Sustainable Land Management Research - Update

Lake Rerewhakaaitu

Sustainable Management Fund, Project Number: 2238

Addressing Land/Water Issues Through partnerships in Rotorua

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landcare action on the ground

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Introduction

This report provides an update on the research inventory on sustainable land management submitted in Year 1. It will look at the projects covered in the last inventory and report on any further results obtained from the research since the last update.

New research projects focusing on nutrient loss mitigations and land use change in the area which were not covered in the last inventory will be added and more focus will be given to Taupo research as it is felt that Rotorua landowners and communities can learn a lot from research findings in the Taupo catchment.

A very thorough review of research has just been compiled by Helen Ritchie for the Land Use Futures Board and this has been added as an appendix to this report.

Rotorua Research

On-Farm Biological Mitigation Options for Nutrient Management (SFF 06/117)

Watercress Harvesting Trial

A trial involving troughs planted with watercress was established at Wharenui Station in December 2007 to investigate watercress growth rates and nutrient uptake with regular harvesting. The troughs receive streamflow, fed by gravity. Two different flow rates are being trialled to assess the impact of contact time on plant uptake. The water quality is sampled fortnightly, with inflow and outflow samples analysed for total phosphorus (TP), total dissolved phosphorus (TDP), total nitrogen (TN), nitrate (NO3) and ammonium (NH4) and the flow between tanks sampled for NO3. An additional study has been completed which looks at ways of removing E-Coli from the watercress once harvested, (SFF Report Oct 2007).

Results to Date

The watercress harvesting trial is progressing well, with regular weekly sampling now underway. Plant cover in each trough is being monitored by taking repeated photographs at fixed points (Figure 1). The slow flowing troughs (designed to have a residence time of 1 day) currently have better plant cover.

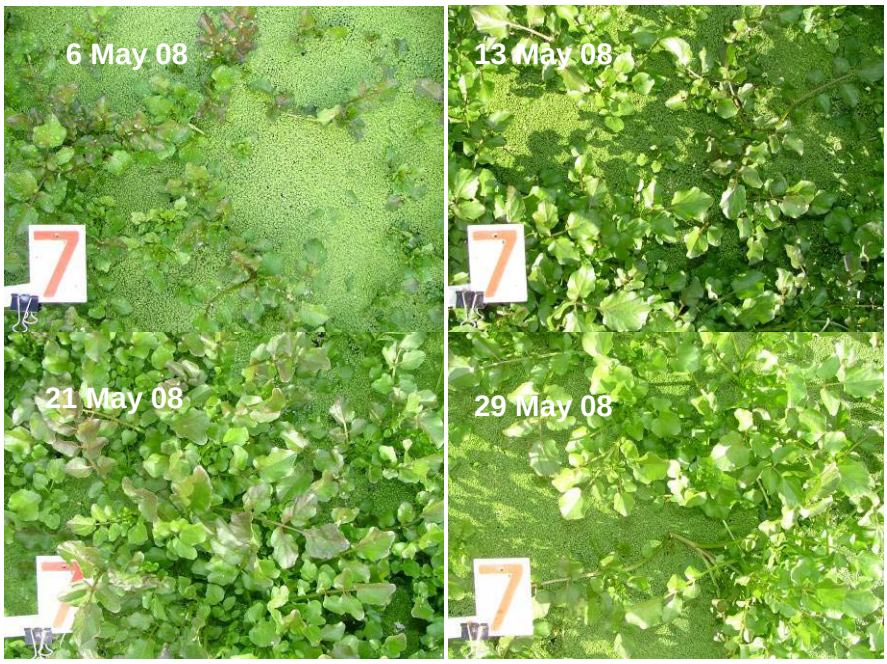


Figure 1: May watercress cover in trough 7 (low flow system).

