IMPACTS OF WATER POLICIES ON NEW ZEALAND LIVESTOCK AGRICULTURE AND THE RUAMĀHANGA CATCHMENT

Abstract

New Zealand communities are seeking improved water quality. Applying New Zealand's legislative framework, policy decisions to achieve these improvements must take account of a range of factors, including the sources of contaminants, and the economic implications of policy changes for resource users such as farmers. This paper outlines key components of agricultural information being used to underpin policy decision-making in the Ruamāhanga River Catchment, and evaluates the economic impacts on farming of one potential policy scenario to achieve improved water quality.

Twelve representative farms are used in the evaluation. Based on this, 24% of the nitrogen load entering the river from livestock agriculture is from dairying, 40% from sheep and beef breeding farms, and 36% from sheep and beef finishing farms. Reducing the nitrogen load in the river from the current levels of 0.64 to 0.53mg/L, requires livestock farmers in the catchment to reduce nitrogen discharges by an estimated 700T of nitrogen per year. Such a water quality target can be achieved if improved farm management practices are adopted, and provided that other human-induced sources of contaminant are also reduced. The costs of the farm management changes required could reduce their contribution to the district GDP by over 10%.

Keywords: Wairarapa, nitrogen, water quality, dairy, sheep and beef

The policy framework for addressing water quality issues in New Zealand

New Zealanders have increasingly expressed concern about water quality (Ministry for the Environment, 2016). In some catchments water quality is deteriorating markedly as the population in urban centres increase and agriculture intensifies (Ministry for the Environment, 2016). In response, the New Zealand government has introduced the National Policy Statement for Freshwater Management (NPS-FM; 2011, 2014). The policy statement requires regional councils through New Zealand to understand their community expectations for the water bodies in their regions (e.g. for swimming, fishing, irrigation or intrinsic purposes). The regional councils must then work with their communities to set limits for water quality and develop methods for achieving them within desired time frames. This includes constraining agriculture, if necessary.

Regional councils throughout New Zealand are currently engaged in this limit setting process. In most cases communities are using this as an opportunity to seek improvements in water quality (Parliamentary Commissioner for the Environment 2015). The NPS-FM outlines a policy decision-making process that requires councils to identify the sources of contaminants, and consider the economic impact of potential limits. In New Zealand, agricultural land uses dominate many lowland catchments and they are the main source of nutrients (nitrogen and phosphorus) polluting the country's waterways. However, the nutrient balance surpluses per hectare are still about half the OECD average (OECD 2008, p415).

Councils need information on current farm contaminant discharges, and must test the economic impact of farm management or farm system changes required to meet particular limits. The sizes of the economic impacts are influenced by the policy implementation-methods used to achieve a water quality reduction. Some regional councils are moving from methods that are based on encouraging or regulating selected practices, to allocation-based approaches for each source of discharges. Allocation approaches enable land owners themselves to select the mix of practices for best achieving a limit within their own production system and farming context. They also provide the flexibility and opportunity for farmers to be adaptive and innovative.

Each implementation method has differing consequences for the way the costs of achieving a limit are shared between farmer groups and between farmers and other sectors present in the catchments. Land owners will have to fund most of the changes themselves without external sources of financial support. As a consequence, there are equity considerations for communities and councils to take into account through this process.

This paper illustrates the farming and economic information required to underpin the policy process for setting and managing within water quality limits based on an example catchment in the Wellington Region. The paper also considers the scale of practice changes required and tests the economic impact on farms and the district of a particular limit, using representative livestock farms. The paper concludes by highlighting some of the issues that policy makers will need to consider when determining water quality limits and how they will be achieved in the catchment. The study draws on information contained in a research project carried out for the Ministry for Primary Industries, to which the author contributed (Ministry for Primary Industries, 2016).

Introduction to the Example Catchment for the Ruamāhanga River

The Ruamāhanga River is a wide slow moving river on the south eastern corner of the North Island of New Zealand. The river begins in the forest-covered hills of the Wairarapa district and finishes confined between the banks of a man-made channel modified to increase flood control for surrounding farms (Greater Wellington 2007). For most of its length of 124km, the river flows through farmland and past small rural towns, until it pushes into the wild waters of Cook Strait and the Pacific Ocean. Primary industry is the single biggest contributor to the local economy, contributing almost 20% to district GDP (BERL, 2008).

