Farm Environment Planning – Science, Policy and Practice

31st Annual FLRC Workshop

This document contains the programme and abstracts of all presentations to the 31st Annual FLRC Workshop at Massey University on the 7th, 8th and 9th February 2018.

They are printed here in the programme order and may be of assistance to people who wish to search for keywords in the abstracts prior to accessing the individual manuscripts.

Individual manuscripts will be available after the event from the website at:

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Programme

Wednesday 7th February

0915-1010 Registration and Morning Tea

1010–1020 **WELCOME**
Professor Mike Hedley
Director, Fertilizer & Lime Research Centre, Massey University

Session 1 : Challenging Pathways for Water Quality

Chairman: **Professor Mike Hedley**
Fertilizer & Lime Research Centre, Massey University

1020-1040 **Alan Campbell** *Invited Speaker*
Waikato Regional Council
THE HEALTHY RIVERS CHALLENGE
– 6,000 FARM PLANS IN TEN YEARS

1040-1100 **Brendan Powell and N Heath** *Invited Speaker*
Hawkes Bay Regional Council, Napier
FARM ENVIRONMENT PLANNING:
WHAT WOULD HELP US GET US TO A BETTER DESTINATION?

1100-1120 **Leo Fietje and L Carmichael** *Invited Speaker*
Environment Canterbury, Christchurch
FARMER ENGAGEMENT IN FARMING WITHIN LIMITS

1120-1140 **Richard Parkes and M Macdougall** *Invited Speaker*
Greater Wellington Regional Council, Masterton
COMMUNITIES AND INDIVIDUALS:
HOW CAPITALISING ON RELATIONSHIPS AT BOTH LEVELS
CAN IMPROVE OUR ENVIRONMENT

1140-1200 **Tom Bowen** *Invited Speaker*
Horizons Regional Council, Palmerston North
ONE PLAN – LOOKING TO THE FUTURE

1200-1215 **Discussion**

1215-1315 **Lunch**

Session 2 : Implementing Policy

Chairman: **Dr Brent Clothier**
Plant & Food Research, Palmerston North

1315-1325 **Ian Lyttle**
Environment Canterbury, Christchurch
THE ROLE OF NUTRIENT BUDGETING IN FARM AND ENVIRONMENTAL MANAGEMENT

1325-1335 **Simon Park, M Hope, I Tarbotton and I Power**
Landconnect Ltd, Tauranga
CO-DEVELOPMENT: A CASE STUDY OF ROTORUA FARMER ON NUTRIENT MANAGEMENT

1335-1345 **Estelle Dominati, A Mackay and F Maseyk**
AgResearch, Palmerston North
HOLISTIC FARM PLANNING – USING AN ECOSYSTEM APPROACH TO ADVANCE FARM PLANNING INTO THE FUTURE

1345-1355 **Roshean Woods**
Agri Magic Ltd, Christchurch
A LICENSE TO FARM – FINDING VALUE BEYOND COMPLIANCE

1355-1405 **Brian Ellwood and B Paton**
Lowe Environmental Impact, Christchurch
ESTIMATING FUTURE NITROGEN LOSS FOR A NEW COMMUNITY IRRIGATION SCHEME WITH OVERSEER

1405-1415 **Hamish Lowe and D Horne**
Lowe Environmental Impact, Palmerston North
THE PROCESS FOR SETTING NUTRIENT LIMITS USING OVERSEER FOR A WASTEWATER DISCHARGE CONSENT

1415-1430 **Richard Christie, C Tidey and I McCarthy**
Ravensdown, Christchurch
THE DIRECT AND INDIRECT COSTS OF CONSENTING DAIRY FARMS UNDER HORIZONS ONE PLAN (PRIOR TO MARCH 2017 ENVIRONMENT COURT DECLARATION)

1430-1445 **Discussion**

1445-1500 **Poster Papers**

Ollie Knowles and A Dawson
Ballance Agri-Nutrients, Tauranga
CURRENT SOIL SAMPLING STRATEGIES – A REVIEW

Stephen McNeill, N Odgers, L Lilburne, S Carrick, S Hainsworth, S Fraser, C Hedley, P Roudier and G Grealish
Manaaki Whenua - Landcare Research, Lincoln
SPATIAL SAMPLING TOOLS FOR REPRESENTATIVE SOIL SAMPLING

Matthew Taylor, J Drewry, B Stevenson, J Cavanagh, N Foster and F Curran-Cournane
Waikato Regional Council, Hamilton
HOW CLOSELY DO DIFFERENT OLSEN P MEASURES CORRELATE?

Angela Lane, K Beecroft and S Cass
Lowe Environmental Impact, Palmerston North
DETERMINATION OF LAND SUITABILITY FOR WASTEWATER IRRIGATION USING A MULTI-LAYERED GIS APPROACH

Cuong H Pham, S Saggar, P Berben, T Palmada and C Ross
National Institute of Animal Sciences, Hanoi 10000, Vietnam
ELIMINATING HYDROGEN SULPHIDE FROM BIOGAS PRODUCED FROM ANIMAL WASTES

Brent Clothier, S Green, R Gentile, M Gitahi, S Murigi, L Nduta and B Lumumba
Plant and Food Research, Palmerston North
DECISION SUPPORT TOOLS FOR SMALL-HOLDER FARMERS AND AN AVOCADO PROCESSOR IN THE CENTRAL HIGHLANDS OF KENYA

1500-1530 **Afternoon Tea**

Session 3 : Considering the Catchment

Chairman: **Dr Lucy Burkitt**
Fertilizer & Lime Research Centre, Massey University

1530-1600 **Craig Thornton and A E Elledge** *Invited Speaker*
Department of Natural Resources Mines and Energy, Rockhampton, Queensland, Australia
THE BRIGALOW CATCHMENT STUDY: THE IMPACTS OF DEVELOPING *ACACIA HARPOPHYLLA* WOODLAND FOR CROPPING OR GRAZING ON HYDROLOGY, SOIL FERTILITY AND WATER QUALITY IN THE BRIGALOW BELT BIOREGION OF AUSTRALIA

1600-1610 **Maggie Rogers, B Jackson, M De Róiste, M Palomino-Schalscha, C Tyler and M Mitchell**
Victoria University of Wellington
PROTOTYPE TESTING OF LUCI SOFTWARE FOR DETERMINING ON FARM NUTRIENT LOSSES AND MITIGATION OPTIONS IN THE MANGATARERE CATCHMENT

1610-1620 **Alicia Taylor, B Jackson and A Metherell**
Victoria University of Wellington
EVALUATING THE UNCERTAINTIES IN NEW ZEALAND'S GIS DATASETS; UNDERSTANDING WHERE AND WHEN FRAMEWORKS SUCH AS LUCI CAN ENABLE ROBUST DECISIONS SURROUNDING FARM MANAGEMENT PRACTICES

1620-1630 **C Rissmann, Lisa Pearson, J Lindsay, T Marapara and A Badenhop**
e3Scientific, Arrowtown
INTEGRATED LANDSCAPE MAPPING OF WATER QUALITY CONTROLS FOR FARM PLANNING - APPLYING A HIGH RESOLUTION PHYSIOGRAPHIC APPROACH TO THE WAITUNA CATCHMENT, SOUTHLAND

1630-1645 **Russell G Death, C J Jordan, R Magierowski, J D Tonkin and A Canning**
Agriculture & Environment, Massey University
WHY AREN'T WE MANAGING WATER QUALITY TO PROTECT ECOLOGICAL HEALTH?

1645-1700 **Discussion**

1700 **Day One concludes**

1715-1815

Norman Taylor Memorial Lecture

Professor Tim Clough, Lincoln University

"DEVELOPING INTEGRATED APPROACHES TO NITROGEN MANAGEMENT: DEFINING SOIL'S ROLE"

All Welcome – Refreshments to follow

Thursday 8th February

Session 4 : Incorporating Attenuation Capacity

Chairman: **Dr Chris Tanner**
NIWA, Hamilton

0845-0915 **Anker Lajer Højberg** *Invited Speaker*
The National Geological Survey of Denmark and Greenland, Copenhagen, Denmark
ON THE TRACK OF TARGETED REGULATION OF NITRATE – EXPERIENCES FROM DENMARK

0915-0935 **Ranvir Singh, D J Horne and M J Hedley**
Fertilizer & Lime Research Centre, Massey University
VARIABLE NITROGEN ATTENUATION CAPACITY FOR TARGETED AND EFFECTIVE WATER QUALITY MANAGEMENT IN NEW ZEALAND AGRICUTURAL CATCHMENTS

0935-0945 **Aslan Wright-Stow, C Tanner, F Matheson, T Stephens, J Quinn, D Burger and J Young**
DairyNZ
ACCELERATING UPTAKE OF CONSTRUCTED WETLANDS AND RIPARIAN BUFFERS BY QUANTIFYING CONTAMINANT ATTENUATION PERFORMANCE: A PROPOSED NATIONAL INVESTIGATION

0945-1000 **Discussion**

1000-1015 **Poster Papers**

Heather Martindale, R van der Raaij and U Morgenstern
GNS Science, Lower Hutt
MEASURING ACTUAL DENITRIFICATION TO UNDERSTAND NITROGEN LOADS THROUGH AQUIFERS

Kathryn Hutchinson, A Taylor, R Moss, D Scobie, G Rennie and R Dynes
AgResearch, Palmerston North
IMPACTS OF FARM SYSTEMS CHANGE AND DROUGHT ON THE GREENHOUSE GAS FOOTPRINT FOR SHEEP AND BEEF FARMS

Kamal Adhikari, S Saggar, J A Hanly and D F Guinto
Agriculture & Environment, Massey University
THE EFFECTIVENESS OF UREASE INHIBITORS 2-NPT AND NBTPT AT REDUCING AMMONIA EMISSIONS FROM PASTURE SOILS – A LABORATORY STUDY

M Sprosen, B Carlson, D Houlbrooke and S Ledgard
AgResearch, Hamilton
EVALUATION OF THE EFFECT OF SOIL COMPACTION ON URINE PATCH AREA AND PLANT RECOVERY OF URINE-NITROGEN

Coby Hoogendoorn, S Saggar, T Palmada, P Berben and D Giltrap
Manaaki Whenua – Landcare Research, Palmerston North
DO NITROUS OXIDE EMISSIONS FROM URINE DEPOSITED NATURALLY DIFFER FROM EVENLY APPLIED URINE?

Bill Carlson, D Houlbrooke, G Lucci and M Sprosen
AgResearch, Hamilton
DRAINAGE WATER QUALITY ON TWO WAIKATO PEAT DAIRY FARMS

1015-1045 **Morning Tea**

Session 5 : Understanding Catchment Processes

Chairman: **Dr Ranvir Singh**
Fertilizer & Lime Research Centre, Massey University

1045-1055 **Chris C Tanner, E Uuemaa, C C Palliser and A O Hughes**
NIWA, Hamilton
ACCOUNTING FOR HEADWATER SEEPAGE WETLAND NITROGEN ATTENUATION IN FARM ENVIRONMENTAL PLANNING

1055-1105 **Neha Jha, R Singh and A McMillan**
Agriculture and Environment, Massey University,
EFFICACY OF SUBSURFACE DENITRIFICATION TO ATTENUATE NITRATE IN SHALLOW GROUNDWATERS

1105-1115 **Grace Chibuike, L Burkitt, M Bretherton, M Camps Arbestain, R Singh and P Bishop**
Fertilizer & Lime Research Centre, Massey University
THE EFFECT OF SOIL TYPE AND SLOPE ON THE DISSOLVED ORGANIC CARBON CONTENT AND DENITRIFICATION CAPACITY OF A HILL COUNTRY SUB-CATCHMENT

1115-1125 **Lucy Burkitt, P Jordan, R Singh, A Elwan, M Patterson and P Peters**
Fertilizer and Lime Research Centre, Massey University
HIGH RESOLUTION MONITORING OF NITRATE IN AGRICULTURAL CATCHMENTS – A CASE STUDY ON THE MANAWATU RIVER, NEW ZEALAND

1125-1135 **Zeb Etheridge, L Fietje, A Metherell, L Lilburne, O Mojsilovich and M Robson**
Environment Canterbury, Christchurch
COLLABORATIVE EXPERT JUDGEMENT ANALYSIS OF UNCERTAINTY ASSOCIATED WITH CATCHMENT-SCALE NITROGEN LOAD MODELLING

1135-1150 **Discussion**

1150-1215 **Poster Papers**

Danilo Guinto, A Stafford, J Blennerhassett and W Catto
Ballance Agri-Nutrients, Tauranga
DRY MATTER YIELD RESPONSE OF PASTURE TO ENHANCED EFFICIENCY NITROGEN FERTILISERS

Neale Hudson, L McKergow, C Tanner, E Baddock, D Burger and J Scandrett
NIWA, Hamilton
DENITRIFICATION BIOREACTOR WORK IN WAITUNA LAGOON CATCHMENT, SOUTHLAND

Bob Longhurst, M Taylor and I Williams
agKnowledge, Hamilton
LONG-TERM MAIZE GROWING IN WAIKATO - FACTORS AFFECTING SUSTAINABILITY

Moira Dexter, R Monaghan, J Chrystal, S Laurenson, T Orchiston, W Worth, D Houlbrooke and D Selbie
AgResearch, Hamilton
THE USE OF IN-FIELD STAND-OFF PADS CONSTRUCTED FROM SAWDUST AND/OR LIGNITE TO CAPTURE URINARY NITROGEN: FIELD AND LAB EVALUATIONS

Phil Journeaux
AgFirst Waikato
ECONOMIC BENEFIT OF REDUCING THE COEFFICIENT OF VARIATION OF FERTILISER APPLICATION

Hayden Brown, M Grafton and C Davies
Agriculture & Environment, Massey University
FEASIBILITY STUDY, EXTENDING THE SWATH WIDTH OF TOPDRESSING AIRCRAFT TO REDUCE STRIPING OF FERTILISER MIXES

Akinson Tumbure, M R Bretherton, P Bishop and M J Hedley
Fertilizer & Lime Research Centre, Massey University
PLANNING LOW COST TECHNOLOGIES TO ENHANCE THE AGRONOMIC EFFECTIVENESS AND USE OF DOROWA LOW GRADE PHOSPHORUS ROCK

Peter Bishop and B F Quin
Advanced Agricultural Additives, Palmerston North
SODIUM/CALCIUM THIOSULPHATE AS AN ALTERNATIVE NITRIFICATION INHIBITOR TO DCD

Peter Carey, B Cotching, K Cameron and H J Di
Lincoln Agritech, Canterbury
POLYMER TECHNOLOGY TO IMPROVE UPTAKE EFFICIENCY AND DISTRIBUTION OF COBALT AND COPPER IN PASTURES

1215-1315 **Lunch**

Session 6 : Our Concern with Soils

Chairman: **Dr Ants Roberts**
Ravensdown, Pukekohe

1315-1325 **Gerard Grealish, S Carrick and A Manderson**
Landcare Research, Palmerston North
FARM-SCALE SOIL MAPPING PROTOCOLS FOR NEW ZEALAND

1325-1335 **Malcolm Todd**
Horizons Regional Council, Palmerston North
LEARNINGS FROM TEN YEARS OF HILL COUNTRY FARM PLAN MAPPING

1335-1345 **Jo-Anne E Cavanagh, Z Yi, C Gray, S Young, S Smith, P Jeyakumar, K Munir, S Wakelin, N J Lehto, B Robinson and C Anderson**
Manaaki Whenua Landcare Research, Canterbury
ASSESSING CADMIUM UPTAKE IN NEW ZEALAND AGRICULTURAL SYSTEMS

1345-1355 **Aaron Stafford, J Jeyakumar, M Hedley and C Anderson**
Ballance Agri-Nutrients, Tauranga
CADMIUM ACCUMULATION IN CHICORY AND RYEGRASS WITH MODIFICATION OF SOIL pH

1355-1405 **Chris Anderson, S Smith, P Jeyakumar and J Cavanagh**
Agriculture & Environment, Massey University
TRANSFER OF CADMIUM TO ANIMALS FROM FORAGES

1405-1415 **Matthew Taylor and R Hill**
Waikato Regional Council, Hamilton
THE 20 YEAR EVOLUTION OF WAIKATO REGION SOIL QUALITY MONITORING

1415-1425 **John Drewry, J E Cavanagh, M D Taylor and S McNeil**
Greater Wellington Regional Council, Masterton
LONG TERM MONITORING OF SOIL QUALITY INCLUDING TRACE ELEMENTS IN THE WELLINGTON REGION

1425-1435 **Roberto Calvelo Pereira, M Hedley, M Bretherton, N Conland and A Tressler**
Agriculture & Environment, Massey University
PLANNING FOR CHANGES IN TOPSOIL C AND N STOCKS – SIGNIFICANCE IN C AND N BUDGETS

1435-1445 **Miko U F Kirschbaum, G Y K Moinet, C B Hedley, M H Beare and S R McNally**
Manaaki Whenua – Landcare Research, Palmerston North
ARE SOIL CARBON STOCKS CONTROLLED BY A SOIL'S CAPACITY TO PROTECT CARBON FROM DECOMPOSITION?

1445-1500 **Discussion**

1500-1515 **Poster Papers**

Roberto Calvelo Pereira, M Camps Arbestain, R Saiz Rubio, Y Kong and Q Shen
Agriculture & Environment, Massey University
DISTRIBUTION OF CARBON IN SIZE-FRACTIONS OF A PASTURE SOIL 26 MONTHS AFTER ADDING BIOCHAR

Kiran Hina, Syeda Somia Kanwal, Muhammad Arshad, Zulfiqar Ahmad Dasti
Department of Environmental Sciences, University of Gujrat, Gujrat, Pakistan
INVESTIGATIONS INTO THE EFFECTS OF CADMIUM STRESS ON *SPINACEA OLERACEA* AND RETENTION PROPERTIES IN SOIL IN RESPONSE TO COW DUNG AND CHARCOAL AMENDMENTS

Michael (Zicheng) Yi, N Lehto, B Robinson and J Cavanagh
Department of Soil & Physical Sciences, Lincoln University
UNDERSTANDING OF THE BIOAVAILABILITY OF SOIL CADMIUM IN NEW ZEALAND CROPS LAND

Nilusha Ubeynarayana, P Jeyakumar, R Calvelo Pereira, P Bishop and C Anderson
Fertilizer & Lime Research Centre, Massey University
DETERMINATION OF THE Cd UPTAKE MECHANISM IN FORAGE SPECIES IN LIVESTOCK GRAZING SYSTEMS

T Geretharan, P Jeyakumar, M R Bretherton and C W A Anderson
Fertilizer & Lime Research Centre, Massey University
EFFECT OF FLUORINE ON *RHIZOBIA*: A RESPIRATION-INHIBITION ASSAY

1515-1545 **Afternoon Tea**

Session 7 : OVERSEER – Future Footprint

1545-1700 *- At the request of Overseer Ltd.*

Facilitator: Dr Caroline Read
OVERSEER Ltd, Wellington

Overseer Limited was established in 2016 to create a sustainable future for the now nationally significant nutrient budgeting tool OVERSEER. Over the next year the company will make two significant changes to OVERSEER to ensure the benefits of nutrient budgeting and greenhouse gas modelling are realised into the future:

1. Release new software specifically for individual farm modelling that maximises the value of the information that OVERSEER generates to support farm businesses.
2. Make available a research version of OVERSEER that supports non-commercial research by providing more data options and flexibility in dealing with bulk datasets and results.