Results collected while the plants were establishing are promising and show that the low flow (residence time 1 day) system is reducing the nitrate and dissolved reactive phosphorus concentrations by 40% or

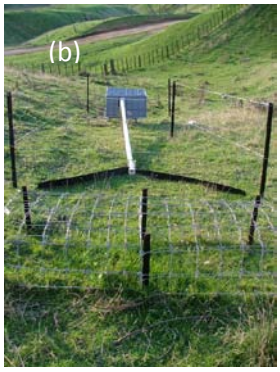
more, while the high flow system (residence time ~2.5 hours) is only reducing concentrations by around 10%. These results indicate that watercress can be effective at removing nutrients from stream water under the right conditions.

Grass Hedge Trial

The grass filter strip trial is investigating the performance of grass hedges on Wharenui. Retired pasture has been protected from grazing by enclosures to create the grass hedges. The surface runoff volumes and sediment, total nitrogen, and total phosphorus concentrations are measured entering and exiting from the grass hedges. Composite samples are collected for each storm event by diverting a proportion of the sample passing through each tipping bucket to a storage container. Two sites have been selected on the sheep/beef unit. Monitoring equipment for the grass hedge trial has been designed and is in place.

Results to date

The grass hedges trials are fully operational. The grass growth has been slow due to the dry weather and is being monitored closely. Large 5 L tipping bucket flow gauges have been installed at the inlet and outlets of both trials (Figure 2). A small fraction of runoff will be captured from the tipping bucket each time it tips and diverted to a storage container.



References

Peters, M., (October 2007) 'On-farm biological mitigation options for nutrient management'. SFF (06/117) Progress Report.

Peters, M. (June 2008) 'On-farm biological mitigation options for nutrient management'. SFF (06/117) Progress Report.

On-Farm Mitigation Options to Control Nutrient Losses from Lake Catchments (SFF 07/085)

The project aims to identify practical, low-cost N and P loss mitigation options that farmers can directly adopt on their farms. The project will demonstrate these mitigation options to farmers using Ngati Whakaue Tribal Lands' Wharenui farm as a working model of what can be achieved. The project has a strong emphasis on (1) raising farmer awareness of these mitigation options, (2) highlighting both the costs and benefits of adopting the technologies and (3) determining the level of farmer adoption as a way of quantifying the outcomes of this project's investment in modifying farm management systems for nutrient management. This is a continuation of the SFF 04/091 project focusing on the N and P loss from farms.

Results to Date

In May 2008, a summary of 3 years of research to date was provided to project stakeholders at Wharenui Station Woolshed. The three specific aspects covered in the presentation were 1. To evaluate the effectiveness of mitigation options applied to minimise N leaching from the Ngati Whakaue Wharenui dairy farm; 2. Evaluating the effectiveness of mitigation options applied to minimise P export from critical source areas from the Wharenui sheep and beef farm, and 3. A desktop scenario analysis of various management options to optimise production and to reduce N leaching.

On the dairy farm, three replicated treatments examining mitigation of N loss were: control (normal grazing and fertiliser regime); control with nitrification inhibitor (DCD) applied twice, following the May grazing and the subsequent winter grazing; and no grazing from May to the end of September (cut-and-carry for the equivalent of two grazings). Over the 3 years, nitrate leaching tended to be lower in the DCD and nil-grazing treatments than the control by 15-25% and 34-42% respectively. The DCD treatment also resulted in increased early-spring pasture production (equivalent to 5-7% of annual DM production), due to a response to N that would otherwise have leached and N applied in the DCD.

Part 2 of the study characterised and quantified different fractions of P in run-off samples from non-grazed, sheep and bull-beef grazed plots and evaluated the effectiveness of hay bale filter dams to reduce sedimentation loss of particulate P in an ephemeral stream. The run-off samples were analysed for dissolved reactive P (DRP), total dissolved P (TDP), total P (TP) and suspended solids. Results showed that there was more DRP, TDP, and TP lost from the grazed paddocks than non-grazed paddocks. Four hay bale filter dams were constructed across the flow path of the channel at 20 m intervals, but showed rapid degradation, which increased concentrations of all components of P in runoff below the bales.

