FARMING FOR ECONOMIC RESILIENCE AND ENVIRONMENTAL PERFORMANCE: TOMORROWS FARMS TODAY 2010-2013

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Introduction

Dairy farming receives a lot of attention for its effects on water quality largely due to the intensification and expansion that has occurred in the past two decades. The industry has responded to public concern with a number of voluntary initiatives such as the clean streams accord. However, in the face of declining ecosystem health in the Waikato for example, these initiatives are unlikely to be enough to retard further decline. Farm system reconfiguration will be required in the future to lower diffuse nutrient, sediment and pathogen losses. This change will have to occur without significant disruption to profitability and economic resilience. To date most studies have considered single mitigations and the cost of change. An understanding is emerging that if significant reductions in net losses of nitrogen are to be achieved in sensitive catchments, it may mean farm system reconfiguration must occur.

Some farmers already run resilient, profitable businesses while having significantly lower environmental risk than others. This study of 25 farms with similar rainfall and soil types establishes what management factors contribute to environmental risk using a scorecard approach and aligns this with which businesses are the most profitable (return on capital) at a range of milk prices. The most (economically) resilient businesses with the lowest risk to the environment demonstrated excellent cost control, strong milk production per cow and optimal stocking rates for the geophysical risks peculiar to their sub catchment.

The Waikato River & Catchment

River water quality monitoring in NZ includes nutrients (total and dissolved nitrogen and phosphorus concentrations including nitrate, ammoniacal nitrogen and dissolved reactive phosphorus), bacterial, visual clarity, water temperature, dissolved oxygen, and macro invertebrates, (NIWA , 2014).

Overall, river water quality has deteriorated over the past 20 years mainly as a result of diffuse losses from farming, (increased pastoral land cover) despite environmental gains being made in terms of reduced point pollution. (Ballantine, 2010 & 2013)

In a recent study by Vant, (2013) for the Waikato regional council, it was evident that trends were worsening. Clarity, for example has declined by 16% over the period of 1995-2013. This may be partly due to significant areas of pine to pasture conversions in the upper river catchment since 2000. Over 29,000 ha of pine to pasture conversions occurred over the period from 2002 to 2008, (Hill et al, 2011). Since 2008, a further 8-10,000 Ha of conversions have occurred. A trend analysis of river water quality data over two decades (1992-2013) by Vant (2013), shows that turbidity, clarity and nitrogen levels have continued to worsen while phosphorus and chlorophyll a have remained stable or slightly improved. Groundwater is showing a trend of increasing nitrate levels.

