Te Muri Regional Park: Catchment Modelling

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Te Muri Regional Park: Catchment Modelling

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Executive summary

Auckland Council is investigating catchment-scale rehabilitation to address environmental degradation. Te Muri Regional Park, which is owned by the Auckland Council, is being used as a case study farm to better understand catchment-scale rehabilitation.

This report provides a baseline assessment of the effects of land use management and change on farm profitability and environmental performance. Farmax and OVERSEER® (Overseer) Nutrient budget models were used to gain an understanding of the Te Muri Regional Park performance, profitability and baseline nutrient losses. An area of 26ha is to be retired from grazing (conservation catchment) and further analysis was carried out in Farmax and Overseer to gain an understanding of the implications of retiring the conservation catchment on farm profitability and environmental performance.

The reduction in the farm effective area with the retiring of the conservation catchment resulted in economic farm surplus being reduced by approximately 25 per cent when the stocking rate is reduced to match the loss of pasture production. In terms of environmental performance the impact of retiring the conservation catchment resulted in a reduction of total farm phosphorus loss by 0.7 kg P/ha/yr. No change to the amount of nitrogen loss occurred when retiring the conservation catchment. The conservation catchment is fairly similar to the rest of the farm and therefore for a typical farmer considering retiring land for environmental benefit it would be difficult to consider retirement of a catchment so typical of the full farming enterprise. A more targeted retirement of unstable land would be a more favourable proposition for farmers, both economically and environmentally.

Contents

Figures

Tables

1 Introduction

Auckland Council is investigating catchment-scale rehabilitation to address environmental degradation. Catchment-scale rehabilitation has become a widely accepted approach for addressing environmental degradation, but quantitative evidence of its effectiveness is rare. While there is anecdotal and qualitative evidence in the grey literature, well-designed before-after-control-impact (BACI) studies that assess a range of parameters over sufficiently long timeframes to capture restoration effects are rare.

As a result of the lack of robust and convincing evidence of the benefits, together with the perception that such activities represent a cost to the land managers, the uptake and implementation of catchment rehabilitation by the farming community has been limited. The Auckland Council is therefore initiating a study to address both of these issues, by providing quantitative evidence of the environmental and economic effects of a catchment-scale rehabilitation project at Te Muri Regional Park. The opportunity afforded by the use of a Regional Park in this study is particularly valuable. This enables Auckland Council to manipulate both the timing and nature of the farming related activities in the catchment (e.g. fencing and planting regimes, stocking densities) and will provide unprecedented access to farm records for a comprehensive economic assessment.

The wider project Council objectives are to quantitatively assess the environmental and economic effects of ‘sustainable land management’ on a working sheep and beef farm. The results of the project will inform the ongoing management of the Te Muri Regional Park and other Auckland Council farm parks, and provide an important contribution to the evidence based literature around sustainable catchment management.

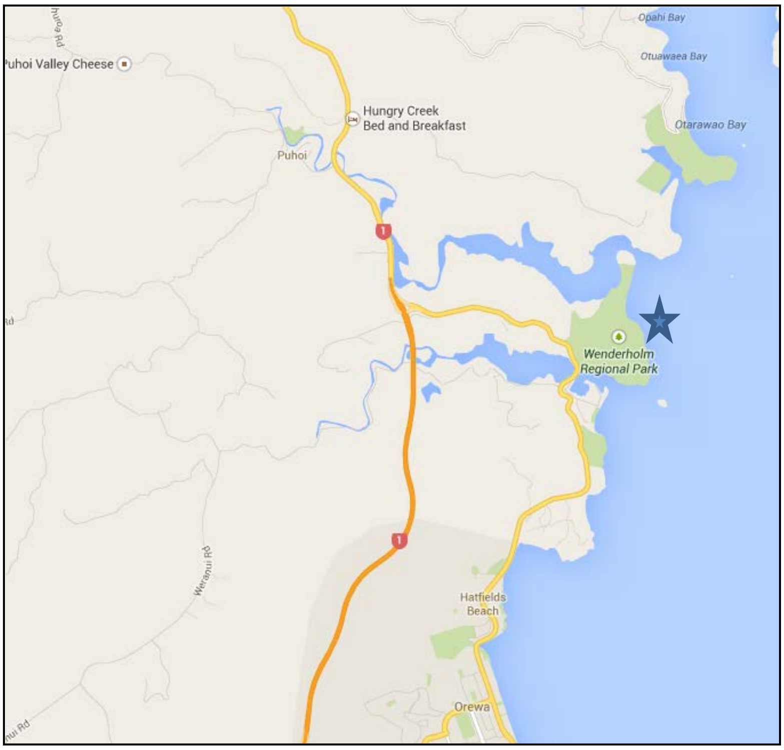
This report provides a baseline assessment of the effects of land use management and change on farm profitability and environmental performance. A brief analysis was provided on the implications of retiring 26ha of land, in terms of farm profitability and environmental performance. Twenty-six hectares was read off the GIS shape file provided by the council. Farmax and OVERSEER® (Overseer) Nutrient budget models were used to gain an understanding of current farm performance, profitability and baseline nutrient losses, respectively. Farmax is a whole farm feed budget model used to evaluate the economics of alternative livestock policies. Overseer is an agricultural management tool which assists farmers and their advisors to examine nutrient use and movements within a farm to optimise production and environmental outcomes. The computer model calculates and estimates the nutrient flows in a productive farming system and identifies risk for environmental impacts through nutrient loss, including run off, leaching and greenhouse gas emissions.

2 Site Description

2.1 Location

The Te Muri Regional Park is located in the Auckland region of New Zealand (Figure 1). The Te Muri property was added to the Auckland Regional parks in 2010, after being purchased under the Public Works Act. With the purchase of the Te Muri property the Auckland Council is able to protect the whole stretch of coast from Mahurangi to Waiwera. The property has the Puhoi River, Te Muri stream and Hauraki Gulf on its boundaries. All of these factors lead to the environmental performance of the farm being put under close scrutiny.