The Greater Wellington Regional Council is responsible for managing water quality in the Ruamāhanga River Catchment. The monitoring of water quality undertaken by the regional council indicates that there is a general decline in water quality with increasing distance along the length of the river (Greater Wellington Regional Council 2007). This decrease in water quality is associated with the cumulative effects of point source municipal wastewater discharges and non-point sources from rural landuses such as agriculture.

Monthly monitoring of the lower Ruamāhanga River (Greater Wellington Regional Council 2007) has had the following results with guideline maximums shown in brackets (ANZECC 2000):

- Total nitrogen median of 0.64mg/L, with a maximum of 2.1 and a minimum of 0.05mg/L (0.614mg/L)
- Total phosphorus median of 0.04mg/L, with a maximum of 0.35 and a minimum of less than 0.01mg/L (0.033mg/L)
- *Escherichia coli* median of 110cfu/100ml, with a maximum of 3,800 and a minimum of 12cfu/100ml (100cfu/100ml).

Annually, about 1,000T of nitrogen and 65T of phosphorus are lost from the catchment into the Pacific Ocean and the ANZECC guidelines are exceeded about half the time that samples have been taken. The results indicate that there will be times when the water in the Ruamāhanga is not suitable for bathing, contact recreation, cultural activities and food gathering. This situation is of concern to the regional council which is required to manage these risks to ecological health and human activity.

Setting Water Quality Limits in the Ruamahanga Catchment

The regional council process for setting water quality limits for the Ruamahanga catchment involves catchment committees to formulate community water objectives, limits and policies. In the Wellington Region these committees are called Whaitua (a Māori word for a "management unit"). As required under the NPS-FM, the Whaitua Committee is taking an evidence-based approach to their role, including information about the impact that farming land uses on river water quality and how possible policy options might in turn impact on farming (Banks 2009).

The Whaitua Committee will deliberate on the information presented to them by the community and technical experts, and identify the national and local values that apply in their catchment. There are two values that are compulsory for all catchments in New Zealand – 'ecosystem health' and 'human health for recreation' (New Zealand Government 2014). Each value has measureable attributes that can be used to help realise the value. For a number of values including human health for recreation, one of the forms of nitrogen (eg nitrate nitrogen) is an attribute for the Whaitua Committee to review in their decision making. The Whaitua Committee will manually calculate an optimum catchment loss rate for nutrients, sediment and faecal coliforms taking into account the Whaitua Committee's social and political drivers as well as the economic consequences of their proposed policies.

The Whaitua Committee has been provided with the information on the representative farms that is outlined in the following section of the paper. The information will be used in biophysical and economic impact models, to test a range of scenarios for potential limits and how they might be managed. In this paper, the representative farm information has been used by the author to carry out a simplified scenario analysis to illustrate the potential economic impacts of one potential limit. The limit in the scenario would reduce the annual nitrogen losses in the Ruamāhanga River by at least 16%.

Research Approach

In a project led by the Ministry for Primary Industries (MPI 2016), a number of representative farms were identified to explore and understand the interactions between catchment-scale policies for managing water quality and individual farming systems. There was no government or industry data available for use in determining a statistically derived sample and so the sample was selected by three farm consultants working together with staff at the Ministry for Primary Industries. The consultants had existing working relationships with farmers in the Wairarapa district. Together they identified the types and numbers of farms to be sampled so that the chosen farms matched the estimated number of farms in each category. It was also desirable that the sample of farms included some that because of their geo-physical location, could be considered to have a range of risk for water quality. This description of sixteen farm types was used as the basis for contacting farmers in the district and inviting them to participate in the project on a voluntary basis. From the volunteered farms the required number were selected so that the sample farms were typical examples fo their farming types rather than representing an average for the district. This paper considers twelve of the farms, covering the main land uses of dairying; sheep and beef breeding; and sheep and beef finishing. As part of the selection process, each farmer agreed to provide their management information for the 2013-14 year, for further analysis in the project.

