NEW ZEALAND'S FRESHWATER REFORMS: WHAT ARE THE POTENTIAL IMPACTS ON GREENHOUSE GAS EMISSIONS?

Motu Note #26

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OVERVIEW

This report is a synthesis of results from two independent studies and was originally prepared for the Ministry of Primary Industries Sustainable Land Management and Climate Change (SLMACC) Research Programme.

The National Policy Statement for Freshwater Management (NPS-FM) 2014 supports improved freshwater management in New Zealand by directing regional councils to establish objectives and set limits for freshwater in their regional plans. The question this project aims to address is whether there are biophysical co-benefits or additional risks for GHG emissions into the future arising from farmer responses to these freshwater reforms. While a great deal of research has been carried out to quantify the processes, transformations, and effects of contaminant loss from land to water, as well as to identify strategies to mitigate contaminant losses to fresh water (e.g. McDowell & Nash 2012; Monaghan et al. 2007; McDowell et al. 2014), no national level research has been undertaken to assess the indirect impacts of the water quality component of the NPS-FM on New Zealand's greenhouse gas (GHG) emissions.

As a result, MPI SLMACC contracted two independent teams, one led by AgResearch with assistance from Scion and Plant and Food (AgR/S/PF); the other led by Motu with Landcare Research (M/LCR) and assistance from NIWA and AgResearch. Both assessed the possible impacts of freshwater reforms on NZ's land-based GHG emissions. The two teams took quite different approaches. Some of their results are directly comparable. This report first compares the methodologies used in the underlying reports (Shepherd et al. 2016 and Daigneault et al. 2016) and then presents the key messages that are consistent across the two reports.

METHODOLOGY FROM AGRESEARCH TEAM

The value in freshwater policy is in the implementation and follow-up of each Council at a catchment and farm scale on the broad polices and few to date actually have reduction targets locked in as enforceable limits. This determined the approach that was adopted. Firstly, the approach focused on the farm level assessment since this is the main unit of management. Secondly, a mix of Regional Councils were engaged to: understand the Regional Council response to freshwater reforms and how policy will be implemented; understand the main enterprises that will likely be impacted and their typical environments (e.g. landscape, soil type, rainfall).

The conclusion was that it was best to cover a range of N, P and sediment targets given uncertainty in the eventual targets and likely variation between regions and sectors (Table 1).

Motu Economic and Public Policy Research | agresearch | Landcare Research Manaaki Whenua | NIWA Taihoro Nukurangi | scion FORESTS PRODUCTS INNOVATION | Plant & Food RESEARCH RANGAHAU AHUMARA KAI

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Table 1: Proposed reductions (farm scale) across regions for the AgR/S/PF study

Sector	Nitrogen	Phosphorus	Erosion risk
Dairy Dairy support	10-40%	5-20%	0-5%
Sheep, beef or deer Other livestock (pigs, goats) Arable/cropping Fruit, viticulture or vegetables	5-10%	5-20%	10-30%

An analysis of potential mitigations was then undertaken, compiling exhaustive lists for each sector (dairy, beef & sheep and cropping), including a qualitative assessment of their potential co-benefit for GHG emissions (based on Newell-Price et al., 2011). This compilation of potential mitigations set a framework for testing results. The analysis of individual mitigations for reducing farm scale nutrient losses to water suggested that most would have a small but positive effect on decreasing GHG emissions. To quantify the system effects, we used farm system models and OVERSEER, analysing different farm systems by sequentially adding mitigations to farm systems and modelling the response in terms of reductions in losses to water and GHG emissions. This 'abatement curve' approach allowed us to estimate the range of mitigations required to achieve a range of target reductions. The mitigations started with those with low/nil cost and deemed relatively easy to implement, through to infrastructure and system changes. Not all were applicable to all systems that were modelled; consideration of factors such as farm production system, climate, topography and soil type are important factors that influence the effectiveness, and thus relevance, of mitigation measures that could potentially be implemented to decrease N and P losses to water. Baseline characteristics of model dairy farm types in four regions (Waikato, Bay of Plenty, Canterbury and Southland) were therefore defined and modelled to cover the necessary variance. Examples of the variability in effectiveness caused by these regionally-specific factors can be seen in Table 6.1 of the main report. A key assumption for dairy analysis was the aim to maintain production and associated intake levels. It was assumed that most of the mitigation options would have no impact on production, with the remaining few having a relatively minor impact on production. This was based on the experiences in the Pastoral 21 (P21) programme, which has shown that it is feasible to decrease N (and P) losses from dairy systems with only small effects on production.