Figure 1: Location of the Te Muri Regional Park (blue star)



2.2 Soil information

Detailed farm scale soil mapping and land use capability (LUC) classification has been carried out across the Te Muri property. Figure 2 shows the predominant soil types found across the property. Table 1 provides further information on the soil types and soil orders provided in the key on Figure 2.

The soil map indicates that the dominant soil order found on the property is Ultic soil order. A small proportion of the property has Brown and Raw soils and a very small section of Gley soils. The Ultic soils are common in the Northern regions of New Zealand and are characterised as being prone to erosion where the surface cover has been removed. Ultic soils are also susceptible to pugging damage and compaction during wet periods and the majority of the soils are imperfectly to poorly drained (McLaren and Cameron, 1996).

Figure 2: Soil map of Te Muri Regional Park

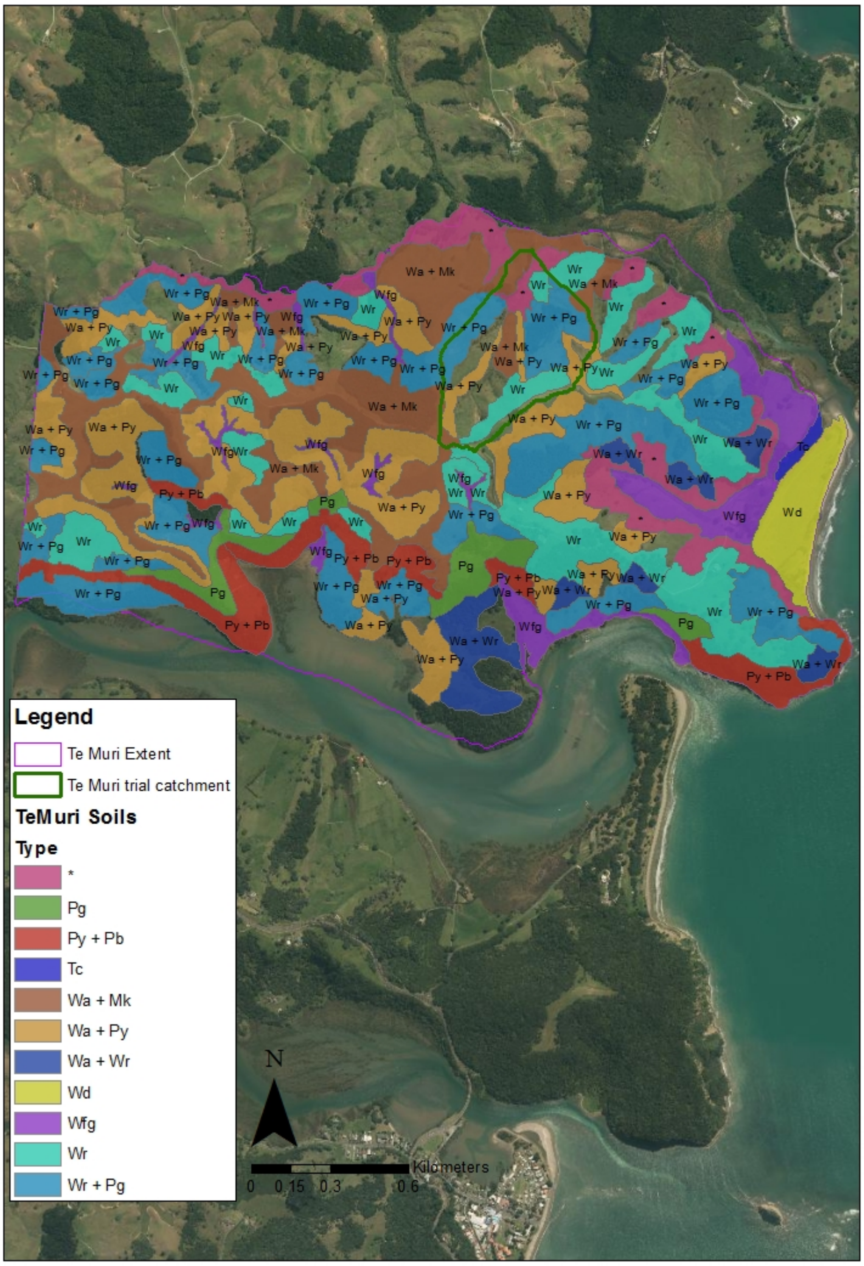


Table 1: Soil types and orders found on Te Muri Regional Park

Legend key	Soil Type	Soil Order
Py+Pb	Puhoi Yellow+ Puhoi Brown	Ultic
Pg	Puhoi Grey	Ultic
Tc	Takahiwai	Gley
Wa+Mk	Warkworth + Matakana	Ultic
Wa+Py	Warkworth + Puhoi Yellow	Ultic
Wa+Wr	Warkworth + Whangaripo	Ultic
Wfg	Whakapara	Raw
Wd	Whananaki	Brown
Wr	Whangaripo	Ultic
Wr+Pg	Whangaripo+Puhoi grey	Ultic

3 Farming Operation

3.1 Overall farm

The Te Muri property is leased by Dan and Nicky Berger. Dan and Nicky own and lease a number of farms within the region and are part of the Beef and Lamb NZ monitor farm program. The Te Muri property is the largest of the farms they lease.

The Te Muri farm is 404ha, with 260ha effective grazing area. The property currently has a stocking rate of around 9 SU/ha or 2150 stock units in total. The farm was described by the farmer as rolling to medium steep country (around 40:60 ratio) with predominantly kikuyu and ryegrass/clover pasture mix. Kikuyu is more dominant on the northern slopes with ryegrass/clover dominant on the colder southern slopes of the farm. The property is well subdivided, with stock water noted as a key barrier to further intensification, with dams and natural water sources being the main supply on most of the farm.