This session will begin with a demonstration of the new software for individual farm modelling and will incorporate time for questions. Overseer Limited will then present early thinking on the research version and seek feedback to gain further understanding of practical needs to support ease of use of OVERSEER. This will include such aspects as:

- data entry flexibility and the range of results to be presented
- understanding documentation and support needs for research use
- defining non-commercial research
- mechanisms to capture feedback and development opportunities

This session will be an opportunity to have a direct input on the design with ongoing engagement throughout the development.

1700-1800 **Poster Papers on Display**
Informal Drinks in the Ag Hort Lecture Block

1815- **Workshop Dinner at Wharerata**

Friday 9th February

Session 8 : Designing Mitigations

Chairman: **Dr Warwick Catto**
Ballance Agri-Nutrients, Tauranga

0850-0900 **John Paterson, G Sveda, T Nolan, T Stephens and H Eikaas**
Phosphorus Mitigation Project (Inc.), Whakatane
USING GIS ANALYSIS OF LIDAR DATA TO PREDICT BEST SITES FOR CONSTRUCTION OF STORM WATER DETAINMENT BUNDS

0900-0910 **Hamish Lowe, S Cass and A Lane**
Lowe Environmental Impact, Palmerston North
COMMUNITY WASTEWATER PROJECTS AS A CATALYST FOR DEVELOPING CATCHMENT MANAGEMENT ENHANCEMENT PROGRAMMES

0910-0920 **Jeff Brown**
Fonterra, Palmerston North
'LEADING INDUSTRY' LAND TREATMENT SYSTEMS FOR DAIRY FACTORY WASTEWATER – NEW FRONTIERS' IN NUTRIENT MANAGEMENT

0920-0930 **Ray Mohan, S J McLaren, C Prichard and E Gray-Stuart**
NZ Life Cycle Management Centre, Massey University
USE OF LIFE CYCLE ASSESSMENT (LCA) TO FACILITATE CONTINUOUS IMPROVEMENT OF ON-FARM ENVIRONMENTAL PERFORMANCE: A SHEEP DAIRY CASE STUDY

0930-0940 **Dan Bloomer, J Pishief, C Folkers and B Searle**
Centre for Land and Water, Hastings
MAPPING AND MODELLING ONIONS – IMPLICATIONS FOR NITROGEN APPLICATION

0940-0950 **Steve Wakelin, L Dowling, J Monge and G West**
Scion, Dunedin
CARBON FORESTRY AS A DRIVER FOR LAND USE CHANGE

0950-1005 **Discussion**

1005-1035 **Morning Tea**

Session 9 : On-Farm Considerations

Chairman: **Dr James Hanly**
Fertilizer & Lime Research Centre, Massey University

1035-1045 **Mark Shepherd, D Selbie, R Monaghan, D Wheeler, K Cameron, H J Di, G Edwards, R Bryant, D Chapman, D Dalley and B Malcolm**
AgResearch, Hamilton
UNDERSTANDING NITROGEN FLOWS THROUGH WINTER FORAGE CROPS: OBSERVATIONS FROM NEW ZEALAND

1045-1055 **Kathryn Hutchinson, T van der Weerden, P Beukes, C de Klein and R Dynes**
AgResearch, Palmerston North
CAN WE PROVE MODELLED MITIGATION STRATEGIES WORK ON FARM?

1055-1105 **Aimee Dawson and O Knowles**
Ballance Agri-Nutrients, Tauranga
TO GRID OR NOT TO GRID – A REVIEW OF SOIL SAMPLING STRATEGIES

1105-1115 **Yongshan Chen, M Camps-Arbestain, Q Shen, B Singh and M Luz Cayuela**
Agriculture and Environment, Massey University
THE LONG-TERM ROLE OF ORGANIC AMENDMENTS IN BUILDING SOIL NUTRIENT FERTILITY: A META-ANALYSIS AND REVIEW

1115-1125 **Keith Woodford, A Roberts and M Manning**
Lincoln University, Christchurch
DAIRY COMPOSTING BARNS CAN IMPROVE PRODUCTIVITY, ENHANCE COW WELFARE AND REDUCE ENVIRONMENTAL FOOTPRRINT: A SYNTHESIS OF CURRENT KNOWLEDGE AND RESEARCH NEEDS

1125-1135 **Jeerasak Chobtang, D Donaghy, S Ledgard, N Lopez-Villalobos, S J McLaren and N Sneddon**
NZ Life Cycle Management Centre, Massey University
ENVIRONMENTAL EVALUATION OF ONCE-A-DAY MILKING ON A PASTURE-BASED DAIRY SYSTEM IN NEW ZEALAND

1135-1145 **Soledad Navarrete, M J Rodrigues, P D Kemp, M J Hedley, D J Horne and J A Hanly**
Agriculture & Environment, Massey University
THE POTENTIAL OF PLANTAIN BASED PASTURES TO REDUCE NITROGEN LOSSES FROM DAIRY SYSTEMS

1145-1200 **Discussion**

1200-1300 **Lunch**

Session 10 : Farm Environment Planning

Chairman: **Professor Mike Hedley**
Fertilizer & Lime Research Centre, Massey University

1300-1320 **Andrew Kempson and D Chan** *Invited Speaker*
Fonterra Farm Source, Hamilton
DELIVERING TAILORED FARM ENVIRONMENT PLANS AT SCALE

1320-1340 **Corina Jordan and Julia Beijeman** *Invited Speaker*
Beef + Lamb New Zealand, Christchurch
FARM ENVIRONMENT PLANNING – 2.0

1340-1400 **Victoria Caseley, T Lissaman and C Tyler** *Invited Speaker*
Ravensdown Environmental, Christchurch
FARM ENVIRONMENTAL PLANS IN RELATION TO RESOURCE CONSENTS, REGIONAL/DISTRICT PLAN COMPLIANCE AND ON-FARM MANAGEMENT; THE ESSENTIAL ELEMENTS

1400-1420 **Alastair Taylor, C Finlayson and L Aubrey** *Invited Speaker*
Ballance Agri-Nutrients, Tauranga
FARM ENVIRONMENT PLANS – HELPING FARMERS THROUGH THE FOURTH AGRARIAN REVOLUTION

1420-1430 **Anna Carlton**
Ravensdown, Christchurch
SIX MONTHS ON FROM COMPLETING MY PhD – LESSONS LEARNT AND HOW THEY ARE RELEVANT TO MY CURRENT ROLE AS A FARM ENVIRONMENTAL ADVISOR

1430-1445 **Discussion**

1445-1500 **Closing Remarks**

1500 **Afternoon Tea and depart**

THE HEALTHY RIVERS CHALLENGE
– 6,000 FARM PLANS IN TEN YEARS

Alan Campbell

Waikato Regional Council, Hamilton

In October 2016 the Waikato Regional Council (WRC) notified its Proposed Plan Change 1 – Waikato and Waipa River Catchments. This plan aims to take the first of eight ten-year steps to improve water quality for four contaminants to help achieve the Vision and Strategy for the catchments under the co-governance arrangements for the catchments.

This first step addresses diffuse discharges of nitrogen, phosphorus, sediment and bacteria and its objective is to achieve ten percent of the required change between current water quality and the 80 year targets. One of the key policies to achieve this is to require almost all of the 6,000 farms in the catchments to prepare a tailored Farm Environment Plan (FEP). The use of land for farming activities is either permitted as part of an industry scheme, or requires a consent. In either case a FEP must be approved by a certified person and submitted to WRC. The FEP must identify risks of losing the four contaminants and include actions and timeframes to reduce discharges.

Implementing the policies involves establishing a training and certification process for farm planners, developing a FEP guide, templates, an electronic submission process, monitoring, audit and compliance systems, as well as data management and reporting processes. Engaging farmers in the process will be key to ensuring the eventual success of the policies, so significant effort is also going into developing and testing methods to engage farmers at a sub-catchment and community scale.

There is currently a variety of approaches to certification of farm environment planners in other regions and a high degree of public interest in ensuring that FEPs are robust and will deliver on environmental objectives. This has led to support for a national certification system for Farm planners and Waikato Regional Council is leading a project with stakeholders across the country to develop a system that will meet those various needs. It is expected that that work will take time, so work is also under way to establish an interim Waikato system that will give farmers certainty as soon as possible that their FEP meets expectations.

This paper will describe some of the practical challenges - and the opportunities - of putting in place the partnerships, mechanisms, support systems and regulatory machinery to implement that policy.

FARM ENVIRONMENT PLANNING:

WHAT WOULD HELP US GET US TO A BETTER DESTINATION?

Brendan Powell and Nathan Heath

Hawke's Bay Regional Council, Napier

Farm environmental plans have a long history. The first were prepared in the early 1950's.

Over the succeeding 60 years the context and breadth of issues we are seeking to address and improve through farm planning has changed hugely. This has led to some differing expectations of what farm plans are for, and can do. Farm plans represent a pressure point between the search for policy solutions to environmental issues and the reality of implementation challenges.

In this paper we will briefly reflect on where farm plans have come from and possible future directions. We will cover some essential components of current plans, as well as some of the major challenges in building the necessary supporting structures and human capacity around the processes of plan preparation.

Some questions remain:

- Currently government and councils are driving the imperative to get farm plans done. Primary industry bodies and independent providers have responded to this driver but are we missing "out of scope" opportunities with this approach?
- Do we have consistent and compatible, or differing expectations of what these plans are for?
- Is it possible, or even desirable, to have a single plan template to encompass and satisfy all expectations?
- How do we ensure plans connect to their purpose and prioritize the most important issues to address?
- How do we integrate the dynamism of the farm system with the inertia of a plan?

FARMER ENGAGEMENT IN FARMING WITHIN LIMITS

Leo Fietje and Lyn Carmichael

Environment Canterbury, Christchurch

The need for limits on loss of nutrients from the use of land has achieved considerable acceptance over recent years, but there are catchments for which capping losses at present levels may not be enough. This is envisaged in the National Policy Statement for Freshwater Management which refers to both maintaining and improving water quality as a bottom line. The key pathways for reducing the impact of farming on water quality are the implementation of Industry Agreed Good Management Practices and Farm Environment Plans, but what happens when this is not enough and we need to make further reductions? Is that feasible and if so at what cost?

There's no shortage of advice in the public arena, particularly around the benefits of reducing stocking rates and improving profitability for some farming sectors – but is it really that straight-forward?

To better understand this challenge, ECan assembled two groups of farmers from separate planning zones that are each going through a process of establishing water quality outcomes and limits for their zones. Farmers were invited based on their reputation as respected and influential thought leaders covering the major farm types, along with industry representatives from DairyNZ, Beef + Lamb NZ, and Foundation for Arable Research. Meetings were generally held over dinner and lasted two to three hours, every four to six weeks. Each group established ground rules early on and while the groups never met as one, knowledge was exchanged between them.

The results from both groups were presented to the respective Zone Committees setting out the groups answers to the questions posed above and providing valuable information that will continue to be used in future decision-making. The work has highlighted the importance of considering all aspects when assessing mitigation options, including consequences of increasing management complexity, farming skill and resource required. Feedback from both Committees was very positive and both groups received thanks for their work.

The presentation and paper describe the factors contributing to the success of the groups, along with results and lessons learned for use in future groups.

COMMUNITIES AND INDIVIDUALS: HOW CAPITALISING ON RELATIONSHIPS AT BOTH LEVELS CAN IMPROVE OUR ENVIRONMENT

Richard Parkes and M Macdougall

Greater Wellington Regional Council, Masterton

Working with landowners at a catchment community level and one-on-one through farm plans allows a two-pronged approach to fostering behaviour change and action towards environmental improvement and protection.

Enabling catchment communities gives those communities the ability to identify and progress shared priorities and work on collaborative projects at a scale beyond the means of individuals. This is critical to any important challenge. There is a lot of change required and this will require the sustained efforts of whole communities, covering extensive areas over several decades.

At the same time, working with individual landowners allows for a more intensive relationship to develop between the landowner and professional. This can allow greater knowledge transfer and foster behaviour change at an individual level at a farm scale.

The NPS on Freshwater requires regional councils to set limits on nutrients in waterways. Under the Wellington Proposed Natural Resources Plan this task has been given to the Whaitua. The region has been divided into five Whaitua, or catchments, each with a committee that develops a Whaitua Implementation Plan. The Implementation Plan details each Whaitua will meet the NPS requirements. These plans will then be incorporated into the Regional Plan.

The first Whaitua that was set up was for the Ruamahanga catchment. The Ruamahanga Whaitua Committee has decided on a collective responsibility pathway for achieving water quality outcomes by catchment communities. The Ruamahanga Whaitua area will be divided into Freshwater Management Units. These will be a catchment or group of catchments that will be managed as one for regulatory purposes. Water quality objectives and nutrient limits will be set for each Freshwater Management Unit, which the community within that Freshwater Management Unit will have to show they are meeting. This will be done using land use data, modelling, and monitoring of point sources. Each Freshwater Management Unit will have a state of the environment monitoring site which will measure progress towards the Freshwater Management Unit's water quality objective.

ONE PLAN – LOOKING TO THE FUTURE

Tom Bowen

Horizons Regional Council, Palmerston North

Horizons' One Plan was a pioneering attempt at integrated catchment management, including diffuse nutrient sources. Perhaps in no other region has a statutory plan occupied so much public and media attention.

While much of the One Plan is effective, putting nutrient management rules into practice has proven challenging. This year the council will embark on a programme of plan review responding to what we have learned, locally and nationally, since the One Plan was developed. We will need to address both technical challenges - setting resource limits; how best to use models in regulation - and also social ones - building trust and engagement; dealing with ambiguity. We will need to deal with immediate pressures and longer-term direction.

The One Plan will evolve through that process to reflect the changing circumstances of our catchments and communities.

THE ROLE OF NUTRIENT BUDGETING IN FARM AND ENVIRONMENTAL MANAGEMENT

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Concern about water use and quality has become one of the most significant issues for New Zealand's voting public, for lawmakers and regulators, for domestic and international markets and of course for farmers and their industry bodies.

Farm and environmental planning is essential for farmers to effectively manage the efficient use of resources, including nutrients, for optimising farm profitability and minimising environmental impacts.

Efficient use of nutrients requires the means for modelling nutrient movements in the farm ecosystem to determine nutrient inputs and outputs. The basis for modelling nutrient movements on farm is OVERSEER® - a modelling programme jointly owned by the 2 major fertiliser companies and the Ministry for Primary Industries.

This paper explores the use of OVERSEER®, the PORTAL and N-CHECK. The latter two tools are based on the OVERSEER® engine and provide options to model good management practice loss rates, and in the case of N-Check to have a much simpler data entry process. They are either mandated or proposed to be mandated through the Canterbury Regional Council Land and Water Regional Plan.

The Environment Canterbury experience over the last 4 years has demonstrated the importance of OVERSEER® for implementing the National Policy Statement for Freshwater Management and some of its limitations in the regulatory sphere for effective farm environmental planning.

The paper reviews the other tools used to achieve improved environmental management alongside the use of nutrient budgeting tools. These include the ways that environmental management is mandated by Environment Canterbury, through planning documents and consent conditions, as well as the adoption of farm environment plans (FEPs), and good management practices (GMPS) and the leadership roles industry has taken in developing these tools and engaging with farmers

The effects of the dramatic increase in demand by farmers for OVERSEER® nutrient budgets is reviewed, principally from a regulatory perspective, and also from an industry or farming perspective.

CO-DEVELOPMENT: A CASE STUDY OF ROTORUA FARMERS ON NUTRIENT MANAGEMENT

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Lake Rotorua catchment farmers are faced with the challenge of reducing nitrogen (N) and phosphorus (P) losses from their land, while remaining profitable. New RMA rules require 'nutrient management plans' (NMPs) with staged N loss reductions and Good Management Practice (GMP) adoption to manage P loss risk.

Through farmer and agency co-development, ten short videos were produced to promote proven, fit for purpose GMPs that can help reduce on-farm nutrient losses. The video series was one of several catchment projects funded by the Bay of Plenty Regional Council and the Ministry for the Environment. Additional support was received from Ballance Agri-Nutrients with technical analysis provided by Perrin Ag Consultants, AgFirst and Ballance.

In eight of the videos, farmers talk about their experience with introducing a particular GMP and its impact on nutrient losses, profitability and their wider farm system. The videos are complemented by relevant web-based resources and a GMP cost-benefit analysis expressed as a $ cost per hectare and/or per kilogram of N and/or P mitigated. The farmer videos are book-ended by an introductory video on nutrient cycling and a final video on pulling GMPs together in a NMP.

The project was guided by the principle of 'by farmers for farmers'. Positive farmer engagement was enabled by using local farmers who were known and respected by their farmer peers. Video topics were selected by farmers from the Lake Rotorua Primary Producers Collective. The GMP series can be accessed via the Collective's website www.rotoruafarmers.org.nz/gmp/.

As at December 2017, total video views were 1350, greatly surpassing the number of commercial farms in the catchment. The average GMP video view time is three minutes i.e. most are watched to completion. The long-term impact of the video series will be difficult to separate from the raft of parallel regulatory, incentive and extension mechanisms. However, farmer, Council and agency feedback on the videos has been very positive and supports the co-development approach applied to this GMP video project.

HOLISTIC FARM PLANNING – USING AN ECOSYSTEM APPROACH TO ADVANCE FARM PLANNING INTO THE FUTURE

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Land evaluation historically uses environmental data to evaluate the productive capacity of land and is the base of farm planning. However, there is an increasing recognition that land evaluation needs to evolve beyond the almost singular focus on production values to take a wider, more holistic view. This broader assessment needs to account for impacts on receiving environments as well as include assessment of the other ecosystem services provided by agricultural landscapes.

We suggest that embedding farm-planning within an ecosystems approach provides the pathway to operationalise this shift. This would require land evaluation to take a less pedocentric approach to include other environmental as well as cultural information such as stocktakes and state of water resources, biodiversity or sites of cultural significance. It is common for soil or biodiversity conservation to be dealt with in isolation from each other, both at the policy and farm scales which narrows the opportunities to increase farm sustainability and resilience, and to achieve wider outcomes across the landscape.

We present a way forward that takes a more holistic approach to farm-planning that brings together business, environment and cultural goals and in doing so allows for social, cultural, environmental, and production values to be recognised and enhanced while focusing on the farm performance as a business.

A LICENSE TO FARM
– FINDING VALUE BEYOND COMPLIANCE

Roshean Woods

Agri Magic Limited, Christchurch

In Canterbury, the Land and Water Regional Plan is operative. The rules which apply to a farm depend on which nutrient allocation zone(s) or catchment(s) it falls within. In most zones (outside of irrigation schemes) farmers are required to apply for a land use consent to continue with their farming activity. First, the Nitrogen Baseline must be determined. This is the OVERSEER nitrogen (N) loss (kg N/ha/yr) averaged for 2009-2013. A nitrogen discharge allowance (NDA) is then calculated which sets the nutrient constraint for the property. In some areas, reductions are also required.

