER's three scenarios that the non-Kyoto estate is destined for 100% deforestation is so extreme and unrealistic as to render the results of those scenarios irrelevant for serious policy analysis. This could be easily remedied by re-specifying the "non-restocking" model runs on the basis that only part of the non-Kyoto estate is to be deforested, while the rest would remain under continuous restocking - the landuse which NZIER p.23

provisionally identifies as "the best option" for the non-Kyoto estate taken as a whole, but which may well not be optimal for some forest owners. Such revised model runs would be a way to take account of the heterogeneity of the actual forest estate, and would best be reported in the form of experimental deviations from the continuous-restocking scenario (which rests on the equally extreme, though less unrealistic, hypothesis that none of the non-Kyoto estate currently has the incentive to deforest).

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- The processing sectors analysis is limited to simple operating-cost comparisons between New Zealand and Chile – two countries which are generally at the low-cost end of the world processing sector, and both of which therefore ought to be able to attract capital for further development. The proposition that a shift in the bilateral cost relativities between New Zealand and Chile would lead to a reallocation of world capital flows such as to starve the New Zealand industry of investment funds is not compelling, given the fact that the bulk of the world's processing is in higher-cost locations from which, if NZIER's hypothesis is correct, large volumes of capital ought to be flowing to both New Zealand and Chile. There is, in other words, no obvious reason for New Zealand policymakers to be deeply concerned about the cost data in the Stage II report.

- The processing industry analysis, because of its partial-equilibrium nature, lacks any consideration of the effects of exchange rate changes in maintaining international competitiveness. The importance of using a comparative-advantage economy-wide framework to answer the questions being addressed here has already been discussed in detail in our review of the Stage I report.

The central difficulty for New Zealand policymakers in interpreting NZIER's simulated results will lie in isolating what are the policy implications for New Zealand, if any.

The quantitative findings, in summary, say that

- International implementation of Kyoto will impact on world log prices.;
- Forestry as a whole will benefit from Kyoto, but part of the non-Kyoto forest estate may lose out if log prices move unfavourably;
- Deforestation of the non-Kyoto forest estate would result in substantial losses for the forest owners relative to ongoing rotation forestry, which implies that restocking is the optimal strategy unless higher-yielding opportunities for use of land exist to offset the simulated losses (such alternative uses of land, and the consequent land value changes, have not been accounted for in the Stage II exercise);
- New Zealand's forestry sector as a whole would gain from higher rather than lower carbon charges under the Protocol (cf Table 1 above) because of the major gains to Kyoto forests from trading credits for carbon absorption at higher prices.

The next step would appear to be a refinement and revision of the input assumption used, to explore these and other issues more fully.

[1] In the course of this review NZIER demonstrated to us to their spreadsheet forestry model and made the modeling staff available to discuss the structure of the model and the basic assumptions used in their analysis. We record with gratitude our appreciation of their assistance.

[2] Resource Information Systems Inc (RISI) is a major US-based economic forecasting firm for the international forest products industry, specializing in supply and demand statistics and forecasts for the pulp and paper industry. Its latest comprehensive world supply-demand forecasting exercise, with computable-equilibrium market projections broken down to detailed results for 33 regions including New Zealand, was published in September 2001. The study carries a price tag of US$19,000 and we did not have access to it in preparing this review. RISI's web address is www.resourceinfo.com.

[3] Forest categories modelled are Kyoto forests under rotation and permanent forest; non-Kyoto forests under continuous restocking; and non-Kyoto forests deforested either at the first harvest or with some delay.

[4] This corresponds roughly to the $13 per tonne CO2 carbon charge modeled by NZIER last year in their early-action report.

[5] Total estate of 1,768,638 minus NZIER's estimate (Stage II p.3) of 570,000 ha of Kyoto forests.

[6] The title of the Stage II report specifically refers to "effects of New Zealand's climate change policies" [emphasis added].

[7] The point here is that "restock once only" is essentially the same as non-restocking except that the carbon charge is deferred for one rotation. In terms of NZIER's model structure, there is no reason to think that such tax deferral will have any interesting implications vis-à-vis the simple deforest-now option. It has to be emphasized that the model itself contains no routines related to the economics of when to deforest, and NZIER's verbal analysis offers no reason for thinking that a forest owner for whom deforestation is the optimal landuse decision would find it rational to defer the landuse change for one rotation. For purposes of argument one could certainly hypothetically construct such a story, but NZIER have not done so.

[8] Strictly, forest owners are assumed indifferent between forestry and alternative land uses. This is captured by assuming the current market value of land as the terminating entry in the cashflow stream.

[9] This modelling assumption is not to be confused with the entirely separate suggestion made on p.23 of the Stage II report to the effect that, by reducing world log prices in the short run, climate change policies may cause forest owners' profitability to decline and thereby make switching of land "a more attractive option" than it would otherwise be. First, this statement relates to an output from the model, not an input, and hence is contingent on the credibility of the output. Second and more fundamental, because NZIER's partial-equilibrium approach does not take account of economy-wide market feedback, their argument on landuse change overlooks the elementary economic principle of rent on land. As the Stage I report conceded, until we know what happens to the value of land in alternative uses we cannot predict that forestry will become less attractive relative to the alternative opportunities for land allocation, and we therefore cannot make any prediction that downward pressure on profitability will lead to deforestation, because "other things" do not remain "equal" in the face of such pressure on profit. If all land-based activities face a profit squeeze, this simply passes through to a lower value of land, enabling the highest-valued use of land to recover a commercial return on capital. A switch from forestry to other uses requires a change in the merit-order of alternative opportunities – not simply a profit squeeze that will be passed through to a reduced rental value of land. NZIER are well aware of this issue of land prices, and are explicit in ignoring it for their analysis: "We ignore the effects of climate change policies on land prices, as there is considerable ambiguity around the direction of change in these prices given the variable effect of the policies on sectors that compete for use of land" (Stage II report p.10). The effect of this omission is to leave completely unsupported the various assertions and propositions about the economics of deforestation that appear in the middle four paragraphs on page 23 of the report.