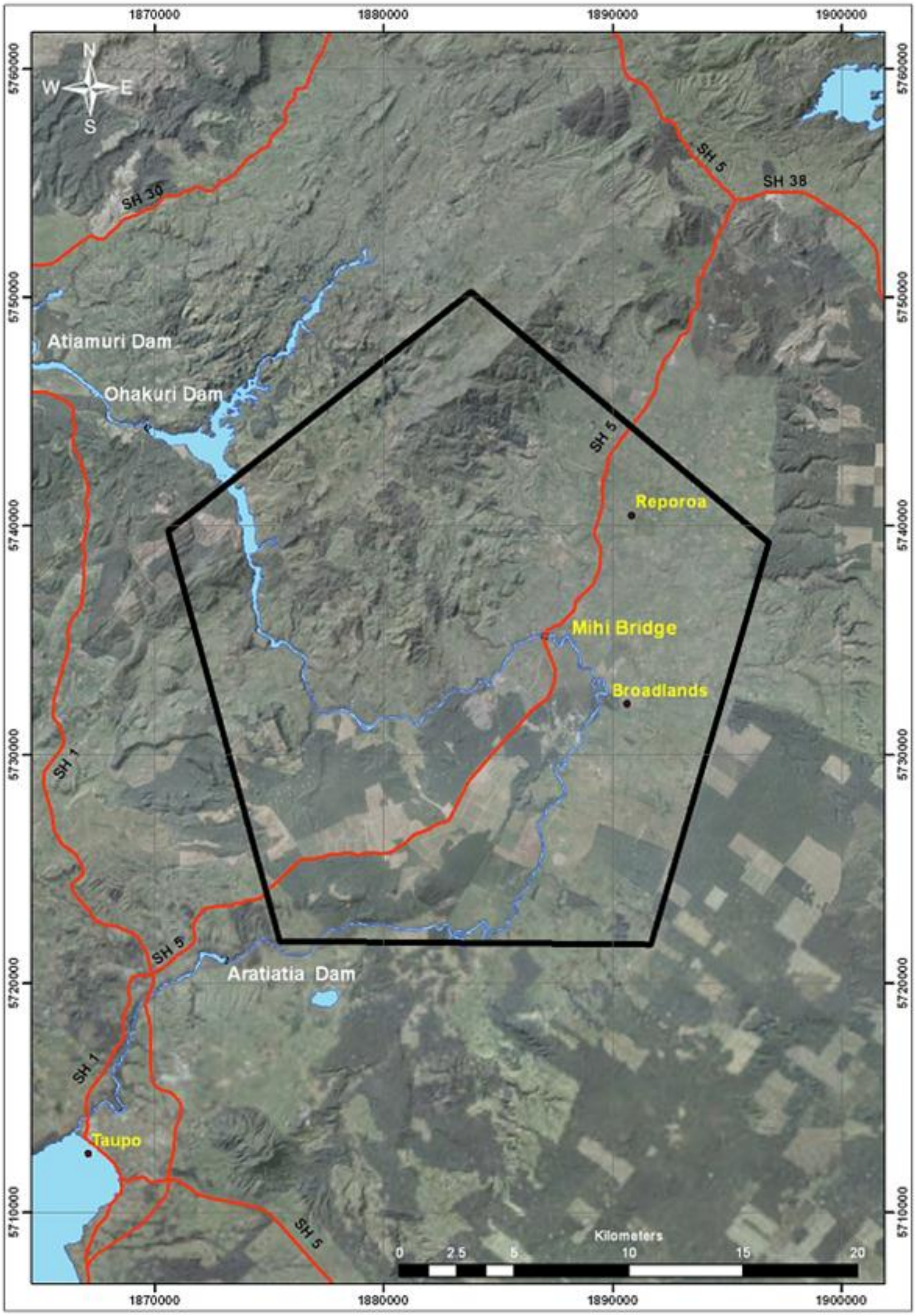


Figure 1 - Map of study area - upper Waikato

The upper Waikato catchment between Karapiro and Taupo comprises an area of 4,400 km2. The Waikato River below Taupo flows along 336 km of channel, is fed by over 17,000km of tributary streams, and drains a catchment area totalling 11,013 km2. This sub-catchment is characterised by pumice soils that consist of hydrological and erosion sensitive pumice soils, (Taylor, 2009). Within this upper catchment, 52% of land cover is exotic forest, indigenous vegetation, scrub, or unmanaged areas, while 45.7% is being used for agricultural purposes with potential for further conversion of 567 km2 of forest (24% of the existing forested land) to pastoral agriculture, (Woods et al, 2010). The upper catchment comprises a mixture of steep to moderately steep land: (42% of land area) with land cover evenly spread between pastoral land and planted forest. There are approximately 200 dairy farms in the study area and around 700 dairy farms in the upper catchment, (Collier et al, 2010).

Twenty five farms for the study were selected for this study using the following criteria:

(1) Availability of accurate farm and financial reporting information over a year

(2) Willingness to discuss financial and physical farm performance, participate in the group, and share information

(3) Owned or operated farms within the study catchment

(4) Demonstrated motivation to understand and improve environmental and economic performance. Farm characteristics are detailed in Table 1.

Information Collection and Scorecard Development

The information was collected and analysed for the year of 2010-11 and 2011-12 at a farm visit. Data was collected using farm input purchase records, a drive around the farm, and an interview with the farmer including consultation about the farm's biophysical characteristics, the collection of financial account, fertiliser and feeding histories, and any details required to update the farms OVERSEER model. Data was collected by observation of environmental practises. Groups of indicators were compared with the latest available "best management codes of practice" at the time by the dairy industry, and weighted based on whether they were "improved or best practises."

Management practices and OVERSEER outputs were scored from best to poor practice. Higher "total risk points" were given, when higher risk activities undertaken. E.g: extensive cropping areas, wintering full time on fodder crops, or unlined effluent ponds, resulting in higher overall total of risk points for all the sections.

Table 1 Overview of Farm Characteristics from the Study Group.

