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Beef and sheep farming – grazing management practices in the Waikato region

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Executive summary

Nutrient management is a focus for the Waikato Regional Council due to its role in managing the region's water quality. Nutrients from the land seep into groundwater, flow into waterways and lead to reduced water quality. Monitoring shows that nutrient concentrations in waterways are increasing across intensively farmed areas in the region.

Related to the issue of increased nutrients in waterways, are soil compaction and excessive fertility in the region's soils. Stocking pressure can lead to pugging of soils. Pugging results in compaction of the pore spaces in the soil so that water logging can occur leading to nutrients and bacteria running off into waterways. Excessive fertility results when more fertiliser is added to soils than plants can use. This extra fertiliser can leach into waterways or get washed off with soil particles when it rains (Environment Waikato, 2008). These processes mean that there is a strong connection between beef and sheep farmers' grazing management practices and nutrient management.

The purpose of this research is to understand the grazing management decisions of beef and sheep farmers' in the Waikato region, and relate that to nutrient management issues to give a picture of how nutrient management practices are, or could be, incorporated into the various farm contexts. Those farmers providing dairy support through dairy heifer grazing or wintering dry dairy cows were considered to be part of the beef and sheep sector as these activities are on the increase (Ministry of Agriculture and Forestry, 2011b). The focus of the research is on the winter practices on farm that help or exacerbate nutrient management. See Davies and Topperwien (2011) for the companion report on dairy farmers.

Asking farmers why they choose certain practices over others, or why they may have made changes to their farm system, can provide insight into the likelihood of the adoption of practices. It can help identify areas of the farm system where farmers are already exercising recommended practices. It can also indicate potential barriers or obstacles associated with certain practices, which could impede the adoption of new practices that could contribute to Council's objectives.

In all, 32 beef and sheep farmers participated in the research through in-depth interviews. Interviews were undertaken in the main beef and sheep areas of the region. Interviews were held with farmers running a wide range of enterprises and livestock combinations. Half of those interviewed stocked beef and sheep. Of the half that stocked only cattle half of them had dairy support activities on farm. Four farmers were operating as dairy support only, three were raising dairy heifers for trade or on grazing contracts and one farmer took dairy cows through winter. This mix of beef cattle farming with dairy support is now common in the sector, with 19 per cent of income coming from dairy grazing on Waikato/Bay of Plenty beef and sheep farms (Ministry of Agriculture and Forestry, 2011b).

Farm effective area ranged from 35 to 3000 ha, with the average effective area being 336 ha, close to the Northland/Waikato/ Bay of Plenty region average of 339ha (Beef and Lamb New Zealand, 2011a). Numbers of stock by type and age class varied according to the farm enterprise mix and business scale. Total stock numbers ranged from less than one hundred up to 21,000 (though not all stock were on the farm throughout the year). Soils, climate, rainfall and topography varied, which lead to variation in grazing management practices.

This report presents the recommended nutrient management practices available to farmers and the actual grazing management practices of farmers from the interviews. Grazing practices (such as rotation, extensive or intensive and winter cropping), fertiliser application, wet soils management practices, feed systems (including the use of grown supplements) are covered in the report.

The table below draws together the recommended practices with the interviewees' farm practice to see where practices are currently undertaken and where potential exists for practice change and where barriers exist to adoption. The report contains more detail, including verbatim comments from the participant farmers to illustrate how and why these practices are integrated into their respective farm systems.

Table 1 Summary of farm practices for nutrient management

Recommended Management Practice	Summary of practices and potential barriers to uptake
Wintering practices – destocking, managing wet soils Reduce stocking pressure over winter by selling stock, returning grazed stock or manipulating the beef to sheep ratio. Run lighter stock in winter, particularly on steeper, erosion prone land. Use break feeding and rotational grazing regimes to relieve stocking pressure.	Most beef and sheep farmers ran their enterprises to allow for de-stocking during the winter, either by selling stock or returning grazed stock prior to winter. Strategies to avoid compaction or pugging were seen as important, and most farmers were aware of the damage to pasture and soil condition if soils were not properly managed in wet periods. Beef and sheep farmers we interviewed did not have infrastructure for standing off. However, a few did use their raceways to stand off when needed. This lack of standing off infrastructure meant that, to avoid pasture damage through erosion, pugging and compaction, heavier stock were moved off steeper land and onto easier contoured land with less erosion risk. Farmers relied on either set stocking over larger areas, break feeding, strip grazing smaller paddocks, or changing rotation depending on weather events and stock condition. Farmers stated clear preferences and reasons for those preferences for the management practices they had chosen. Given the increasing intensity of beef farming, farmers may need more management options in the future to minimise soil compaction and reduce the risk of N leaching and P run-off in high risk months.
Winter cropping Crops can support feed deficits, but concentrating large numbers of stock for long periods in cropped paddocks can result in pugging and compaction of soil, increased risk of P and N loss from urine and dung and transport of faecal coliforms from dung, and damages to the soil reducing long-term productivity.	One in eight farmers in this study were reliant on winter crops to fill feed deficits. A number of farmers grew crops that were used to finish stock as part of pasture renewal programmes.
Riparian Management Riparian fencing can reduce the amount of P, sediment and microbes (such as faecal bacteria) entering the water by preventing stock from trampling banks and accessing waterways, including wetlands. Riparian planting further helps stabilise banks and block the movement of soil particles from land into waterways.	Half of the beef and sheep farmers interviewed reported having fenced off waterways on some or all of their property. Two interviewees reported that they had fenced their wetlands. In general they held favourable attitudes towards this practice as it provided benefits in terms of stock management, and for some water quality in their local stream. However, not all waterways were considered necessary to fence, and some farmers observed that beef cattle would ignore a natural waterway where trough water was supplied. For others, the perceived risk of animal pests and weeds was a barrier to fencing and to riparian planting. Those with swampy areas on their properties would graze

Recommended Management Practice	Summary of practices and potential barriers to uptake
	them as times throughout the year. Two farmers mentioned that they were intending to drain these areas as part of their pasture renewal and subdivision programme. This suggests that while farmers may hold favourable attitudes towards riparian management in general, areas such as swamps and swales may not be perceived as useful for nutrient mitigation purposes.
Soil Conservation and Afforestation Soil conservation and afforestation practices assist in the reduction of phosphorus losses: Soil conservation works to control erosion and sediment sources in upper catchments Afforesting steep southern slopes with low production value and high erosion risk. For example, with space planted poplars or production forestry.	Over a third of interviewees mentioned that they had areas of farm forestry on their properties. These areas were on steeper, unproductive or erosion prone land. A further five interviewees had retired areas or plantings for soil conservation areas. Some farmers identified benefits beyond erosion control from retiring areas for soil conservation or for production forestry such as increased animal safety through fencing off steeper areas.
Nutrient Budget Nutrient Budgets assist farmers to identify where savings can be made and monitor the amount of nutrient leaching occurring from their system	Several interviewees were aware that their fertiliser representatives made fertiliser application recommendations based on nutrient budgets, but most did not mention having a nutrient budget. Nutrient budgets offered by fertiliser representatives have potential to be adopted as they offer potential to reduce fertiliser costs.
Nutrient Management Plan (NMP) A NMP provides farmers with a list of actions to mitigate nitrogen (N) and phosphorus (P) losses from their system	None of the farmers interviewed indicated that they had an NMP. Many farmers in this study were probably not required to have an NMP as they were unlikely to be applying N in excess of the 60kg of N/ha/yr threshold prescribed by the Waikato Regional Plan. However, total quantities of N applied had not been calculated and some farmers indicated that they were applying amounts of 50-60 kg of N/ha/yr based on their urea application. Taken with the N content of other fertiliser applied they may well be over the Plan's threshold. Regardless of the compliance trigger for a NMP, preparation of a plan is a useful step in identifying where nutrient losses are occurring and how to mitigate them. The effectiveness of nutrient management plans depends on their successful implementation, and recommendations in a NMP may have significant impacts on a farm system. While a NMP preparation may have a limited focus, for example on the nutrient budget and some good practices, a fuller farm system based plan prepared by a farm consultant may cost in the order of $3,000 to $5,000 and is likely to be a disincentive to adoption by beef and sheep farmers. The benefits of a NMP over a nutrient budget would need to be demonstrated to farmers to increase uptake.
Fertiliser management - nitrogen management Nitrogen management practices include: avoiding applications in winter to reduce the risk of leaching, reducing N rates in line with the Nutrient Budget, using nitrification inhibitors	This study found that two-thirds of the farmers were applying dressings of nitrogen as urea in addition to their main fertiliser. In general, these were of low quantities (20 – 50 kg/N/ha/yr) and applied in separate dressings in autumn or spring or both. Winter applications were generally avoided, but were made by some farmers to fill feed deficits when they were unable to feed out supplements as their paddocks were too wet. For these farmers the potential to reduce winter applications

Recommended Management Practice	Summary of practices and potential barriers to uptake
	of nitrogen may be limited. The use of nitrification inhibitors was not mentioned by any of the farmers interviewed.
Fertiliser management – phosphate management Phosphorus adheres strongly to soil particles, which can be transported via overland flow to waterways. Management practices should avoid pugging of soils, stock grazing on steeper slopes and near waterways and avoid soluble fertiliser P applications during high risk months, use slow release forms of phosphate fertiliser	Many farmers stated that avoiding pugging was a priority because of the potential for pugging to reduce productivity. Farmers usually moved heavier classes of stock off slopes to avoid pugging and erosion. In general, this meant that heavier stock were concentrated on flatter contoured areas of the farm and were generally managed by intensive grazing practices such as break feeding or strip grazing. These practices have the propensity to lead to pugging and compaction and therefore increase the risk of transportation of phosphate via overland flow. Farmers avoided applying fertiliser in the high risk, wetter months. Of those that knew their Olsen P levels, half had levels within the recommended optimum economic return levels of 20-30 for ash and sedimentary soils and 35-45 for pumice soils. Some farmers had Olsen P levels above the recommended level and therefore the risk of phosphorus transport to waterways was increased. A third of the farmers interviewed did not know their Olsen P levels. This could indicate a potential opportunity for beef and sheep farmers to reduce nutrient emissions by nutrient budgeting. A few interviewees mentioned the use of slow release forms of phosphate fertiliser such as RPR.
Supplementary feed Importing Low-N supplements can be used to overcome feed deficits instead of relying on N to boost pasture growth.	Importing feed was not common among the farmers interviewed. There was a general preference towards growing feed supplements as a feed buffer or insurance against summer or winter feed deficits because of the costs of imported feed. Commonly grown supplements for cattle were hay, grass, triticale or maize silage. However, some preferred to use nitrogen fertiliser to boost pasture growth as they were unable to feed out when paddocks were waterlogged, and some stated that nitrogen was more cost effective than growing supplements.

Summary and recommendations

There is a deficit of information on the environmental and economic benefits of nutrient mitigation practices for beef and sheep farming systems.

This research has shown that there are a number of factors that beef and sheep farmers must consider (including climate, soils and topography) when assessing the potential benefit of changing wintering practices. Some changes may not even be feasible in some farm contexts. For example, restricting grazing of winter crops to reduce nutrient emissions is impractical when winter cropping is essential to fill feed deficits. This means that farmers are unlikely to change practices to reduce nutrient emissions unless the change offers a clear advantage over current management practices for the winter months.

For these reasons, it is clear that ‘a one size fits all’ approach to improving nutrient management on beef and sheep farms is not feasible. Nutrient management on such farms must be tailored to account for site-specific factors. For example, some practices such as applying nitrogen in winter months are relied on to meet feed deficits that can not be met by providing supplements because land is too wet to feed out on. Other practices such as utilising nutrient budgets and preparing nutrient management plans may be more easily adopted, but their execution might not be fulfilled.

It is clear from the results reported here that there are a number of wintering practices that align with the policy objective to reduce nutrient loss, particularly during the winter risk period such as stock reduction, removing heavier stock from erosion prone areas and in the main, timing of fertiliser applications. These practices enable farmers to manage the condition of pasture and stock and so maintain farm productivity over the winter.

In addition, from a policy perspective, some practices adopted are not necessarily carried out in a manner that will achieve the policy objective to limit nutrient losses to waterways, for example the extent of riparian fencing and planting.

Based on the findings reported, the following recommendations are made. That the Waikato Regional Council:

1. Promote research on nitrogen and phosphorus transport mechanisms to waterways on beef and sheep farms, and in particular the risk periods for stock management and relative contribution of mitigation practices.

2. Promote research into practices to minimise nutrient losses from dairy support activities on beef and sheep farms.

3. Continue to work with beef and sheep farm advisors/consultants to assist the development of consistent messaging around nutrient management tools.