At Agri Magic we support farmers through this process. One of our focus areas is to ensure a farm's NDA has context by comparing it to the losses estimated for their current farm system and future scenarios using the same version of OVERSEER. It is important that farmers have sight over what these nutrient constraints mean for their farm business so they can make appropriate daily decisions.

Using OVERSEER in this way allows us to highlight the key drivers of N loss for a particular farm through the use of the OVERSEER block reports. When we share this information with the farmers and explain the impact of these drivers, this provides them with the information they need to do what they do best… to innovate. They can come up with practical solutions to manage the risk of this diffuse pollution and to decouple the impact of nutrient losses from improving on-farm productivity. It is possible to intensify farm systems and reduce nutrient losses. OVERSEER allows for a customised approach for each farm business. In this presentation an example case study farm will be used to illustrate how OVERSEER can provide context and help farmers to plan for the future.

Once farmers understand the key drivers of nutrient loss in the context of <u>their</u> property this allows them to innovate to address it. By using this approach farmers are able to choose their approach to manage the nutrient loss on their property, and this could ultimately have a better outcome for both the catchment and for their farm business.

ESTIMATING FUTURE NITROGEN LOSS FOR A NEW COMMUNITY IRRIGATION SCHEME WITH OVERSEER

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The establishment of a new community irrigation scheme comes with a complex set of regulatory challenges. The main challenge stems from planning and the uncertainty that many dryland farms have with their exact level of development and future farm system once irrigation commences. This makes it complicated to estimate future nutrient losses, and the associated potential environmental impacts of the irrigation scheme. Adding to the uncertainty is the need for a resource consent to change land use, or to use water from an irrigation scheme, which requires a full assessment of environmental effects, often for a system that has some uncertainty over the sought term of consent.

A proposed irrigation scheme near the Waiau River, North Canterbury which could supply water to approximately 40 farms, used a unique approach to deal with these issues. For this scheme, OVERSEER was used at a whole scheme level (24,000 ha) to give a prediction of nutrient loss from future potential land use changes. Rather than creating individual budgets for every farm's predicted future with irrigation, reference farm nutrient budgets for four different farm types (dairy, dairy support, cropping, sheep and beef) across the range of soil types in the area, were established.

The average catchment N loss load was calculated based on the percent of each soil type and the overall expected percent change in land use/farm type across the scheme command area. This allowed a total scheme nutrient load to be estimated for potential land use change within the scheme area and provided a nutrient loss estimate from which potential environmental impacts could then be assessed during the pre-feasibility phase of scheme development. A resource consent for the scheme nutrient load could then be applied for.

In the future, farms associated with the scheme will be managed based on this scheme nutrient load. This method permits flexibility for farmers and certainty for regulators and stakeholders. It also means farmers do not have to lock in their future farm system and potential N losses before scheme costs and water supply reliability are known.

THE PROCESS FOR SETTING NITROGEN LEACHING LIMITS USING OVERSEER FOR A WASTEWATER DISCHARGE CONSENT

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More intensive farming operations potentially have a greater impact on the environment. Horizons Regional Council (HRC) acknowledged this when developing their combined regional plan (One Plan) by introducing resource consent requirements based on farming type and land class. As part of a project to irrigate wastewater from the Foxton community onto a bull beef operation, consent from HRC was required. The conditions associated with this consent specified nitrogen leaching limits as required under the One Plan due to the intensification of land use as a result of the new irrigation system.

The volume of wastewater requiring irrigation annually is variable. Also, the same farming operation will likely have different modelled leaching values as predicted using OVERSEER as a result of version updates during the course of the consent term. This introduces complications when having to meet set nutrient leaching compliance limits. Furthermore, HRC advisors wanted to limit stock class and numbers, despite a need for them to change to meet pasture seasonal growth, market demands and variability in stock class.

While it was preferable to not specify an annual consent limit for nitrogen leaching, and include it as a management function, recent environment court proceedings required the specification of a nominated limit.

For this project consent conditions were developed and proposed to the Environment Court that provided for seasonal variability and version changes. Variability was to be managed by ensuring nitrogen leaching losses did not exceed a nominated value (34 kg N/ha/y) when averaged over a rolling five year period; and version changes were managed by recalculating and the resetting of the consented nitrogen leaching limit using the initial input data file.

THE DIRECT AND INDIRECT COSTS OF CONSENTING DAIRY FARMS UNDER HORIZONS ONE PLAN (PRIOR TO MARCH 2017 ENVIRONMENT COURT DECLARATION)

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As at June 2016, 111 of the 141 Land Use consents in the Horizons region were granted via a restricted discretionary pathway, prior to an Environment Court declaration that the Horizon's process was invalid. Industry involvement and pragmatic consenting solutions had aimed to keep costs for dairy farmers down, while still achieving reductions in nutrient loss. This paper is based on the Master of AgriCommerce thesis of Chris Tidey, completed in late 2016. It investigates the direct and indirect costs incurred by dairy farmers throughout the process of obtaining land use consent. Twenty Manawatu farmers were involved in the study.

Direct costs to obtain consent were largely made up of the consultancy fees incurred in preparing the consent documentation, and council fees. The average direct cost was $5,080.00 (excl. GST). The spread was skewed towards the lower end due to the original DairyNZ system, used for the first 50 applicants.

A variety of mitigation actions were agreed upon and implemented to achieve reductions in nutrient losses. The costs incurred in implementing these mitigations often remain unseen and are referred to as "Indirect cost". The average indirect net cost incurred was $20,364.00 (excl. GST). The majority of mitigation action costs are absorbed within the first three years of obtaining the consent.

This paper suggests that on-farm nutrient reductions can be achieved without significant impacts on financial viability. An average reduction in baseline nitrogen loss of 7.7% came at an average net cost of 15 cents/kg MS, with the cost spread over up to five production seasons.

Cost incurred varied significantly between farms. This was caused by factors including; the level of non-compliance with Table 14.2 of the Horizons One Plan, farm intensity, and the selected mitigation actions implemented. The process and notion of obtaining a Land Use consent was daunting for many of the 20 farmers, with high levels of stress driven by uncertainty and the perceived impact on their properties and valuations.

Horizons has yet to finalise its new system for consenting subsequent to the 2017 Environment Court declaration. This paper provides a benchmark from the initial consenting system

CURRENT SOIL SAMPLING STRATEGIES – A REVIEW

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Soil testing ensures sufficient quantities of fertiliser and lime are applied to achieve crop and pasture yields, while limiting the potential of losses to the environment. Historically, fertiliser applications have been applied uniformly taking into account variability such as, soil type, topography and land management through soil sampling. A standard method has been outlined and widely adopted in New Zealand for obtaining soil samples. However, there is a growing trend driven by early adopting farmers and numerous agricultural consulting firms in New Zealand, to increase the sampling resolution determining the variability in soil fertility on farm. With current trends of farm expenditure on the rise relative to returns, and improved nutrient use efficiency driving change, a spotlight has been placed on soil testing practices.

The aim of this paper is to assess the current soil sampling protocol, review the literature and identify if there is a need to modify current soil sampling methods. The authors conclude that in depth sampling processes need to consider the specific nutrient or soil characteristic being analysed and that although one hectare grid sampling is commonly used, this may not be the most accurate for all nutrients or soil characteristics.

SPATIAL SAMPLING TOOLS FOR REPRESENTATIVE SOIL SAMPLING

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Soil surveys provide critical information for farm environment plans delineating soil patterns that control nutrient pathways through the profile. For large scale surveys of soil properties where it is impractical to visit every location, field sampling is typically carried out on a selection of sites. Spatially balanced designs are often favoured since they spread the sample points evenly over the study area and tend to minimise the chances that measured properties from one site are correlated to measurements from a nearby site. However, other spatial sampling design methods can also be useful, such as where new samples must be spread evenly over the study area but avoiding previously-sampled areas, so that the combination of new and old field samples cover the study area as evenly as possible. All sample designs, of course, must operate within constraints of resource cost, overall effort, and efficiency.

While assessment of the “best” sample design for a survey can be undertaken by a statistician, it is often useful for the field scientist to understand how different sampling approaches affect the distribution of samples, and how compromises in sample designs affect the sampling result. While software packages for spatial sampling design have improved over the years, they can be complicated for many who are not specialists in statistical sampling design.

We have developed a graphical tool written in the R language that allows the field scientist to experiment with a number of different spatial sampling strategies in a study area. The tool does not require the field scientist to be an expert in R for it to be successfully used. The tool provides sampling strategies such as spatially balanced, coverage, infill, and grid sampling methods. It produces various measures of sample efficiency (e.g. mean sum of squared distance to boundary), allows the user to specify the overall required sample numbers, provides for the inclusion of simple sampling constraints, and permits sampling through covariate as well as spatial space. The tool is intended to make it easier for the field scientist and the sampling specialist to jointly produce a more effective design for a specified purpose, by allowing “What if?” scenarios to be examined and compared.

HOW CLOSELY DO DIFFERENT OLSEN P MEASURES CORRELATE?

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Olsen P is a commonly used method for the estimation of available P in New Zealand soils for fertiliser recommendations and regional soil quality assessment. It is also under consideration as a measure of soil quality for national reporting by government agencies, and as part of the Environmental Monitoring and Reporting (EMAR) process, where method consistency is very important. However, Olsen P may be reported on a gravimetric or volumetric basis and there are differences in the analytical methods that appear to confound ready comparison of results reported from different laboratories. We aim to overcome this confounding issue and the potential of methological differences to influence results by determining the best method for comparing the different Olsen P datasets. Results for regression analysis of Olsen P results from a set of samples analysed by different laboratories and converted between volumetric and gravimetric results using different approaches (field bulk density, volume weight) are presented.

DETERMINATION OF LAND SUITABILITY FOR WASTEWATER IRRIGATION USING A MULTI-LAYERED GIS APPROACH

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An alternative to surface water discharge of treated wastewater is application to land via irrigation. Identification and evaluation of suitable land for irrigation is an essential step in the design and consenting process.

A desktop investigation process using a geographical information system (GIS) has assisted with identifying suitable land for irrigation of wastewater. These desktop investigations are based on using fundamental soil layers (FSL) and New Zealand land resource inventory (NZLRI) layers and combining selected parameters to establish 'zones' of suitability. This system gives areas for irrigation based on their mapped soil, geological and in some cases, hydrogeological and climatic properties. Following this GIS process, acceptance of using and feasibility of acquiring parcels of land needs to be determined through field investigations and consultation with interested parties.

Through incorporating GIS layers, a five-step process is used to determine the suitability of land. This begins with nominating those parameters that impact on irrigation (i.e. nutrient uptake potential, soil attributes, hydrological parameters); rules are then established around each parameter which enable any location to have a score applied; a scoring system is then used for each parameter that ranges from 0 (unsuitable) through to 5 (most preferred) for land application; the scores given for each parameter assessed are then added to give a total score for a specific land area; five zones are then determined based on the total scores and are listed as Zone A (most suitable for land application), Zone B (moderately well suited), Zone C (minor limitations for suitability), Zone D (significant limitations for suitability) and Zone E (severe limitations for suitability).

A combination of factors determines irrigation suitability. For example, land that is flat and well drained with limited flood risk may score highly (Zone A) compared to land that has a degree of slope >30°, or is poorly drained and has a high flood risk (Zone E).
Determination of land areas to target through a desktop investigation is important for application of treated wastewater to land. Undertaking this step provides an avenue for more focused field investigations.

REMOVING HYDROGEN SULPHIDE CONTAMINATION IN BIOGAS PRODUCED FROM ANIMAL WASTES

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A huge amount of excess biogas is releasing to the atmosphere in developing countries such as Vietnam (3 - 51% of total biogas produced), because metal components in gas burners are corroded by the hydrogen sulfide (H_2S) content of biogas. This biogas amount (50–70% methane) can be a potent greenhouse gas contributing to global warming. The objective of this study was to develop a cost-effective H_2S removal technology using local materials rich in iron that could be used to adsorb H_2S in a filtering system. Seven New Zealand soils were examined at various gas flow rates (i.e. gas retention times). The results indicated that the H_2S removal efficiency was high and stable (almost 100%) at all gas flow rates for Allophanic soil, Brown soil, and Black sand, then followed by Typic sand (90–99%). The local soils with rich in iron are suggested to be used as H_2S adsorption beds to remove H_2S of biogas. Regenerating iron oxide by simply exposing adsorption bed material to the atmosphere can improve H_2S removal efficiency.

DECISION SUPPORT TOOLS FOR SMALL-HOLDER FARMERS AND AN AVOCADO PROCESSOR IN THE CENTRAL HIGHLANDS OF KENYA

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Our NZ Aid project in the Central Highlands of Kenya is a public-private partnership that is improving on-farm practices for the small-holder farmers growing avocados. As well, we are creating post-harvest protocols for the private partner Olivado to ensure quality fresh fruit for export, and higher yields of oil from the fruit used in pressing. We are developing a suite of Decision Support Tools to facilitate these goals.

The DSTs we have designed, and are implementing, will be dual purpose, as they will deliver to the farmers via SMS text messaging, and also deliver to the avocado processor Olivado via a PC-based application.

The farmers' DST will deliver two forms of information and guidance.

One will be a weekly weather-update for all farmers based on the weather station we have installed at the Murang'a factory. Added to this will be specific SMS messages stratified to farmers in six geopgraphical regions (Meru, Embu, Nyeri, Murang'a, Upper and Lower Maragua) based on soil-water information from simple sensors we have installed there, along with the weekly measured values of the local rainfall. This messaging will include:

- The temperature and rainfall year-to-date at Murang'a, and its deviation from average conditions.
- Real-time advice on what warmer/colder and wetter/drier weather will mean for tree phenology and fruit growth.
- A prediction of an earlier/later time-to-harvest across the Highlands.

The other farmers' DST component will be regular SMS messaging, probably every 2-3 weeks, to advise the farmer of what farm practices and actions should now be carried out. This will also cover information for farmers on other crops, as well as advice for assessing pest and disease risks.

We have also developed a DST for use by Olivado that will predict farmer-specific Times-To-Harvest (TTH), both for fresh fruit, and fruit for oil processing. This will be an app installed on Olivado's computers. This will enable Olivado to plan the logistics of harvesting across the complex geography of the Highlands for the nearly 2,000 small-holders, and for the farmers it will ensure that their fruit are picked in optimal condition, both for oil processing and fresh.

THE BRIGALOW CATCHMENT STUDY: THE IMPACTS OF DEVELOPING *ACACIA HARPOPHYLLA* WOODLAND FOR CROPPING OR GRAZING ON HYDROLOGY, SOIL FERTILITY AND WATER QUALITY IN THE BRIGALOW BELT BIOREGION OF AUSTRALIA

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The 36.7 Mha Brigalow Belt bioregion of north-eastern Australia is characterised by brigalow (*Acacia harpophylla*) vegetation on clay soils. This bioregion has been extensively cleared, predominantly for agriculture. The Brigalow Catchment Study commenced in 1965 to quantify the effects of agricultural development on water and soil resources. It is a paired, calibrated catchment study consisting of three catchments that were monitored in their virgin state for 17 years. One catchment remained virgin brigalow as a control and the other two catchments were cleared and developed for cropping or grazing. Post-development monitoring commenced in 1984 and continued for 27 years. In 2010, land management practices for cropping and grazing were modernised and another two adjacent catchments with alternative management practices were incorporated into the study. All five catchments have been monitored since 2010. Clearing brigalow for cropping and grazing doubled total runoff, while peak runoff rates increased 96% and 47%, respectively. Various legume based pastures showed similar runoff responses. Overgrazing increased both total runoff and peak runoff rates compared to conservative grazing. Deep drainage increased from <0.34 mm/yr to 59 mm/yr under cropping and 32 mm/yr under grazing. Soil fertility was reduced under agriculture. Total nitrogen declined 61% under cropping and 37% under grazing. Similarly, organic carbon declined 46% under cropping and 8% under grazing. Runoff from brigalow contained 81 kg/ha/yr of total suspended solids, 2.61 kg/ha/yr of total nitrogen and 0.08 kg/ha/yr of total phosphorus. Post-development, these parameters increased 645%, 42% and 253% from cropping, respectively. Grazing increased loads of total suspended solids 146% and total phosphorus 721%; however, nitrogen was only 43% of brigalow. Legume based pastures posed a risk to water quality until the plants were well established. Overgrazing substantially increased loads of sediment and nutrients in runoff compared to conservative grazing. The Brigalow Catchment Study has shown changes in hydrology, soil fertility and water quality resulting from developing brigalow for agriculture. This >50 year study can be considered a model in its own right and a sentinel site for management and climate impacts within the Brigalow Belt.

PROTOTYPE TESTING OF LUCI SOFTWARE FOR DETERMINING ON FARM NUTRIENT LOSSES AND MITIGATION OPTIONS IN THE MANGATARERE CATCHMENT

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Fresh water is one of New Zealand's most valuable natural resources and our ecology and economy is heavily dependent upon it. However, the intensification of agricultural land use is resulting in increased levels of diffuse pollutants such as sediment, nitrogen and phosphorus in New Zealand waterways, degrading the water quality.

Recent and incoming regulation on water quality places farmers and other land managers under pressure to reduce nutrient losses to waterways while retaining profitability and production. The Land Utilisation and Capability Indicator (LUCI) software can assist farmers and land managers to explore solutions to degraded water quality. LUCI is a land management decision support framework that evaluates the effect of current and future management on a range of ecosystem services (Jackson et al., 2016). LUCI conveys this information through spatial maps and other outputs. A recent collaboration with Ravensdown has focused on enhancing LUCI's ability to predict water quality outcomes given a range of farm environments and management practices, and to quickly target where management interventions could improve water quality while minimising productivity loss (Jackson et al., 2016). The overall objective of this collaboration is to provide a decision support tool identifying opportunities for cost-effective nutrient mitigation on farms.

The main aim of this project is to establish how credible and accurate predictive models such as the enhanced LUCI model are for a group of 6 farmers in the Mangatarere Catchment. We will evaluate LUCI's ability to manage nutrient losses to waterways and explore a range of potential mitigation scenarios that could achieve environmental benefits such as improved on-farm nutrient management. The aim of this presentation is to present the ground truthed baseline maps of the 6 farms and showcase the preliminary results of comparisons between the potential on-farm mitigation scenarios and their predicted impacts. Any changing perspectives on potential mitigation measures and the usability and value of the LUCI model will also be commented on.