Information from the sample was used in two farm system models developed for each farm. These were a farm enterprise model (Farmax 7.0) and a nutrient model (Overseer

Version 6.2.1) that described the pathways through which nutrients from the farms could be lost and potentially flow through into catchment waterways. The two software models have been used in this paper to estimate the nutrient losses and financial costs for each of the representative farms in the catchment before and after the possible environmental mitigations were introduced.

The financial budgeting side of Farmax interacts with the pasture and livestock performance part of the modelling so that farm system changes can be reflected in the estimated financial results (Marshall, McCall and Johns 1991). Figures from actual farm accounts were used to establish the base-line results and then the farm enterprise model estimated new results after the mitigations had been introduced. Farmax modelling does not calculate nutrient interactions for each farming system so these were calculated by transferring the Farmax results into Overseer. The Overseer model has been specifically designed to quantify estimates of nutrient inputs, outputs and net balances for pasture-based farming systems. The European method of calculating the soil surface nitrogen balance does not account for the pasture-animal component in the same way as Overseer which incorporates animal grazing as an input to the nutrient balance (Fraters, et.al. 2015). Comparisons using Overseer between European countries and New Zealand suggest a much lower contribution in New Zealand from fertiliser and concentrates and greater nitrogen efficiencies (milk N/total input N; Ledgard et al.)

Dairy Farm Baseline Results

There were six dairy farms modelled, all of which grazed their cows outdoors year-round. The physical dimensions of the representative dairy farms are summarised in Table 1 and their production in Table 2.

The dairy farms were estimated to be losing 24-47kgN/ha/yr nitrogen into ground water or surface water, predominantly as leached nitrate from livestock urination. Nitrogen losses were not directly determined by the type of farming system and even the organic producer and the moderate intensity farms had similar nitrogen losses to the other farms.

Table 1. Physical dimensions of the representative dairy farms.

Farm name	Management Description	Dominant Soil Order	Rainfall (mm/yr)	Irrigation (mm/yr)	Total Area (ha)	Milking Area (ha)	Topography	Area Irrigated (ha)
Dairy 1	High intensity	Pallic	967	819	367	171	flat	100
Dairy 2	Moderate intensity	Gley	1356	887	171	171	flat	100
Dairy 3	High intensity	Pallic	1100	580	301	185	flat	60
Dairy 4	Moderate intensity,	Brown	1546	0	204	125	rolling	0
Dairy 5	Moderate intensity	Gley	915	819	426	270	flat	135
Dairy 6	Low intensity, organic	Recent	801	819	355	210	flat	159

Table 2. Production of the representative dairy farms

Farm name	Milking Area (ha)	Milking Cows	Farm Production (kgMS/yr)	Milk volume (litres/yr)	Imported Nitrogen (kg/ha)	Available Nitrogen (kg/ha)	Lost Nitrogen (kg/ha)	Operating Profit per Effective Area ($/ha)
Dairy 1	171	635	286,597	3,588,194	94	238	42	1309
Dairy 2	171	430	150,590	1,653,218	105	250	34	3277
Dairy 3	185	629	228,105	2,913,091	87	212	24	1157
Dairy 4	125	355	159,249	1,802,699	102	220	47	2413
Dairy 5	270	840	295,000	3,393,351	77	215	24	1492
Dairy 6	210	567	213,462	2,417,522	0	150	35	2428 [1708 (before premiums)]

However, there was a tendency for higher stocked farms in this sample to be importing higher amounts of nitrogen fertiliser, and achieving higher levels of production and so to have greater nitrogen losses (Parliamentary Commissioner for the Environment 2015, p19). Nitrogen losses tended to be higher on those farms with coarse undeveloped soil structure and high rainfall and/or using irrigation.

Farming profitability was related to having a high proportion of milking animals, a moderate stocking rate and high production per cow. The intensity of the farming systems used in the Table is based on their dependence on the use of imported supplementary feed to maintain milk production early and/or late in the milking season, as well as during the winter when the cows were dry (Shadbolt, 2012).

Sheep and Beef Breeding Farm Baseline Results

There were two sheep and beef breeding farms selected, where the dominant farm output was the production of young animals of six months age or younger, for sale to other finishing farmers.