4. Work with industry to improve beef and sheep farmers' understanding of nutrient budgeting and interpretation of Overseer results to increase farmers' perception of the value-add of nutrient management to their business.

5. Be a party to current research and development of mitigation measures with the science and industry sectors to assure alignment of outcomes between the sector and policy developments both national and regional.

6. Address the gap in research on new technologies such as nitrification inhibitors and alternative low-N feed supplements for the beef and sheep sector by advocating for specific field trials within the region.

7. Address the gap in research on new technologies for the management of phosphorus loss for the beef and sheep sector.

8. Continue to promote appropriate riparian management as an effective nutrient mitigation measure. Consider targeted communication about requirements tailored to this sector and promote available incentives to increase uptake.

9. Incorporate the variety in farm context in any nutrient management 'tool kits' which WRC develops or promotes.

10. Promote research into practices to minimise nitrogen and phosphorus losses from winter cropped areas.

11. Recognise the variation in farm context in any regulatory framework put in place to promote nutrient management practices on beef and sheep farms.

1 Introduction

Waikato Regional Council has a statutory role to manage water quality and land use where it affects soil and water bodies. There is a clear trend towards greater concentration of nutrients in the region’s waterways, making nutrients a focus for the Waikato Regional Council. Nutrients from the land leach into groundwater, or flow into streams, rivers and lakes. Increasing nutrient concentrations can lead to increased weed and algae growth (decreasing water clarity), low oxygen levels (affecting aquatic life) and can lead to toxic algal blooms (Waikato Regional Council, 2008). Moreover, declining waterway health can affect both the mauri of the waterway and its capacity to support traditional cultural activities (Ritchie, 2007). Water quality is consistently rated the highest environmental concern in surveys of the Waikato community (Gravitas, 2006).

Sediment, microbial contamination and nutrients adversely affect water quality. Land use practices contribute these and other contaminants to water bodies, much of which comes from diffuse sources. For instance, soil compaction and excessive fertility are common problems in the region and both may increase nutrients in waterways. Excessive stocking pressure can lead to pugging of soils. Pugging results in compaction of the pore spaces in the soil so that water-logging can occur leading to nutrients (predominately sediment and associated phosphorus) and bacteria running off into waterways. Furthermore, as a general rule, as stocking rates increase on grazed pasture more urine is deposited. This increases the potential for nitrogen to be leached below the root zone and enter ground and surface water (Waikato Regional Council, 2008).

Excessive soil fertility results when more fertiliser is added to soils than plants can use. The extra fertiliser can be leached into waterways or get washed along with soil particles into waterways when it rains (Waikato Regional Council, 2008). Therefore, there is a strong connection between farmers’ management practices (such as stocking rate and management, fertiliser use, feed management) and nutrient losses.

In August 2007, the Waikato Regional Council commissioned a report to summarise current scientific understanding of, and gaps in knowledge about, management practices and nutrient losses on dairy and to some extent beef and sheep farms, and to identify the effectiveness of practices in reducing nutrient losses from these farm systems (Ritchie, 2007).

In that report Ritchie (2007) observed that while there were a range of management practices available for pastoral farmers to adopt that affected nutrient losses, there were only a few practices that were easily incorporated into these farm systems that had a beneficial impact on both farm income and the environment. In addition, local climatic, soil and farm management variables influenced the magnitude of environmental gain from implementing different practices (Ritchie, 2007). However, information on the extent to which beef and sheep farmers were adopting management practices that influence nutrient losses, and knowledge of the factors that influenced their decision-making about adopting these practices was not covered.

Consequently, the council commissioned this report on the adoption of management practices by beef and sheep farmers in the Waikato region. In particular, this report provides an understanding of beef and sheep farmers’ decision-making around the adoption of a number of practices within the context of their grazing management systems, and how these practices link to nutrient losses from beef and sheep farms. A companion study focuses on dairy farming systems (Davies and Topperwein, 2011).

The aim of this report is to assist policy makers in developing practical recommendations to achieve policy outcomes by providing information about beef and sheep farmer decision-making and farm practices. The report is also intended to support delivery of targeted advisory and education programmes in relation to nutrient management on farms.

The findings in this report are based on interviews with 32 beef and sheep farmers in the Waikato region. Interviews were not intended to be an assessment of environmental best practice or compliance with Waikato Regional Council rules, for example the stock exclusion rule (see Waikato Regional Plan 4.3.1).

The theoretical framework used to inform the design of this study and interpret the results was the Kaine Framework (Kaine, 2004); which is briefly outlined in section three of this report. Interviews were conducted following the process described by Kaine (2004; 2008). This process enabled the interviewers to develop a systematic understanding of farmers decisions to adopt or reject management practices based on farmers descriptions of (1) their farm systems and (2) the reasoning underpinning their choice of management practices.

The findings for each of the management practices are presented with an emphasis on their role in contributing to, or mitigating, nutrient losses from beef and sheep farms.

A discussion of the findings about management practices in relation to nutrient losses is given. An assessment about the likely adoption by beef and sheep farmers of each practice is provided by taking account of the benefits and costs that farmers' decision-making revealed about each practice, including the ease of its integration with the farm system.

2 Background

Statistics New Zealand reports that there are 3,700 sheep, beef cattle and grain farmers in the Waikato region (Statistics New Zealand, 2011a). The region's beef and sheep industry is traditionally characterised by pasture-based, dry-land activities (that is not irrigated) and is a major land use with 0.5 million beef cattle and 1.8 million sheep in the region in 2011(Statistics New Zealand 2011b).

Beef and sheep farms are categorised by Beef and Lamb New Zealand into farm classes. Relevant to the Waikato region are class 3, North Island hard hill country, class 4, North Island hill country and class 5, North Island intensive finishing (Beef and Land New Zealand 2011b).

Class 3 farms are characterised as being on steep land or low fertility soils, mostly with a stocking rate of 6-10 stock units per hectare and mostly operating as a breeding or trading enterprise. Class 4 farms are typically on easier hill country or higher fertility soils, carrying 7-13 stock units per hectare. These farms are mostly operating as trading or finishing enterprises. Class 5 farms are on easy contour land, mostly stocked between 8-15 stock units per hectare. These farms are mostly operated as finishing enterprises and replacement stock are often purchased rather than bred (Beef and Lamb New Zealand, 2012)

Finishing systems were those where livestock were fattened for slaughter, trading systems were those where livestock were grown and sold on to be fattened elsewhere and those undertaking breeding focussed on supplying livestock for their own production or for onward sale.

The average size of sheep and beef farms in the Northland/Waikato/Bay of Plenty region is 339 effective hectares. (Beef and Lamb New Zealand, 2011a) The 2011-12 estimated average size of a Class 3 farm is 782 ha, of a Class 4 farm is 419 ha and of a Class 5 farm, 269 ha (Beef and Lamb New Zealand, 2012).

Recent trends in the industry have seen the conversion of beef and sheep land to dairying, a move towards higher intensity beef and sheep systems which are more economically viable and an increased level of dairy support activities on beef and sheep farms. The Ministry of Agriculture and Forestry's Farm Monitoring Report 2011 states that:

> "Despite the increase in sheep, beef and wool prices there was still an increase in dairy support activities through wintering dairy cows on kale crops, selling surplus hay and baleage to dairy farmers and increased heifer grazing …. In some cases dairy grazing allowed farmers to maintain their stocking rate when they couldn't afford to purchase high priced trading cattle" (Ministry of Agriculture and Forestry, 2011a p7).

In areas closer to towns, there has been some fragmentation of beef and sheep farms into lifestyle blocks. In a review of agricultural trends in the region, Cameron et al, (2008) reported a decline in beef and sheep farming over the last decade with large scale de-stocking in the sheep industry. However, they concluded that "sheep and beef farming will continue as a pasture-based activity on land that is not suitable for dairying" (Cameron et al., 2008, p 35).

This mix of beef cattle farming with dairy support is now common in the sector, with 19 per cent of income coming from dairy grazing on Waikato/Bay of Plenty beef and sheep farms (Ministry of Agriculture and Forestry, 2011b).

Nitrogen leaching from dairy farms is higher than from beef and sheep farms (McDowell and Wilcock, 2008). Judge and Ledgard (2009) reported an average nitrogen leaching rate of 38kg N/ha/yr for dairy compared to rates of 10kg N/ha/yr for class 3 sheep, beef and deer farms, 14 kg N/ha/yr for class 4 and 16kg N/ha/yr for class 5 in 2007/08. The higher rates of nitrogen leaching from class 5 farms reflects the increased use of nitrogen particularly on these more intensively farmed systems despite "no change in overall stocking rate" (Judge and Ledgard, 2009, p 9).

In comparison, phosphorus losses from dairy farms are lower than from sheep, beef and deer farms (McDowell and Wilcock, 2008). Judge and Ledgard found that for the same period, with dairy farms averaging 0.8kg P/ha/yr and sheep, beef and deer farms averaging 2kg P/ha/yr on classes 3 and 4 farms and 0.5kg P/ha/yr on class 5 farms. (Judge and Ledgard, 2009). This is because slope is the largest determinant of P loss as soil particles are mobilised running off to waterways or erosion occurs. Most class 5 farms and dairying in the Waikato region occurs on flat to rolling land.

In addition to differences in farm scale and production systems, rainfall (average annual rainfall in the region is 1,250 mm), soils and topography are significant contributors to the variation in the management practices adopted by beef and sheep farmers across the region.

2.1 Nutrient management practices

Within the region, some practices that contribute to nutrient losses are regulated through the Waikato Regional Plan (WRP) to encourage nutrient mitigation such as those for fertiliser use and application and stock exclusion from water bodies. However, a number of the practices that have been shown to reduce nutrient losses are not regulated and it is up to beef and sheep farmers to put these practices in place voluntarily.

A range of management practices have been shown to reduce nutrient losses from pastoral farms (Longhurst, 2008; Ritchie, 2007). However, strategies to mitigate nutrient losses on beef and sheep farms are not as well developed as those for dairy farms (McDowell and Houlbrook, 2009; AgFirst Waikato, 2009, Monaghan et al., 2010) and research gaps exist, particularly around nitrogen losses from grazed winter crops and the effectiveness of nitrification inhibitors in the Waikato region (Ritchie, 2007; Mercer et al, 2011).

Check lists of potential nutrient mitigation measures are available, however, as Ritchie (2007, p 7) notes, "it is impossible to be definitive about which nutrient practices will be most affective across all farms… [and that] … not all practices have equal scope to reduce nutrient losses." In recent years work has been done on demonstrating the need for customised assessments of nutrient mitigation practices for farms, including a limited case study of beef and sheep and deer farms in the Upper Waikato Nutrient Efficiency Study (AgFirst Waikato, 2009). While this was not a large study it illustrated the variance that the optimisation of nutrient mitigation practices can have on different dry stock systems, and concludes that "there does not appear to be any one 'recipe' which reduces nitrogen leaching and optimises farm systems performance and profitability" (AgFirst Waikato, 2009, p 3.)

Practices can be divided into those that assist with reducing nitrogen (N) losses and those that reduce phosphorus (P) losses because the pathways of phosphorus and nitrogen to water are different.

The majority of nitrogen (69 per cent) entering water from grazed farmland comes from stock urine, with 13 per cent from lanes or raceways, 8 per cent from dung and other natural sources, 5 per cent from applied sources and 5 per cent from nitrogen fertiliser (Waikato Regional Council, 2008). Most phosphorus travels to water attached to particles of soil or dung that wash off the land into streams, while nitrogen mainly leaches with drainage water through the soil to groundwater and, eventually, into waterways. Phosphorus can also enter waterways from direct application of fertiliser (Monaghan et al., 2010).

The following section briefly outlines the range of practices generally regarded as useful to reduce nutrient losses from beef and sheep farms (Longhurst, 2008; Ritchie, 2007; Wise Use of N-Fertiliser on Hill Country Pastures, 2006; Beef and Lamb New Zealand, 2011c). These practices should only be considered as background to the discussion of farm practices and not a definitive suite of recommended practice, and should not be read as presenting the relative order of contribution to nutrient losses.

Winter grazing management – the environmental effects of leaving cattle on wet pastures for extended periods have been widely documented (Betteridge et al., 2003; Ritchie, 2006; McDowell et al., 2008). Stocking pressure can severely damage the topsoil through pugging and compaction by reducing air spaces which can lead to reduced water holding capacity and infiltration. The use of break feeding and rotational grazing regimes can relieve stocking pressure. Shifting mobs regularly (twice per day) and back fencing can reduce excessive treading (Beef and Lamb New Zealand, 2011c).

