Moving Farm Systems to Improved Nutrient Attenuation

This document contains the programme and abstracts of all presentations to the 28th Annual FLRC Workshop at Massey University on the 10th, 11th and 12th February 2015.

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

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

http://flrc.massey.ac.nz/publications.html

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Programme

Tuesday 10th February

0915-1015 Registration and Morning Tea

1015–1030 **Professor Mike Hedley**
Director, Fertilizer & Lime Research Centre, Massey University
WELCOME AND INTRODUCTION

Session 1 : Some Wider Perspectives

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

1030-1100 **Phil Jordan,** *(Invited Speaker)*
P Mellander, C Buckley, M Shore, N McDonald and G Shortle
Agricultural Catchments Programme, Ireland
FROM SOURCE TO IMPACT: MEASURING THE NUTRIENT CASCADE RESPONSE TO EU POLICIES IN IRISH AGRICULTURAL CATCHMENTS....

1100-1110 **Lucy McKergow, T Faulkner, A Stewart, R Parkes, S Ihaka, S Elliott, A MacKay, M Freeman and B Longhurst**
NIWA, Hamilton
FOCUS = FARM PLANS + OUTCOMES + CATCHMENT PRIORITIES + USERS

1110-1120 **Roger Williams, H Brown, I Brown, R Ford, L Lilburne, I Pinxterhuis, M Robson, V Snow, K Taylor and T von Pein**
Plant & Food Research, Christchurch
THE MATRIX OF GOOD MANAGEMENT: TOWARDS AN UNDERSTANDING OF FARM SYSTEMS, GOOD MANAGEMENT PRACTICE, AND NUTRIENT LOSSES IN CANTERBURY

1120-1130 **Helen Moodie, T Stephens and A Brocksopp**
DairyNZ, Hamilton
FARMING WITH LIMITS NORTHLAND STYLE – THE POSSIBILITIES WHEN SCIENCE AND COMMUNITY JOIN FORCES

1130-1140 **Simon Park, T Kingi, S Morrell, L Matheson and S Ledgard**
Landconnect Ltd, Tauranga
THE CONTEXT AND PRACTICE OF NUTRIENT MITIGATION ON ROTORUA DAIRY FARMS

1140-1150 **Selva Selvarajah**
Enviroknowledge Ltd, Dunedin
CAN THE RMA TOOLBOX PROVIDE EFFECTIVE TOOLS TO MANAGE THE IMPACTS OF FARMING ON FRESH WATER QUALITY?

1150-1205 Discussion

1205-1215 Poster Paper Presentations

Adrian Brocksopp, M Bramley, N McHaffie, D Burger and M Scarsbrook
DairyNZ, Hamilton
ACCELERATING THE ADOPTION OF GOOD ENVIRONMENTAL PRACTICE ON DAIRY FARMS IN THE UPPER WAIKATO CATCHMENT

Jayson Benge, D Lucock, J Manhire and A Topp
The Agribusiness Group, Mt Maunganui
THE FARMING FOR THE FUTURE RESEARCH PROJECT – UNDERSTANDING THE OUTCOMES OF LOWER NUTRIENT INPUT ON SHEEP/BEEF FARMS USING DICALCIC PHOSPHATE

Danilo Guinto, S Lauga, L Dauara, E Walasi and D Autufuga
Ballance Agri-Nutrients, Tauranga
SOIL HEALTH ASSESSMENT OF TARO FARMS IN SAMOA

1215-1315 Lunch

Session 2 : Regional Policy

Chairman: **Emeritus Professor Russ Tillman**
Fertilizer & Lime Research Centre, Massey University

1315-1320 **Jon Roygard** *(Invited Speaker)*
Horizons Regional Council, Palmerston North
POLICY IMPLEMENTATION - AN UPDATE FROM HORIZONS REGIONAL COUNCIL (INTRODUCTION)

1320-1330 **Jess Hughes J Roygard, P Taylor, D Ryan, M Chakraborty, M Clark and L Brown**
Horizons Regional Council, Palmerston North
ENVIRONMENTAL FARM PLANS – OUR EXPERIENCE IN THE MANGATAINOKA CATCHMENT

1330-1340 **Lucy Ferguson, J Roygard, A Deverall, A Cooper, M Clark and L Brown**
Horizons Regional Council, Palmerston North
MANAWATU ACCORD AND CLEAN-UP FUND PROJECT - PROGRESS REPORT

1340-1350 **Jon Roygard, L Brown, M Clark, L Ferguson, A Deverall and A Cooper**
Horizons Regional Council, Palmerston North
LAKE HOROWHENUA ACCORD AND CLEAN-UP FUND - PROGRESS REPORT

1350-1405 **Terry Parminter and S Ridsdale** *(Invited Speaker)*
PACT Consulting, Paraparaumu
ADAPTING MANAWATU DAIRY FARMS TO REGIONAL COUNCIL CATCHMENT TARGETS

1405-1415 **Alan Campbell** *(Invited Speaker)*
Waikato Regional Council, Hamilton
POLICY DEVELOPMENT AND IMPLEMENTATION - AN UPDATE FROM WAIKATO REGIONAL COUNCIL

1415-1425 **Leo Fietje** *(Invited Speaker)*
Environment Canterbury, Christchurch
POLICY IMPLEMENTATION - AN UPDATE FROM ENVIRONMENT CANTERBURY

1425-1435 **Ned Norton, I Lyttle, N Newman, C Hurst and I Whitehouse**
Environment Canterbury, Christchurch
PROCESS AND OUTCOMES OF THE NITROGEN ALLOCATION REFERENCE GROUP (NARG) FOR SOUTH CANTERBURY COASTAL STREAMS (SCCS) AREA

1435-1450 **Ants Roberts** *(Invited Speaker)*
Ravensdown, Pukekohe
SNAKES AND LADDERS:
HELPING FARMERS IMPLEMENT THE NUTRIENT MANAGEMENT PROVISIONS OF THE ECAN LAND AND WATER REGIONAL PLAN

1450-1500 **Mark and Devon Slee** *(Invited Speaker)*
National Winners 2014 BFEA, Ashburton
DAIRY FARMING AT EALING, SOUTH CANTERBURY

1500-1515 Discussion

1515-1545 Afternoon Tea

Session 3 : Tools for Managing Nutrients

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

1545-1555 **Philip Mladenov, L Hargraves and J Clayton**
Fertiliser Association of New Zealand, Wellington
CERTIFICATION OF NUTRIENT MANAGEMENT ADVISERS – ONE YEAR ON

1555-1605 **Caroline Read**
Overseer Management Services, Wellington
OVERSEER GOVERNANCE - 2014 AND BEYOND

1605-1615 **David Wheeler and J Bright**
AgResearch, Hamilton
NEW IRRIGATION MODULE IN OVERSEER 6.2 – WHAT TO EXPECT

1615-1625 **Rich McDowell, G M Lucci, G Peyroux, H Yoswara, N Cox, M Brown, D Wheeler, N Watkins, C Smith, R Monaghan, R Muirhead, J Risk and A Old**
AgResearch, Mosgiel
MITAGATOR™: A FARM-SCALE TOOL TO ESTIMATE AND MITIGATE THE LOSS OF NUTRIENTS AND CONTAMINANTS FROM LAND TO WATER

1625-1635 **Jim Risk, A B Old, G R Peyroux, M Brown, H Yoswara, D M Wheeler G M Lucci and R W McDowell**
Ballance AgriNutrients, Invercargill
MITAGATOR^{TM} - IN ACTION SOLUTIONS FOR MANAGING NITROGEN, PHOSPHORUS, SEDIMENT AND *E. COLI* LOSS

1645-1655 **Andrew Manderson and A Palmer**
Landcare Research, Palmerston North
ARE WE ON COURSE FOR A TRAIN WRECK WITH SOIL INFORMATION AND DATA FOR SUSTAINABLE NUTRIENT MANAGEMENT?

1655-1710 Discussion

1710-1715 Poster Paper Presentations

Ronaldo Vibart, I Vogeler, R Cichota and D J Horne
AgResearch, Palmerston North
A COMPARISON OF APSIM AND OVERSEER PREDICTIONS OF N LEACHING FROM A WELL-DRAINED SOIL UNDER DAIRYING

Bernard Simmonds, R McDowell and L Condron
Faculty of Agriculture & Life Sciences, Lincoln University
THE INFLUENCE OF PHOSPHORUS FERTILITY AND LIMING ON THE FORMS AND FRACTIONS OF PHOSPHORUS LEACHED FROM ORGANIC SOILS

Bernard Simmonds, R McDowell and L Condron
Faculty of Agriculture & Life Sciences, Lincoln University
CAN LOW WATER SOLUBILITY PHOSPHORUS FERTILISERS DECREASE PHOSPHORUS LOSSES FROM AN ORGANIC SOIL?

Bernard Simmonds, R McDowell and L Condron
Faculty of Agriculture & Life Sciences, Lincoln University
SOIL TYPE AND MOISTURE AFFECTS PHOSPHORUS LOSS PATHWAYS, FORMS AND AMOUNTS

1715-1845 **Farm Visit**. An opportunity to see research facilities at the Massey University Agricultural Experiment Stations.
- Buses will return to hotels in the city by 7pm.