The sheep and beef breeding farms in the sample were low intensity and had estimated losses of nitrogen lower than for the dairy farms (Tables 3 and 4). In the Table, sheep and beef breeding farm 1 was a hill farm with high annual rainfall. This farm was similar to the second sheep and beef breeding farm but it used a lot more nitrogen fertiliser and it had higher profitability and higher estimated nitrogen losses.

Sheep and Beef Finishing Farm Baseline Results

There were four sheep and beef finishing farms selected (Tables 5 and 6). These farms tended to have flatter land than the breeding farms and although they still had a proportion of breeding animals, they finished most of their young stock.

The sheep and beef finishing farms tended to have higher profitability than the sheep and beef breeding farms, but were still only half the profitability of dairy farms ($/ha). The finishing farms with the highest and lowest profitability both had similar stocking rates. The finishing farms had estimated nitrogen losses of 8-17kgN/ha per year. The highest nitrogen loss farms (farms 2 and 4) had high cattle numbers or concentrated grazing of cattle in winter, contributing towards these losses.

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Table 3. Physical dimensions of the representative sheep and beef breeding farms.

Farm name	Management Description	Dominant Soil Order	Rainfall (mm/yr)	Irrigation (mm/yr)	Total Area (ha)	Effective Area (ha)	Flat (%)	Area Irrigated (ha)
S&B Breeding 1	Low intensity	pallic	1340	0	380	360	0	0
S&B Breeding 2	Low intensity	brown	909	0	680	620	9	0

Table 4. Production of the representative sheep and beef breeding farms

Farm name	Stocking Rate (su/ha)	Cattle (%su/ha)	Breeding Ewes	Net Product (kg/ha)	Feed Conversion (kgDM/ kg product)	Imported Nitrogen (kg/ha)	Available Nitrogen (kg/ha)	Lost Nitrogen (kg/ha)	Operating Profit ($/ha)
S&B Breeding 1	9.1	22	2023	208	30	38	102	23	438
S&B Breeding 2	9.0	23	3112	202	29	8	84	8	345

Table 5. Physical dimensions of the representative sheep and beef finishing farms.

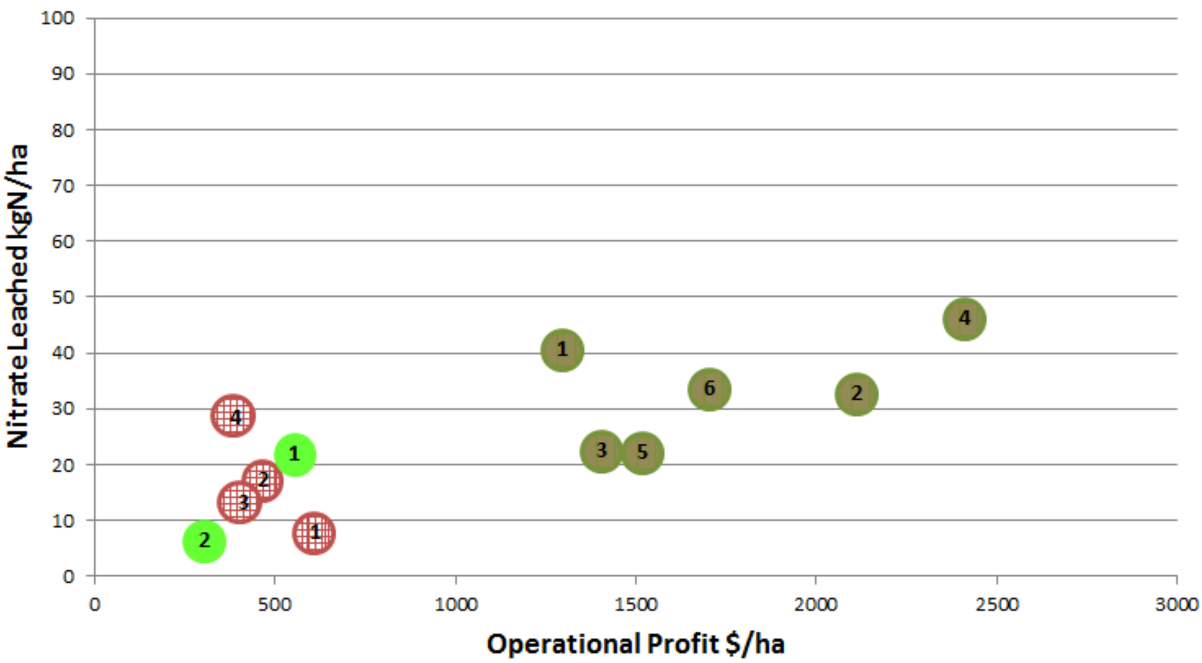
Farm name	Management Description	Dominant Soil Order	Rainfall (mm/yr)	Irrigation (mm/yr)	Total Area (ha)	Effective Area (ha)	Flat (%)	Area Irrigated (ha)
S&B Finishing 1	Moderate intensity	Brown	825	0	620	585	27	0
S&B Finishing 2	Moderate intensity	Pallic	1491	0	540	450	0	0
S&B Finishing 3	Moderate intensity	Pallic	870	0	1110	927	65	0
S&B Finishing 4	High intensity	Gley	778	814	360	350	70	84

