# The price of feeling good

## A review of the emission target options in 'Our climate your say'

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tailrisk economics
te maha hoki o nga pihikete

## About Tailrisk economics

Tailrisk economics is a Wellington economics consultancy. It specialises in the economics of low probability, high impact events including financial crises and natural disasters. Tailrisk economics also provides consulting services on:

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## Introduction

As part of the consultation process on New Zealand's greenhouse gas emission targets the Ministry for the Environment issued a discussion paper 'Our Climate Your Say: Consultation on the Zero Carbon Bill' (Our Climate). Purportedly, the main purpose of Our Climate was to set out the options and to provide information that would help New Zealanders understand the issues.

This paper discusses the following issues that arise from the analysis and discussions in Our Climate.

- The abatement target options set out in Our Climate
- The economic analysis of the options
- The importance of co-benefits
- The costs and benefits of global warming for New Zealand
- The pros and cons of New Zealand being a global leader in greenhouse emission abatement.

Finally, it suggests some policies that will secure some of the benefits of 'global leadership', but at a much lower cost.

## Key Conclusions

**The Zero emissions by 2050 target is a $200 billion 'feel good' project**
Compared to the alternative, zero carbon, target, the zero emissions target could cost an additional $200 billion; is unlikely to have a material impact on the behavior on the rest of the world; on innovation in New Zealand; or generate significant 'co-benefits'.

The major benefit will be a 'feel good' factor for some people, at least until the effects of the policy start to bite.

**The consultation on the options was a sham**

Our Climate did not provide an assessment of the pros and cons of the three options: zero carbon; zero carbon with a cap on other emissions; and zero emissions, that were presented. The document only promoted what appears to be the preferred option of zero net emissions by 2050. The reporting of the economic analysis was fabricated to make it appear that the three options had been considered.

**The economic modelling was manipulated to reduce the economic impact of the zero emissions target**

The marginal cost of emissions reductions falls with a tougher target. This doesn't make sense. Lower cost emission improvements should occur first, so the additional reductions under the tougher target will have a higher cost. The lower marginal cost outcome was achieved by restricting the amount of afforestation offsets (which are costless in the model) for the 50 percent reduction target, and giving the zero emissions target twice the allocation. The effect of this was to push most of the economic costs into the lower target option, reducing the marginal cost of the zero emissions option.

**The reporting of the economic analysis obscured many of the negative economic impacts**

Most of the results were presented as the difference between a 50 percent emissions target and a zero emissions target. This obscured the losses in getting from our current position to a 50 percent fall in emissions. Some of the modelling impacts, with prudent assumptions about technical change, are severe. For example, pastoral farming outputs fall by 60 percent, and household incomes could fall in absolute terms as the policy bites.

**The economic modelling is deficient and needs to done again from scratch**

The critical variable in any analysis is the rate of conversion of farmland to forestry, but this has not been modelled. There is no analysis of the optimal timing of emission reductions. The implied carbon prices appear to be unrealistically high which makes it difficult to draw conclusions from the analysis,

**Climate change may have positive effects on New Zealand this century**

The Ministry has not produced a report on the costs of climate change.
Our assessment is that climate change may have a small positive impact this century. The main reason is that more CO2 in the atmosphere promotes plant growth and increases output, which is significant for an economy with a large land based sector. This outweighs the economically relatively minor impacts from changes in weather patterns, and the cost of mitigating the impact of sea level rises.

**Changes in the incidence of extreme weather events have been exaggerated**

Only moderate changes in extreme weather events have been projected in the UN Intergovernmental report on Climate Change. For example on the incidence of storms the report says ' *Increase in intensity of cyclones in the south in winter but decreasing elsewhere. Increase in conditions conducive to convention storm development is projected to increase by 3-6 percent by 2070-2100 compared to 1970-2000.'*

**The benefits of innovations that will give New Zealand an 'early mover' competitive advantage have been exaggerated**

Most of the reductions in emissions will come from forest plantings, imported technology (such as electric cars), closing businesses such as New Zealand Steel, and by reducing livestock numbers. Most of this does not involve much innovation. A Ministry consultant described this innovation optimism this way. *To presume that climate policy could make the difference would be a kind of exceptionalism and a serious leap of faith.*

**Economic costs of zero emissions target are significant**

The economic cost of the zero carbon target could be in the order of $75 billion.[1] The additional cost of the zero emissions target, which requires twice the net abatements at a higher average cost, could be around $200 billion.

**New Zealand's sacrifice unlikely to change the world**

The argument for zero emissions is that it will encourage other countries to meet their commitments. The argument that going from a zero carbon target to a zero emissions target will make a material difference to the actions of other is at best another 'serious leap of faith'. Depending on your viewpoint the zero emissions target is either a $200 billion vanity project, or a noble sacrifice. There are much cheaper ways of trying to influence world opinion.

**Cheaper ways to influence world opinion**

Four ways of getting international attention and promoting the fight against climate change are suggested. They are: Taxes on international air travel; a ban on official business class air travel; virtual attendance at climate change conferences; travel to Wellington airport by bicycle by officals.

[1] These estimates are present values calculated with a 5 percent discount rate.

# What are the options?

In the forward to the discussion paper the Minister for the Environment, James Shaw said

*…. In 2015, we, alongside almost all countries in the world, decided that the world should achieve net zero greenhouse gas emissions by the second half of this century through the Paris Agreement. This Government has committed to setting a net zero target for New Zealand to meet by 2050.*

Our Climate explains that there are actually two different versions of net zero by 2050, depending on how the zero greenhouse gas commitment by the second half of the century is interpreted. It sets out the following discussion.

*Three main elements need to be considered when setting a new 2050 target:*

***the Paris Agreement**, because New Zealand has signed and ratified this global agreement*

***the science of short-lived and long-lived gases**, given the important differences between the impact of these gases on the climate*

***economic impacts**, meeting the different targets has implications for New Zealand's economy over the coming decades*.

***The headline emissions reduction objectives of the Paris Agreement are:***

- *holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" – Article 2.1 (a)*
- *'[i] n order to achieve the long-term temperature goal set out in Article 2 [...] to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century' – Article 4.1 (ie, achieving net zero emissions).*

*Any domestic action needs to be consistent with our commitment to the Paris Agreement goals. By honouring our commitments, we are better placed to encourage other countries to keep to theirs, including countries with much greater emissions than our own.*

*There are two scenarios where New Zealand's domestic emissions impact on global temperatures could be defined as zero.*

- *Reducing long-lived greenhouse gas emissions to zero and stabilising our short-lived gases, which would mean our domestic emissions would not contribute to any further increase in global temperatures.*
- *Reducing all greenhouse gas emissions to net zero, which would mean our domestic emissions would have no impact on the climate from that point forward. Hypothetically, if both scenarios were applied worldwide then global temperatures would stabilise in each case, but they would stabilise at a lower temperature under the second scenario.*

It then turns out that there are three not two options.

**1*. Net zero carbon dioxide by 2050:*** *this target would reduce net carbon dioxide emissions in New Zealand to zero by 2050 (but not other gases like methane or nitrous oxide, which predominantly come from agriculture).*

***2 Net zero long-lived gases and stabilised short-lived gases by 2050:*** *this target would reduce emissions of long-lived gases (including carbon dioxide and nitrous oxide) in New Zealand to net zero by 2050, while stabilising emissions of short-lived gases (including methane).*

***3. Net zero emissions by 2050:*** *this target would reduce net emissions across all greenhouse gases to zero by 2050.*

The above explanation is somewhat misleading. It leaves the impression that it is open to countries, under the Paris Agreement, to select their own measure of greenhouse gas emissions. They can select just long-lived emissions, or both long and short-lived emissions. While the Paris Agreement is open to country interpretation we doubt that it is that elastic, and New Zealand has already agreed to include agricultural emissions. Technically though, the first option is 'Paris compliant' because it is just a statement about 2050, and leaves open what we will do in the second half of the century.

However, the first option implies that we will not seek to reduce agricultural emissions at all, which is not really credible[2], begging the question of why it was presented.

Under the second option, we are signaling that we are doing something about agricultural emissions, but the focus to 2050 will be on the demanding, but more technically achievable, target of reducing carbon emissions to net zero. We will more substantively address agricultural emissions post 2050, when it is more likely that economic technical fixes will become available.

This makes sense. There is no current technical solution to substantially reducing animal greenhouse emissions without getting rid of the animals. A zero net emissions targets can be achieved, mostly by very large-scale forestry conversions

[2] Note that a case could be made for excluding animal emissions from the emission target framework altogether, or at least amend the way it is treated to reduce its significance. Non-Carbon emissions will increase global warming by only about 0.2 degrees C at the end of this century. It only assumes importance, because of the tight temperature increase target. A 2C degrees limit from pre-industrial levels leaves 1 degree in hand, and the 1.5C degree target only 0.5. The 2 degrees target is sometimes represented as the tipping point, or the point at which temperature becomes 'dangerous'. These are overstatements, the target is best thought of as a somewhat arbitrary rallying point necessary to build a global coalition for action. The case for omitting agricultural emissions, or more acceptably providing a free allocation for emission levels up to, say, 1990, is that: most counties will not comply even if they say they will; the conversion of the gases to C02 equivalents is controversial; and actual reductions will have a trivial impact on global temperature change.

and a significant reduction in sheep and beef and (to a lesser extent) dairy numbers, but this would be very costly and would achieve little. Any reduction in animal emissions in New Zealand will likely be offset by increased emissions elsewhere as other countries replace the fall in New Zealand production. There will be little impact on global emissions, which is the ultimate objective.

This staged approach also levels the playing field with advanced countries. Animal emissions are not as significant for them, so their task substantially reduces to reducing carbon emissions.

So the second option could be interpreted as follows. New Zealand will reduce its carbon emissions to zero by 2050, and on a best endeavors basis, to reduce its emissions zero by, say, 2070 or 2080. This is consistent with our obligations under the Paris agreement.

Thus the choice could be described as follows. Zero net emissions by 2050, or zero emissions by 2070 or 2080, with a waypoint for carbon emissions of net zero by 2050.

There are of course, other options. 2050 is not a mandatory date, although it has become something of a fashion. It is open to New Zealand to select a later (or earlier) date. We could also be somewhat tougher on short-term emissions. They could be limited to no further increase from now, or an earlier date such as 1990, with any excess emissions being converted to C02 equivalents and added to the zero carbon requirement.

