Economic Impacts of Rotorua Nitrogen Reduction

District, Regional and National Evaluation

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Market Economics Limited
Level 5, 507 Lake Road
PO Box 331 297, Takapuna
Auckland 0740, NZ
P 09 915 5510

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Glossary

Computable General Equilibrium (CGE): A class of applied economic models typically used to illustrate an economy's responses to changes in policy, technology or other external shocks.

Households: New Zealand resident individuals and families, and Private Non-Profit Organisation (PNPO) serving households.

Input-Output Model: A quantitative economic technique that represents the interdependencies between different branches (industries or sectors) of a national economy or different regional economies. The technique depends on a matrix of raw economic data collected by companies and governments to study the relationship between suppliers and producers within an economy. Of particular interest is the extent that the outputs of one industry become the inputs to another.

Industry Value Added: Value added summed according to industry groups.

Modified Employment Counts (MECs): Statistics New Zealand typically reports employment data according to the Employee Count (EC) measure. ECs are a head count of all salary and wage earners for a reference period. This includes most employees but does not capture all working proprietors – individuals who pay themselves a salary or wage. The modified employment count or MEC measure is based on ECs but includes an adjustment to incorporate an estimate of the number of working proprietors.

Value Added: The value added to goods and services by the contributions of capital and labour, i.e. the value of output after the cost of bought-in materials and services has been deducted. It includes the national accounts categories 'gross operating surplus', 'compensation of employees', 'other taxes on productions' and 'subsidies'. The sum of all value added is equal to gross domestic product (GDP), excluding taxes on products and import taxes net of subsidies. Thus in New Zealand, total value added is equal to approximately 88% of GDP.

Executive Summary

Background

To limit the deterioration of the water quality in Lake Rotorua, a nitrogen limit of $435tNyr^{-1}$ has been set by the Bay of Plenty Regional Policy Statement. This target requires a total reduction of 320 t N yr^{-1} with approximately 280 t N yr^{-1} arising from the pastoral sector. A Stakeholder Advisory Group was established to provide advice and recommendations on the development of policy to meet the nitrogen discharge restrictions set by the Policy Statement. It is envisaged that in addition to changes in pastoral land use and land management, the N targets will be met through allocation of N discharge allowances to land owners, purchases of those allowances from land owners by an 'incentives fund', and trading among landowners of the N discharge allowances.

Using input-output analysis this report calculates economic impacts, in terms of changes in industry value added and employment, for the district, regional and national economies arising out of changes in agriculture and forestry land use and practices to meet the nitrogen load targets. In addition to the national and economic data underlying the construction of the economic input-output model, the primary information relied on in this analysis is the outcomes of the farm and forestry-level modelling work undertaken on behalf of the Stakeholder Advisory Group (Parsons et al., 2015). Eight different scenarios were considered in the farm and forestry-level modelling, each involving alternative assumptions about the way in which nitrogen discharge rights are initially allocated among land owners. This report considers only three of the eight scenarios: the 'single sector target' scenario (S1), the 'natural capital allocation' scenario (S4), and the 'sector ranges' scenario (S8).

Importantly, providing the trading of nitrogen discharge rights is fully efficient, the farm and forestry-level modelling produces the same distribution of land uses and types of farm systems across the catchment. This is because regardless of the allocation mechanism, the management regimes moves towards the same (most efficient) use of land (although capital/equity impacts will vary for landowners depending on the initial allocation). To help further inform stakeholders of the potential outcomes of the policies, the farm and forestry-level modelling also considers situations where land use change and trading in N discharge allowances is not fully efficient. Thus this report also presents results for scenarios assuming that total land use change is restricted to 5000ha and/or 50% N trading frictions.

To help place the impacts arising out of changes in pastoral and forestry systems in context, and to explore some of the potential positive impacts on the economy arising out of reduced nitrogen accumulation, this report also presents possible changes in value added and employment from increased tourism in Rotorua District. Conceptually, positive tourism impacts may arise from both increased visitor/tourist spending within the Rotorua District, or avoided losses in visitor/tourist spending. It is beyond the scope of this study to precisely identify the magnitude of likely tourism impacts associated with a cleaner Lake Rotorua. Instead, we approach the quantification of these potential impacts thorugh the use of a 'what if' scenario analysis, specifically by assessing the implications of a 1, 2 and 3 percent change in tourist expenditure within the Rotorua district economy.

Results

Comparison of Scenarios

As explained above, a key aim of this work is to compare alternative scenarios pertaining to the allocation of N discharge rights among land owners. Considering four sets of assumptions regarding land use change and trading frictions, S8 performs the best of the allocation options considered, closely followed by S1 (Table E.1). S4 is clearly the least favourable allocation option, particularly when the possibility of trading frictions is considered. Under this allocation scenario, considerable trading in nitrogen entitlements would be required in order to achieve the optimum land uses in the catchment, which is not possible when trading is restricted. It is important to note that while the value added and employment impacts may overall be the least severe when we assume only 5000ha and 50% trading frictions, the N load reduction achieved under this set of assumptions is less than that achieved under the other assumption sets.

Table E.1 New Zealand Annual Value Added and Employment Impacts by Scenario

	Scenario 1	Scenario 4	Scenario 8
Value Added ($mil)			
Optimum land use, no trading frictions	-12.9	-12.9	-12.9
Optimum land use, 50% trading frictions	-15.6	-25.9	-14.4
5000 ha land use change, no trading frictions	-16.7	-16.7	-16.7
5000 ha land use change, 50% trading frictions	-11.1	-15.1	-9.2
Employment (MECs) [2]			
Optimum land use, no trading frictions	-190	-190	-190
Optimum land use, 50% trading frictions	-180	-240	-180
5000 ha land use change, no trading frictions	-220	-220	-220
5000 ha land use change, 50% trading frictions	-130	-130	-110

1 Excludes tourism impacts. 2 Figures are rounded to the nearst 10

Distribution of Impacts

Assuming land owners fully optimise by way of land use change and nitrogen right trading, a total annual value added loss of $12.9 mil is estimated for the New Zealand economy as a result of changes within the pastoral sector to reduce N discharges (Table E.2). Of this total impact, $3.4 mil originates from within the Bay of Plenty Region and $2.5 mil from the Rotorua District. These impacts equate to approximately 0.09% of the economy at the district level, 0.03% at the regional level, and 0.01% at the national level. For Rotorua District, the economic impacts are primarily within the agricultural sectors themselves (e.g. of a total of 89 job losses, 60 job losses are in dairy farming and 48 in sheep, beef and grain), along with some flow-on impacts to dairy product manufacturing and services supporting agriculture. Value added impacts are about 36% greater at the regional level compared to the district level, and more than four times greater at the national level compared to the district. The primary differences between the region and district appear to be greater losses at the regional level for meat and dairy processing and agricultural supporting services (e.g. transportation and wholesale trade), as well as generally higher losses for service sectors due to supply chain linkages and reductions in consumer spending.

There are three primary reasons why a very high proportion of the total value added and employment impacts (at least in absolute terms rather than percentage terms) occur outside of the district and even the region: (1) the incentives scheme is funded equally by the Regional and National governments. This essentially creates a net flow of funds from the whole region and nation into Rotorua District to foster land use change, and by corollary the opportunity cost in terms of reduced expenditure elsewhere is felt across the whole region and nation; (2) a high proportion of the key manufacturers responsible for processing primary outputs from the Lake Rotorua Catchment are not located within the local catchment, or even the local district; and (3) a high proportion of the *indirect* effects associated with changes in agricultural systems affect organisations outside of the district.

Table E.2 Annual Value Added and Employment Impacts of N Load Reduction Policies[1]

Sector	All Allocation Scenarios with Optimum Land Use and No Trading Frictions							
	Lake Catchment		Rotorua District		Bay of Plenty Region		New Zealand	
	Value Added ($2015 mil)	Jobs (MECs)	Value Added ($2015 mil)	Jobs (MECs)	Value Added ($2015 mil)	Jobs (MECs)	Value Added ($2015 mil)	Jobs (MECs)
Optimum Land Use, no trading friction								
1 Sheep, beef & grain	-1.8	-48	-1.8	-48	-1.8	-48	-1.8	-50
2 Dairy farming	-3.6	-60	-3.6	-60	-3.6	-61	-4.0	-65
3 Forestry	2.7	15	2.8	15	2.7	15	2.8	15
4 Other primary	0.0	0	0.0	0	-0.1	-1	-0.3	-4
5 Agriculture and forestry support	-0.1	-1	-0.1	-2	-0.3	-5	-0.6	-10
6 Meat manufacturing	0.0	0	0.0	0	-0.1	-1	-0.4	-5
7 Dairy manufacturing	0.0	0	-0.2	-1	-0.3	-2	-2.8	-14
8 Wood and paper manufacturing	0.7	10	0.8	11	0.9	13	1.3	19
9 Other manufacturing	0.0	-2	-0.1	-2	-0.2	-3	-1.3	-16
10 Utilities	0.0	0	0.0	0	0.0	0	-0.4	-1
11 Construction	0.1	2	0.1	2	0.1	2	-0.1	-2
12 Wholesale & retail trade	-0.1	-2	-0.1	-2	-0.2	-3	-0.9	-14
13 Transport	0.0	0	0.0	0	-0.1	-1	-0.7	-9
14 Scientific, profess. & admin. servs	-0.1	-1	-0.1	-1	-0.2	-3	-1.0	-16
15 Local & central government	0.0	1	0.0	1	0.0	1	-0.2	-2
16 Other services	-0.2	-1	-0.2	-1	-0.3	-2	-2.4	-21
Total	-2.3	-88	-2.5	-89	-3.4	-97	-12.9	-192
Share of Total	0.09%		0.09%		0.03%		0.01%	

1. Excludes tourism-related impacts

Impacts for Rotorua District

The appropriate management of nitrogen load reductions for the Lake Rotorua Catchment is a policy issue particularly pertinent to Rotorua District economy and its local government. Table E.3 places the estimated economic impacts on the district resulting from changes in farm systems necessary to meet N reduction policies alongside the estimated impact for the district assuming 1% net gain in tourism. In the interest of brevity, only results for the optimum land use and no trading friction assumptions are reported. These results help to highlight the importance of trade-offs in the allocation and use of the district's valuable environmental capital. Of no surprise, the sectors which are most likely to benefit from a net gain in tourism activity are also those which are among the least impacted within the region from the likely changes in farm systems. Importantly, just over half of the total tourism impact occurs within the two industries 'accommodation' and 'food and beverage services' (these are aggregated into the sector 'other services' for reporting), whereas for the farm-system impacts these same two industries account for only about 0.1% of the total loss in value added (assuming optimal land use and no trading frictions

Table E.3 Rotorua District Annual Value Added Impacts ($mil)

	Farm-System Impacts[1]	Tourism Impacts[2]	Total
Optimum Land Use, no trading friction			
1 Sheep, beef & grain	-1.8	0.0	-1.8
2 Dairy farming	-3.6	0.0	-3.6
3 Forestry	2.8	0.0	2.8
4 Other primary	0.0	0.0	0.0
5 Agriculture and forestry support	-0.1	0.0	-0.1
6 Meat manufacturing	0.0	0.0	0.0
7 Dairy manufacturing	-0.2	0.0	-0.2
8 Wood and paper manufacturing	0.8	0.0	0.8
9 Other manufacturing	-0.1	0.0	0.0
10 Utilities	0.0	0.0	0.0
11 Construction	0.1	0.0	0.1
12 Wholesale & retail trade	-0.1	0.2	0.1
13 Transport	0.0	0.2	0.2
14 Scientific, profess. & admin. servs	-0.1	0.1	0.0
15 Local & central government	0.0	0.0	0.0
16 Other services	-0.2	0.9	0.8
Total	-2.5	1.4	-1.1

Notes: 1. All impacts discussed in this report except those relating to tourism
2. Assuming a 1% increase in Rotorua District Tourism-Related Expenditure

Other Considerations

This analysis has not attempted to calculate the full range of potential benefits (including avoided costs) and costs of reduced nitrogen discharges for the district, regional and national economies. This is largely justified given that the focus has been on evaluating alternative allocation options for nitrogen discharge rights under a consistent nitrogen load target. Nevertheless, it is acknowledged that avoiding the accumulation of reactive nitrogen within the environment is likely to be of significant benefit to environmental/ecological systems and the industries and people who obtain value from these systems. Furthermore, the benefits of reducing nitrogen accumulation are likely to be of an ongoing nature, affecting generations to come. Equally this analysis does not attempt to evaluate any social costs arising from the N-reduction policies, including stress and disruption to land owners associated with transitioning to a lower-nitrogen discharge future.

It is also worth noting that this study (and the farm and forestry-level modelling upon which this study depends) applies current prices and mitigation options in evaluating the future outcomes of the N reduction policies. Additionally, forestry is the only major low-N land use option considered in the farm and forestry-level modelling. Future changes in prices may alter the assessment of optimum land uses and thus impact on land owner's decisions in ways different from those modelled. Also, significant research is being undertaken, both in New Zealand and abroad, on ways to improve nitrogen management within farming systems. Uptake of new methods, technologies and land use options could potentially mean that the nitrogen targets assigned to land uses could be met at different costs than those evaluated in this study.

1 Introduction

With the aim of improving water quality in Lake Rotorua, the Bay of Plenty Regional Council (BoPRC) is currently investigating options to reduce nitrogen discharges from agricultural land. The Bay of Plenty Regional Policy Statement (the Regional Policy Statement) sets a nitrogen limit of 435 t N yr^{-1} for Lake Rotorua, and requires that the council allocate the capacity of the lake to assimilate nutrients among land use activities. To achieve the 435t annual target, an estimated reduction of 320 t N yr^{-1} is required, with approximately 270 t N yr^{-1} arising from the pastoral sector. This 270 tonne reduction will require land use and land management change, and will be achieved by the purchase of 100t of nitrogen discharge allowances from farmers, on-farm reduction of nitrogen discharges by farmers, and the conversion of gorse land to forestry.[1] This report describes methods employed to assess economy-wide effects resulting from proposed policies and interventions to reduce nitrogen discharges from pastoral activities.

This report has been commissioned by the Bay of Plenty Regional Council, and is part of a wider programme of work concerned with evaluating the economic effects of alternative nitrogen discharge allowance allocation methods. Various management options or scenarios have been considered, incorporating alternative nitrogen trading right allocations and assumptions. This report concentrates on presenting economic outcomes, in terms of value-added and employment change, across the full range of economic sectors[2] within the Lake Rotorua Catchment, Rotorua District, Bay of Plenty region and New Zealand. Reference should also be made to the farm and forestry-level modelling work undertaken on behalf of the Lake Rotorua Catchment Stakeholder Advisory Group (the Stakeholder Advisory Group), and contributed to by DairyNZ, Beef and Lamb New Zealand, and the Bay of Plenty Regional Council (Parsons et al., 2015). The changes in farm level systems evaluated in that work, for each scenario, constitute a direct input to the regional and national level economic modelling described in this report. For ease of reference, the key assumptions from the farm and forestry-level modelling work as described by Parsons et al. (2015) are collated and included in Appendix B.

This study of district/regional/national economic impacts has been undertaken through a modelling framework that is based primarily on Input-Output (IO) analysis. Today, IO analysis is one of the most widely applied methods in economics, with the approach being especially popular in the study of regional-level economics (Miller and Blair, 2009). One of the core strengths of IO analysis is that it captures the complex interactions and interdependencies occurring between different actors within an economy. This means that it is possible to consider a vast number of the indirect or flow-on effects that occur throughout an economy as a result of any type of economic change. IO analysis also enables

[1] These approaches are referred to collectively as the 'integrated framework' (Bay of Plenty Regional Council, 2013).

[2] Impacts were assessed for 106 economic industries as per Statistics New Zealand's latest inter-industry study of the New Zealand economy (Statistics New Zealand, 2012). Sector definitions are as per the Australia and New Zealand Standard Industrial Classification (ANZSIC) 2006 system.

economic impacts to be evaluated at the level of individual sectors or industries, thus providing a disaggregate picture of the nature of economic impacts.

It is important to note that other methods do exist for assessing district, regional and national level economic impacts associated with nitrogen reduction initiatives. The key alternative, which is also based on IO analysis, is Computable General Equilibrium (CGE). Market Economics has specialist skills in the application of both IO and CGE models, particularly multi-regional and fully dynamic CGE modelling. The selection of an IO rather than dynamic CGE modelling framework for use in this study is primarily a consequence of the need to ensure compatibility with the farm and forestry-level modelling work[3].

[3] This work has been undertaken in a Comparative Static Partial Equilibrium framework which reports only on the equilibrium consequences of nitrogen discharge reduction initiatives i.e. this work is unable to trace the transition pathways, which key stakeholders face, through time. This simplification is required as current farm and forestry level data sources are insufficient to support a fully dynamic analysis – which would be compatible with dynamic CGE modelling.

2 Background

2.1 Scenarios Evaluated

The Stakeholder Advisory Group was established to provide oversight, advice and recommendations on the development of policy to meet the nitrogen discharge reduction targets, including allocation of allowances and development of a nitrogen trading scheme within the catchment.