Table 6. Production of the representative sheep and beef finishing farms

Farm name	Stocking Rate (su/ha)	Cattle (%su/ha)	Breeding Ewes	Net Product (kg/ha)	Feed Conversion (kgDM/ kg product)	Imported Nitrogen (kg/ha)	Available Nitrogen (kg/ha)	Lost Nitrogen (kg/ha)	Operating Profit ($/ha)
S&B Finishing 1	11.4	26	2,990	279	24	3	90	10	673
S&B Finishing 2	8.2	28	1,800	237	25	18	74	17	402
S&B Finishing 3	10.7	43	3979	266	19	9	68	8	329
S&B Finishing 4	11.4	48	0	320	26	44	116	15	267

The profitability of the farms and their nitrogen losses is shown in Figure 1. Due to the small sample size, there are no statistically significant relationships. On the representative farms, dairying in 2013-14 was considerably more profitable (per unit area) than sheep and beef farming. Although there was some overlap between them, the sheep and beef farms tended to have lower losses of nitrogen than dairying.

Figure 1. Profitability and nitrogen losses for the representative farms in the Ruamāhanga Catchment



Legend for Figure 1.

The six olive circles represent the dairy farms in Table 1.

The two green circles represent the sheep and beef breeding farms in Table 3.

The four brown hatched circles represent the sheep and beef finishing farms in Table 5.

Scaling Up the Representative Farms to the Catchment-Scale

Each of the representative farm types relate to different numbers of farms within the catchment as a whole. As the farms also have different land areas associated with each of them, their contribution to catchment attributes are also different (Table 7). Table 7 shows that sheep and beef breeding farms dominate the other land uses in the catchment, followed by sheep and beef finishing farms and then dairying. There are a further 1260 owners of rural lifestyle blocks, forests and sub-economic blocks of land in the Wairarapa, most of whom are residents of the Ruamāhanga Catchment (Statistics New Zealand, 2017). Their properties and forestry areas cover a further 110,000ha.

In Table 7 the calculations for farming's contribution to district GDP uses adjusted gross margins as their basis (MAF, 2004). The adjusted gross margins do not include the costs of farm labour, rates, or depreciation.

Although it has the smallest area in the catchment, dairying is estimated to make the largest contribution to district GDP of any farm type, followed by sheep and beef breeding, and then sheep and beef finishing.

The sheep and beef breeding farms had a substantial number of large sized properties and so contributed most towards estimated nitrogen losses in the catchment. Sheep and beef finishing farms also contributed more towards estimated nitrogen losses than dairying. However, each individual dairy farm contributes more towards nitrogen losses than any of the individual sheep and beef farming types.

For phosphorus, dairy, breeding, and finishing farms, contributed an estimated 7%, 24% and 69% of the phosphorus load respectively.

Policy Implications of Potential Water Quality Limits

Previous studies show that annual nitrogen losses in the river will have to be reduced by at least 16% or 180T if the catchment is to meet ANZSECC guidelines 65% of the time rather than the current estimate of 50% (Greater Wellington Regional Council 2007). If the 16% reduction in nitrogen discharges is carried equally by all sources, then based on the data in Table 7, livestock farming would have to reduce nitrogen losses by over 700T.