3.2 Farm management blocks

The farm has been grouped into several management blocks as shown in Table 2. Understanding how a property is managed and grouped into appropriate management blocks is important for correctly setting up the models. The setup of blocks in Farmax is based on areas with different pasture growth. In Overseer, blocks are areas that may be subjected to different management including; pasture growth, soil groups, fertiliser application rates, soil test values and topography. Blocks may be added for specialist hay or silage paddocks, irrigation or effluent blocks. For the Te Muri farm, blocks within Overseer were set-up to take account of different soil test values, topography and grazing management. A large proportion of the land is classified as unproductive (144ha), which takes into account large areas of bush (native and pine) on the property.

Table 2: Management blocks for the Te Muri property used in Farmax and Overseer

Farmax Blocks	Area (ha)	Overseer Blocks	Area (ha)	Olsen P
Te Muri Main Block	214	Te Muri Stream Block	40	21
Sandy Flats	20	Kauri Bush Block (Fig 3)	160	36
Conservation catchment	26	Valley Block (Fig 4)	14	37
		Sandy Flats	20	26
		Conservation catchment	26	43
		Non-productive	144	n/a

Figure 3: View of the Kauri Bush block

Figure 4: View of the Valley block

4 Te Muri Stream Conservation Catchment

4.1 Introduction to the Te Muri stream conservation catchment

A 26ha Te Muri sub-catchment (Figure 5) will be retired from grazing as part of a catchment-scale reforestation process to investigate the environmental impacts of farming practices on the Te Muri stream. On the initial visit to the farm it was noted that the conservation sub-catchment contained easy country as well as steep and unstable land (Figure 6). The catchment was visually assessed to be of similar contour to much of the remaining farm. It was the opinion of the farmer that the sub-catchment was representative of the rest of the Te Muri farm. The farm scale Land Use Capability (LUC) classification within the conservation sub-catchment and between the conservation sub-catchment and the rest of the farm were compared to confirm the above observations.

Figure 5: Te Muri farm boundary and Te Muri stream conservation catchment

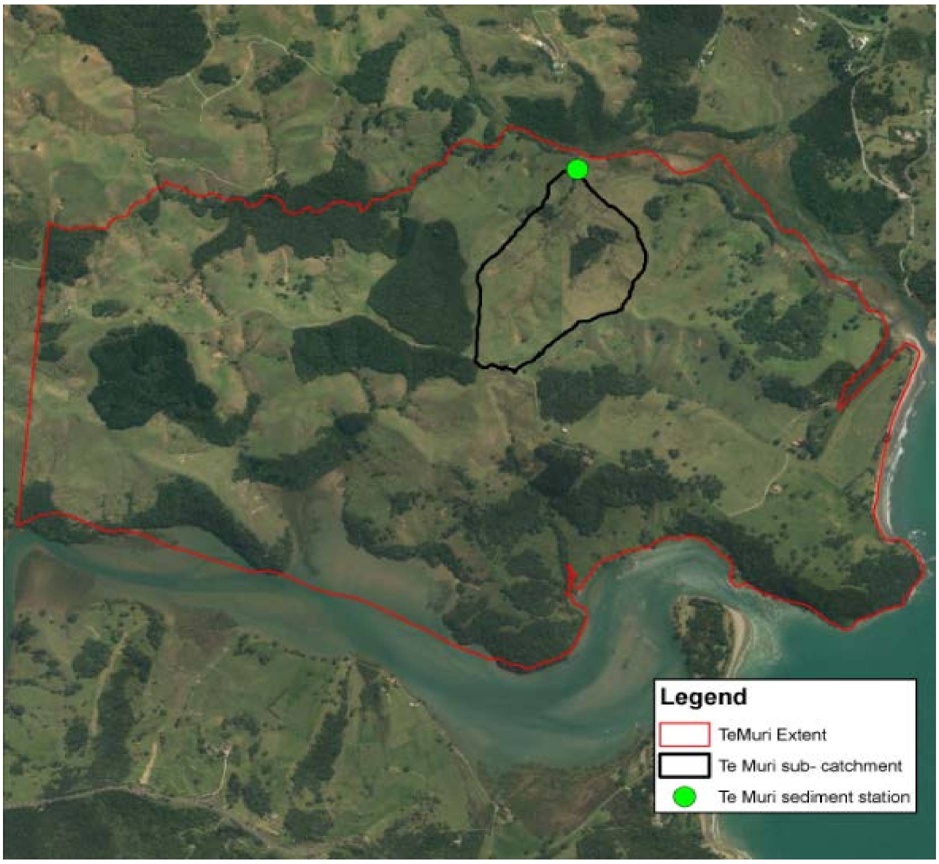


Figure 6: View of the Te Muri stream conservation catchment

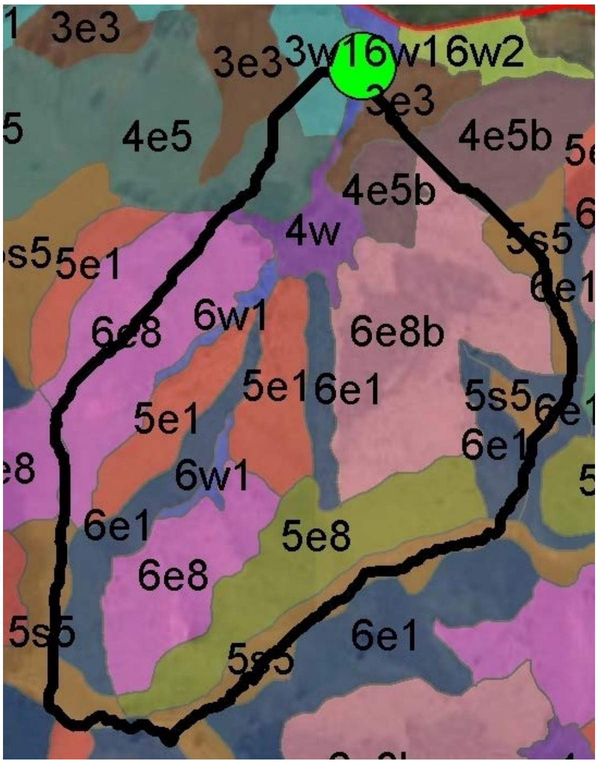
4.2 LUC within Te Muri stream conservation catchment

The LUC distribution within the Te Muri stream conservation catchment was identified from the ‘TeMuriLUC_AgR’ GIS files supplied by Auckland Council. The proportion of each LUC is shown in Table 3 and Figure 7.