In the Waikato region there are no specific rules in relation to the practice of using sacrifice paddocks as stand off areas. However, farmers are subject to the general rules that prohibit run off and discharge of contaminants into waterways (see Appendix 1) and under the Resource Management Act, 1991 15 (1b). Sacrifice paddocks are not a recommended practice because the concentrated treading from cows can cause pugging and soil compaction, which can then increase phosphorus runoff by increasing overland flow. Where sacrifice paddocks are used, farmers should avoid using paddocks near waterways as sacrifice paddocks and should distribute feed in different parts of the paddock to minimise stock trampling (Waikato Regional Council, 2008).

Reducing stock numbers over winter when the risk of nitrogen leaching is high is a key strategy to reduce nitrogen losses, as the majority of losses arise from stock urine (Betteridge et al., 2009; AgFirst Waikato, 2009).

Winter cropping - nutrient mitigation practices are important in the management of forage crops, that is, supplements grown on farm. There are a number of winter forage crops suitable for New Zealand dairy, beef and sheep farms, the most common being brassicas and cereals. Concentrating large numbers of stock for long periods in cropped paddocks can result in pugging and compaction. This damages the soil which reduces long-term productivity, increases the risk of phosphorus and nitrogen loss from urine and dung, and the transport of faecal coliforms from dung.

As cropping is frequently incorporated into a pasture renovation programme, care needs to be taken not to leave bare soils exposed as this increases the risk of runoff, sediment loss, faecal contamination and direct losses of nitrogen through mineralisation and volatilisation processes.

Riparian management – riparian fencing can reduce the amount of phosphorus, sediment and faecal bacteria entering waterways by preventing stock from trampling banks and accessing waterways. Wetland areas are effective at removing nitrate in drainage water, so fencing wetlands to restrict stock access is important. Riparian planting helps stabilise banks and block the movement of soil particles from land into waterways. In general, the steeper and longer the slope that feeds into a waterway the wider riparian planting needs to be to achieve the maximum filtering effect (Legg, 2004).

However, riparian management is less successful at reducing nitrogen entering waterways as nitrogen tends to infiltrate through the soil into groundwater from the paddock surface, rather than be transported along the surface with soil particles into waterways (Waikato Regional Council, 2008).

Nutrient Budget (NB) – a NB models farm inputs and outputs to predict the amount of nitrogen leaching and phosphorus run-off. A NB should provide a system to determine the levels of nutrient surplus once all the farm inputs (fertiliser, feed supplements, clover nitrogen fixations, animal manure) and farm outputs have been calculated to estimate the levels of N and P leaching (Longhurst and Smeaton 2008, p 34). Farmers can use the information from their NB to identify where savings in nutrients (particularly fertiliser purchases) may be made.

Nutrient Management Plan (NMP) – a NMP extends the NB by taking into consideration the whole farm context to identify how nitrogen and phosphorus losses can be reduced. The NMP provides an action plan to reduce farm nutrient losses and is a requirement under the WRP once nitrogen fertiliser is being applied at rates greater than 60kg/N/ha/year (see Appendix 2). Under this rule a NB must be modelled using an approved programme such as OVERSEER®.

These actions fall into one or more of the following categories:

- fertiliser management
- effluent management
- soil management
- pasture management
- production and stock management
- riparian management
- cropping management
- management of waterways at risk from hot spots: silage pits, offal holes and farm dumps (Waikato Regional Council, 2009).

Fertiliser Management

- Nitrogen management – recommended practices include avoiding nitrogen applications during the winter when there is more risk of leaching or runoff (May to July), making sure nitrogen is applied about 4-6 weeks before there is a feed deficit and when there is a rapid uptake by actively growing pasture.
- Total nitrogen fertiliser applications of 200 kg N/ha/year or more should only be implemented after referring to the Code of Practice for Nutrient Management (New Zealand Fertiliser Manufacturers' Research Association Inc, 2007) and obtaining the advice of an accredited consultant (Roberts and Morton, 2009, p 49).

- In general farmers could consider using nitrogen inputs in line with their NB.

- Strategic dressings of nitrogen fertiliser to fill anticipated feed deficits are useful, but high rates of nitrogen may give short-term benefits at the expense of long-term environmental damage. Appropriate rates of N application range from 20-60 kg/ha (Beef and Lamb New Zealand, 2011c).

- Nitrification inhibitors may provide a future technology with which to lower nitrogen losses in the Waikato region. However, most trials to date have been in a dairy setting and outside the region. In one study relevant to beef and sheep enterprises Betteridge et al (2009) found that while farm-wide application of nitrification inhibitors was cost-prohibitive, targeted application on easy contoured, cattle-grazed hill country areas, accessible by farm vehicle was potentially cost-effective.

- Phosphate management – phosphorus adheres strongly to soil particles. In the main these are transported via overland flow to waterways depending on the availability of natural drainage pathways, which are in turn controlled by climate, catchment characteristics and land management (McDowell 2008, p 8). For this reason it is important to avoid pugging of soils in winter, to time grazing on steeper slopes and near waterways to minimise run-off, to avoid applications of soluble phosphate fertiliser during high risk months (May to October), and to consider slow release forms of phosphate fertiliser such as RPR (depending on the pH of the soil).

- For most farms, it is appropriate to maintain soil Olsen P levels within a specific range (20-30 for ash and sedimentary soils, 35-45 for pumice and peat soils) to get the best agronomic return (Ritchie, 2007). In general, keeping Olsen P within this range ensures that any soil loss does not transport high phosphorus loads to waterways. Olsen P is a useful indicator of potential phosphorus loss. As Olsen P increases the risk of soil P loss increases. This illustrates the benefit of not exceeding the optimum soil P status for plant brought to reduce P losses (Mercer, 2011, p 16). However, losses vary with slope, soil and climate and P loss can be quite high on steep slopes even with low Olsen P (Abercrombie, 2012).

Supplementary feed – supplements can be used to overcome feed deficits instead of relying on nitrogen to boost pasture growth. However, the crude protein level of supplements needs to be considered to ensure this practice enables nutrient mitigation rather than increasing nutrient loss.

The higher the crude protein level, the more nitrogen a feed supplement contains. For example, palm kernel and maize silage contain 16 per cent and 8 per cent crude protein respectively, whereas pasture contains 20-25 per cent and Lucerne 18-22 per cent (Longhurst and Smeaton 2008, p.21).

Reduction of phosphorus losses - in addition to the practices described already, a number of other practices specifically assist in the reduction of phosphorus losses:

- Controlling erosion and sediment sources in upper catchments through soil conservation works;
- Changing stock types (for example, running lighter stock particularly during winter and on steep slopes);
- Grazing management of sensitive areas (for example, no heavy stock near waterways during winter).
- Afforesting steep southern slopes with low production value and high erosion risk. For example, with space planted poplars or production forestry.
- Retaining upper catchment wetlands, swales and seeps (Abercrombie, 2012)

General farm environmental management – hot spots or critical source areas such as silage pits and offal holes or badly maintained tracks and races can increase nutrient losses. Good design initially, and ongoing maintenance, will remove most of the risk of nutrient loss from these areas (for example, cut-offs to direct water into rough grass or wet areas).

3 Theoretical framework

Kaine (2004) suggested that farming systems theory and principles from consumer behaviour theory can be used to gain an understanding of the reasons why agricultural innovations have been adopted and applied. Using the processes described in Kaine (2004) we can identify the size of the market for an agricultural innovation, describe the segments within that market based on the mix of benefits farmers expect from the innovation, and develop strategies to increase the rate of adoption of the innovation.

Farming systems theory holds that farm context (strategic, labour and lifestyle, technology and practice, and biophysical dimensions) determines the likelihood of an innovation (that is, new farm technologies and practices) offering a net benefit and, consequently, being adopted.

This means the benefits of changes to technologies and management practices on farms can only be properly appreciated by understanding how they integrate with other practices in the farm system (Crouch, 1981, p 126). Given this context, Kaine (2004) proposed that through the application of principles from consumer behaviour theory we can identify and genuinely understand the likely population of potential adopters (the market) for an innovation. This is important as the population of potential adopters may, in fact, be only a small fraction of all the farmers in a region or industry.

Consumer behaviour theory seeks to understand the decision-making processes of individuals when they are making purchase decisions about products and services. The theory proposes that purchase decisions are categorised as being on a continuum between low and high involvement (Assael, 1998). Involvement refers to the personal relevance or importance of a product or service to the consumer, and is not an attribute of a product.

High involvement purchases are those where considerable effort is put into the purchase decision prior to, and post the purchase, for example purchasing a house or a car. Whereas with low involvement purchases, such as buying bread, little cognitive effort is required with consumers preferring to rely on habit, price or other attributes (e.g. grain). Kaine and Johnson (2004) state that adoption of innovations by farmers is a high involvement decision, especially where the innovation is novel and unfamiliar, needs careful integration into the existing farm system and has serious financial implications.

Kaine (2004) proposed that where failure of an innovation can have serious consequences for their business, farmers may sensibly resist the introduction of new technologies or practices – thus non-adoption can be seen as a strategic and rational response to risk (Kaine, 2004).

Figure 2 and Figure 3 below illustrate the importance of distinguishing between the scope for, and rate of, adoption of an innovation. Figure 3 shows the total population (N1) that will likely voluntarily adopt a technology or innovation; the market for the innovation. The use of non-regulatory persuasive policy initiatives such as provision of extension, promotion or incentives (for example Waikato Regional Council's Clean Streams incentive) has the effect of increasing the rate of adoption in this population (that is shortening the time of adoption by all users from T1 to T2) (Kaine and Johnson, 2004; Pannell et al., 2006). Importantly, the total number of adopters (N1) does not change.

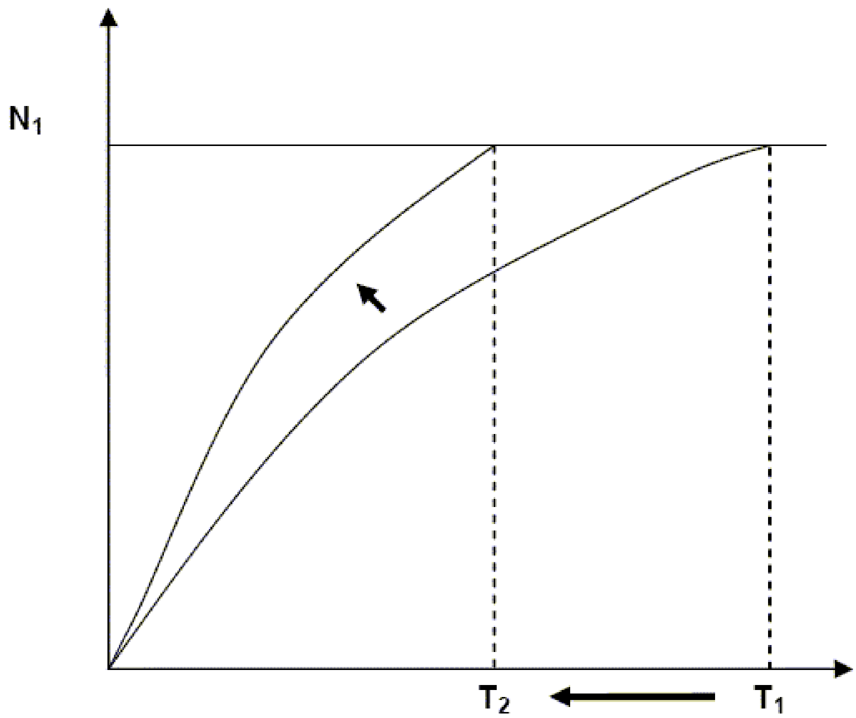

Figure 1: Accelerating the rate of adoption (source: Kaine and Johnson, 2004).

However, management practices promoting environmental outcomes may not always align with farmers’ motivations to adopt innovations that integrate well into their farming system and are beneficial to their business. As a result, practices that may be considered best practice from an environmental perspective may not be widely adopted voluntarily (Pannell et al., 2006; Kaine et al., 2004). In other words, the market for the best practice is only a fraction of the number of farmers that is required to adopt the practices to achieve the environmental outcome. In these circumstances the size of the market (the population of potential adopters) must be increased to achieve the environmental outcome.

Figure 3 below illustrates how the implementation of a regulatory policy could expand the population of potential adopters by compelling those not 'in the market’ to change their management practices.