Mostly this is not spelt out in Our Climate. And there is almost no substantive discussion of the key considerations, and of the pros and cons of the options, that would be expected in a serious consultation discussion document.

Our Climate does says that it studied the economic impacts of the options

*We have looked at a series of models and other studies, to assess the implications for the New Zealand economy.*[11] *This work can give a general sense of the range of economic impacts of our target options. This includes how they might affect different sectors, regions and households.*

*These studies have been carried out by a range of sources, including independent external experts and government economists.*

*Under any of the 2050 target options, our economy can continue to grow, possibly just not as quickly as it might have done without any further climate action. Table 2 provides a summary of the economic opportunities and challenges that could result from further climate action*

This description is misleading. The centrepiece of the economic analysis was the NZIER report, but the NZIER did **not** analyse the options set out in Our Climate. They looked at percentage reductions in emission levels of 50, 75 and 100 percent. The 50 and 75 percent options included pastoral farming emissions, but they should have been excluded from consideration under the zero carbon options. The 50 percent reduction may provide some guidance on the zero carbon option, which excludes agricultural methane and nitrogen emissions, because agricultural emissions are nearly 50 percent of total emissions, but we cannot be sure. The 75 percent reduction is not relevant to any of the options. The Ministry has simply failed to analyse all of the options they presented.

The Ministry tried to paper over this omission by presenting a summary of key results from the NZIER analysis in table four of Our Climate. The headings for the options are: Zero carbon, Net zero long term emissions and stabilised short-term emissions; and zero net emissions. This table is a fabrication. There was no such presentation of this data in the NZIER report, because they did not do the analysis.

Footnote 11 directs the reader to the appendix for more information on the **studies** used to assess the economic impacts. The only content in the appendix was more detail on the NZIER study. There were no other economic studies.

The consultation on the 'options' was a sham. The only option that was effectively on the table was the preferred zero emissions target. The bulk of the discussion and analysis was directed to promoting it.

# The NZIER economic analysis

The economic analysis presented in the paper is almost entirely based on the NZIER report to the Ministry, 'Economic impact analysis of 2050 emissions targets' June 2018. This section is complicated, as we pick apart analysis that was designed to hide rather that highlight some of the key results. The reader who wants to push on might want to skip to the next section and take our key conclusion set out above at face value.

> **The economic modelling was manipulated to reduce the economic impact of the zero emissions target**

## The description of the NZIER's results in Our Climate

The summary description of the modelling results is as follows.

*Overall, the modelling suggests the following.*

- ***The economy and household incomes will continue to grow but possibly not as quickly.*** *Achieving a net zero emissions target by 2050 could cause average GDP to grow less quickly, with the rate of growth depending on the target we aim for and how innovation in key emitting sectors develops*.
- ***A strong economy will require innovation and a lot of trees.*** *Emissions prices could be higher and growth rates lower if we do not plant enough trees or continue to innovate, or the impacts could be milder if we plant more trees or innovate faster.*
- *By 2050, per household national income would still have increased by 40 per cent, instead of 55 per cent.* ***Supporting lower income households will need to be part of our approach*** *– otherwise the impacts on these households could be disproportionate.*
- *The economic impacts could still be significant. Some sectors may face a greater challenge, unless there are technical breakthroughs or support, particularly those with high emissions and those competing in international markets and/or that have limited opportunities to reduce their emissions*.
- *The difference in economic impact of moving from the current domestic target to a net zero emissions target is not substantial. The annual growth rate could slow by about 0.2 per cent.*

Mostly this is anodyne stuff, designed to reassure, rather than inform. No one will be worse off than the are now, and the effect of on the annual growth rate of a net emissions emissions target is 'not substantial'. And if there is a problem with lower income households, it can be fixed.

In addition, the Ministry further downplays the severity of the NZIER results. The focus in the wider discussion is on the 0.2 fall in the growth rate. It is suggested that the impacts could be less that this. It is noted that the C02 price estimates of analysis in the Vivid[3] report are substantially below the NZIER's.

*We can infer that, at the emissions prices Vivid suggests necessary to meet the targets, the impact on economic growth would be milder than the NZIER results indicate.*

And

*Given the difference in modelling approaches across Vivid and NZIER, and the range of scenarios considered, we think it is plausible that the relative costs and benefits of transition may fall somewhere in between the Vivid and NZIER results.*

[3] Vivid 2017

This doesn't make sense, Vivid did not estimate relative costs and benefits so there is no 'inbetween.'

Further

*It can also be argued that the NZIER figures may be overestimates of the economic impacts because it is difficult to assess the responses of households and businesses to changes in the economy.*

It could also be argued, rather more convincingly, that the NZIER figures underestimate the economic impacts because they use an equilibium model that is best suited to analysing relatively small shocks to an economy. It may understate the impact of large structural shocks.

## The NZIER modelling in detail

We now turn to the detailed NZIER modelling. Here we have some very significant concerns, and some questions.

The NZIER analysis is complicated because they have a combination of three targets: 50, 75 and 100 percent reductions, and three innovation levels: energy innovation; agricultural innovation, which assumes that a costless vaccine to reduce methane emissions will be discovered by 2030 and deployed by 2035; and a combination of both innovations. To simplify the discussion, we can ignore the 75 percent target, and we focus on one of the innovation assumptions, energy innovation. This is the least optimistic innovation assumption, which is we think appropriate here, because policy decisions should not rest on a costless early partial solution to the difficult methane emissions problem. There is probably enough optimism built into the energy innovation scenario to cover improvements in agricultural emissions through changes in management practices.

**Marginal cost of abatement falls with tougher targets**

The NZIER's GDP change estimates show that the impact on GDP, compared to the baseline current policy setting scenario, will be greater for the 50 percent reduction, than for the further 50 percent reduction to zero. In the energy innovation scenario the growth rate falls by 0.54 for the 50 percent target and by 0.73 percent for the 100 percent target. The marginal impact is 0.19 percent. This doesn't seem to make sense. We would expect the lower cost emission improvements would occur first, so the additional reductions under the tougher target would have a higher cost.

The relative size of the economic impacts should be roughly in line with the increase in the total cost of carbon credits. In the energy innovations scenario the average carbon costs are $612 and $845 per ton respectively, for the 50 percent and 100

percent targets. The 100 percent target is twice as big, so the total cost of the 100 percent target is 175 percent higher than the 50 percent target. However, the NZIER's marginal growth impact for the 100 percent target is only 35 percent of the 50 percent target.

The main explanation for this perverse result lies with the NZIER's arbitrary assumptions about the contributions of forest plantings for different targets, and critically, it is assumed that all the land required for increased forestry has no alternative use, so there is no economic cost in terms of forgone agricultural production. In the model the 50 percent target scenario is assigned 25 million tons of this free good. The 100 percent scenario gets 50 million tons. There is, obviously, no reason to restrict access to a free good for the 50 percent scenario.

NZIER conducts a sensitivity analysis where 40 million tons are allocated to both the 50 percent and 100 percent scenarios. Predictably, the cost of abatement for the 50 percent target falls to zero. GDP growth holds steady at 2.2 percent. There is, however, a severe impact for the 100 percent scenario. Real GDP is 12.9 percent lower by 2050. Real wages are 20 percent lower. These are optimistic results. The sensitivity analysis was only conducted for the wide innovation scenario and results would have been much worse with the more prudent energy innovation only scenario.

The manipulation of the forest planting assumptions allows the NZIER to hide much of the costs of emissions abatement for the 100 percent target. Costs are artificially shifted into the 50 percent reduction option. They then argue that we should ignore those costs, because they represent the 'status quo', and focus just on the marginal impact on GDP. The argument is that the previous government has already 'signed up' to a 50 percent target. So 50 percent is a done deal and it is only the additional changes that matter. This is disingenuous. The previous government did not sign up to a strategy that limited the use of forestry sequestrations.

The 0.19 growth impact figure is an artifact of what can only be described as a fabrication. A better approach would be to allocate the 0.73 total fall in the GDP growth rate on the basis of the relative total costs of the options. On that basis the 50 percent option would have 0.19 percent impact on the growth rate, and the marginal cost of 100 percent option an would be 0.54 percent.

The other point to note is that a fall in the growth rate of even 0.2 percent is significant, not 'not substantial' as the Ministry suggests, because the impact on GDP increases over time. The present value of the GDP losses for the 50 percent target (discounted at 5 percent) over 30 years comes to about $150 billion. The additional

cost of the 100 percent target is around $400 billion, for a total of more than $550 billion. There would be further costs beyond 2050 that we have not counted.

**Presentation of the results**

The way most of the results are presented obscures important information. Most of it is presented as differences from the 'status quo'. The reader gets limited easily useable information on the impact of the 50 percent option, so it is hard to make a comparison with the 100 percent option. An important example is the impact on household income. The only information we have on the energy innovation option is that average household income will fall by $46,000 compared to the 'status quo'. The fall from the baseline should be much greater and it is possible that real household incomes will fall in absolute terms from current levels. It is highly likely that the incomes of the bottom 40 percent will fall.

**Table 1: GDP growth results**

| | GDP growth % | Av carbon price $ |
|---|---|---|
| Baseline | 2.2 | 20 |
| 50% energy innovation | 1.5 | 612 |
| ZNE energy innovation | 1.7 | 845 |
| 50% ag. innovation | 1.8 | 386 |
| ZNE ag. innovation | 1.6 | 605 |
| 50% Wide innovation | 2.1 | 109 |
| ZNE Wide innovation | 1.9 | 272 |

**International travel not addressed**

No account is made on the impact of carbon taxes on international tourism. Emissions from international flights are not formally within the Paris framework, but they should be. And, if the world is at all serious about reducing carbon emissions to zero, they eventually will be. There should be a shock to tourist related activities, such as accommodation and transport in the NZIER model. The capacity of these sectors to 'mop-up' resources from sectors already heavily impacted by carbon prices would be reduced and the negative overall economic impact would increase.

**Impact on exports**

There is little information on what happens to exports. We are told that

*the volume of exports in 2050 falls by between $5.2 billion and $18.7 billion from the status quo of $138.2 billion for the ZNE target scenarios.*

We are not told what the baseline exports will be in 2050. However, we know from the industry output impacts (figure 23) that there are substantial reductions in the output of the traditional export industries, compared to the baseline. Dairy output goes from a 25 percent increase to a fall of about 60 percent; horticulture from plus 55 percent to minus nearly 50 percent; sheep and beef from plus 40 percent to minus 60 percent; other primary plus 40 to minus 65.