	Study Group 25 Farms Average	Range in Study Group	Average Dairy Central Plateau	Ave Central Waikato Dairy
Rainfall	1100	1000-1300	1200	1200-1500
Soil Types	Pumice	Pumice (small area peat and ash soil types)	Pumice	Diverse: Ash Clay, Peat.
Effective Ha (designated milking)	124.7	74 - 646	174	105
Total Ha	129.7	75-652	174	114
Herd Size	350.6	187-1621	403	360
Stocking Rate (cows/eff ha)	2.85	2.4-3.3	2.75	3.3
Kg bodyweight per Ha	1385	1104 - 1650	1350	1584
MS kg/ha/yr	1208	816-1585	1125	1200
Total MS per farm.	151229.3			133266
Winter Graze Off				
% herd off	43	0-100	0-100	0-100
% year off	12	0- 16	0-20	0-20
Supplements Imported(T DM)				
T maize silage/year	94	0-660	0-100T	30-100T
T pasture silage/year	98	0-167	0-200T	0-300T
T Hay/Year	50	0-213		
T PKE/Year	306.8	30-1473		50-300T
T Concentrates	192	0-660		
Winter cow grazing t	59	0-264		
Total Tonnes Imported	493.5	30-2859		
Total Imported excl winter grazing	434.4	30-2659		
Home grown feed eaten per Ha per year(tDM/Ha)	10.4	9.30- 13.8	10.5	12.5
T DM Suppl imp/(T DM pasture+ supp eaten/Ha) %	30	5 – 41%	20-30%	20-30%
Farm System 1-5 Dairy Systems	3-4	1-5	3	3
Fertiliser and Lime				
kg N/ha/yr	99			128
P	20.7			66
K	36.6			73
S	56.3			78
Nutrients imported via Imported Feeds (kg/ha/yr)				
N	93			
P	21			
K	52			
S	13			
Change in P pool.	-15			

	Study Group 25 Farms Average	Range in Study Group	Average Dairy Central Plateau	Ave Central Waikato Dairy
N loss: kg N/ha/yr (Ov.v.6.0)	31.4	15-48	39	36
Efficiency: Kg MS/kg N Loss	39	18-60	29	33
N Conv Efficiency %	32	21-41		28
N Surplus kg/yr	193			150-200
Total N Loss kg/farm/year	4155	1903-9925		4095
Phosphorus Report (kg P Ha/year)				
Farm P loss kg P/ha/yr	3.8	0.7 – 6.7		1.5-3
Total P loss: kg/farm/yr	230	70-5353		
Area of effluent: % of farm	25	9-44		10-20
Total Loading N on Effluent Block(fert/feed/effluent)	254	86-342		
kg CO2 equiv/kg MS	7.5	7.2-19		