Wednesday 11th February

Session 4 : Farm Scale

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

0830-8040 **Diana Mathers**
Foundation for Arable Research, Havelock North
ROOTZONE REALITY- A NETWORK OF FLUXMETERS MEASURING NUTRIENT LOSSES UNDER CROPPING ROTATIONS

0840-0850 **Edith Khaembah, H Brown, J Sharp and R Zyskowski**
Plant & Food Research, Christchurch
SOIL NITROGEN AND SOIL WATER DYNAMICS IN ARABLE CROP ROTATIONS: ESTIMATION WITH THE MULTIPLE CROP SINGLE PURPOSE MODEL

0850-0900 **Mike Dodd, A Manderson, P Budding, S Dowling, S Ganesh and C Hunt**
AgResearch, Palmerston North
PRELIMINARY EVALUATION OF THREE METHODS FOR DETECTING URINE PATCHES IN THE FIELD

0900-0910 **Iris Vogeler and R Cichota**
AgResearch, Hamilton
NITROGEN CONCENTRATION IN PASTURE AS A TOOL FOR GUIDING FERTILISER REQUIREMENTS

0910-0920 **John-Paul Praat, J Sukias and T Faulkner**
Groundtruth Ltd, Te Awamutu
ON-FARM DRAINAGE REMEDIATION PROJECTS TO PROTECT WAIRARAPA MOANA

0920-0930 **Miko U F Kirschbaum, S Rutledge, P L Mudge, N Puche, L A Schipper and D I Campbell**
Landcare Research, Palmerston North
CHANGES IN SOIL CARBON STOCKS OF NEW ZEALAND'S GRAZED PASTURE IN RESPONSE TO VARIATIONS IN MANAGEMENT AND ENVIRONMENTAL FACTORS

0930-0940 **Dawn Dalley, I Pinxterhuis, R Kyte, R Monaghan, M Hunter and J Kerslake**
DairyNZ, Canterbury
ON-FARM PRACTICES FOR MITIGATING N LOSSES TO WATER – IMPACTS ON DAIRY FARM SYSTEMS IN THE SOUTHERN SOUTH ISLAND

0940-0950 **Mike Hedley, D J Horne, J A Hanly, C L Christensen, J Howes, M Bretherton and J Margerison**
Fertilizer & Lime Research Centre, Massey University
PROGRESS WITH OPERATING A DURATION CONTROLLED DAIRY GRAZING SYSTEM FOR PRODUCTIVITY GAIN AND FOOTPRINT REDUCTION

0950-1005 Discussion

1005-1015 Poster Paper Presentations

Diana Selbie, D Wheeler and M Shepherd
AgResearch, Hamilton
AN ANALYSIS OF RECENT URINE PATCH NITROGEN RESEARCH

Mark Shepherd, A Ghani and J Morton
AgResearch, Hamilton
SOIL TOTAL N CONTENT INFLUENCES PASTURE FERTILISER N RESPONSE

Mark Shepherd and S Balvert
AgResearch, Hamilton
DOES SIZE MATTER? THE EFFECT OF URINE PATCH SIZE ON PASTURE N UPTAKE

Innocent Rugoho, C Gourley and S Aarons
Dept of Economic Development, Jobs, Transport and Resources, Victoria, Australia
HOW EVENLY ARE N AND P LOADS FROM ANIMAL EXCRETA DISTRIBUTED ACROSS THE FARM LANDSCAPE?

Jessica Roberts, M Trotter, S Woodward and A Werner
Lincoln Agritech, Canterbury
NITROGEN FERTILIZER MANAGEMENT WITH ZONE CHARACTERIZATION IN GRAZED PASTURE SYSTEMS

Dinanjana Ekanayake, J Roberts, A Royal and A Werner
Lincoln Agritech, Canterbury
MANAGEMENT ZONE DELINEATION IN ARABLE CROP SYSTEMS

1015-1045 Morning Tea

Session 5 : The Next Steps …. “Underseer”

Chairman: **Dr Caroline Read**
Overseer Management Services, Wellington

1045-1100 **Ranvir Singh, L L Burkitt, D J Horne and M J Hedley**
Fertilizer & Lime Research Centre, Massey University
UNDERSTANDING AND ENHANCING NUTRIENT ATTENUATION CAPACITY IN NEW ZEALAND AGRICULTURAL CATCHMENTS

1100-1110 **Aldrin Rivas, R Singh, D J Horne, J Roygard, A Matthews, M Hedley**
Fertilizer & Lime Research Centre, Massey University
AN ASSESSMENT OF THE DENITRIFICATION POTENTIAL IN SHALLOW GROUNDWATERS OF THE MANAWATU RIVER CATCHMENT

1110-1120 **Ahmed Elwan, R Singh, D J Horne, J Roygard and B Clothier**
Institute of Agriculture and Environment, Massey University
NITROGEN ATTENUATION FACTOR:
CAN IT TELL A STORY ABOUT THE JOURNEY OF NUTRIENTS IN DIFFERENT SUBSURFACE ENVIRONMENTS?

1120-1130 **Roland Stenger, J Clague, S Woodward U Morgenstern and T Clough**
Lincoln Agritech, Hamilton
MULTI-PRONGED APPROACH TO ELUCIDATE NITRATE ATTENUATION IN SHALLOW GROUNDWATER

1130-1140 **Lucy Burkitt, Mike Bretherton and Ranvir Singh**
Fertilizer & Lime Research Centre, Massey University
MONITORING STREAM SEDIMENT, NITROGEN AND PHOSPHORUS CONCENTRATIONS IN GRAZED HILL COUNTRY IN THE MANAWATU REGION

1140-1150 **Chris Tanner, J Sukias and D Burger**
NIWA, Hamilton
REALISING THE VALUE OF REMNANT FARM WETLANDS AS ATTENUATION ASSETS

1150-1200 **Hugh Canard**
Lincoln Agritech, Canterbury
THE ROLE OF CURRENT AND FUTURE GROUNDWATER RESEARCH IN COLLABORATIVE MANAGEMENT OF WATER QUALITY

1200-1215 Discussion

1215-1230 Poster Paper Presentations

James Sukias, K Robertson, W Tuckey and C Tanner
NIWA, Hamilton
SOUTHLAND GRAVEL PITS CONVERSION TO WETLANDS:
A WIN-WIN FOR FARMERS AND THE ENVIRONMENT

Cameron Black, L Burkitt and R Singh
Fertilizer & Lime Research Centre, Massey University
WATER QUALITY IMPACTS OF CRASH GRAZING A HILL COUNTRY WETLAND

Rashad Syed, S Saggar, K Tate and B H A Rehm
Institute of Agriculture & Environment, Massey University
ASSESSMENT OF POTENTIAL BIOFILTER MATERIALS TO MITIGATE
METHANE EMISSIONS

Stuart Lindsey, J Luo, J Wyatt and S Ledgard
AgResearch, Hamilton
NITROUS OXIDE EMISSIONS DURING MAIZE CROPPING

Donna Giltrap, J Rodriguez, P Berben, T Palmada and S Saggar
Landcare Research, Palmerston North
IDENTIFYING IMPROVEMENTS REQUIRED TO SIMULATE NH_3 VOLATILISATION
FOLLOWING URINE OR UREA APPLICATION USING NZ-DNDC

Pranoy Pal, A M S McMillan and S Saggar
Landcare Research, Palmerston North
ROUTES OF DCD UPTAKE IN PASTURE PLANTS:
A PRELIMINARY GLASSHOUSE STUDY

Moira Dexter, A Ghani, P Johnstone, D Houlbrooke, M Norris, J Sharp
and B Longhurst
AgResearch, Hamilton
LAB ASSESSMENT OF NITROGEN MINERALISATION FROM FARM
DAIRY EFFLUENT, SLURRY AND MANURES

Bert Quin, A Gillingham, S Spilsbury D Baird and M Gray
Quin Environmentals, Auckland
IMPROVING THE EFFICIENCY OF FERTILISER UREA ON PASTURE
WITH ONE*system*®

1230-1330 Lunch

Session 6 : Economics

Chairman: **Professor Nicola Shadbolt**
Centre of Excellence In Farm Business Management,
Massey University

1330-1400 **Graeme Doole** *(Invited Speaker)*
The University of Waikato, Hamilton
THE ECONOMIC IMPACT OF WATER QUALITY REGULATION IN NEW ZEALAND

1400-1410 **Ron Pellow**
South Island Dairying Development Centre, Christchurch
THE REAL (RATHER THAN MODELLED) COST OF MEETING N LIMITS – PART 1: AN ONGOING CASE STUDY OF A CANTERBURY DAIRY FARM

1410-1420 **Trevor Sulzberger, T Phillips, N Shadbolt, B Ridler and R McCallum**
Institute of Agriculture & Environment, Massey University
LESS COWS, MORE PROFIT, BETTER ENVIRONMENT

1420-1430 **Estelle Dominati and A Mackay**
AgResearch, Palmerston North
IMPACT OF ON-FARM BUILT INFRASTRUCTURE INVESTMENTS ON THE PROVISION OF ECOSYSTEM SERVICES: IRRIGATION FOR DAIRY SYSTEMS

1430-1445 Discussion

1445-1500 Poster Paper Presentations

Ian McIvor
Plant and Food Research, Palmerston North
BIG STORMS CAN COST FARMERS BIG DOLLARS

Ian McIvor
Plant and Food Research, Palmerston North
YOUR SOIL IS VALUABLE – PLANT TREES TO KEEP IT!