Again a serious shock is masked by a comparison with the 'status quo', not the baseline.

The other issue is what replaces the export industries, and how plausible are the outcomes. Probably the model will push services exports to take up the slack, but as noted above there has to be a question mark about the tourism industry.

A response to the emissions pricing shock that the NZIER model doesn't explore is that the economy will shrink further compared to the baseline. The exchange rate should fall substantially given the implosion of the traditional export sector, and New Zealand incomes, relative to other advanced countries will fall. There should be a migration outflow, compared to the baseline, as New Zealand 'climate policy refugees' leave for better prospects elsewhere. The labour force and hence the size of the economy should fall.

**Key time paths are not shown**

The actual time paths of key economic variables, GDP, family income and unemployment are not shown. Instead we have to make-do with differences from the status quo, and make some guesses on the implications of the time path of carbon prices. Given the carbon pricing time paths, which are rapidly increasing towards the end of the modelling period, it is possible that there could be a recession in the 2040s. This is masked by the focus on average growth rates for the period 2017 to 2050. But little should happen in the short term, and the adverse effects will be concentrated in the decades beyond 2030. So the average impact on the growth rate could be closer to 1 percent for that shorter later period, rather than 0.74 for the whole period. Given the shock to real wages generated by the model, due to disequilibrium conditions in the labour market, there will be a further shock to household incomes. They could fall in real terms.

**Cost of forest sequestration may be overstated**

The discussions in the NZIER report, and elsewhere, suggest that there is a limit on land 'suitable' for afforestation. This understates its potential role. How much land is 'suitable' will depend on the carbon price. If the price is high enough then almost all farmland is suitable. To gain an insight into the amount of land that could switch to forestry, we conducted a 'back of the envelope' land valuation at different carbon prices.

We assumed:

- No emission charge on farming so there is no avoided tax benefit.
- Establishment costs of $1500 per hectare.
- No carbon benefits for the first 5 years. It takes a while for growth to be material so this delay roughly accounts for this.
- The forest is not harvested, and there is no growth after 35 years. This is worse case scenario.
- A real discount rate of 5 percent, which is consistent with the 7 percent nominal rate often used to evaluate forestry investments.

The results are set out in table 2.

**Table 2: Land value forestry**

| Carbon price $/tonne | Land value per hectare $ |
|---|---|
| 25 | 3650 |
| 50 | 8800 |
| 75 | 14000 |
| 100 | 19300 |
| 150 | 29500 |
| 200 | 39800 |
| 300 | 60500 |
| 800 | 164000 |

Recent farmland sales indicate that a typical per hectare price for sheep and beef farms is around $6000 – $8000. The above valuation figures suggest that there could be significant conversions from sheep and beef once the price gets to around

$75. For more marginal or wasteland, conversions may become attractive at $50 or lower.

The second factor to consider is the impact of carbon pricing on farm profitability, and hence on land prices. Assuming greenhouse emissions of 8 tons a hectare for dairy[4], at $75 per tonne the cost per hectare would be $600, and the total cost $94000 for an average 156 hectare farm[5]. Emissions of 1.5 tonnes per hectare for sheep and beef would cost $112.5 per hectare, and $74000 for a 600 hectare farm. For sheep and beef this might be around half of average annual profits. Once, after 5 years, when the forest is generating carbon credits, the annual income from carbon farming would be $765,000. While the income stream will only last for 30 years it would be hard to resist.

Once we get to higher emission prices, conversions of sheep and beef farms become compelling. At $200 a sheep and beef farmer has an emissions bill of $180,000 and in most years has to pay to work. If he converts to forestry, in 5 years or so, he will have an income of $2,000,000 a year and can lead a life of leisure. Many dairy farmers would also be tempted to join the leisure class. At the much higher prices (over $2000 in the energy innovation zero emissions scenario) generated by the NZIER model, farmers who convert become fabulously wealthy.

The NZIER admits that they have not integrated forestry sequestration into their model, due to time constraints. But there is also a problem with farming. At the higher carbon prices, sheep and beef farming should definitely be taxed out of existence, and the survival of most dairy farms would be problematic, just on the basis of the tax alone. But they are not, suggesting an issue with the sensitivity of the farming sub-model to carbon prices.

What our analysis suggests is that forestry might set a cap on emission prices, which is much lower than the NZIER estimates and, also lower than the higher Vivid estimate of $250 per tonne. Of course this conclusion is based on our very simple model. Actual outcomes will also depend on behavioral and risk factors that would tend to have a dampening effect. These factors would have been picked up, implicitly in the Vivid analysis, which is based on empirical analysis of responses to product market prices. But it is not clear how applicable their calibrations will be to the introduction of carbon prices, which should be driven by long-term structural factors, rather than potentially cyclical wood product pricing. Much will depend on the design of the carbon pricing regime and confidence in the arrangements that will deliver carbon sequestration benefits to foresters. If there is a perceived high risk

[4] Kerr et al. 2014

[5] LIC 2016

that future prices could collapse, as they have in the past, then the conversion response will be muted. If there is a high degree of confidence that prices will be high and sustained then there will be a much greater response.

The other issue with afforestation is timing. Afforestation is not a permanent solution as the forests will mature and the sequestration benefits will end. If the objective is to meet a point of time target, then it makes sense to plant close to the target date. An exotic forest planted in 2040, will be delivering a significant benefit per year by 2045. It will continue to produce benefits, at a high rate for, say, another 25 years. At that point a new forest has to be planted to maintain the sequestration contribution. A forest planted in 2020 will only provide benefits for 5 years beyond 2050. From this perspective early action is not a good idea.

## What to make of the NZIER result?

Put bluntly the NZIER analysis is a bit of a mess and a muddle.

- It doesn't address the target options that are on the table.
- There is no afforestation model.
- The emission prices are unreasonably high.
- The farm sub-model appears to be overly insensitive to emission prices and there may be an issue with other sectors.
- The reporting has been contrived to hide much of the costs of the zero emissions option.
- The equilibrium model omits important variables including impacts on labour market growth and the exchange rate.

Our Climate is probably right when it says that the NZIER results overstate the costs, though by how much we don't know. But if we assume that losses were exaggerated by a factor of two, we are still dealing with some big numbers. The 50 percent reduction target has a present value cost of $75 billion, and the 100 percent target cost is $275 billion. The additional cost is $200 billion. That is our working number.

If the lower cost is just something we will have to live with to be part of the international effort, then the issue here is why should we spend the additional $200 billion. What do we get for our investment?

As a comparison of the costs other countries are likely to incur, the estimates of the costs presented in the 5$^{th}$ IPCCs report are worth a look. They reviewed the modelling literature and found that the median present value (with a 5 percent discount rate) of the reduction in consumption to 2050 due to mitigation efforts was 3.4 percent of the base year consumption.

# The cost of climate change for New Zealand

In the discussion of the cost of the target options it is stated.

*Neither model includes many of the benefits set out above of taking action on climate change, such as the wider co-benefits, or the potential benefit of avoiding damage to the economy caused by a changing climate, if the rest of the world acts too.*

The inference here is that climate change is costly to New Zealand and that the wider co-benefits are significant.

Our Climate does not present an assessment of the costs (and benefits) of climate change for New Zealand. The Ministry for the Environment says such an assessment has not been done for New Zealand. That is not quite true. The author of this paper presented an assessment of the costs and benefits to a Select Committee hearing on New Zealand's Climate change targets. But that was many years ago, so the submission would be hard to find.

The submission concluded that global warming would be positive, not negative for New Zealand, at least over this century. The reason is that higher temperatures and elevated CO2 levels have a positive impact on a landbased industry productivity, which more than offsets the negative impacts that are mentioned in Our Climate report: more droughts; a rising sea level; more floods and storms, health impacts, and more wild fires.

The question arises why the Ministry has not commissioned a costs and benefits paper. In a recent op ed in the Dominion Jim Rose[6] said that both the Minister and the Ministry had been approached but said "such an estimate was too hard to do". We suspect the reason is that they wouldn't like the result.

## Evidence on the effects of climate change in Our Climate

Despite the lack of solid analysis, Our Climate tries to leave the impression that the costs are large and justify early action. There are four pieces of 'evidence'.

### Impact on Global GDP

*Recent analysis also suggests that limiting global warming to 1.5 degrees Celsius instead of 2 degrees Celsius by mid-century could lead to an increase in global GDP of 1.5 per cent to 2*

[6] Dominion Post 26 July 2018

*per cent and avoids damages from climate change globally of around $11 trillion to $16 trillion.*

We have read the 'recent analysis'[7]. The paper estimates a simple relationship between variations in annual average temperatures and annual changes in GDP in a panel of 165 countries over 1960-2010. It uses this relationship to calculate the difference in GDP when the temperature increases by 1.5 degrees and 2 degrees.

There are a number of problems in drawing any inference from this paper for New Zealand. First, the results will be heavily influenced by underdeveloped countries in hot areas of the globe. While it is plausible that there was a historical relationship between temperature and short run variations in economic activity in these counties, it is a big step to claim that these results apply to a slow secular increase in temperature for all countries, 60 years from now. In any event the results suggest that for New Zealand there will not be a material impact. The paper shows an inverted U shaped relationship between temperature change and GDP changes. There is an economically 'optimal' annual averge temperature of 13.1 degree C, at which there is no economic impact. New Zealand sits close to this climatic sweet spot. If the Ministry wanted to cite this paper then they should have have presented the whole story.

**Drawing conclusions from recent events**

Our Climate goes on to make a case for negative impacts under the heading "Impact of climate change so far"

*We are already feeling the effects from a changing climate. In the past 100 years, seas have risen around 14 to 22 centimetres in New Zealand ports. More recently, we have suffered costly damage and disruption from coastal erosion, more frequent and severe weather events (flooding, droughts and wildfires) and damage to infrastructure and assets.*

While it is true that sea levels have risen, it cannot be said that recent weather events have been due to climate change, any more than it can be said that unusual cold snaps refute the global warming hypothesis. New Zealand's weather is simply too variable to draw the conclusion that there has been an increase in extreme events as temperatures have increased. This was the position in the section of the Fifth Report of the Intergovernmental Panel on Climate Change (IPCC) relating to New Zealand trends.