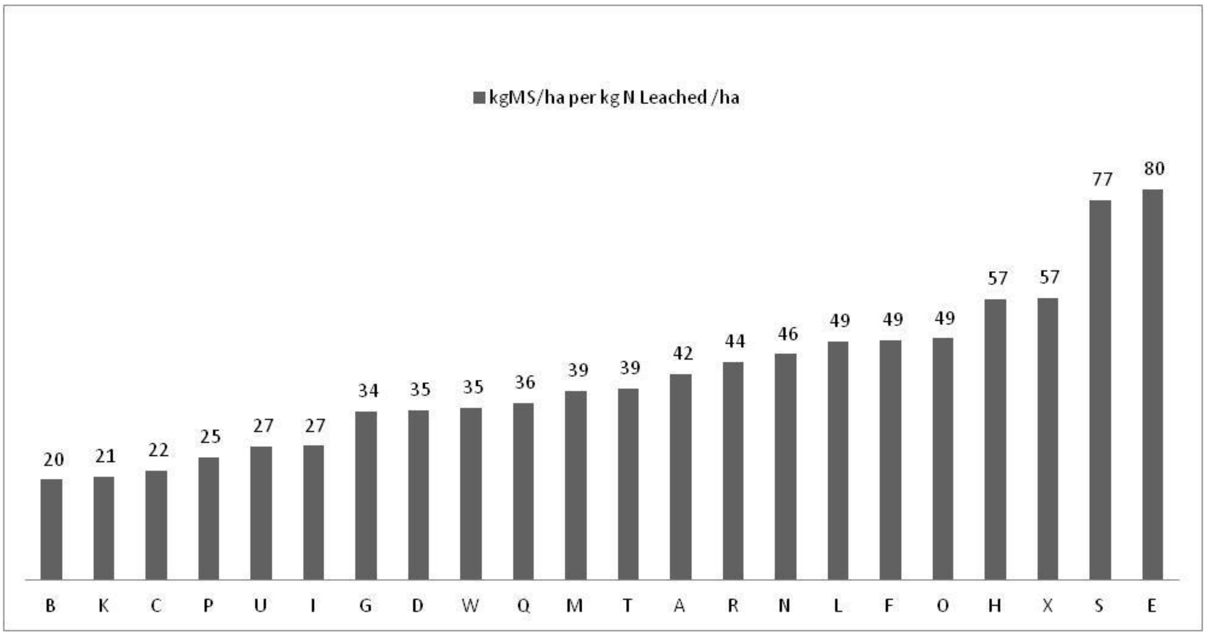
2.3.2 Results of Eco Efficiencies

The range of GHG loss per kg of milk solids produced ranges from 6.3 to 19 kg CO_2 equivalents per kg MS. The excessively high output on one farm reflects significant losses that are likely to be a result of a large winter cropping area. 10% of the farm was cropped conventionally. The large area (60ha) when aligned with constrained milk solids production from the farm, accentuates the eco efficiency ratio. On average, there was low risk performance (high eco efficiency) on the majority of farms for GHG losses. Nitrogen conversion efficiency ranged from 20% to 53%. The highest nitrogen conversion efficiency did not necessarily correlate with the lowest leaching. Although it is a useful measure of how much nitrogen is being converted to product, it does not appear to relate well to lower risk of nitrogen loss to the receiving environment.

In this study, farm-gate N surplus is defined as the difference between ‘external’ farm N inputs (atmospheric, fertilizer, legume N_2 fixation, supplementary feed and brought-in manure) and ‘external’ farm N outputs in products (milk, meat, fibre, hay/silage leaving the farm), (Ledgard, 2004). Farm-gate N surplus can be related to the production from the farm, giving a measure of N eco efficiency, (Beukes, 2012). However, more recently the industry has been using a measure of “technical efficiency or nutrient use efficiency” to describe how many kilograms of milk solids per hectare can be generated for each kilogram of nitrogen leached (Anastasiadis & Kerr, 2013). Essentially this compares production relative to pollution, the study farms appears to be more efficient producers on average with 39 kg of milk solids produced per kg of N leached, and a range of 18-60 kg MS per kg of N leached across the participants, compared with the upper Waikato (Headlands data) average of 29 kg of milk solids per kg of N leached.

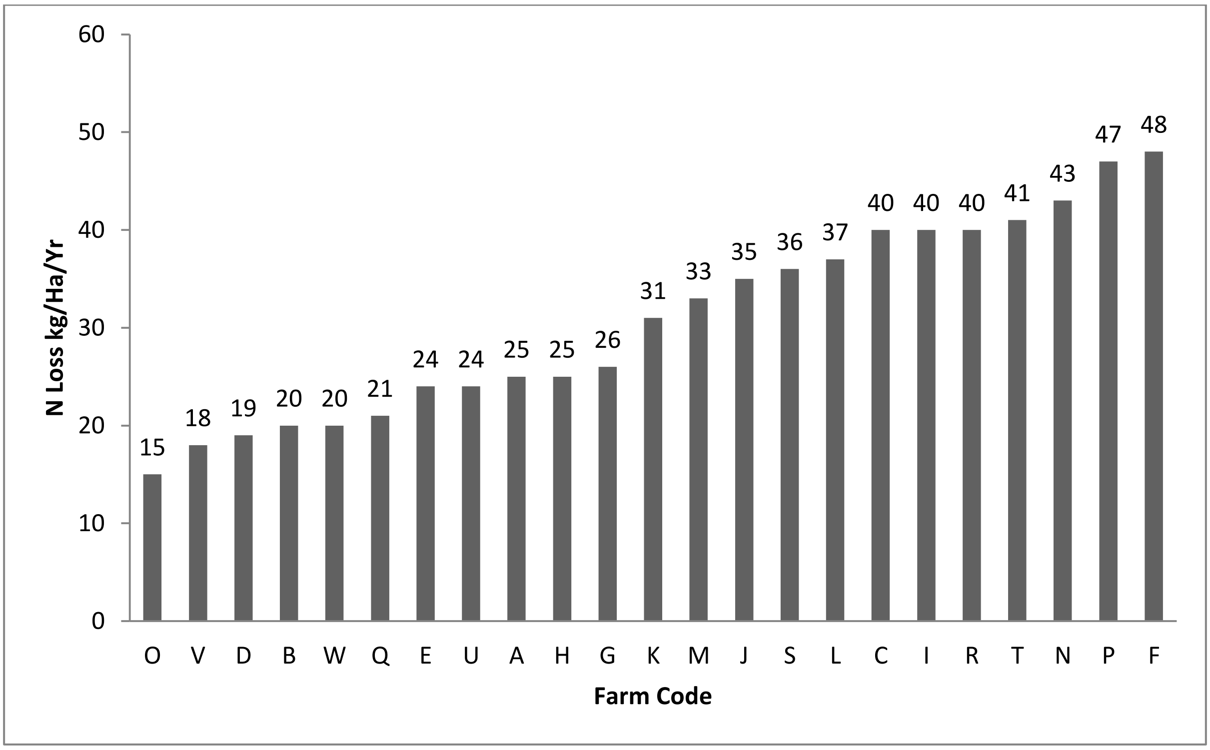
Anastasiadis & Kerr (2013) refer to a mean in their studies of being 34 kg MS/kg N leached and a range of 10-105 kg MS/kg N leached. It was noted only 48% percent of the OVERSEER-modelled variation in New Zealand dairy farms’ nitrogen use efficiency was based on geophysical factors. This suggests there is potentially a large role for management factors and farmer skill to impact on efficiency and losses.