A number of policies could be used to drive this reduction, including restricting the types of landuse within a catchment, regulating farm practices or an allocation based approach. An allocation approach provides flexibility for farmers in how they meet their nitrogen cap and is economically more efficient than councils directly regulating practice change or landuse (MacDonald, Connor and Morrison 2004, p57).

Table 7. Estimation of Catchment Results Using Farm-gate Results

Farm name	Number of Farms	Farm Area (ha)	Catchment Area (ha)	Gross Margin ($000/farm/yr)	Contribution to district GDP ($Mill)	Nitrogen Loss (kgN/farm/yr)	Contribution to Catchment Nitrogen Loss (T/yr)
Dairy 1	10	170	1700	656	6.6	7140	71.4
Dairy 2	40	150	6,000	601	24.0	5100	204.0
Dairy 3	30	150	4,500	468	14.0	3600	108.0
Dairy 4	40	200	8,000	943	37.7	9400	376.0
Dairy 5	40	250	10,000	925	37.0	6000	240.0
Dairy 6	4	250	1,000	1,347	5.4	8750	35.0
S&B Brdg 1	70	650	45,800	289	20.2	14950	1,046.5
S&B Brdg 2	85	1000	85,000	373	31.7	8000	680.0
S&B Fin 1	10	800	8,000	555	5.6	8000	80.0
S&B Fin 2	100	650	65,000	264	26.4	11050	1,105.0
S&B Fin 3	30	300	9,000	132	4.0	2400	72.0
S&B Fin 4	50	400	20,000	104	5.2	6000	300.0
Total	509		264,000		217.8		4,317.9

Section 10 of the Resource Management Act (New Zealand Government 1991) limits the ability of regional councils in New Zealand to regulate landuses as they might be able to do in other OECD countries (Van der Molen, Breeuwsma and Boers 1997).

Allocating nutrient discharge allowances by regional councils is based on "grandparenting" each farm's past discharges, adjusted to incorporate the use of good management practices. The adjusted allocation minimises the reduction required by existing land users, while recognising and rewarding farmers that have previously adopted good management practices. It is up to each farmer to choose how they will remain under the nutrient-cap imposed by the allocation method.

Good management practices and adjusted allocation policies

If an adjusted allocation were to be applied in the Ruamāhanga Catchment, the good management practices included in the allocation calculation could be (Waikato Regional Council 2016):

- Changing effluent management on dairy farms by introducing storage and increasing application areas to reduce leaching and increase the use of its fertilising value.
- Changing fodder crop strategy on sheep and beef farms so that no crops are grazed by cattle over winter. Imported baleage is used as a substitute. Using imported supplementary feed avoids creating nitrogen losses from cultivation and has a greater utilisation of the available nitrogen content, for animal production.
- Changing the use of nitrogen fertiliser to reduce annual applications below 150kg N/ha, and avoiding winter applications (in cold wet weather).
- Grazing dry dairy cows out of the catchment for eight weeks over winter. Each catchment has its own policy constraints and the effect on other catchments of transferring nutrient losses in this way has not been included in this analysis.

These management practices have been identified as reducing nitrogen losses on dairy farms for the minimum amount of structural change in farming systems (including farmer competencies; McDowell, Wilcock and Hamilton 2013; Parminter 2015). Not all the farms suited every practice change and the contribution made by each practice towards reducing nitrogen losses varied with differences in farming systems, soils and climatic zones (Ministry for Primary Industries 2016).

Generally when the mitigation practices were introduced to the models and the existing farming systems maintained, nitrogen use efficiency stayed the same or dropped slightly (nitrogen in the products per unit nitrogen input).

The effect of introducing the mitigating practices on reducing nitrogen loads (compare with Table 7) is shown in Table 8. The combined effect of introducing these mitigations is a reduction of 691 T/year, close to the target of 700 T/year. In the Table the largest reductions are for those farming systems where cropping for winter grazing can be replaced by importing supplementary feed or grazing cows off the property. Greater reductions are possible in the catchment, but these would generally require large capital investments on livestock farms or land use change away from livestock farming entirely, e.g. expanding the area in forestry.