Our Climate goes on

*The costs we face are continuing to rise. As an example, in the* past 10 years, the cost of *weather events to our transport network has risen from about $20 million per year to over*

[7] Burke 2018

*$90 million per year.[8] The 2013 drought in the North Island cost the economy around $1.5 billion, and climate change will make droughts like this more likely.*

**Cost to transport infrastructure**

The source of the $20 to $90 million increase in the cost was the Ministry's 2017 report[9]. That document in turn referenced a Ministry of Transport report as the source. That document was written in 2009, so it did not and could not provide evidence on the costs over the last 10 years.

**The 2013 drought**

On the 2013 drought the inference is that climate change was responsible for the drought. In the 2017 report it is stated that climate change was 'partially responsible' but this is not supported by any reference. While droughts are forecast to become more likely, for the most part the changes are expected to be moderate. A one in twenty year risk becomes a one in ten year risk. And these droughts are short duration events, not the multiple year events we see in Australia. The exceptions are the north east of the North Island, Canterbury and Central Otago. The first is not economically significant and in the latter two areas irrigated agriculture is important and less vulnerable to droughts.

**Cost of sea level rises**

*Reports from the Parliamentary Commissioner for the Environment indicate that the cost of replacing every building within half a metre (above current sea level) could be $3 billion and within 1.5 metres as much as $19 to 20 billion.*

The value of buildings 'at risk' is interesting, but not the important data. We need to know how much it would cost to defend those buildings, or when it is appropriate to retreat, the value of the abandoned properties. In that respect there is some useful information in a report by Beca Ltd. to the Dunedin City Council [10](2014).

Their broadbrush assessment of the costs of dealing with a 0.8 metre sea level rise (0.6 metres is the projected rise by 2100) are a capital cost of $75 million and $3.5 million a year in running costs. The value of buildings at risk was over $1 billion.

Unfortunately, there is no broadbrush overview of these costs on a national scale that would contribute to the climate change policy debate. To get a sense of the scale of the problem, let us assume that the future cost is, say $10 billion for coastal protection and land loss. These costs will be incurred in the future, and in some

8 Ministry for the Environment (2017).

10 Beca Ltd. 2014

cases well into the future, but say the average delay is 40 years. Using a 6 percent discount rate, which is conventional for this kind of expenditure, the present value of the $10 billion is $840 million. With a 30 year delay the cost is $1560 million. These are not big numbers compared to, say, the cost of improving Aucklands transport infrastructure.

**Wildfires**

The only information we have on the cost of wildfires is the following statement in The Westpac report[11] cited in Our Climate.

*The most serious risk faced by the Forestry sector is the increasing likelihood of bushfires, as days with a fire index of 'very high' and 'extreme' will increase in some New Zealand locations up to 400% by 2040 and 700% by 2090 like the 2017 Port Hills fire in Christchurch and the 2015 and 2016 Marlborough fires are expected to occur with increasing frequency and severity. Over the last 70 years, wildfires have cost the forestry industry at least an estimated NZ$300 million and 40,000 hectares of plantations.*

The assessment of the higher incidence of fires was taken from the New Zealand chapter of the fifth IPCC report. The estimated increases were 0-400 percent and 0-700 percent respectively.

The average cost to the forestry industry was $4.4 million a year though the total cost of fires will be bigger than this figure. Even if the annual costs were three or four times as big by 2100, this would still not be material in terms of the larger economy. In terms of insured losses, the only event recorded by the New Zealand Insurance Council as a catastrophic event in the last 50 years, was the Port Hills fire which cost $18.3 million.

**The Fifth Intergovernmental Panel on climate report: Chapter 25 on Australasia**

Some of the information and analysis that would inform an assessment of the extent of climate change and its effects, is set out in chapter on Australia and New Zealand in the Fifth Intergovernmental Panel on Climate Change report. This is the 'go to' document for the Ministry and many other commentators. It was obviously not written by climate change deniers, so it can be relied on not to understate climate change effects.

To assist the reader, and to avoid accusations of cherry picking, we have set out, in the appendix, nearly all of the New Zealand material in the report, with the exception of some technical detail that does add to the substance. We have commented where appropriate.

[11] Westpac 2017

Notably, the Australasian chapter, is not referenced by Our Climate, nor are any of the assessments of the climate changes reported.

In our view the evidence presented in the IPCC report does not support a conclusion that the global warming impacts would be strongly negative, or even negative at all for New Zealand. There are a number of reasons for this.

First, the extent of the negative climate change is much less than often claimed.

- There is no material increase in the incidence of severe storms
  The IPCC report says
  *Increase in intensity of cyclones in the south in winter but decreasing elsewhere. Increase in conditions conducive to convention storm development is projected to increase by 3-6 percent by 2070-2100 compared to 1970-2000*
- The increase in extreme rainfall events is not large (up to 20 percent more).
- The increase in the incidence of short summer droughts is moderate over most of the country.

Second, the present value of costs relating to sea level rises, is not large in relation to the economy.

Third, health costs are trivial (see the discussion on co-benefits) and there might be positive effect on health.

Fourth, and most importantly, carbon fertilisation will have a positive impact on agricultural production. This is discussed in more detail below.

Fifth there will be amenity benefits from a warmer climate.

**The Ministry of Primary Industry report on climate change impacts**

The IPCC reporting on the impacts of climate change on land-based industry is fragmentary, and mostly omits hard numbers. It does not come to an overall conclusion, but leaves the impression that the impact is negative. A more comprehensive and balanced assessment is in the Ministry of Primary Industry's 2012 report 'Impacts of climate change on land-based sectors and adaptation options: Stakeholder report'.

The main purpose of the report was to look at adaptation and resilience issues, rather than to make an overall assessment of the economic costs and benefits, but two major themes suggest that the overall impact would be positive. The first is that C02 fertilisation will have a positive impact and that in many cases this impact will be material. The second is that New Zealand farmers are very good at adapting, both

tactically and more strategically, to climate events. This would help mitigate some of the adverse impacts, which are, in any event, less quantitatively significan

On C02 fertilisation the report says

*Increased carbon dioxide ($CO_2$) concentrations affect all land- based sectors. They mean higher potential growth of biomass for many key crops, pastures and trees in the future. This is known as '$CO_2$ fertilisation'.*

- *Higher $CO_2$ concentrations stimulate plant photosynthesis and growth.*
- *Pasture, tree and crop varieties do not respond equally to changes in $CO_2$ concentrations. The effect is stronger in C3 plants (ryegrass, clover, wheat, kale) than C4 plants (maize, kikuyu).*
- *Plants close their stomata to cope with the increased $CO_2$, transpiring less water in the process. $CO_2$ fertilisation also stimulates more growth per unit of water, making plants less water-dependent.*

*In pre-industrial times – before around 1870 – atmospheric $CO_2$ concentrations averaged 280 parts per million (ppm). In early 2012, they measured 390 ppm. By the 2050s, those levels could climb to between about 475 and 565 ppm; and by the 2100s, to between 540 and 955 ppm. The $CO_2$ fertilisation effect is well documented from greenhouse production systems, where the environment is controlled.*

*Estimates of the net effect of $CO_2$ fertilisation vary widely. For New Zealand pastures, estimates range from 5 per cent to 30 per cent increases in above-ground biomass for a doubling of C02.*

For pastoral farming, management practices will have to evolve to maximize the potential benefits and to mitigate the downsides. Seasonal rainfall patterns will change towards drier summers and there will be more droughts. In the most productive areas the incidence of short-term summer droughts are expected change from around one year in twenty to one year in ten.

For some other products the impacts are clearly positive

*Assuming adequate water and soil nutrient supply, potential yields of temperate cereal crops could increase by as much as 20 per cent under future temperature and $CO_2$ concentrations.*

*Similar potential yield increases are projected for forage crops, like winter cereals and brassicas, which are harvested in a vegetative state and have longer periods to grow, thanks to the shortening of cycles of adjacent annual crops.*

*For other crops and locations, climate change effects were more variable, and some were*

*slightly negative. Without adaptation, yields of forage crops, such as silage maize, along with more temperature-sensitive crops like potatoes and peas, are reduced under some climate change scenarios.*

For horticulture the impact is probably neutral.

*The main impacts on apple, kiwifruit, and grape growers will be increases in vegetative biomass, pest/disease risks and changes in plant development.*

*The sector has considerable adaptive capacity, in that growers can relocate and expand relatively rapidly, as exemplified by the recent spread of vineyards.*

The most positive effect is on forestry.

*With higher concentrations of atmospheric $CO_2$, radiata pine productivity is expected to increase in most plantations by an average of 19 per cent by 2040, and an average of 37 per cent by 2090. South Island plantations will receive additional benefit as warmer temperatures boost photosynthesis. Precipitation might decrease in some areas, but this can, up to a point, actually improve productivity, as trees use water more efficiently. However, where water or nutrients are in short supply, productivity will fall.*

**The Ministry's assessment in 2017**

All of the positive effects of CO2 fertilisation are airbrushed out of the Ministry's economic assessment. It reads as follows.

*primary industries are particularly exposed to the impacts of climate change. For example, they are strongly linked to freshwater availability, and climate change is expected to increase competition for freshwater resources (RSNZ, 2016). While the severity of impacts will vary by sector and region, the risks and costs from extreme weather and wildfires are expected to increase across all land based sectors and supply sectors will be affected by impacts which interfere with the ability to get primary products from the farm to processing facilities and then to markets or ports. Climate change impacts may affect transport (for example due to storms and slips closing routes) and also the operation of processing facilities (for example interruption to the supply of energy or water required for processing).*

This presents a misleading picture of the implications of a warming climate for agriculture.

**The amenity impact of climate change**

The positive amenity effect of climate change has not been considered in any of the Ministry's assessments (or generally elsewhere). The Fifth IPCC report, however, noted that a warner climate had been identified as one reason for New Zealand migration to Australia.

New Zealand has relatively cool and unreliable summers. While higher summer temperatures and droughts are an issue for farmers, they are a boon to holidaymakers. The summer of 2017-18 was perhaps a portent of things to come. Many people loved it and are looking forward to a repeat. Many people too will be happy if the winter chill is reduced by two or three degrees.

With climate change, perhaps not so many people will go to Queensland and elsewhere in search of better weather. It may also have an impact on internal migration. Southerners will not have to go Auckland for a bit more warmth. Auckland's weather will come to them.

# Why have we signed up to fight climate change?

If the overall impact of climate change for New Zealand in this century is positive, then why should we be 'fighting' climate change? There are two reasons.