Table 3: Proportion of LUC within the Te Muri stream conservation catchment

LUC	Description	Percentage of catchment
Productive flats and foot-slopes		**18.4**
4e5	Regolithic foot-slope	1.7
4e5b		3.8
3e3	Colluvial foot-slope	9.7
3w1	Slow-draining flat on low terrace	3.2
Less productive flats and foot-slopes		**8.9**
4w	Wet collegial foot-slope	3.7
5w1	Free-draining floodway or infilled channel	0.7
6w1	Slow-draining floodway or infilled channel	4.5
Productive ridges and slopes		**69.0**
5s5	Stable ridge	2.1
5e1	Stable upper slope	15.2
5e8	Stable upper slope	5.6
6e1	Unstable hillslope	13.0
6e8	Unstable hillslope	16.0
6e8b	Slump basin, recently active	17.1
Not in use		**3.7**
6w2		3.7

Figure 7: Land Use Capability (LUC) classification within the Te Muri stream conservation catchment



To determine if the Te Muri stream conservation catchment is an at risk catchment or if it is representative of the remainder of the farm the above values were compared to the rest of the farm. The LUC throughout the farm were separated into productive and stable pastoral land (2w1, 3w1, 3e3, 4e5, 5e15, 4w, 5w1, 5w2, 6w1, 5s5, 5e1, 5e8, 5e8b), environmentally risky unstable slopes (6e1, 6e8, 6e8b, 7e4, 7e) and fragile soils and unproductive slopes (6w2, 6e15, 7w1, 7w3, 8s1, 8e3) currently not in use. The proportions in each group are reported in Table 4 below.

Table 4: Proportion of stable, unstable, and not in use land in the total farm and the Te Muri stream conservation catchment

	Farm total	**Conservation catchment total**
Productive and stable	47	50
Productive but unstable slopes and less productive slopes	50	46
Not in use	3	4

These results show that there is a similar proportion of productive and less productive but stable land within the conservation catchment as in the whole farm. There is also a similar amount of land with an unstable slope within the catchment as in the whole farm. Of note is that the unstable land within the conservation catchment (classes 6e1, 6e8, 6e8b) has improved pasture (along with woodlots) as a sustainable land use. This information was used to justify that the conservation catchment to be retired from grazing had a similar pasture production and relative value to the farm system as the remainder of the Te Muri farm block.

5 Farmax Modelling

5.1 Introduction to Farmax modelling

Farmax Pro is a computer based farm system and economic simulation model developed to improve the transfer of information about alternative livestock policies to New Zealand Sheep and Beef farmers. The model indicates the biological feasibility of a livestock system and allows users to evaluate the economics of alternative livestock policies. The model platform was developed in 1991 as the Stockpol model, and has since been refined, updated and tested against scientific data (Webby et al., 1995). The model calculates the required feed demand for a modelled livestock system within the restraints of input pasture growth rates and animal performance data.

The farmer currently leasing the Te Muri block uses Farmax Pro for monitoring the farm performance in conjunction with other properties under their management. A copy of the monitoring file containing current animal numbers, growth rates, sales, and pasture covers correct to April 2014 was obtained. The data in this file was used for developing a cost to the farm system of retiring grazing area within the Te Muri stream conservation catchment.

To develop various test scenarios a standard ‘base farm’ scenario was required from which to build further scenarios. To create the base farm scenario, the Farmax monitoring file was converted to a scenario file (.fmx to .spl) prior to having any irregularities within the model resolved. The conservation catchment was modelled by creating a 26ha block with the same growth rates as the Te Muri main block, which was reduced in sized by 26ha. The 100ha Nitrogen (N) application applied to the whole farm in the original model was proportioned over the two blocks to 16ha of the conservation catchment and 84ha of N over the Te Muri main block applied at the same rate in August. A greater proportion of farm N per block area was allocated to the conservation catchment. This was appropriate as an early spring N application is more likely to be applied to a north facing block. Pasture production was optimised, to make the model feasible. This step allows more accurate manipulation of stock numbers with a reduced influence of pasture mass.

Two sets of scenarios were investigated: the first contained the current stock policies, animal numbers and proportions of stock classes, while the second was converted to a stable stock policy. This policy had been identified by the farmer to be the best use for this farm when paired with better finishing land on a second farm. No attempt was made to design a new farm system for the farm that may (or may not) better match the regional and seasonal conditions on the farm. A strong consideration of risk, viability and operator expertise must be considered in a change in farm system that is not able to be incorporated into a farmax model. This kind of analysis is beyond the scope of this investigation.

5.2 Current stock scenario

The current stock classes on the farm are in a state of change with the stock policies moving from a breeding and finishing unit to breeding and selling store, or in this case transferring to a finishing property also run by the farmer.

To model the retirement of the Te Muri stream conservation catchment the following parameters were modified within the conservation catchment block:

- Pasture production set to zero
- Remove N application
- Reduce the annual fertiliser costs (non-N fertiliser)
- Overall result: reduced net pasture production.

To match the feed demand with the reduced pasture supply, stock numbers were lowered to ensure that production targets such as weaning weights and lambing percentages would still be met. The following parameters were changed to compensate for the loss of pasture production:

The number of mixed aged ewes, two tooth ewes, replacement hoggets and weaned lambs were reduced by 11 per cent to compensate for the loss of pasture grown. This was required to keep pasture intake similar to allow a similar level of animal performance.

Lambing rates of the relevant classes above were kept constant but the lamb numbers were reduced.

Sales were reduced in proportion to animal numbers on farm.

The number of breeding cows, breeding yr2 heifers, finishing yr2 heifers and yr1 heifers were reduced by 10 per cent to compensate for the loss of pasture grown. This was required to keep pasture intake similar to allow a similar level of animal performance.