The desktop modelling of scenarios to reduce N leaching from the Wharenui dairy farm were estimated using UDDER and OVERSEER® models. Ceasing N fertiliser use gave the largest estimated reduction in N leaching but led to reduced profitability. DCD use, as in the part 1 study, was approximately cost neutral at $4/kg milksolids. An optimised system with greater wintering off and less maize silage increased profitability and gave an estimated 15% reduction in N leaching.

Project Rerewhakaaitu II: Phosphate Mitigation (SFF 06/032)

The aim of this project is to improve pastoral management to protect the lake from phosphorus inputs while maintaining Farm business.

This project has progressed well since the last update. Five mitigation options have been put in place. At each mitigation site sampling jars were set before and after the mitigation position. This is the basis for loss or gain measurements of the different forms of phosphate.

Results from the different trials

Surface Runoff Water Analysis pre-mitigation

Surface water analysis from 20 farms in the catchment before mitigations were introduced show that 77% of the phosphate in runoff water is in particulate form.

Phosphorous in sediment

Olsen P levels in sediment were higher than for farm paddocks. The results show that runoff water is carrying massive amounts of phosphorous off the farm. Therefore, particulate phosphate sediment has to be a key focus.

Mitigation One

This mitigation was capturing surface runoff from alongside a stream. The mitigation consisted of a turf mat followed by a shallow trench filled with socks containing Melter slag (by-product from iron making) and EAF (Electric Arc Furnace, by-product from steel scrap) slag.

The results show a 24% reduction in dissolved reactive phosphate (DRP) through the turf filter and a 60% reduction in DRP with Melter slag. The Melter slag showed a better result than EAF slag at this site. Particulate P increased due to heavy rain events causing runoff to bypass mitigations – a design fault that can be fixed.

Mitigation Two

This mitigation is a sediment trap taking surface runoff from a farm race. This trap is at the base of a moderate sloping race. Beyond the sediment trap is a grass filter strip before the stream.

The results show a 44% reduction in dissolved reactive phosphate (DRP), a 49% reduction in total dissolved phosphate (TDP) and a 10% reduction in total P. Below the grass strip particulate P has increased. This was due to runoff water bypassing the sediment traps – a design feature that can be improved.

Mitigation Three

This mitigation is for an ephemeral stream. At this site the water in the gully goes to and flows under a culvert to bare ground through a stand of trees. On this bare ground two shallow pits were dug and filled with 10kg socks filled with EAF slag.

Results show a 37% increase in DRP, a 53% reduction in TDP and a 22% decrease in Total P. The EAF slag is not as effective in taking out DRP at this site. Here again particulate P increase below the slag due to a heavy rain event causing runoff water to bypass the mitigation – a design feature that can be improved.

Mitigation Four

This mitigation is a grass filter strip. It is located at a low point on a paddock boundary where surface water collects and runs through the grass strip to a drain.

Results show a 9% increase in DRP, a 10% increase in TDP, a 43% reduction in particulate P, and a 21% reduction in Total P. The grass filter strip has been effective in trapping particulate P (sediment).

Mitigation 5

This mitigation is located at the end of a culvert under a farm race. Runoff water comes from higher ground, runs down alongside the race and through the culvert. The mitigation is a large drum divided into two sections. Runoff flows into a course grade Melter slag on one side and then through a fine grade Melter slag on the other.

Results show a 15% reduction in DRP, a 16% reduction in TDP and a 75% increase in PP (residual sediment in pipe). The increase in particulate P and total P was due to sediment in the pipe before the mitigation was established. The melter slag gave reductions in DRP.

Conclusions so far

- Controlling sediment is a major issue. Loss of sediment =loss of fertility
- Mitigations have to withstand ‘rain bombs’
- Filter strips and sediment traps are effective at removing DRP
- Slag P-socks are effective at removing TDP
- Melter slag appears to be more effective at removing DRP

References

Parker, B., June 2008, Lake Rerewhakaaitu II News Letter Number 4.