Thomas Macdonald, J S Rowarth and F G Scrimgeour
The University of Waikato, Hamilton
MEASURING THE COMPARATIVE COST OF ENVIRONMENTAL COMPLIANCE AND MITIGATION OPTIONS FOR WAIKATO DAIRY FARM SYSTEMS

Weiwen Qiu, P Johnstone, D Wallace, N Arnold, B Searle, J Sharp,
M Beare and D Curtin
Plant & Food Research, Christchurch
SPATIAL VARIABILITY OF NITROGEN SUPPLY ASSESSED USING SOIL AND PLANT BIOASSAYS

Hamish Lowe and S Cass
Lowe Environmental Impact Limited, Palmerston North
HIGH RATE LAND PASSAGE STRUCTURES FOR ATTENUATION AT HIGH RISK LAND APPLICATION PERIODS

1500-1530 Afternoon Tea

Session 7 : Nitrogen

Chairman: **Mr Hamish Lowe**
Lowe Environmental Impact, Palmerston North

1530-1540 **Frank Eulenstein, U Schindler, L Müller, M Willms, A K Sheudzhen, S L Schlindwein, M Tauschke, A Behrendt and M A Lana**
Leibniz-Centre for Agricultural Landscape Research (ZALF), Germany
THE EFFECTS OF CLIMATE CHANGE ON NITROGEN AND SULPHUR LOAD IN PERCOLATION WATER FROM AGRICULTURE LANDSCAPE

1540-1550 **Steve Thomas, A Horrocks and C Tregurtha**
Plant & Food Research, Christchurch
NITROGEN FERTILISER USE EFFICIENCY ON WEST COAST HUMPS AND HOLLOWS

1550-1600 **Malcolm McLeod**
Landcare Research, Hamilton
NITROGEN LEACHING FROM CUT-AND-CARRY LUCERNE

1600-1610 **John Drewry, F Curran-Cournane, M Taylor and B Lynch**
Greater Wellington Regional Council, Masterton
SOIL QUALITY MONITORING ACROSS LAND USES IN FOUR REGIONS: IMPLICATIONS FOR REDUCING NUTRIENT LOSSES AND FOR NATIONAL REPORTING

1610-1620 **Ronaldo Vibart, I Vogeler, S Dennis, W Kaye-Blake, R Monaghan, V Burggraaf, J Beautrais and A Mackay**
AgResearch, Palmerston North
COST-AND EFFECTIVENESS OF MITIGATION MEASURES FOR REDUCING EMISSIONS TO WATER AND AIR FROM PASTORAL FARMS IN SOUTHLAND, NEW ZEALAND

1620-1630 **John de Ruiter and B J Malcolm**
Plant & Food Research, Christchurch
NITROGEN USE EFFICIENCY IN DIFFERING DAIRY WINTERING SYSTEMS IN CANTERBURY

1630-1645 Discussion

1645-1700 Poster Paper Presentations

Frank Eulenstein, M A Lana, S L. Schlindwein, A K Sheudzhen, M Tauscke, E Guevara and S Meira
Leibniz-Centre for Agricultural Landscape Research (ZALF), Germany
IMPACT OF CLIMATE SCENARIOS ON SOYBEAN YIELDS IN SOUTHERN BRAZIL

Marcos A Lana, F Eulenstein, S L Schlindwein, M Tauscke, A Behrendt, A K Sheudzhen, J Monk, E Guevara and S Meira
Leibniz-Centre for Agricultural Landscape Research (ZALF), Germany
MAIZE FOR ETHANOL PRODUCTION: REGIONALIZATION OF RESPONSES TO CLIMATE SCENARIOS, N USE EFFICIENCY AND EFFECTIVENESS OF ADAPTATION STRATEGIES

Abie Horrocks, S Thomas, C Tregurtha, E Meenken and R Horrell
Plant & Food Research, Christchurch
DEVELOPING GUIDELINES FOR FERTILISER SPREADING ON WEST COAST HUMPS AND HOLLOWS

Rebecca Withnall and S Bowie
Analytical Research Laboratories, Napier
WHOLE FARM TESTING: A REVIEW OF DATA

Daniel Mason, K Cooper, J Drysdale, A Dyer, E Meehan, M Stanley and P Lorentz
Analytical Research Laboratories, Napier
EFFECTS OF HOLDING TIME AND TEMPERATURE ON *E. COLI* AND TOTAL COLIFORMS IN SURFACE WATER SAMPLES

Marion Tauschke, A Behrendt, J Monk, F Eulenstein and S Monk
Leibnitz Centre for Agricultural Landscape Research (ZALF), Germany
IMPROVING THE WATER USE EFFICIENCY OF CROP PLANTS BY APPLICATION OF MYCORRHIZAL FUNGI

Jana Monk
AgResearch, Christchurch
MYCOGRO AG® - A MYCORRHIZA PRODUCT MADE IN NEW ZEALAND

Lisanne F Hageman, P Jeyakumar, S Smith, C W N Anderson
Utrecht University, Netherlands
SERUM AND FAECAL ZINC CONCENTRATIONS IN SHEEP FOLLOWING LOW DOSE ORAL ZnO TREATMENT

1700-1800 **Poster Papers on Display**
Informal Drinks In The Ag Hort Lecture Block

1815- **Workshop Dinner at Wharerata**

Thursday 12th February

Session 8 : Phosphorus and Cadmium

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

0845-0915 **Rich McDowell** *(Invited Speaker)*
AgResearch, Mosgiel
CAN I FARM WITHIN A PHOSPHORUS LIMIT?

0915-0925 **Robert Simpson, K Mason, C Robertson and K Müller**
Plant & Food Research, Palmerston North
SOIL WATER REPELLENCY: INVESTIGATING POTENTIAL BIOLOGICAL DRIVERS AND CONSEQUENCES FOR APPLIED PHOSPHATE

0925-0935 **Greg Sneath**
Fertiliser Association of New Zealand, Wellington
THE TIERED FERTILISER MANAGEMENT SYSTEM FOR MANAGING SOIL CADMIUM IN AGRICULTURAL SOILS IN NEW ZEALAND

0935-0945 **Jo Cavanagh**
Landcare Research, Lincoln
DEVELOPING SOIL GUIDELINE VALUES FOR THE PROTECTION OF SOIL BIOTA IN NEW ZEALAND

0945-0955 **Aaron Stafford, C W Anderson and M J Hedley**
Ballance AgriNutrients, Tauranga
SPATIAL DISTRIBUTION OF SOIL CADMIUM IN TWO LONG-TERM DAIRY FARMS

0955-1005 **Andrew Pearson and R Vannoort**
Ministry for Primary Industries, Wellington
CADMIUM IN THE DIET: UPDATING AND EXPANDING THE EXPOSURE MODEL FOR NEW ZEALAND CONSUMERS

1005-1020 Discussion

1020-1050 Morning Tea

Session 9 : Precision Agriculture

Chairman: **Professor Ian Yule**
NZ Centre for Precision Agriculture, Massey University

1050-1120 **Jim Wilson** *(Invited Speaker)*
Hilton of Fern, Brechin, Scotland
PRACTICAL USES OF SMART TECHNOLOGIES

1120-1130 **Colin Brown**
TracMap, Mosgiel
VARIABLE RATE FERTILISER APPLICATION ON PASTORAL HILL COUNTRY - A SIMPLE AND EFFECTIVE SYSTEM

1130-1140 **Colin Hurst, S Lovell, T Lund and A Holmes**
Smart Ag Solutions, Timaru
PRECISE SURVEYING OF SOIL PRODUCTIVITY INDICATORS USING ON-THE-GO SOIL SENSORS

1140-1150 **Dan Bloomer and C Folkers**
Centre for Land and Water, Hastings
MONITORING & MAPPING CROP DEVELOPMENT

1150-1200 **Miles Grafton and I J Yule**
NZ Centre for Precision Agriculture, Massey University
FARM SYSTEM RISK ANALYSIS: BUILDING A FARM RISK PROFILE TO IMPROVE FARM ECONOMIC OUTCOMES

1200-1215 Discussion

1215-1315 Lunch

Session 10 : Smart Technologies

Chairman: **Mr Mike Manning**
Ravensdown, Christchurch

1315-1325 **Dan Bloomer**
LandWISE, Hastings
ON-FARM FERTILISER APPLICATION CALIBRATION

1325-1335 **Jessica Roberts, B Schäbitz and A Werner**
Lincoln Agritech, Canterbury
ACTIVE LIGHT SENSING OF CANOPIES IN CROP MANAGEMENT: PASTURES AND ARABLE CROPS

1335-1345 **Jaco Fourie, A Werner and N Dagorn**
Lincoln Agritech, Canterbury
ASSESSING BIOMASS YIELD OF KALE (*BRASSICA OLERACEA VAR. ACEPHALA L.*) FIELDS USING MULTI-SPECTRAL AERIAL PHOTOGRAPHY