For beef and sheep, it was assumed there are two drivers for on-farm change: (i) addressing soil erosion and the associated emissions of sediment and P through ecological and built infrastructure; and (ii) the ongoing drive to increase meat and fibre production per ha through improvements in sheep genetics, performance of high fecund ewes, high growth rates in young stock, changes in cattle policy away from breeding cows to dairy beef and environmental management beyond direct mitigation of emissions to air and water (e.g. shade and shelter). The former brings with it some enterprise change and the latter eco-efficiency benefits.

The challenge with cropping systems was how to model some of these mitigations within OVERSEER as arable farming systems have complex rotations and event-specific activities with varying degrees of leaching risks. Nevertheless, we were able to estimate the potential benefits of a range of mitigations across a number of different rotations.

Forestry represents an important part of GHG balances in catchments. We therefore made an assessment of the likelihood of how farms might respond to ETS rules and how this might drive on-farm responses to GHG mitigation using planted trees. This assessment was integrated into our farm modelling for each sector.

Modelling was undertaken using OVERSEER version 6.2.1 (April 2016) supported with Farmax modelling to ensure that the pastoral systems were feasible and any effects of mitigation on feed supply/production were captured. From this analysis we were able to draw conclusions about the potential impacts of NPS-FM on N (and P losses) and the resultant implications for GHG emissions. The farm system was our main unit of investigation. This was used along with land-use statistics and assumptions around areas of land affected by NPS-FM and possible targets to undertake some limited scale up to estimate regional and national-scale effects on GHG emissions.

METHODOLOGY FROM MOTU / LANDCARE RESEARCH TEAM

For this project, we reviewed and collected information on (a) the current level of development for reduction targets that are intended or likely to be applied to four key freshwater contaminants: nitrogen (N), phosphorus (P), sediment, E.coli; (b) the freshwater management units (FMU) at which these targets will be set; (c) the range of policy options that may be used to meet these targets; (d) the cost and effectiveness for a wide-range of options to mitigate the four contaminants as well as GHG emissions; (e) the distribution of management practices that are likely to be implemented based on a least-cost criteria; and (f) the change in land-based GHG as a result of these policy approaches.

The M/LCR modelling analysis is based on the following methodology:

- NZ is divided into 225 FMUs, as defined by each regional council (RC) in the country. Note that some of the areas to which we refer as FMUs are currently draft FMUs and/or referred to in regional plans as other geographical features such as water management zones or catchments.
- Limits are set for each FMU and contaminant based on published targets and interviews with the RCs responsible for implementing them, and on modelling scenarios. The specific limits for N, P, sediment, and E.coli are modelled in our 'core' policy scenario.
- We model the impact of FMU-level reduction targets for 4 contaminants: N leaching, P loss, sediment, and E.coli. Although sediment is not currently in NPS-FM, it is expected to be added in a future iteration. Targets are for 2030 and based on a change from baseline (2012) loads.
- The baseline assumes 2012 land use, commodity prices, and carbon price. The model incorporates a land-use map developed for this project and contaminant loads estimated by NIWA's CLUES model. We assume that these figures remain the same in the future, i.e. land use, farm profits, and load intensities are assumed to remain constant through 2030 for the no policy baseline.
- The policy impacts are modelled using the economic land use model New Zealand Forest and Agricultural Regional Model (NZFARM). NZFARM is a comparative-static, non-linear, partial equilibrium mathematical programming model of New Zealand land use operating at the catchment scale (Daigneault et al. 2012, 2016). Its primary use is to provide decision-makers with information on the economic impacts of agri-environmental policy.
- The policy scenario is assumed to be fully implemented by 2030.
- As the model is comparative static, it is progressed to estimate outputs under a new steady state as a result of the policy. Thus, outputs are measured as policy impacts in 2030 under the assumption that the policy scenario is fully implemented and landowners are collectively in compliance.
- The analysis includes a 'core' policy scenario and a number of sensitivity cases that adjust assumptions about the stringency of the targets and mitigation options available. All cases assume full compliance in each FMU.