The Regional Policy Statement requires the Council have regard to the following principles when allocating nitrogen discharge allowances:

a) Equity/fairness, including intergenerational equity
b) Extent of immediate impact
c) Public and private benefits and costs
d) Iwi land ownership and its status including any Crown obligation
e) Cultural values
f) Resource use efficiency
g) Existing land use
h) Existing on-farm capital investment
i) Ease of transfer of the allocation

This report informs considerations particularly in relation to principles a) and f). Within economics, resource use efficiency (principle f) is generally considered to be achieved when scarce resources are allocated in a way so as to provide the best outcomes for society. Indicators such as employment and value added or GDP can be used to help compare the efficiency of alternative scenarios or allocation options. The relative distribution of alternative options is, however, also important to considerations of equity and fairness (principle a). This report considers particularly how economic impacts are distributed differently across space (catchment, district, region and nation) and across different economic activities or sectors.

Eight scenarios were considered in the farm system modelling, each involving alternative assumptions about the way in which nitrogen discharge rights are initially allocated among land owners (see Parsons et al., 2015, p.24).

The regional/national economic analysis has concentrated on three of the eight allocation scenarios investigated by the farm system modelling. These are:

- **Single sector target (S1)**, where each sector (dairy, drystock, forestry) is allocated a constant amount. This corresponds with an allocation to dairy of 42.5kg/ha, to drystock of 20.kg/ha and to forestry of 3kg/ha.
- **Natural capital allocation (S4)**, where allocation is based on the inherent productivity of land. Average pasture production per year is estimated for each spatial zone based on expert opinion, reported pasture production for farms in the region, and data available

for the representative farms. The total amount of nitrogen to be allocated among farmers in each zone is then distributed according to the proportion of total pasture production that can be achieved within that zone. The model uses proven productive capacity rather than potential according to land use capability (LUC), due to the ready availability of data.

- **Sector ranges (S8)**, where the final dairy allocation range is 40-53kgN/ha with an average of 46.6kgN/ha, and the final drystock allocation range is 15.5-31.5kgN/ha with an average of 20.5kgN/ha.

It is important to note that provided trading in nitrogen discharge rights is fully efficient, the farm system modelling produces the same distribution of land uses and types of farm systems across the catchment. In other words, the allocation mechanism determines who receives the initial distribution of discharge rights (a form of capital), but over time the management regime will all move towards the same (most efficient) use of the land. Nevertheless, to help inform stakeholders of the types of outcomes that are possible, this analysis has considered situations of no trading and trading at 50 percent efficiency[4] for each of the three allocation scenarios listed above. Additionally, the analysis tests the outcomes when it is assumed that land use change is limited to 5,000 ha.

The BoPRC has available a fund of approximately $40 mil[5] to purchase nitrogen discharge entitlements from farmers who wish to change to lower nitrogen leaching land uses. These purchases will occur under any allocation scenario, although depending on the extent to which trading occurs, and the level land use change assumed, the degree to which this fund is drawn down varies under different scenarios. Additionally, the BoPRC has a fund of $5.5 mil for providing advice and support to farmers. The total funding is to be contributed to equally by central government (i.e. taxes) and BoPRC (i.e. regional rates) (Pers. Comm. May 2015, Sandra Barns, BoPRC). The wider economic implications of these funding mechanisms are included in the results for the three scenarios.

An additional baseline or reference scenario was assessed in the farm system modelling (Parsons et al., 2015). This scenario essentially records the situation were we to assume that the current rules and circumstances were to continue into the future. When undertaking the district, regional and national economic modelling for each of the scenarios S1, S4 and S8, we consider only *net changes* from the baseline scenario.

2.2 Selection of an Appropriate Modelling Framework

Although IO analysis has been selected as the core analytical framework for this study, alternative methodologies exist for assessing economic impacts; the most notable

[4] A 'trading friction' is a broad term that outlines that the optimal level of trading predicted by economic theory is not realised due to people being unwilling to trade. There may be a variety of reasons for unwillingness to trade including hoarding related to risk aversion, desires to retain flexibility, or utilisation as an investment for future periods. In this study, trading friction is simulated through limiting the total amount of trade that can occur. For example, the 50% trading friction means that a bound limiting trading to less than or equal to half of the optimal level of trade (measured in tonnes of nitrogen) is introduced into the model for these particular runs.

[5] Throughout this report, all dollar values are stated in current (i.e. $ 2015) terms unless stated otherwise.

alternative is the use of Computable General Equilibrium (CGE) modelling. The authors of this report are published in the application of both input-output and general equilibrium techniques (see, for example, McDonald and Smith (2010, 2013), Yeoman *et al*. (2009), Zhang *et al*. (2008) Smith and McDonald (2011, 2014), Fairgray et al. (2014) and Smith *et al*. (2015)). Key studies undertaken by the authors include the 2010 Waikato Independent Scoping Study Economic Impact Assessment (EIA) (NIWA, 2010, 2010a), the official 1999 and 2003 America's Cup EIAs for the Office of Tourism and Sport/Ministry of Tourism, the EIA of the 2011 Rugby World Cup for the NZRFU, EIAs for Auckland International Airport, Exercise Ruaumoko.

Key reasons for adopting an IO rather than CGE framework for use in this study are:

- *Disaggregation* – The IO approach readily produces results that are disaggregated by study regions (in this case the Lake Rotorua Catchment, Rotorua District, Bay of Plenty Region and New Zealand) and economic sector (altogether 106 economic sectors or 'industries' are reported in the model), thus providing important information on the distribution of economic impacts.
- *Paucity of data* – Creation of a multi-regional CGE model that reports down to the level of the Rotorua Lake Catchment would necessitate the construction of a Social Accounting Matrix (SAM) for the local area. There is a lack of information pertaining to interregional investment flows upon which to complete this task.
- *Full analysis of 'circular flow of income'* – Although based on IO, a concerted attempt is made in this study to take full consideration of the 'circular flow of income' within an economy, much like an analysis based on a social accounting matrix or CGE. Both 'backward' and 'forward' linkages are considered,[6] as well as the 'opportunity costs' of funding alternative policy options. Thus, it is an example of an extensive application of IO for the purposes of economic impact assessment.
- *Timeframe and budget* – It was feasible to couple an IO-based model to the selected farm system models, so as to produce a picture of district, regional and national economic impacts, while keeping within the timeframe and budget of the project. Linking a CGE model to the outputs of the farm system models is a major piece of work and is beyond the scope of this project. To date this type of work has not been undertaken within New Zealand, although it is the topic of a research funding proposal recently submitted in part by the authors of this report to the Ministry of Business, Innovation and Employment.

2.3 An Introduction to Input-Output Analysis

Prior to describing the specifics of the methodology, it is helpful to provide readers, particularly those not familiar with input-output analysis, with a brief introduction to the IO

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[6] A backward linkage effects are those experienced by suppliers, or in other words, organisations situated upstream within the supply chain. This includes, for example, the loss in demand for products of fertiliser manufacturers as a result of a reduction in farming activities. Forward linkage effects, by contrast, are experienced by those who purchase goods or are situated 'downstream' within a supply chain. This includes the loss in dairy product manufacturing necessitated by a fall in the supply of raw milk from farms.

framework.[7] This introduction is provided below. The remaining sections of the methodology describe the way the different scenarios are incorporated into an IO framework, including the major assumptions that are applied.

At the core of any IO analysis is a set of data that measures, for a given year, the flows of money or goods among various sectors or industrial groups within an economy. These flows are recorded in a matrix or 'IO table' by arrays that summarise the purchases made by each industry (its inputs) and the sales of each industry (its outputs) from and to all other industries. By using the information contained within such a matrix, IO practitioners calculate mathematical relationships for the economy in question. These relationships describe the interactions between industries – specifically, the way in which each industry's production requirements depend on the supply of goods and services from other industries. With this information it is possible to calculate, given a proposed alteration to a selected industry (a scenario), all of the necessary changes in production that are likely to occur throughout supporting industries within the wider economy. For example, if one of the changes anticipated for the Bay of Plenty region were to be a loss in the amount of dairy farming, the IO model would calculate all of the losses in output that would also occur in industries supporting dairy farming (e.g. fertilizer production, fencing contractors, farm machinery suppliers), as well as the industries that, in turn, support these industries.

As with all modelling approaches, IO analysis relies on certain assumptions for its operation. Among the most important is the assumption that the input structures of industries (i.e. the mix of commodities or industry outputs used in producing output for a specific industry) are fixed. In the real world, however, these 'technical coefficients' will change over time as a result of new technologies, relative price shifts causing substitutions, and the introduction of new industries. For this reason IO analysis is generally regarded as most suitable for short-run analysis, where economic systems are unlikely to change greatly from the initial snapshot of data used to generate the base IO tables.

[7] Those who wish to learn more about IO analysis please refer to Miller and Blair (2009).

3 Method

3.1 Overview of Impacts Assessed

The study of economy-wide economic impacts commenced with identifying nine key categories of likely economic effects associated with the proposed options for nutrient reductions:

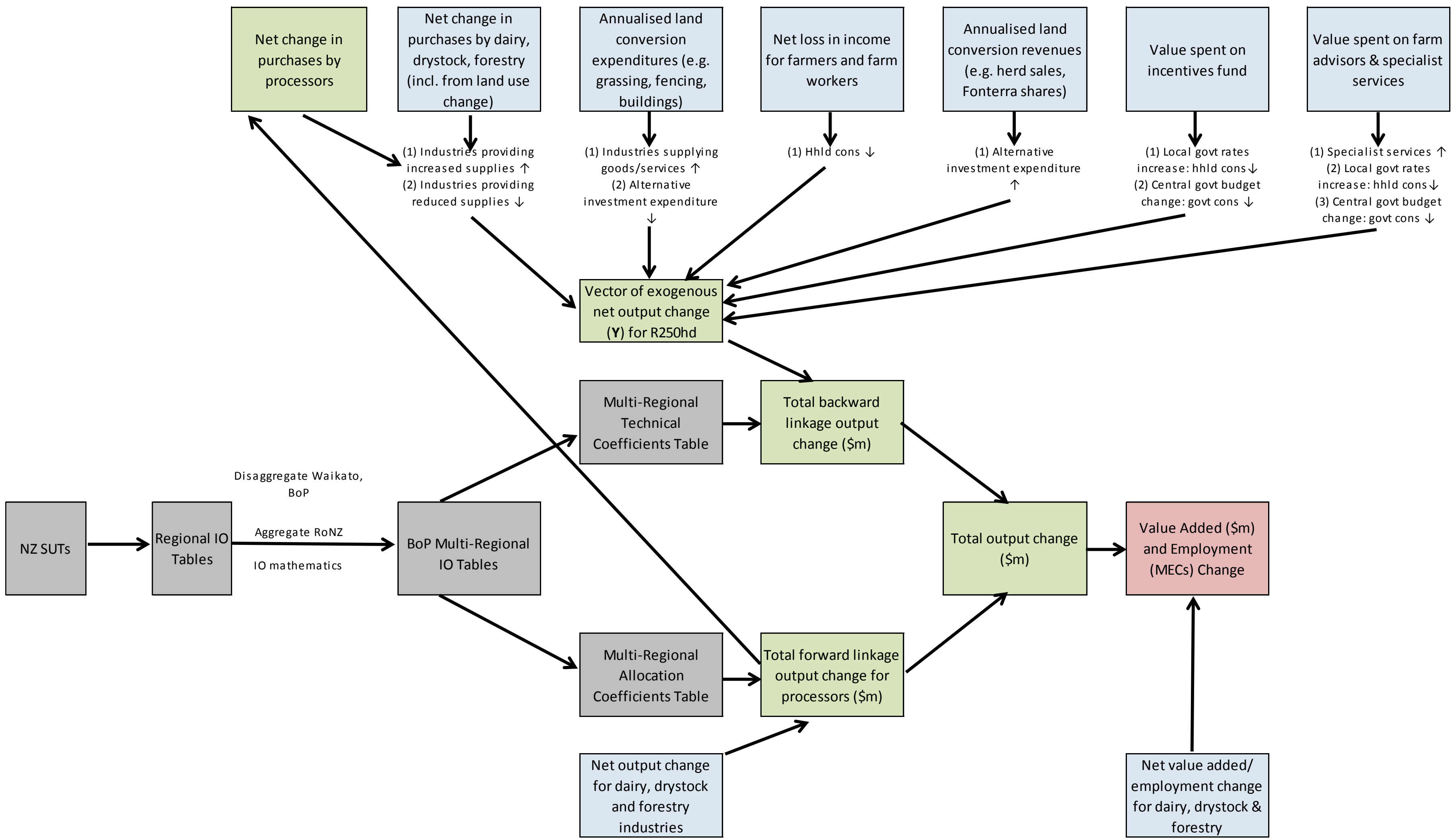
1. *Changes to dairy farming and drystock farming systems – backward linkage supply chain impacts*. Nitrogen limits cause changes in land management practices for both dairy and drystock farms within the Lake Rotorua catchment. Examples might include removing summer crops and replacing with supplements and lowering fertiliser use. These measures result in changes to the purchase patterns of dairy and drystock farms, creating flow-on upstream impacts through economic supply chain linkages.
2. *Changes to dairy farming and drystock farming systems – forward linkage supply chain impacts*. The changes in farming practices will also result in reductions to the overall output of farms. With less output (e.g. milk, wool, meat) produced per hectare, the supply to downstream processes (dairy manufacturers, meat processors, textile manufacturers etc) will be reduced, ultimately leading to a reduction in sales by these industries.
3. *Conversion between land uses – backward supply chain impacts*. In addition to the changes in land management, the nitrogen limits, trading and incentives scheme will result in changes in land use across the catchment. This will create additional impacts for industries that would otherwise be involved in supplying goods and services to the existing farms. Businesses that are responsible for providing direct inputs to the forestry sector (e.g. pruning contractors, accountants etc) will be positively impacted by conversion of land to forestry. Businesses involved indirectly in forestry supply chains (e.g. firms selling supplies to contractors) will also be positively impacted.
4. *Conversion between land uses – forward linkage supply chain impacts*. Similar to the forward linkage effects resulting from changes in farming systems, the conversion of land from one use to another will result in changes to the supply of key products to downstream processors (for example, more timber to processors, but less raw milk to dairy product manufacturing).
5. *Changes in incomes for land owners*. For each of the scenarios evaluated, there will be changes in income for landowners in the form of wages/salaries and profits. This will cause changes in expenditure patterns of these land owners, hence creating impacts through the rest of the economy.
6. *Outlays and revenues associated with land conversion*. The conversion of land into different uses is associated with a set of discrete capital investments and other economic transfers. For land owners these can be both outlays (e.g. land improvement costs, planting costs) and revenues (e.g. sale of Fonterra shares, sale of dairy herds). The income and expenditure patterns of land owners will have flow on implications through the district, regional and national economies.

7. *Advice and support to farmers*. The provision of advice and support to farmers will create some (minor) additional income to pass through the Rotorua District economy via farm advisors, thus creating small positive economic impacts for the wider regional and national economy. However the funds required to pay for advice/support will likely divert expenditure from elsewhere in the economy.
8. *Incentives funding*. A fund of $40 million has been established by the regional and national governments to buy nitrogen discharge allowances from farmers. There is an opportunity cost associated with the establishment of this fund in terms of reduced ability to purchase other goods and services.
9. *Positive impacts associated with reduced nitrogen*. The reduction of nitrogen levels in Lake Rotorua has the potential to create positive economic spin-offs. Among the most obvious are opportunities for improved water-based activities such as tourism and recreation. The direct increase in expenditures resulting from such activities (e.g. on tourism operators, accommodation) will have flow-on implications through the district, regional and national economies.

3.2 Incorporation of the Scenarios within the Modelling Framework

3.2.1 Overview

A summary of the method used to calculate catchment, district, regional and national economic impacts is provided in Figure 1 below. Information obtained from the farm systems modelling that flows in as inputs to the modelling exercise, is depicted in the circles. The primary components of the IO framework are depicted in the grey boxes. The final results produced by the model (depicted in pink at the centre of the diagram) are the value added and employment impacts associated with each scenario. All results are reported in terms of the net change from the baseline scenario. For example, the value added impact of S1 without trading is not the total value added in the economy under this scenario, but rather the difference in value added between that scenario and the baseline scenario.



Notes: hhld = household, cons = consumption,

Figure 3.1 Summary of Modelling Approach

3.2.2 Step 1: Production of multi-regional input–output table

At the core of an IO modelling framework is a matrix recording transactions between different actors within an economy. Each column of the matrix reports the monetary value of an industry's inputs, while each row represents the value of an industry's outputs. Sales by each industry to final demand categories (i.e. households, local and central government, gross fixed capital formation, etc) are also recorded, along with each industry's expenditure on primary inputs (wages and salaries, consumption of fixed capital, gross operating surplus, etc). The data requirements for constructing IO matrices are enormous, and this is part of the reason IO tables are produced in New Zealand on an irregular basis. The latest available IO table for the New Zealand economy is based on data for the 2006–07 financial year. This means that except in the case of the agriculture and forestry sectors which are considered in detail through the farm system modelling, the industry production mixes used in this study are based on 2006-07 information. Changes in technology and/or production techniques that have occurred since 2006-07 are not considered. Note, however, that when determining the likely destination of agriculture/forestry output for processing, consideration is given to changes in the distribution of processing employment since 2006-07. Where necessary the allocation coefficients determining the destination of output are adjusted. This is discussed in more detail below.