Calving rates of the relevant classes above were kept constant which required the calf numbers to be reduced.

Steers were kept constant due to the low numbers on farm.

Overall result: the stock numbers were reduced to ensure that a similar pasture utilisation pattern to the base farm model was achieved.

The sub-totals of the modelled profit and loss reports for each farm are shown in Table 5. The loss of the conservation catchment resulted in a significant reduction in the economic farm surplus (EFS). The EFS is a measure of farm business profitability, independent of ownership or funding, used to compare performance between farms, or in this case, scenarios. The Gross Margin is revenue less expenditure and interest on capital and is a high level profit target. The gross margin was reduced by a smaller proportion than EFS although this metric is not as easily transferable to other farms or farm systems.

Table 5: Revenue, expenses and the economic farm surplus for the Te Muri farm base model with and without the Te Muri stream conservation catchment

Modelled financials	**Te Muri base farm with conservation catchment**	**Te Muri base farm without conservation catchment**
Revenue	$168,812	$149,444
Expenses	$131,890	$122,582
Economic farm surplus	$36,922	$26,862
Gross Margin	$110,224	$96,703

The reduction in revenue associated with the retirement of the conservation catchment was caused by a reduction in stock numbers reducing the value of the sales minus the purchases for the sheep enterprise and a reduction in the capital value change in the beef enterprise. Expenses were reduced by a smaller margin. The expenses database loaded into the original file as supplied by the farmer were used throughout the analysis to reduce the number of variables manipulated. The expenses in the base model as received from the farmer included a cost for rates although it is understood that these are not applied to regional parks. The model links some expenses to animal numbers and some to area of the farm and these links were not modified. The reduction in expenses was attributed to those costs appropriately fixed to animal numbers such as wages, shearing, repairs and maintenance, freight and electricity. In addition there was $5000 of expenses linked to land area that did not reduce when the conservation catchment was retired from grazing. These include weed and pest control, vehicle expenses, fuel, administration expenses, insurance and ACC levies.

5.3 Stable stock scenario

When a variable, such as stock policy, is changed within a farm system it can take some time for the effect on profitability to fully eventuate. To counter this, a long-term Farmax model was developed. This type of model requires all start and end variables to match and approximates a (theoretical) stable farm system. The advantage in this scenario is that stock numbers can be more easily manipulated to match an increase or decrease in pasture production. The modelled system was based on the stock policy that the farmer had identified as a profitable and suitable system for the farm, especially when paired to a finishing farm in the area as is the current practice. The system modelled focuses on a breeding policy with young animals sold to store shortly after weaning to reduce the feed demand in dry summers and over winter.

Table 6: Revenue, expenses and the economic farm surplus for the Te Muri farm long-term model with and without the Te Muri stream conservation catchment

Modelled financials	Te Muri farm with catchment	Te Muri farm without catchment
Revenue	$176,647	$157,997
Expenses	$135,629	$126,631
Economic farm surplus	$41,018	$31,366
Gross Margin	$116,930	$103,595

The stable stock scenario had a similar effect on EFS and gross margin as the reduction in current stock numbers. A reduction in the EFS of 24 per cent is a significant reduction in profitability from a 10 per cent reduction in effective farm area. While the EFS per ha for this farm is good for the region, the small size of the farm reduces the total EFS to below the expected average for the 2013/14 season (Table 7, Note: the Beef + Lamb New Zealand (B+LNZ) class system is not equivalent to the LUC system. B+LNZ class 4 is North Island hill country compared to class 3 North Island hard hill country or class 5 intensive finishing). Lowering farm profitability on small farm holdings will mean more farms are no longer profitable enough to be operated as a stand-alone economic unit. Economic management of such small areas of productive farming land may then be limited to leasing to other local landholders as grazing land.

Table 7: Economic farm surplus data for class 4 North Island hill country farms in the Northern North Island (Waikato, BOP, Northland). Information taken from by Beef and Lamb New Zealand Economic Service information. (Note: B+LNZ class system is not equivalent to LUC system) http://www.beeflambnz.com/information/on-farm-data-and-industry-production/sheep-beef-farm-survey/nni/

Class 4 North Island Hill Country	Mean 2011-12	Mean 2012-13	Provisional 2013-14	Forecast 2014-15
EFS ($)	48,327	3168	33,243	35,192
EFS ($/ha)	144.26	9.90	103.88	109.98

6 Overseer Modelling

6.2 Introduction to Overseer modelling

Overseer is an agricultural management tool which assists farmers in examining nutrient use and movement within a farm. Overseer calculates and estimates the nutrient flows in a farming system and can be used to identify where efficiencies in managing nutrients can be made as well as the potential risk of environmental impacts from losses through run-off, leaching, and greenhouse gas emissions.

The core of the model is a nutrient budget. The nutrient budget shows the inputs and outputs of a farm system much like a financial budget. Inputs can include fertiliser, imported supplements and stock. Outputs can include produce, supplements exported, atmospheric loss and leaching/runoff. From this information, Overseer creates reports that enable fertiliser recommendations, nutrient use efficiency and potential environmental effects to be assessed.

Overseer nutrient budgets can be created for a large range of farm systems in New Zealand, from dairy farms to cropping and some horticultural operations. Overseer was developed with a set of key ground rules that are necessary to provide comparable results over time. For example, Overseer assumes the farm management system is constant, good management is practiced and the information put into the model is reasonable and accurate.

One of the key features of Overseer is that it is based largely on information that farmers have or that can be readily obtained, and where this is not the case suitable defaults are generally available. Overseer requires information about the farm at two scales: farm and management block scale. At the farm scale the type of information required includes: location, types of enterprise (stock), structures present (feed-pads etc.) and supplements imported. Splitting the farm into management blocks is an essential part of correctly setting up the model. Management blocks within a farm system are defined as the sum of areas of the farm that are managed differently (e.g. irrigated, cropped, effluent applied), have different soil types, topography, fertiliser application rates or soil test values. At the block scale the type of information Overseer requires includes: topography, climate conditions, soil type, pasture type, supplements used, fertiliser applied, irrigation or effluent applied. The nature of the information required will vary depending on the block type i.e. pasture block or crop block.