Dairy farmers can mitigate their overall losses in proportion to their initial overall contribution to the catchment. Sheep and beef breeding farmers appear to be able to mitigate less than their overall contribution, whereas sheep and beef finishing farmers, using the practices listed above, can mitigate more than their overall contribution. The farmers estimated to be currently losing more than 20kg N/ha, as a group, appear able to mitigate an estimated 4.4kg N/ha, but this, on its own would not be able to achieve the targeted reduction of nitrogen loss.

In Table 8 the proposed mitigations are estimated to cost the Wairarapa annually about $24 million (at the farm gate). The costs in the Table, average $90/ha or $34/kg nitrogen reduction. They are similar to the $95/ha calculated for a mix of mitigations modelled in Southland and the $100/ha for the cost of introducing mitigations on dairy farms in the Waikato (Vibarta et. al. 2015; McDonald et. al. 2015).

Table 8. Estimation of Catchment Reductions in Nitrogen and Gross Margin from Introducing On-farm Mitigations

Farm name	Number of Farms	Reduction in Nitrogen Loss (kgN/farm/yr)	Contribution to Catchment Reduction in Nitrogen Loss (T/yr)	Reduction in Farm Gross Margin ($000/farm/yr)	Reduction in District GDP ($Mill)
Dairy 1	10	1,118	11.2	70.6	0.7
Dairy 2	40	1,883	75.3	79.5	3.2
Dairy 3	30	242	7.3	75.1	2.3
Dairy 4	40	838	33.5	83.5	3.3
Dairy 5	40	946	37.8	113.3	4.5
Dairy 6	4	798	3.2	95.8	0.4
S&B Brdg 1	70	2,937	205.6	11.0	0.8
S&B Brdg 2	85	31	2.6	0	0
S&B Fin 1	10	1,806	18.1	32.0	0.3
S&B Fin 2	100	2,377	237.7	30.0	3.0
S&B Fin 3	30	153	4.6	102.4	3.1
S&B Fin 4	50	1,074	53.7	45.0	2.3
Total	509		690.6	23,808.9	23.9

In this study, the mitigation costs for the dairy farms were $416/ha ($85/kg N), this was largely the result of de-stocking over the winter. For sheep and beef farmers the costs were $58/ha and $84/ha for breeding and finishing farms respectively, mainly due to the extra costs of purchasing supplementary feed to replace winter cropping. It may be possible for the farmers in the Wairarapa to improve on-farm efficiencies when introducing the possible mitigations, by upskilling in a number of ways to increase their pasture utilisation and decrease their feed costs (DairyNZ 2010). Farmers may also find more cost-effective ways of reducing their discharges to meet their allocation than those outlined here. In both cases, this would reduce the net costs of reducing discharges.

Conclusion

The focus of this paper has been on using examples of farming systems to illustrate an approach to setting nutrient load limits in catchments through New Zealand. Catchment communities are making decisions about water quality objectives and limits. When they do, they often want to improve water quality and reduce the nutrient losses into catchments from agriculture.

In the example catchment, it is possible to improve water quality from achieving ANZECC guidelines for nitrogen from 50% of the time to 65% of the time. The changes required on farms involve a greater use of imported supplementary feeding of cattle during the winter on sheep and beef farms, and destocking dairy farms over winter. In a catchment such as the Ruamāhanga, the large area committed to sheep and beef farming means that even small changes to their nitrate leaching can have a big impact on the whole catchment. On the other hand, while dairying does not involve a large proportion of the land area of the catchment, the higher intensification of dairy farms means that it has an influence on nutrient losses greater than its area would suggest.

This example catchment highlights some of the difficult decisions facing policy makers to determine the water quality limits, and how to efficiently and equitably share the financial cost of improving water quality. In this example, farming was not able to fully achieve its reductions in discharges without also introducing significant land-use changes. Sharing the burden for achieving water quality targets amongst farming, urban and industrial sources is likely to be necessary in most catchments. Similarly, equity issues also arise when considering how to share the costs within the farming sector. The good management practice-based approach tested in the case study catchment resulted in dairy farms facing much higher mitigation costs per hectare than sheep and beef farms.

The New Zealand Government has recognised these difficulties facing regional councils and communities. The Government has indicated that it is working towards an allocation framework which will identify and develop acceptable options for the allocation of discharges that will increase the sustainable economic and social benefits to New Zealand. Final recommendations are to be provided by November 2017, with legislation to follow in 2018.

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