EVALUATING THE UNCERTAINTIES IN NEW ZEALAND'S GIS DATASETS; UNDERSTANDING WHERE AND WHEN FRAMEWORKS SUCH AS LUCI CAN ENABLE ROBUST DECISIONS SURROUNDING FARM MANAGEMENT PRACTICES

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The connection between agricultural activities and water quality degradation is not new, with many studies identifying forms of diffuse pollution such as nitrogen, phosphorus and sediment emitted from intensive agriculture. While the quantities of nutrients lost from agriculture are not large compared to the total nutrient amounts residing in the soil-plant-animal system, the transfer of nutrients from agricultural land to water causes significant environmental impact. With increasing attention on more sustainable land-use practices and mitigating the impact of agricultural intensification on the environment, decision support tools like the Land Use Capability Indicator (LUCI) are well suited to aid agricultural management, at both small and large scales.

LUCI is a GIS-based framework that explores land management scenarios to identify locations where changes in land use might deliver improvements in ecosystem services, or where trade-offs between services are present. The algorithms in LUCI explore the impacts of land management changes on flood risk, habitat connectivity, erosion and sedimentation, carbon sequestration and agricultural productivity. This research is solely focused on LUCI's ability to model and track the flow of nitrogen, phosphorus and sediment across the landscape to waterways.

Models such as LUCI rely on spatially detailed data to produce high-resolution outputs. The level of accuracy and uncertainty in soil, elevation, climate and land use datasets is known to influence the output of such decision support tools. Understanding the quantitative differences in predictions that arise from the sensitivity of LUCI to different datasets, with varying precision and accuracy, will provide valuable information to model developers, industry specialists and end users.

This presentation discusses how the varying quality and resolution of New Zealand's soil and elevation datasets impact LUCI's output. Determining the sensitivity of the LUCI model to these datasets will provide guidance on how robust LUCI's predictions are of nitrogen, phosphorus and sediment loads entering waterways.

INTEGRATED LANDSCAPE MAPPING OF WATER QUALITY CONTROLS FOR FARM PLANNING - APPLYING A HIGH RESOLUTION PHYSIOGRAPHIC APPROACH TO THE WAITUNA CATCHMENT, SOUTHLAND

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Water quality outcomes can vary spatially across the landscape, even when there are similar land use pressures. These differences are often the result of natural spatial variation in the landscape, which alters the composition of the water through coupled physical, chemical and biological processes. Living Water (a Fonterra and Department of Conservation partnership) commissioned a high-resolution physiographic assessment of the Waituna Catchment, Southland, to support water quality and biodiversity investment decisions for the catchment. The physiographic approach is an integrated or 'systems view,' predicated upon the spatial coupling between landscape attributes and the key processes governing water quality outcomes in surface and shallow groundwater. For example, the relationship between soil drainage class (*attribute*) and redox (*process*) can predict soil denitrification potential. Unlike other mapping and classification approaches, water chemistry data and hydrological response signals are used within GIS to identify, select, combine and classify those landscape gradients that drive variation in water quality outcomes. The key process-attribute layers identified for the Waituna catchment are hydrology and redox.

Areas characterised by similar process-attribute classes for both hydrology and redox are defined as Fundamental Landscape Units (FLUs). Each FLU responds in a similar fashion at the process level to broadly equivalent land use pressures. Through classification of the catchment into FLUs we demonstrate that: (i) physiographic mapping is able to estimate the steady-state water composition of surface water and shallow unconfined groundwater with a high degree of confidence, and; (ii) process-attribute gradients and resultant FLUs are a powerful tool for informing and optimising efforts to improve water quality – matching efforts to the process level controls over water quality at the land parcel scale. Over the next few years, a national physiographic classification (Physiographic Environments of New Zealand) is being developed in conjunction with Our Land and Water National Science Challenge and a range of stakeholders.

WHY AREN'T WE MANAGING WATER QUALITY TO PROTECT ECOLOGICAL HEALTH?

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Eutrophication of waterbodies is a major stress on freshwater ecosystems globally and New Zealand is no exception. Expanding agricultural intensification is increasing nutrient levels in rivers throughout the country and as a response the New Zealand Government has established a policy of freshwater management (NPS-freshwater management) where waterbodies are managed within four states ranging from high to low ecosystem health (states A, B, C and D). However, the National Policy Statement for freshwater management does not currently have attributes to manage the two main stressors of lotic ecosystem health: deposited sediment and nutrients. It does have attribute states for nitrate (the dominant form of the nitrogen nutrient), but only at levels where it acts as a toxin. Levels at which nitrate acts as a toxin are however considerably higher than those where it can adversely impact on ecosystem health. There are currently no dissolved reactive phosphorus (DRP) attribute states for ecosystem health of rivers.

We compiled a large range of data sources and used a weight-of-evidence approach to objectively determine nitrate and dissolved reactive phosphorus limits to manage rivers and streams into the four ecological states. This established that the critical nutrient concentrations differentiating rivers in each of the states are 0.11, 0.58 and 1.66 mg/l for nitrate and 0.006, 0.015 and 0.054 mg/l for DRP.

While ecological health of rivers is affected by a range of interacting stressors we believe the evidence supports the view that managing to these nutrient thresholds will provide for better ecological condition in New Zealand's rivers and streams. It seems strange to us that these nutrient attributes are currently present in the NPS-freshwater for lakes but not for rivers and streams, when the data for them is readily available. If we truly want to manage ecosystem health we must surely consider the most important determinates of its condition so that informed, objective decisions can be made on the implications of particular actions.

ON THE TRACK OF TARGETED REGULATION OF NITRATE – EXPERIENCES FROM DENMARK

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European member states must comply with the EU Water Framework Directive (FWD) on reaching a good ecological status for all waters. A major challenge in this ambitions goal is to lower nutrients loads to the coastal waters to reduce the risk for eutrophication.

Nitrate comprise the largest problem in many fjords and estuaries in Denmark, where it is estimated that approximately 90% of the load is from diffuse sources, primarily agriculture. Historically, the Danish nitrogen regulation has been based on a uniform approach, imposing the same restrictions for all areas independent on drainage schemes, hydro-geochemical conditions in the subsurface and retention in surface waters. Although this regulation, implemented in several national action plans since the mid-eighties, has been successful in nearly halving the nitrogen loads to the marine recipients, further abatements are required.

A uniform regulation is not cost-effective, as the vulnerability of the individual marine recipients are different, and the nitrogen is reduced naturally, but with large spatial variations depending on the local transport pathways and the hydro-geochemical conditions. New and innovative regulation approaches therefore need to be developed that utilises this natural variation, and targeted and spatially differentiated regulation has been intensively debated in Denmark in the past five years.

Presently, new nitrogen measures are implemented at catchments scale, for which the farmers are compensated, and this will be complemented by a targeted regulation in 2019. The strategy for targeted regulation has not been defined in details, but several recent national projects have been devoted to study how spatial variation can be identified at relevant scale with sufficient certainty and included in national regulation.

The paper will draw on the results from these studies with emphasis on transport and degradation in the subsurface system, where the largest natural reduction occurs, and the importance of the redox conditions, drainage conditions and riparian lowlands.

VARIABLE NITROGEN ATTENUATION CAPACITY FOR TARGETED AND EFFECTIVE WATER QUALITY MANAGEMENT IN NEW ZEALAND AGRICUTURAL CATCHMENTS

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Soluble inorganic nitrogen, particularly nitrate has been implicated as one of the key contaminant in the deterioration of surface and ground water quality across New Zealand's agricultural catchments. Hence, there are increasing efforts to identify and reduce nitrogen losses from intensive farming activities. However, there is great deal that is yet to be understood about the manifold processes and pathways that lead to nitrogen contamination of rivers and lakes in New Zealand agricultural catchments. In the simplest of terms, nitrogen movement from farms to rivers and lakes might be thought of as a three stage process: nitrogen exits the root zone, travels through a complex range of intermediary subsurface materials, and enters and effects the receiving water body. During the middle phase of this journey, which varies in time from days to many years, nitrate may undergo transformation before entering the receiving water body. Our on-going field observations, surveys and experiments suggests that, in low oxygen subsurface environments, nitrate can be reduced and emitted as a nitrogen gas via a biogeochemical process of denitrification in the subsurface environment. As a result, nitrogen losses are said to be attenuated before entering and effecting the receiving water body.

The flow of nitrogen from farms to rivers and lakes, however, is simply viewed as a black box in the formulation and implementation of policy and management practices for decreased nitrogen contamination of receiving waters in sensitive agricultural catchments. Unfortunately, Regional Councils have to set N loss allocations in this context of limited knowledge, and they generally tend to assume a value of 0.5 for the nitrogen attenuation factor. However, our research in the Manawatu and Rangitikei River catchments has shown that nitrogen attenuation factor is only occasionally 0.5, but rather it varies markedly across sub-catchments within the catchment.

In this paper, we will discuss some of the implications of this variable nitrogen attenuation phenomena to present day policy and regulation formulation, particularly those initiatives that seek to allocate N loss limits to farmers based on the Landuse Classification system (LUC). We will explain why, in theory, such frameworks are unlikely to deliver the desired water quality outcome unless accurate and detailed spatially variable nitrogen attenuation factors are assessed and used. Finally, we will present and discuss a potential process or mechanism for setting N loss allocations for farms using spatially explicit nitrogen attenuation factor for achieving targeted and effective water quality outcomes in New Zealand agricultural catchments.

ACCELERATING UPTAKE OF CONSTRUCTED WETLANDS AND RIPARIAN BUFFERS BY QUANTIFYING CONTAMINANT ATTENUATION PERFORMANCE: A PROPOSED NATIONAL INVESTIGATION

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Many landowners are in the process of identifying and implementing mitigations to reduce diffuse contaminant loss to waterbodies, under regional limit-setting processes required by New Zealand's National Policy Statement for Freshwater Management (NPS-FM). Constructed wetlands (CWs) and riparian buffers (RBs) are increasingly being considered as part of the toolbox of mitigation options available to meet limits. However, research is needed to better quantify their environmental performance and benefits, so that landowners can claim expected contaminant load reductions and regulators have confidence that specific riparian or wetland mitigations will deliver the reductions to on-farm contaminant budgets, required to meet catchment load objectives. This is expected to promote their adoption by land owners and facilitate regulatory acceptance.

We outline a national approach to quantifying contaminant attenuation performance for CWs and RBs in five regions of New Zealand (e.g., nutrients, sediment, bacteria). Each regional RB experiment will be applied to ~5km head-water stream reaches, including before/after and control testing to quantify catchment-scale effectiveness. The CW trials will compare inflow and outflow loads under differing flow regimes and contaminant concentrations over periods of 2-3 years.

We will develop provisional performance estimates and standardised design guidance for initial use by councils. This will be refined following long-term temporal monitoring (5+ years) to determine the regional variance in CW and RB efficacy and quantify actual attenuation performance in different landscape and climate settings. Combined, the quality and regional resolution of attenuation performance will shape use of CW and RB mitigations in regional policy, accelerate their uptake on-farm, and support robust reporting for the NPS-FM.

MEASURING ACTUAL DENITRIFICATION TO UNDERSTAND NITROGEN LOADS THROUGH AQUIFERS

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Nitrate is the most pervasive contaminant in New Zealand's groundwaters. Thus, understanding and managing nitrogen loads through New Zealand's aquifers is vital for maintaining the quality of groundwaters and connected surface waters.

Denitrification is a natural process that is mediated by the metabolism of aquifer microorganisms by which dissolved nitrate is reduced eventually to nitrogen gas (N_2). However, the extent of denitrification within New Zealand's groundwater system is largely unknown. Denitrification only occurs under reducing (e.g., anoxic) subsurface conditions, with nitrate becoming the energy source for the microbes after the oxygen is exhausted. Much emphasis has been placed on identifying where optimal redox conditions are present to allow for the facilitation of denitrification (Stenger et al. 2008). However, assessment of the redox status of the groundwater only suggests whether denitrification could be possible in an aquifer, not whether it has actually occurred (Langmuir 1997).

Calculation of the concentration of excess nitrogen in groundwaters is a promising technique to quantify the amounts of denitrification occurring in the groundwater system. All groundwaters contain dissolved gases derived from the atmosphere during recharge, including N_2. Comparing the ratio of the two gases dissolved in the groundwater, usually N_2 and argon, to the known ratio of the gases in atmospheric air allows for the calculation of recharge conditions. When denitrification occurs, the concentration of dissolved N_2 increases, distorting the relationship, and therefore the calculated recharge conditions, between argon and N_2. Measurement of a third dissolved gas, neon, is needed in order to determine the ratio of dissolved atmospheric gases which will enable the calculation of any excess N_2 from denitrification to be determined. This enables differentiating the excess nitrogen produced via denitrification reactions from atmospherically derived dissolved nitrogen.

In this poster, we will show simultaneously measured neon, argon and nitrogen results from paleo waters which demonstrate the ability to measure dissolved neon concentrations in groundwater, allowing for the calculation of excess N_2.

IMPACTS OF FARM SYSTEMS CHANGE AND DROUGHT ON THE GREENHOUSE GAS FOOTPRINT FOR SHEEP AND BEEF FARMS

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Advances in animal genetics and health along with changes in farm management practices in response to economic drivers have led to ongoing improvements in farm productivity from New Zealand sheep and beef farms over time. The national average lambing percentage has increased from 100 to 124% from 1990 to 2015-16 and lamb carcass weight 13 to 19.5 kg per ewe over the same period. Despite the decline in the area in sheep and beef, the export value of lamb, sheep meats and beef has more than doubled since 1990. Both nationally and globally, the increasing focus on environmental impacts of land use, through legislation and global consumer demands will shape farming futures. An evaluation of the impact of systems changes since 1990 on greenhouse gas (GHG) emissions is provided in this paper.

A South Canterbury farm was monitored for the NZAGRC PGgRc farms systems research programs. It is a 400 ha property, (30km inland of Timaru) comprising 80% rolling flats and 20% steep hills (150-300 m above sea level), with 600mm of annual rainfall. Using total animal production (from Farmax) and greenhouse gas emissions (from OVERSEER), the GHG emissions were calculated for current (2014-2017) and past (1990/91) systems. Over time the farm has transitioned from a traditional breeding and finishing system to a finishing system focused on resilience and performance. Total animal production (kg product/ha) was 246, 344, 241 and 337 in 1990/91, 2014/15, 2015/16 and 2016/17 respectively. GHG emissions have increased with production, however GHG emissions intensity (kg CO_2-e/kg product) was considerably lower in the current compared with the 1990 system. Destocking to manage the impact of drought resulted in almost halving the total CO_2 emissions (CO_2-e/ha) in the drought year compared with other current years, and was much greater than the impact of long term management changes. The results highlight both the extent to which sheep and beef farms have improved systems efficiency and emission intensity but also the impacts of proactive management of seasonal conditions (drought) on total emissions.

THE EFFECTIVENESS OF UREASE INHIBITORS 2-NPT AND NBTPT AT REDUCING AMMONIA EMISSIONS FROM PASTURE SOILS – A LABORATORY STUDY

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This study compares the effectiveness and longevity of the urease inhibitor N-(2-Nitrophenyl) phosphorictriamide (2-NPT) with the commonly used N-(n-butyl) thiophosphoric triamide (nBTPT), (i.e. Agrotain®), in reducing ammonia (NH_3) emissions from pasture soils.

A laboratory study was conducted using two dairy-grazed pasture soils with contrasting organic carbon (C) levels. Treatments were; i) a control (deionised water), ii) cow urine, iii) cow urine + nBTPT (0.025% of total N), iv) cow urine + 2-NPT (0.025% of total N), v) cow urine + 2-NPT (0.050% of total N), and vi) cow urine + 2-NPT (0.075% of total N), which were applied to air-dried soils (7.8 cm depth) in plastic containers.

Ammonia emissions were measured at four stages; a) immediately before inhibitor application, b) 29 days after inhibitor application, c) 56 days after inhibitor application, and d) reapplication to stage (b).

The results showed that the inhibitors significantly reduced total NH_3 emissions from applied urine at stage (a) from both soils, but the difference between inhibitors was not significant. The use of 2-NPT achieved reduced emission up to stage (c) (56 days), which was a longer period than with nBTPT. However, no reduction in emission was observed during stage (d) by either the inhibitors. These results show that 2-NPT has the ability to extend the longevity of urease inhibition compared to the currently available inhibitor.

EVALUATION OF THE EFFECT OF SOIL COMPACTION ON URINE PATCH AREA AND PLANT RECOVERY OF URINE-NITROGEN

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Recent research has indicated that higher stocking rates may, in certain cases, result in lower nitrogen (N) leaching losses. One possible explanation for this is that higher stocking rates can increase soil compaction. This can reduce soil porosity and surface infiltration rates and could increase the area covered by individual urine patches, due to greater dispersion following deposition. Increased urine spread would result in reduced urine-N deposition rate and potential for greater uptake of urine N by pasture.

A plot trial was established on a ryegrass/white clover pasture on a Te Kowhai soil in the Waikato in late autumn 2017. Four treatments were applied: compacted or uncompacted, and with or without urine. Compaction was carried out using a roller to apply a pressure similar to that exerted by a 500 kg dairy cow. Two litres of artificial urine was applied to the centre of a 1 m^2 plot according to a standard cow height and time interval for each of the urine treatment plots. The area covered by the urine patches was measured using an infra-red camera and soil samples were collected to measure physical properties. Four pasture harvests were taken from the plots following treatment application and pasture dry matter and N content were measured.

The compacted soil had significantly fewer pores in the greater than 30 micron range (commonly referred to as macroporosity) than the uncompacted soil and this was reflected in the approximately 40% greater area covered by the urine applied to the compacted plots. There was no significant difference in pasture N concentration between urine treatments at any harvest but the urine treatments did produce significantly more dry matter than non-urine (control) treatments at the first two harvests (24%). At the first harvest the compacted control treatment produced less dry matter (15%) than the uncompacted control. However, the compacted urine treatment produced the same amount of dry matter as the uncompacted urine treatment. Recovery of urine-N in herbage was the same in the compacted and uncompacted plots. Further research is needed to understand the potential effects on leaching of surplus urine-N through these soils as affected by the differences in urine-N deposition rate and soil physical properties associated with the soil compaction

DO NITROUS OXIDE EMISSIONS FROM URINE DEPOSITED NATURALLY DIFFER FROM EVENLY APPLIED URINE?

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The current approach of measuring nitrous oxide (N_2O) emissions from urine deposited during grazing by evenly applying urine to the entire N_2O flux measurement area does not account for the possible effect of heterogeneous horizontal and/or vertical distribution of urine (and hence urine nitrogen) over the patch area, or for possible plant and soil effects at the patch periphery. The objective of this research was to compare the effect of application methods on N_2O emissions from urine applied to a dairy soil (evenly over the entire surface area of the measurement chamber (standard chamber) and to a central point and allowed to spread naturally within a measurement chamber designed to capture any influence of plants and soil at the patch periphery (large chamber). Two nitrogen transformation inhibitor treatments (the urease inhibitor N-(n-butyl) thiophosphoric triamide (nBTPT) and the nitrification inhibitor Nitrapyrin) were superimposed over the urine application method treatments.

A preliminary study was conducted to evaluate the practical and logistical issues such as insulation requirements to maintain chamber temperature, number of sampling ports, fan for mixing the gases, linearity of N_2O flux, and urine patch size.