A key development focus for Overseer has been to incorporate a wide range of possible on-farm management practices including many that can be used to enhance nutrient use efficiency and/or mitigate environmental impacts. This ability to model different practices enables decisions to be made for farm management planning purposes.

The key strengths of Overseer is it provides a very good indicator of farm nutrient ‘balances’ and nutrient management efficiencies. Overseer equips farmers to make sound decisions about nutrient management and fertiliser and meets current and emerging market expectations. Overseer limitations include that it models most but not all farm systems and models most but not all management practices.

6.2 Whole farm nutrient budget

The Overseer whole farm nutrient budget of the Te Muri property is shown in Table 8. The nutrients added to the property are in the form of fertiliser, rain and clover N fixation. Nutrients removed from the property are as products or as losses to the atmosphere and water. Total N leaching from the property is 8 kg N/ha/yr and total P runoff from the property is 5.1 kg P/ha/yr. In sheep and beef farms N losses can range from 5-20 kg N/ha/yr (Per comms. David Wheeler (based on typical values from a range of Sheep and Beef farm Overseer files)), indicating that this property is at the lower end of the scale. Modelled losses of P from this property were higher than the average (1.3 kg P/ha/yr, range = 0.3 – 2.1 kg P/ha/yr) generated from a survey of 37 studies of losses from field to catchment-scale in New Zealand (McDowell and Wilcock, 2008).

Table 8: Te Muri Property Whole Farm Nutrient Budget

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na
Nutrients added							
Fertiliser, lime & other	21	12	0	14	26	0	0
Rain/clover N fixation	45	0	3	5	4	10	60
Irrigation	0	0	0	0	0	0	0
Nutrients removed							
As products	16	3	1	2	6	0	0
Exported effluent	0	0	0	0	0	0	0
As supplements and crop residues	0	0	0	0	0	0	0
To atmosphere	38	0	0	0	0	0	0
To water	8	5.1	18	17	26	3	17
Change in farm pools							
Plant Material	0	0	0	0	0	0	0
Organic pool	5	7	0	1	0	0	0
Inorganic mineral	0	4	-12	0	-1	-2	-3
Inorganic soil pool	0	-7	-4	0	-1	9	45

6.3 Nitrogen report

Nitrogen (N) is essential for plant growth and function. Strategic use of N can increase pasture growth, however excess N in the soil can easily be lost from the soil profile and can have negative impacts on the environment if not managed correctly. Soil N losses occur from two major pathways: gaseous loss (to the atmosphere, ammonia volatilisation and denitrification) and leaching. Atmospheric loss of N in the form of nitrous oxide (N2O), a potent greenhouse gas, can contribute to global warming (McTaggart et al, 1997). The leaching of nitrate (NO3-) with drainage can increase the concentration of NO3- in ground water and surface water (Cameron et al, 2013). High nitrate levels of NO3- in surface water bodies can contribute to accelerated eutrophication by promoting plant and algal growth (Smith and Schindler, 2009). Nitrate concentrations in drinking water can cause methemoglobinemia 'blue baby syndrome' in infants. The New Zealand Ministry of Health has set the maximum acceptable value of 11.3 ppm in NO3-N for drinking water.

Using Overseer, Table 9 shows that for this property, N in drainage is not of concern, with levels well below 11.3 ppm. The 'Sandy Flats' block has the highest N loss and this is due to the soil type of this block. The texture of a soil profile has a large impact on the drainage characteristics of soil. Soils with a lighter (sandy) soil profile texture tend to be free draining with a low available water holding capacity and are more prone to leaching losses (Cameron et al, 2013).

Table 9: Nitrogen report showing N losses from each block

Block name	Total N lost kg N/yr	N lost to water kg N/ha/yr	N in drainage * ppm	N surplus kg N/ha/yr	Added N ** kg N/ha/yr
Te Muri Stream Block	450	11	1.8	79	35
Kauri Bush Block	1634	10	N/A	78	35
Valley Block	106	8	1.2	92	35
Sandy Flats	814	41	6.1	84	0
Conservation Catchment	293	11	N/A	78	35
Other sources	82				
Whole farm	3378	8			
Less N removed in wetland	0				
Farm output	3378	8			

Total modelled N lost to water is 8 kg N/ha/yr. The critical period for NO3- leaching is the late autumn/early winter period, when plant uptake of N is low and rainfall exceeds evapotranspiration, resulting in drainage. The Sandy Flats block has a lighter soil texture and is grazed predominantly over the winter months by beef cattle, thus creating a higher NO3- leaching risk compared to the other blocks.

6.4 Phosphorus report

Phosphorus (P), like N is essential for plant growth, however excess P in the soil can have negative impacts on the environment if not managed correctly. In New Zealand, it is often P that is limiting algal growth in waterways, not N. Small increases in the amount of P entering waterways can have significant detrimental effects on the quality of the receiving water body (McDowell, 2010).

The major pathway for P loss from the soil is via surface runoff and erosion of sediments. Surface runoff transports nutrient rich topsoil from the land directly into lakes and surface water courses. The amount transported depends on land-use, topography, fertiliser use, P levels in the soil, rainfall and infiltration rates (McDowell, 2004).

Based on Overseer model outputs, Table 10 shows P lost to water from each block. Total P loss from the whole farm is 5.1 kg P/ha/yr. The greatest P loss is from the Conservation Catchment, with the lowest from the Sandy Flats. Key drivers of P loss within Overseer are topography, soil type, P fertilisers, climate and stock management. The Te Muri Stream and Valley block are classified as rolling and the Kauri Bush block and Conservation Catchment as easy hill. All blocks receive 200 kg/ha superphosphate (18 units of P) in April. April is a relatively high risk month for P fertiliser application due to climatic conditions.