The first major step required for the assessment of economy-wide effects is regionalisation of the national table so as to produce tables for the following regions or study areas:

1. Lake Rotorua Catchment,
2. Rest of Rotorua District in Bay of Plenty,
3. Rest of Rotorua District in Waikato
4. Rest of Bay of Plenty
5. Rest of New Zealand.

For each region, 106 different economic industries are defined.

The process adopted to disaggregate the latest available input-output tales from Statistics New Zealand into input-output tables covering New Zealand's 16 regional councils is described in Smith et al (2015).[8] A modified version of the Generating Regional Input-Output Tables (GRIT) procedure (Jensen *et al*. 1979; West *et al*. 1980) then further disaggregates the regional IO tables to delineate the Rotorua District and Lake Rotorua Catchment. The GRIT method consists of a series of mechanical steps that reduce national input-output coefficients to sub-national (or sub-regional) equivalents with reference to available regional data. In this case, reference was made particularly to employment by industry, population and household income data for each of the study areas. A gravity modelling approach, partly based on big-data obtained for EFT-POS and credit card transactions, is also applied to estimate the magnitude of trade between different study areas. The general idea behind a

[8] To be precise, our regionalisation processes generates multi-regional supply and use tables. These are then translated into the symmetric industry-by-industry input output format utilising the 'Industry Technology' assumption (ITA). For more information on the difference between supply-use and input-output tables and the ITA, refer to Smith and McDonald (2011).

gravity model is that the flow of goods between two locations is a function of the supply or production at the origin location, the demand or consumption at the destination location, and some measure of the impedance factors, usually distance, existing between the two locations.

Importantly, the IO framework used in this study is multi-regional. This means that the model considers not only the relationships between economic actors within any given study area, but also the relationships between economic actors across study areas. This multi-regional approach provides a means to evaluate the nation-wide implications.

3.2.3 Step 2: Calculation of technical coefficients and allocation coefficients tables

The multi-regional IO tables created for the study areas are now translated into tables of technical coefficients (i.e. **A** matrices) and tables of allocation coefficients (**B** matrices). The technical coefficients indicate, for each industry, how much input is required to produce one dollar's worth of output, and are derived from the Base IO tables assuming continuous, linear relationships between inputs and outputs of each industry. Allocation coefficients can also be calculated from input–output tables in a similar manner to the calculation of technical coefficients. However, whereas technical coefficients describe the value of inputs purchased from each industry per unit of output, allocation coefficients detail the value of outputs sold to each industry per unit of output.

In this study the allocation coefficients are used solely for the purposes of determining the likely shares of primary commodities produced within the Lake Rotorua Catchment distributed to key processing activities (e.g. meat processing, dairy product manufacturing, timber processing). A detailed analysis of employment data is also undertaken to capture likely changes in processing locations occurring since 2007 (which is the year described by the data within the IO tables).

3.2.4 Step 3: Calculation of output change vectors (Y and M)

The purpose of this Step is to devise a set of industry output change vectors, for which we wish to trace the backward-linkage (i.e. vector **Y**) and forward linkage (i.e. vector **M**) impacts. The first of these set of output vectors, **Y**, is a summation of:

1. *Net changes in purchases by farming activities within the Lake Rotorua Catchment*. These changes in input purchases include changes brought about by stronger nutrient regulations causing changes in farming practices (point 1 in Section 3.1 above) , as well as switching from one type of farming activity to another (point 3 in Section 3.1). The magnitude of these input changes is derived directly from the results of the farm system modelling (Parsons et al. 2015). The revenue/expenditure line items from the farm system modelling accounts are matched to the input categories (i.e. different types of commodities/services as well as primary inputs such as wages and salaries) specified in the multi-regional input output table.
2. *Net changes in expenditure resulting from loss or gain in household income within Lake Rotorua Catchment*. The outputs of the farm system modelling are used to determine

the net changes in income for land owners and employees. This includes changes in income resulting from changes to the nature and extent of different types of farm systems within the catchment (point 5 in Section 3.1), as well as revenues and expenditures associated with land conversion (point 6 in Section 3.1). It is assumed that any income loss (or gain) will result in a corresponding loss (or gain) in household expenditure. In order to translate income changes into spending changes, average household expenditures shares generated from the National Social Accounting Matrix (see Smith *at al*. 2015) are used. In generating these average household expenditures shares, consideration is given to the proportion of household income that is used to purchase goods and services overseas, and is thus effectively lost from the New Zealand economy.

3. *Additional purchases of goods and services necessary to undertake land conversion* (point 6 in Section 3.1). This information is derived from the forestry and farm-level system modelling (Parsons et al. 2015) and is matched to the input output categories.
4. *Net changes in expenditure resulting from funding of the incentives scheme and advice and support for farmers* (points 7 and 8 in Section 3.1). It is assumed that Council supplied funding is ultimately derived through rates[9], and that the consequence of funding the scheme is therefore a reduction in regional household expenditure. As with (2) above, average household expenditure shares are used to apportion the total loss of expenditure among different types of commodities and services. Similarly, it is assumed that national government funding results in a corresponding decrease in other government expenditures.
5. *Additional demand for farm advisors and other specialist services* (point 7 in Section 3.1). To maintain consistency with the farm system modelling, these expenditures are 'annualised' over 25 years. These expenditures appear in vector **Y** as an additional demands for services from the IO sectors 'agriculture, forestry and fishing support services' and 'scientific, architectural and engineering services'.
6. *Net changes in demand for goods and services used as inputs to agriculture processing* (an outcome of points 2 and 4 in Section 3.1). The changes in output produced by agriculture and forestry within the catchment will impact the industries directly responsible for processing these commodities (dairy, meat and wood processing) and, in turn, the industries responsible for supplying goods to these processing sectors. This includes, for example, a loss of demand for electricity, chemicals and other goods as a result of a loss in dairy product manufacturing output – see Section 3.2.6 below. These additional backward linkage effects are also included in vector **Y.**

Note that as the IO table is expressed entirely in 2007 prices, it is necessary for all values to be translated into 2007 prices prior to input into the model. For these purposes a combination of price index series produced by SNZ are used, i.e. the Farm Expenses Price Index Series, Producers Price Index – Output Series and the Implicit Price Deflator (GDP) Series. The outputs of the input-output model (in value added terms) are then translated back into 2015 terms for presentation in the results tables below.

[9] Other funding mechanisms are possible.

Finally, the other output vector, **M**, is an estimate of the change in production of agricultural/forestry commodities for the Lake Rotorua Catchment, under each of the scenarios. This information is derived directly from the farm system modelling for outputs of commodities sheep, beef/cattle, wool and milk.[10,11]

3.2.5 Calculation of backward–linkage impacts

As previously explained, the direct changes in output occurring in each industry will create indirect economic impacts that flow through the wider New Zealand economy. For example, reductions in fertiliser use by farmers is a reduction in demand for fertiliser manufacturers. In turn, the industries that supply fertiliser manufacturers will experience some loss in demand, and so on. Very simply, the vector of direct and indirect output effects by industry, **X**, is calculated according to the equation,

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{Y} \qquad (1)$$

Where **A** is the matrix of technical coefficients (refer to Miller and Blair (2009) for further explanation), **I** is the identity matrix and the vector **Y** is a set of exogenous output changes by industry, the impacts of which are sought to be measured. The inverse matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is termed the 'Leontief Inverse Matrix'.

There is some debate within IO literature and applications of the degree to which an input-output model should be 'closed' with respect to the household sector[12] when calculating the impacts according to Equation (1) above (Miller and Blair, 2009), so as to capture the relationships between income and consumer spending.[13] This study utilises a model that is 'open' with regards to the household and other final demand sectors. The primary reasons are:

- The method described above already captures some income effects associated with changes in profits and wages/salaries for farming systems within the catchment. These are likely to be the most significant income related effects.
- The input-output approach can in some cases overestimate impacts, primarily due to the absence of price-related feedback mechanisms that help to regulate economies. The use

[10] To avoid double-counting of economic interlinkages, it is necessary to adjust the estimates of output change to account for output changes that are already included as a backward linkage effect.

[11] The conversion of dairy farms to other land uses creates an additional supply of beef from the catchment. These sales enter the model as 'annualised' data directly from the farm system modelling.

[12] Under this approach, households are treated in a similar manner to industries in the IO matrix, with a column and row of the matrix recording inputs and outputs of the household 'sector'. Transactions presented along the household row of the matrix record the income generated for households by each industry within the economy in the form of payments for labour, while transactions recorded in the household column of the matrix record the structure of household purchases (i.e. consumption). If it is assumed that the structure of household expenditure among different product types remains constant irrespective of the level of income, it is possible to calculate a vector of technical coefficients for households which can be included in the **A** matrix described above. When the vector of exogenous output changes (**Y**) is multiplied by the Leontief Inverse Matrix $(\mathbf{I} - \mathbf{A})^{-1}$, the model will calculate the value of outputs from each industry that will be purchased by households. Household incomes are, in turn, also determined by the level of output of each industry.

[13] Often referred to as 'induced' impacts in economic impact assessments.

of the open Leontief Inverse Matrix helps to therefore moderate the economic impact estimates generated by the analysis.

3.2.6 Calculation of forward–linkage impacts

In most examples of regional economic impact analysis, the focus is on estimating backward linkage or demand-side effects. In this study we have endeavoured to also capture the most important supply-side or forward-linkage effects associated with changes in agriculture/forestry output under each scenario, such as supply of raw milk to local manufacturers. The basic assumption in applying this supply-side approach is that the output distributions within the economic system are stable. This means that if the output of a sector is, say, doubled, sales from that industry to all other industries that purchase from that industry will also be doubled. Although this assumption is unlikely to hold for many economic situations (see, for example, Giarrantani 1980, 1981), it is a reasonable assumption for changes in output for agricultural and forestry industries. This is because the industries that will be primarily affected by the supply-side effects are those that use the agricultural and forestry commodities to manufacture products (i.e. dairy product manufacturing, wood product manufacturing, meat product manufacturing, and textile manufacturing). For these industries a relatively constant relationship between the availability of commodities for processing and the value of manufactured products produced is likely.

It is assumed that a change in supply of an agricultural/forestry commodity to a processor will result in a proportional change in processing output. For example, if the supply of raw milk to dairy product manufacturing in the Bay of Plenty reduces by 10 percent, then total output of the dairy product manufacturing industry also reduces by 10 percent. Additional backward linkage effects associated with the loss of dairy product manufacturing are then included in the calculation of vector **Y** (see above).

3.2.7 Capital-related impacts

IO-based modelling is generally not designed to capture changes in capital stocks. The indicators produced by IO analysis, such as changes in value added, are flow-based measures rather than stock-based measures. Nevertheless, some of the implications of changes in capital are addressed in this study:

1. *Sale of Fonterra shares* – Under the farm system modelling, the one-off income derived from sale of Fonterra shares is incorporated into the decision making of farmers by translating the income into an 'annualised income'. In the IO modelling this addition to farmer annual income adds to regional investment spending (ie. farmers choose to substitute their sale of capital (ownership in Fonterra) for new capital investments).[14] In theory, there will be purchases of these shares by farmers within the rest of the region or nation. Given that these purchases will experience both positive (right to now supply

[14] The value of share sales are not included when deriving value added for the catchment because they are a sale of capital (a stock), rather than income (a flow).

milk to Fonterra and receive income from milk sales and dividends) and negative (expenditure to purchase shares) impacts associated with the share sale, it is not necessary to undertake any further adjustments to the IO model.[15]

2. *Greenhouse gas emission rights* – In line with the recommendations of Statistics New Zealand (Statistics New Zealand, 2010), acquisition/surrender of emission rights are considered a subsidy/tax flow between industry and government, while trading of emission rights are considered capital transfers. Similar to the situation with Fonterra shares, the net annualised proceeds from sale of greenhouse gas emission rights are assumed to add to the available funds within the catchment for investment. While purchasers of greenhouse gas emission rights must expend funds they will also receive the right to undertake activities that emit greenhouse gases. Presumably the value of purchasing the emission rights will roughly balance the additional income received from undertaking industrial activities. Thus no additional adjustments are made to the IO model.

3.2.8 Translation of output impacts into value added and employment impacts

The final stage of the analysis is to transform estimates of net output change into value added and employment impacts. This occurs by multiplying the output change for each industry by the industry's ratio of (1) value added per unit of output, and (2) employment per unit of output. These ratios are assumed to be constant and are obtained from data for the 2006–07 financial year.[16]

3.2.9 Tourism Impacts

The importance of freshwater resources is undeniable. These resources provide for a myriad of values, and often-times these values are competing. For example, competition for use of waste assimilation services of water bodies by the farming sector versus recreational use by anglers. No economic evaluation has ever attempted to measure all of the various trade-offs between different types of water values that may occur under alternative water management options. A full evaluation of the costs and benefits of water management options is difficult as while some values can be easily associated with some type of market transaction (e.g. incomes derived from farm-based production, purchases of fishing licences), other values are more loosely derived from market behaviour (e.g. comparisons of prices of houses within and without close proximity to recreational water resources) and others are not captured by market behaviours at all (e.g. satisfaction derived from conserving resources for future generations and contribution to cultural identity). Also, while some impacts on freshwater resource values are likely to occur almost immediately, other impacts may be in the distant future and thus very difficult to predict. Another complication is that freshwater resources not only provide value to people *directly*, but also

[15] It is beyond the scope of this study to consider the implications of price change for Fonterra shares or greenhouse gas emission rights brought about by changes in the ratio of supply and demand.

[16] Due to data limitations it has not possible to take into account changes in labour efficiency (ie. the ratio of output per worker) since 2007. Note, however, that labour generally becomes more efficient over time. The employment results should therefore be interpreted as '2007 employment equivalents'.

indirectly, via their contribution to the functioning of health ecosystems which, in turn, provide for a variety of ecosystem goods and services.[17] Ecosystems themselves are 'complex adaptive systems', characterised by uncertainty, non-linear dynamics and marked thresholds or 'tipping points'. Thus the behaviour of ecosystems under different management options and levels of stress can be very difficult to ascertain.

Previous work which has considered some of the more difficult-to-measure values of freshwater resources includes studies by Shaw (1990), Weber et al. (1992), Andrews (2000), Bell and Yap (2004, updated 2011) and Mkwara and Marsh (2011). Shaw (1990) estimated that in the 1986-87 season, anglers spent more than $\$_{1990}$13 million in the Rotorua Lakes district on their sport, while Andrews(2000) estimated that the freshwater recreational fishing industry bring more than $\$_{2000}$25 million to the Bay of Plenty Region. In a survey Weber et al (1992) found widespread willingness-to-pay to improve the quality of water in Lake Rotorua, even by households that did not use the lake. Similarly, Bell and Yap (2004, 2011) reported that both locals and those living outside the district and region were willing to pay for improvements in water quality. For a hypothetical closure of Lake Rotorua to anglers in 2008, Mkwara and Marsh (2011) estimated a welfare loss of $235 per angler per year ($5.1 million over the study population).[18]

As with the previous study undertaken for the Bay of Plenty Regional Council (Market Economics, 2011), M.E has been asked to provide some indication of the possible economic implications of changes in tourism based on the quality of the lake. Importantly, unlike the studies quoted above, our analysis is not an assessment of changes in welfare or components thereof (i.e. as would contribute to a cost-benefit analysis). Rather, maintaining consistency with our evaluation of economic impacts from agriculture and forestry system changes, we seek to calculate the changes in industry value added and employment arising from changes in tourism within the district. While these provide indicators of the general 'economic health' of the district/region/nation and trade-offs occurring between different economic sectors, they are not measures of welfare in themselves. Theoretically, an assessment of welfare would measure all of the benefits and costs to society of freshwater management options (including changes in market and non-market, direct and indirect, use and non-use, present and future values) as experienced by society.

It is also beyond the scope of this study to precisely identify either (a) the type of tourism-related activities which would most likely eventuate due to a cleaner Lake Rotorua, or (b) the size of the potential economic impact associated with these tourism-related activities. This would require a substantial study in its own right. Instead, we approach the quantification of these potential impacts through the use of a 'what if' scenario analysis, specifically by assessing the implications of a 1 percent, 2 percent and 3 percent increase in tourist activity within the Rotorua district economy. The rationale for selection of 1, 2 or 3 percent change in tourist activity is arbitrary; however, it is our expert opinion that the tourism-related

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[17] Refer to Millennium Ecosystem Assessment (2005), Boyd and Banzhaf (2007), Wallace (2007) and Fisher and Turner (2008) for a discussion and classification of ecosystem services.