Soil moisture levels (VWC = 33%) were below field capacity at the time of urine application and decreased steadily (to 12%) over the first 7 weeks of the N_2O flux measurement period. Significant rainfall in week 8 increased soil moisture (to 30–21%) over weeks 8 and 9, followed by a gradual decrease in weeks 10 and 11. Nitrous oxide flux from the urine and urine plus inhibitor treatments were elevated for the first 2 weeks after treatment application and then decreased sharply, returning to background levels by week 3. Gas flux measurements continued for 11 weeks, at which time N_2O flux for all treatments had been at background level for approximately 8 weeks. The data are being collated and analysed. The results will be presented at the workshop.

DRAINAGE WATER QUALITY ON TWO WAIKATO PEAT DAIRY FARMS

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Farm drains on two Waikato dairy farms located on peat (Organic) soils were monitored over two winter drainage seasons in 2016 and 2017. The purpose of this monitoring was to provide insight into the scale of contaminant losses (nutrients and faecal microorganisms) to surface water from farm paddocks on two peat soils of contrasting development status. Development status increases with increasing time under pastoral land use. The farm near Motumaoho had relatively well developed Kaipaki peat loam soils with a moderately high anion storage capacity (ASC) of 49%. The other farm, near Orini, has less developed Rukuhia peat soils and a low ASC of 19%. Soils with low ASC have limited ability to hold negatively charged ions in the soil and to prevent nutrients leaching beyond the root zone (typically to ground water). Well-developed peat soils have higher ASC than the less developed peats, and typically have characteristics more similar to mineral soils.

On each farm, a block of approximately 120 hectares was selected, where measurements were made of drain flow. Water samples were collected periodically for analysis of nitrogen (N), phosphorus (P) and *E.coli* concentrations. At the Orini farm, measurements were also made of depth to groundwater and water samples were analysed for N and P concentrations.

Results of water quality testing are presented with comparisons to regional council guidelines for water quality for E. coli, total phosphorus (TP), ammonium N (NH_4-N) and total inorganic nitrogen (TIN).

Using drain flow data and contaminant concentration data, estimates of the amount nutrients removed in the drains in each of the two seasons were calculated.

Cumulative TP loadings (kg P/ha/year) in drains at the less developed site were on average over 10 times those at the well-developed site. Cumulative TIN loadings (kg N/ha/year) in drains at the well-developed site were on average about five times higher than those at the less developed site.

We hypothesise that the large differences in cumulative TP and TIN loadings in drainage water between the two sites are attributable to the respective soil ASC.

ACCOUNTING FOR HEADWATER SEEPAGE WETLAND NITROGEN ATTENUATION IN FARM ENVIRONMENTAL PLANNING

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Wetlands are one of the key edge-of-field options available for managing diffuse pollution from agricultural land-use. A high proportion of diffuse nitrogen and phosphorus losses from agricultural land are generated in first-order headwater catchments.

We assessed the nitrogen removal performance of a small natural headwater wetland in a pastoral agricultural catchment in Waikato, New Zealand over two-year period (2011–2013). The ~0.15 ha wetland occupies 2.8% of its surface catchment and is enclosed in a ~1.9 ha paddock rotationally grazed by dairy cows. Flow and water quality samples were collected at the top and bottom of the wetland, and in piezometers installed at strategic points inside and outside the wetland. A simple dynamic model operating on an hourly time step was used to assess wetland nitrogen removal performance. Measurements of inflow, outflow, rainfall and Penman evapotranspiration estimates were used to calculate a dynamic water balance for the wetland. N concentrations at inflow and outflow and piezometers were used as input data for the model.

Nitrate and organic forms dominated the N load entering the wetland (~60% and 30% of in-load, respectively). A dynamic nitrate-N mass balance was calculated by coupling influent concentrations to the dynamic water balance and applying a first order areal removal coefficient (k20) adjusted to the ambient temperature. The model showed that despite large episodic inputs of highly contaminated surface run-off during heavy rainfall, shallow groundwater was the dominant source of flow and N load. The concentrations of nitrate-N, Dissolved Inorganic Nitrogen and Total-N were always lower at the outlet of the wetland regardless of flow conditions or seasonality, even during winter storms. The modelled water quality measurements showed high seasonal variability of pollutant loads with wetland N removal efficiency best during low flow, and poorest during high flow events and low temperatures.

Overall, we estimate the wetlands were able to reduce headwater nitrate-N loads by 76% and TN loads by 57%. Implications for management of headwater seepage wetlands in agricultural landscapes will be discussed.

EFFICACY OF SUBSURFACE DENITRIFICATION TO ATTENUATE NITRATE IN SHALLOW GROUNDWATERS

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Leaching of nitrate (NO_3^-) from grazed pastoral systems and other intensive land uses has been implicated as a key water contaminant in the deterioration of surface and ground water quality in New Zealand's agricultural catchments. The impact of NO_3^- leaching from agricultural soils, however, strongly depends on its losses, flow pathways and potential attenuation (removal) in subsurface environment.

Microbial denitrification, a multistep sequence of N reduction reactions, has been identified as one of the effective mechanisms attenuating NO_3^- in subsurface environment including shallow groundwaters. Environmental benefit of subsurface denitrification, however, may be limited if subsurface denitrification is incomplete and the terminal product of NO_3^- reduction is N_2O (a harmful greenhouse gas) rather than N_2 (an inert and harmless gas making up 78% of the atmosphere).

We are undertaking a field study assessing whether NO_3^- reduction in shallow groundwater is due to incomplete and environmentally harmful (i.e. N_2O release) or complete and environmentally benign (i.e. N_2 release) denitrification and what are the main processes and factors driving complete denitrification. We have been collecting monthly shallow groundwater samples from 6 pastoral farms located in various hydrogeological settings in Manawatu and Rangitikei River catchments. The study sites have been identified as oxidized or reduced shallow groundwater conditions.

The shallow groundwater samples are being collected and analyzed for redox parameters (i.e. dissolved oxygen, oxidation-reduction potential (ORP), pH, nitrate, nitrite, ammonium, dissolved organic carbon, iron, manganese, and sulfate) and dissolved gases N_2O and N_2, using the standard in-field and laboratory equipment and practices. Also, the collected groundwater samples are analysed for quantification of denitrifier genes (*nos*Z, *nir*S, and *nir*K) using Quantitative Polymerase Chain Reaction (qPCR).

We found that different study sites show variability in denitrification parameters and denitrifier gene abundances. A preliminary analysis of these results will be presented and discussed in detail at the Workshop.

THE EFFECT OF SOIL TYPE AND SLOPE ON THE DISSOLVED ORGANIC CARBON CONTENT AND DENITRIFICATION CAPACITY OF A HILL COUNTRY SUB-CATCHMENT

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Characterising the dissolved organic carbon (DOC) content and denitrification capacity of the varying soils and slopes in hill country is important in order to manage the leaching and availability of nitrate in ground and surface waters.

There is a pressing need to assess soil types and slopes within a farm or catchment, in terms of their denitrification capacity, as this knowledge will allow more accurate and equitable allocation of nitrogen loss restrictions, should they apply to hill country in the future.

This study investigated the denitrification capacity of the soils and slope classes of a sub-catchment within a hill country farm, located in Palmerston North, Lower North Island, New Zealand. Fifty locations comprising of 8 soil types (grouped into 3 drainage classes) and 3 slope classes were sampled from different soil depths down to 1 m.

The results suggest that soil parent materials have an influence on the availability of nitrate below the surface soil, regardless of the slope class. Soils with the highest DOC and moisture content had the highest denitrification capacity, and these were well-drained soils on medium slope. This suggests that farms and catchments with these specific soil type and slope combinations may have a greater capacity to attenuate nitrogen losses to the environment.

HIGH RESOLUTION MONITORING OF NITRATE IN AGRICULTURAL CATCHMENTS – A CASE STUDY ON THE MANAWATU RIVER, NEW ZEALAND

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High resolution monitoring (≤15 mins) of nitrate-N concentration in streams and rivers in New Zealand agricultural catchments would improve our understanding of nitrate-N dynamics and increase the accuracy of our nitrate-N load calculations. However currently, the use of these sensors is rare. Most of the nitrate sensors available on the market are manufactured in Europe and are designed to measure higher nitrate-N concentrations than are typical of New Zealand freshwater conditions. For this reason, it is important to thoroughly assess the precision and bias of nitrate sensors in order to make informed decisions about their use under New Zealand conditions. In 2016, a NITRATAX (Hach Lange GmbH, Germany) UV/VIS sensor was loaned by Ulster University and deployed in the Manawatu river (catchment area: 3,914km^2) for a period of one year. The NITRATAX sensor provided accurate and precise nitrate-N measurements over the entire range of nitrate-N concentrations, with concentrations ranging from 0.00 to 1.29 mg/L. The NITRATAX values, however, were slightly negatively biased in comparison to the standard laboratory analysis method, and a comprehensive calibration was used to apply a correction factor to the data.

High resolution monitoring allowed a detailed examination of the annual fluctuation of nitrate-N concentrations in the Manawatu River, revealing trends that have rarely been studied at a catchment scale in New Zealand, and improved the quantification accuracy of the nitrate-N loads in the study river. There was a 14% difference between the annual nitrate-N load measured using the NITRATAX sensor data and monthly grab samples analysed in a laboratory (using the flow-weighted method), with higher annual nitrate-N load measured using the NITRATAX (1926 vs 1674 t/yr). The data analysis confirmed that the monthly grab sampling missed some of the highest flow events, resulting in an underestimation of annual nitrate-N loads in the Manawatu River.

This study confirmed that the NITRATAX high-resolution sensor is a promising, novel tool to allow detailed measurement of nitrate-N concentrations and loads in the Manawatu River, provided that extensive calibration and adjustment is undertaken. On this basis, this sensor is recommended for further testing and evaluation, as a new tool to improve our understanding of nitrate-N loss processes from New Zealand catchments and to improve the accuracy of our nitrate-N load calculations.

COLLABORATIVE EXPERT JUDGEMENT ANALYSIS OF UNCERTAINTY ASSOCIATED WITH CATCHMENT-SCALE NITROGEN LOAD MODELLING

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Background

The Waimakariri Water Zone Committee is currently exploring options to achieve environmental, economic and community outcomes through a range of non-statutory and statutory measures, including controls on nitrogen leaching from farmland. Current and Good Management Practice nitrogen loads were modelled at catchment scale by the project team (by upscaling Overseer-based nitrogen loss rates from a series of representative farms), in order to provide the information required for this decision-making process.

The level of uncertainty associated with this modelling approach has been widely discussed amongst scientists and stakeholders during previous Environment Canterbury planning processes, but until now has not been formally evaluated. Understanding nitrogen loss uncertainty allows decision-makers to consider the likelihood that a given management approach would be successful, and weigh this likelihood against potential economic impacts.

Method

The Sheffield Elicitation Framework (SHELF) for expert judgment was used to develop a set of nitrogen leaching probability density functions (PDFs) for Waimakariri Zone.

Results

Uncertainty estimates are presented for the predominant soil and land use classes found within the Waimakariri zone. The framework presented in this paper could be used in other geographic areas to provide relatively quick, low cost approximate estimates of modelled nitrogen loss uncertainty.

DRY MATTER YIELD RESPONSE OF PASTURE TO ENHANCED EFFICIENCY NITROGEN FERTILISERS

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Field trials were conducted during winter to spring/early summer 2016 at three sites in the North Island (Hawke's Bay, Rotorua and Northland) to compare the performance of soluble N fertiliser (SustaiN), polymer-coated urea, methylene urea, and combination of SustaiN and polymer-coated urea (30%:70% mix) on pasture dry matter yield. All treatments were applied at an equivalent rate of 100 kg N/ha and applied only once except for SustaiN which was applied in three equal splits to mimic farmers' practice. Polymer-coated urea and the 30% SustaiN:70% polymer coated urea mix gave comparable dry matter yields as the SustaiN treatment. On the other hand, methylene urea generally produced lower dry matter yield than all the other treatments. While a single application of a slow release or controlled release N fertiliser to pasture represents a reduction in labour/application cost, this benefit will have to be weighed against its significantly higher cost per tonne relative to soluble N fertiliser like urea or SustaiN.

DENITRIFICATION BIOREACTOR WORK IN WAITUNA LAGOON CATCHMENT, SOUTHLAND

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Subsurface drainage of agricultural land provides multiple "conduits" that potentially facilitate transport of contaminants from field to stream. In addition to increasing the efficiency of transport, these "conduits" may also allow contaminants to bypass natural attenuation zones and processes. Adoption of tile or mole drainage has contributed to the trend of increasing nitrate-nitrogen loads observed in many rural streams. Despite creating the potential to degrade downstream water quality, relatively few long-term, field-scale trials have been undertaken to quantify the hydraulic and contaminant load from these drainage systems.

We quantified the mass load of nitrogenous material derived from a representative subsurface drain, and the reduction in nitrate-nitrogen provided by a woodchip filter during a 17-month trial. The tile drain delivers seasonally-varying concentrations and mass of contaminants, driven primarily by rainfall. The annual median concentrations of nitrate-nitrogen entering the filter (i.e. discharged from the tile drain), and discharged from the filter were 2190 ug/L and 421.5 ug/L, respectively. The median daily load was reduced from 47.1 g/d to 2.9 g/d (a reduction of 93.8 percent), and the median nitrate-nitrogen yield from the field was reduced from 1.83 kg/ha/yr to 0.11 kg/ha/yr.

Efficacy of the woodchip treatment filter was strongly dependent on hydraulic retention time, and to a lesser extent, temperature. These dependencies were evident as seasonally varying treatment efficacy. These factors should be considered before modifying the design of a woodchip filter to enhance efficacy. For example, if seasonally large hydraulic loading determines treatment efficacy during autumn and winter, it may be possible to improve performance by buffering the flow (e.g. by incorporating a buffer chamber into the filter design), or by temporarily retaining some of the drainage water in the landscape, within the drains themselves. Another approach could include a bypass system to limit inflow to the filter once a defined flow threshold was achieved. Several of these and other approaches may be combined to accommodate site-specific considerations (e.g. soil, gradient and farming system factors). It is also conceivable that seasonally varying treatment efficacy may be consistent with the seasonality of the receiving environment and with water quality improvement goals.

LONG-TERM MAIZE GROWING IN WAIKATO

- FACTORS AFFECTING SUSTAINABILITY

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Maize is a common forage crop grown in the Waikato for either silage or grain production. Typically maize crops are sown in September/October, however maize silage is harvested earlier (March/April) compared to maize grain (May/June). Growers harvesting maize silage have time in the autumn to get pasture established before the winter. In contrast, maize grain growers typically leave the soil fallow over the winter period as pasture can't be established in time. This results in certain paddocks being dedicated to continuous maize growing year after year. The effect of these monoculture crops on soil quality and its sustainability is of great interest.

The Waikato Regional Council (WRC) soil quality programme covering chemical, physical and biological indicators from long-term monitoring sites include many arable sites (which are predominantly maize crops). The WRC findings for arable sites shows loss of Total C and Total N, indicating loss of soil organic matter, compaction (increased BD and lower macroporosity) and excessive nutrients (high Olsen P levels).

With the aim of identifying land management practices that maintain soil quality two Waikato sites with good records of decades of continuous maize growing history were studied. Data on soil analysis, fertility inputs and maize yields have been collated and compared against the trends of some of the key soil quality indicators found from the WRC monitoring.

THE USE OF IN-FIELD STAND-OFF PADS CONSTRUCTED FROM SAWDUST AND/OR LIGNITE TO CAPTURE URINARY NITROGEN: FIELD AND LAB EVALUATIONS

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Lower cost alternatives to traditional stand-off infrastructure are sought that deliver the same or similar benefit in terms of nitrogen (N) leaching reductions and animal welfare performance. This study evaluated the practicality and potential benefits of using a temporary standoff pad system, constructed from a mix of sawdust and lignite, to accommodate cows during winter in Southland. Accompanying laboratory incubation experiments were carried out to test the ability of the mix to adsorb or immobilise urinary N under controlled conditions. Novel aspects of the field-tested system were (i) its location in a field used to provide winter feed which reduced travel distances to a fixed stand-off pad, and (ii) the use of a sawdust-lignite mix for the standoff surface.

The on-off grazing management of the crop-pad system proved a feasible approach for wintering cows in terms of labour and animal welfare. In the field, attempts to quantitatively measure the amounts of excretal N immobilised by the field pads were unsuccessful due to methodological difficulties. A lysimeter experiment highlighted the impact on soil drainage of effluent slurry application in combination with simulated treading damage of the wet soil; this was also observed on the pad, and could result in loss of nutrients via surface run off. If temporary stand-off pads are further explored, changes in the configuration of the pad to encourage even utilisation/effluent loading of its area in a break feeding situation may overcome this drainage issue.

A laboratory adsorption test showed sawdust and lignite adsorbed no more than 10% of ammonium-N in solution, by comparison the soil used in the incubation study was just as effective. A laboratory incubation study was conducted where sawdust, lignite and a combination of the two materials were mixed with soil, treated with urine, incubated at 6 or 17ºC and periodically extracted for soluble C and N forms. None of these treatments showed any significant reduction in soluble N contents compared with the soil-only urine treatment at any stage of the incubation. Soil soluble C:N ratio never exceeded 4:1 for the duration of the incubation. The sawdust and lignite had high total C:N ratios but very little of the C was soluble, a requirement to immobilise urinary N. Provision of a soluble carbon source (to temporarily immobilise urinary N), is recommended if further testing of sawdust-lignite mixtures for use in temporary stand-off pads is undertaken.

ECONOMIC BENEFIT OF REDUCING THE COEFFICIENT OF VARIATION OF FERTILISER APPLICATION

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AgFirst, Hamilton

This analysis investigates the economic impacts of varying the coefficient of variation of fertiliser application (CV - essentially the evenness of the spread of fertiliser), and its subsequent impact on farm profitability.

It is based on published research relating CV to changes in pasture DM production, which was used to model a representative North Island Hill Country sheep & beef farm and Waikato/Bay of Plenty dairy farm, within Farmax.

Subject to the assumptions made, the results showed, that for a representative North Island hill country sheep & beef farm, increasing CV's above 40% had an impact on dry matter production and subsequently on farm profitability.

Similarly, for the representative Waikato/BoP dairy farm, increasing CV's above 50% had an impact on dry matter production and subsequently on farm profitability.

While the impact on total DM grown was not large, it was the seasonal variation that had a greater overall impact.

There is also an inference that increasing CV's have a larger impact at lower fertility levels (or conversely a lower impact at higher fertility levels).

FEASIBILITY STUDY, EXTENDING THE SWATH WIDTH OF TOPDRESSING AIRCRAFT TO REDUCE STRIPING OF FERTILISER MIXES

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Fertiliser mixes of magnesium oxide coated urea and super phosphate require high application rates 250kg/ha - 500kg/ha. These rates have been known to clog spreaders reducing their efficiency, and also compromising operational safety. As a result, current spreader designs cannot be used. The swath width from a Cresco 08-600 without a spreader is only 12m wide, meaning many passes are required to cover a field. The mixture also tends to segregate which leads to striping.