A key mitigation strategy for reducing P loss from a farm is to identify critical source areas (CSAs) for P loss. A general rule is 80 per cent of P loss comes for only 20 per cent of the catchment (McDowell, 2007). Therefore, identifying CSAs around a catchment or property for P loss and applying mitigation strategies to these areas could result in greater gains in terms of P loss. Mitigation options centre on either reducing the amount of P in CSAs, or breaking the connectivity between the source and the water body. Further improvements of models to better predict CSAs will provide more targeted P mitigation strategies, which will aid the management of P loss from farms (Stafford and Peyroux, 2013).

Table 10: Phosphorus report showing P losses from each block

Block name	Total P lost	P lost to water	P loss categories		
	kg P/yr	kg P/ha/yr	Soil	Fertiliser	Effluent
Te Muri Stream Block	165	4.1	Extreme	High	N/A
Kauri Bush Block	1476	9.2	Extreme	Extreme	N/A
Valley Block	117	8.4	Extreme	Extreme	N/A
Sandy Flats	5	0.2	Low	Low	N/A
Conservation Catchment	275	10.6	Extreme	Extreme	N/A
Other sources	22				
Whole farm	2060	5.1			

6.5 Individual block nutrient budgets

Individual block nutrient budgets are presented below (Tables 11 – 15). The block reports highlight the source of nutrients added to each block, nutrients removed from each block and the changes occurring in block nutrient pools. The majority of nutrients added to the blocks are the same, except the Sandy Flats block that receives no N fertiliser and supplements are fed out on this block. Nutrients removed are also relatively similar across all blocks, except the Sandy Flats block. Nutrient losses are similar for the Conservation Catchment and Kauri Bush block, which has the same topography (easy-hill) and nutrient losses are similar for the Te Muri Stream block and Valley block, which are also classified as having the same topography (rolling). The Sandy Flats block shows different nutrient loss pathways with a greater proportion of N losses to water and a lower proportion of P loss to water, compared to the rest of the farm. In all the blocks, except the Sandy Flats block N loss to the atmosphere is greatest from denitrification from urine. For the Sandy Flats block N loss to the atmosphere is greatest from volatilisation from urine. The Sandy Flats block only has animals on the block in June, July and August.

Table 11: Conservation Catchment Nutrient Budget

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na	H+*
Nutrients added								
Fertiliser, lime & other	35	18	0	22	40	0	0	0.0
Rain/clover N fixation	67	0	4	8	6	15	93	0.3
Irrigation	0	0	0	0	0	0	0	0.0
Nutrients removed								
As animal products	24	4	1	3	9	0	1	0.0
As supplements	0	0	0	0	0	0	0	0.0
Net transfer by animals	2	0	2	0	0	0	0	0.0
To atmosphere	58	0	0	0	0	0	0	0.0
To water	11	10.6	33	26	48	5	28	-0.2
Change in block pools								
Organic pool	7	12	0	1	0	0	0	-0.1
Inorganic mineral	0	7	-18	0	-2	-3	-4	0.0
Inorganic soil pool	0	-16	-15	0	-8	13	68	0.7

Table 12: Kauri Bush Block Nutrient Budget

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na	H+*
Nutrients added								
Fertiliser, lime & other	35	18	0	22	40	0	0	0.0
Rain/clover N fixation	67	0	4	8	6	15	93	0.3
Irrigation	0	0	0	0	0	0	0	0.0
Nutrients removed								
As animal products	24	4	1	3	9	0	1	0.0
As supplements	0	0	0	0	0	0	0	0.0
Net transfer by animals	2	0	2	0	0	0	0	0.0
To atmosphere	58	0	0	0	0	0	0	0.0
To water	10	9.2	33	26	47	5	28	-0.2
Change in block pools								
Organic pool	7	11	0	1	0	0	0	-0.1
Inorganic mineral	0	6	-18	0	-2	-3	-4	0.0
Inorganic soil pool	0	-13	-15	0	-8	13	68	0.6

Table 13: Te Muri Stream Block Nutrient Budget

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na	H+*
Nutrients added								
Fertiliser, lime & other	35	18	0	22	40	0	0	0.0
Rain/clover N fixation	68	0	4	8	6	15	93	0.3
Irrigation	0	0	0	0	0	0	0	0.0
Nutrients removed								
As animal products	24	4	1	3	9	0	1	0.0
As supplements	0	0	0	0	0	0	0	0.0
Net transfer by animals	2	0	2	0	0	0	0	0.0
To atmosphere	59	0	0	0	0	0	0	0.0
To water	11	4.1	14	26	15	2	20	-0.2
Change in block pools								
Organic pool	6	8	0	1	0	0	0	-0.1
Inorganic mineral	0	4	-21	0	-2	-3	-4	0.0
Inorganic soil pool	0	-2	8	0	24	16	76	0.7

Table 14: Valley Block Nutrient Budget

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na	H+*
Nutrients added								
Fertiliser, lime & other	35	18	0	22	40	0	0	0.0
Rain/clover N fixation	81	0	4	8	6	15	93	0.2
Irrigation	0	0	0	0	0	0	0	0.0
Nutrients removed								
As animal products	24	5	1	3	9	0	1	0.0
As supplements	0	0	0	0	0	0	0	0.0
Net transfer by animals	2	0	2	0	0	0	0	0.0
To atmosphere	88	0	0	0	0	0	0	0.0
To water	8	8.4	26	26	29	2	21	-0.1
Change in block pools								
Organic pool	-6	11	0	1	0	0	0	-0.1
Inorganic mineral	0	6	-21	0	-2	-3	-4	0.0
Inorganic soil pool	0	-12	-4	0	10	16	75	0.4