1345-1355 **Geoff Bates, B Quin and P Bishop**
Pastoral Robotics Ltd, Auckland
LOW-COST DETECTION AND TREATMENT OF FRESH COW URINE PATCHES

1355-1405 **Graeme Pile, F Sultanbawa and M Diaz**
Fertigation Systems Ltd, Canterbury
USING FERTIGATION AS A TOOL TO MITIGATE NITROGEN LEACHING UTILISING THE INCREASED EFFICIENCIES OF WATER AND NUTRIENTS

1405-1415 **Andrew Curtis**
Irrigation New Zealand, Christchurch
SMART IRRIGATION

1415-1430 **Ian Yule**
NZ Centre for Precision Agriculture, Massey University
SENSORS – WHAT HAVE WE GOT AND WHERE ARE WE HEADED

1430-1445 Discussion

1445-1500 Closing Remarks

1500 Afternoon Tea and depart

FROM SOURCE TO IMPACT:

MEASURING THE NUTRIENT CASCADE RESPONSE TO EU POLICIES IN IRISH AGRICULTURAL CATCHMENTS

Phil Jordan[1,2], Per-Erik Mellander[1], Cathal Buckley[3], Mairead Shore[1], Noeleen McDonald[1] and Ger Shortle[1]

[1]*Agricultural Catchments Programme, Teagasc, Johnstown Castle, Wexford, Ireland*
[2]*School of Environmental Sciences, Ulster University, Coleraine, N. Ireland*
[3]*Agricultural Catchments Programme, Teagasc, Mellows Campus, Athenry, Ireland*

The Nitrates Directive is the main tool to manage agricultural nutrient pollution risk in the EU and is legislated in Ireland under Good Agricultural Practice regulations. The Irish regulations maximise nutrient attenuation on land by limiting the timing and magnitude of nitrogen (N) and phosphorus (P) application and the modes of mobilisation from land to water. This policy tool is conditional on a catchments based monitoring programme that encompasses intensive agricultural enterprises across different soil types. The programme uses an intensive method to audit the cascade of nutrient sources that are mobilised into hydrological pathways and delivered to catchment rivers. Water quality status and farm economic metrics are also monitored as two perceived impacts to nutrient source regulations. Following several years of monitoring, several important results are emerging. Firstly, nutrient source use has changed and is evidenced by timing practice and soil nutrient status changes. For example, measured declines in excessively high soil P status followed modelled predictions for reduced P inputs although, in some catchments, this decline may be increasing the occurrence of fields with below optimal soil fertility. Secondly, over the short-medium term, the changes in nutrient transfer to rivers as a response to changed nutrient use is more readily interpreted by investigating the nutrient status of hydrological pathways. Mass nutrient fluxes are influenced by inter-annual hydroclimatic variations and, as a result, changes in overall water quality from catchment management have been slower to emerge; longer term datasets will be important in this regard. Thirdly, In terms of economic impact, where excessive soil P was shown to decline in an exemplar dairy catchment, gross margins were not impacted and were comparable to the top 10% of performing dairy farms nationally. These findings add to others showing that there may be a decoupling between nutrient source use and overall impact. Finally, it is becoming clear that the development and management of critical source areas, where the emphasis is on managing the hydrological mobilisation potential of nutrients, will be important to reduce the response time of catchments to changes in nutrient use and status at the field scale.

FOCUS = FARM PLANS + OUTCOMES
+ CATCHMENT PRIORITIES + USERS

Lucy McKergow[1], Tony Faulkner[2], Andrew Stewart[2], Richard Parkes[2], Scott Ihaka[2], Sandy Elliott[1], Alec MacKay[3], Mike Freeman[4] and Bob Longhurst[5]

[1] NIWA, Hamilton
[2] Greater Wellington Regional Council, Masterton
[3] AgResearch, Palmerston North
[4] AgResearch, Lincoln
[5] AgResearch, Hamilton

Land management officers (LMOs) have a unique role in building relationships between regional councils and landowners, and linking farm activities to catchment water quality. FOCUS has been developed with Greater Wellington Regional Council to customise catchment and farm planning. Our goals were to identify water quality 'hotspots', help farmers develop customised solutions to improve water quality, assess catchment outcomes and track change. FOCUS starts with the question – "Is there is a water quality issue?" - before work on the four main modules begins. The **Catchment** module allows rapid creation of a knowledge bank, exploration of local resources and assists in identifying where farm plans should be prioritised in the catchment. The **Farm** module is based around a customised Farm Action Plan, with the farmer in the driver's seat and the LMO as the navigator. The **Farm Action Plan** is developed on farm in a simple spreadsheet format and contains basic farm information, reviews previous farm planning, documents the farmer's view of the catchment and uses a progress-focused conversation to help the farmer develop the direction (longer term-goals) for change, explore what is already working and create small steps to take now. In the real world change lurks around every corner, so detailed action plans may rapidly become outdated or are filed away and never read. The small steps are created by the famer; creating a plan that requires others to take action almost guarantees that the plan will gather dust. **User training** is a key component of FOCUS and is designed to ensure LMOs have an understanding of how to use and customise FOCUS, identify training needs, and provide an introduction to progress-focused conversations. Activities, outputs and **outcomes** are tracked in FOCUS, including documenting changes in farmer awareness and progress on the ground. FOCUS is presented as a VUE content map (available to download on http://www.envirolink.govt.nz/Envirolink-tools/) and our hope is that this prototype is customised by users and continues to evolve as new tools are developed.

THE MATRIX OF GOOD MANAGEMENT: TOWARDS AN UNDERSTANDING OF FARM SYSTEMS, GOOD MANAGEMENT PRACTICE, AND NUTRIENT LOSSES IN CANTERBURY

Roger Williams[1]*, Hamish Brown[1], Ian Brown[2], Raymond Ford[2], Linda Lilburne[3], Ina Pinxterhuis[4], Melissa Robson[2,5], Val Snow[5], Ken Taylor[2] and Tina von Pein[6]

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The Matrix of Good Management (MGM) project is a collaborative initiative between Environment Canterbury, Crown Research Institutes (AgResearch, Plant & Food Research and Landcare Research), primary sector organisations (DairyNZ, Deer Industry New Zealand, NZPork, Beef + Lamb New Zealand, Horticulture NZ and the Foundation for Arable Research) and is overseen by a cross-sector governance stakeholder group.

The project aims to take a consensus approach, involving primary industry sectors, research institutes and Environment Canterbury, to quantifying the typical nitrate nitrogen (N) and phosphorus (P) losses that are expected to occur from the range of farming systems, soils and climates across Canterbury, when managed to industry-agreed, good-management practice (GMP).

This paper provides an update to the introductory paper presented at the 27th FLRC Workshop in 2014. In particular it summarises progress with:

- Collection and analysis of real farm data aimed at characterising the main farm systems in operation in Canterbury;
- Definition of GMP through iterative and consultative approaches within and across primary industry sectors;
- Translation of these narrative descriptions of GMP into inputs that can be used to model N and P losses using Overseer®;
- Creation of clusters of farming systems, soils and climates to provide an appropriate level of detail for the range of possible uses of the matrix.

The first iteration of the 'Matrix of Good Management' is expected by August 2015.

FARMING WITH LIMITS NORTHLAND STYLE – THE POSSIBILITIES WHEN SCIENCE AND COMMUNITY JOIN FORCES

Helen Moodie, Tom Stephens and Adrian Brocksopp

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The Mangere River (Northland) catchment is one of five catchments prioritised for implementation of the National Policy Statement for Freshwater Management by the Northland Regional Council. DairyNZ and council are working together to support a collaborative stakeholder group to determine values and derive water quality objectives in the small (82 km^2), predominantly pastoral catchment.

Data from six monitoring stations within the Mangere catchment, (2007-2010) complemented by a longer-term state of the environment monitoring record at Knight's Bridge (2000-2012) have been collated and analysed for spatial, seasonal and long term trends.

The catchment has already moved from an unacceptable state into a B/C grade for human health under the National Objectives Framework. Dissolved oxygen and sediment are key constraints on ecosystem health, with degradation of seasonal oxygen minima and water clarity concerns for native biodiversity.

Regardless of additional water quality values that may be identified by the stakeholder group, maintaining or improving water quality will require on-farm action for sediment, shade and water conservation across the catchment.

Presentation of science in a way that stakeholders readily understand provides the foundation for greater community understanding and drives behaviour change on-farm to enhance water quality. Many change programs fail because it is assumed that people are ready to change. In reality everyone in a group of farmers will be operating at a different stage in the change cycle. Implementation of Sustainable Milk Plans (individualised farmer environment plan) on each of the 19 dairy farms in the catchment helps to understand the stage a person is at. Extension intervention can then be more effectively targeted to their change stage.

The SMP process is also helping demonstrate to policy makers and to the wider community the collective commitment of farmers to responsible dairying and improved water quality.

This talk will explore the role of water quality science in motivating and guiding on-farm actions for improved water quality.