A new method of spreading fertiliser which provides a wider swath width and an even distribution is required. This method must be able to meet the CAA requirements for topdressing safety, minimise segregation in fertiliser mixtures and preferably should be applicable to most bulk fertilizers in common use; the method must not add any significant weight to the aircraft which would decrease its operating capacity.

The feasibility of developing a means of initiating spreading of bulk fertilisers from topdressing aircraft hoppers from regions outside of the influence of the prop wash is being investigated. If feasible, the system should be able to apply fertiliser across a 40m swath width at the target application rate, in a single pass. This would reduce flight time and improve the distribution pattern leading to reduced operating costs and higher crop yield.

PLANNING LOW COST TECHNOLOGIES TO ENHANCE THE AGRONOMIC EFFECTIVENESS AND USE OF LOW GRADE DOROWA PHOSPHORUS ROCK

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The potential of alternative low cost processes to improve agronomic efficiency of Dorowa phosphate rock (PR) for use in the nearby areas of Buhera, Zimbabwe is discussed. Earlier studies report that directly applied Dorowa PR concentrate does not improve crop yields due to its unreactive nature. With growing interest in economical and environmentally friendly technologies such as hydrothermal carbonization, there is potential to utilize liquid by-products, comprising various acids to improve the agronomic efficiency of Dorowa PR. An assessment of how much P can be made bio-available using dilute organic acids and sintering with silicate minerals is made. The chemical characterization of Dorowa PR concentrate is reported, together with results from titration experiments with dilute acids. The prospects of increasing citric acid soluble P from Dorowa RP by sintering/fusion with soda glass, dunite and serpentine in various ratios is reported and an economic analysis made on the potential of such processes to reduce phosphate fertilizer costs in comparison to the conventional acidulated product.

SODIUM/CALCIUM THIOSULPHATE AS AN ALTERNATIVE NITRIFICATION INHIBITOR TO DCD

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Following the withdrawal of the nitrification inhibitor DCD by Ravensdown in 2012 there has been a significant gap in the mitigation tool box for the reduction treatments of both the greenhouse gas N_2O and nitrate leaching from dairy urine patches. Current developments by Pastoral Robotics Limited (PRL) to produce a commercial system Spikey®, for detecting and treating urine patch following urine dispassion has allowed the development of a range of spray treatment by Advanced Agricultural Additives Limited (AAA Ltd.) under the brand ORUN®.

The ORUN® range initially consisted of combinations of gibberellin, NBPT and AlpHa®Na designed to increase pasture N uptake by increasing pasture growth via gibberellin (ProGibb®).However, these effects are limited by available plant growth conditions prior to drainage and a nitrification inhibitor is required to broaden the ORUN® range.

As Spikey® only treats the urine patch area, pin point applications are now possible of inhibitors previously uneconomic for whole pasture application. AAA Ltd. in conjunction with PRL have identified and patented a range of Thiosulphate compounds which offer the equivalent effectiveness of DCD in soil incubation studies. Sodium thiosulphate (NaTS) solutions applied at rates from 62 to 185 mgS/kg in soil has been shown to produce comparable nitrification inhibition rates as DCD, with 62 and 125mgS/kg of NaTS producing 50 and 80% of the inhibitor effect of 10mgDCD/kg soil (at 20 ^{o}C with 300mg Urea-N/kg added to the soil).

POLYMER TECHNOLOGY TO IMPROVE UPTAKE EFFICIENCY AND DISTRIBUTION OF COBALT AND COPPER IN PASTURES

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Remediating trace element (TE) deficiencies in crops, pastures and livestock has a long history in NZ, where one solution has been to combine trace element compounds as powder and granules with macro-elemental fertilisers. These are then spread over the pasture to increase the TE concentration in the plant and thus, reduce the incidence of deficiency symptoms or poor thrift in the crop, pasture or livestock. However, the risk of uneven TE application increases, the smaller the rate of TE application per hectare, and this is exacerbated where the TE particle size is relatively small, compared to the macro fertiliser size, due to product settling that may occur during transport.

We present the results of a pasture trial testing a new polymer-coating technology (Surflex) that enables TE compounds to be evenly coated around the carrier fertiliser, improving distribution throughout the fertiliser. Such technology should improve herbage TE uptake whilst reducing physical consolidation and dust issues from the physical addition of the TE compounds.

A single application to a dairy pasture in March 2017 of two Surflex coated fertilisers incorporating cobalt (Co) and copper (Cu) as CoCO3 and CuO, respectively, to the surface of single super phosphate (SSP) were compared with a conventional standard TE counterpart and a control of straight SSP. The trial was run over three harvests with yield and plant analysis completed at each harvest. The results are presented looking at the potential of the Surflex technology to both improve the plant uptake efficiency and the spread of the TE across the paddock, whilst offering improvements in fertiliser handling and mixing.

FARM-SCALE SOIL MAPPING PROTOCOLS FOR NEW ZEALAND

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Farm Environment Management Plans and nutrient budgeting is now a compulsory regulatory requirement in a number of regions across New Zealand, and are reliant on quality soil information as a key input. The soil mapping protocol presented here provides standards and guidance to be used nationally for collecting and presenting soil map information. This Envirolink tools project was initiated by Regional Councils to address the need to provide: a framework for consistent soil mapping, identification of appropriate methods, a process to determine if the work has met minimum standards, and guidance on the level of detail required for different land use applications. This was to overcome the variety of soil maps and differing standards of work that could otherwise be generated and provided.

The generic approach used to prepare the soil mapping protocols is based on a quality assurance / quality control process that is applicable at a range of scales and land use applications, allowing the document to be a New Zealand Soil Mapping Protocol.

Standards for different land use applications (these can be expanded as required) are established for 6 procedures (site density, site distribution, soil characterisation, soil variation, provider, and review) that area necessary components of soil mapping. Each of these procedures has 3 levels of detail (low, medium, and high) that are defined along with accompanying guidance information. This provides a framework to determine what is expected to be conducted to construct a soil map for applying to a particularly land use application.

Following on from this, the work outputs can be inspected using a listing of what is expected to be provided. Finally, a self-assessment matrix allows for a summary of the level of work detail to be evaluated.

The entire protocol is contained in 4 tables, with the remaining text providing detailed guidance, rationale and explanation. The protocol is freely available online at http://www.envirolink.govt.nz/assets/Envirolink/Tools/R12-4-New-Zealand-soil-mapping-protocols-and-guidelines.pdf.

LEARNINGS FROM TEN YEARS OF HILL COUNTRY FARM PLAN MAPPING

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In 2004 the Valentines Day storm hit the lower North Island causing massive erosion and flooding. Horizons Regional Council, backed by research and local support, eventually secured ratepayer and government funding to provide hill country farm plans and tree planting assistance to farmers. The Sustainable Land Use Initiative – SLUI for short - is now in its 11^{th} year. Over 650 farm plans have been prepared, covering half a million hectares of land and 32,000 ha of tree planting and retirement has been done in partnership with landowners.

Our implementation confirms that a farm plan based around accurate resource maps provides the best basis for communicating, discussing and recommending actions on farm to address the erosion issue and other on-farm environmental issues. A key point is that the accuracy of any environmental recommendations is only as good as the accuracy of the soil or land use capability mapping that underpins it.

The paper will detail some examples of:

- the suitability of regional scale soil and land use capability information for making recommendations on-farm;
- additional information that was needed alongside the farm-scale Land Use Capability mapping in order to accurately prioritise land within farm plans for action;
- other learnings from the programme including where the big gains came from, social learnings, ability to model and report on the delivery of the programme and potential for future improvements.

ASSESSING CADMIUM UPTAKE IN NEW ZEALAND AGRICULTURAL SYSTEMS

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Soil cadmium (Cd) concentration is the primary indicator through which fertiliser-derived Cd is currently managed under the New Zealand Cadmium Management Strategy (MAF 2011). However, there is a lack of New Zealand-specific data on the soil Cd concentrations that actually pose a risk for New Zealand agricultural systems and how these risks might be managed. This paper presents an overview of the results from a two-year study on cadmium uptake into food crops (wheat, potato, onion and leafy greens), effects on soil rhizobia-clover symbiosis and uptake into lambs grazed on crops with a range of Cd concentrations. Specifically, this includes the results of field surveys of these crops in their primary commercial growing regions across New Zealand and field trials to assess the influence of lime and compost addition on plant Cd; studies to assess the toxicity of Cd to clover in the presence and absence of rhizobia, and the influence Cd on plant nitrogen content, and investigation of the accumulation in the livers of lambs grazed on ryegrass, lucerne, plantain and chicory. The implications for managing the risk associated with fertiliser-derived Cd are discussed.

CADMIUM ACCUMULATION IN CHICORY AND RYEGRASS WITH MODIFICATION OF SOIL pH

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Field trials were established in two contrasting soils (Kereone [total Cd 1.12 mg kg^{-1}, pH 6.1]; and Topehaehae [total Cd 0.67 mg kg^{-1}, pH 6.1]) to evaluate the effect of soil pH modification on soil Cd phytoavailability and Cd accumulation in chicory (Cichorium intybus) and perennial ryegrass (Lolium perenne).

Mean tissue Cd concentrations for chicory in both the Kereone and Topehaehae soils (2.265 and 2.701 mg kg^{-1} DM, respectively) were significantly ($P < 0.001$) greater than those for ryegrass (0.142 and 0.113 mg kg^{-1} DM, respectively).

Ultra-fine elemental sulphur and hydrated lime treatments were effective in producing a wide range in soil pH (approximately 5.0-6.5) in both soils. There was a strong negative (linear) correlation between 0.05 M $CaCl_2$ soil extractable Cd concentration and pH in both soils (R^2 = 0.82 and 0.64 for the Kereone and Topehaehae soils, respectively). Correspondingly, plant tissue Cd concentrations were negatively correlated to soil pH (chicory R^2 = 0.52 and 0.35, and ryegrass R^2 = 0.42 and 0.19, for the Kereone and Topehaehae soils, respectively). However, the correlation between plant tissue Cd concentration and soil extractable Cd concentration was weak (R^2 = 0.11 and 0.28 for chicory and ryegrass, respectively), indicating that 0.05 M $CaCl_2$ soil extractable Cd is a poor predictor of soil Cd phytoavailability across different soil types.

As ryegrass tissue Cd concentrations remained low (<0.3 mg kg^{-1}) across the entire pH range imposed, there appears little risk of increased animal dietary Cd exposure when grazing this plant species, even in Cd-enriched soils at low pH. In contrast, this trial indicates that soil pH should be increased to a minimum pH of 6.5 to decrease animal dietary Cd exposure risk when grazing chicory.

TRANSFER OF CADMIUM TO ANIMALS FROM FORAGES

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Knowledge that forage crops will accumulate a significantly higher concentration of cadmium (Cd) than ryegrass and clover has been well publicised in New Zealand scientific communications over the past three years. Chicory, in particular, can accumulate a Cd concentration in the order of 5 mg/kg (dry weight DW) which is 50 times more than rye grass (0.1 mg/kg). The question that must be asked is 'so what'? Guidelines already prohibit the human consumption of offal from sheep and beef older than 30 months to mitigate risk of Cd exposure, and there has been no reports of Cd accumulation in meat and milk. So from the perspective of animal residue levels, Cd in forage crops is only an issue if retention in animal's bodies is at a rate much quicker than is currently expected.

Over the summer of 2016/2017, groups of lambs at four locations around the North Island (Tangimoana, Waipukurau, and two farms near Taihape), were separately fed ryegrass or one of lucerne, chicory or plantain. Serial liver biopsy samples were taken at up to four time points, over an approximately four-month period. The Cd concentration in liver samples was determined, and compared with the Cd concentration in forage at the time. The maximum Cd concentration in chicory (0.85 mg/kg FW) was significantly higher than in rye grass at the same farm (0.04 mg/kg) and this transferred to a significantly higher concentration of Cd in liver (0.74 and 0.13 DW for chicory and rye grass respectively). However, at no time did the Cd concentration in liver exceed the European Commission or New Zealand maximum limit (fresh weight) for Cd in foodstuffs.

The results from this initial study have provided a first insight into the impact of forage crops on trace element cycling in animals. Ongoing work will assess whether Cd is excreted once diet changes, and the interactive effect of other elements such as Zn and Cu (which can also be high in forage crops) on Cd retention.

THE 20 YEAR EVOLUTION OF WAIKATO REGION SOIL QUALITY MONITORING

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Soil quality monitoring in New Zealand started in 1995 with a national project to test methods and provide data about sustainable land use for state of the environment reporting. Results from the original project and subsequent regional soil quality monitoring programmes have provided a simple sampling strategy, basic indicators and interpretive framework that has enabled New Zealand to obtain and report on soil quality information where none existed prior to 1995.

The monitoring programme developed in the national research project had limitation; inadequate site representativeness due to the uneven regional participation, the intensity of sampling undertaken, and whether sampling was targeted towards certain land uses perceived to be at risk.

However, the programme succeeded in developing a pragmatic national soil quality monitoring programme capable of providing sufficient data to identify soil quality issues for “State of the Environment” reporting at a national scale. In 2003 a review of the national programme guided the establishment of the ongoing regional soil quality monitoring programmes in the Waikato and other regions. There are currently 13 regions with soil quality monitoring programmes, while the number of sites has increased from the original 511 sites (across nine regions) to over 1000 across the 13 regions.

The Waikato soil quality monitoring programme now has data (including data from the original national project) for 148 sites, across nine Soil Orders and six major landuses. The resampling of the same sites over a 20-year period (some up to four times) provides trend data and insights into the strengths and weaknesses of the established regional programme and the original national project.

Collectively, the regional monitoring programmes have contributed to regional and national state of the environment reporting for soil quality, established trends by measuring changes on the same sites, provided the opportunity to improve site representation and methods, and increased communication between regional authorities and scientists. This paper revisits the original design and objectives of the soil quality monitoring programme, assesses the reasons for the programme’s success, how it has responded to issues with consistent methodology, development of new measurements of soil properties, and addressed research gaps.

LONG TERM MONITORING OF SOIL QUALITY INCLUDING TRACE ELEMENTS IN THE WELLINGTON REGION

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There is increasing competition between the demand for land functions that provide food, water, and energy, and those services that support and regulate life cycles. Pressures on land include application of contaminants and nutrients, the effects of which can include reduced provisioning, regulating and cultural services. There can be increased risk of losses to water bodies, contributing to changes in the composition of biological communities or impact on human and animal health.

Recent regulation and implementation of policy initiatives, such as fencing stream margins by regional councils can mitigate some nutrient and contaminant losses. Several recent studies however, show that current stream fencing policy initiatives alone may not be sufficient to improve water quality as needed. Mitigations which reduce diffuse contaminants at their source are likely to be more cost-effective.

Monitoring of soil quality provides evidence for determining the effectiveness of planning and implementation for environmental protection, and acts as an early warning system for emerging issues. Soil quality is therefore an essential link with nutrient and contaminant source, farm practice and to inform policies to improve farm management and water quality. There are few studies that have reported on soil quality monitoring over the long term in New Zealand or internationally. A recent study reported on soil quality monitoring over 20 years in the Waikato region.

This paper reports on key indicators from soil monitoring over a period of 18 years (2000 to 2017 inclusive) in the Wellington region. Farm systems or persistent land use monitored include drystock, dairy, market gardening, mixed cropping, horticulture, exotic forest and native vegetation. A key question we focus on in this paper is how the indicators change over this period. In a longitudinal analysis, repeated measurements of a site are made at different times. We report on this analysis for key indicators including phosphorus, macroporosity (compaction) and cadmium.

PLANNING FOR CHANGES IN TOPSOIL C AND N STOCKS – SIGNIFICANCE IN C AND N BUDGETS

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New Zealand has a history of rapid land use change as trends in global commodity markets influence primary sector financial sustainability. Traditionally, low sheep and beef returns accelerate extensive pastoral land use change to forest, particularly if supported by afforestation schemes (e.g. AGS and ETS). High dairy payout accelerate forest change to intensive pasture. Current debate around the agricultural sector participating in a carbon (C) economy is spreading in New Zealand, coincident with debate on de-intensification to reduce impacts on water quality. Farms including planted forest lands may be rewarded if they are able to show a decrease in nitrogen (N) loss to water and an increase in the terrestrial sink of C. While soil carbon change is not accounted for in the ETS a change from forest to pasture penalises the landowner for the reduction in biomass C with no reward or penalty for change in soil organic matter C and N. To account for soil carbon change, protocols to measure and monitor topsoil organic C and N storage at the farm level are needed. Evidence for consistent quantifiable change is required to support inclusion of soil organic matter change in both C and N accounting. Previous research in the Taupo (Central North Island) area has shown that conversion of forest land back to productive permanent pasture caused a fast accumulation of soil organic C (6.1 t C/ha/y) and of N (450 kg N/ha/y) as a response to fertiliser addition and plant productivity.

In this paper we provide a case study of topsoil organic matter change in a forest to pasture conversion in the Taupo region. 42 paddocks from three sites (Tainui, Tauhara and Waimana; Wairakei Estate, Taupo) were monitored in 2017. The paddocks are currently under pasture management after recent (2-11 years ago) conversion from former planted forest. Marked differences in the storage of C (38 to 51 t C/ha_{15cm}) and N (1.8 to 3.4 t N /ha_{15cm}; Waimana site) were detected. The relevance of these changes to C and nutrient budgeting are discussed in relation to how such large and important changes can be accounted for.

ARE SOIL CARBON STOCKS CONTROLLED BY A SOIL'S CAPACITY TO PROTECT CARBON FROM DECOMPOSITION?

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Greenhouse gas emissions can be reduced by increasing soil organic carbon (SOC), but the factors controlling SOC must be understood so that management changes can be identified to increase SOC. It is known that soils differ in their ability to stabilise SOC. But is SOC stabilisation limited by a soil's maximum protective capacity to stabilise carbon, or do soil stabilising properties act to reduce SOC turn-over rates without defined upper limits? Here, we use observations from two specific New Zealand sites, and from a national soils data set to gain insights into the controls of SOC stabilisation.

They showed:

- When other factors such as climate, soil fertility, plant species and pasture management were the same, SOC was highly (r^2 = 0.84) linearly correlated with the soil's specific surface area (SSA).
- At each soil depth, there were linear correlations between SOC and SSA, with the slopes of the relationships decreasing with depth.
- The linear relationships had intercepts close to zero at zero SSA. That implied that SOC was protected by the soil matrix rather than biochemically, that mineral surface area was the functionally relevant measure of stabilisation capacity, and that its effectiveness was independent of carbon input rates.
- We analysed the national soils data for evidence of a maximum stabilisation capacity. We reasoned that for a given SSA, is SOC were limited by a maximum stabilisation capacity it would have to result in a skewed distribution of SOC around mean values. Some points could be much lower than the maximum stabilisation capacity, but points could not exceed the maximum stabilisation capacity. SOC in the national data set, however, was nearly normally distributed, thus being inconsistent with maximum stabilisation capacity as a SOC limitation.
- An international data set also showed no consistent skew in SOC observations to provide additional evidence against the presence of a maximum stabilisation capacity.
- Instead, our analysis suggests that SOC, C, can be described as: C = i s/t, where i is the carbon input rate, s is SSA and t a specific turn-over rate.