[18] The appropriate study population is deemed to consist of all adult New Zealand resident anglers who brought a fishing licence during the 2007/08 fishing season.

impacts are likely to lie within this range. We note that substantial changes in tourist numbers and visitor spending are by no means unusual for regions within New Zealand. For example, the index of international electronic card purchase value in Rotorua increased by 28.6% for the year ending May 2015, and by 16.7 % at the national level. International visitor nights also went up by 8.0% for Rotorua over the same period, and by 7.1 % at the national level.[19] Importantly, our analysis also does not attempt to analyse any negative consequences for other regions should the changes in tourism activity within Rotorua not equate to *net additional gains for the nation as a whole.* In other words, it is possible that some of the gains in Rotorua tourism (either increased tourism or avoided loss in tourism) will be offset by losses in tourism for other NZ regions. For example, if domestic tourists choose to continue holidaying in Rotorua this might come at the expense of growth that would otherwise be achieved in Queenstown.

The following analytical steps were followed in this assessment;

Step 1: Determine Rotorua District's Tourist Gross Output by Industry

The tourist component of gross output of each of the 106 industries within the 2007 MRIO was determined by multiplying each industry's regional gross output for 2012[20] by the appropriate national level 'Tourism Industry Ratio'[21] obtained from Statistics New Zealand.

Step 2: Determine 1 Percent, 2 Percent and 3 Percent Contributions

The 1 percent, 2 percent and 3 percent gross output contributions were determined for each industry by multiplying the tourism-related regional gross output figures derived in Step 1 by 1 percent, 2 percent and 3 percent.

Step 3: Determine Final Demand Contribution and Economic Impacts

It was assumed that the 1 percent, 2 percent and 3 percent tourism-related regional gross output contributions were all net additional final demand. In turn, these figures were used to 'shock' (change) final demand (i.e. vector **Y**), and through the application of IO mathematics (as outlined in earlier in the report), the value added and employment economic impacts were generated.

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[19] http://www.rotoruanz.com/do-business/key-investment-sectors/tourism/research-and-statistics/

[20] This is the latest date for which we have regional information available.

[21] The 'Tourism Industry Ratio' for an industry shows the percentage share of total output attributable to tourism activity. Ratios are, however, only available at the national level.

3.3 Discussion and Caveats

There are three key caveats that must be acknowledged in this study.

1. *Wider ecological and environmental benefits of reduced nutrient discharges.* The accumulation of reactive nutrients within the environment can be associated with considerable costs, many of which can extend for significant years or generations to come. Excess nitrogen threatens the quality of air, soil and water. It affects ecosystems and biodiversity, and alters the balance of greenhouse gases (see, for example, Sutton et al. (2011)). Due to significant system complexity and limited time and budget constraints, this study has not attempted to evaluate the wider benefits of efforts to reduce the effects of nitrogen accumulation within the catchment. In part this is justified given that the level of nitrogen reduction sought is the same under each scenario, and thus an assessment of the benefits does not add value when comparing the alternative nitrogen discharge allowance allocation scenarios with the same environmental outcome. Nevertheless, to provide some context to the scenarios, a simple analysis of possible tourism impacts is included. It should not be interpreted that these tourism outcomes are the only likely benefits or even the most significant benefits accruing from reductions in nitrogen discharges.
2. *'Average' Impact rather than 'Transition Pathway'.* As discussed, a principal input into the analysis is the farm-system modelling which determines how land use and land management within the catchment is expected to change under the alternative allocation scenarios, in order to reduce nitrogen discharges at the least cost (Parsons et al., 2015). The farm system model is an optimisation model. It describes alternative steady-state or equilibrium outcomes, but does not describe the transition pathway. The district/regional/national economic analysis is consistent with the farm system modelling input data available. Thus the results presented show the 'average' impact on the economy over the impact horizon, acknowledging that during any particular year the outcomes might be greater or less than this 'average' impact.
3. *Application of current prices and mitigation options in an evaluation of the future.* Without better information available, this study (and also the farm system modelling upon which this study depends) applies current relative prices, as well as the mitigation options, technologies and land use options that exist today to the evaluation of each scenario. This is particularly important given that the proposed policies to reduce nitrogen within the catchment run out to 2032, with final reductions by landowners not due until that year. This means that farms have more than 15 years to achieve the proposed nitrogen reductions.

   Future changes in prices may alter the assessment of optimum land uses and thus impact on farmer's decisions in ways different from those modelled. Such changes would also flow into the evaluation of economic impacts at a district/regional/national level. As an example, we know that over the last 15 years world export prices for dairy products have performed better than wood/log prices. Should the relative prices of these commodities to continue to grow disparately, the income loss for landowners, and the flow on effects to the rest of the country, associated with converting to forestry would be relatively larger than those assessed.

   By applying only nitrogen mitigation and land use options that exist today the analysis also does not take into account possible improvements that may occur in land management techniques and technologies. Significant research is being undertaken, both within New Zealand and abroad, on ways to improve nitrogen management within farming systems. Uptake of new methods and technologies could potentially mean that the nitrogen targets assigned to land uses could be met at less costs than those evaluated in this study, with flow on benefits to the district, region and nation. Also, it is quite possible that other low-nitrogen land use possibilities that are viable alternatives to forestry could emerge of the next one to two decades.

Finally it is worth noting that, consistent with the farm system modelling, income and expenditure flows that do not occur each year (for example initial land development costs for converting to another land use, revenues for timber harvest) are 'annualised' by determining the 'constant periodic payment' over a 25 year horizon, assuming an interest rate of 8 percent per annum.[22] Another important consideration is that benefits/costs occurring nearer in time are given more weight than benefits/costs occurring later in time. This is particularly relevant to the forestry sector, where revenues from timber sales are generated many years after expenditure on land development.

[22] A discount rate is intended to reflect the opportunity cost of capital and simultaneously reflect the preference for current, over deferred consumption. The discount rate applied is selected so as to be consistent with the farm system modelling. There is a wide-ranging academic literature on the setting of discount rates. Treasury recommends a default rate of 8% for public sector projects (Treasury, 2008).

4 Results

4.1 Impacts Related to Changes in Agricultural and Forestry Systems

Tables 4.1 and 4.2 below describe the value added and employment impacts associated with the proposed measures to reduce nitrogen discharge, excluding those associated with increased tourism (tourism is covered separately in Section 4.2 below). Consistent with the scenarios chosen for evaluation, these impacts are described for the single sector target (S1), a natural capital allocation (S4) and sector ranges (S8). Furthermore the scenarios are evaluated under four different combinations of assumptions:

1. Optimum land use change and no trading frictions,
2. Optimum land use change and 50% trading frictions,
3. Restricted to 5000 ha of land use change and no trading frictions
4. Restricted to 5000 ha of land use change and 50 % trading frictions.

Within these results, impacts are also disaggregated according to 16 economic sectors (also termed 'industries').[23] Employment results are measured by the 'modified employment count' or 'MEC' indicator.

Some key observations from the results are:

1. Regardless of the allocation scenario (i.e. S1, S4 or S8), the results are almost identical for the optimum land use and no trading frictions set of assumptions. This is consistent with the outputs provided by the farm system modelling. Altogether an annual value added loss of $12.9 mil is estimated for the New Zealand economy, with $3.4 mil originating from within the Bay of Plenty Region and $2.5 from the Rotorua District, most of this within the Lake Rotorua catchment. To place these results in context, the total industry value added for New Zealand and Bay of Plenty Region was estimated as $212,000 mil and $11,000 mil for 2014.[24] Also, industry value added in the Rotorua District is estimated to be equal to approximately one-quarter of the total industry value added of Bay of Plenty. Thus at least in terms of value added, the impact equates to approximately 0.09% at the district level, 0.03% at the regional level, and 0.01% of the economy at the national level.
2. Within the Lake Rotorua Catchment itself, the impacts are confined largely to the agricultural/ forestry industries under all scenarios and land use/ trading assumptions. The annual loss in value added from the local dairy farming sector ranges from $3.6 mil under all scenarios with optimum land use and no trading friction, to $11.5mil under S4 with optimum land use and 50% trading frictions. For the sheep, beef and grain sector the annual value added impacts range from a gain of $4.4 mil (S4, optimum land use and

[23] A concordance matching the 16 sectors to the 106 sectors contained in the IO model is provided in Appendix A

[24] Statistics New Zealand, 2015. Regional and Gross Domestic Product: Year Ended March 2015. www.stats.govt.nz

50% trading frictions), to a loss of to a loss of $1.8 mil (all scenarios, optimum land use change, 50% trading frictions). The local forestry sector experiences a maximum annual gain in value added of $2.7 mil (all scenarios, optimum land use change, 50% trading frictions), and at worse a loss of $0.5 mil (S4, 5000 ha land use change, 50% trading frictions).

3. For Rotorua District, the economic impacts are primarily made up of those captured within the Rotorua Lake Catchment, with addition of some relatively minor additional impacts for processing sectors (e.g. under the optimum land use and no trading friction assumptions, 91% of the total value added impact and 98% of the total employment impact for the district is comprised of impacts occurring within the Rotorua Catchment).
4. On average the value added impacts for the Bay of Plenty Region are 25% higher than those occurring within Rotorua District, and the employment impacts are 10% higher at the regional level compared with the district. The primary differences appear to be greater losses at the regional level for meat and dairy processing and agricultural supporting services (e.g. transportation and wholesale trade), as well as generally higher losses for service sectors due to supply chain linkages and reductions in consumer spending.
5. At the national level the impacts on service industries become even more pronounced. Service industries tend to be highly interconnected within an economy, and thus are impacted through a myriad of supply chain interconnections when there is a change in the system. Also, many of the service industries are particularly affected by reductions in spending necessary to finance the nutrient reduction interventions. Notice that for each of the scenarios and sets of assumptions evaluated, a small additional loss of value added/employment is experienced for the dairy cattle farming industry at the national level, beyond that which is explained by impacts within the Lake Rotorua Catchment. This is derived by the input-output model simply due to supply-chain interconnections – i.e. a proportion of the output from dairy farms in the rest of New Zealand is supplied to some other industry which is impacted by the proposed nitrogen reduction measures. In the real world, however, much of the loss of demand experienced by farmers in the rest of New Zealand could probably be compensated by providing additional supply to the export market rather than local market. In this way the model is likely to slightly overstate the impacts on rest of New Zealand farmers.
6. Regardless of the allocation mechanism and set of assumptions employed in the modelling regarding land use change and trading frictions, the majority of the economic impacts are not felt within the local catchment, or even the local district. For example under the scenarios with optimum land use change and no trading frictions, approximately 81% of the total value added impact is outside of Rotorua District. Even for S1 with 5000 ha land use change and 50% trading frictions, approximately 66 percent of the total value added impact is outside of Rotorua District. There are three primary causes for these results: (1) the incentives scheme is funded equally by the Regional and National governments. Essentially this creates a net flow of funds from the whole region and nation into the Rotorua Catchment to foster land use change. As explained above, we assume that this funding is derived by across-the-board changes in expenditure which ultimately has negative consequences for all sectors within the wider national economy regardless of location; (2) A high proportion of the key manufacturers responsible for processing primary outputs from the Lake Rotorua Catchment

(particularly dairy product, meat product and textile manufacturers) are not located within the local catchment, or even the local district; and (3) A very high proportion of the *indirect* effects associated with changes in agricultural systems affect organisations outside of the catchment (e.g. changes in demand for fertiliser products, transport services, machinery).

7. Employment impacts are a little more concentrated within the local catchment compared to value added impacts. To a large extent this is because a number of the key sectors impacted within the rest of the region and nation exhibit relatively low employment intensities (e.g. dairy product manufacturing).
8. When looking at the employment impacts, it is important to note that a lot of the changes in employment demand associated with changes in land use are captured within the 'agriculture and forestry support sector', rather than in the dairy, sheep and beef and forestry sectors themselves. This is consistent with the FARMAX model applied as part of the farm system modelling, as it assumes that many of the changes in inputs to farms are contract-based. Note that the agriculture and forestry support sector experiences both losses in demand (e.g. from dairy) but also increase in demand (e.g. from forestry) so at a total level appears only moderately impacted.
9. The model includes some additional demand for services providing advice and support for farmers under each of the scenarios. Nevertheless, for the industries responsible for providing these services, i.e. scientific, professional and administrative services and central and local government, this additional demand is more-than-compensated by other losses captured by the model. This includes, in particular, reductions in household spending on central government and local government services, and reductions in demand for scientific, professional and administrative services by the dairy and drystock sectors and related processors.

Table 4.1 Annual Value Added Impacts by Industry, excluding Tourism-Related Impacts ($mil)

Sector	Scenario 1				Scenario 4				Scenario 8			
	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand
Optimum Land Use, no trading friction												
1 Sheep, beef & grain	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8
2 Dairy farming	-3.6	-3.6	-3.6	-4.0	-3.6	-3.6	-3.6	-4.0	-3.6	-3.6	-3.6	-4.0
3 Forestry	2.7	2.7	2.7	2.8	2.7	2.7	2.7	2.8	2.7	2.8	2.7	2.8
4 Other primary	0.0	0.0	-0.1	-0.3	0.0	0.0	-0.1	-0.3	0.0	0.0	-0.1	-0.3
5 Agriculture and forestry support	-0.1	-0.1	-0.3	-0.6	-0.1	-0.1	-0.3	-0.6	-0.1	-0.1	-0.3	-0.6
6 Meat manufacturing	0.0	0.0	-0.1	-0.4	0.0	0.0	-0.1	-0.4	0.0	0.0	-0.1	-0.4
7 Dairy manufacturing	0.0	-0.2	-0.3	-2.8	0.0	-0.2	-0.3	-2.8	0.0	-0.2	-0.3	-2.8
8 Wood and paper manufacturing	0.7	0.7	0.9	1.3	0.7	0.7	0.9	1.3	0.7	0.8	0.9	1.3
9 Other manufacturing	0.0	-0.1	-0.2	-1.3	0.0	-0.1	-0.2	-1.3	0.0	-0.1	-0.2	-1.3
10 Utilities	0.0	0.0	0.0	-0.4	0.0	0.0	0.0	-0.4	0.0	0.0	0.0	-0.4
11 Construction	0.1	0.1	0.1	-0.1	0.1	0.1	0.1	-0.1	0.1	0.1	0.1	-0.1
12 Wholesale & retail trade	-0.1	-0.1	-0.2	-0.9	-0.1	-0.1	-0.2	-0.9	-0.1	-0.1	-0.2	-0.9
13 Transport	0.0	0.0	-0.1	-0.7	0.0	0.0	-0.1	-0.7	0.0	0.0	-0.1	-0.7
14 Scientific, profess. & admin. servs	-0.1	-0.1	-0.2	-1.0	-0.1	-0.1	-0.2	-1.0	-0.1	-0.1	-0.2	-1.0
15 Local & central government	0.0	0.0	0.0	-0.2	0.0	0.0	0.0	-0.2	0.0	0.0	0.0	-0.2
16 Other services	-0.2	-0.2	-0.3	-2.4	-0.2	-0.2	-0.3	-2.4	-0.2	-0.2	-0.3	-2.4
Total	-2.3	-2.5	-3.4	-12.9	-2.3	-2.5	-3.4	-12.9	-2.3	-2.5	-3.4	-12.9
Optimum land use, 50% trading friction												
1 Sheep, beef & grain	0.1	0.1	0.1	0.1	4.4	4.4	4.4	4.4	-0.1	-0.1	-0.1	-0.1
2 Dairy farming	-5.3	-5.3	-5.4	-5.9	-11.5	-11.5	-11.5	-12.6	-4.8	-4.8	-4.8	-5.3
3 Forestry	1.5	1.5	1.5	1.5	0.2	0.2	0.2	0.1	1.7	1.7	1.7	1.7
4 Other primary	0.0	0.0	0.0	-0.2	0.0	0.0	0.0	-0.2	0.0	0.0	-0.1	-0.3
5 Agriculture and forestry support	-0.1	-0.1	-0.3	-0.5	-0.1	-0.1	-0.3	-0.5	0.0	-0.1	-0.3	-0.5
6 Meat manufacturing	0.0	0.0	0.2	0.9	0.1	0.1	0.7	3.6	0.0	0.0	0.1	0.7
7 Dairy manufacturing	0.0	-0.3	-0.5	-3.9	0.0	-0.5	-0.9	-7.5	0.0	-0.3	-0.4	-3.6
8 Wood and paper manufacturing	0.4	0.4	0.5	0.7	0.1	0.1	0.1	0.0	0.4	0.5	0.5	0.8
9 Other manufacturing	0.0	0.0	-0.1	-1.1	0.0	0.0	-0.1	-1.2	0.0	0.0	-0.2	-1.1
10 Utilities	-0.1	-0.1	-0.1	-0.5	-0.2	-0.2	-0.2	-0.9	-0.1	-0.1	-0.1	-0.5
11 Construction	0.3	0.3	0.3	0.1	0.4	0.4	0.4	0.0	0.3	0.3	0.3	0.1
12 Wholesale & retail trade	-0.1	-0.1	-0.2	-1.0	-0.2	-0.2	-0.3	-1.5	-0.1	-0.1	-0.2	-0.9
13 Transport	0.0	0.0	-0.1	-0.8	-0.1	-0.1	-0.2	-1.2	0.0	0.0	-0.1	-0.8
14 Scientific, profess. & admin. servs	-0.1	-0.1	-0.2	-1.1	-0.1	-0.1	-0.2	-1.8	-0.1	-0.1	-0.2	-1.0
15 Local & central government	-0.1	-0.1	-0.1	-0.5	-0.2	-0.2	-0.2	-0.9	-0.1	-0.1	-0.1	-0.5
16 Other services	-0.3	-0.3	-0.5	-3.3	-0.7	-0.7	-1.0	-5.8	-0.3	-0.3	-0.4	-3.0
Total	-3.8	-4.1	-4.9	-15.6	-7.7	-8.3	-9.2	-25.9	-3.2	-3.5	-4.3	-14.4