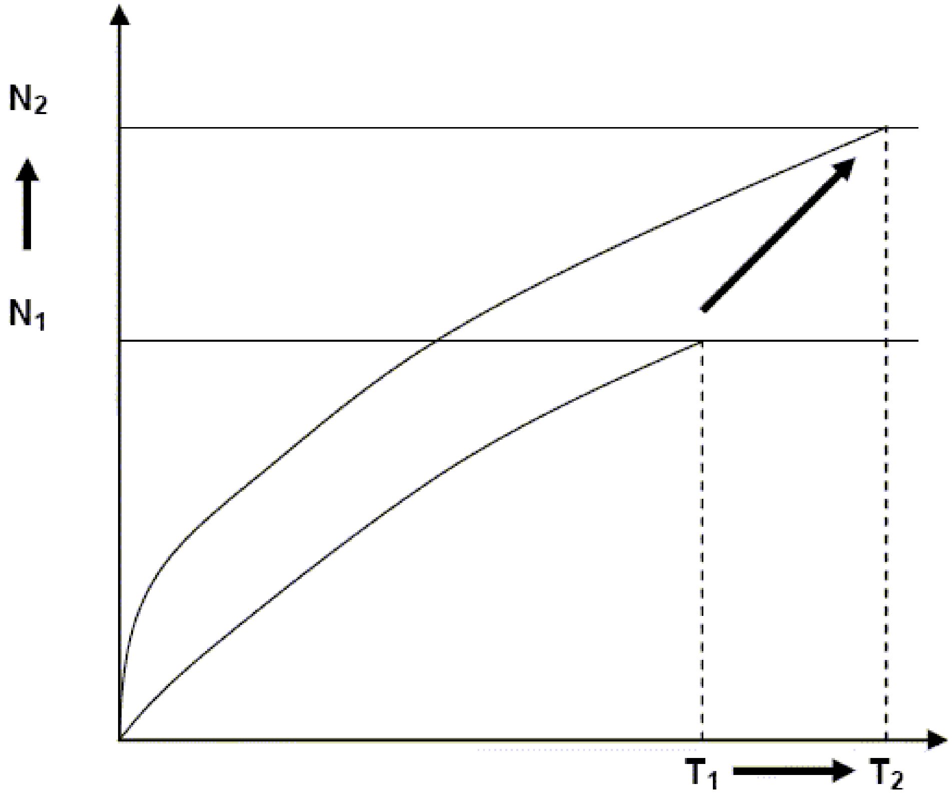

Figure 2: Increasing the population of adopters (source: Kaine and Johnson, 2004).

4 Method

Semi-structured interviews were conducted with council agricultural extension officers prior to interviewing farmers, to provide the researchers with some background in the subject area and the governance context in which farmers' make their decisions.

In the application of the Kaine Framework two techniques are used in collecting qualitative data; laddering and convergent interviewing. These techniques are used to explore the perspectives and diversity of experiences of the participants (Flick, 2002). These techniques enable the researcher to explore in detail, various components of a farming system from the perspective of each participant to systematically develop a comprehensive picture of their farming system, and how it differs or not from the farming systems of other participants.

Convergent interviewing involves comparing and contrasting the data gathered in one interview with that gathered from all other interviews and is used to determine the sample size. Researchers take a reflexive approach to sampling, analysing interview content continuously, so that sampling concludes when no new themes emerge to explain the phenomena of interest (Dick, 1998).

A combination of purposive and snowball sampling was used to identify participants. Given the influence of soil and topography in determining winter management, purposive sampling was used to efficiently identify interviewees. In addition, given the number of lifestyle enterprises in the drystock sector, farms greater than 50ha were selected as part of the purposive sampling selection. The combination of laddering and convergent interviewing techniques provides a basis for generalising the interview findings, subject of course to any bias in sampling.

In each interview, farmers' decision-making was explored using the laddering technique. This technique is particularly useful as it specifically seeks to reveal the chains of reasoning underpinning people's decision making by discovering the attributes, consequences and values behind decision (Grunert and Grunert, 1995; Reynolds and Gutman, 1988). This was done by encouraging participants to talk through their decision-making. Interviewers clarified their understanding of the participants' reasoning by summarising what had been said. This ensured that the interviewers had understood the interviewee correctly and allows the interviewee the opportunity to add or explain in more detail particular aspects of their farming context. As Kaine suggests this can 'reveal subtle differences' in farmers contexts that are important to identify in terms of the applicability of certain practices' (Kaine 2008, p 91).

The interviews were carried out by two or more researchers. This enabled one researcher to remain actively engaged in conversation, prompting the interviewees, asking for clarification and generally encouraging and maintaining a free-flowing dialogue with the interviewee while the other researcher recorded the conversation in written form, recording as much of the conversation verbatim as possible.

Interviews were carried out in farmers' homes or at a location that suited them and typically took 40 minutes to an hour to complete. This proved to be sufficient in terms of allowing each farmer to explain their reasoning underpinning their choice of management practices. After each interview, the research team took time to debrief and discuss the data gathered in the interview in detail. This debriefing process assists in identifying the similarities, accuracies and consistencies between recorded notes, and enables the sharing of information that may have been missed by one team member, but captured by another.

In total 32 personal interviews were conducted between March and December 2009. The use of purposive sampling gave a satisfactory coverage of soil, climate and topography within the Waikato region's beef and sheep farming areas. The map below shows the location of beef and sheep farms over 50ha in the region.

Figure 3: Location of beef and sheep farms over 50 hectares in the Waikato region

Commensurate with the convergent interviewing process, the data from each interview was then analysed case-wise to ensure that the research team had a detailed picture of each farm context and the factors that contributed to each farmer's decision-making. Cross-case analysis was then conducted to identify patterns in key farming practices, to explore and describe similarities and differences between farmers' systems, and to obtain a comprehensive understanding of how differences in farm contexts related to differences in the reasoning underpinning farmer's choice of practices.

4.1 Sample structure

Interviews were conducted in the Coromandel (4), north-west Waikato (5), central – south Waikato (5) Hauraki (4), western King Country (8) and southern areas such as Reporoa and Bennydale (6).

Farm effective area ranged from 35 to 3000 ha, with the average effective area being 336 ha, close to the region average of 339ha. Numbers of stock by type and age class varied according to the farm enterprise mix and business scale. Total stock numbers ranged from less than one hundred up to 21,000 (though not all stock were on the farm throughout the year). Stock units per hectare were not calculated.

The sample included a wide range of beef and sheep enterprises. The categorisation of enterprise type was based on the farmers' description of their business enterprise as finishing, trading, breeding or dairy support or combinations of these, for the livestock they carried (see the definition in section 2). For example, some farmers described themselves as a breeder and trader of beef cattle and a finisher of lambs, which is common practice in the industry (Beef and Lamb New Zealand, 2011).

Dairy support farmers were those that only ran dairy heifers or took dry dairy herds in the winter.

Half of those interviewed ran beef and sheep systems, with combinations of sheep and beef, or sheep, beef and dairy cattle, or sheep and dairy cattle only.

Around a quarter of farmers interviewed had single livestock enterprises, comprising cattle only. Half of the beef farmers had some dairy support activities on farm. Four farmers were operating as dairy support only, three were raising dairy heifers for trade or on grazing contracts and one farmer took dairy cows through winter. One farmer also ran goats, another deer and one small-scale farmer had horses (on agistment), as part of their production system.

The table below summarises the enterprise types by the frequency occurrence.

Table 2 Enterprise types and frequency

Stock type	Trader	Finisher	Breeder	Dairy Grazing
Beef	11	12	9	19
Sheep		14	13	
Goats		1		
Deer	1	1		

Farms were on a range of topographies and soils. Three farmers interviewed described the topography of their farm as flat, seventeen said they had some flat areas and the rest was of rolling or steep contour and the remaining twelve said their farms had a mix of rolling and steep areas. Farmers that undertook finishing beef cattle generally had flat areas on their farm, with the exception of two farmers who described their farm contour as rolling. Of the 19 farmers undertaking dairy grazing, 13 had flat areas on their property.

To ensure the sample was representative of soil and, to some extent, drainage characteristics in the region, farmers were asked to characterise the soils on their farm. This information was then compared with the region's soils. The table below shows the main soils in the region matched against the soil descriptions given by the interviewees and are listed from most to least free-draining (see Appendix 2 for a map showing the distribution soils of the region and the average rainfall throughout).

Table 3 Farm soils matched to soil order

Soil	Soil description given by interviewee
Pumice	Pumice
Allophanic	Maeroa Ash, Ash, Volcanic Ash, Waihi Ash, Tirau Ash, Dunmore Silt Loam, Loam, Silty Loam
Granular	Hamilton Clay Loam, Pukekohe soils, Clay Loam
Brown/Ultic	Clay, Papa, Akatea Clay Loam, Mahuta Clay Loam
Organic	Peat, Loamy Peat
Gley	Clay, Marine Mud, Puniu Silt, Loam Clay, River Silt, Marine Gley/Mud, Mahoenui Clay

In general, the sample reflects the Beef and Lamb New Zealand's classification of farms as being of Class 3, 4 and 5 in terms of size, topography, soil fertility and enterprise type; with a reasonable spread across the classes (Beef and Land New Zealand 2011b).

The selection of farms over 50 ha to remove lifestyle blocks however, may provide some bias in the sample towards larger operations. Stocking rate has not been considered in this sample description.

5 Results

This section is divided into key management components on beef and sheep farms with particular emphasis on winter management as this is the key period for nutrient loss.

Each subsection has a detailed summary of the findings for a particular practice and evidence for the findings is provided by representative quotes taken from the farmer interviews.

5.1 Grazing practices

As noted previously, three quarters of those interviewed ran mixed enterprises. Choice of livestock type and age was driven by price, farm suitability, animal husbandry and lifestyle preferences. For example, while prices influenced interviewees' decisions about the age of beef cattle they would carry and for how long, steep land was usually stocked with sheep, or particular breeds of beef cattle such as Angus. Some interviewees mentioned that they ran trading enterprises as their land was susceptible to facial eczema or was not good enough for fattening beef cattle or lambs.

> *"Got out of sheep and Angus because farm is prone to eczema. Lot of lambs got eczema" (interview 5)*

Nine interviewees raised beef bulls, with some expressing a preference for raising bulls because they felt that they received the best price per kilogram for bulls. Others would not have bulls on their property because of handling problems and damage to paddocks and fences.

Some interviewees had changed livestock enterprises, either between properties or on the same property. Some were prompted to change enterprises because the market had changed, while others had changed because of lifestyle preferences. For example, many interviewees had switched to contract dairy heifer or cow grazing because these enterprises were seen as having a steady cash flow together with a less stressed lifestyle.

"Changed to grazing dairy heifers because less outlays each year and steady, regular income" (interviewee 7)

Decisions on livestock mix were also driven by the need to control pasture quality. This meant that farmers made careful choices about which type and age of livestock to run on different areas, and the order in which paddocks were grazed by livestock. To illustrate:

"Goats don't make us a lot of income directly but clean paddocks" (interviewee 13)

"I put young cattle in first …Graze different, chew paddocks better. Calves then dairy heifers. Dairy heifers chew out rest, will eat anything" (interviewee 11)

In terms of grazing management, some stock choices required different management regimes. For example bulls needed to be kept in separate mobs. The management of other types of livestock could be changed during the year, especially leading up to, and during, winter. For example, grazing management might be changed from rotational grazing to set stocking, or from rotational grazing to strip grazing depending on circumstances.

Grazing management practices were chosen to maximise the utilisation of pastures. For example sheep farmers put dry ewes on the poorest pasture (generally on the steeper land) while pregnant ewes grazed better pasture. Some sheep farmers also prioritised grazing depending on whether ewes were holding single, twins or triplets. Breeding cows were usually grazed on poorer pastures while stock to be fattened were grazed on the best pasture and generally flatter contoured areas to maximise their weight gain.

For those finishing lambs, Pasja was often planted as a summer finishing crop as it was considered eczema safe and a good food source to fatten lambs quickly for sale.

For the two farmers that wintered cows as their main enterprise, pasture was managed during the year to ensure enough feed for the duration of the contract.

Other farmers commented that they considered dairy cows to be too heavy to have on their farm as they would do too much damage to their pasture through wetter months, so this was not an option they would consider as this quote illustrates:

"They do too much damage to pasture. Did do some when had old pasture. Now chomp through too much and too heavy" (interviewee 16)

Those taking dairy heifers or wintering dairy cows kept their clients' stock in separate mobs to their own cattle so they could be managed separately in terms of feed requirements and location on the farm. While farmers moved their own stock around the farm depending on weight; lighter stock on the hills, heavier stock on easier contour, and many fed supplements during the winter, the main concern for farmers grazing dairy heifers or dairy cows was that condition was maintained (as this was often stipulated in the contract).

This meant that most interviewees did not undertake to provide supplements to grazed stock, preferring that the owner or grazing contractor be responsible for meeting deficits if feed shortages occurred. Carry-over cows, that is heifers or cows that had failed to get in-calf, and breeding cows were considered hardier and did not need as much feed to maintain condition. Consequently, they were often put on the steeper country for the winter to assist with weed and pasture control.