DISTRIBUTION OF CARBON IN SIZE-FRACTIONS OF A PASTURE SOIL 26 MONTHS AFTER ADDING BIOCHAR

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Fractionating soils according to size and/or density of particles improves our understanding of the importance of interactions between organic and inorganic soil components on the turnover of soil organic carbon (SOC). Conventional soil physical fractionation methodologies misrepresent the contribution of pyrogenic C (e.g., biochar-derived C) to the total SOC because of the relative long turnover time of this fraction, regardless the physical SOC physical fraction in which this is found. In this study, a combination of particle size fractionation and wet sieving, as well as chemical analysis (dichromate oxidation) was tested to isolate meaningful SOC fractions in a set of 34 soils with C content ranging from 19.1–43.0 g SOC/kg soil. Topsoil and subsoil samples were obtained after 26 months of simulating cultivation at pasture renewal including pine biochar (10 t/ha) as amendment (below 10 cm depth) and growth of contrasted plant species (ryegrass vs a mixture of red clover and cocksfoot) in a lysimeter experiment using a silt loam soil (Tokomaru soil, a Pallic soil with limited drainage at depth). Across all the soils considered, the allocation of SOC in size-fractions (i.e., 2000-200, 250-53 and <53 m) was obtained by conventional wet sieving. Additionally, the total content of resistant forms of SOC (i.e. both alkyl C forms and pyrogenic C from biochar) was calculated as the sum of the dichromate-resistant C obtained in the different size-fractions fractions. This sum of all dichromate-resistant C pools can be used as a proxy to estimate contribution of pyrogenic C to the total SOC in the soils studied.

The different C fractions isolated by the appropriate combination of methodologies (particle size fractionation, wet chemistry) is proposed as an alternative to obtain the particulate, humus and resistant organic carbon fractions (POC, HOC and ROC, respectively) used in models (e.g. RothC). The developed methodology will help to improve the prediction of SOC dynamics and any impact of climate change on SOC stocks when these contain pyrogenic C.

INVESTIGATIONS INTO THE EFFECTS OF CADMIUM STRESS ON *SPINACEA OLERACEA* AND RETENTION PROPERTIES IN SOIL IN RESPONSE TO COW DUNG AND CHARCOAL AMENDMENTS

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Vegetables grown in Pakistan are irrigated usually with wastewater originated from industries in Pakistan. The wastewater from household, municipal and industries contains a variety of organic and inorganic contaminants including metals. It can cause several bio-security issues and risks to human health.

The aim of present study was to evaluate the effects of Cd stress from synthetic irrigation wastewater on test plant *Spinacea oleracea* **(**spinach) and subsequently development of a strategy to mitigate the stress. In this study, spinach was grown in triplicate in earthen pots with two types of amendments namely cow dung and charcoal (from *Vachellia Karroo* wood at 500^{0}C). Cow dung was collected from a village near Gujrat city (Pakistan) in sun dry form.

The impacts of Cd stress on soil and plants were evaluated using different physico-chemical analysis after sample preparation using di-acid digestion procedure.

Two different organic amendments i.e. cow dung and wood charcoal was added into 2 kg soil prior to sowing @ 20 and 30 t ha^{-1} to check the kinetics and retention properties of Cd in soil and plants. Almost 7-8 seeds of spinach were sown in each pot which was later thinned to 5 plants per pot after one week of germination. After three weeks of irrigation water (without Cd) application, Cd contaminated synthetic wastewater @20 mL per week per pot of 100 µM of metal Cd solution was applied. At sixth week, plants were cut 5 cm above the top of the plant.

Results from this experiment are presented in the poster.

UNDERSTANDING OF THE BIOAVAILABILITY OF SOIL CADMIUM IN NEW ZEALAND CROPS LAND

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The total and potentially phyto-accumulated soil Cadmium (Cd) in New Zealand (NZ) differ at various levels of phosphate fertilisers and soils properties. In order to assess the main soil factors determining Cd uptake into plants based on NZ soil environment, a soil survey covering key agricultural crops throughout NZ was carried out. To seek an optimal method to understand the soil-plant relationships involved Cd, we are applying DGT technology to predict soil bioavailable Cd. The better understanding the relationship between soil bioavailable Cd and plant Cd provides a baseline assessment of Cd uptake into New Zealand crops, and insight into management practices that can reduce plant uptake of Cd.

DETERMINATION OF THE CD UPTAKE MECHANISM IN FORAGE SPECIES IN NEW ZEALAND LIVESTOCK GRAZING SYSTEM

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Cadmium (Cd) is a key environmental contaminant associated with long-term high application rates of superphosphate fertiliser particularly on soils used for dairying and horticulture. Although cadmium (Cd) is considered to be a non-essential element for plants, it is effectively absorbed by the root systems of many plant species and can be subsequently transported throughout the plant. Recent studies indicate that elevated levels of Cd in New Zealand soils can lead to a cadmium concentration in forage species such as Chicory (*Cichorium intybus L)* and Plantain *(Plantago lanceolate L)* that is orders of magnitude higher than in ryegrass or clover. The results of such studies suggest different abilities of pastoral species used in New Zealand to both absorb Cd from soils and to translocate this from roots to shoots. However, there have been no studies published on the Cd uptake mechanisms of common forage species used in New Zealand agriculture. Ongoing research into rhizosphere chemistry and Cd uptake mechanisms of such species will help to understand species and cultivar variations in Cd uptake, and associated rhizosphere soil functions.

Literature reviewed for the doctoral research underpinning this presentation has identified the research gap that must be addressed to better understand Cd uptake mechanisms in forage species and to propose advanced analytical methods to quantify the forms of plant tissue Cd in New Zealand livestock grazing system.

EFFECT OF FLUORINE ON *RHIZOBIA*:

A RESPIRATION-INHIBITION ASSAY

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The soil fluorine (F) concentration in New Zealand agriculture soils has increased over time as a direct result of the widespread application of phosphate fertiliser to land. Elevated soil F concentrations may be harmful to soil microorganisms which are important for nutrient cycling and soil formation.

Rhizobium leguminosarum is a nitrogen fixing soil bacteria which is a fundamental component in New Zealand legume-based pastoral farming, and any impact of F on *Rhizobium leguminosarum* would have an adverse effect on New Zealand pasture production. Quantifying the effect of F on *Rhizobium leguminosarum* is therefore necessary to ensure that the increasing F concentration of New Zealand soils does not threaten the value of this ecosystem service. Initial efforts are being made to determine Inhibitory Concentration (IC) limits for F toxicity to *Rhizobium leguminosarum* as a first step to develop F guideline values for New Zealand agriculture soils. In this context, IC_{10} is defined as the fluoride concentrations that causes 10% inhibition of *Rhizobium leguminosarum* respiration.

The fluoride IC_{10} value for *Rhizobium leguminosarum* was determined using the MicroResp 96-well format respiration-inhibition assay. Three different F salts (NaF, KF and NH_4F) were used in an attempt to differentiate any cation affect from the fluoride ion. Replicate plate wells were charged with YM broth (YMB), varying concentrations of NaF, KF and NH_4F (0, 10, 20, 50, 100, 200, 500 and 1000 mg F^-/L), and *Rhizobium leguminosarum* (strain TA1). The resulting microplate was sealed and incubated for 24 hours at 27ºC, and absorbance differences (ΔA_{590}) were measured using a plate scanner.

The determined IC_{10} values (solution) for fluoride toxicity to *Rhizobium leguminosarum* were higher than 100 mg F^-/L for each of the F salts used in the assay. This concentration is orders of magnitude higher than those recorded for New Zealand agriculture soils under ‘normal conditions’. Therefore, there is no indication of imminent risk of soil F to *Rhizobium leguminosarum.*

USING GIS ANALYSIS OF LIDAR DATA TO PREDICT BEST SITES FOR CONSTRUCTION OF STORM WATER DETAINMENT BUNDS

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Storm water surface runoff is the primary conduit of pastoral phosphorus losses in many New Zealand catchments. By targeting storm water, Detainment Bunds (DBs) may be able to mitigate the phosphorus load carried by storm water.

DB's are subtle low profile raised earthen berms specifically constructed across valley floors that intercept and temporarily detain storm water runoff to settle suspended particulates and adsorb or infiltrate dissolved contaminants. Importantly, DBs can be managed to minimise ponding time to prevent pasture damage. So, DBs offer the exciting potential to mitigate phosphorus loss without reducing pastoral production.

In 2016, pastoral farmers in the Rotorua lakes catchments developed an applied research project dedicated to advancing knowledge of DBs, the Phosphorus Mitigation Project (PMP). The PMP aims to quantify DB efficacy across farm systems, for phosphorus and sediment mitigation.

Presently, we remain uncertain if DB's can operate effectively and widely across New Zealand's farming landscapes and various pastoral systems. Despite this, over 20 early adopter farmers in the Central North Island have constructed DBs for varying reasons (e.g., for downstream storm water damage control, sediment capture, phosphorus capture, prevention of erosion). However, more widespread uptake of DB's is hindered by three unknowns: (1) robust DB performance estimates for phosphorus and sediment; (2) knowledge of DB suitability across landscapes; and ultimately (3) cost-effectiveness of DB's over other on-farm mitigations.

Here, we demonstrate a method, using GIS analysis of LiDAR data, to determine landscape suitability for DB emplacement. This methodology is able to readily predict potential suitability for DB sites across diverse landscape types at national and finer scales within New Zealand. Our intention is a proof-of-concept that DB's can be "scoped" quite readily with appropriate GIS data so that when validation of DBs is concluded (pending B Levine PhD due 2019), roll out of the DB mitigation tool can progress rapidly where landscape conditions are suitable.

COMMUNITY WASTEWATER PROJECTS AS A CATALYST FOR DEVELOPING CATCHMENT MANAGEMENT ENHANCEMENT PROGRAMMES

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Community wastewater discharges to water are often seen as being significant contributors to nutrient and pathogen loads in a much larger catchment, typically as a result of the scrutiny during resource consent public engagement processes; this is something that individual farms and the catchment as a whole are not subject to. In order to provide the required information for the consenting engagement process, considerable background investigations are often undertaken to demonstrate the effects of the community discharge, and in many cases this highlights the relative contributions made to the catchment's river system from land use in general and specific discharges. This information can then be used to initiate a community discussion as to where effort should be placed, specifically a discussion about key values; being cultural, economic, financial and recreational/social values.

Surface water discharges are often considered by communities to be undesirable and the major contributor to poor water quality, which must be addressed. However, in many cases there is potentially much greater environmental, recreational, financial and cultural benefit to be gained by investing in the health of waterways rather than investing in further treatment of wastewater, or completely changing the treatment or discharge system.

Recent work has shown that the cost per kilogram of nitrogen removal for a wastewater treatment plant could be tens to hundreds of times more expensive than initiating rural catchment improvements such as good farm management practices to achieve similar overall results. With many rural communities being fiscally constrained, and recognition that everyone has to do their part, it is clear that a holistic catchment approach offers benefits.

Initiation of catchment management programmes driven by wastewater discharge consenting processes in three catchments; Whangawehi, Mahia Peninsula; Waiwiri, Horowhenua; and Wairoa, Hawke's Bay will be discussed in this paper. These three catchment programmes provide an outline of the different stages of catchment management and highlight the importance of community engagement.

While seen as being complex and often considered in isolation, the need to consent community wastewater discharges has shown itself to be a valuable catalyst for initiating and supporting catchment management enhancement programmes.

'LEADING INDUSTRY' LAND TREATMENT SYSTEMS FOR DAIRY FACTORY WASTEWATER– 'NEW FRONTIERS' IN NUTRIENT MANAGEMENT

Jeff Brown

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The new Fonterra Group Environmental Policy (version 4.0) requires that Fonterra '*minimise the impacts of discharges on the environment and ensure that farm and factory waste is treated to leading industry standards*'. 'Leading industry standards' is defined as '*current industry best practice, acknowledging regional considerations and that these standards may shift over time. In the context of water discharge, this means the systems and practices which are considered leading within the dairy industry globally'.* The latest date to achieve compliance with these self-imposed targets is 2026.

For Fonterra's 16 New Zealand sites utilising land based treatment for the factory process wastewater, 'leading industry standards' has been assessed as achieving a 'whole farm' nitrogen leaching value in the range of 20-30 kgN/ha/yr as determined by Overseer. Traditionally, wastewater irrigation farms involved dairying operations. High nutrient loads and wastewater volumes, in combination with dairy, could see annual nitrogen leaching values in the range of 70-90 kgN/ha/yr (depending on climate and soil types). Farming system e.g. dairying versus dry stock with cut and carry silage removal, is a key lever that can influence nitrogen leaching results. Two other key levers are wastewater nitrogen load and the hydraulic load (monthly irrigation depth) of the wastewater.

This paper presents results from a case study of a land treatment system where farming system, nutrient load and hydraulic load are all optimised in order to meet a leaching value of 30 kgN/ha/yr. It was found that a combination of a dual discharge regime (surface water and land irrigation) plus decoupling of nutrient load versus hydraulic load (via wastewater treatment prior to irrigation) was capable of delivering the desired outcomes. Additional benefits of the optimised system will likely involve lower sodium, potassium and phosphorus loadings to land, drier soils via less irrigation during wetter periods, and resulting improvements in soil health plus pasture growth rates.

USE OF LIFE CYCLE ASSESSMENT (LCA) TO FACILITATE CONTINUOUS IMPROVEMENT OF ON-FARM ENVIRONMENTAL PERFORMANCE: A SHEEP DAIRY CASE STUDY

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While originally developed for industrial operations, the application of Life Cycle Assessment (LCA) methods in the agricultural sector is growing; to date it has primarily been utilised for carbon footprinting but can be used to assess a wider range of environmental issues. An LCA provides an evaluation of resource use and the environmental emissions of a production system and/or products along the life cycle from extraction of raw materials, through manufacturing, distribution and on to use and waste management. Utilising a Life Cycle Assessment (LCA) as a tool to support continuous improvement of on-farm environmental management can support the emerging sheep dairy industry in realising and demonstrating more sustainable farming practices.

This case study assessed the following stages in the life cycle of sheep milk: raw material extraction, feed production, sheep rearing and milking. The following activities were assessed: the manufacture and application of agrichemicals, on-farm and external feed production, sheep emissions, milk production, and the generation and use of fuels and electricity. The aims of the study were to: (i) identify environmental hotspots in New Zealand sheep dairy farming and potential mitigation strategies, and (ii) formulate key performance indicators (KPIs) for a prototype LCA-based environmental certification system. The LCA assessed twelve impacts: Climate Change, Fossil Depletion, Freshwater Ecotoxicity, Freshwater Eutrophication, Human Toxicity, Marine Ecotoxicity, Marine Eutrophication, Metal Depletion, Particulate Matter Formation, Photochemical Oxidant Formation, Terrestrial Acidification, and Terrestrial Ecotoxicity.

The results showed that both the off-farm and on-farm stages contributed to environmental impacts and that the relative contributions of the life cycle stages varied across different impact categories. In general, the production and use of fertilisers, application of pesticides, and enteric fermentation of livestock were found to be the biggest contributing sources. Sensitivity analyses were conducted using alternative farm scenarios: (i) alternative pesticide (ii) on-farm rearing of replacement lambs and (iii) maize grain feed. Based on the study, it was concluded that the KPI framework should focus on (i) the appropriate use and management of agrichemicals, with a risk assessment on the risk of pesticide drift conducted, (ii) Re-calculation of carbon footprint with any major changes in stocking rates (iii) Preparation of a soil map stating the different soil types present and the identification of areas prone to compaction, erosion, runoff and leaching.

MAPPING AND MODELLING ONIONS

– IMPLICATIONS FOR NITROGEN APPLICATION

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Four years' experience mapping onion crops gives confidence that image analysis provides a reliable method to assess canopy development. A prototype smartphone based tool has been developed to capture and process images and link the result to a GPS location at least once per second. Crops can be readily surveyed at three leaf stage using tractor mounted equipment. Kriging and data analysis enables production of stratified zone maps of apparent ground cover.

For three years we have established replicated measurement plots within different zones. Ground cover assessments are combined with population counts to classify if the crop is at a potential or if it is limited by growth, population or both.

At the LandWISE MicroFarm we now have evidence of areas that are stable high growth and stable lower growth. This indicates soil effects, and although the actual causal factors have yet to be identified, drainage and soil physical properties are implicated.

Work to use the survey and population data for yield prediction is ongoing. A critical factor is relative growth stage which we measured by leaf number. Recent observations suggest an alternative such as growing degree days may be better.

We have used the management zones to question management decisions including fertiliser management and agrichemical rates.

Applying excess nitrogen has downsides including reduced storage quality and increased leaching risk. There is some indication it may be associated with increased disease susceptibility.

In a zone where canopy cover was about half that of an adjacent unlimited zone, we trialled half fertiliser against full (normal practice) rates. In a full canopy area, supported by Quick Test assessments of available nitrate-N, we also compared fertiliser timing, delaying any application until bulbing. Results will be presented.

We have first evidence that the difference in canopy volume between zones affects disease risk. In a high disease pressure year like 2017-18, we have seen the best areas of the MicroFarm badly affected by mildew while the lower volume areas appear more resistant. Potential causes include lower relative spray deposition rates and cover and higher intra-canopy humidity.

CARBON FORESTRY AS A DRIVER FOR LAND USE CHANGE

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Land use change in New Zealand towards a mosaic of forested and pastoral landscapes may occur through regulatory and market drivers. The implications for natural resource research programmes and consultants in this area is quite significant. Carbon sequestration to meet the Paris Agreement limits by 2030 is likely to be the short-term driver. Longer term public expectation on water quality and animal welfare will add to this.

Government's "one billion trees" proposal together with signals that agriculture sector emissions may be brought into the ETS have heightened interest in tree planting. However, modelling the carbon and financial implications of tree planting presents several significant complications for analysts, and there has been some inconsistency in how these are addressed. Tree planting can serve multiple purposes, and these multiple objectives need to be explicitly recognised in a more integrated analysis.

This paper describes work undertaken to "demystify" small scale carbon forestry for landowners, as a step towards removing some of the barriers to participation in the Emissions Trading Scheme. Difficulties arise in addressing the 'permanence" of carbon sequestered by trees, affecting the degree to which on-farm emissions can be offset and the benefit to the landowners from ETS participation. While more demand for carbon units to offset agricultural emissions would go some way towards making carbon forestry more financially attractive to landowners, there is abundant evidence that this will not in itself lead to the desired land use change. There is a need to develop economic and financial metrics that resonate with land managers, and to understand their broader objectives.

More generally, sustainable land use and intergenerational equity requires analyses that consider ecosystem services, social license to operate, health and safety, and resilient cash flows. Through the integration of these factors, the best use of NZs finite land resource may be better rationalised.