First, unabated greenhouse emissions are a grand experiment that may have much more significant and possibly irreversible impacts over longer time horizons. It is one thing to deal with a 0.6 metre sea level rise in 2100, but another if the sea level rise is 20 metres or so, albeit hundreds of years later.

Second, we might become an international pariah if we entirely stand aside from the process. Being Donald Trump's new best friend on the issue is not a good look.

From a self-interested perspective the National interest report[12] on the Paris Agreement puts the case as follows.

*As a small export-dependent economy, New Zealand relies on effective operation of the international rule of law and on the leverage created through active and constructive engagement internationally. If New Zealand is seen to free-ride on climate change, it would risk damaging New Zealand's international reputation in areas such as trade and foreign policy as well as our influence in international climate change processes.*

Being involved is an act of international solidarity for what is a global problem. But this does not require us to be a global leader, particularly if the impacts of taking the lead are severe.

[12] New Zealand Government. (2016). National interest analysis: The Paris Agreement.

# The co-benefits from climate change policies

It is argued that co-benefits will reduce the economic costs of the emissions policies, and it is implied that these benefits are significant. A list of benefits is the benefits set out in table 3. 'Potential benefits of transitioning to a low emissions economy'.

**Better health from drier warmer homes**

*Every $1 spent on the 'Warm Up New Zealand: Heat Smart' programme generates benefits of around $4. Retrofitting insulation can help deliver particularly strong health cost savings from at-risk groups (e.g., children and the elderly). The emissions reduction benefits are relatively small.*

This suggests that there are plans afoot to strengthen insulation standards. That should be assessed on its own merits. Do the benefits exceed the costs? However, this is not really an example of a co-benefit. The evidence is that most people respond to insulation by having a warmer house, not by reducing their heating. In any event New Zealand's electricity generation is projected to be almost entirely renewable by 2050, so electricity consumption will not be an emissions issue. Climate change will, of course, in itself, make houses warmer in winter.

**Better health from more exercise and improved air quality**

*An investment of $630 million in infrastructure to support active transport could generate net benefits of $13 billion by 2050, mostly due to the health benefits from increased exercise.*

The exercise argument is largely irrelevant to the choice between the zero carbon and zero emissions targets. Both will have the same impact on the mode of transport. It is assumed that cars will be mostly electric by 2050, so using a car, rather than walking or biking will not impact on emissions.

The source of the above figures is not given but they came from Macmillan et.al. 2014. This paper reports on a number of bicycle lane investment scenarios. The biggest investment is the one reported above. It assumes 'international best practice' of building separated bicycle paths on arterial routes will deliver Copenhagen levels (the highest in the world) of bicycle trips (40 percent compared to two percent now) by 2051. If you build it they will come. This looks to be more than optimistic. They have a complicated model, with many inputs, but the critical variable driving the benefits is the number of lives 'saved' through the health benefits of cycling. Here they relied on two studies on the difference in death rates of cyclists and non-cyclists. The first[13] was a study on women in Shanghai aged

[13] Mathews et.al. 2007

between 40 and 70. It showed that cyclists had a lower death rate but the effect was not quite statistically significant. The second is a Danish study [14]of 20-93 year olds. It is claimed that cycling to work reduces mortality rates by 28 percent, after accounting for a number of covariates including other exercise. In other words, even if you do other exercise, including leisure time cycling, cycling to work will reduce your expected mortality rate by 28 percent. It is a public health silver bullet. We don't believe this, it appears to be a medical nonsense.

What matters for these health benefit assessments is the number of people who would otherwise be sedentary, and who have resisted advice and pressures to exercise more, and have many opportunities to do, to change their ways when bike paths are constructed. Evidence on this point is generally lacking in these kinds of studies.

Our main point here is that it is not enough, just to cite, or look at the abstract, of an article that appears to support a favoured outcome. The article has to be read, understood, the source of critical inputs read and understood, and an evenhanded assessment made of reliability. But repeatedly the Ministry, as we have demonstrated in this paper, does not appear to have done this.

The message for decision-makers is that if you are presented with 'evidence' based on the 'literature', that appears to be too good to be true, it probably is.

**Reduced air pollution**

*Human-caused air pollution can cost up to $4.3 billion each year, which includes costs from premature deaths, hospital visits and restricted activity days.*

This cost has been grossly overstated. This is explained in detail below. Again there should be little difference on this count between a zero carbon and a zero emissions target.

**Reduced road traffic congestion**

*Traffic congestion in Auckland costs $0.9 billion to $1.3 billion.*
*The benefits from the existing passenger rail network in Wellington and Auckland are estimated at between $1.1 billion and $1.2 billion, almost all from reduced congestion. Safety and air quality benefits made more modest contributions.*

Traffic congestion, and the role of public transport, is largely a separable issue from emissions reductions. The roads will be just as congested with electric vehicles as with internal combustion engine vehicles. If there is an effect it could be negative. Electric vehicles have a higher capital cost, but a low marginal cost, so these vehicles could be driven more.

[14] Andersen et. al. 2000

However, there is one meaninful argument here that is not used in Our Climate. Under the zero emissions option many people will be much poorer than they otherwise would be. They may cycle or walk, or take public transport, because they cannot afford a car.

**Better health outcomes from fewer road accidents**
Bike riding is more dangerous than taking a car.

**Improved freshwater quality; Reduced soil erosion; Improved biodiversity and species protection**
*Forestry can improve water quality, enhance biodiversity, reduce soil erosion, improve land use productivity and stimulate regional economic development.*

Exotic forests do not increase biodiversity. To the extent that reliance is placed on new indigenous forests, then more afforestation will be required to meet the 2050 target.

*Nearly one million hectares of private land subject to moderate to extreme erosion are potentially well suited to afforestation.*

Possibly true, but more than three million hectares are needed to meet the zero emissions target.

*For example, the ecosystem value of each hectare of plantation forestry in the Ohiwa catchment was $5,600 per annum, over half of which is from improved water quality.*

We have reviewed the analysis in the report 'Ecosystem Services in the Ōhiwa Catchment'. The estimate of the econsystem value of improved water quality is, put bluntly, nonsense. This requires some explanation. The purpose of the report was to calculate the ecosystem values (including marketable outputs and postive and negative environmental impacts) for all land based activity in the catchment.

The most important positive for forests was the value of nitrogen leaching. Here they set up an artifical cap-and-trade scheme. It is assumed that forests leach 3 kg. per hectare, but are allocated a cap of 10 kgs. So they have 7 kg. to sell at a price of $400/kg. This generates an income of $2800, which is 'water quality' benefit that is cited in Our Climate.

The source of the $400 estimate was a short power point conference presentation [15] Under the heading 'Likely incentives below the line' there was a bullet point.

[15] Barns, S. (2014). Lake Rotorua: Incentivising land use change In *NZARES Conference*

$400/kg? It is not clear what point the presenter was making here, but it certainly did not provide robust evidence for the $400/kg estimate that drove the Ohiwa catchment results.

The serious error here is that the $400/kg is not remotely near to the nitrogen leaching price that would emerge in a real market. At $400/kg a dairy farmer with an operating income of less than $1700 a hectare would pay a leaching charge of $12,000 a hectare. Sheep and beef farmers will pay $3200 on an income of $156. The only rational response would be immediately convert to forestry to collect the $2800 leaching income. Of course there would be no one left to pay and the price would collapse to zero, or close to it.

The other key driver is the assumption that forests would be generously allocated a cap of 10kg, which amounts to a gift.

The report was written by the New Zealand Forest Research Institute Ltd. trading as Scion.

Again this points, at least, to carelessness by the Ministry. If they are to cite a study then they should read it and ensure that the results are robust. What is more worrying is that analysis like this may be influencing the Ministry's thinking on land use issues.

**Reduced road maintenance costs; Improved road safety**

*Estimated benefits of current rail freight are about $200 million per year from reduced congestion, $80 million per year from reduced maintenance costs and $60 million per year from safety*.

This implies that there should be a large scale switch to rail transport. This is unlikely to be efficient in most cases, and if artificially promoted, the costs could be considerable. The emission reductions are likely to be very small, and could readily be achieved by planting more forests. Again the source of the figures is not given.

**Improved freshwater quality**

*Reduced nitrogen use (eg, fertiliser) and improved pasture management could reduce nitrogen leaching into rivers by 13 per cent.*

Much of this could be achieved under existing programmes without a zero emissions target.

**Co-costs**

The economic analysis assumes that emissions are abated at least cost. However, there is a risk of 'co-costs'. A co-cost occurs when an emission reduction effect is used to partially justify direct interventions and projects whose costs exceeds the

benefits. The emission reduction effect should be picked up in a cost benefit analysis through a carbon shadow price or will be already captured by the emission pricing regime. However, what is likely to happen in many cases, is that there won't be a robust assessment and that the emissions reduction impact, however small, will be used to justify the project.

**Better air quality**

A frequently cited co-benefit of emissions reductions is the improvement in health resulting from improved air quality as internal combustion vehicles are phased out. The primary source on the health costs is the 'Updated health and air pollution in New Zealand' (HAPINZ) study (2012). It was reported that in 2006 that more than 2300 New Zealanders are estimated to die prematurely each year, with 1175 due to anthropogenic sources.

The total social costs associated with anthropogenic air pollution in New Zealand was estimated to be $4.28 billion per year or $1,061 per person, with the following contributions attributed to each source:

- 56 per cent due to domestic fires
- 22 per cent due to motor vehicles
- 12 per cent due to open burning
- 10 per cent due to industry.

The social cost of motor vehicle pollution was $941 million. With increasing population and prices that social cost would now be up to 50 percent higher.

There are significant issues with this study.

The social costs are almost entirely driven by the number of deaths and the cost of each death.

The estimate of the number of deaths appears to be grossly exaggerated and bears no relationship with the estimates reported by the World Health Organization in their paper 'Ambient air pollution: A global assessment of exposures and burden of disease' 2016.

The study found that New Zealand had the equal first best air quality in the world, and that the number of deaths from all sources in 2012 was **20.** The death rate per 100,000 people was 0.5 compared to the HAPINZ estimate of about 40. If the HAPINZ estimates are correct then New Zealand has the highest social cost due to air pollution in the developed world, not amongst the lowest.

Looking at the analysis underpinning the New Zealand study, we identified a number of issues that could have resulted in overstated results. For example, deaths are

estimated to increase by 7 percent per 10 mg. per square metre increase in air particulates, but hospital admissions in classes related to pollution, increase by only about 1 percent. In our view the WHO number provides the better estimates for policy purposes.