"Cows are there as a pasture management tool to clean up ratty pasture. Considering I feed them hardly anything, still make something out of it" (interviewee 9)

5.2 Winter management

Management practices over winter are a key factor in nutrient losses from beef and sheep farms (Ritchie, 2007). As stated previously, having stock on wet pastures can result in soil compaction and erosion resulting in leaching and run-off of nutrients. In addition, fertiliser application should be avoided in winter (see section 5.3 for discussion on fertiliser).

Interviewees managed their pastures over winter to allow for slower grass growth and higher risk of pasture damage from pugging. In doing so they had to consider topography and soil and the need to provide sufficient feed to meet the growth and condition requirements of their stock. For example, the feed needed to meet the weight gain requirements of two or three year old bulls was different than that of dairy heifers or carry-over cows. And as mentioned earlier the feed requirements of pregnant ewes meant that they were prioritised over the other sheep classes on farm onto better pasture.

The use of supplements grown on farm was crucial to fill winter feed deficits for many interviewees. Feeding out hay or silage and standing livestock on crops were also discussed in relation to winter grazing management.

5.2.1 Wet soils management

This section reviews the practices undertaken to manage pasture in wet conditions. The following section will review the management of winter cropped areas.

In general interviewees held favourable attitudes towards the management of pasture and soil damage over the winter months and were aware of the cost of pugging in terms of pasture condition (impaired growth and weed infiltration) as these quotes illustrate.

"damage pasture more by pugging than by overgrazing. …Grass doesn't grow in it properly, damaging roots of grass. Farm to minimise it, never get rid of it" (interviewee 20)

"don't want pugging…it can take 12 months for it to recover" (interviewee 30)

Most of the farmers interviewed reduced stock numbers prior to winter, and/or changed to lighter stock classes. Farmers deliberately chose a mix of age and livestock types that allowed them to reduce numbers by selling stock, or in the case of dairy heifer grazing returning stock, ahead of winter and in time to build up pasture for the winter. For example dairy heifers were returned to the owner before they got "too heavy for the land" and pasture would be needed for the farmers' own livestock to get through winter. The availability of grown supplements was also a consideration in determining what stock to carry through winter.

For most interviewees, preparing the farm for winter meant setting up paddocks for the different livestock types and classes. This might involve strip grazing, break feeding, set stocking or rotational grazing and depended on the interviewees' overall objectives with respect to feed quantity and quality. A common practice was to shift heavier stock off the steeper country in favour of the lighter stock to avoid pugging and erosion damage. This meant that the sheep, lighter beef classes and older breeding cows or carry-over cows were put on the steeper areas as this quote illustrates:

"Pasture damage can be chronic in this country with older heavier cows, but with calves not lasting damage" (interviewee 4)

"big help keeping big cattle off steep country over winter" (interviewee 13)

While this was common practice amongst interviewees, in this study one farmer was interviewed that could not put his heavier stock on the farm's flat area because this area has gley soil. This meant that lighter stock went on the flats and heavier stock on the hills.

Break feeding or strip grazing was commonly practiced among those with cattle and was applied across all age classes. However, not all interviewees with beef cattle favoured these practices. Some preferred less intensive grazing practices such as rotational grazing and set stocking, or stated that their property could not support break feeding.

"I don't like break feeding because have them all standing at fence waiting or get down on flats…If you leave stock on there in exceptionally wet weather, as long as you have the room to move …hill paddocks 8-10 acres and put 18 steers in so not living in each other's pockets" (interviewee 15)

"It can well and truly pug up there in flat area…only takes a wee corner, if its wind and rain [cattle] will go into a corner huddle and pug. [prefers] Bigger area, not break feed area for when bad weather comes don't stand in corners" (interviewee 12)

Conversely one farmer held strong preferences against set stocking because he felt that break feeding was better for pasture quality.

"Set stock depletes root reserve and pasture quality …[stock] hammer nice stuff and don't hammer bad stuff. Look after pastures more when you break feed. They eat everything and eat all in one day that way. Soon as take off, root reserves come away and good pastures are more dominant because of that" (interviewee 24)

A few interviewees who mentioned that they used races to stand off some stock if they needed to manage wet soils, because of a rain event:

"When it's [weather] extreme, in a race. Some winters dozen times, some half that. Take them off at two p.m. and back on the paddock at 8 the next morning, so overnight" (interviewee 19)

None of the interviewees mentioned having purpose-built stand off infrastructure such as a stand or loafing pad or a feed pad to reduce the amount of time stock were on paddocks in winter.

Some interviewees expressed the view that standing off was not required on a dry stock farm as beef and sheep were lighter than dairy cows and stocking rates in winter were lower:

"No need for standing off as numbers are lower. Dairy farmers have big numbers on smaller areas" (interviewee 17)

Grazing residuals

Grazing residuals were commonly assessed by eye, with some interviewees explaining that in addition to grass length they relied strongly on monitoring stock condition and behaviour to decide when to move stock on.

"Purely by eye. [shifts stock] Stick to 2-3 day rule of thumb, kind of works. Big bulls, if I drive past the paddock and see them in the corner fighting …[bulls] temperament, fight when want to move, plus grass length" (interviewee 21)

Grazing residuals for winter mentioned by some interviewees ranged from 1,000 DM/kg to 1,500 DM/kg. Others mentioned that they were conscious to manage pasture residuals to a length that allowed for quick regrowth. However, for some this became more difficult towards the end of winter as these quotes illustrate:

"Depends on how pushed, if heading for a deficit start slowing them up in their rotation; before that we usually skin [graze down low], need to keep condition, in phase two growth, they eat the grass down more. If decking it, grass takes 50-60 days to grow back. Try not to deck it too early. As long as I keep animal health [dairy heifers] good on them, you can hold them back. If stock are in poor condition and light, I couldn't hold them" (interviewee 29)

"Winter is hardest bit to get through like the darkest part of night is just before dawn just at end of winter and if everything is skinned away then doesn't come back as well" (interviewee 9)

Farms with free drainage
Around quarter of farmers (n=7) interviewed stated that they had no problems with pugging through the winter. These interviewees were all on free draining soils such as ash and pumice.

Apart from shifting lighter stock to steeper county, the most common strategies these interviewees used to avoid pugging were to speed up their grazing rotation or simply avoid grazing wetter paddocks. While some were in areas where heavy rain events were experienced these events were infrequent during the winter and stock could be moved to another paddock if necessary.

"move them every day when wet and maybe twice a day if small paddock. Use certain paddocks in winter…boggy paddocks not good pasture anyway" (interviewee 7)

"shift them the night before" (interviewee 8)

Two interviewees set stocked in mid-winter. Another also used break feeding when needed, but this was only in bad weather.

"Set stock in mid-winter …trips with huge trailer loads of hay…belly full hay … it's warm, graze and rest better" (interviewee 17)

Farms with poor drainage
Almost a quarter of interviewees stated that pugging was a problem that had to be managed on their farms. Farms had mainly clay soils or had areas that were harder to manage. These farmers said that they were always watchful of weather and pasture conditions.

"Clay gets water on it, turns really wet …stay off them [paddocks] as even a motorbike can get stuck" (interviewee 1)

"Winter wet through here. I have to monitor day to day, I keep an eye on forecast … We go round whole farm every day" (interviewee 28)

The interviewees ran a number of strategies to manage their heavier stock through winter.

Most undertook strip grazing or break feeding to manage feed demand and pugging of heavier soils by cattle. Some needed to shift cattle every day to manage feed and pasture quality, while others shifted cattle onto a new break every 4-6 days. In very wet weather those that shifted their cattle daily said they might need to shift their cattle twice in one day. Some interviewees who strip grazed their cattle, also back fenced to reduce trampling of pastures by cattle.

Different to other farmers carrying bulls, who were generally reluctant to shift their bulls in winter and preferred to set stock; farmers with poor drainage said they shifted their bulls daily.

As with the other farmers, all moved lighter stock onto steeper areas. One farmer undertook set stocking and tried not to feed out, preferring to rely on all grass having de-stocked prior to winter. Some had swamp or peat areas which they were able to place cattle on to relieve their more water logged paddocks.

A number of farmers fed out supplements, such as silage and hay, to keep stock content so that they were less likely to "walk" which was seen as contributing to pugging and compaction. Supplements were fed-out usually on the 2^{nd} or 3^{rd} day of a break.

However, feeding-out in winter was a problem for some of these interviewees because the heavy machinery could damage the soil. Some did not feed-out at all, while others swapped from silage to hay because the silage wagon, being heavier than a quad bike and trailer, was more damaging to soils. This meant for some that they needed to lower stocking rates for winter in line with pasture growth.

"Feed out as little as possible. Cost related and makes a mess. Got to adjust stock accordingly" (interviewee 21)

Two interviewees used set stocking as a management strategy for their heavier bulls. One ran an open gate strategy while the other increased the paddock size relative to the number of bulls and moved them less often, in this way "*taking weight off the ground"*. Grazing rotation was reduced from 25-30 days in summer to 18 days in winter.

One farmer described the balance between maintaining pasture condition and holding cattle back to build feed for spring:

"bigger areas in nasty weather, and when get drier colder weather gave them more supplementary feed. During wet periods give more area and to compensate, when dry areas hold them up and feed supplements. When it's wet they're eating with 5 mouths, their hooves, they're wasting it" (interviewee 16)

Farms with intermediate drainage
About half of those interviewed (n=17), who were farming mainly free draining soils such as ash, pumice soils or loam, said that their farm had some potential to pug. The most common practice for managing pugging was to vary rotation length. Four farmers used set stocking to manage pasture and soil quality through winter. Four farmers did strip grazing or break feeding.

5.2.2 Winter cropping management

Section 5.4.1.below sets out the practices of interviewees that grew supplements on their properties such as hay and crops. Eleven interviewees grew crops. Six grew crops for winter feed. These farmers were all in the cooler, southern end of the region, Reporoa, Otorohanga and the King Country.

The winter crops were often put in to manage specific livestock. For example one interviewee put in a winter crop specifically for the dairy herd they took for 10 weeks, and used the dairy herd to clean up pasture as part of their pasture renewal programme.

Cattle are break-fed and can be on the crop for the whole winter period. This quote illustrates the typical cycle of break feeding on winter crops.

"*They go on and stay on for whole winter to two-year olds. One day silage and rest of bulbs and stalks of swedes. Next day new break swedes. Two days per break" (interviewee 11)*

Interviewees were not asked whether areas that were cropped were close to waterways. One mentioned that they had cropped an area of steeper land that they had then put the sheep on. However, this was not their usual practice.

5.3 Riparian management

Riparian fencing and planting can be an effective way to reduce the amount of phosphorus, sediment and microbes entering the waterways (Waikato Regional Council, 2008).

Nearly all those interviewed (29) had waterways on their farms in the form of drains, springs, streams, rivers swamps or wetlands. Of those, eight stated that all their waterways were fenced, with three of these stating that they also had riparian planting. Only two farmers with waterways on their farms said that they had not done any fencing or planting.

Half of the farmers interviewed reported that some or most of the waterways on their properties were fenced. Two farmers reported that their wetland areas were fully fenced, but not all other waterways.

Most interviewees had favourable attitudes towards riparian fencing with some mentioning improvements in water quality as a benefit in addition to the usual benefit of stock control:

"Do it mainly to improve water quality one reason and has helped with management issues, in summer gets low and sheep and cattle coming backwards and forwards and getting mixed up. And keeps bulls apart too. Works a lot better" (interviewee 3)

However, a number mentioned problems with weeds and vermin arising from fencing and, particularly, planting riparian areas. Some also mentioned the difficulty of maintaining fences in flood prone areas.

"[farm has many springs and small streams] Can't [fence]. Where would I stop? It'd create lot of work, floods all the time" (interviewee 27)

In the lower Waikato area a number of interviewees observed that, without tree planting, banks were still prone to erosion by the koi carp:

"Bad problem with carp. Carp coming up, have eroded bottoms of banks away. Don't think they've helped, so in dry summer is hardly stock proof" (interview 3)

A few mentioned that they had received or applied for the council's Clean Streams funding and some had received funding through other soil conservation programmes such as Project Watershed. Some reported they had had considerable fencing done in the 1970s as part of the Lake Taupō or other soil conservation programmes.

A few interviewees mentioned that they did not believe that fencing of drains was warranted, or where streams were steep sided, as their stock did not go near these waterways as this quote illustrates:

"'Not always feasible to fence. Our creeks are two metres deep so we don't get stock in them. I'm a bit against fences, get too many blackberry, weeds and big flood… we farm bulls, they're not the least bit adventurous and don't go there" (interviewee 5)

Some interviewees expressed a preference expressed for “hot wire” or “single wire” fences where flooding was a risk. They thought that this type of fencing kept cattle out and although sheep could graze underneath sheep caused very little damage to stream banks.