Figure 2 Nitrogen Use Efficiency (Kg MS per Kg N loss) ranked for 25 farms. Overseer version 6.11, March 2014)



This efficiency measure was one of the efficiency criteria tested against farm profitability on the 25 farms (ROC).

Figure 3 - Nitrogen Loss Risk for Study Farms (Overseer Version 6.0)



The range across the study group was extremely wide. This reflected a variation in the farm systems and their respective management systems in the study.

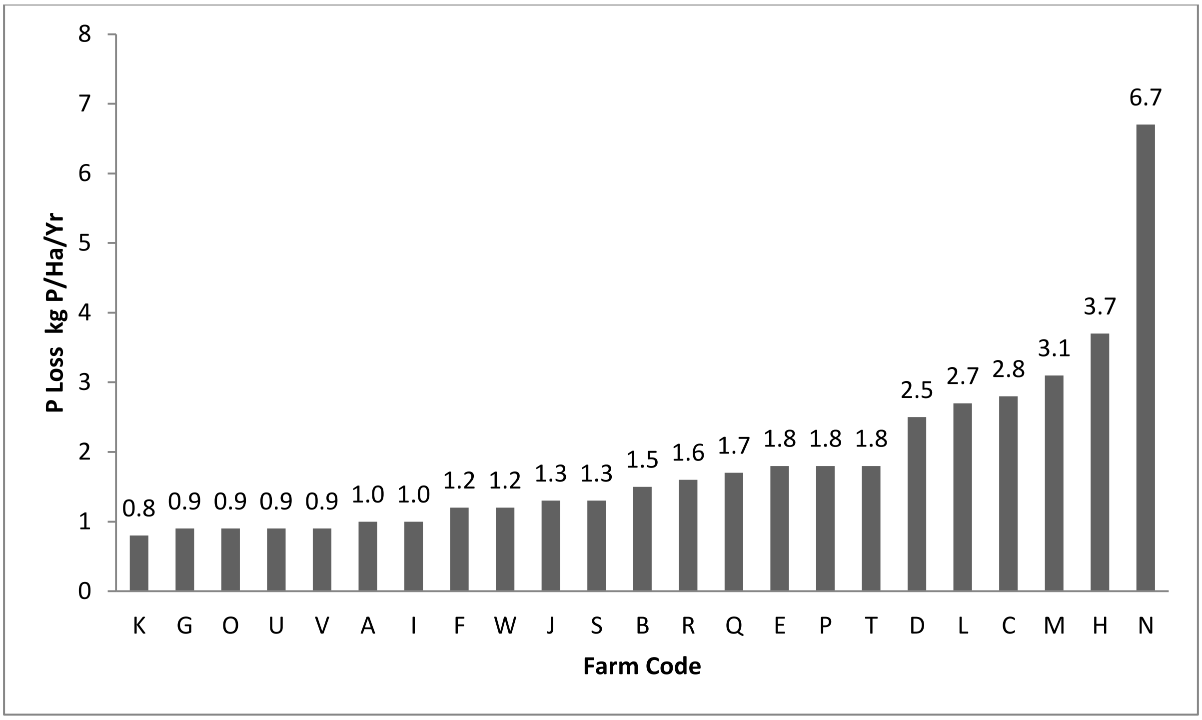


Figure 3 - Phosphate Loss Risk from Case Study Farms, (using Overseer Version 6.1 using DairyNZ protocol)

It was noticeable with the version 6.1 (2013) OVERSEER that was released that the phosphate loss risk was significantly higher than the 2011 years P outputs from previous versions.