THE CONTEXT AND PRACTICE OF NUTRIENT MITIGATION ON ROTORUA DAIRY FARMS

Simon Park[1], Tanira Kingi[2], Sharon Morrell[3], Lee Matheson[4] and Stewart Ledgard[2]

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Dairy farmers in the Lake Rotorua catchment have been involved with multiple initiatives to manage nutrient losses to water since the early 2000s. These have included:

- Rule 11 which capped N and P losses at 2001-2004 levels, and its subsequent implementation via farm-based Overseer assessments
- Setting a sustainable catchment nitrogen load limit of 435 tonnes via changes to the Regional Policy Statement, associated Environment Court appeals and their resolution
- NIWA's catchment scenario modelling that indicated average pastoral N leaching needed to be halved to meet the 435 limit
- DairyNZ supported reassessments of Rule 11 and 2009-10 N leaching
- Individual farmer-led mitigation initiatives, including several recent detention bund structures focused on mitigating sediment and P loss.
- Economic studies – Farmer Solutions Project and Nitrogen Discharge Allowance (NDA) Impacts
- Two Sustainable Farming Fund Projects, including the current SFF11-023 project titled "Meeting nutrient loss targets on dairy farms in the Lake Rotorua catchment".

The current policy context for Rotorua farmers is dominated by the collaborative development of new N rules, incentives scheme and advisory services. While several farmers are actively involved in the policy process, they generally remain concerned at the complexity, extended development, uncertainty, potential costs and the scientific validity/necessity of large N leaching reductions. The latter concern is exacerbated by Lake Rotorua actually meeting its water quality target for the last three years due to ongoing alum dosing in two streams which limits in-lake P and (consequently) algal growth. The Regional Council anticipates that new N rules will be notified by mid-2015.

The concurrent Parekarangi Trust SFF farmlet trials have continued to show significantly lower N leaching rates on the nil N fertiliser treatments relative to standard N (140-160 kgN/ha/yr), albeit with large differences between 2013 and 2014. There has been no deterioration in grass species when N fertiliser was withheld over 2 years.

CAN THE RMA TOOLBOX PROVIDE EFFECTIVE TOOLS TO MANAGE THE IMPACTS OF FARMING ON FRESHWATER QUALITY?

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Economic contribution of farming to Gross Domestic Product (GDP) in New Zealand remains significant. It may be argued farming component is only 13% of the GDP in 2013. However, the farming input to total NZ export earnings is 1/3, which is nearly 50% of the export earnings derived from the exports of goods alone.

Farm production, particularly dairy has been increasing more rapidly in the past decade. For example, increasing dairy production is attributed to increased productivity per cow and increased expansion. Concerns had been raised by water users and environmental advocates about growing dairy expansions and the subsequent increasing pressure on water resources.

Much of the concerns have been on degrading water quality, particularly increasing nutrient levels in waterways. The paper takes the view that while nutrient monitoring is critical and useful to monitor potential adverse effects on waterways, long-term biological health monitoring of the waterways is also vital to capture actual adverse effects on freshwater habitats.

The paper analyses long-term water quality, including biological status of the rivers and lakes in New Zealand using regional and national monitoring reports results to gauge the actual impacts of farming on water quality. The overall analyses indicated that there had been compelling evidence on deteriorating nutrient levels in waterways in many agricultural catchments. Such deterioration has not yet, however, fully or correspondingly manifested into significant habitat damage.

The paper nevertheless takes the view that environmental impacts, both potential and actual, have to be managed promptly and effectively. It analyses the effectiveness of a range of tools in the Resource Management Act to manage the impacts of farming on water quality.

ACCELERATING THE ADOPTION OF GOOD ENVIRONMENTAL PRACTICE ON DAIRY FARMS IN THE UPPER WAIKATO CATCHMENT

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The Upper Waikato Sustainable Milk Project is the largest environmental good-practice catchment project ever undertaken by the New Zealand dairy industry. Co-funded by the Waikato River Authority, Primary Growth Partnership and DairyNZ, the project aims to accelerate the adoption of good environmental practice on farm to ultimately improve the health of the Waikato River. Over a three-year period from June 2012, all 700 dairy farms in the Upper Waikato Catchment are being offered one-on-one advice and support via the development of a farm-specific DairyNZ Sustainable Milk Plan (SMP). The SMP process involves consultants working with farmers individually to assess the current status of their farming system and identify risks in the key areas of nutrient, effluent, waterways and land management, as well as water use efficiency. An action plan is developed and follow-up support is provided by the consultant during implementation.

All individual actions implemented are being documented to enable estimation of potential changes in nitrogen (N), phosphorus (P), sediment and *E. coli* losses off-farm before and after plan implementation. Two years into the project, preliminary results indicate an average 8% (range 0-49%) reduction in N and 16% (range 0-63%) reduction in P across the first 439 farms analysed. The project is on track to improve the health of the Waikato River through the collective actions of all 700 dairy farms in the catchment.

The poster presentation will report of the analysis of the actions from 591 Sustainable Milk plans that have been completed up to 20 December 2014.

THE FARMING FOR THE FUTURE RESEARCH PROJECT – UNDERSTANDING THE OUTCOMES OF LOWER NUTRIENT INPUT ON SHEEP/BEEF FARMS USING DICALCIC PHOSPHATE

Jayson Benge[1], D Lucock[1], J Manhire[1] and A Topp[2]

[1]*The Agribusiness Group*
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Since 2009, the Farming for The Future Research Project has been monitoring 11 NZ North Island Class 3 (hard hill country) to 4 (hill country) sheep/beef farms that have applied dicalcic based fertilisers instead of traditional superphosphate fertilisers. Where possible, the management and outcomes of these has been compared with Ministry for Primary Industries (MPI) and Beef & Lamb NZ (BLNZ) benchmarks. These farms have applied noticeably less P (and S). Average soil quality values including P have generally been in the medium to high ranges (reported by the lab). The exceptions have been low S and pH. Soil P levels have tended to decline. This has been less so for those farms that have been using dicalcic for the longest. Overall, there has been little change in pH across the farms. Average earthworm numbers have tended to be highest on the farms that have been using dicalcic for the longest. Generally, pasture quality measures have been in the medium to high ranges (reported by the lab), with the exceptions of low digestibility of organic matter in dry matter and low nitrogen (%). The latter may be due to sampling before maximum clover production. Some micronutrients have been high. Most of the average pasture quality values have not changed markedly with the exception of a decline in some micro-nutrients and P which has varied notably between years compared to other macronutrients. Production and financial measures have varied between farms with some being above industry average and some below. On the whole, average production and financial values have tended to fall between average BLNZ values for Class 3 and Class 4 farms. According to *Overseer*, for the last two seasons, the amounts of P reported to be lost to water ranged from 0 to around 4 kg/ha/yr across all the farms. It is recognised that this project is case study based, with a limited number of farms. Nevertheless, some interesting trends have been identified and additional research looking at the outcomes on farms applying less nutrient could be valuable particularly given that phosphate rock is finite and the lower environmental impacts.

SOIL HEALTH ASSESSMENT OF TARO FARMS IN SAMOA

Danilo Guinto, S Lauga, L Dauara, E Walasi and D Autufuga

Ballance Agri-Nutrients, Tauranga

Forty composite topsoil samples (0-10 cm deep) were collected from farms exporting taro from the two main islands of Upolu and Savaii in Samoa in order to measure the farms' soil chemical, biochemical/biological health status, and to evaluate any soil nutritional problems that may affect taro productivity. Chemical indicators measured include pH, organic C, total N, Olsen P, exchangeable cations (K, Ca and Mg) and micronutrients (Cu, Fe, Mn and Zn). Biochemical indicators include anaerobically mineralisable N (AMN), labile carbon (LC) and fluorescein diacetate (FDA) activity. Nematode counts (parasitic and free-living) were used as biological indicator. The topsoils are moderately acidic (pH 5.53). The levels of organic C (11.3%) and total N (1.02%) are high since long-term cultivation by machinery has not occurred in Samoa. However, mean Olsen P level is low (10 mg/kg) and can potentially be a limiting nutrient for taro in the long term. Exchangeable Ca and Mg are both high. However, the topsoils contain only medium levels of exchangeable K and given the high uptake of taro for this nutrient and high rainfall and leaching rates, this could be another nutrient element that may limit production in the future. Micronutrient levels are generally very high so deficiencies are unlikely. Biochemically, the level of AMN (32.7 mg/kg), LC (1310 mg/kg) and FDA (153 mg/kg) were high indicating microbial activity is high and is significant for the fertility of Samoan soils. The population of free-living nematodes is higher than the population of parasitic nematodes with a ratio of almost 3:1 suggesting biologically good soils with a low biosecurity risk during taro exportation.

POLICY IMPLEMENTATION

- AN UPDATE FROM HORIZONS REGIONAL COUNCIL

(INTRODUCTION)

Jon Roygard

Horizons Regional Council, Palmerston North

On the 19th of December 2014 Horizons One Plan (Horizons combined Regional Policy Statement, Regional Plan and Coastal Plan) became operative. From that date the previous regional plans, regional policy statement and proposed versions of the One Plan no longer have legal effect.

The One Plan contains rules around nutrient management for existing intensive farming operations (dairy, intensive sheep and beef, cropping and commercial vegetable growing) within targeted catchments. Conversions from extensive to intensive farming operations anywhere in the Region also fit into this rule stream. This presentation will provide an update on the implementation of policies for nutrient management in the One Plan.