New Research

Nitrate Leaching from Gorse in New Zealand

Project Manager
John McIntosh

Funding Providers
Environment Bay of Plenty

Research Provider
SCION

Key Concepts
Investigation into Nitrate Leaching from gorse in Rotorua

Time Frame
Completed February 2008

Project Description

Nitrate contributions to receiving waters from various sources including agricultural lands, fertilisers, grazing animals and land application of wastes have been studied. However, the contributions from leguminous weeds (e.g. gorse) have not received much attention (Magesan et al, 2008), despite the fact that this weed has infested approximately 900,000 ha or 3.3% of New Zealand's total land area.

Within the Rotorua Lakes catchments many pasture and forest areas have been colonised by gorse.

Aim

The aim of the study was to estimate N contribution in litterfall, and nitrate leaching from mature gorse stands.

A field trial on two typical mature stands of gorse at Tikitere Forest and Wharenui Station was established – within the Rotorua Lakes catchment from March 2006 to October 2007. Soils at both sites are classified as Pumice Soils (Hewitt, 1989)

Nitrogen input from gorse litterfall to soils was monitored monthly using litter collectors on both experimental sites. Samples of soil solution (leachate) were collected monthly using six suction cup samplers place 90cm below the soil surface at each site. Samplers were also installed at the same depth at a nearby pine plantation forest on each site to serve as a control. It was found that the annual dry biomass returned from gorse litter to soil was about 10,000 kg ha^{-1}. With measured nitrogen content of about 2% in litter, the estimated annual nitrogen input from the litterfall was approximately 200 kg N / ha.

Only nitrate-N concentration of suction cup samples collected monthly between March 2006 and September 2007 was determined. At both sites, the concentration of nitrate-N in leachate collected from control sites was negligible. However, the nitrate concentrations under gorse stands remained at a relatively high level in both experimental sites, ranging from 3 to 17 g N m^{-3}. During the first 3-4 months of the soil drainage season, mean values for nitrate-N concentration in leachate collected beneath the gorse stands were greater than 11.3 g m^{-3} , the limit set for potable water by the World Health Organisation. At Tikitere, nitrate concentrations under gorse did not fluctuate as much as those at Wharenui, and between November 2006 and March 2007 only one sampler contained leachate. At Wharenui, nitrate-N concentrations under gorse were high at the start of the drainage season and decreased during winter and spring.

To estimate leaching losses from the soil, the average nitrate-N concentration in soil solution samples was multiplied by the volume of water draining below the level of the ceramic cups. When nitrate moves below 90 cm in the soil, it is probable that it will reach the groundwater system, since most plant roots are within this depth. Estimated nitrate-N losses under gorse in 2006 and 2007 were 63 and 40 kg ha -1 at Tikitere; 59 and 36 kg ha -1 at Wharenui, differences being attributable to drainage fluctuations. In contrast to gorse stands, during the entire 20 month experimental period, only 0.8 and 0.7 kg N ha^{-1} was leached from the nearby P. radiata forest stands on Wharenui Station (about 20 year old pine stands) and Tikitere Forest sites (about 7 year old pine stands), respectively.

Conclusion

The researchers concluded that considerable amounts of the N continuously fixed by gorse accumulate in the soil and eventually pass into water draining from the site. Groundwater enriched with nitrate-N may enter the lake system and contribute to the eutrophication process. Nitrate concentrations in soil solution below the gorse rooting zone are sometimes higher than those acceptable for drinking water, but tend to decrease during winter months.

References

G.N. Magesan, H. Wang , J. McIntosh, Is Gorse (leguminous weed) a water polluter? Lakes Water Quality Symposium 2008, Poster Presentation Abstracts.

Magesan, G. N. Wang, H. Clinton, P. W. McIntosh, J. 2008, Nitrate Leaching From Gorse in New Zealand: A Review. Agriculture, Ecosystems and Environment.

Hewitt, A. E, 1988, New Zealand Soil Classification. Landcare Research Science Series No. 1. Manaaki Whenua Press, Landcare Research ltd, Lincoln, New Zealand.

Taupo Research

Nitrogen and Lake Taupo - New nitrogen mitigation technologies for evaluation in the Lake Taupo catchment.