Table 15: Sandy Flats Block Nutrient Budget

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na	H+*
Nutrients added								
Fertiliser, lime & other	0	18	0	22	40	0	0	0.0
Rain/clover N fixation	98	0	4	8	6	15	93	0.1
Irrigation	0	0	0	0	0	0	0	0.0
Supplements fed on block	13	2	13	2	3	1	1	0.4
Nutrients removed								
As animal products	27	7	2	3	14	0	1	0.0
As supplements	0	0	0	0	0	0	0	0.0
Net transfer by animals	2	0	2	0	0	0	0	-0.1
To atmosphere	34	0	0	0	0	0	0	0.0
To water	41	0.2	11	27	39	9	34	-2.7
Change in block pools								
Organic pool	7	4	0	1	0	0	0	-0.1
Inorganic mineral	0	10	-20	0	-2	-3	-4	0.0
Inorganic soil pool	0	-1	22	0	-2	10	63	3.4

6.6 Impact of retiring land in Overseer

The effect of retiring the Conservation Catchment block from grazing reduced total P loss by 0.7 kg P/ha/yr. Within Overseer the retirement of the land was modelled by removing the Conservation Catchment block all together and adding the area of the Conservation Catchment block to the total farm non-productive area. This resulted in a reduction in total P loss to water from 5.1 to 4.4 kg P/ha/yr. N loss to water remained the same at 8 kg N/ha/yr (Table 16). Key drivers of P loss within Overseer are topography, soil Olsen P level, fertiliser use, climate and soil type. Sources of P loss are generally easier to identify and mitigate than sources of N loss. The loss of P is typically linked to CSAs and identifying these and apply specific mitigations can have a large impact on reducing P loss.

Table 16: Whole Farm Nutrient Budget taking in account the retirement of the 26ha conservation catchment

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na
Nutrients added							
Fertiliser, lime & other	19	11	0	13	23	0	0
Rain/clover N fixation	46	0	2	5	4	9	54
Irrigation	0	0	0	0	0	0	0
Nutrients removed							
As products	16	3	1	2	6	0	0
Exported effluent	0	0	0	0	0	0	0
As supplements and crop residues	0	0	0	0	0	0	0
To atmosphere	37	0	0	0	0	0	0
To water	8	4.4	17	15	24	3	15
Change in farm pools							
Plant Material	0	0	0	0	0	0	0
Organic pool	4	6	0	1	0	0	0
Inorganic mineral	0	3	-11	0	-1	-2	-2
Inorganic soil pool	0	-6	-4	0	-1	8	40

7 Conclusion and implications of retiring land

The catchment proposed for retirement from grazing is typical of the rest of the farm. Economic modelling of the farm system using Farmax shows that the cost of removing the conservation catchment from grazing can be estimated by reducing the effective farm area by the area of the conservation catchment. The loss of 10 per cent of the effective farm area required similar reductions in stock numbers and led to a 12 per cent reduction in gross margin. However, the EFS, a measure of farm business performance independent of ownership and funding, was reduced by approximately 25 per cent when the stocking rate is reduced to match the loss of pasture production.

The effect of retiring the Conservation Catchment block from grazing reduced total P loss from the whole farm by 0.7 kg P/ha/yr. This resulted in a reduction in total P loss to water from 5.1 to 4.4 kg P/ha/yr. The retiring of the Conservation Catchment block had no impact on N leaching.

For a typical farmer considering retiring land for environmental benefit it would be difficult to consider the retirement of a catchment so typical of the full farming enterprise. As the catchment is typical of the majority of the remaining farm, it is expected that the production cost to environmental advantage ratio of the retired catchment would be the same as retiring the full farm. Full farm retirement would rarely be considered where a significant proportion of the farm is in productive and stable LUC units. A more targeted retirement of unstable land would be a more favourable proposition for farmers, both economically and environmentally. Strategies to stabilise at risk LUC units with poor pasture production would reduce sediment loss or trap sediment at strategic places. These strategies could show similar environmental advantages to the proposed land retirement without major losses of grazing land and the subsequent effects on farm profitability. If retirement of productive stream catchments was enforced through, for example, legislation, farmers could realistically expect a significant reduction in farm business performance.

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9 References

Cameron, K C., Di, H J and Moir, J L (2013). Nitrogen losses from the soil/plant system: a review. *Annals of Applied Biology,* (162), 145-173

McDowell, R W (2007). *Assessment of altered steel melter slag and P-socks to remove phosphorus from streamflow and runoff from lanes*. Client report Environment Bay of Plenty. http://www.boprc.govt.nz/media/34458/TechReports-070601-AssessmentAlteredSteelmelterslag.pdf

McDowell, R W (2010). *The efficacy of strategies to mitigate the loss of phosphorus from pastoral land use in the catchment of Lake Rotorua*. Client report Environment Bay of Plenty. http://www.boprc.govt.nz/media/99964/the_efficacy_of_strategies_to_mitigate_the_loss_of_phosphorus_from_pastoral_land_use_in_the_catchment_of_lake_rotorua.pdf

McDowell, R W and Wilcock R J (2008). Water quality and the effects of different pastoral animals. *New Zealand Journal of Veterinary Research,* (50), 289-296

McDowell, R W., Bigg, B J F., Sharpley, A N and Nguyen, L (2004). Connecting phosphorus loss from agricultural landscapes to surface water quality. *Chemistry and Ecology,* (20), 1-40

McLaren, R G and Cameron, K C (1996). *Soil science, a sustainable production and environmental protection*. Oxford University Press

McTaggart, I P., Clayton, H., Parker, J., Swan, L and Smith K L (1997). Nitrous oxide emissions from grassland and spring barley, following N fertiliser application with and without nitrification inhibitors. *Biology and Fertility of Soil*, (25), 251-268

Smith, V H and Schindler, D W (2009). Eutrophication science: where do we go from here? *Trends in Ecology and Evolution*, (24), 201-207

Stafford, A and Peyroux, G (2013). Clearview Balance PGP – A first look at new solutions for improving nitrogen and phosphorus management. In: *Accurate and efficient use of nutrients on farms*. Eds L.D. Currie and C.L. Christensen. http://flrc.massey.ac.nz/publications.html. Occasional Report No. 26. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand

Webby, R W., McCall, D G and Blanchard, V J (1995). An evaluation of the StockpolTM model. *Proceedings of the New Zealand Society of Animal Production* (55), 145-149