ENVIRONMENTAL FARM PLANS
– OUR EXPERIENCE IN THE MANGATAINOKA CATCHMENT

Jess Hughes, Jon Roygard, Peter Taylor, Derek Ryan, Manas Chakraborty, Maree Clark and Logan Brown

Horizons Regional Council, Palmerston North

The Mangatainoka Environmental Farm Plans Project was a 2 year project carried out by Horizons Regional Council from 2012 to 2014. This project was one of 8 projects under the Manawatu Leaders Accord and the Fresh Start for Fresh Water Clean-up Fund.

The project involved working with dairy farmers in the Mangatainoka catchment to prepare an Environmental Farm Plan (EFP) for each farm. Participation by farmers was voluntary and the EFPs sought to identify opportunities to reduce nutrient losses to water in the catchment.

This addressed one of the objectives of the Manawatu Clean-up Fund which was to reduce the contaminant contribution from dairy farms to the Manawatu Catchment by 10% by 2021.

The Mangatainoka catchment lent itself to the project due to known water quality issues and its high proportion of dairy land. The Mangatainoka Catchment is also one of the Target Catchments for nutrient management as identified in Horizon's One Plan, requiring dairy farms to have existing land use consent by July 2015.

83 of the 88 dairy farms in the Mangatainoka catchment were involved in the project and had an EFP completed. Each EFP contained comprehensive information on each farm's physical resources and management system. As a part of the EFP a nutrient budget was also completed and mitigation options explored to achieve a reduction in N loss specific to each farm.

Completion of the 83 EFPs allowed for a range of farm specific data to be collected. This data was then analysed with respect to farm physical resources and management and their relationship with N leached.

The results of this analysis are presented in this paper.

MANAWATU ACCORD AND CLEAN-UP FUND PROJECT
- PROGRESS REPORT

Lucy Ferguson, J Roygard, A Deverall, A Cooper, M Clark and L Brown

Horizons Regional Council, Palmerston North

Water Quality in the Manawatu Catchment has been subject to much debate over recent years particularly during the regional planning process known as the One Plan, consenting processes and the media. There are a range of views on the state of water quality and how it should be addressed. This paper focuses on the efforts of the Manawatu River Leaders' Forum in partnership with the Government's Fresh Start for Freshwater Clean-up fund to address water quality issues in the Manawatu Catchment.

In early 2010, Horizons invited key leaders with a stake in the future of the river to meet and discuss the state of water quality in the Manawatu Catchment. These leaders represented iwi across the catchment, local government, industry, farmers and environmental representatives. This meeting occurred in the midst of the One Plan process and following the Manawatu River being reported as one of the worst in the western world. Over the next six months they debated the issues from contrasting perspectives with a view of reaching an agreed solution. In August 2010, the Leaders' Forum signed an accord pledging to work together to improve the health of the Manawatu River. The Accord set out a focus, goals, and vision for the Manawatu River and, most importantly, committed the leaders to a path of action. The group continued its work and in June 2011 launched an Action Plan to the community that contained over 130 volunteered actions.

In 2012, the Manawatu River Leaders' Forum received $5.2 million from the Government's Fresh Start for Freshwater Clean-up fund. This assisted toward implementation of a suite of projects totalling over $30 million. The further funding for the project was contributed by Tararua, Manawatu and Horowhenua District Councils, landowners, DairyNZ and Horizons Regional Council. The projects involve upgrading sewage treatment plants, land-based disposal, environmental farm plans, stream fencing, habitat restoration and supporting community-based initiatives.

This presentation will show the scientific background to the selection of the projects and how they complemented other work in the catchment. Further it will report on the progress of the projects and the outcomes from these.

LAKE HOROWHENUA ACCORD AND CLEAN-UP FUND

- PROGRESS REPORT

Jon Roygard, L Brown, M Clark, L Ferguson, A Deverall and A Cooper

Horizons Regional Council, Palmerston North

Lake Horowhenua is a vital taonga, highly valued by local iwi for a range of reasons including the provision of significant fishery. The lake has the potential to be a considerable recreational asset for the southern part of the North Island.

Water quality in Lake Horowhenua is degraded. Based on the tropic level, Lake Horowhenua was ranked the 105 worst out of 112 monitored lakes in New Zealand in 2010. Efforts to clean-up up the lake have been ongoing for several decades and include the establishment of a full native planting buffer strip around the lake and a formal catchment management strategy being established by the Regional Council. However, these efforts have not curbed the decline in water quality and further significant water quality interventions are necessary.

Alongside the science and restoration efforts, several key partners have developed and signed the Lake Horowhenua Accord in August 2013. This development was led by Horowhenua District Council and draws together: the Lake Horowhenua Trustees (who represent the beneficial owners of the Lake); the Lake Domain Board; Horowhenua District Council; the Department of Conservation and Horizons Regional Council.

In February 2014, Minister for the Environment Hon. Amy Adams announced a funding injection of $540,000 from Central Government towards the Lake restoration. This complements $730,500 of funding from HRC, HDC and industry. This presentation will show the scientific background to the selection of projects for funding and how they complemented other work in the catchment. Further it will report on the progress of the projects to date.

ADAPTING MANAWATU DAIRY FARMS TO REGIONAL COUNCIL CATCHMENT TARGETS

Terry Parminter[1] and Scott Ridsdale[2]

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The Manawatu-Wanganui Regional Council (MWRC) One Plan has identified 31 sensitive water management sub-zones of catchments. The approximately 420 dairy farmers in these sub-zones must prepare farm plans describing the practices that they will use to manage the impacts of potential nutrient, sediment and microbial contamination of their farms. They must use these plans to apply to the MWRC for a landuse consent.

DairyNZ has worked with MWRC to put in place a pilot project that assists farmers develop the farming system changes required in their farm plans and to apply for their consents. Two examples are described in this paper of relatively high producing farmers that have successfully participated in the project. These farmers intend to modify their farming systems including increasing their use of dairy effluent, reducing nitrogen fertiliser, improving feed flow, and herd composition, to increase dairy production by 5-10% and decrease estimated nitrate leaching by over 10%.

In both examples the farmers have committed themselves to making changes that could be difficult to implement in an uncertain future. The changes will require the farmers to develop their existing skills in farm management even further. Both the farmers are motivated by wanting their communities and the public to be more positive about the contribution of dairying to the economy, New Zealand’s way of life and our national environmental stewardship.

POLICY DEVELOPMENT AND IMPLEMENTATION – AN UPDATE FROM WAIKATO REGIONAL COUNCIL

Alan Campbell

Waikato Regional Council, Hamilton

The Healthy Rivers: Plan for Change/Wai Ora: He Rautaki Whakapaipai project is working with stakeholders to develop changes to the Waikato Regional Plan to help restore and protect the health of the Waikato and Waipa rivers.

Waikato and Waipa River iwi and Waikato Regional Council are partners on this project, as set out in settlement and co-management legislation for the Waikato and Waipa rivers.

Collaborating with stakeholders to develop the plan change

The Collaborative Stakeholder Group (CSG) is the central channel for stakeholder and broader community involvement in the project. This group will:

- actively involve communities affected and understand their views
- play a key role in leading further opportunities for involvement
- review and deliberate on technical material on the environmental, social, cultural and economic complexities of the project
- recommend solutions to decision makers.

An alliance of technical experts

The Technical Alliance will collate, analyse, summarise and present environmental, social, cultural and economic information about the rivers and the consequences of different land management scenarios. This information will be used by the Collaborative Stakeholder Group and decision makers on the proposed plan change.

Preparing for farming within limits

In anticipation of the objectives, limits and targets to be included in the plan change, Waikato Regional Council is working with stakeholders to prepare the agriculture industry for the change. This work includes developing menus of practices to improve water quality, supporting the joint DairyNZ / Waikato River Authority Sustainable Milk Projects, and bringing the Massey nutrient management courses to the region to build capacity among rural professionals.

When it's happening

We expect to notify the proposed plan change in 2015. Allowing a couple of years for hearings, and any Environment Court appeals, the whole plan could be operative in 2019. Plan changes for the remainder of the region will follow over subsequent years.

POLICY IMPLEMENTATION
- AN UPDATE FROM ENVIRONMENT CANTERBURY

Leo Fietje

Environment Canterbury, Christchurch

The Land & Water Regional Plan is a new planning framework for Canterbury. It aims to provide clear direction on how land and water are to be managed and help deliver community aspirations for water quality in both urban and rural areas. Delivering these aspirations means addressing all sources of nutrients entering or with the potential to enter water, including those originating from land.

The new framework takes a region-wide "hold the line" approach with provision for zone by zone variations if needed to better meet community aspirations. The region-wide approach relies heavily on OVERSEER®, effectively requiring every land-owner to estimate nitrogen "baseline" losses that occurred over a historic four-year period. In areas where water cannot absorb more nutrients without compromising community aspirations, the estimate of the baseline loss becomes a limit to future losses, unless losses are very low.

Community reaction to the new framework has been mixed, though there is broad acceptance of the need to do something about the ongoing degradation of water quality. In my experience farmers take their role as land stewards seriously. I have yet to meet one who doesn't genuinely care about the quality of their favourite fishing spot or swimming hole, or the quality of water available to their stock, who doesn't care about the cost of nutrients they are losing or want to leave the farm to the next generation in better shape than when they took it over. The challenge is at a level below these areas of broad agreement, such as reasons and responsibilities.