Table 4.1 (continued) Annual Value Added Impacts by Industry, excluding Tourism-Related Impacts ($mil)

Sector	Scenario 1				Scenario 4				Scenario 8			
	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand
5000 ha land use change, no trading friction												
1 Sheep, beef & grain	-0.6	-0.6	-0.6	-0.7	-0.6	-0.6	-0.6	-0.7	-0.6	-0.6	-0.6	-0.7
2 Dairy farming	-4.7	-4.7	-4.7	-5.2	-4.7	-4.7	-4.7	-5.2	-4.7	-4.7	-4.7	-5.2
3 Forestry	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4 Other primary	0.0	0.0	-0.1	-0.4	0.0	0.0	-0.1	-0.4	0.0	0.0	-0.1	-0.4
5 Agriculture and forestry support	-0.1	-0.2	-0.5	-0.8	-0.1	-0.2	-0.5	-0.8	-0.1	-0.2	-0.5	-0.8
6 Meat manufacturing	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	-0.3
7 Dairy manufacturing	0.0	-0.3	-0.4	-3.5	0.0	-0.3	-0.4	-3.5	0.0	-0.3	-0.4	-3.5
8 Wood and paper manufacturing	0.5	0.5	0.6	0.9	0.5	0.5	0.6	0.9	0.5	0.5	0.6	0.9
9 Other manufacturing	0.0	0.0	-0.2	-1.4	0.0	0.0	-0.2	-1.4	0.0	0.0	-0.2	-1.4
10 Utilities	0.0	0.0	-0.1	-0.5	0.0	0.0	-0.1	-0.5	0.0	0.0	-0.1	-0.5
11 Construction	0.1	0.1	0.1	-0.1	0.1	0.1	0.1	-0.1	0.1	0.1	0.1	-0.1
12 Wholesale & retail trade	-0.1	-0.1	-0.2	-1.1	-0.1	-0.1	-0.2	-1.1	-0.1	-0.1	-0.2	-1.1
13 Transport	0.0	0.0	-0.1	-0.9	0.0	0.0	-0.1	-0.9	0.0	0.0	-0.1	-0.9
14 Scientific, profess. & admin. servs	-0.1	-0.1	-0.2	-1.3	-0.1	-0.1	-0.2	-1.3	-0.1	-0.1	-0.2	-1.3
15 Local & central government	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	-0.3
16 Other services	-0.3	-0.3	-0.4	-3.1	-0.3	-0.3	-0.4	-3.1	-0.3	-0.3	-0.4	-3.1
Total	-3.4	-3.7	-4.8	-16.7	-3.4	-3.7	-4.8	-16.7	-3.4	-3.7	-4.8	-16.7
5000 ha land use change, 50% trading friction												
1 Sheep, beef & grain	1.2	1.2	1.2	1.1	2.7	2.7	2.7	2.6	1.0	1.0	1.0	1.0
2 Dairy farming	-4.5	-4.5	-4.5	-4.9	-6.6	-6.6	-6.6	-7.2	-3.8	-3.8	-3.8	-4.2
3 Forestry	0.9	0.9	0.9	0.9	-0.5	-0.5	-0.5	-0.5	0.9	0.9	0.9	0.9
4 Other primary	0.0	0.0	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
5 Agriculture and forestry support	0.0	-0.1	-0.2	-0.4	0.1	0.1	0.1	0.0	0.0	0.0	-0.2	-0.3
6 Meat manufacturing	0.0	0.0	0.2	1.0	0.1	0.1	0.4	2.3	0.0	0.0	0.2	0.9
7 Dairy manufacturing	0.0	-0.2	-0.4	-3.2	0.0	-0.3	-0.5	-4.5	0.0	-0.2	-0.3	-2.8
8 Wood and paper manufacturing	0.2	0.3	0.3	0.4	0.0	0.0	-0.1	-0.1	0.2	0.3	0.3	0.4
9 Other manufacturing	0.0	0.0	-0.1	-0.8	0.0	0.0	-0.1	-0.7	0.0	0.0	-0.1	-0.7
10 Utilities	-0.1	-0.1	-0.1	-0.4	-0.1	-0.1	-0.1	-0.5	-0.1	-0.1	-0.1	-0.3
11 Construction	0.2	0.2	0.2	0.0	0.2	0.2	0.2	0.0	0.2	0.2	0.2	0.0
12 Wholesale & retail trade	-0.1	-0.1	-0.1	-0.8	-0.1	-0.1	-0.2	-0.9	-0.1	-0.1	-0.1	-0.7
13 Transport	0.0	0.0	-0.1	-0.6	0.0	0.0	-0.1	-0.7	0.0	0.0	-0.1	-0.5
14 Scientific, profess. & admin. servs	0.0	0.0	-0.1	-0.8	0.0	0.0	-0.1	-0.9	0.0	0.0	-0.1	-0.7
15 Local & central government	0.0	0.0	0.0	-0.3	-0.1	-0.1	-0.1	-0.5	0.0	0.0	0.0	-0.2
16 Other services	-0.2	-0.2	-0.3	-2.3	-0.4	-0.4	-0.6	-3.4	-0.1	-0.1	-0.2	-1.9
Total	-2.4	-2.7	-3.3	-11.1	-4.8	-5.2	-5.6	-15.1	-1.8	-2.0	-2.5	-9.2

Table 4.2 Annual Employment Impacts by Industry, excluding Tourism-Related Impacts (MECs)

Sector	Scenario 1				Scenario 4				Scenario 8			
	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand
Optimum Land Use, no trading friction												
1 Sheep, beef & grain	-48	-48	-48	-49	-48	-48	-48	-49	-48	-48	-48	-50
2 Dairy farming	-60	-60	-61	-65	-60	-60	-61	-65	-60	-60	-61	-65
3 Forestry	15	15	15	15	15	15	15	15	15	15	15	15
4 Other primary	0	0	-1	-4	0	0	-1	-4	0	0	-1	-4
5 Agriculture and forestry support	-1	-2	-5	-10	-1	-2	-5	-10	-1	-2	-5	-10
6 Meat manufacturing	0	0	-1	-5	0	0	-1	-5	0	0	-1	-5
7 Dairy manufacturing	0	-1	-2	-14	0	-1	-2	-14	0	-1	-2	-14
8 Wood and paper manufacturing	10	11	13	19	10	11	13	19	10	11	13	19
9 Other manufacturing	-2	-2	-3	-16	-2	-2	-3	-16	-2	-2	-3	-16
10 Utilities	0	0	0	-1	0	0	0	-1	0	0	0	-1
11 Construction	2	2	2	-2	2	2	2	-2	2	2	2	-2
12 Wholesale & retail trade	-2	-2	-3	-13	-2	-2	-3	-13	-2	-2	-3	-14
13 Transport	0	0	-1	-9	0	0	-1	-9	0	0	-1	-9
14 Scientific, profess. & admin. servs	-1	-1	-3	-16	-1	-1	-3	-16	-1	-1	-3	-16
15 Local & central government	1	1	1	-2	1	1	1	-2	1	1	1	-2
16 Other services	-1	-1	-2	-21	-1	-1	-2	-21	-1	-1	-2	-21
Total	-87	-89	-97	-191	-87	-89	-97	-191	-88	-89	-97	-192
Optimum land use, 50% trading friction												
1 Sheep, beef & grain	-11	-11	-11	-12	59	59	59	59	-17	-17	-17	-18
2 Dairy farming	-75	-75	-75	-81	-139	-139	-140	-151	-69	-69	-69	-75
3 Forestry	8	8	8	8	1	1	1	1	9	9	9	9
4 Other primary	0	0	-1	-3	0	0	0	0	0	0	-1	-3
5 Agriculture and forestry support	-1	-2	-4	-10	-1	-2	-4	-10	-1	-2	-4	-9
6 Meat manufacturing	0	0	2	11	2	2	7	43	0	0	1	8
7 Dairy manufacturing	0	-1	-2	-19	0	-2	-4	-37	0	-1	-2	-17
8 Wood and paper manufacturing	6	6	7	11	1	1	1	1	6	7	8	12
9 Other manufacturing	0	0	-1	-10	2	2	0	-6	0	0	-1	-10
10 Utilities	0	0	0	-1	0	0	-1	-2	0	0	0	-1
11 Construction	5	5	6	2	7	7	8	1	5	5	6	2
12 Wholesale & retail trade	-2	-2	-3	-15	-4	-4	-6	-23	-2	-2	-3	-14
13 Transport	0	0	-1	-10	-1	-1	-2	-16	0	0	-1	-9
14 Scientific, profess. & admin. servs	-1	-1	-2	-17	-1	-1	-3	-27	-1	-1	-2	-16
15 Local & central government	-2	-2	-3	-7	-4	-4	-4	-12	-2	-2	-3	-7
16 Other services	-3	-3	-5	-33	-6	-6	-9	-58	-2	-2	-4	-30
Total	-76	-78	-85	-185	-84	-88	-96	-237	-75	-76	-83	-178

Table 4.2 (continued) Annual Employment Impacts by Industry, excluding Tourism-Related Impacts (MECs)

Sector	Scenario 1				Scenario 4				Scenario 8			
	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand	Lake Catchment	Rotorua District	Bay of Plenty Region	New Zealand
5000 ha land use change, no trading friction												
1 Sheep, beef & grain	-29	-29	-29	-31	-29	-29	-29	-31	-29	-29	-29	-31
2 Dairy farming	-71	-71	-72	-77	-71	-71	-72	-77	-71	-71	-72	-77
3 Forestry	11	11	11	11	11	11	11	11	11	11	11	11
4 Other primary	0	0	-1	-5	0	0	-1	-5	0	0	-1	-5
5 Agriculture and forestry support	-2	-3	-7	-14	-2	-3	-7	-14	-2	-3	-7	-14
6 Meat manufacturing	0	0	0	-3	0	0	0	-3	0	0	0	-3
7 Dairy manufacturing	0	-1	-2	-17	0	-1	-2	-17	0	-1	-2	-17
8 Wood and paper manufacturing	7	8	10	14	7	8	10	14	7	8	10	14
9 Other manufacturing	-1	-1	-2	-15	-1	-1	-2	-15	-1	-1	-2	-15
10 Utilities	0	0	0	-1	0	0	0	-1	0	0	0	-1
11 Construction	2	2	3	-2	2	2	3	-2	2	2	3	-2
12 Wholesale & retail trade	-2	-2	-4	-16	-2	-2	-4	-16	-2	-2	-4	-16
13 Transport	0	0	-1	-11	0	0	-1	-11	0	0	-1	-11
14 Scientific, profess. & admin. servs	-1	-1	-3	-20	-1	-1	-3	-20	-1	-1	-3	-20
15 Local & central government	0	0	0	-3	0	0	0	-3	0	0	0	-3
16 Other services	-2	-2	-4	-29	-2	-2	-4	-29	-2	-2	-4	-29
Total	-88	-91	-102	-219	-88	-91	-102	-219	-88	-91	-102	-219
5000 ha land use change, 50% trading friction												
1 Sheep, beef & grain	5	5	5	5	40	40	40	39	0	0	-1	-1
2 Dairy farming	-61	-61	-61	-66	-84	-84	-85	-91	-51	-51	-51	-56
3 Forestry	5	5	5	5	-3	-3	-3	-3	5	5	5	5
4 Other primary	0	0	0	-1	0	0	0	1	0	0	0	-2
5 Agriculture and forestry support	0	-1	-3	-7	1	1	1	0	0	-1	-2	-6
6 Meat manufacturing	0	0	2	12	1	1	5	27	0	0	2	10
7 Dairy manufacturing	0	-1	-2	-16	0	-1	-3	-22	0	-1	-2	-13
8 Wood and paper manufacturing	3	4	4	6	-1	-1	-1	-2	4	4	5	7
9 Other manufacturing	0	0	-1	-6	1	1	0	-3	0	0	-1	-6
10 Utilities	0	0	0	-1	0	0	0	-1	0	0	0	-1
11 Construction	3	3	3	0	4	4	4	0	3	3	3	1
12 Wholesale & retail trade	-2	-2	-2	-11	-2	-2	-3	-14	-1	-1	-2	-10
13 Transport	0	0	-1	-7	0	0	-1	-9	0	0	-1	-6
14 Scientific, profess. & admin. servs	-1	-1	-2	-12	-1	-1	-2	-14	-1	-1	-2	-10
15 Local & central government	-1	-1	-1	-4	-1	-1	-1	-6	-1	-1	-1	-3
16 Other services	-2	-2	-3	-22	-4	-4	-6	-35	-1	-1	-2	-18
Total	-49	-50	-56	-125	-49	-51	-54	-132	-44	-45	-50	-109

An additional table, Table 4.3 below, describes the value added loss per kg of reduction in the nitrogen commercial load. This can be a useful indicator to compare the scenarios at a top level. Generally the scenarios with optimum land use change and no trading frictions perform the best in terms of loss of New Zealand value added per kg of nitrogen load reduced. This is not surprising, as it is under these assumptions that land owners move to the optimum use of their land which is of benefit not only to themselves, but also the wider district, regional and national communities. Interestingly, under Scenario 8 with 5000 ha land use change 50% trading friction, the outcome is actually slightly better than the scenarios with optimum land use change and no trading frictions, at least as measured by loss of industry value added per kg of nitrogen reduced. It is, however, worth noting that while all scenarios meet the target nitrogen reduction (see Parsons et al. 2015), under the 5000 ha land use change and 50% trading frictions assumption set, the environmental outcome is not as good as under the other sets of assumptions. Specifically for each of S1, S4 and S8, the agriculture system modelling predicts a total level of nitrogen load reduction for the 5000ha land use change and 50% trading frictions assumption set that is about 80% of that achieved under the other sets of assumptions. Presumably the less-costly nitrogen reduction options are implemented first, and thus the indicator produced for S8 under these assumptions is best overall.

Considering all of the sets of assumptions, S8 performs the best of the allocation options considered, closely followed by S1. S4 is clearly the least favourable allocation option when the possibility of trading frictions is considered. Under S4, considerable trading in nitrogen entitlements is required in order to achieve the optimum level of dairying in the catchment (see Parsons et al. 2015). However, when trading frictions are introduced this is not possible, resulting in quite substantially lower production of value added and employment in dairying compared with the other scenarios. With restricted trading, the farm system modelling also does not generate the same level of land conversion to forestry, particularly for S4.

Table 4.3 Annual Loss in New Zealand Industry Value Added per unit of Nitrogen Load Reduction ($/kg)

Sector	Sc enario 1	Scenario 4	Scenario 8
Optimum land use, no trading frictions	49	49	49
Optimum land use, 50% trading frictions	60	99	55
5000 ha land use change, no trading frictions	64	64	64
5000 ha land use change,50% trading frictions	54	73	45

4.2 Tourism-Related Impacts

Tables 4.4 and 4.5 describe the value added and employment impacts estimated for Rotorua District and New Zealand following a gain of 1%, 2% and 3% of tourism-related activities within Rotorua District. Of no surprise, it is particularly the service sectors that are positively impacted by a gain in tourism. When interpreting the employment results it is important to keep in mind that the employment indicator now used by Statistics New Zealand (i.e. the employment count or 'EC') does not account for part time employment. Thus an employee working part time is counted the same as an employee working full time. Many tourism oriented services, such as restaurants and hospitality, tend to employee a high proportion of part time workers.