Project Manager
Dr Stewart Ledgard

Project Partners
Taupo Lake Care Group, Environment Waikato

Funding Providers
Foundation for Research Science and Technology (Contract Number C10X0315)

Research Provider
AgResearch

Key Concepts
High sugar rye grass, strategic salt supplementation, animal DCD supplementation and steers to compare the spread of urine with female cattle.

Time Frame
2006 –2010

Project Description – (Ledgard et al, 2007)

A key part of the Nitrogen and Lake Taupo research programme is the selection of potential N mitigation options for evaluation in a grazing study in the Lake Taupo catchment. Regular communications and meetings with farmers in the catchment on this topic have been used to identify a farm in the catchment for evaluation of the N mitigation options under grazing conditions representative of those for beef cattle. Additionally, these farmer interactions have been used to discuss results from research to date and identify up to four N mitigation options for evaluation.

The outcomes of the research on strategic immobilisation of animal urinary-N were not seen as being sufficiently practical and this option was not considered for field evaluation. The use of salt and animal delivery of DCD were seen as new and potentially practical options warranting testing under field conditions. Similarly, improved grasses were seen as a useful option which could be introduced when pastures were being renovated or following winter crops. However, because selections for increased root depth and N recovery were not yet ready for field scale testing it was decided to only test high sugar ryegrass. Farmers were also particularly keen on evaluating male cattle as an alternative to breeding cows to test anecdotal evidence of greater spread of urinary-N by male cattle than female cattle.

A grazing system trial (planned to run for at least 3 years) commenced on a commercial farm in the Lake Taupo catchment in autumn 2007 with the following treatments:

1. A control with beef breeding heifers under standard management,
2. High sugar ryegrass sown after spraying out existing grasses and managed as for the control,
3. Strategic supplementation of salt to beef breeding heifers under standard management,
4. Strategic supplementation of DCD to beef breeding heifers under standard management,
5. Steers, of similar age to heifers, managed to achieve similar pasture intake to that of the control treatment.

Measurements in the grazing systems (six paddocks/ treatment) include pasture intake, pasture chemical composition, cattle water intake, cattle urination frequency and composition, and N leaching. The latter uses ceramic cup samplers (150 per treatment; 60 cm depth) for regular sampling of soil solution at depth combined with measurements of drainage (using lysimeters and water balance calculations).

A series of small plot and lysimeter trials have also been set up on-site to provide related data on N leaching from urine patches and a better understanding of mechanisms and appropriate rates and timing of application of these and other potential mitigation options.

Results to date – (Personal coms. Keith Betteridge, AgResearch)

At a Field Day in autumn 2008 N leaching results from the first year of data collection were reported. The Control, DCD Salt and Steer treatments each leached < 10 kg N ha^{-1} in this dry year, but the pasture renovated and sown with high sugar grasses (it could have been any grass) leached around 60 kg N ha^{-1} as a result of the renovation process that involved killing pasture with Roundup and direct drilling the seed (NB there was no cultivation).

Betteridge believes that that any renovation of pasture, with or without growing a crop in between, will result in large N leaching losses. Therefore farmers working within N caps, need to carefully weigh up the effects of renovation on N leaching vs the expected benefits of growing more or better quality pasture. There will always be a place for pasture renovation, but this comes with an environmental cost that is perhaps larger than previously appreciated.

A study with Control and Salt-treated cows, each fitted with urine sensors, clearly indicated that Salt was working as a diuretic, since urination frequency was some 30% greater than in Control cows and water consumption was similarly elevated. Computer modelling predicted that this Salt treatment could reduce N leaching by more than 45%.

References

Ledgard, S, Welten, B, Menneer, J, Betteridge, K, Crush, J, Barton, M; (2007), New Mitigation Technologies for Evaluation in the Lake Taupo Catchment

Energy Farming with Willow

Project Manager
Kevin Snowdon

Project Partners
Pure Power, HortResearch, SCION, Lake Taupo Development Company, Environment Waikato, Biojoule

Funding Providers
Sustainable Farming Fund (Project # 05/058)

Key Concepts
Alternative land use, willow farming for Biofuel.