OVERSEER® has and continues to be challenging, with concerns around its predictive accuracy, the number of new versions with sometimes significant changes in estimates, consistent use amongst practitioners and the capacity of rural professionals to deliver the many thousands of nutrient budgets needed in Canterbury. Environment Canterbury has set up an industry working group to advise and where appropriate, make decisions on these issues and ensure blockages to the successful use of OVERSEER® are removed.

Another area of challenge is the need for the management of nutrients and allocation of available load to be absolutely fair, both between rural and urban sources and amongst land owners at different stages of development and varying levels of historic nutrient loss. There are no simple solutions, but there are some promising approaches which my colleague Ian Lyttle will talk about.

PROCESS AND OUTCOMES OF THE NITROGEN ALLOCATION REFERENCE GROUP (NARG) FOR SOUTH CANTERBURY COASTAL STREAMS (SCCS) AREA

Ned Norton, Ian Lyttle, Nic Newman, Colin Hurst and Ian Whitehouse

Environment Canterbury, Christchurch

When developing the Zone Implementation Plan (ZIP) addendum for the SCCS, the Lower Waitaki Zone Committee (ZC) engaged the public in a number of meetings to explore scenarios and solutions for the regional plan. The draft addendum with recommendations for nitrogen load limits and N allocation frame work was met with protest from 80 farmers at the ZC meeting. How was the issue resolved?

Commissioners extended the timeframe and the 'NARG' established, comprising farmers from a range of sectors, rūnanga and members with general community interests. The purpose of the group was "to work with ECan to assess and describe the consequences of different options for allocating N Load in the SCCS area".

The first meeting acknowledged that some farmers had not enough opportunity to understand the implications of N limits and N allocation framework for them. It was agreed to reconsider the background information and develop more acceptable solutions. To develop an acceptable model for N allocation, the group considered a range of models which to distribute the proposed and accepted N discharge limits.

The process involved meetings, workshops and extensive communications among participants, ECan staff and others over six months. The NARG kept the Zone Committee informed and received feedback from them. The three phases of the group were: developing common understanding; assessing N allocation options; facilitated consensus.

Farmers from the different farming sectors developed a new N allocation model, ultimately adopted by the Zone Committee. High emitters agreed to progressively reduce emissions to provide a flexible N pool that low emitters could draw on to intensify and satisfy their needs for a profitable business

Lessons for the collaborative public process have been carried through to other Zones in Canterbury as each develops their own solutions for inclusion in the regional plan. The principle of public collaboration has been strengthened and reaffirmed by the positive outcomes from South Canterbury Coastal Streams agreed nutrient allocation model in the regional plan.

SNAKES AND LADDERS:

HELPING FARMERS IMPLEMENT THE NUTRIENT MANAGEMENT PROVISIONS OF THE ECAN LAND AND WATER REGIONAL PLAN

A H C Roberts

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Environment Canterbury's operative Land and Water Regional Plan (LWRP) has a requirement for some 8000 farmers and growers to estimate their annual N loss below the root zone using the latest version of OVERSEER®. Additionally they are also required to estimate their baseline N loss below the root zone for the years 2009 to 2013 using OVERSEER®.

The fertiliser industry, that is principally Ballance Agri Nutrients and Ravensdown, have around 140 technical service representatives and agri-managers between them nationwide. Around 15 of these staff operate in the Canterbury region and are trained and competent in using the nutrient budgeting tool.

While there is an expectation both within the fertiliser industry itself but also the Regional Council that fertiliser co-operative staff will be involved in providing both annual N loss estimates and baseline N losses to assist our shareholders to retain their 'licence to operate' it is also recognised that there is a capability shortage. Private agricultural consultants, Irrigation consultants and staff working within irrigation companies also prepare nutrient budgets using OVERSEER®, which assists in bridging the capability shortage.

In order to ensure consistency in the delivery of nutrient management services consistent with the LWRP to the farmers and growers in Canterbury an informal 'Implementation Committee' was formed consisting of staff from the Regional Council, private consultants (NZIPIM), irrigation company representatives and the two fertiliser co-operatives.

This paper discusses some of the issues that have surfaced around farmer awareness of the Plan and its ramifications, prioritising which farms are modelled first, data inputs, what constitutes significant 'change' in a farm system, OVERSEER® capability in modelling farm systems and other initiatives taken to assist farmers meet the requirements of the Plan.

DAIRY FARMING AT EALING, SOUTH CANTERBURY

Mark and Devon Slee

National Winners 2014 BFEA, Ashburton

We are Dairy Farming 25km South of Ashburton in Canterbury.

Our home property consists of 3 dairy units each milking approx 880 cows on a total of 705ha. An additional 217 ha is used for young stock and winter grazing support.

Part of our farming philosophy is to be efficient with the way we use our resources on farm. From a nutrient management perspective; the management of our irrigation, fertiliser and greenwater applications. Being efficient with these resources is part of maintaining a profitable and sustainable business moving forward.

My presentation will cover how we practically use this technology on farm. This will include irrigation type and technology, soil moisture monitoring and use of GPS. I will also provide information which supports what this change in technology has given to our production and environmental outcomes on farm.

CERTIFICATION OF NUTRIENT MANAGEMENT ADVISERS – ONE YEAR ON

Philip Mladenov[1], Louise Hargraves[1] and John Clayton[2]

[1]*Fertiliser Association of New Zealand,*
[2]*Emerging Technologies Centre, Waikato Institute of Technology*

The certification programme for nutrient management advisers was initiated in late 2013. The programme has so far certified 85 advisers who work across almost all regions of New Zealand. These people comprise representatives from the two main fertiliser companies as well as agri-business consultants. In addition, there are more than 50 people enrolled in the programme who are in the process of seeking certification.

To become certified an adviser must be actively engaged in providing nutrient management plans to farming enterprises, have completed the Intermediate and Advanced Courses in Sustainable Nutrient Management offered at Massey University, passed a rigorous online assessment, and provided testimonials from farmers verifying the usefulness of their nutrient management plans. The names of certified advisers are posted on the programme's website (www.nmacertification.org.nz).

A programme of Continuing Professional Development (CPD) was introduced into the programme at an early stage. A minimum of 15 hours of CPD must be gained by certified advisers each year. Qualifying activities include the completion of educational modules, attendance at approved workshops and conferences, and authoring conference and journal papers.

The programme's learning management system is powered by the Moodle open-source e-learning platform. This system provides a robust environment for advisers to upload their qualifications, undertake online assessments, access CPD learning modules and upload evidence of CPD. Moodle has proved effective in minimising the administrative overheads associated with the programme. An e-newsletter, Nutrient News, provides advisers with up-to-date information about the programme, including new educational modules, upcoming events, and other relevant information.

OVERSEER® GOVERNANCE 2014 AND BEYOND

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The presentation *Overseer® Governance 2014 and beyond* will review the internal changes made in 2014 to support a more transparent approach to managing the development of this increasingly important nutrient management decision support tool and provide an update on the current work priorities.

OVERSEER® Nutrient Budgets (*Overseer*) is a farm-scale nutrient management tool owned by the Ministry for Primary Industries, The Fertiliser Association of New Zealand and AgResearch Limited.

Overseer provides information to examine nutrient use and movements within a farm to optimise production and environmental outcomes. This is done by estimating nutrient transfers in, around, and out of a farm, including nitrogen leaching losses.

The objective of the Overseer development program is to maintain and continue development of a New Zealand wide strategic farm-specific model that is 'fair and equitable' by:

- Capturing nutrient pathways and transfers within the farm system.
- Modelling processes where paths change using robust science processes.
- Using data that the farmer knows, or is readily available and where it's not using industry informed defaults.
- Maintaining consistency between farm systems by modelling all systems in an integrated model to the same scale.
- Maintaining focus on mitigation options

No model is perfect and the pipeline of enhancements for *Overseer* is managed collaboratively so that the assumptions are based on NZ conditions, industry agreed where possible and include the most up-to-date science.

Three advisory groups to support the strategic development of *Overseer* met for the first time in 2014. The advisory groups include key stakeholders, expert users as well as independent scientists to ensure that the development programme has robust and comprehensive advice. The outcomes of the advisory group meetings, changes being made to the tool and supporting features and the ongoing development agenda will be set out in this presentation.

It is tools like *Overseer* and the potential they represent that enables New Zealand to apply an effects–based approach to managing off-farm nutrient losses and as a result stimulating innovation and flexibility in the industry to continue as world leaders in nutrient management.

NEW IRRIGATION MODULE IN OVERSEER 6.2

– WHAT TO EXPECT

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OVERSEER® Nutrients Budgets (*Overseer*) is a farm scale model that estimates nutrient transfers in, around, and out of a farm, including nitrogen (N) leaching losses. The two major drivers of N leaching are animal feed intake, which drives N intake and N excretion; and soil properties and drainage, which strongly influence the risk of excreted N being leached. Irrigation increases dry matter (DM) production and hence animal intake. The extra DM production is captured from user input of production information. Irrigation may also increase drainage, particularly if excess water is added that exceeds the crops requirements and soil holding capacity. *Overseer* includes an irrigation sub-model so that the effect of irrigation applications on drainage, and hence N leaching losses can be estimated.