- Unless specified, all policies assume that each FMU meets the target at the least aggregate cost to landowners operating in that geographical area (i.e. model run as an optimisation problem with the least cost combination of mitigation options available). We focus on on-farm mitigation. These mitigation options were reassessed and validated against new empirical evidence developed alongside the optimisation modelling approach. FMUs that listed specific policies or allocation options (e.g. natural capital in Manawatū-Wanganui regions) were also accounted for in the model.
- As in the AgR/S/PF study, the focus is on mitigation options within existing land uses, not options that involve significant changes in production. Land-use change is mostly limited to among pastoral uses. In actuality, it is possible that a noticeable proportion of the mitigation could occur through planting trees on marginal pasture, particularly in FMUs with high erosion and/or P rates, and as a result we relax this assumption for one of the alternative policy scenarios.

A summary of the policy scenario assumptions are listed in Table 2.

Table 2: Motu/LCR policy scenario overview

Scenario	Mitigation Options Available	2030 Reduction Targets*
Baseline	None. Assume all landowners implement current/baseline practices	None. Assume current loads are maintained through 2030
Core Policy	Individual practices & mitigation bundles	Regional Council (RC) interview info only (non-reported FMUs assume no change)
Core + Afforestation	Individual practices, mitigation bundles, and afforestation	Regional Council (RC) interview info only (non-reported FMUs assume no change)
Min 10% Target	Individual practices & mitigation bundles	All FMUs at least a 10% reduction in N, P, E, and S from baseline. RC reported targets greater than 10% continue to be implemented
Min 20% Target	Individual practices & mitigation bundles	All FMUs at least a 20% reduction from baseline. RC reported targets greater than 20% continue to be implemented

* from 2012 contaminant levels

KEY MESSAGES

Many of the results aligned between the two studies despite strikingly different methodologies. Overall, both M/LCR and AgR/S/PF analysis found that the impact of the freshwater reforms on greenhouse gases was not large. This is because (a) many of the mitigation options that are likely to be employed to meet freshwater contamination reduction targets have a limited effect on animal production and hence on GHG emission profiles, and (b) the NZ-wide aggregate contaminant reductions to water are relatively small.

How much might contaminants to water and GHG emissions fall?

- Land-based gross GHG emissions are estimated by M/LCR to be reduced by 0.8-1.7 million tonnes carbon dioxide equivalent per annum (MtCO2-e/yr), or 2-4% of 2014 agricultural emissions, as a result of RCs' current interpretation of freshwater reforms and without considering block-level afforestation as a mitigation options (M/LCR). AgR/S/PF estimated reductions were a little more conservative at 0.2-1.3 MtCO2-e/yr if 5-30% of land was affected by NPS-FM, again with the assumption that there is no major afforestation (some implemented on mixed livestock farms for sediment control) or other land use change.
- The total land area likely to be affected by the freshwater reforms is about 3 million ha, or 13% of New Zealand's area (M/LCR)
- The average reduction in contaminants expected as a result of the NPS-FM is less than 10% from current loads. M/LCR estimated that at the national level, aggregate reductions will be 6% for N, 5% for P, 18% for sediment, and 10% for E.coli (M/LCR). AgR/S/PF again estimated more conservative reductions of c. 4% for N based on a scenario of 30% of land affected by NPS-FM and some regional differences.
- GHG emissions are relatively inelastic to N mitigation. For each 1% of nitrogen reduced, gross GHG emissions are on average reduced by about 0.4% (M/LCR) or 0.3-0.7% (AgR/S/PF dairy/cropping – mixed livestock).
- Accounting for additional carbon sequestration from adding trees as a part of the mitigation mix makes the relationship between N and gross GHG closer to 1:1.