Variations and Upgrades to Overseer and protocols during the course of the study.
The OVERSEER version underwent five modifications during the course of study resulting in output data for the scorecard requiring alteration several times. There were upgrades to the code of practise for effluent management which also affected the scores. Although it should be clear that the Waikato Regional Council Rule 3.5.5 permitted activity for the discharge of effluent to land, would mean that all storage ponds for effluent are lined to prevent connectivity to ground water, this particular rule has not been enforced in the upper catchment, sending a confusing message to both the industry and farmers. 80% of the ponds in the study group were unable to demonstrate proof of lining when data was collected in 2012. This would not be unusual for the southern Waikato region.

Due to versions and protocol changes during the course of the study, N loss results produced for the irrigated farms varied significantly. One irrigated farm had N loss figures alter by a magnitude of 100% over the 12 months of the study.

Overseer assumes (using DNZ designated protocol default settings) that all effluent irrigation systems are entered into Overseer as being actively managed (that is: application of effluent is only occurring under low risk conditions). Overseer also assumes that all ponds are lined, and not connecting to groundwater. In this study, most of the ponds were unlined and not all best management practices were in place, and therefore the Overseer outputs could be underestimating the N loss figure by 10% or more (*pers. comm* Horne 2013). The Overseer Version has changed from 5.4 to version 6.1 during the course of this study and is part of long term continual change. Some of the modifications have (particularly on irrigated farms) resulted in significant changes to the models and farms N loss outputs. The input protocol used for the model was consistent between versions.

Some of the study farms' N losses altered by 30-50% between version modifications, yet there had been little change to the farm system and inputs.

Understanding Economic Resilience and Environmental Performance

In this study of 25 dairy farms with geophysical variability minimised and similar characteristics, Figure 2 page 6 shows that there is a wide variation in N loss across farms, thus reinforcing that management factors have a significant impact on N losses.

This study of low footprint, profitable dairy farms is as significant and pertinent for NZ as it is for Waikato. It is relevant to Canterbury, Otago, Horizons, and Hawkes Bay regions as they are currently undertaking and implementing plan changes for land and water policy. This study builds on earlier work (Beukes, 2012; Agfirst Waikato, 2009; Doole, 2013; Anastasiadis, 2013) by analysing actual dairy farm data on 25 dairy farming systems in the Upper Waikato. In this case, the full extent of the farms risk management practises are included and reported on in a transparent manner using the scorecard (rather than assuming BMP in all cases: OVERSEER), combined with a full farm performance and economic analysis.

Anecdotal evidence from farm performance data reflected that some dairy farms in the Upper Waikato were well below the average for the region in terms of N loss while having resilient economic performance and high levels of "nutrient use efficiency", generating over 60 kg milksolids per kilogram of nitrogen leached (average is 25-30 kg MS/kg N leached). This warranted further study to ascertain what farm management characteristics let to greater profitability, lower diffuse losses and greater resilience in the face of changing commodity prices, climate and emerging policies on diffuse nutrient limits.

The wider public are cognisant of the requirement that farm mitigation measures allow farm profitability to be maintained for this important industry (Monaghan, 2008). For example: managements that optimised soil Olsen P levels were observed to result in win-win outcomes. Other BMPs generally reduced nutrient and faecal bacteria losses but at a small cost to the farm business. (Monaghan, 2008; Agfirst Waikato, 2009 and Beukes, 2012 &2013) and more recently Dairy NZ and Horizons Regional Council, (2013) note that a range of technological measures and farm system change can deliver substantial reductions in nutrient losses from dairy farms, while also maintaining profitability.

There is a notion that milk price volatility will be the major challenge for farm businesses as we move forward. Milk price cycles now average around $6.50, but with a fluctuation of 20%. This can significantly impact economic performance and resilience if climatic variability, milk price and feed costs are increasingly variable. (Moynihan, 2013). This study data on 25 dairy farms spans two years of milk prices. The 2010-11 price of $7.50 and the 2011-12 price $6.08. The average price over the two seasons of data was $6.80. This demonstrates a 20% fluctuation. Resilience therefore is becoming increasingly important.