A further quarter of the farmers reported that they had riparian planting on some or all of their waterways on farms, though a number mentioned leaving a buffer of rank grass.

> *“Left as rank grass. Looked at it. My neighbour has done some planting. He said planting is easy part, maintenance and releasing plants is harder” (interviewee 3)*

Where buffer strips were mentioned they were one to four metres wide. One interviewee stated that the width depended on the potential for bank erosion.

> *“Might be as much of a metre to 50 metres. It depends on what damage stock are going to do to the banks. Need enough of a set back so stock don’t damage banks” (interviewee 28)*

A number of problems were raised in respect to the width of buffers and type of planting as these quotes illustrate:

> *“about a four metre buffer, left in rank grass. Grasses thick so can leave it. Don't want to plant out because will restrict our view of the yards for security aspect” (interviewee 18)*

> *“will just be one hot wire, one metre wide. Waste of money to do more” (interviewee 19)*

> *“[planting] about one metre …every vermin breeding in the strip beside river. Lot more vermin control. [planting of] rank grass. Some shelter trees. Not allowed to plant because it’s a flood way” (interviewee 17)*

Seven interviewees mentioned that they had wetlands, swamps or swampy areas on their properties. As mentioned earlier two interviews had fenced their wetlands. Those with swampy areas stated that they grazed these areas at times during the year. Two interviewees mentioned that they intended to drain these areas as part of their pasture renewal and subdivision programme.

Stock access to water

Many farmers interviewed had troughs in all, if not most of their paddocks. In general, where waterways were not fully fenced interviewees said they observed that their stock preferred to use the troughs and did not enter the streams.

> *“There are troughs in every paddock. Stock don't need to go to the creek for water” (interviewee 5)*

> *“…interesting phenomena - go to trough before creek. Think of as round things with water, don't even forage” (interviewee 18)*

> *“In the places where there's streams, they're small. Don’t see them standing in there. 1 or 2 will drink out of it, but mostly out of troughs” (interviewee 9)*

Some interviewees stated that they let stock access waterways for drinking water because they did not have enough water on their farm or available in those paddocks.

One interviewee made an access point from metal for their livestock to limit stream bank erosion, while another did not mob-stock a paddock with an unfenced waterway to reduce damage to banks. These interviewees also mentioned their stock were not dairy cattle, which they thought were more damaging. Some farmers interviewed also mentioned that their property's streams were too small to fence, and stock crossing them or grazing to them, was not damaging.

5.4 Soil conservation and afforestation

Over a third of interviewees mentioned that they had areas of farm forestry on their properties. These areas were on steeper, unproductive, erosion prone land.

> *"had a problem with erosion. EW came and had a look, three places are eroding quite hard" (interviewee 7)*

A further five interviewees had areas retired for soil conservation purposes.

> *"Last owner planted lots poplars out there on steep country" (interviewee 29)*

Almost half of those interviewed had areas of bush on their property, of which five interviewees said these areas were covenanted. Interviewees reported a number of reasons for retaining bush areas including leaving areas in bush because they were on steeper or inaccessible land, biodiversity values and farm subdivision purposes as these quotes illustrate:

> *"[area of native bush] too hard land, couldn't be farmed… couldn't get to it geographically, too hard" (interviewee 21)*

> *"Whatever we do, if we move on, quite a nice thing to do to know got something protected and always going to be protected and funding available, always an incentive" (interviewee 23)*

> *[reason for extending the covenant area] "Wasn't happy with where fence line was, stock hopped across creek, [fence line] created laneway for me, changed fence line to exclude creek" (interviewee 26)*

5.5 Nutrient management

5.5.1 Nutrient budgets, nutrient management plans and soil testing

Nutrient budgets

A Nutrient Budget identifies nutrient inputs to the farm, such as, fertiliser, purchased feed, clover nitrogen fixation and effluent. It also identifies where nutrients go off the farm (outputs), such as farm products and transfer to non-productive areas - for example, races, stock camps, yards, leaching and runoff losses to waterways and gaseous losses to the air.

Several were aware that their fertiliser representatives gave recommendations based on nutrient budgets, but most did not mention having a nutrient budget.

Nutrient management plans

Under Rule 3.9.4.11 of the Waikato Regional Plan, fertiliser application is a permitted activity subject to conditions. One of these conditions is that a Nutrient Management Plan must be used to plan fertiliser application where nitrogen fertiliser is applied at rates greater than 60kg N/ha/yr. None of the farmers we interviewed mentioned that they had such a Plan.

Soil testing

Generally speaking, interviewees did not rely solely on soil tests to gauge soil fertility, using their own judgement from observations and experience of the pasture quality and stock performance.

Most interviewees stated that they soil tested some, or all of their farm every 2-3 years. A few tested at longer intervals up to five years and a couple of farmers interviewed did not soil test at all. These farmers stated that they had tested in the past and were comfortable that they had the experience to make fertiliser decisions without soil testing.

Soil tests were either undertaken by the fertiliser representative or commissioned elsewhere, and were found by most interviewees to be useful in making fertiliser decisions.

A number of farmers mentioned that they assessed if they needed to apply fertiliser by the look of the pasture, which was based on experience on that property as this comment illustrates:

> *"eyeometre [visual assessment] if meeting our growth requirements, benefit of history…don't use grass plate monitors, been around long enough. Benefit of history of what numbers can be sustainable and grown to owners requirements" (interviewee 17)*

Around two thirds[1] of those interviewed were able to provide their Olsen P levels. These ranged from 5 to 110, with most farmers reporting levels of around 30-40. Seven interviewees reported levels above optimal levels for ash and sedimentary soils and for pumice soils. A couple of interviewees had levels lower than these levels.

A number of farmers were conscious of keeping, or reducing, their Olsen P levels around optimal levels as an indicator of soil fertility to save money:

> *"All ours are high, too high [Olsen P levels]. If P is too high, you're not getting any benefit from it" (interviewee 10)*

> *"Go up to a certain level of fertiliser, and then can maintain. Any more a waste of time" (interviewee 14)*

> *"[Olsen P level] 27 which little bit high. Not going to put too much fertiliser on. It's a cost. If can grow grass without fert, [fertiliser] is preferable." (interviewee 19)*

> *"Don't need it, just washing dollars away if too much fertiliser" (interviewee 29)*

However one farmer was critical of Olsen P as a measure of fertility on this farm as he was using a slow release phosphate fertiliser.

> *"Olsen P's not giving all the information as RPR releases over the years and Olsen P doesn't pick up that" (interviewee 23)*

5.5.2 Fertiliser application

In the interviews farmers were asked about their purchase and use of fertiliser including type, quantity and fertiliser application and timing.

5.5.2.1 Fertiliser type

Commonly mentioned fertilisers were Super 10, Super P, Potash Super, Surpentine Super 10, Dicalcic Super, DAP and urea. One interviewee was using chicken manure, and three used liquid seaweed fertilisers.

Those that used RPR mentioned its slow release quality as a benefit, and some mentioned this in relation to nutrient loss off the farm.

[1] About one third either did not know their farm's Olsen P levels or this was not covered in the interview.

"Don't think it washes down, just moves into the soil, lot of the RPR is locked up in the soil particles" (interviewee 8)

"We're quite keen to farm in a sustainable way and trying to keep things in balance on farm…farm year in, year out and not have detrimental effect on soils and on waterways and also aware that market is continually moving in that direction as well (interviewee 23).

Nitrogen

Two-thirds of farmers interviewed applied separate dressings of nitrogen fertiliser as urea, with most of these interviewees, applying urea across the whole farm. But some only used nitrogen on newly sown grass or on crops or on better contoured land as these quotes illustrate:

"Have used some in past but not a great fan. Have used N when I put in new grass pasture to establish new pasture as there's no clover" (interviewee 24)

"Italian rye grass needs urea. Put on urea every time grass goes yellow and if there's enough moisture at the time. You have to feed Italian ryegrass. Renovation is annual. Make sure putting on what needs to go on. Got to feed it in spring and autumn" (interviewee 30)

"On the warmer country and better contoured stuff. I don't put urea on hill country because urea is expensive so I want to get best advantage from it and see the results. Very expensive product. Depends on season. Always check through to see what cost benefit is and only put nitrogen fertiliser on if I know we are going to get a good response, and what the grass is worth, and depends on what the stock are worth" (interviewee 28)

Reasons given by interviewees for not using nitrogen fertilisers were that they were unsure of their performance in terms of quality and quantity of grass growth, or they were concerned about potentially unfavourable impacts on soil, stock health or water quality in streams:

"Have used nitrogen, but when it's set stock in every paddock, don't see benefit of it too much" (interviewee 4)

"N is a growth enhancer, but pointless putting on N unless underlying soil fertility enables plants to grow. If not there, danger is pushing your plants too much. If put on without underlying soil fertility, get an N boost/rush and then it shuts up shop. Plants go nuts for 6 weeks then slow/shut right down to semi-dormant period" (interviewee 14)

"I don't like using nitrogen....call me old fashioned…it isn't about the N or the fact that when putting it on. Hay silage is money in bank whereas if overgrow extra rye and don't need it, what do you do with that? You worry. You're stuck. Put on urea only gives you double grass growth. Put [N] on in the stage of winter when no growth, double nothing" (interviewee 16)

"Don't use Urea at all on established pasture. Don't use it as a management tool. Partly the sustainability thing, also wanting clover to do N fixing [economic for] clovers to fix as much N as can. Using urea makes clovers a little bit lazy. What you're trying to do is encourage healthy plant with deep root system. Urea's a quick fix, hindering root development in a way and the leaching from N into waterways is an issue" (interviewee 23)

"I'm not keen on using N because people say bad things about it - N draws other nutrients out of soil that otherwise not be. Nitrate soil poisoning in stock

and runoff in streams. Doubt the amount I use would have much impact" (interviewee 7)

Lime

Two thirds of the farmers interviewed had applied a dressing of lime in this year, most to all of their farm and some to areas that were either in new pasture or had been reworked. Lime was considered essential to lower acidity, "sweetening" the soil. Some interviewees also commented that lime was good for soil biology, and they had noted increased worm activity in their soils.

"Fertility is good here, just helping release it, that's what lime does" (interviewee 29)

As stated previously, this year about half the interviewees were not applying their usual fertiliser and many were relying on lime dressings to manage soil fertility up.

"prefer to spread super this year but can't afford it." (interviewee 9)

'lime does unlock bit of P and fert[fertiliser] price's nearly doubled' (interviewee 20)

5.5.2.2 Fertiliser quantity

Interviewees stated that in this year they were applying less fertiliser in response to a recent drought and increased fertiliser costs. About half of those interviewed were not applying phosphate fertiliser or were relying on applications of lime to lower acidity and release phosphate from the soil.

Most appeared satisfied with the amount of fertiliser they applied. These quotes illustrate the views held by many that phosphate fertiliser applications could only be missed for a period of time, and that interviewees would not apply too much fertiliser as it was uneconomic to do so.

"because my silage and hay making is exhaustive system, I can't get away with not putting on in spring" (interviewee 14)

"No point having too much. There's a point you get to where it's uneconomic, there's no benefit. The grass only needs so much to grow. Don't need it, just washing dollars away if too much fertiliser" (interviewee 29)

A few farmers made comments that the 'conventional wisdom' or cultural practice around fertiliser applications in the sheep and beef sector had changed, with more cost focussed practices leading to reduced quantities purchased in general.

"Not going to put too much fertiliser on. It's a cost. If I can grow grass without fertiliser it's preferable. I think farmers are changing, that's my view" (interviewee 19)

Amount of nitrogen applied

For nearly all farmers that applied urea in addition to their other fertiliser, the amount of N being applied ranged from 20 – 50kg/N/ha per year. Only one farmer was applying more than 60kg/N/ha.

5.5.2.3 Fertiliser application and timing

Nearly a third of the farmers interviewed applied fertiliser in the autumn. Some applied fertiliser in both the spring and autumn and others applied fertiliser only in spring.

There were a number of reasons given by interviewees as to when they apply fertiliser. Those who said they applied fertiliser in the autumn did so because:

"Winter is our growth deficit" (interviewee 17)

“Because of the topography of the farm, easier to go on in autumn” (interviewee 16)

Those that applied fertiliser in spring did so to meet the needs of new pastures.