Where might mitigation of contaminants and GHGs occur?

- The largest GHG co-benefits are estimated to occur on hill country sheep and beef farms – from efforts to control P and sediment via pole planting and/or afforestation.
- Reducing N from dairy farms contributes about 25% of the gross emissions reductions when afforestation is not included (M/LCR).
- Both studies primarily focused on options that maintained land use and productivity as this has been a policy signal from several RCs and industry organisations. However, additional analysis found that if farmers were willing to afforest some of the higher emitting areas of the landscape, particularly for P and sediment, a high proportion of the mitigation could be achieved through this option – as demonstrated by the mixed livestock farms where trees were used to mitigate sediment and P losses (AgR/S/PF).

How is mitigation achieved?

- No single measure will substantially mitigate the impacts of farming activities on the environment: Improvements in freshwater quality will instead be achieved by the implementation of a range of measures. These include stock exclusion from streams and wetlands (via fencing and riparian planting), controlling hill-country erosion (e.g., via pole planting and afforestation), improved stock, effluent and fertiliser management, and, where deemed necessary, the introduction of farm infrastructure that allows for soil protection and the capture of animal excreta during periods when the risk of runoff is relatively high,
- In many cases, it is possible to achieve the N mitigation targets without changes in animal numbers; this consequently limits effects on GHG emissions.

- If afforestation is adopted as a mitigation option for freshwater contaminants, it may be widely implemented on marginal and/or relatively sloped pastoral land. This will likely lead to much larger GHG co-benefits (reduced methane and nitrous oxide plus sequestration) than the case where afforestation is not considered.
- A majority of P and sediment reductions are likely to occur from pole planting and afforestation on hill country, with relatively large co-benefits for GHGs, especially through carbon sequestration (although pole planting sequesters much less than afforestation).
- Sheep-beef management on hill country had much larger impacts on P and sediment than on N.

Are there any unintended consequences of the freshwater reforms on GHG emissions?
Both analyses found that a strong majority of mitigation options considered will not increase GHG emissions, but there is some uncertainty about whether a few options may increase GHG emissions. These include:

- Implementing medium and high cost arable cropping mitigation (M/LCR) because some of of the management changes may lead to improved yields and higher density stock grazing.
- Housing animals (AgR/S/PF) because of the risk of pollution swapping, reducing N leaching risk but increasing gaseous losses of N and methane. More research is required to evaluate this risk.

SUMMARY

In summary, if afforestation in response to NPS_FM is limited and we focus on practices that sustain production levels in pastoral farming, the impacts of the NPS_FM on gross GHG emissions are projected to be relatively small. This is because the area affected is not great, the required reductions in contaminants are not likely to be large and the likely (i.e. low cost) mitigation options outside of reforestation may have only small effects on gross GHGs. Significant increases in GHG emissions resulting from the reforms are very unlikely. The greatest co-benefits are likely to be seen on sheep and beef farms, especially hill country. On this land afforestation would provide the greatest reductions in sediments and P and greatest GHG co-benefits, lessened by intensification on the remaining farmland and subject to careful management of sediment at harvesting. Spaced pole planting provides a good alternative and may be preferred by landowners wishing to maintain stock production, although the added benefit of carbon sequestration would be lower.

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