Resilience is described by Shadbolt et al (2013) is a prerequisite for achieving sustainability in a turbulent environment. It is defined as an ability to adjust, either within a system, as with buffer capacity, or across systems, as with adaptability and transformability. It reflects the flexibility a farm business has to respond to and learn from shocks, both negative and positive.

Results

Low impact farms and their profitability

A large range of management factors were assessed to see if there was an impact on profitability. There was no significant correlation between stocking rate, pasture harvested, milksolids production, nitrogen use per hectare when compared with profitability (operating profit, or ROC%). The strongest correlation to improved profitability found was cost of production as denoted by the cost of production per kg of milk solids. When operating profit was tested against cost of production and milk solids per hectare, the relationship was strong suggesting that if a low cost of production can be maintained while milk solids output remains strong, then there is a high probability of the business being profitable. This information was also used to help identify the most resilient businesses from the study.

Three of the better performing farms featured as being strong performers in both 2010-11 and 2011-12 seasons. This study set out to find if there were common characteristics in farm systems that led to strong performance. The conclusions that were common amongst the best performing businesses were:

a) They managed their costs extremely well while still achieving higher than average levels of production per cow and per hectare.

b) The farms were not overstocked relative to their historical pasture harvest, and therefore were able to feed cows well on home grown feed supplies.

c) The strongest performers were getting more than 3.8 -4.4 TDM of home grown feed consumed by each cow, with the best performer (Parnwell) getting 4.44 T DM of home grown feed eaten by each cow, and milk solids performance was > 90% of cow bodyweight compared with the average at 77%. This reflected an understanding of an "optimum stocking rate" for the farm, whereby cows were well fed, showed high productivity from low cost feeds (home grown) and pasture harvested was also high, despite a "lower than average" stocking rate.

d) The cows on the best performing farms demonstrate high productivity per cow (>90% bodyweight as milksolids) and per ha, reflecting high genetic merit in the herds.

e) The farms had the ability to store and spread effluent at optimum times over as much of the farm (>40%) and minimise imported soluble fertiliser. Soluble nitrogen use per hectare on two of the top performing farms was only a third of the average for the region with no loss of productivity.

f) These better operators all demonstrated an ability to source feeds consistently at a good price, make decisions quickly and plan ahead well.

g) They demonstrated "farm systems thinking"

h) They had a focus on simplicity, efficiency and wise use of infrastructure.

i) They tend to be excellent risk managers bearing in mind that "It's not the good years that make you but the tough years that break you."

Unfortunately in NZ, most dairy farms are not routinely measuring or monitoring their historical average pasture consumed, and as a consequence, are farming instinctively with regard to stocking rate. There is also a perception that increasing stocking rate correlates with increasing profitability. This study failed to show any correlation between stocking rate and profit.

The stocking rate on a farm can underpin the whole farm system resilience across different milk prices and seasons, and can significantly influence the degree and cost of environmental mitigation requirements required. An optimum stocking rate requires knowledge of what the farms long term capability is, this can be evaluated with farm performance analysis and historical assessment. Many farms are harvesting a lot less pasture than they expect , hence stocking rates above "optimum" are driving a need for annualised cropping, reactive nitrogen use, soil damage, a high reliance on bought in feeds (> 20% is now typical), and subsequently reduced profit margins from systems.

There will be a different solution for each farm, and the most appropriate solution will largely be governed by the risk preferences and values of the business operator. Farm systems ideally should be assessed using historical farm performance analysis, along with Overseer and the scorecard approach to identify risks other than just nitrogen loss. Dairy farm systems in NZ will need to undergo reconfiguration in order to adapt to withstand economic and climatic volatility and now a requirement to meet environmental, policy and skilled labour constraints.

Table 2 Summary of characteristics of the most resilient farms with the lowest risk environmental scores in the study.