UNDERSTANDING NITROGEN FLOWS THROUGH GRAZED WINTER FORAGE CROPS: OBSERVATIONS FROM NEW ZEALAND RESEARCH

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Grazing winter forage crops in situ in winter means that a large proportion of the consumed nitrogen (N) will be returned as excreta, on to bare soil, at a time when rainfall generally exceeds evaporation and is therefore susceptible to N leaching loss. A number of studies on winter forage crops have now been completed, most recently under the Pastoral 21 (P21) research programme, but also in other projects. The completion of the P21 programme provided opportunity for collation of experimental data and identification of the key messages from the data.

The dataset comprised of experiments that measured N leaching at the paddock-scale (using porous cups or measuring drainage from a pipe and mole system) or urine patch-scale (lysimeters or small plots).

At the paddock-scale, there were, in total, about 15 experiment years of leaching data covering a range of circumstances. The majority of measurements in paddocks were made with grazed brassicas, with only three years of fodder beet data. Nitrogen leaching losses were variable, but the trends appeared to be: on free-draining soils, mineral N leaching losses from brassicas were >80 kg N/ha and fodder beet <45 kg N/ha; generally, mineral N leaching loss from grazed brassicas on the heavier textured Pallic soils was <45 kg N/ha, i.e. about half that of free-draining soils.

The lysimeter studies showed that an amount of N equivalent to 52% of the applied urine N was lost by leaching, although this was highly variable (range 26-80%). Thus, even though the lysimeters represent the worst case situation (i.e. loss directly under a urine patch on a bare soil) only half was apparently lost by leaching. There was no obvious explanation for the difference in the range of reported losses, although the dataset was too small to test for direct relationships. The lysimeter studies demonstrated the effect of grazing date on N leaching (with less N leached from grazing events later in the drainage period), and indicated scope for a catch crop to capture some of the leachable N if established soon after grazing.

Further research is required to develop greater understanding of nitrogen flows through the winter forage crop system, and implications for losses to the environment and for developing mitigation strategies.

CAN WE PROVE MODELLED MITIGATION STRATEGIES WORK ON FARM?

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Demonstration farmlets in four regions of New Zealand (Waikato, Manawatu, Canterbury and Otago) were designed to investigate options to reduce nitrate leaching from dairy farms as part of the Pastoral 21 (P21) research program (funded by MBIE, DairyNZ, B+L New Zealand, Fonterra and the Dairy Companies Association of New Zealand). These farmlets ran from 2011 to 2015, the practicality, production, profit and nutrient losses to water of a system currently typical (Current) for the region was compared with an "increased efficiency" (Future) system.

The Future systems were designed to achieve increased profitability and decreased nutrient losses to water by implementing strategic changes to the current system that were previously evaluated in farm system modelling. Some changes had been shown in an earlier systems modelling study to have potential to deliver reduced emissions of greenhouse gases.

Here we evaluated the effects of these system changes on GHG emissions through comparing current and Future dairy systems in Waikato, Canterbury and Otago in an NZAGRC funded project. Annual average GHG emissions for each system were estimated for three (Canterbury and Otago) or four (Waikato) years, using calculations based on the New Zealand Agricultural Inventory methodology. This methodology uses estimates of dry matter intake, N inputs, and N leaching losses, in combination with CH_4 and N_2O emission factors. The effects of system changes designed for N leaching mitigation on the GHG footprint of the P21 farmlets will be presented.

TO GRID OR NOT TO GRID
– A REVIEW OF SOIL SAMPLING STRATEGIES

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Soil sampling assesses the nutrient status of the soil from which fertiliser and lime recommendations can be made. Spatial variability of soil fertility between and within paddocks can lead to over and under fertilisation. Traditional soil sampling treats paddocks as homogenous areas of similar soil fertility. More in depth sampling strategies such as all paddock, grid and directed soil sampling aim to look at soil fertility spatially with the aim to improve return on investment of crop yield or pasture production. This review looks at the advantages and disadvantages of traditional, all paddock, grid and directed soil sampling and aims to identify opportunities for each strategy to be used. The authors conclude that when deciding what strategy to use the variability in soil fertility, maximum crop/pasture yield and crop/pasture value need to be considered.

THE LONG-TERM ROLE OF ORGANIC AMENDMENTS IN BUILDING SOIL NUTRIENT FERTILITY: A META-ANALYSIS AND REVIEW

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An exhaustive meta-analysis of 132 long-term (≥ 10 yr) studies worldwide was carried out to determine the effects of the use of organic amendments (OA) and OA + inorganic fertiliser (IF) on soil nutrient fertility.

The responses of (i) crop yield [over the whole duration of the period ($yield_m$) and at the end of the experiment ($yield_f$)], (ii) soil organic carbon (OC), (iii) size of microbial biomass, and (iv) Olsen phosphorus (P) to OA and OA + IF compared with IF only (*standard control*) and no fertilisation (*nil control*) were investigated.

The overall effect of OA alone on yield was significant when compared with the *nil control*, but not when compared with the *standard control*. Only when OA and IF were added to soils that met specific conditions (low initial fertility, sandy texture, near-neutral pH values, under tropical climate) they rendered a significantly greater $yield_f$ than the corresponding *standard controls*.

The continuous application of manure caused greater relative and absolute gains in soil OC than straw + IF but did not produce significant greater yields while causing a considerable increase in Olsen P over time. The use of OA and OA + IF increased the resilience of agronomic systems over that of IF alone, as inferred from the smaller coefficient of variation of crop yield over time.

We conclude that while the use of OA along with IF provides some additional benefits on yields as compared with IF application alone (especially under the above-mentioned conditions), the selection of the OA type and application rate should be carefully considered in order to maximise the nutrient use efficiency and minimise any undesirable effects to the environment.

DAIRY COMPOSTING BARNS CAN IMPROVE PRODUCTIVITY, ENHANCE COW WELFARE AND REDUCE ENVIRONMENTAL FOOTPRRINT: A SYNTHESIS OF CURRENT KNOWLEDGE AND RESEARCH NEEDS

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Dairy composting barns involve innovative technologies that collectively address dairy farm productivity, cow welfare and environmental footprint, with transformational potential for New Zealand dairy. The technologies were developed overseas. The underlying principle is that dung and urine combine with biological bedding materials to produce *in situ* composting within loafing barns, and cows rest on this dry compost. Key requirements are appropriate infrastructure design and associated air movement, combined with twice daily tilling by tractor. All liquid is removed by natural evaporation, facilitated by internal compost temperatures of approximately 55 degrees C. The external compost temperature provides a comfortable resting surface, with compost typically replaced once per year. In New Zealand, there are probably no more than four operational composting barns, but with multiple others planned. They are used within high performance hybrid pasture-grazing systems. Compared to most other bedding systems, and assuming appropriate management, cows remain remarkably clean and healthy. This facilitates barn-use for lactating cows, with usage determined by seasonal grazing rules and weather-related conditions.

We have been monitoring two such farms, both designed with cow welfare and productivity paramount, and with minimal focus on leaching. As such, it is notable that although enhanced animal welfare and markedly improved productivity criteria have been met, there remains considerable scope for reducing nitrogen leaching without further radical farming-system change. A cautionary note is that some other farms have failed with composting barns. The reason has been a failure to understand fundamental elements of composting-barn systems, including both structure design and management.

If dairy composting barns are to become mainstream in New Zealand, then R&D investigations are needed. Investigations need to span the farming system, but with particular focus on composting processes and outcomes using a range of bedding materials, and in different geographical locations. Also, investigations are needed of nutrient loss within the compost, together with the effect of adding composted nutrients to soils at different C: N ratios, and across different soil types. Monitoring of commercial farms can provide major insights but structured investigations are also needed within more formal R&D settings. Accordingly, this paper is a call to action.

ENVIRONMENTAL EVALUATION OF ONCE-A-DAY MILKING ON A PASTURE-BASED DAIRY SYSTEM IN NEW ZEALAND

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Twice-a-day (TAD) milking is predominantly used in pasture-based dairy farming in New Zealand. However, once-a-day (OAD) milking is an alternative production system and is becoming more common among dairy farmers. The environmental impacts of OAD relative to TAD farming systems have not been examined to date, and this study used a cradle-to-farm gate Life Cycle Assessment (LCA) approach to quantify twelve environmental impact indicators for an OAD pasture-based dairy farm in the Manawatu. The functional unit was 1 kg of fat- and protein-corrected milk.

The results showed that the on-farm stage was the key hotspot in 10 out of 12 indicators (contributing > 50% to the total impacts). The off-farm contribution of the rearing of replacement animals was between 7% and 24% for the different impact categories. The contribution of the off-farm production of brought-in feed was negligible (ranging from nil to 1% of the total impacts), due to low use of brought-in feed. The contribution of the manufacturing of agrichemicals (fertilizers and pesticides) was substantial for the impacts on Ozone Depletion Potential (ODP) (32% of the total impact), Human Toxicity-Cancer (20%), Particulate Matter (11%), Ionizing Radiation (IR) (35%), and Ecotoxicity for Aquatic Freshwater (27%). Transport of farm inputs for use on the farm accounted for 7% of the total impacts for the ODP and IR indicators.

The environmental profile of milk from the OAD case study farm compared favourably with the average environmental profile of both low and high intensity TAD dairy farms in the Waikato. However, this was at least partly due to the relatively low amount of brought-in farm inputs (in particular, brought-in feed). Further studies should be undertaken of other OAD farms in order to substantiate the conclusions of this study.

THE POTENTIAL OF PLANTAIN BASED PASTURES TO REDUCE NITROGEN LOSSES FROM DAIRY SYSTEMS

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Agriculture & Environment, Massey University

Plantain (*Plantago lanceolata*) appears a sustainable option to reduce urinary nitrogen (N) excretion from cows thereby minimising the nitrate (NO_3-N) leaching from pastoral dairy systems. The potential of plantain to decrease NO_3-N leaching while maintaining, or increasing, milk production is being evaluated in a dairy systems experiment at Massey University's Dairy Farm No 4.

Three pasture treatments were established in a complete randomised design with five replicate plots (800 m^2), with an isolated mole-pipe drain system for each plot to collect drainage water samples. The pasture treatments are: (i) plantain, (ii) plantain-clover mix, containing plantain, red (*Trifolium pratense*) and white clover (*T. repens*), and (iii) ryegrass (*Lolium perenne*)/white clover. They were grazed by lactating dairy cows over 10 consecutive days in March and in April, 2017 (autumn). The milk production of cows, the N and urea concentrations in the cows' urine, and the NO_3-N leached in drainage were measured.

After 10 days of grazing, cows grazing the three pasture treatments had similar ($P>0.05$) milk solids production, but urinary N and urea concentrations were significantly ($P<0.01$) lower in cows grazing plantain and the plantain-clover mix. Cows grazing both plantain and plantain-clover mix excreted a urinary N concentration 50 and 53% less ($P<0.01$) than cows grazing the ryegrass/white clover in March and April, respectively.

The urea concentration in the urine of cows grazing plantain was 28% lower compared to those cows grazing the plantain-clover mix during autumn and 80 and 67% less than urea concentrations from cow's urine on the ryegrass/white clover pasture in March and April, respectively. There was an overall 388 ± 65 mm (mean ± SD) of drainage for the winter-spring period with no consistent difference in the drainage volumes from the treatments. The quantity of NO_3-N leached in drainage was 90 and 85% lower ($P<0.001$) from the plantain and plantain-clover mix plots than from the ryegrass/white clover pasture, however, overall losses were low from all treatments.

These results demonstrate the potential benefit of plantain pastures as a natural mitigation option to reduce the urinary N excretion from dairy cows and the NO_3-N leached from dairy farm systems.

DELIVERING TAILORED FARM ENVIRONMENT PLANS AT SCALE

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In November of 2017, Fonterra launched six ambitious commitments to improve water quality in New Zealand. Fonterra believe that New Zealand can have a globally competitive dairy industry, a thriving economy and a healthy environment. We all want swimmable waterways for our families to enjoy. That's why Fonterra and our farmer shareholders are going to continue to be part of the solution to the water quality challenge.

Fonterra has committed to helping our farmer shareholders to farm within regional environmental limits and encourage strong environmental practices. A key tool to assist farmers in meeting these commitments is the use of tailored farm environment plans (FEP's), and the delivery of tailored FEP's is a core activity of the Fonterra Farm Source Tiaki Sustainable Dairying Programme.

Through the Tiaki Sustainable Dairying Programme, Fonterra continues to develop and invest in systems, digital tools and people to support on-farm change. In particular, Fonterra has had to ensure that its systems, digital tools and people can develop and deliver FEP's at a significant scale to meet a variety of different needs; from different regional regulatory requirements to different property variations and different farmer personality types. In building tools that allow for a tailored FEP, Fonterra has had to develop some structure and rigour to ensure that the potential variations do not lead to inconsistent outcomes.

Fonterra will present on the Farm Source Tiaki Sustainable Dairying Programme, and how the Tiaki programme has developed systems and tools to deliver tailored FEP's at a significant scale in New Zealand.

FARM ENVIRONMENT PLANNING – 2.0

Corina Jordan and Julia Beijeman

Beef + Lamb New Zealand, Christchurch

For approximately 15 years, sheep and beef farmers have been using B+LNZ's LEP templates to assess their natural resources, improve their understanding of soils, and manage critical source areas. More recently B+LNZ's regionalised Farm Environment Plan (FEP) templates have been provided to assess, optimise, and document the strengths and challenges of their farm's unique physical resources.

Increasing public pressure around agricultural land uses and environment impacts, changing consumer requirements around ethical sustainable food, and tightening domestic regulation, offer both challenges and opportunities for the red meat sector. In response, B+LNZ is shifting gears.

Under a newly developed Environment Strategy, B+LNZ is assessing its Farm Environment Planning programme, and shifting its focus from outputs to outcomes.

Through a series of projects including assessment of our current FEP resources, marketing, leading edge tools, revised resources, data collection, and the collective brute force of our farming leaders, we are revising our FEP programme. With our FEP 2.0, we plan to fundamentally change the conversation.

We aim to connect farmers to 'the why', to connect farmer actions with community values, and to understand how we are tracking against audacious goals around fresh water, greenhouse gas emissions, biodiversity, and soil health.

Our vision for sheep and beef farmers is "*He kaitiakitanga mo te tai ao – world leading stewards of the natural environment and sustainable communities*". A second generation of Farm Environment Plans is fundamental to realising this vision.

FARM ENVIRONMENTAL PLANS IN RELATION TO RESOURCE CONSENTS, REGIONAL/DISTRICT PLAN COMPLIANCE AND ON-FARM MANAGEMENT; THE ESSENTIAL ELEMENTS

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Ravensdown Environmental, Christchurch

Farm Environment Plans (FEP's) have become a critical farm management and compliance tool for farmers. They need to be flexible and adaptable to changing environmental conditions and farming practises to remain current and beneficial. In a regulatory environment which requires fixed certainty and clarity this can be difficult to achieve. When using FEP's for resource consents and Regional/District Plan compliance care must be taken by the regulator, the farm consultant and planner, and the farmer themselves that they do not constrain the ability to adapt the FEP in the future.

At the resource consent stage, this means consideration of the role of the FEP and the scope of the application, as well as how it is required to be implemented through any conditions of the consent. The wrong referencing in both a consent application and a decision could lead to a FEP with little opportunity to adapt and change.

The FEP needs to be specific to each farming operation, relative to the conditions on each farm and the workability for the farmer. This may require a three-way conversation between the farmer, the farm consultant and the planner to ensure a workable, cost effective and efficient operation within the current regulatory requirements and which can enable future regulatory requirements to be achieved.

Initially FEPs need to be structured to meet legislative requirements including regional plans. This includes but is not limited to an assessment of the farm's ability to meet nutrient loss allowances, stock exclusion rules, water use efficiency, riparian management and other land management requirements.

In our view the key requirements of an effective "operative and auditable" FEP is that they are:

- Aligned with catchment and regional requirements;
- Flexible and adaptable in order to be able to include new technology and farming practices;
- Realistic, affordable and practical;
- Effective management tools which are implemented, not a doorstop stored in the bottom drawer

in order to achieve the desired environmental outcomes.

FARM ENVIRONMENT PLANS – HELPING FARMERS THROUGH THE FOURTH AGRARIAN REVOLUTION

Alastair Taylor, C Finlayson and L Aubrey

Ballance Agri-Nutrients, Tauranga

10,000-2,000 BC	The First Agricultural Revolution, was the transformation of human societies from hunting and gathering to farming.
17th – 19th Century	The Second Agricultural Revolution occurred alongside the Industrial Revolution. It was a period of technological improvement and increased crop productivity.
1930 – 1970's	The Third Agricultural Revolution was a period in time when new agricultural practices were created to help farmers all over the world. It was an international effort that was planned to eliminate hunger by improving crop performances.
2000's	The Fourth Agricultural Revolution? Led by the 2003 Mid-Term Review of the EU CAP farm subsidies and regulations began to focus on sustainability rather than production maximisation.

The 2003 Mid-Term Review of the European Union's Common Agricultural Policy introduced the idea of "modulation" and the shifting of support focus from production to "environmental goods. Farming was encouraged to produce safe, healthy and nutritious food; responsibly manage the countryside; and contribute to thriving rural economies. Similar goals can be seen in the RMA and the National Policy Statements on Freshwater which have led to the introduction of tighter regulations on diffuse pollution from agriculture.

In 2016 Ballance commissioned market research to establish the wants and needs of New Zealand farmers. Nearly 2,000 farmers were spoken to, in person, with encouraging results.

- 93% of farmers believe that they have a real responsibility to look after the environment,
- 83% class themselves as passionate about the environment
- 68% will "happily do what they have to keep the Council happy.

Our farmers want to leave their farms in a better condition than when they took them over and Ballance is committed to helping them to achieve that. In recent years Ballance has invested heavily in mechanisms to help our shareholders to produce meaningful environmental change on farm, and how that can be demonstrated in a Farm Environment Plan. 2018 will see the commercial launch of the MitAgator™ decision support tool, developed with New Zealand scientists to achieve this.

SIX MONTHS ON FROM COMPLETING MY PHD – LESSONS LEARNT AND HOW THEY ARE RELEVANT TO MY CURRENT ROLE AS A FARM ENVIRONMENTAL ADVISOR

Anna Carlton

Ravensdown, Christchurch

Many farmers, particularly in Canterbury, are now facing the challenge of meeting nitrogen leaching reductions while retaining a profitable system. In New Zealand an outputs approach using OVERSEER® in conjunction with Farm Environmental Plans (FEP) has been adopted to regulate nutrient loss as opposed to an inputs regulated approach which still leaves room for flexibility in both farming systems and potential mitigation options.

When exploring research options those relating to irrigation management and diverse forage species to reduce nitrate leaching losses from the cow urine patch therefore had a strong appeal, particularity from a practical farm systems point of view.

This presentation will therefore focus on the lessons learnt during my PhD and if/how they are relevant to my current role as a farm environmental advisor, particularly relating to: the day to day use of Overseer, FEP's and communication with farmers in the nutrient management space.