Using the HAPINZ estimates of the sources of the emissions, 15 percent of the total deaths can be related to sectors (transport and industry) that will be affected by a zero carbon policy. That gives 3 deaths a year on the WHO numbers. Most of these would be saved, under a 50 percent target, so the marginal number saved under the zero emissions target might be, at most, one.

The HAPINZ update study valued a death at $3.5 million, which was the figure used to value the cost of traffic accident deaths. The previous HAPINZ study used a figure of $750,000. Because air quality primarily causes deaths in old age, it was assumed that only 5 years of life would be lost. The Update assumed that all deaths should be valued equally, regardless of age. The social cost of a death at 20 years of age, with the loss of 60 future years of life, is the same as a death at 85 with the loss of, say, 2 years of life. This is not a judgment we share. We prefer the initial HAPINZ estimate, which updated for price changes, would be about $1million.

Saving one life with value of $1 million, gives a marginal social cost saving of $1 million by 2050. This is inconsequential given the magnitude of the costs of the abatement policies.

# The choice between the zero carbon and zero emissions targets

## The case for a zero emissions target

While Our Climate does not clearly set out the costs and benefits of the options, there is a strong suggestion that faster is better, and that New Zealand should target zero emissions by 2050. Four advantages of early action are cited in the paper.

- *reduce the potential for sudden, drastic economic shocks*
- *gain an economic advantage as an early mover in emerging markets*
- *get the most from wider benefits like cleaner air and water and better health*
- *meet international commitments and encourage other countries to meet theirs.*

**Reduce potential for sudden, drastic economic shocks**

It is not explained why a tighter deadline would reduce the potential for sudden, drastic economic shocks, and what those drastic economic shocks would be. Logic would suggest that in New Zealand more time would reduce those risks. In particular, reducing animal methane emissions per animal is challenging, and will take time. The NZIER report shows that if we pursue a zero emissions target without a technical solution the impact on the pastoral sector would be devastating with output falling by 70 percent, from baseline projections, by 2050.

**Gain an economic advantage from being an early mover in emerging markets**

This argument is overblown and reflects wishful thinking rather than hard analysis. The reduction in emissions will not involve (much) marketable technological innovation. We will mainly grow more trees. The rest of the world already knows how to do that. We will import electric cars, leveraging off innovation elsewhere. Norway has been an earlier adopter of electric cars (care of some large subsidies), but no one has suggested that Norway has innovated to produce better electric cars. We may close down some carbon intensive industries such as iron and steel and cement manufacturing. Painful, but it doesn't require much innovation that we can sell to the rest of the world.

Some of the innovation that might occur may be a response to very high emission prices that the rest of the world is unlikely to tolerate, and so will not be marketable overseas because the innovation will not be economic at lower carbon prices.

We have reviewed the Ministry's reports on the subject of innovation.

The first [16]is a Ministry report that reviews the international literature on the impacts of emissions pricing on innovation and competitiveness.

The report concluded that emissions pricing at current levels reduces emissions, but does not weaken the overall economic performance of most businesses.

*Emissions pricing increases innovation activity in low-emission technologies, which may be of high economic value. Recent preliminary evidence suggests emissions pricing may also provide small positive economic impacts.*

*Some emissions-intensive and trade-exposed sectors show potential for emissions leakage and negative economic impacts with emissions pricing, although these negative impacts are small.*

[16] MFE 2018

The overseas literature is not really helpful. The emissions prices were very low, compared to the levels which will be required to meet the New Zealand targets, and the emission and industrial structure of the countries covered is very different to New Zealand's, with its high percentage of agricultural emissions. The results in some of the studies were mainly showing that the shift from coal to gas generted power had no negative effect on economic activity. This is not suprising given the fall in gas prices that drove the change.

The second paper 'Countervailing forces: Climate targets and implications for competitiveness, leakage and innovation' by a consulting firm is not so upbeat.

*But empirical evidence about innovation, evidence that is applicable to New Zealand and to climate policy, is hard to come by. What data there is, such as on productivity growth, casts some doubt over whether innovation and adaptation by New Zealand firms will be sufficient to overcome potentially wide cost differentials.* ***To presume that climate policy could make the difference would be a kind of exceptionalism and a serious leap of faith*** (Our emphasis).

These are strong words from a consultant. Consultants are generally careful not to bite the hand that feeds them.

Nothing of course, about the zero carbon target, precludes New Zealand firms competing in emerging world markets for emission abatement technology. In the agricultural sector we can, and should, undertake the abatement research, without including those emissions in the 2050 target.

**Get the most from wider benefits like cleaner air and water and better health**
Again, overblown. As explained above, according to the WHO we already have the cleanest air in the world and the social costs of air pollution are very low We will probably, mostly, make the switch to electric cars by 2050 under either option, which will have a minor impact on social costs. Water might get cleaner at the margin, but this will come at a cost. The emission targets are a scattergun and inefficient way to address the issue in the particular localities that matter most. The primary impact will be on sheep and beef farms not dairying.

**Meet international commitments and encourage other countries to meet theirs**.
The option of meeting the 50 percent reduction target or carbon neutrality by 2050 does meet New Zealand's international commitments. Nothing compels us to be greenhouse gas neutral by 2050. The real argument here is that by 'overachieving' New Zealand will have enough of an impact on the actions of enough countries to make a difference. While New Zealand's actions, in themselves, cannot make to make a difference to global warming, our 'moral influence' can.

Again this is mostly wishful thinking. Does anyone seriously expect the countries that matter: the US, China and India, to be influenced by what New Zealand does. Even if they noticed there is a ready response. New Zealand intends to meet the zero emissions target mainly by planting trees. They have plenty of suitable land, we don't. New Zealand has large hydroelectric resources and the best wind resources in the world. We don't. New Zealand will incur very high economic costs to meet its targets, including the destruction of much of its tradition export base. We don't think they will follow through as the consequences start to emerge. We are not prepared to inflict such damage on our economy.

More to the point on the impact of the options, if other countries are not influenced by New Zealand's commitment to zero carbon by 2050, what difference will the zero emissions target make? Will India be inspired to impose a carbon tax on cows, or drastically reduce their numbers?

But perhaps some countries will be inspired to announce more ambitious targets, after all it is just words, which don't necessarily drive actions.

The real benefits here are, first, some sections of the community will get a 'warm glow' from New Zealand being at the forefront of the fight against climate change. Others will put a positive value on the demise of livestock farming. On the other hand, this will be balanced by negative reactions in sections of the community who are more likely to bear the consequences of the policies.'

Second, politicians and bureaucrats will benefit by being able to preen on the international climate mitigation stage. They will get a short-term benefit from looking good.

## Arguments against emission neutrality by 2050

On the other hand there are a number of arguments against a zero emissions target by 2050.

**Economic costs**

It will have a high economic cost. The Ministry has tried to hide this. The exact number is uncertain, but as discussed above, the marginal cost of the zero emission target could be, in present value terms, in the order of two hundred billion dollars.

**Increased risk of leakage**

Getting ahead of the pack increases the risk that the policies will result in emissions shifting to other countries with weaker standards, with little or no impact on global emissions. To our knowledge no country has announced a policy to apply charges to livestock emissions. As New Zealand dairy and meat production is reduced we can be reasonably sure that it will be replaced by production elsewhere.

Other energy intensive traded goods industries such as iron and steel and cement will close and we will import our requirements. Again, there will be no impact on global emissions.

**Forestry sequestration resources will be dissipated**

Forestry sequestration is not a permanent solution. As the net sequestration effect wears off we will have to plant new forests to maintain our net zero position. If this resource is dissipated early then we will have fewer options later. In section three we explained why we should delay forestry plantings until around 2035.

**New Zealand not a natural candidate to lead the world**

It is generally accepted that the rich countries should take the lead in reducing greenhouse emissions. However, New Zealand is not really a rich country, sitting on the margin of being upper middle-income. This weakens the case for New Zealand bearing a disproportionate share of the mitigation burden, particularly if the result is to push us more firmly into middle-income territory.

Second, climate change will not be costly for New Zealand, at least in this century. It is not clear why we should be making a special effort in a global process that will actually make us worse off for many decades.

Third, reducing gross emissions from animals is especially difficult. More time is valuable.

**Emissions framework fairness**

It can be argued that the emissions measurement framework is not fair to New Zealand. Nearly half of our emissions relate to agriculture, but most of the output is exported. If the assessment was done on a consumption, or carbon footprint basis, our abatement responsibilities would exclude exports and account for the emission content of imports and would be lower considerably lower than under the current system.

By contrast, Norway is a large oil and gas producer and exporter, but does not have take responsibility for the emission consequences of its exports. Norway has just

announced that it plans to be emissions neutral by 2030 (mainly by buying international carbon credits) while planning to increase its oil exploration.

New Zealand's emission record is often painted as poor. For example, the Productivity Commission, in its Low Emissions Economy report presented a figure showing New Zealand to have the fifth highest gross emissions per capita. If the emissions were calculated on a net footprint basis, we would be well down into the low emission end of the figure.

**Other countries are likely to renege**

There is a high likelihood that countries will not follow through on their explicit and implicit commitments, and that New Zealand's special effort will be in vain.

**Many other countries are not doing as much as New Zealand**

As an example, consider the case of Singapore. As a high-income country, which is directly in the climate change firing line, we might expect a sense of urgency and substantive actions. So what is Singapore doing?

First, it signed up to a fairly soft 'developing country' Paris agreement target, promising that their emissions will peak in 2030. To our knowledge they have made no commitments beyond that date. In terms of what they are actually doing, we have relied on a January 2018 report from the Singapore Energy Studies Institute.[17] The main action is the introduction of a carbon tax, apparently to be at a fairly low level, for large companies from 2019. Between 30 and 40 companies will be affected.

In addition:

- 2018 has been declared the year of climate action
- Singapore will host a special ASEAN Ministerial meeting on Climate change
- There will be some financing subsidies.

## Assessment

In our view the arguments are clearly in favour of the zero carbon option. There was little in the four arguments for early action presented in Our Climate, and there are a host of arguments against.

The real arguments for the zero emissions by 2050 is that it would have a feel good effect for some members of the community, and that New Zealand would look good internationally. The issue is whether this is worth $200 billion.