Table 4.4 Annual Value Added Impacts due to Increase in Tourism ($mil)

Sector	Assumed increase in Rotorua District tourism					
	1%		2%		3%	
	Rotorua District	New Zealand	Rotorua District	New Zealand	Rotorua District	New Zealand
1 Sheep, beef & grain	0.0	0.0	0.0	0.0	0.0	0.0
2 Dairy farming	0.0	0.0	0.0	0.0	0.0	0.0
3 Forestry	0.0	0.0	0.0	0.0	0.0	0.0
4 Other primary	0.0	0.0	0.0	0.0	0.0	0.1
5 Agriculture and forestry support	0.0	0.0	0.0	0.0	0.0	0.0
6 Meat manufacturing	0.0	0.0	0.0	0.0	0.0	0.0
7 Dairy manufacturing	0.0	0.0	0.0	0.0	0.0	0.0
8 Wood and paper manufacturing	0.0	0.0	0.0	0.0	0.0	0.0
9 Other manufacturing	0.0	0.1	0.0	0.2	0.0	0.3
10 Utilities	0.0	0.0	0.0	0.1	0.0	0.1
11 Construction	0.0	0.0	0.0	0.1	0.0	0.1
12 Wholesale & retail trade	0.2	0.2	0.3	0.4	0.5	0.7
13 Transport	0.2	0.2	0.3	0.5	0.5	0.7
14 Scientific, professional & admin. s	0.1	0.3	0.2	0.5	0.3	0.8
15 Local & central government	0.0	0.0	0.0	0.0	0.0	0.0
16 Other services	0.9	1.2	1.9	2.5	2.8	3.7
Total	1.4	2.2	2.8	4.5	4.2	6.7

Table 4.5 Annual Employment Impacts due to Increase in Tourism (MECs)

Sector	Assumed increase in Bay of Plenty Region tourism					
	1%		2%		3%	
	Rotorua District	New Zealand	Rotorua District	New Zealand	Rotorua District	New Zealand
1 Sheep, beef & grain	0	0	0	0	0	0
2 Dairy farming	0	0	0	0	0	0
3 Forestry	0	0	0	0	0	0
4 Other primary	0	0	0	1	0	1
5 Agriculture and forestry support	0	0	0	0	0	0
6 Meat manufacturing	0	0	0	0	0	0
7 Dairy manufacturing	0	0	0	0	0	0
8 Wood and paper manufacturing	0	0	0	0	0	0
9 Other manufacturing	0	1	0	2	0	3
10 Utilities	0	0	0	0	0	0
11 Construction	0	1	1	1	1	2
12 Wholesale & retail trade	3	4	7	9	10	13
13 Transport	1	2	3	4	4	6
14 Scientific, professional & admin. servs	2	4	4	9	5	13
15 Local & central government	0	0	0	0	0	0
16 Other services	26	29	53	57	79	86
Total	34	43	67	85	101	128

4.3 Rotorua District Results

The appropriate management of nitrogen load reductions for the Lake Rotorua Catchment is a policy issue particularly pertinent to Rotorua District economy and its local government. To complete the results section we therefore provide a collation of the impacts, both those from Sections 4.1 and 4.2 at the district level.

Overall, the value added impacts stemming from changes in agriculture and forestry land management to reduce nitrogen loads (refer to Section 4.1 above) range from a loss of $2.0mil (S8, 5000 ha land use change and 50% trading friction) to $8.3mil (S4, optimum land use and no trading friction). These can be compared to impacts from tourism that range from a gain in total value added of $1.4mil (assuming a 1% increase in tourism) to a gain of $4.2mil (assuming a 3% increase in tourism) –see Table 4.4. Annual employment losses stemming from changes in agriculture and forestry land management to reduce nitrogen loads range from 45 MECs (S8, 5000 ha land use change and 50% trading friction) to 91 MECs (all scenarios, 5000 ha land use change and no trading friction). By comparison, employment gains from changes in tourism range from 34 MECs (assuming a 1% increase in tourism) to 101 MECs (assuming a 3% increase in tourism).

Similar to Table 4.3 above, Table 4.6 provides an estimate of the value added impacts per kg of nitrogen load reduced, for each of the scenarios and sets of assumptions evaluated. This time, however, the impacts are considered only for Rotorua District, the impacts are disaggregated by economic industry, and both farm-system and tourism related impacts are included. With optimal nitrogen trading and unrestricted land use change, all scenarios generate an annual estimated loss of value added of $9.5 per kg of N reduction for the district, as a result of farm-system changes. The estimated loss of value added per kg of N reduced is greater when taking into consideration restrictions on land use change and possible trading frictions. A maximum impact of $31.9 per kg of N reduced is estimated for Scenario 4, assuming 50% trading frictions.

By comparison, if tourism were to increase by (or experienced avoided losses of) 1% across the district, the gain (or avoided loss) in value added is calculated as $5.3 per kg of N reduced (these values do not change between the scenarios and different assumptions regarding land use change and trading frictions). It is, however, also important to note that the sectors which are most likely to benefit from a net gain in tourism activity are also those which are among the least impacted within the region from likely changes in farm systems as a result of N reduction policies. Importantly, just over half of the total tourism impact occurs within the two industries ‘accommodation’ and ‘food and beverage services’ (these are aggregated into the sector ‘other services’ for reporting), whereas for the farm-system impacts these same two industries account for only about 0.1% of the total loss in value added (assuming optimal land use and no trading frictions).

Once again allocation option S8 generally comes out as the most favourable option in terms of least impacts on total industry value added, across the range of assumptions investigated.

Table 4.6 Net Annual Change in Rotorua District Value Added per unit of Nitrogen Load Reduced, by Economic Industry ($/Kg)

Sector	Scenario 1			Scenario 4			Scenario 8		
	Farm-System Impacts[1]	Tourism Impacts[2]	Total	Farm-System Impacts[1]	Tourism Impacts[2]	Total	Farm-System Impacts[1]	Tourism Impacts[2]	Total
Optimum Land Use, no trading friction									
1 Sheep, beef & grain	-6.7	0.0	-6.7	-6.7	0.0	-6.7	-6.7	0.0	-6.7
2 Dairy farming	-13.8	0.0	-13.8	-13.8	0.0	-13.8	-13.8	0.0	-13.8
3 Forestry	10.5	0.0	10.5	10.5	0.0	10.5	10.5	0.0	10.5
4 Other primary	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 Agriculture and forestry support	-0.4	0.0	-0.4	-0.4	0.0	-0.4	-0.4	0.0	-0.4
6 Meat manufacturing	-0.1	0.0	-0.1	-0.1	0.0	-0.1	-0.1	0.0	-0.1
7 Dairy manufacturing	-0.8	0.0	-0.8	-0.8	0.0	-0.8	-0.8	0.0	-0.8
8 Wood and paper manufacturing	2.9	0.0	2.9	2.9	0.0	2.9	2.9	0.0	2.9
9 Other manufacturing	-0.2	0.0	-0.2	-0.2	0.0	-0.2	-0.2	0.0	-0.2
10 Utilities	-0.1	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0
11 Construction	0.4	0.1	0.5	0.4	0.1	0.5	0.4	0.1	0.5
12 Wholesale & retail trade	-0.4	0.6	0.2	-0.4	0.6	0.2	-0.4	0.6	0.2
13 Transport	-0.1	0.6	0.6	-0.1	0.6	0.6	-0.1	0.6	0.6
14 Scientific, profess. & admin. servs	-0.3	0.4	0.1	-0.3	0.4	0.1	-0.3	0.4	0.1
15 Local & central government	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1
16 Other services	-0.7	3.6	3.0	-0.7	3.6	3.0	-0.7	3.6	3.0
Total	-9.5	5.3	-4.2	-9.5	5.3	-4.2	-9.5	5.3	-4.2
Optimum land use, 50% trading friction									
1 Sheep, beef & grain	0.6	0.0	0.6	16.9	0.0	16.9	-0.3	0.0	-0.3
2 Dairy farming	-20.4	0.0	-20.4	-43.9	0.0	-43.9	-18.4	0.0	-18.4
3 Forestry	5.8	0.0	5.8	0.6	0.0	0.6	6.5	0.0	6.5
4 Other primary	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 Agriculture and forestry support	-0.4	0.0	-0.4	-0.4	0.0	-0.4	-0.4	0.0	-0.4
6 Meat manufacturing	0.1	0.0	0.1	0.5	0.0	0.5	0.1	0.0	0.1
7 Dairy manufacturing	-1.1	0.0	-1.1	-2.1	0.0	-2.1	-1.0	0.0	-1.0
8 Wood and paper manufacturing	1.6	0.0	1.6	0.2	0.0	0.2	1.8	0.0	1.8
9 Other manufacturing	-0.1	0.0	0.0	0.1	0.0	0.1	-0.1	0.0	-0.1
10 Utilities	-0.4	0.0	-0.4	-0.6	0.0	-0.6	-0.4	0.0	-0.4
11 Construction	1.1	0.1	1.1	1.5	0.1	1.5	1.0	0.1	1.1
12 Wholesale & retail trade	-0.4	0.6	0.2	-0.7	0.6	-0.1	-0.4	0.6	0.2
13 Transport	-0.2	0.6	0.5	-0.3	0.6	0.4	-0.1	0.6	0.5
14 Scientific, profess. & admin. servs	-0.2	0.4	0.1	-0.3	0.4	0.0	-0.2	0.4	0.1
15 Local & central government	-0.5	0.0	-0.5	-0.7	0.0	-0.7	-0.5	0.0	-0.4
16 Other services	-1.2	3.6	2.4	-2.6	3.6	1.0	-1.0	3.6	2.6
Total	-15.8	5.3	-10.4	-31.9	5.3	-26.6	-13.5	5.3	-8.2

Notes: 1. All impacts discussed in this report except those relating to tourism 2. Assuming a 1% increase in Rotorua District Tourism-Related Expenditure

Table 4.6 (continued) Net Annual Change in Rotorua District Value Added per unit of Nitrogen Load Reduced, by Economic Industry ($/Kg)

Sector	Scenario 1			Scenario 4			Scenario 8		
	Farm-System Impacts[1]	Tourism Impacts[2]	Total	Farm-System Impacts[1]	Tourism Impacts[2]	Total	Farm-System Impacts[1]	Tourism Impacts[2]	Total
5000 ha land use change, no trading friction									
1 Sheep, beef & grain	-2.4	0.0	-2.4	-2.4	0.0	-2.4	-2.4	0.0	-2.4
2 Dairy farming	-18.0	0.0	-18.0	-18.0	0.0	-18.0	-18.0	0.0	-18.0
3 Forestry	7.7	0.0	7.7	7.7	0.0	7.7	7.7	0.0	7.7
4 Other primary	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 Agriculture and forestry support	-0.7	0.0	-0.7	-0.7	0.0	-0.7	-0.7	0.0	-0.7
6 Meat manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 Dairy manufacturing	-1.0	0.0	-1.0	-1.0	0.0	-1.0	-1.0	0.0	-1.0
8 Wood and paper manufacturing	2.1	0.0	2.1	2.1	0.0	2.1	2.1	0.0	2.1
9 Other manufacturing	-0.2	0.0	-0.1	-0.2	0.0	-0.1	-0.2	0.0	-0.1
10 Utilities	-0.1	0.0	-0.1	-0.1	0.0	-0.1	-0.1	0.0	-0.1
11 Construction	0.5	0.1	0.6	0.5	0.1	0.6	0.5	0.1	0.6
12 Wholesale & retail trade	-0.5	0.6	0.1	-0.5	0.6	0.1	-0.5	0.6	0.1
13 Transport	-0.1	0.6	0.5	-0.1	0.6	0.5	-0.1	0.6	0.5
14 Scientific, profess. & admin. servs	-0.3	0.4	0.0	-0.3	0.4	0.0	-0.3	0.4	0.0
15 Local & central government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16 Other services	-1.0	3.6	2.6	-1.0	3.6	2.6	-1.0	3.6	2.6
Total	-14.1	5.3	-8.8	-14.1	5.3	-8.8	-14.1	5.3	-8.8
5000 ha land use change, 50% trading friction									
1 Sheep, beef & grain	5.6	0.0	5.6	12.8	0.0	12.8	4.8	0.0	4.8
2 Dairy farming	-21.6	0.0	-21.6	-31.7	0.0	-31.7	-18.3	0.0	-18.3
3 Forestry	4.4	0.0	4.4	-2.4	0.0	-2.4	4.6	0.0	4.6
4 Other primary	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 Agriculture and forestry support	-0.3	0.0	-0.2	0.4	0.0	0.4	-0.1	0.0	-0.1
6 Meat manufacturing	0.2	0.0	0.2	0.4	0.0	0.4	0.2	0.0	0.2
7 Dairy manufacturing	-1.1	0.0	-1.1	-1.6	0.0	-1.6	-1.0	0.0	-1.0
8 Wood and paper manufacturing	1.2	0.0	1.2	-0.2	0.0	-0.2	1.3	0.0	1.3
9 Other manufacturing	0.0	0.0	0.0	0.1	0.0	0.1	-0.1	0.0	0.0
10 Utilities	-0.3	0.0	-0.3	-0.4	0.0	-0.4	-0.3	0.0	-0.3
11 Construction	0.8	0.1	0.9	1.0	0.1	1.1	0.7	0.1	0.8
12 Wholesale & retail trade	-0.4	0.7	0.3	-0.6	0.7	0.2	-0.3	0.7	0.4
13 Transport	-0.1	0.8	0.7	-0.2	0.8	0.6	-0.1	0.8	0.7
14 Scientific, profess. & admin. servs	-0.2	0.5	0.2	-0.2	0.5	0.3	-0.2	0.5	0.3
15 Local & central government	-0.2	0.0	-0.2	-0.3	0.0	-0.3	-0.2	0.0	-0.1
16 Other services	-1.0	4.6	3.6	-2.1	4.6	2.5	-0.7	4.6	3.8
Total	-13.0	6.7	-6.3	-25.0	6.7	-18.2	-9.7	6.7	-3.0

Notes: 1. All impacts discussed in this report except those relating to tourism 2. Assuming a 1% increase in Rotorua District Tourism-Related Expenditure

5 Conclusion

To limit the deterioration of the water quality in Lake Rotorua, a nitrogen limit of 435tNyr^{-1} has been set by the BoPRC Policy Statement. This target requires a total reduction of 320tNyr^{-1} with approximately 280tNyr^{-1} arising from the pastoral sector. Using input-output analysis this report calculates economic impacts, in terms of changes in industry value added and employment, for the district, regional and national economies arising out of changes in agriculture and forestry land use and practices to meet the nitrogen load targets. Assuming land owners fully optimise by way of land use change and nitrogen right trading, an annual value added loss of $12.9 mil is estimated for the New Zealand economy, with $3.4 mil originating from within the Bay of Plenty Region and $2.5 from the Rotorua District. These impacts equate to approximately 0.09% of the economy at the district level, 0.03% at the regional level, and 0.01% at the national level.

Three alternative scenarios pertaining to initial allocation of nitrogen discharge rights among land owners have been considered in this report. These are a subset of the eight allocation scenarios investigated by the farm system modelling. Consistently, allocation option S8 (i.e. 'sector ranges') performs the best. Across the range of different assumptions trialled regarding land use change and trading efficiency, losses in value added/ employment are either lower or equal to the other two scenarios.

To help place the impacts arising out of changes in agriculture and forestry systems in context, and to explore some of the positive impacts on the economy arising out of reduced nitrogen accumulation, this report has also calculated possible changes in value added and employment arising from increased tourism. Conceptually, positive tourism impacts may arise from both increased visitors/tourist spending within the Rotorua District, or avoided losses in visitors/tourist spending. At the total district level, the analysis shows that a 1% gain in tourism within the Rotorua District will offset the losses at the district level arising from changes in farm systems by approximately 56 percent (assuming optimum land use change and no trading frictions). There are, however, significant differences in the distribution of impacts across economic industries, with the service sectors benefitting in particular from increased tourism activities and the primary sectors receiving relatively little benefit.