Time Frame
May 2005 – June 2008

Project Description

Finding alternative land uses that are commercially viable and which will contribute to reducing N emissions into the Taupo catchment is a prospect for land owners faced with limits on pastoral production.

Short Rotation Coppice (SRC) willow provides landowners with a new land use opportunity. There are many potential market routes for willow to contribute to farm returns, either directly as market products or indirectly as co-products. It is envisaged that the primary uses of willow in New Zealand will be:

- Ethanol for fuel
- Lignin for the production of biopolymers
- Xylose for food sweetening

With secondary uses:

- Fuel in cogeneration plants (heat and electricity generation)
- Stock fodder

The most value will be obtained from the production of Lignin rather than the production of Ethanol at the moment however a rise in oil prices will create a higher value for ethanol in the future.

Willow plantations could also provide increased biodiversity, shelter, nitrate management, waste water treatment (in the form of a place to dispose of effluent) and carbon sequestration.

The development of a vibrant willow biomass enterprise has the potential to play an important role in bolstering a regions' rural sector, increasing energy independence, strengthening the protection of the environment, and mitigating polluting problems such as the nitrogen impact of current land use practices and thereby protecting Lake Taupo. (Snowdon et al, 2008)

Seven hectares of trials were established on three sites on Ngati Tuwharetoa land during 2005. Evaluation over three years has allowed a handbook to be produced. Trials will also be available for demonstration of the concept to land owners.

References

Snowdon, K. McIvor, I. Nicolas, N. (2008), Energy Farming with Willow in New Zealand. Handbook .

Energy Farming to Protect Lake Taupo, Sustainable Farming Fund Project Summary # 05/058, SFF website: http://www.maf.govt.nz/sff/about-projects/search/05-058/index.htm

Meat and Wool Monitor Farms - Taupo

The Meat & Wool New Zealand Monitor Farm Programme is one of the world's most successful agribusiness programmes. The programme was developed in 1991 with the aim of helping farmers to better understand their business, and then put in place plans to achieve both personal and financial success. The programme is driven by local community ownership and commitment with specialists' input to aid planning and implementation.

Local community groups select a facilitator and Monitor Farmer who is relevant and applicable to the local region, both geographically and in the issues being addressed by the farm business. A business plan is then developed and implemented along with associated monitoring plans for 3-4 years. Monitor Farmers are assisted through the process by a community group which comprises local agribusiness people including vets, consultants, farmers, scientists, financiers and processors (Meat and Wool Website).

Two farms have been selected in the Taupo area to become monitor farms, Rangiatea Station (Maori Incorporation, 1593ha effective) and Alex and Anne Richardson (290ha effective).

The overarching goal of the Lake Taupo Monitor Farm Programme is *to farm sustainably and profitably under Nitrogen cap and provide a financially, environmentally and socially sustainable farming system for the next generation.*

Programme Objectives:

- Provide farmers with options for their farming systems based on sound scientific and practical reasoning.
- Provide a long term focus beyond the three year programme.
- Provide a greater understanding of analysis tools i.e. Overseer
- Analyse the viability and practicality of all potential land use and business options e.g. traditional stocking, cropping, carbon trading, nitrogen trading, outside investment.
- Educate all parties affected by lake quality
- Educate the wider community as to what actions farmers are taking
- Changing perception through education
- Developing robust tools for farm system analysis

A key component of the programme is the background research to ensure that the programme is not "re-inventing the wheel" and is utilising all research and trial work conducted to date dealing with issues pertaining to the Nitrogen cap. Farm days will take place to demonstrate (personal coms. with Jessie Chan - Environment Strategy Manager Meat & Wool New Zealand)

References

Meat and Wool New Zealand website: http://www.meatandwoolnz.com/main.cfm?id=40

Conclusion

It can be seen from the report that current research projects are progressing well in relation to nutrient mitigation techniques and new research is being undertaken investigating different aspects of the issue. Land use change options are also starting to be looked at as in the case of energy farming with willow in the Taupo region.

This report will be the basis for an event focusing on research into nutrient loss mitigation options during 2009.