[17] 2018 as Singapore's year of climate action

# Alternative actions

As discussed above, the main benefits to the zero emissions target by 2050 is to get favourable attention internationally, which hopefully will add momentum to the international community's path to zero emmission world.

There are much cheaper ways to securing these benefits. We have set out four. Some are a little whimiscal and are there to promote debate and thinking on other possibilities.

**A tax on international air travel**

International air travel emissions have been pretty much ignored in the New Zealand policy discussions. But New Zealand must have one of the most emissions intensive international tourist industry's in the world, and New Zealander's have a high rate of long distance travel.

If we moved early to impose a significant tax on international travel, that would attract favourable international attention and may induce other countries to follow. It would reduce the incongruity in the argument that New Zealand needs to be carbon or emissions neutral to enhance our clean and green image and so benefit the tourist industry.

We could impose a departure tax, which could be calibrated to roughly reflect a realistic CO2 price. There would be two prices, say $150 for long haul and $50 for the Pacific and Australia. Alternatively, a tax could be levied on jet fuel. Airlines have a limited ability to avoid this tax by fuelling before getting to New Zealand.

The objections are that it would reduce tourist arrivals who would we more inclined to travel to destinations that don't impose the tax, or divert outward travel through Australia. On the last point, the diversion would be expensive, so the effect might be limited, but in any event, $50 is better than nothing.

There will be an impact on tourist numbers, but that is the point of the tax. The negative volume impact would likely be offset by the revenue benefits.

From a pure tax perspective, an exit tax is relatively efficient because more than half of the cost would fall on foreigners, whose welfare does not count from a New Zealand perspective. With respect to New Zealanders the tax would be largely progressive, compared to the regressive element in in many other proposals. It would also offset part of the distortion in the tax system because international travel does not incur GST.

**A ban on government business class air travel**

A business class traveller generates three times the emissions of an economy class traveller. There should be an absolute ban on business class travel by all government officials (including politicians). This has several advantages.

- It would get international attention.
- It would be domestically popular. Most people would support a policy that would require politicians and bureaucrats to put their butts where their mouths are. This would promote social solidarity.
- It would save money.
- It would reduce incentives to go on junkets.

**A ban on travel to climate change conferences**

The technology exists to attend a conference virtually**.** New Zealand would send a signal that it was serious about climate change by using this technology to reduce emissions from international travel. This would have the co-benefits mentioned above. It would also address a divergence between social and private benefits. The policy elite that attends these conferences gets a private benefit from mixing with likeminded colleagues, and the need to gain social acceptance may bias their judgments to the detriment of New Zealand interests.

**Domestic travel**

All government employees (and politicians) would be required to travel to and from Wellington airport by electric bike (or manual if they wish). There could be exceptions on medical grounds, but to reduce the incidence of abuse, there would be a requirement for (named) exceptions to be posted on line, together with the reason for the exemption. In addition to the benefits already mentioned there are the following co-benefits.

- Government employees and politicians would become healthier
- New Zealand would secure a competitive advantage by innovating to make electric bikes and bike clothing more 'business friendly'.

# References


Andersen LB, Schnohr P, Schroll M, Hein HO 2000 *All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work.* Arch Intern Med. 2000 Jun 12;160(11):1621-8.

Barnes S. 2014 *Lake Rotorua*: *Incentivising land use change* Bay of Plenty Regional Council, NZ Tahuna Conference Centre, Nelson, New Zealand. August 28-29, 2014

Beca Ltd. 2014 *Assessment of Options for Protecting Harbourside and South City from Direct Impacts of Sea Level Rise* Prepared for Dunedin City Council (Client) By Beca Ltd (Beca)

Burke et al., 2018 *Large potential reduction in economic damages under UN mitigation targets.* Nature, 557: 549-553.

Fisher et. al. 2007 *Health and Air Pollution in New Zealand Main report HAPINZ*

HAPINZ 2012 '*Updated health and air pollution in New Zealand'*

IEA 2017 *Energy policies of IEA countries: New Zealand 2017 review*. Paris: International Energy Agency

IPCC Fifth report 2014. *Climate Change 2014 Synthesis Report Summary for Policymakers.*

IPCC 2014 *Fifth report Chapter 25 Australasia*

Keal M. et. al 2016 *Health outcomes projected from Transportation Modelling for the New Zealand Transport Outlook* Ministry of Transport

Kerr, S., & Olssen, A. 2012. *Gradual land-use change in New Zealand: Results from a dynamic econometric model.* Motu Working Paper 12-06.

Lenton et. al. 2008 *Tipping elements in the Earth's climate system*. Proceedings of the National Academy of Sciences, 105(6), 1786-1793.

LIC, & Dairy NZ. 2016 *New Zealand dairy statistics*. Hamilton: LIC and Dairy NZ.

Lloyds. 2014 *Catastrophe modelling and climate change*. London: Lloyds.

MFE 2016. *Climate change projections for New Zealand: Atmosphere projections based on simulations from the IPCC Fifth Assessment*. Wellington: Ministry for the Environment.

MFE 2017 *Adapting to climate change in New Zealand: Stocktake report from the Climate Change Adaptation Technical Working Group: December 2017*. Wellington: Ministry for the Environment.

MFE 2018 *Emissions pricing impact on innovation and competitiveness: A review of the international literature*

MFE 2018 *The co-benefits of emissions reduction An analysis*

McMichael et.al. 2002 *Human health and Climate Change in Oceania: A risk Assessment*

Macmillan A, Connor J, Witten K, Kearns R, Rees D, Woodward A. 2014. *The societal costs and benefits of commuter bicycling: simulating the effects of specific policies using system dynamics modeling.* Environmental Health Perspectives, 122: 335-344.

Mathews C.E. et al. 2007 *Influence of Exercise, Walking, Cycling, and Overall Nonexercise Physical Activity on Mortality in Chinese Women* American Journal of Epidemiology, Volume 165, Issue 12, 15 June 2007, Pages 1343–1350,

New Zealand Government 2016 *National interest analysis: The Paris Agreement*. Wellington: New Zealand Government.

New Zealand Government 2017 *New Zealand submission under the Paris Agreement: New Zealand's nationally determined contribution*. Wellington: New Zealand Government.

New Zealand Productivity Commission 2018. *Low-emissions economy: Draft report.*

Office of the Minister for Climate Change 2017 *The 100 day plan for climate change.* Cabinet Paper

Parliamentary Commissioner for the Environment 2015 *Preparing New Zealand for Rising Seas: Certainty and Uncertainty*.

Parliamentary Commissioner for the Environment 2018 *A Zero Carbon Act for New Zealand: Revisiting Stepping Stones to Paris and beyond*.

Reisinger A. 2017 *Agricultural emissions: Their role in climate change*. Paper presented at the New Zealand Agricultural Greenhouse Gas Mitigation Conference 2017, Palmerston North

Reisinger, et. al. 2013 *Implications of alternative metrics for global mitigation costs and greenhouse gas emissions from agriculture*. Climatic Change, 117(4), 677-690.

Reisinger, A., & Stroombergen, A. (2011). Economic and policy implications of alternative metrics to account for emissions of non-CO2 greenhouse gases. Wellington: New Zealand Agricultural Greenhouse Gas Research Centre, Infometrics.

Royal Society 2017 *Human Health Change Impacts of Climate Change for New Zealand*

Sense Partners 2018 *Countervailing forces: Climate targets and implications for competitiveness, leakage and innovation*

Singapore Energy Studies Institute 2018 *2018 as Singapore's year of climate action*

Stiglitz, J., & Stern, N. (2017). *Report of the high-level commission on carbon prices* Paris: Carbon Pricing Leadership Coalition.

Stroombergen, A. (2010). The international effects of climate change on agricultural commodity prices, and the wider effects on New Zealand. Motu Working Paper 10-14. Wellington: Motu Economic and Public Policy Research.

Velarde S. Yao R. 2014 Ecosystems in the Ohiwa catchment Scion

Vivid Economics, Concept, and Motu Economic and Public Policy Research 2018. *Modelling the transition to a lower net emissions New Zealand: Interim results.*

Westpac NZ 2018. *Climate Change Impact Report.*

West, J. et al 2013. Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health. *Nature ClimateChange, 3*(10), 885.

WHO 2016. *Burden of disease from the joint effects of household and ambient air pollution for 2012* Geneva, Switzerland: World Health Organisation.

# Appendix

## The Fifth IPCC report on New Zealand

### Observed and projected climate trends

*Natural climatic variability is very high in the region*

*This variability poses particular challenges for detecting and projecting anthropogenic climate change and its impacts in the region. For example, changes in ENSO* (El NINO/Southern Oscillation*) in response to anthropogenic climate change are uncertain (WGI AR5 Chapter 14) but, given current ENSO impacts, any changes would have the potential to significantly influence rainfall and temperature extremes, droughts, tropical cyclones, marine conditions, and glacial mass balance (Mullan, 1995; Chinn et al., 2005; Holbrook et al., 2009; Diamond et al., 2012; Min et al., 2013).*

*The region has exhibited warming to the present (very high confidence) and is virtually certain to continue to do so (Table 25-1). Observed and CMIP5-modeled over 1950–2004 increases in annual rainfall in the south and west of the South Island and west of the North Island of New Zealand, and decreases in the northeast of the South Island and east and north of the North Island. …. For New Zealand, annual average rainfall is projected to decrease in the northeastern South Island and eastern and northern North Island, and increase in other parts of the country (medium confidence).*

*New Zealand extreme one-day events decreased in the north and east and increased in the west since 1930.*

Projected magnitude of temperature extremes
*Spring and autumn frost free land to at least triple by 2080*
*Up to 60 more hot days +25 degrees in the north by 2090*

Comment: Other country reports typically focus on days exceeding 40C. The New Zealand test is more a measure of the increase in pleasantly warm than extremely hot days.

Drought
*Time spent in drought in eastern New Zealand is expected to double or treble by 2040.*

On the frequency of observed droughts there is no comment. Instead it is explained how a drought is defined.

Wind
*mean westerly wind projected to increase….. decreases of 20% in Summer and Autumn*

Fire risk

*Changes in high and extreme fire risk days by 0-400% using one model 0-700% another by 2040.*

Precipitation intensity

*Increase in precipitation intensity of rare intense high rainfall events (low confidence)*
*Increase of daily extreme rainfalls of 8% per degree of warming*

Comment: If temperature increases by 2 degrees then extreme daily rainfall events increase by 16 percent. This is not really a world changing outcome, but an increase in extreme rainfall events is often cited as a major climatic risk. Restricting the temperature change to one degree doesn't make much difference. There is low confidence in the intensity of intense rainfall events.