“If putting it in new grass, wasting time if not feeding it properly” (interviewee 26)

And to take advantage of suitable soil moisture:

“Spring fertiliser, put it on when it’s still raining to let sink in. Why put on in autumn when it's dry? It’s sitting on top of the ground and paid for [the fertiliser]”(interviewee 18)

Those that applied fertiliser in spring and autumn felt it provided better value for money and pasture growth in response to fertiliser application:

“Two applications works better than one lump sum for pasture growth, time management. Easier on pastures. Need the rain to wash [the fertiliser] in. If it’s left sitting on the paddock, big amount on burns off the grass if you have lime in it” (interviewee 16)

“Money. Spread my outgoings, but above that we're doing right thing, much better in relation to plants' needs, rather than putting on bulk. What I put on I want to go straight onto plants. Not going anywhere else. I'm not a tree hugger. If plant’s not in a position to use the fertiliser then they’ll be leaching, losing money, I'm losing money” (interviewee 14)

Nitrogen application timing

In general those applying nitrogen based fertiliser did so as separate dressings in spring, autumn, or both. A couple of interviewees applied a separate dressing of urea in the winter to promote grass growth as this quote illustrates:

“use N in winter a bit… put on urea for extra grass, [in the] paddocks we’re block grazing. Cattle shut off for a month and build up grass before back on. Just extra feed doesn't stay in soil long” (interviewee 3)

5.6 Feed supplements

Incorporating feed supplements into the farm system can help to fill pasture deficits that may occur over winter or summer. This section describes the range of feed supplements used on beef and sheep farms, some of which are grown on the farm and some are imported, for example palm kernel. In this study, 27 out of the 32 farmers interviewed incorporated feed supplements into their farm system.

Three quarters of the farmers interviewed experienced a winter feed deficit. Four farmers said they could have feed shortages starting in late summer, through to autumn and winter. One farmer reported they could be short of feed in summer, another in spring. And only one farmer reported not having a feed deficit at any time of year.

The growth of feed supplements was regarded by interviewees as “insurance” or a “feed bank” against feed deficits:

“Hay silage is money in bank whereas if oversow extra rye and don't need it, what do with that” (interviewee 16)

5.6.1 Grown supplements

All but four of the farmers interviewed grew supplements. Commonly grown supplements for cattle were hay, grass, triticale or maize silage. Nearly a third of the farmers also grew crops such as swedes, turnips, kale, choumolier or pasja.

For most interviewees with cattle, grown supplements were used to fill any winter feed deficit. A few grew supplements to cover a summer feed deficit. Supplements were not generally grown for sheep, with the exception of those using crops to fatten lambs.

Four farmers grew pasja or a mix of pasja and turnips to fatten lambs through spring and summer, though this was not because they had a summer deficit. Pasja was considered high protein, good for weight gain and safe from facial eczema. Pasja was also part of their pasture renewal programme, as was the case for the one beef farmer growing pasja, as these quotes illustrate:

> *"Like to do about 5 ha per year …sprayed out, put through summer crop, pasja. Good feed for fattening lambs and eczema safe" (interviewee 23)*

> *"Main reason for supplement growing is pasture renewal. If farm was immaculate, I wouldn't be cropping" (interviewee 30)*

Most interviewees that grew maize did so mainly to fill feed deficits with pasture renewal as a supplementary benefit, however one interviewee stated they grew maize mainly as part of their pasture renewal programme.

Six farmers interviewed grew winter crops such as swedes mixed with kale or choumolier, and four of these farmers said they relied on crops to fill their winter deficit. This allowed them to carry larger stock numbers through the winter, with two using these crops to feed the dairy cows they took through the winter. These farmers were in more southern parts of the region.

> *[the cows are] "here for short term. Get 10-12 kilos of dry matter per day mainly on swedes, bit of bailage and grass to balance the diet" (interviewee13)*

> *"Crops give enough feed with beef heifers through winter" (interviewee 32)*

Again, these crops were part of farmers' pasture renewal programme, but the main motivation for growing them was to meet a winter feed deficit.

Ten interviewees grew supplements but did not, or seldom did, pasture renewal.

Five of the farmers interviewed that grew supplements sold their surplus on a regular basis, indicating that this was part of their overall revenue stream. One farmer explained that he got enough money from the sale of his silage to buy fertiliser, which in turn produced extra dry matter to increase his overall feed budget.

A couple of interviewees who grazed dairy heifers were required by their contract to provide supplements.

The four interviewees that did not grow supplements did not undertake pasture renewal. They described their enterprises as a low cost system, which excluded the costs of ownership of machinery or paying contractors to harvest supplements. Three stated that their farm was unsuitable for feeding out on because of the damage to soil as they were in a high rainfall area.

> "*We don't like turning the ground here, it runs off. Sediment runs into streams. High rainfall got cattle on crop turns to mud. Low cost system in this country. Got to think of the country with high rainfall" (interviewee 27)*

> *"Making it, feeding it out damages country when I've got a tractor on it" (interviewee 28)*

5.6.2 Purchased supplements

In general, those interviewed stated that it was uneconomic to buy in supplements for beef and sheep enterprises, with a few saying that they had to very occasionally, but that it was expensive.

Three farmers interviewed had been forced to purchase palm kernel as supplements for their cattle that year or in the previous year. They did so because of drought conditions and viewed this supplement as a cheaper option than buying nitrogen fertiliser and a good protein source for stock. One interviewee, who wintered dairy cows, had bought in palm kernel on the request of the herd's owner, who paid for the supplement. Another who grazed stock stated that it was cheaper to send the stock back than it was to buy supplement if feed was short.

5.6.3 Feed system

The majority of interviewees fed out supplements to cattle on the paddock. However, for some it was not possible to get onto wet paddocks with a tractor. These interviewees preferred to feed out hay instead of silage and some preferred to use nitrogen fertiliser to encourage winter growth. Some mentioned that they ensured a feed wedge before winter so that they would not have to feed out on wet paddocks and risk pasture damage.

None of the farmers interviewed had installed infrastructure such as feed pads or stand off pads for use during the winter to avoid soil and pasture damage.

6 Discussion

This study has found that the grazing management practices of beef and sheep farmers are influenced by their farm context. This has implications for policy development and education programmes.

Unlike dairy enterprises, beef and sheep enterprises are characterised by livestock of different types and age classes and greater variety in topography. Farmers make stocking decisions based on the capacity of their farm to carry stock of different types and weights and to manage stock to meet different market requirements (breeding, trading or finishing). Consistent with Stevens (2011) and Lambert et al., (2000), decisions on livestock mix were also driven by the need to control pasture quality. This meant that farmers made careful choices about which type and age of livestock to run on different areas, and the order in which paddocks were grazed by livestock. As Stevens states "The farmer then applies various management practices aiming to optimise the use of the pasture resource and to meet the feeding requirements of the livestock" (Stevens, 2011 p191).

The mix of livestock on beef and sheep farms has implications for nutrient management as different activities are involved in the management of each stock type and age class. Beef and sheep farmers may have some flexibility to influence nutrient losses by changing output mix. However, the linking of the beef and sheep industry to the dairy industry by provision of dairy support, and the intensification of particularly beef enterprises have implications for the potential to reduce the amount of nitrogen leached from beef and sheep farms.

In the following table the implications of the findings for the commonly recommended nutrient management practices for the Waikato region are reported, including commenting on current practices and potential obstacles or barriers to adoption.

Table 4 Summary of farm practices for nutrient management

Recommended Management Practice	Summary of practices and potential barriers to uptake
Wintering practices – destocking, managing wet soils Reduce stocking pressure over winter by selling stock, returning grazed stock or manipulating the beef to sheep ratio. Run lighter stock in winter, particularly on steeper, erosion prone land. Use break feeding and rotational grazing regimes to relieve stocking pressure.	Most beef and sheep farmers ran their enterprises to allow for de-stocking during the winter, either by selling stock or returning grazed stock prior to winter. Strategies to avoid compaction or pugging were seen as important, and most farmers were aware of the damage to pasture and soil condition if soils were not properly managed in wet periods. Beef and sheep farmers we interviewed did not have infrastructure for standing off. However, a few did use their raceways to stand off when needed. This lack of standing off infrastructure meant that, to avoid pasture damage through erosion, pugging and compaction, heavier stock were moved off steeper land and onto easier contoured land with less erosion risk. Farmers relied on either set stocking over larger areas, break feeding, strip grazing smaller paddocks, or changing rotation depending on weather events and stock condition. Farmers stated clear preferences and reasons for those preferences for the management practices they had chosen. Given the increasing intensity of beef farming, farmers may need more management options in the future to minimise soil compaction and reduce the risk of N leaching and P run-off in high risk months.
Winter cropping Crops can support feed deficits, but concentrating large numbers of stock for long periods in cropped paddocks can result in pugging and compaction of soil, increased risk of P and N loss from urine and dung and transport of faecal coliforms from dung, and damages to the soil reducing long-term productivity.	One in eight farmers in this study were reliant on winter crops to fill feed deficits. A number of farmers grew crops that were used to finish stock as part of pasture renewal programmes.
Riparian Management Riparian fencing can reduce the amount of P, sediment and microbes (such as faecal bacteria) entering the water by preventing stock from trampling banks and accessing waterways, including wetlands. Riparian planting further helps stabilise banks and block the movement of soil particles from land into waterways.	Half of the beef and sheep farmers interviewed reported having fenced off waterways on some or all of their property. Two interviewees reported that they had fenced their wetlands. In general they held favourable attitudes towards this practice as it provided benefits in terms of stock management, and for some water quality in their local stream. However, not all waterways were considered necessary to fence, and some farmers observed that beef cattle would ignore a natural waterway where trough water was supplied. For others, the perceived risk of animal pests and weeds was a barrier to fencing and to riparian planting. Those with swampy areas on their properties would graze them as times throughout the year. Two farmers mentioned that they were intending to drain these areas as part of their pasture renewal and subdivision programme. This suggests that while farmers may hold favourable attitudes towards riparian management in general, areas such as swamps and swales may not be perceived as useful for nutrient mitigation purposes.
Soil Conservation and	Over a third of interviewees mentioned that they had areas

Recommended Management Practice	Summary of practices and potential barriers to uptake
Afforestation Soil conservation and afforestation practices assist in the reduction of phosphorus losses: Soil conservation works to control erosion and sediment sources in upper catchments Afforesting steep southern slopes with low production value and high erosion risk. For example, with space planted poplars or production forestry.	of farm forestry on their properties. These areas were on steeper, unproductive or erosion prone land. A further five interviewees had retired areas or plantings for soil conservation areas. Some farmers identified benefits beyond erosion control from retiring areas for soil conservation or for production forestry such as increased animal safety through fencing off steeper areas.
Nutrient Budget Nutrient Budgets assist farmers to identify where savings can be made and monitor the amount of nutrient leaching occurring from their system	Several interviewees were aware that their fertiliser representatives made fertiliser application recommendations based on nutrient budgets, but most did not mention having a nutrient budget. Nutrient budgets offered by fertiliser representatives have potential to be adopted as they offer potential to reduce fertiliser costs.
Nutrient Management Plan (NMP) A NMP provides farmers with a list of actions to mitigate nitrogen (N) and phosphorus (P) losses from their system	None of the farmers interviewed indicated that they had an NMP. Many farmers in this study were probably not required to have an NMP as they were unlikely to be applying N in excess of the 60kg of N/ha/yr threshold prescribed by the Waikato Regional Plan. However, total quantities of N applied had not been calculated and some farmers indicated that they were applying amounts of 50-60 kg of N/ha/yr based on their urea application. Taken with the N content of other fertiliser applied they may well be over the Plan's threshold. Regardless of the compliance trigger for a NMP, preparation of a plan is a useful step in identifying where nutrient losses are occurring and how to mitigate them. The effectiveness of nutrient management plans depends on their successful implementation, and recommendations in a NMP may have significant impacts on a farm system. While a NMP preparation may have a limited focus, for example on the nutrient budget and some good practices, a fuller farm system based plan prepared by a farm consultant may cost in the order of $3,000 to $5,000 and is likely to be a disincentive to adoption by beef and sheep farmers. The benefits of a NMP over a nutrient budget would need to be demonstrated to farmers to increase uptake.
Fertiliser management - nitrogen management Nitrogen management practices include: avoiding applications in winter to reduce the risk of leaching, reducing N rates in line with the Nutrient Budget, using nitrification inhibitors	This study found that two-thirds of the farmers were applying dressings of nitrogen as urea in addition to their main fertiliser. In general, these were of low quantities (20 – 50 kg/N/ha/yr) and applied in separate dressings in autumn or spring or both. Winter applications were generally avoided, but were made by some farmers to fill feed deficits when they were unable to feed out supplements as their paddocks were too wet. For these farmers the potential to reduce winter applications of nitrogen may be limited. The use of nitrification inhibitors was not mentioned by any of the farmers interviewed.
Fertiliser management – phosphate management Phosphorus adheres strongly to soil particles, which can be transported via overland flow to	Many farmers stated that avoiding pugging was a priority because of the potential for pugging to reduce productivity. Farmers usually moved heavier classes of stock off slopes to avoid pugging and erosion. In general, this meant that heavier stock were concentrated on flatter contoured areas

Recommended Management Practice	Summary of practices and potential barriers to uptake
waterways. Management practices should avoid pugging of soils, stock grazing on steeper slopes and near waterways and avoid soluble fertiliser P applications during high risk months, use slow release forms of phosphate fertiliser	of the farm and were generally managed by intensive grazing practices such as break feeding or strip grazing. These practices have the propensity to lead to pugging and compaction and therefore increase the risk of transportation of phosphate via overland flow. Farmers avoided applying fertiliser in the high risk, wetter months. Of those that knew their Olsen P levels, half had levels within the recommended optimum economic return levels of 20-30 for ash and sedimentary soils and 35-45 for pumice soils. Some farmers had Olsen P levels above the recommended level and therefore the risk of phosphorus transport to waterways was increased. A third of the farmers interviewed did not know their Olsen P levels. This could indicate a potential opportunity for beef and sheep farmers to reduce nutrient emissions by nutrient budgeting. A few interviewees mentioned the use of slow release forms of phosphate fertiliser such as RPR.
Supplementary feed Importing Low-N supplements can be used to overcome feed deficits instead of relying on N to boost pasture growth.	Importing feed was not common among the farmers interviewed. There was a general preference towards growing feed supplements as a feed buffer or insurance against summer or winter feed deficits because of the costs of imported feed. Commonly grown supplements for cattle were hay, grass, triticale or maize silage. However, some preferred to use nitrogen fertiliser to boost pasture growth as they were unable to feed out when paddocks were waterlogged, and some stated that nitrogen was more cost effective than growing supplements.