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Appendix A Industry Concordance

Table A.1 Concordance between Input-Output Industries and Reporting Industries

106 Input-Output Industry	Reporting Industry
1 Horticulture and fruit growing	4 Other primary
2 Sheep, beef cattle and grain farming	1 Sheep, beef & grain
3 Dairy cattle farming	2 Dairy farming
4 Poultry, deer and other livestock farming	4 Other primary
5 Forestry and logging	3 Forestry
6 Fishing and aquaculture	4 Other primary
7 Agriculture, forestry and fishing support services	5 Agriculture and forestry support
8 Coal mining	4 Other primary
9 Oil and gas extraction	4 Other primary
10 Metal ore and non-metallic mineral mining and quarrying	4 Other primary
11 Exploration and other mining support services	16 Other services
12 Meat and meat product manufacturing	6 Meat and meat product manufacturing
13 Seafood processing	6 Meat and meat product manufacturing
14 Dairy product manufacturing	7 Dairy product manufacturing
15 Fruit, oil, cereal and other food product manufacturing	9 Other manufacturing
16 Beverage and tobacco product manufacturing	9 Other manufacturing
17 Textile and leather manufacturing	9 Other manufacturing
18 Clothing, knitted products and footwear manufacturing	9 Other manufacturing
19 Wood product manufacturing	8 Wood and paper manufacturing
20 Pulp, paper and converted paper product manufacturing	8 Wood and paper manufacturing
21 Printing	9 Other manufacturing
22 Petroleum and coal product manufacturing	9 Other manufacturing
23 Basic chemical and basic polymer manufacturing	9 Other manufacturing
24 Fertiliser and pesticide manufacturing	9 Other manufacturing
25 Pharmaceutical, cleaning and other chemical manufacturing	9 Other manufacturing
26 Polymer product and rubber product manufacturing	9 Other manufacturing
27 Non-metallic mineral product manufacturing	9 Other manufacturing
28 Primary metal and metal product manufacturing	9 Other manufacturing
29 Fabricated metal product manufacturing	9 Other manufacturing
30 Transport equipment manufacturing	9 Other manufacturing
31 Electronic and electrical equipment manufacturing	9 Other manufacturing
32 Machinery manufacturing	9 Other manufacturing
33 Furniture manufacturing	9 Other manufacturing
34 Other manufacturing	9 Other manufacturing
35 Electricity generation and on-selling	10 Utilities
36 Electricity transmission and distribution	10 Utilities
37 Gas supply	10 Utilities
38 Water supply	10 Utilities
39 Sewerage and drainage services	10 Utilities
40 Waste collection, treatment and disposal services	10 Utilities
41 Residential building construction	11 Construction
42 Non-residential building construction	11 Construction
43 Heavy and civil engineering construction	11 Construction
44 Construction services	11 Construction
45 Basic material wholesaling	12 Wholesale and retail trade
46 Machinery and equipment wholesaling	12 Wholesale and retail trade
47 Motor vehicle and motor vehicle parts wholesaling	12 Wholesale and retail trade
48 Grocery, liquor and tobacco product wholesaling	12 Wholesale and retail trade
49 Other goods and commission based wholesaling	12 Wholesale and retail trade
50 Motor vehicle and parts retailing	12 Wholesale and retail trade
51 Fuel retailing	12 Wholesale and retail trade
52 Supermarket and grocery stores	12 Wholesale and retail trade

Table A.2 (continued) Concordance between Input-Output Industries and Reporting Industries

106 Input-Output Industry	Reporting Industry
53 Specialised food retailing	12 Wholesale and retail trade
54 Furniture, electrical and hardware retailing	12 Wholesale and retail trade
55 Recreational, clothing, footwear and personal accessory retai	12 Wholesale and retail trade
56 Department stores	12 Wholesale and retail trade
57 Other store based retailing; non-store and commission based	12 Wholesale and retail trade
58 Accommodation	16 Other services
59 Food and beverage services	16 Other services
60 Road transport	13 Transport
61 Rail transport	13 Transport
62 Other transport	13 Transport
63 Air and space transport	13 Transport
64 Postal and courier pick up and delivery services	13 Transport
65 Transport support services	13 Transport
66 Warehousing and storage services	16 Other services
67 Publishing (except internet and music publishing)	16 Other services
68 Motion picture and sound recording activities	16 Other services
69 Broadcasting and internet publishing	16 Other services
70 Telecommunications services including internet service prov	16 Other services
71 Library and other information services	16 Other services
72 Banking and financing; financial asset investing	16 Other services
73 Life insurance	16 Other services
74 Health and general insurance	16 Other services
75 Superannuation funds	16 Other services
76 Auxiliary finance and insurance services	16 Other services
77 Rental and hiring services (except real estate); non-financial	16 Other services
78 Residential property operation	16 Other services
79 Non-residential property operation	16 Other services
80 Real estate services	16 Other services
81 Owner-occupied property operation	16 Other services
82 Scientific, architectural and engineering services	14 Scientific, professional and adminstrative services
83 Legal and accounting services	14 Scientific, professional and adminstrative services
84 Advertising, market research and management services	14 Scientific, professional and adminstrative services
85 Veterinary and other professional services	14 Scientific, professional and adminstrative services
86 Computer system design and related services	14 Scientific, professional and adminstrative services
87 Travel agency and tour arrangement services	14 Scientific, professional and adminstrative services
88 Employment and other administrative services	14 Scientific, professional and adminstrative services
89 Building cleaning, pest control and other support services	14 Scientific, professional and adminstrative services
90 Local government administration	15 Local and central government
91 Central government administration and justice	15 Local and central government
92 Defence	15 Local and central government
93 Public order, safety and regulatory services	15 Local and central government
94 Preschool education	16 Other services
95 School education	16 Other services
96 Tertiary education	16 Other services
97 Adult, community and other education	16 Other services
98 Hospitals	16 Other services
99 Medical and other health care services	16 Other services
100 Residential care services and social assistance	16 Other services
101 Heritage and artistic activities	16 Other services
102 Sport and recreation activities	16 Other services
103 Gambling activities	16 Other services
104 Repair and maintenance	16 Other services
105 Personal services; domestic household staff	16 Other services
106 Religious services; civil, professional and other interest grou|	16 Other services

Appendix B Key Assumptions in Farm System Modelling

Perrin Ag Consultants Limited
Box 596 Rotorua
1330 Eruera Street
Rotorua, New Zealand
Ph 07 3491212, Fax 07 349 1112
consult@perrinag.net.nz
www.perrinag.net.nz

MEMORANDUM

TO: Bay of Plenty Regional Council
FROM: Perrin Ag Consultants Ltd
DATE: 5 August 2015
SUBJECT: Methodology for farm-level modelling for Rotorua N-reduction economic impacts project

1. Background

1.1 In order to derive profit-N leaching relationships for a range of pastoral activity across the twelve geo-physical zones in the catchment in the Rotorua catchment, a two stage process was utilised.

1.1.1 These geophysical zones, as prescribed by the Bay of Plenty Regional Council ("BOPRC"), comprised the four main soil orders found in the catchment, two slope classes and, if the range in rainfall across a soil order was broad enough, a delineation for either high or low rainfall. The boundary that defined the high and low rainfall bands varied for the pumice (1,900mm) and podzol soils (2,000mm), as did the nominal delineation of the slope classes for dairy (13°) and drystock (16°) sectors. Each zone was defined on the basis of the parameters and associated nomenclature in Table 1 below i.e. the geophysical zone consisting of a podzol (Po) soil receiving 2200mm (H) of rainfall annually with an average slope of 8° (1) would be defined as **Po1H**.

Table 1: Lake Rotorua geophysical parameters and nomenclature

<table>
<tr><th>Soil type</th><th colspan="2">Slope class</th><th colspan="2">Rainfall band</th></tr>
<tr><td>Allophanic (Al)</td><td rowspan="4">Gentle (1)</td><td rowspan="4">Steep (2)</td><td colspan="2" rowspan="2">n/a</td></tr>
<tr><td>Recent (Re)</td></tr>
<tr><td>Podzol (Po)</td><td rowspan="2">Low (L)</td><td rowspan="2">High (H)</td></tr>
<tr><td>Pumice (Pu)</td></tr>
</table>

1.2 Baseline status quo models of representative dairy and dry stock farming operations were developed in Farmax and Overseer software, with the Farmax models based on actual farming enterprises within the catchment's geophysical zones. The profit forecasting functionality within Farmax was utilised to estimate the annual operating profit generated from each of these systems. Medium term pricing expectations for used for forecasting income, while operating expenses were based on representative industry averages, moderated for locality and system specific variance as necessary.

1.3 A cumulative stepwise N-loss mitigation protocol was then applied to each representative farm system, with a scenario run created for each mitigation that was deemed applicable to the system. The dairy and dry stock mitigation protocols had been previously developed by a group of industry professionals (including the author, DairyNZ & Beef+Lamb NZ) on the basis of how it was perceived farmers in the catchment might rationally apply sequential changes to their system to reduce N loss to water, in the context of both their likely commercial and emotional reality.

1.4 This simulated change process was constrained by an assumption that farm productivity was limited to the existing management capability represented by each modelled farm system. This constraint was captured in the step-wise modelling process by excluding system responses that would result from improved pasture management/utilisation. This was typically expressed as an inability to increase per head performance in response to the need to reduce stocking rate. The singular exception to this was where the potential to lamb ewe hoggets and reduce ewe numbers was deemed to be a viable mitigation, in which case the feed intake and productivity of the ewe hogget obviously increased. This assumed that the decision to mate or not mate ewe lambs was based on farmer preference, rather than any perception that lambing ewe hoggets required an increase in management ability.

1.5 Accordingly neither the baseline status quo nor mitigated farm models are "optimised" for profit or nutrient use efficiency.

1.6 The step-wise mitigation protocol for both the dairy and dry stock models are presented in Figure 1and Figure 2 below.

Dairy

1 Baseline

Contain production losses

2 Remove summer crop, replace with supplements
3 Reduce autumn N application (if any), replace with appropriate low(er) N feed
4 Cull early as feed demand allows (10% culls early Feb, 10% culls early March)
5 Replace high N feed (imported pasture, PKE) with low N feed (maize silage) as appropriate

Reduce supplement up to 20% reduction, targeting lower value feed and autumn feed first, reduce SR/production

6.1 20% autumn feed reduction
6.2 20% spring supplement reduction
6.3 Reduce spring fert to deliver annual N use to 100kg N/ha
6.4 Reduce winter supplement by 20%

7 Retire marginal land and decrease SR (assume 5% marginal)

Figure 1: Dairy step-wise mitigation protocol

1.7 This process resulted in series of paired Farmax and Overseer outputs that could be analysed for changes in N leaching to water and financial performance (as measured by operating profit).

1.8 This output could then be utilised to derive the quantitative relationship between the application of likely sequential mitigations on farm systems and farm operating profit.

Drystock

1 Baseline

2 Reduce N that supports capital livestock (i.e. primarily maintenance feed demand)
3 Reduce winter cropping providing it doesn't affect dairy support enteprise (if any)
4 Lamb hoggets and decrease ewe numbers
5 Decrease dairy young stock (R1, R2), replace with bulls or steers as appropriate. For sole dairy support system, remove calf grazing (R1) only.
6 Remove wintering dairy cows. Increase other stock numbers
7 Graze any dry hoggets off
8 Increase sheep: cattle ratio - limit of 70% sheep

Figure 2: Drystock step-wise mitigation protocol

1.9 A total of 7 representative dairy models and 36 representative dry stock models were developed to cover the sector spread within the geophysical zones in the catchment. Each model was then run through the entire step-wise mitigation protocol. This resulted in 54 dairy scenarios and 111 dry stock scenarios in addition to the baseline models. A total of paired 208 Farmax and Overseer files were created.

2. Establishment of baseline models

2.1 Dairy systems

2.1.1 Dairy farm activity was identified via BOPRC data to have the potential to occur within 7 geophysical zones – 6 zones where dairying currently or recently occurred and one zone where future land use change to dairy was considered viable

2.1.2 Analysis of the "current areas" of milking platform (including effluent and any contiguous cropping areas to support dry or milking dairy cows) of Rotorua dairy farms was undertaken to establish an appropriate average size for the seven dairy farm models developed. Utilising the most accurate data available to the author, the average size of milking platform in the Rotorua area comprised 219ha (range 48ha to 633ha). As discussed with DairyNZ, this average milking platform was to be used as the basis for the baseline Farmax models generated for the seven representative dairy systems modelled.

2.1.3 Real farms that DairyNZ and the author agreed as being the most representative of all farms in each identified geo-physical zone were then modelled in Farmax as they currently exist. This was possible for five of the geo-physical zones, being Al1, Pu1H, Po1H, Po2H and Pu2. Where replacement yearling heifers were grazed on contiguous land owned by the farm that wasn't milked off, heifers were treated as being grazed off farm for the purposes of modelling, given dairy heifer grazing is captured in the drystock systems modelling. Land area was then increased up to or down to 219ha (with associated activities like silage making and cropping pro-rated accordingly) utilising the "scale" function in Farmax. Stock numbers and pasture management were then scaled up or down, again utilising the "scale" functionality in Farmax, to deliver identical level of feasibility. Systems were then reviewed to ensure stocking rates and per cow production were consistent with the original farm systems.

2.1.4 Hypothetical farms were then created for the Re1 and Pu1L zones. For the Re1 zone, where there had previously been dairying activity up until 2007, a model was created based on real historical farm performance to derive pasture growth parameters. The farm system was then adjusted to reflect reasonable changes that were likely to have occurred with the production system in the intervening 7 years.

2.1.5 For the Pu1L zone, where no singular dairying enterprise exists but such future activity was deemed feasible, pasture growth parameters were derived based on an average between the Re1 and Pu1H models, subsequently adjusted to ensure relativity with the Pu2 pasture growth model and altitude differences with Re1. This pasture growth curve was then applied to the Re1 model (given the physical characteristics would be similar) and the production system adjusted to reflect the higher summer pasture growth.

2.1.6 Note that average slope for Pu2, is >13°, based on the actual data from what is recognised as the steepest farm in the catchment.

2.1.7 Cost and revenue assumptions used for forecasting the financial performance of these systems in Farmax were primarily based off the 2012/13 Central Plateau Owner-Operator benchmark from DairyBase data. Where necessary, these were moderated to reflect justifiable deviations from the benchmark average within specific farm models, predominantly the Pu2 geophysical zone. This essentially resulted in two sets of broad financial assumptions; one specific to the dairy activity in the Pu2 zone (which supports a more extensive and lower production dairy system) and one for the remainder of the dairy farm systems, which were considered more homogeneous in nature.

2.1.8 These operating cost structures were used to create two "Farmax expense plans" which were then applied consistently across the models based on their underlying system parameters.

2.1.9 A milk price of $6/kg MS was used for determining dairy farm milk revenue, while an appropriate medium term price expectation for manufacturing beef was applied to the normal seasonal schedule distributions in Farmax. The milk price used reflected both the nominal average Fonterra milk price ($6.07/kg MS)[1] for the period 2006/07 through 2014/15 and the fact that the real (CPI adjusted) NZ milk price since 1975 is just under $6/kg MS[2].

2.1.10 All of the financial assumptions are summarised in Appendix 1 below.

2.1.11 These baseline farm systems were then modelled in Overseer™6.1.3, utilising geophysical data representative of the midpoint of the rainfall bands of the geophysical zones to assign appropriate climate data to the models. Soil orders, rather than individual soil types, were utilised to allocate soil characteristics in Overseer, with the exception of anion storage

[1] Source: interest.co.nz and Fonterra Cooperative Group Ltd

[2] LIC, BERL 2015

capacity ("ASC"), which was manually input to reflect local conditions specific to each farm model.

2.2 *Drystock systems*

2.2.1 Given the significant number of possible combinations of operating system and geo-physical zone within the Rotorua catchment, a simplified process was undertaken to derive representative models for each combination.

2.2.2 Three real farms were modelled in Farmax to derive both realistic pasture growth curves for areas of differing slope within the catchment and physical performance parameters for three base operating policies – sheep & beef cattle, sheep and dairy support and dairy support. These were then applied across all six geo-physical zones and two slope classes by way of a varying pasture growth curve for each slope and soil & rain interaction. The models were also adjusted on the basis of an assumption that the wintering of dairy cows only occurs where average slope is <16°, beef cows replace beef finishing as a policy above 16° and that the mowable area comprised no more than 15% of total farm area for properties with >16° average slope. This resulted in six different representative farm systems for the catchment.

Table 2: Livestock policies modelled for the representative farm models

	Sheep/Beef ("SB")	Sheep/Dairy ("SD")	Dairy Support ("DS")
Slope low (<16°) ("L")	Breeding ewes Beef cattle for finishing	Breeding ewes Dairy heifers Wintering dairy cows	Dairy heifers Wintering dairy cows
Slope high (>16°) ("H")	Breeding ewes Beef cows	Breeding ewes Dairy heifers	Dairy heifers

2.2.3 Beef+Lamb NZ data for Class 3, 4and 5 farms from the 2014/15 Beef + Lamb Economic Service Sheep & Beef Farm Survey was then used to set both the modal property size and to inform the operating expense parameters used in Farmax[3] for the low and high slope class non-dairy support sheep & cattle farm models for the Rotorua catchment, as presented in Table 3 below. For the dairy support properties, due to their small size and specialist activity, both sets of parameters were adapted from Class 5 Beef+Lamb NZ survey data and then moderated where applicable using actual farm data from the catchment used as the basis of the models. The operating cost structures were used to create four "Farmax expense plans" which were then applied consistently across the models based on their underlying system parameters.

[3] Farmax defaults, adjusted by the author for local market conditions were used for variable farm expenses determined by functionality in the Farmax model (such as crop costs, direct stock expenses etc)

Table 3: Source of representative model farm size and operating cost structure ("Farmax expense plans")

	Sheep/Beef ("SB")	Sheep/Dairy ("SD")	Dairy Support ("DS")
Slope low (<16°) ("L")	BLES Class 4 survey	BLES Class 5 survey	BLES Class 5 survey, Perrin Ag Consultants
Slope high (>16°) ("H")	BLES Class 3 survey	BLES Class 4 survey	

2.2.4 Medium term revenue expectations were applied to the normal seasonal schedule distributions in Farmax for sheep meat ($5.50/kg), beef ($4.20/kg base price) and wool ($3.40/kg). These are summarised, along with the operating expense parameters and how they were applied, in Appendix 2 to Appendix 6 below. Note that analysis was also completed for a second base beef price ($3.75/kg).

2.2.5 These baseline farm systems were then modelled in Overseer™6.1.3, utilising geophysical data representative of the midpoint of the rainfall bands of the geophysical zones. As with the dairy farm models, soil orders, rather than individual soil types, were utilised to allocate soil characteristics in Overseer, with the exception of anion storage capacity ("ASC"), which was manually input to reflect local conditions specific to each farm model.