Tropical cyclones and other severe storms

*Increase in intensity of cyclones in the south in winter but decreasing elsewhere.*

*Increase in conditions conducive to convention storm development is projected to increase by 3-6 percent by 2070-2100 compared to 1970-2000.*

Comment: An increase in severe storms is often cited as an important driver of climate change costs. The increase, if any, is expected to be minimal.

## Projected Impacts

Freshwater resources

*In New Zealand precipitation changes are projected to lead to increased runoff in the west and south of the south island and reduced runoff in the northeast of the south island and the east and north of the north island Annual flows of east flowing rivers with headwaters in the southern alps are projected to increase by 5 to 10%. Retreat of the glaciers has only a minor effect.*

*In New Zealand a single study projects ground water recharge in the Canterbury Plains to decrease by 10 percent by 2040.*

*In New Zealand there is little evidence of water resource adaptation specifically to climate change. Water in New Zealand is not a scarce resource generally and water policy reform is generally driven more by pressure to maintain water quality while expanding agricultural activities.*

*Impacts of climate change on water supply, demand, and infrastructure have been considered by several New Zealand local authorities and consultancy reports (Jollands et al., 2007; Williams et al., 2008; Kouvelis et al., 2010), but no explicit management changes have*

*yet resulted.*

## Inland freshwater and terrestrial ecosystems

*In New Zealand, few if any impacts on ecosystems have been directly attributed to climate change rather than variability. Alpine treelines in New Zealand have remained roughly stable for several hundred years despite 0.9 degrees C average warming over the past century.*

*The few studies of climate impacts on biodiversity in New Zealand suggest that ongoing impacts of invasive species and habitat loss will dominate climate change signals in the short to medium term but that climate change has the potential to exacerbate existing stresses. There is limited evidence but high agreement that the rich biota of the alpine zone is at risk through increased shrubby growth and loss of herbs, especially if combined with increased establishment of invasive species. Some cold water-adapted freshwater fish and invertebrates are vulnerable to warming and increased spring flooding may increase risks for braided river birds. For some restricted native species suitable habitat may increase with warming although limited dispersal ability will limit range expansion. Tuatara populations are at risk of warming increases in the ratio of males to females, although the lineage has persisted during higher temperatures in the geological past.*

*Biodiversity research and management in New Zealand to date has taken little account of climate related pressures and continues to focus largely on managing pressures from invasive species and predators, freshwater pollution exotic diseases and halting the decline in in native vegetation.*

## Coastal and Ocean Ecosystems

*No climate change impacts have been reported at this stage, although this may be due to insufficient monitoring*.

*Even though evidence of climate impacts on coastal habitats is limited to date, confidence is high that negative impacts will arise with continued climate change (Lovelock et al., 2009; McGlone and Walker, 2011; Traill et al., 2011; Chapter 6). Some coastal habitats such as mangroves are projected to expand further landward, driven by sea level rise and exacerbated by soil subsidence if rainfall declines (medium confidence; Traill et al., 2011), although this may be at the expense of saltmarsh and constrained in many regions by the built environment (DCC, 2009; Lovelock et al., 2009; Rogers et al., 2012). Estuarine habitats will be affected by changing rainfall or sediment discharges, as well as connectivity to the ocean (high confidence; Gillanders et al., 2011). Loss of coastal habitats and declines in iconic species will result in substantial impacts on coastal settlements and infrastructure from direct impacts such as storm surge, and will affect tourism (medium confidence; Section 25.7.5).*

Comment: These are mostly qualitative, and somewhat shrill, assertions without any attempt to quantify the extent of the 'negative impacts'.

*A strengthening East Auckland Current in northern New Zealand is expected to promote establishment of tropical or subtropical species that currently occur as vagrants in warm La Niña years (Willis et al., 2007). Such shifts suggest potentially substantial changes in production and profit of both wild fisheries (Norman-Lopez et al., 2011) and aquaculture species such as salmon, mussels, and oysters (medium confidence; Hobday et al., 2008; Hobday and Poloczanska, 2010). Ecosystem models also project changes to habitat and fisheries production (low confidence; Fulton, 2011; Watson et al., 2012).*

Comment: Here we have suggestions of 'potentially subtantial changes in production and profit' but no actual analysis to back it up.

### Production forestry

*In New Zealand, temperatures are mostly sub-optimal for growth of P. radiata and water relations are generally less limiting (Kirschbaum and Watt, 2011). Warming is expected to increase growth in the south and reduce it in the north but CO2 fertilization may offset this (medium confidence;*

*the above studies provide limited evidence but high agreement of potential net increased productivity in many areas, but only where soil nutrients are not limiting. Adaptation strategies include changes to species or provenance selection toward trees better adapted to warmer conditions, or adopting different silvicultural options to increase resilience to climatic or biotic stresses, such as pest challenge Agricultural production is sensitive to climate (especially drought; Box 25-5) but also to many non-climate factors such as management, which thus far has limited both detection and attribution of climate-related changes*

### Agriculture

*Agricultural production is sensitive to climate (especially drought; Box 25-5) but also to many non-climate factors such as management, which thus far has limited both detection and attribution of climate-related change.*

*Projected changes in national pasture production for dairy, sheep, and beef pastures in New Zealand range from an average reduction of 4% across climate scenarios for the 2030s (Wratt et al., 2008) to increases of up to 4% for two scenarios in the 2050s (Baisden et al., 2010) when the models included $CO_2$ fertilization and nitrogen feedbacks.*

*Studies modeling seasonal changes in fodder supply show greater sensitivity in animal production to climate change and elevated $CO_2$ than models using annual average production, with some impacts expected even under modest warming (high confidence) in both New Zealand (Lieffering et al., 2012) and Australia*

*In New Zealand, projected changes in seasonal pasture growth drove changes in animal production at four sites representing the main areas of sheep production (Lieffering et al., 2012). In Hawke's Bay, changes in stock number and the timing of grazing were able to maintain farm income for a period in the face of variable forage supply but not in the longer term.*

*In Southland and Waikato, projected increases in early spring pasture growth posed management problems in maintaining pasture quality, yet, if these were met, animal production could be maintained or increased*.

*The impact of elevated $CO_2$ on forage production, quality, nutrient cycling, and water availability remains the major uncertainty in modeling system responses (McKeon et al., 2009; Finger et al., 2010);*

*New Zealand agro-ecosystems are subject to erosion processes strongly driven by climate; greater certainty in projections of rainfall, particularly storm frequency, are needed to better understand climate change impacts on erosion and consequent changes in the ecosystem services provided by soils (Basher et al., 2012).*

### Cropping

*Modeling suggests there is the potential to increase New Zealand wheat yields under climate change with appropriate choices of cultivars and sowing dates (high confidence; Teixeira et al., 2012*).

*Widespread drought in New Zealand during 2007–2009 reduced direct and off-farm output by about NZ$3.6 billion (Butcher, 2009). The 2012–2013 drought in New Zealand is estimated to have reduced national GDP by 0.3 to 0.6% and contributed to a significant rise in global dairy prices, which tempered even greater domestic economic losses (Kamber et al., 2013). Drought frequency and severity are projected to increase in many parts of the region*

### Energy supply demand and transmission

*New Zealand's predominantly hydroelectric power generation is vulnerable to precipitation variability. Increasing winter precipitation and snow melt, and a shift from snowfall to rainfall will reduce this vulnerability (medium confidence) as winter/spring inflows to main hydro lakes are projected to increase by 5 to 10% over the next few decades (McKerchar and Mullan, 2004; Poyck et al., 2011). Further reductions in seasonal snow and glacial melt as glaciers diminish, however, would compromise this benefit (Chinn, 2001; Renwick et al., 2009; Srinivasan et al., 2011). Increasing windpower generation (MED, 2011) would benefit from projected increases in mean westerly winds but face increased risk of damages and shutdown during extreme winds (Renwick et al., 2009).*
*Climate warming would reduce annual average peak electricity demands by 1 to 2% per degree Celsius across New Zealand.*

### Tourism

*Ski tourism is expected to decline in the Australian Alps due to snow cover reducing more rapidly than in New Zealand (Pickering et al., 2010; Hendrikx et al., 2013) and greater perceived attractiveness of New Zealand (Hopkins et al., 2012).*

### Human health

*In the southern states of Australia and parts of New Zealand, this* (heat related deaths) *may be partly offset by reduced deaths from cold at least for modest rises in temperature.*

Comment: This information comes from a study that examined the impact on mortality of heat and cold. It was based on empirical data from Christchurch prior to 2000. It was claimed that almost all of the winter excess mortality was due to air pollution not cold, and that cold only became a factor with temperature below 0C, and that heat was a factor above 28C. It is not consistent with many studies that find a relationship between cold and excess mortality at higher temperature thresholds.

Intra-and Inter-regional Flow-on Effects among Impacts, Adaptation, and Mitigation

*For New Zealand, there is limited evidence but high agreement that higher global food prices driven by adverse climate change impacts on global agriculture and some international climate policies would increase commodity prices and hence producer returns. Agriculture and forestry producer returns, for example, are estimated to increase by 14.6% under the A2 scenario by 2070 (Saunders et al., 2010) and real gross national disposable income by 0.6 to 2.3% under a range of non- mitigation scenarios (Stroombergen, 2010) relative to baseline projections in the absence of global climate change.*

*Some climate policies such as biofuel targets and agricultural mitigation in other regions would also increase global commodity prices and hence returns to New Zealand farmers (Saunders et al., 2009; Reisinger et al., 2012). Depending on global implementation, these could more than offset projected average domestic climate change impacts on agriculture*

*Few studies consider mitigation benefits explicitly for New Zealand, but scenario-based studies give high confidence that, if global emissions were reduced from a high (A2) to a medium- low (B1) emissions scenario, this would markedly lower the projected increase in flood risks (Ballinger et al., 2011; McMillan et al., 2012) and reduce risks to livestock production in the most drought-prone regions (Tait et al., 2008a; Clark et al., 2011)*

*Migration within countries, and from New Zealand to Australia, is largely economically driven and sustained by transnational networks,* ***though the perceived more attractive current climate in Australia is reportedly a factor in migration from New Zealand*** *(Goss and Lindquist, 2000; Green, A.E. et al., 2008; Poot, 2009*). (Our emphasis).