Summary and recommendations

There is a deficit of information on the environmental and economic benefits of nutrient mitigation practices for beef and sheep farming systems.

This research has shown that there are a number of factors that beef and sheep farmers must consider (including climate, soils and topography) when assessing the potential benefit of changing wintering practices. Some changes may not even be feasible in some farm contexts. For example, restricting grazing of winter crops to reduce nutrient emissions is impractical when winter cropping is essential to fill feed deficits. This means that farmers are unlikely to change practices to reduce nutrient emissions unless the change offers a clear advantage over current management practices for the winter months.

For these reasons, it is clear that ‘a one size fits all’ approach to improving nutrient management on beef and sheep farms is not feasible. Nutrient management on such farms must be tailored to account for site-specific factors. For example, some practices such as applying nitrogen in winter months are relied on to meet feed deficits that can not be met by providing supplements because land is too wet to feed out on. Other practices such as utilising nutrient budgets and preparing nutrient management plans may be more easily adopted, but their execution might not be fulfilled.

It is clear from the results reported here that there are a number of wintering practices that align with the policy objective to reduce nutrient losses, particularly during the winter risk period such as stock reduction, removing heavier stock from erosion prone areas and in the main, timing of fertiliser applications. These practices enable farmers to manage the condition of pasture and stock and so maintain farm productivity over the winter.

In addition, from a policy perspective, some practices adopted are not necessarily carried out in a manner that will achieve the policy objective to limit nutrient losses to waterways, for example the extent of riparian fencing and planting.

Based on the findings reported, the following recommendations are made. That the Waikato Regional Council:

1. Promote research on nitrogen and phosphorus transport mechanisms to waterways on beef and sheep farms, and in particular the risk periods for stock management and relative contribution of mitigation practices.

2. Promote research into practices to minimise nutrient losses from dairy support activities on beef and sheep farms.

3. Continue to work with beef and sheep farm advisors/consultants to assist the development of consistent messaging around nutrient management tools.

4. Work with industry to improve beef and sheep farmers' understanding of nutrient budgeting and interpretation of Overseer results to increase farmers' perception of the value-add of nutrient management to their business.

5. Be a party to current research and development of mitigation measures with the science and industry sectors to assure alignment of outcomes between the sector and policy developments both national and regional.

6. Address the gap in research on new technologies such as nitrification inhibitors and alternative low-N feed supplements for the beef and sheep sector by advocating for specific field trials within the region.

7. Address the gap in research on new technologies for the management of phosphorus loss for the beef and sheep sector.

8. Continue to promote appropriate riparian management as an effective nutrient mitigation measure. Consider targeted communication about requirements tailored to this sector and promote available incentives to increase uptake.

9. Incorporate the variety in farm context in any nutrient management 'tool kits' which WRC develops or promotes.

10. Promote research into practices to minimise nitrogen and phosphorus losses from winter cropped areas.

11. Recognise the variation in farm context in any regulatory framework put in place to promote nutrient management practices on beef and sheep farms.

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Appendix 1

3 Water Module

3.9 Non-Point Source Discharges*

3.9.4 Implementation Methods - Non-Point Source Discharges

3.9.4.11 Permitted Activity Rule - Fertiliser Application

The discharge of fertiliser* into air and onto or into land is a **permitted activity** subject to the following conditions:

a. The discharge shall not result in any objectionable odour or particulate matter beyond the subject property boundary.
b. The discharge does not result in any avoidable direct application of fertiliser to any water body.
c. Where the fertiliser is being used in other than domestic gardening situations the fertiliser must be applied in accordance with the NZ Fertiliser Manufacturers Research Association, 1998 (updated 2002): Code of Practice for Fertiliser Use.
d. A nutrient management plan of the type specified in Table 3-10 must be used to plan fertiliser application where nitrogen fertiliser is being applied at rates greater than 60kg/N/ha/year.
e. The contents of the nutrient management plan required by condition d) must be made available to the Waikato Regional Council upon request.
f. A nutrient management plan shall be provided to Environment Waikato on request in accordance with condition d) where fertiliser is to be applied to an area of land that has also had farm animal effluent applied to it within the preceding 12 months.

Table 3-10 Nutrient Management Requirements by Land Use Type

Land Use Type	Nutrient Management Plan Requirements
All Land Uses applying more than 60Kg N/ha/yr	A nutrient management plan must be prepared that, as a minimum records the following information for at least nitrogen (N) and phosphate (P) (in units of kg of N and P per hectare per year) : • Inputs from fertiliser. • Inputs from other sources such as manures, green crops and soil mineralization. • Outputs in product. • Results of soil testing for levels of available N and P. • Documentation of consideration given to climatic and soil conditions for the life of the crop to account for the effects of rainfall and irrigation on the potential for N and P leaching through the soil in to ground and surface water. • Practices that will be implemented to reduce nutrient and sediment losses from the property and to avoid, remedy or mitigate adverse effects on the environment.
Pastoral	The nutrient management plan specified above must be developed based on the outputs of either Overseer (AgResearch) or any other nutrient management

	planning tool that meets the criteria set out in the fifth advisory note below.
Commercial Vegetable and Fruit Production, Arable/Mixed Cropping and Livestock or any other land use not otherwise captured in this table	From 1 January 2011, the nutrient management plan specified above must be developed based on the outputs of any nutrient management planning tool that meets the criteria set out in the fifth advisory note below.

Advisory Notes:

- The discharge of fertiliser into air and onto or into land that does not comply with Rule 3.9.4.11 is a discretionary activity in accordance with Rule 3.5.4.5.
- Application of fertiliser should follow the good practice guide on fertiliser use in Section 3.9.7 and any other relevant industry nutrient management tools, including "Doing it Right" (the Franklin Sustainability Project, 2002).
- The processes for determining the objectionable effects of odour or particulate matter beyond the property boundary are set out in Chapter 6.4 of this Plan.
- This rule does not specify a nutrient leaching rate for the model. It is Environment Waikato's intention to survey modelled leaching rates and if necessary develop rules that specify nutrient leaching rates for sensitive locations in accordance with Method 3.9.4.8.
- In order to comply with the requirements of this Rule Nutrient Management Planning tools other than Overseer and SPASMO must:
    a. Be a Crown Research Institute, University or Industry developed model that has successfully completed commercial trials commensurate with climatic, terrain and soil conditions expected to be encountered in the Waikato Region.
    b. Be able to predict annual, seasonal or crop nutrient losses at either a paddock or total crop area scale with a margin of error no more than 30%.
    c. Have been calibrated against current versions of either Overseer or SPASMO, or versions that are no more than 3 years old, and any departures from those models when using identical data sets documented and explained.
    d. Have product maintenance and support currently available as of the date of use or guaranteed for a period of one year.
- A register of nutrient management planning tools that meet the criteria set out in the above advisory note is maintained by Environment Waikato. If by 2011 models that meet these criteria have not been developed for the subject crop or land use, a model based on the crop or land use with the most similar nutrient leaching behaviour will be acceptable.

Appendix 2

Map showing the distribution soils of the region and the average rainfall throughout.

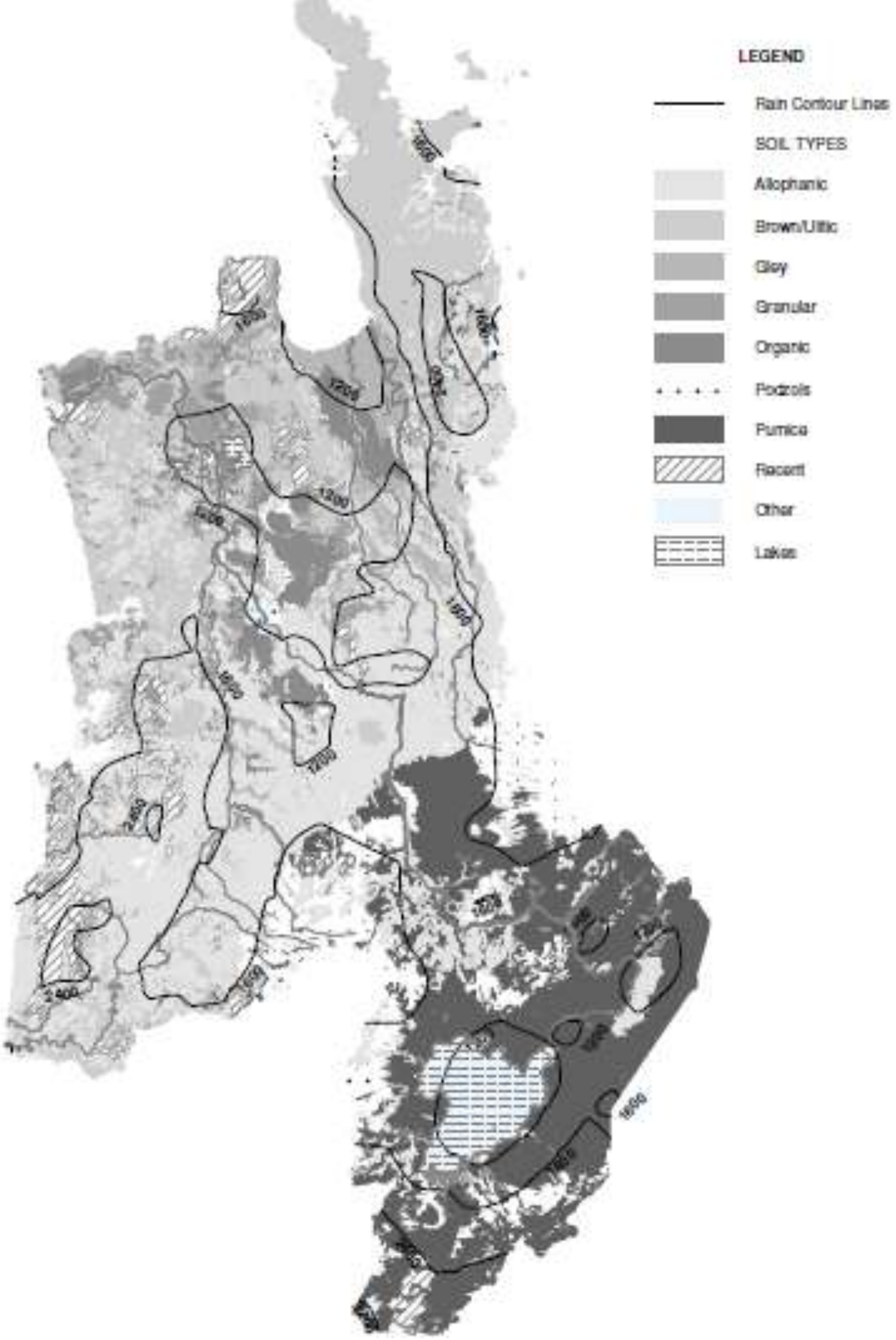

Figure 4 Distribution of soils and average annual rainfall in the Waikato region