	Z	B	V	Q	D	Central Plateau Average *
Cows per Milking Hectare	2.59	2.67	2.47	2.75	2.80	2.79
BWt per Milking Hectare	1,165	1,199	1,185	1,291	1,345	1325
Milksolids per Cow	388	368	462	469	432	367
Milksolids per Milking Hectare	1,005	979	1,140	1,287	1,210	1,009
Milksolids as % of Bwt	86	81	96	99	90	77
Pasture Dry Matter Harvested (tDM/Ha)	11.7	9.9	11.7	11.1	11.1	11.0

ECONOMIC PERFORMANCE						
Operating Profit per Hectare	3,210	2,753	3,087	3,312	2,645	1,885
Operating Profit per Cow	1,239	1,033	1,251	1,206	944	676
Return on Capital (ROC) at 4-Yr Av Values @$6.08 kg MS	6.3%	5.9%	7.7%	7.9%	4.6%	4.6%
Return on Capital at $5.50kg MS (ROC) at 4-Yr Av Values	5.1%	4.8%	6.2%	6.3%	3.6%	3.6%
Cost of Production per kg Milksolids	$3.10	$3.58	$3.69	$3.77	$4.22	$4.57
Cows per Full Time Staff Equivalent	145	167	161	134	154	165
Pasture as % of Total Consumed	88.7%	81.9%	90.1%	75.5%	80.5%	79.8%
ENVIRONMENTAL PERFORMANCE						
N Leaching kg/N/ha/yr Overseer V 6.0	25	20	19	22	23	36
N Conversion Efficiency	26%	27%	25%	29%	35%	30%
Kg Milksolids per kg N lost.	41	49	60	59	53	28
Environmental Score	2.3	2.2	1.9	2.1	2.2	N/A
Soluble Nitrogen Use(pasture) kg/N/ha/yr Applied	55	91	130	57	140	126.4

Conclusion

This study has shown that the most efficient farmers are already achieving twice the productivity and profitability of the average, while having a significantly lower risk to the environment than others. Increased understanding of what separates the “best from the rest” in farming systems is essential, followed by a concerted extension process of what these concepts are to “average farmers” in order to speed up adoption and adaptation

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Bibliography

Agfirst Waikato. (2009). *Upper Waikato Nutrient Efficiency Study.* Hamilton: Waikato Regional Council.

Anastasiadis & Kerr. (2013). *Mitigation and Heterogeneity in Management Practises on NZ Dairy Farms.* Motu.

Ballantine *et al*. (2010). *Water Quality Trends at NRWQN sites for the period 1989-2007. (page 18, 3.4.2).* MFE 09202.

Ballantine *et al*.. (2013). Water Quality Trends in NZ Rivers. *Environmental Monitoring Assessment.*

Beukes, P. S. (2012). The relationship between milk production and farm gate nitrogen surplus for the Waikato Region NZ. *Journal of Environmental Management.*, 43.

Collier, et al. (2010). *The Waters of the Waikato. Ecology of New Zealands longest river.* Hamilton: Environment Waikato and CBER (University of Waikato).

Doole., G. M. (2013). Evaluation of agri environmental policies for reducing nitrate pollution from NZ dairy farms accounting for farm heterogenerity. *Land Use Policy(vol 1)*, 57-

Dairy NZ and Horizons Regional Council. (2013). *Cost Benefit and Economic Analysis of the Horizons One Plan: prepared by Nimmo Bell and MfE.* Dairy NZ.

Hill & Borman. (2011). Estimated Pastoral Land Use Change in the Waikato Region. *FLRC Massey*.

Ledgard., S. (2004). Use of nutrient budgeting and managemnet options for increasing nutrient use efficiency and reducing environmental emissions from NZ dairy farms. *OECD expert meeting on farm managemnet indicators and the environment.* 66.

Monaghan., et al. (2008). Prioritisation of farm scale remediation efforts for reducing losses of nutrients and faecal indicator organisms to waterways: A case study of New Zealand dairy farming. *Journal of Environmental Management*, 609-622.

Moynihan, H. (2013). *Agriculture in Focus: No Longer a Low Cost Producer Down Under.* Rabobank.

NIWA . (2014, March 6th). *www. niwa.co.nz*. Retrieved; 2014, from https://www.niwa.co.nz/freshwater/water-quality-monitoring-and-advice/national-river-water-quality-network-nrwqn: https://www.niwa.co.nz/our-science/freshwater/our-services/water-quality-monitoring-and-advice/national-river-water-quality-network-nrwqn/what-do-we-measure

Taylor, M. (2009). *Infiltration Characteristics of Soils Under Forestry and Agriculture in the Upper Waikato Catchment.* Waikato Regional Council.

Woods, R et al. (2010). *Summary of the effects of Land Use Change between Taupo and Karapiro on the Flood Hydrology of the Waikato River Catchment.* Hamilton: Waikato Regional Council (ISSN 1177-9284).

Vant, W. (2013). *Trends in river water quality in the Waikato region, 1993–2012.* Hamilton: Waikato Regional Council.