2.2.6 We note that no deer farm systems were modelled. Deer were excluded from the project brief due to the small proportion of deer that are farmed in the catchment as a proportion of other drystock systems. We note, however, that the economic outcomes from lowering nitrate leaching from a deer farm system was modelled in the BOPRC funded 2014 NDA Impact Analysis Project.

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Appendix 1: Dairy operating expense assumptions

Expense item	Applied	All except PU2	Pu2
Wages	/cow	$ 256.00	$ 256.00
Management Wage	/cow	$ 105.00	$ 105.00
Electricity	/cow	$ 42.00	$ 42.00
Fertiliser (Excl. N)	/kg MS	$ 0.51	$ 0.64
Weed & Pest	/ha	$ 34.00	$ 34.00
Vehicles	/ha	$ 169.00	$ 40.00
Fuel	/ha	$ 73.00	$ 37.00
R&M Land & Buildings	/ha	$ 274.00	$ 147.00
R&M Plant & Equipment	/ha	$ 72.00	$ 46.00
Freight	/cow	$ 23.00	$ 23.00
Administration	/ha	$ 142.00	$ 142.00
Insurance	/ha	$ 62.00	$ 40.00
ACC	/ha	$ 21.00	$ 21.00
Rates	/ha	$ 107.00	$ 63.00
Depreciation	/ha	$ 317.00	$ 237.00

Source 1: DairyBase 2012/13 Central Plateau Owner Operator Survey

Animal Health Costs

Stock Class	$ / hd / yr
Heifer Calf	35.00
1-Year Heifer	35.00
2-Year Heifer	67.50
Cow	67.50
Bull Calf	18.00
1-Year Bull	8.00
2-Year Bull	7.00
Bull	20.00

Source 2: Farmax 2014

Breeding Costs

AI	25.00	$/submission
ET	250.00	$/submission
Sexed Semen	50.00	$/submission

Source: Farmax 2014

Nitrogen Fertiliser

Nitrogen Cost	1.80	$/kg N
	828	$/t Urea

Source: Perrin Ag Consultants 2014

Regrassing

Regrassing cost ($/ha)	600

OK Cancel

Source: Perrin Ag Consultants 2014

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Dairy feed assumptions

Name	Class	Units	Unit Size	Dry Matter	Energy	Default Yield	Cash Price	Production Cost	
			kg/unit	%	MJME/kgDM	units/ha	$	$/ha	$/unit
Pasture Silage	Conserved	tonnes DM	1,000	100	10.0	2.0	210.00	450.00	
Maize Silage	Harvested Crop	tonnes DM	1,000	100	10.8	22.0	320.00	3,600.00	
Annual ryegrass	Grazed Crop	tonnes DM	1,000	100	12.5			1,200.00	
Kale	Grazed Crop	tonnes	1,000	100	11.5	13.0		1,259.00	
Swedes	Grazed Crop	tonnes DM	1,000	100	12.8	15.0		1,259.00	
Turnips	Grazed Crop	tonnes DM	1,000	100	12.0	12.0		1,259.00	
Maize Silage bought	Bought	tonnes DM	1,000	100	10.8	22.0	320.00	2,700.00	60.00
Palm Kernel	Bought	tonnes	1,000	90	11.0		250.00		
Pasture Silage bought	Bought	tonnes DM	1,000	100	10.0	2.0	340.00		110.00
PKE with Canola	Bought	tonnes DM	1,000	90	12.0		380.00		
Calf Meal	Calf Feed	tonnes	1,000	89	13.0		650.00		
Colostrum/Milk	Calf Feed	litres	1	100	3.2				
Milk Replacer	Calf Feed	litres	1	100	3.2		0.40		

Source: Farmax 2014, Perrin Ag Consultants 2014

Appendix 2: Sheep revenue assumptions for a $5.50/kg base schedule

FARMAX YOUR ADVANTAGE

Sheep Prices Prices / kg for Rotorua

Prices / kg												
Works ($/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
17 kg PM Lamb	6.16	6.00	5.50	5.12	5.01	4.95	5.01	5.22	5.45	5.61	5.89	6.11
24 kg Sheep	2.96	2.76	2.53	2.35	2.25	2.33	2.50	2.46	2.72	2.80	2.94	3.11
Store ($/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
Ewe Lamb	2.59	2.52	2.25	2.15	2.15	2.13	2.15	2.25	2.29	2.41	2.59	2.75
Ewe Hogget	2.83	2.82	2.64	2.46	2.20	1.98	1.90	1.83	1.96	2.24	2.71	2.81
MA Ewe	2.22	2.22	2.04	1.43	1.40	1.39	1.40	1.46	1.58	1.68	2.06	2.14
Ram Lamb	2.77	2.64	2.37	2.30	2.25	2.23	2.25	2.35	2.40	2.52	2.77	2.87
Ram Hogget	4.25	4.38	4.29	2.51	2.50	2.57	2.85	3.03	3.21	3.37	3.65	3.85
MA Ram	7.45	7.25	7.59	8.34	8.51	8.61	8.91	8.36	8.17	7.80	7.77	7.57
Wether Lamb	2.71	2.58	2.37	2.25	2.20	2.18	2.20	2.30	2.34	2.47	2.71	2.81
Wether Hogget	2.34	2.22	2.04	1.94	2.05	2.03	2.00	2.19	2.34	2.52	2.59	2.44
MA Wether	1.97	2.04	1.76	1.59	1.80	1.83	1.85	1.67	1.74	1.80	1.82	1.71

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Sheep Prices Charges for Rotorua

Charges				
	Transport $/head	**Commission** % of gross	**Headage** $/head	**Killing** $/head
Purchases	1.50			
Store Sales		5.50		
Works Sales				2.00

FARMAX YOUR ADVANTAGE

Sheep Prices Relativities for Rotorua

Relativities												
Works (/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
17 kg PM Lamb	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
24 kg Sheep	0.48	0.46	0.46	0.46	0.45	0.47	0.50	0.47	0.50	0.50	0.50	0.51
Store (/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
Ewe Lamb	0.42	0.42	0.41	0.42	0.43	0.43	0.43	0.43	0.42	0.43	0.44	0.45
Ewe Hogget	0.46	0.47	0.48	0.48	0.44	0.40	0.38	0.35	0.36	0.40	0.46	0.46
MA Ewe	0.36	0.37	0.37	0.28	0.28	0.28	0.28	0.28	0.29	0.30	0.35	0.35
Ram Lamb	0.45	0.44	0.43	0.45	0.45	0.45	0.45	0.45	0.44	0.45	0.47	0.47
Ram Hogget	0.69	0.73	0.78	0.49	0.50	0.52	0.57	0.58	0.59	0.60	0.62	0.63
MA Ram	1.21	1.21	1.38	1.63	1.70	1.74	1.78	1.60	1.50	1.39	1.32	1.24
Wether Lamb	0.44	0.43	0.43	0.44	0.44	0.44	0.44	0.44	0.43	0.44	0.46	0.46
Wether Hogget	0.38	0.37	0.37	0.38	0.41	0.41	0.40	0.42	0.43	0.45	0.44	0.40
MA Wether	0.32	0.34	0.32	0.31	0.36	0.37	0.37	0.32	0.32	0.32	0.31	0.28

Source: Farmax 2014, Perrin Ag Consultants 2014

Appendix 3: Bull beef revenue assumptions for a $4.20/kg base beef schedule

FARMAX — Bull Beef Prices Prices / kg for Rotorua

Prices / kg												
Works ($/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
295 kg M Bull	4.54	4.37	4.16	4.03	3.95	3.95	3.95	4.03	4.16	4.28	4.45	4.54
Store ($/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
R1 Bull	4.81	4.32	3.91	3.75	3.55	2.92	2.57	2.46	2.45	2.61	2.76	2.68
R2 Bull	2.54	2.36	2.29	2.14	2.05	2.01	2.01	1.98	2.00	2.23	2.45	2.45
MA Bull	2.54	2.40	2.29	2.14	2.05	2.01	2.01	1.98	2.00	2.23	2.49	2.45

FARMAX — Bull Beef Prices Charges for Rotorua

Charges	**Transport** $/head	**Commission** % of gross	**Headage** $/head	**Killing** $/head
Purchases	12.00			
Store Sales		5.50		
Works Sales				32.35

FARMAX — Bull Beef Prices Relativities for Rotorua

Relativities												
Works (/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
295 kg M Bull	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Store (/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
R1 Bull	1.06	0.99	0.94	0.93	0.90	0.74	0.65	0.61	0.59	0.61	0.62	0.59
R2 Bull	0.56	0.54	0.55	0.53	0.52	0.51	0.51	0.49	0.48	0.52	0.55	0.54
MA Bull	0.56	0.55	0.55	0.53	0.52	0.51	0.51	0.49	0.48	0.52	0.56	0.54

Source: Farmax 2014, Perrin Ag Consultants 2014

Appendix 4: Prime beef revenue assumptions for a $4.20/kg base beef schedule

Prime Beef Prices Prices / kg for Rotorua

Prices / kg												
Works ($/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
295 kg M Steer	4.74	4.52	4.35	4.18	4.13	4.09	4.05	4.13	4.26	4.39	4.61	4.74
220 kg LT Heifer	4.69	4.43	4.22	4.13	4.05	4.01	3.96	4.09	4.09	4.26	4.66	4.74
230 kg M Cow	3.70	3.57	3.39	3.26	3.22	3.19	3.12	3.14	3.37	3.51	3.73	3.75
Store ($/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
R1 Heifer	2.75	2.62	2.52	2.42	2.40	2.41	2.27	2.23	2.26	2.37	2.54	2.56
R2 Heifer	2.56	2.53	2.48	2.34	2.23	2.13	2.02	1.98	2.05	2.15	2.26	2.32
MA Cow	1.90	1.95	1.83	1.67	1.78	1.68	1.86	1.82	1.88	1.89	1.84	1.85
R1 Steer	3.32	3.17	3.04	2.92	2.89	2.86	2.71	2.64	2.64	2.77	2.95	2.94
R2 Steer	2.80	2.58	2.52	2.38	2.36	2.29	2.23	2.15	2.17	2.28	2.49	2.56
MA Steer	2.70	2.49	2.39	2.30	2.27	2.25	2.18	2.15	2.17	2.28	2.49	2.56

Prime Beef Prices Charges for Rotorua

Charges				
	Transport $/head	**Commission** % of gross	**Headage** $/head	**Killing** $/head
Purchases	12.00			
Store Sales		5.50		
Works Sales				32.35

Prime Beef Prices Relativities for Rotorua

Relativities												
Works (/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
295 kg M Steer	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
220 kg LT Heifer	0.99	0.98	0.97	0.99	0.98	0.98	0.98	0.99	0.96	0.97	1.01	1.00
230 kg M Cow	0.78	0.79	0.78	0.78	0.78	0.78	0.77	0.76	0.79	0.80	0.81	0.79
Store (/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
R1 Heifer	0.58	0.58	0.58	0.58	0.58	0.59	0.56	0.54	0.53	0.54	0.55	0.54
R2 Heifer	0.54	0.56	0.57	0.56	0.54	0.52	0.50	0.48	0.48	0.49	0.49	0.49
MA Cow	0.40	0.43	0.42	0.40	0.43	0.41	0.46	0.44	0.44	0.43	0.40	0.39
R1 Steer	0.70	0.70	0.70	0.70	0.70	0.70	0.67	0.64	0.62	0.63	0.64	0.62
R2 Steer	0.59	0.57	0.58	0.57	0.57	0.56	0.55	0.52	0.51	0.52	0.54	0.54
MA Steer	0.57	0.55	0.55	0.55	0.55	0.55	0.54	0.52	0.51	0.52	0.54	0.54

Source: Farmax 2014, Perrin Ag Consultants 2014

Appendix 5: Other drystock revenue assumptions used

FARMAX	Dairy grazing contract		
Age (months)	**Grazing Fee ($/hd/week)**	**Age (months)**	**Grazing Fee ($/hd/week)**
0 - 4	6.50	15	8.50
5	6.50	16	8.50
6	6.50	17	8.50
7	6.50	18	8.50
8	6.50	19	8.50
9	6.50	20	8.50
10	8.50	21	8.50
11	8.50	22	28.00
12	8.50	23	28.00
13	8.50	24 +	28.00
14	8.50		

Source: Perrin Ag Consultants 2014

FARMAX	Wool and Velvet Prices	
Wool Prices		
Crossbred Lamb	3.50	$ / kg Greasy
Crossbred Hogget	3.60	$ / kg Greasy
Crossbred Adult	3.40	$ / kg Greasy
Superfine Lamb	9.40	$ / kg Greasy
Superfine Hogget	9.40	$ / kg Greasy
Superfine Adult	8.45	$ / kg Greasy
Ultrafine Lamb	11.16	$ / kg Greasy
Ultrafine Hogget	11.16	$ / kg Greasy
Ultrafine Adult	9.55	$ / kg Greasy
Velvet Prices		
Spiker	40.00	$ / kg
2-year	45.00	$ / kg
Adult	50.00	$ / kg

Source: Farmax 2014

Appendix 6: Drystock operating expense assumptions

Expense item	Applied	Class 3	Class 4	Class 5	Dairy support
Wages	/SU	$ 19.00	$ 19.00	$ 19.00	$ 19.00
Fertiliser (Excl. N & Lime)	/SU	$ 11.00	$ 13.47	$ 12.50	$ 13.00
Nitrogen					
Lime	/SU	$ 0.40	$ 1.00	$ 1.30	$ 1.30
Weed & Pest Control	/SU	$ 0.75	$ 1.17	$ 1.17	$ 1.17
Vehicle Expenses	/ha	$ 14.00	$ 29.30	$ 37.00	$ 37.00
Fuel	/ha	$ 16.00	$ 25.00	$ 38.00	$ 38.00
Repairs & Maintenance	/ha	$ 48.00	$ 64.21	$ 75.00	$ 75.00
Freight & Cartage	/SU	$ 0.70	$ 1.67	$ 1.60	$ 1.60
Electricity	/SU	$ 0.86	$ 0.86	$ 1.05	$ 1.05
Other Expenses	/SU	$ 0.60	$ 0.60	$ 0.60	$ 0.60
Administration Expenses	/ha	$ 17.00	$ 29.19	$ 34.00	$ 34.00
Insurance	/ha	$ 13.97	$ 13.97	$ 18.00	$ 18.00
ACC Levies	/SU	$ 0.46	$ 0.46	$ 0.87	$ 0.87
Rates	/SU	$ 2.00	$ 2.00	$ 4.00	$ 4.00
Depreciation	/ha	$ 26.81	$ 52.62	$ 70.00	$ 70.00

Source: Beef+Lamb Economic Service Survey 2014, Perrin Ag Consultants Ltd

Animal Health Costs (excl. Velveting)

Sheep	$ / hd / yr	Beef	$ / hd / yr	Deer	$ / hd / yr
Ewe Lamb	2.40	Heifer Calf	12.00	Hind Fawn	5.00
Ewe Hogget	2.40	1-Year Heifer	8.00	1-Year Hind	7.00
Ewe	3.65	2-Year Heifer	7.00	2-Year Hind	5.00
Ram Lamb	2.40	Cow	12.00	Hind	4.00
Ram Hogget	2.40	Bull Calf	18.00	Stag Fawn	5.00
Ram	5.00	1-Year Bull	108.00	1-Year Stag	7.00
Wether Lamb	2.40	2-Year Bull	7.00	2-Year Stag	5.00
Wether Hogget	2.40	Bull	20.00	3-Year Stag	5.00
Wether	2.00	Steer Calf	7.00	Stag	5.00
		1-Year Steer	8.00		
		2-Year Steer	7.00		
		Steer	7.00		

Source: Farmax 2014

Shearing Costs

Shearing	$ / head	Crutching	$ / head
Lambs	3.25	Lambs	1.15
Hoggets	3.55	Hoggets	1.50
Adults	3.55	Adults	1.50

Source: Farmax 2014

Nitrogen Fertiliser

Nitrogen Cost	1.81	$/kg N
	833	$/t Urea

Source: Farmax 2014, Perrin Ag Consultants 2014

FARMAX YOUR ADVANTAGE — Drystock feed assumptions

Name	Class	Units	Unit Size	Dry Matter	Energy	Default Yield	Cash Price	Production Cost	
			kg/unit	%	MJME/kgDM	units/ha	$	$/ha	$/unit
Baleage	Conserved	big bales	525	38	10.0	15.0	95.00		42.00
Pasture Silage	Conserved	tonnes DM	1,000	100	10.0	3.0	210.00	450.00	
Kale	Forage Crop	tonnes DM	1,000	100	11.0	12.0		1,259.00	
Plantain	Forage Crop	tonnes DM	1,000	100	12.5	14.0		260.00	
Swedes	Forage Crop	tonnes DM	1,000	100	12.8	10.5		1,259.00	
Calf meal	Bought	tonnes	1,000		13.0		665.00		

Source: Farmax 2014, Perrin Ag Consultants 2014