Currently, *Overseer* users include irrigation by selecting an irrigation method and an additional option to enter application depth for each month irrigation is applied. If the method of application only is selected, a default irrigation management practice is assumed when estimating the irrigation application depth. This management practice assumes irrigation is applied so that soil water contents are maintained between 70% and 95% of profile available water (PAW). However, this option does not allow the range of irrigation management practices currently used of New Zealand farms to be modelled, or for the effect of changing irrigation management practices to be reflected in the N leaching estimate.

If irrigation application depth is entered, it is important that climate data and irrigation depth data are commensurate, and with the information coming from differing sources this is not always easy to achieve. Entering irrigation depth can lead to high estimates of drainage and hence N leaching.

With the increasing use of *Overseer* by regulators and the growing understanding of how different irrigation management practices can reduce N-losses, users have been looking for more differentiation in the irrigation submodel in *Overseer*. Given this and known limitations on the current functionality, a project to improve the irrigation submodel has been undertaken.

This paper will describe the improved sub-model, and provide example outputs of drainage and N leaching.

MITAGATOR™:

A FARM-SCALE TOOL TO ESTIMATE AND MITIGATE THE LOSS OF NUTRIENTS AND CONTAMINANTS FROM LAND TO WATER

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The MitAgator™ is a software-based decision support tool that estimates and maps the risk of nitrogen, phosphorus (P), sediment and faecal indicator bacteria (*E. coli*) losses from land to water. It is also designed to estimate the cost and effectiveness of strategies to mitigate these losses. The algorithms used in MitAgator™ are derived from published studies and uses the OVERSEER® Nutrient budgets (Overseer) urine N leaching model. To maximise compatibility and minimise setup requirements, inputs to the MitAgator are derived from an Overseer file and augmented with spatial databases.

As part of a corroboration exercise, MitAgator™ loss estimates were compared against measured data and a sensitivity analysis was conducted. The most complete dataset is for studies of P losses and hence is the focus of this presentation. Losses were measured from 48 sites (Bay of Plenty, Canterbury, Hawkes Bay, Manawatu-Wanganui, Otago, Southland, Taranaki, Waikato and Westland regions) varying from plot to catchment (250 km^2) scale. Almost half the variation in losses was predicted by the model (P<0.001). However, the mean error of estimation increased in high rainfall areas (> 1200mm/y).

A sensitivity analysis was conducted to determine which parameters had the most leverage on estimated P losses, and so identify which factors were the priorities for good quality input data. This analysis modelled losses for eight agricultural enterprises (irrigated and dryland dairy, sheep and beef, deer, wheat-fallow-wheat, wheat-winter crop-wheat, kiwifruit and forestry). In general, the most sensitive inputs were hydrological characteristics, followed by soil characteristics and P inputs (e.g. P application rate and form). Other important, but enterprise-specific parameters, included deer wallowing or the presence of winter forage crops.

There are a number of limitations attached to the use of the MitAgator™ tool. It has been designed for farm-scale application, not for large catchments (>1000 ha) where other models such as CLUES, which can account for in-stream attenuation, are more appropriate. It should also be recognised that outputs describe annual losses; seasonal or episodic losses are not explicitly considered. Finally, cost estimates of mitigations constantly change and users should therefore input the most up-to-date estimates relevant for their operation.

MITAGATOR™ - IN ACTION SOLUTIONS FOR MANAGING NITROGEN, PHOSPHORUS, SEDIMENT AND *E. COLI* LOSS

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With ever increasing pressure to address on farm nutrient losses to the environment while maintaining productivity and profitability, land owners require the appropriate decision support tools (DST) to support nutrient management decisions. With many regions throughout New Zealand either part way through or entering the process of nutrient limit setting, the need to be more efficient in the area of nutrient use and loss is becoming of increasing importance.

Through Ballance's Primary Growth Partnership programme (co-funded by MPI) a new decision support tool called MitAgator™ has been developed to help landowners make more informed decisions about where nutrient loss occurs and the most appropriate mitigation options.

MitAgator is a farm scale GIS based DST that has been developed to identify and estimate nitrogen, phosphorus, sediment and *E. coli* loss spatially across a farm landscape. It draws on a wide base of New Zealand relevant science.

MitAgator™ requires base data, which includes the relevant farm's Overseer® file, geo-referenced farm map, soil, elevation data and aerial photo. Overseer® data is linked with spatial soil and elevation data allowing MitAgator™ to make more refined calculations of the relative risk of nutrient loss in a spatial context.

Loss areas are shown for each nutrient on risk maps which allows those areas of higher nutrient loss to be identified and targeted (as a starting point) with the most suitable and cost effective mitigations.

MitAgator™ will be of value to land owners who are looking at ways of reducing nutrient loss, particularly those who are in catchments that may have nutrient limits imposed or catchments where there are concerns around nutrient loss and associated water quality. Whether in a catchment with restrictions, areas of nutrient concerns or looking at where nutrient losses can be managed more effectively, MitAgator™ allows the user to better understand spatial variability of nutrient loss providing the opportunity to be strategic in mitigation placement. This provides the ability to plan and cost mitigation strategies, implementing them as finances and time frames allow.

ARE WE ON COURSE FOR A TRAIN WRECK WITH SOIL INFORMATION AND DATA FOR SUSTAINABLE NUTRIENT MANAGEMENT?

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Information and data regarding the properties and distribution of New Zealand soils has traditionally been collected by research-orientated organisations, generally at scales that facilitate the mapping of large areas efficiently. Increasingly, however, a variety of new providers are emerging to service the growing demand for more detailed soil surveys of individual farms, driven largely by council-requirements for sustainable nutrient management, and by the pursuit of resource-use efficiencies around fertiliser and irrigation. While aptly qualified providers exist, there is a risk of new providers entering the market without experience or qualification. Currently there are no standards or quality controls regarding farm soil survey, and anyone can claim to have expertise in soil characterisation and farm soil mapping.

In this paper we discuss why the collection of reliable farm-scale soil information is a difficult undertaking, and demonstrate financial and environmental risks of ‘getting it wrong’ with soil information for farm management and compliance requirements. Considerations for promoting greater transparency, assurance to end users, and national consistency, are also discussed.

A COMPARISON OF APSIM AND OVERSEER PREDICTIONS OF N LEACHING FROM A WELL-DRAINED SOIL UNDER DAIRYING

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Reducing nitrogen (N) leaching is a big challenge for the New Zealand dairy industry. Regulations are being proposed for intensive pastoral dairy farming to adopt systems and technologies that increase productivity while reducing environmental impact. Providing tools to assess farm systems and ensure their impact is within limits is a great challenge for the research community. The aim of this study was to compare two contrasting tools, the OVERSEER Nutrient Budget Model and the Agriculture Production Systems Simulator (APSIM), and their capacity for predicting N leaching under grazing dairy farming conditions. The study was conducted on a well-drained irrigated Manawatu silt loam soil within Massey No. 1 Dairy Farm. APSIM is a process-based model that works on a fine scale and daily time-step whereas OVERSEER produces annual averages of relatively large areas, with drainage and leaching calculations on a monthly time-step. As OVERSEER has been calibrated for New Zealand's farming systems and uses inputs that are easily accessible by farmers, it is the favoured tool for assessing compliance of dairy farms to proposed new regulations.

Results from both models were analysed in order to obtain long-term estimates of N leaching. Both models agreed reasonably well for the conditions studied, provided that appropriate data was provided to the models. The APSIM model estimated N leaching with a high degree of detail and was more sensitive to variations in environmental conditions and management practices. The APSIM model showed that most N leaching occurs in winter but indicated that the highest risk of N leaching is from the urine deposited in late summer and early autumn. The APSIM model also showed that N leaching increases with increasing N load in the urine. While the APSIM model is more sensitive to environmental conditions and management practices and allowing tactical management decisions, the model requires many inputs, with many model parameters not readily available at farm level. In contrast, the OVERSEER model is more user-friendly and has the ability to easily upscale nutrients lost from paddock to farm scale level, with the assumption that good management practices have been implemented on the farm.

THE INFLUENCE OF PHOSPHORUS FERTILITY AND LIMING ON THE FORMS AND FRACTIONS OF PHOSPHORUS LEACHED FROM ORGANIC SOILS

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Acid Organic soils often require considerable development for intensive agriculture. One key limitation to pastoral productivity is soil acidity, which is corrected by the application of lime. However, the application of lime also increases the mineralisation of organic matter (OM), releasing phosphorus (P) that could potentially impair water quality. The aim of this study was to identify the effect of changing pH in Organic soils on the quantities and forms of P lost in leachate. Our hypothesis was that the quantity and bioavailability of P lost from organic soils would increase with pH and that this would be exacerbated when P fertiliser was also applied. An acid mesic Organic soil was collected (30-60 cm) from a single paddock, dried and sieved (8 mm) then packed into lysimeters at field bulk density. Lysimeters received treatments of superphosphate (equivalent to 0, 50, 100 or 200 kg P/ha) and lime, to generate an initial soil pH of 4.5, 5.5 and 6.5. Lysimeters were sown in ryegrass, and artificial rainfall was applied over 11 months approximating the mean annual rainfall at the collection site, with leachate collected.

Mean soil Olsen P, water extractable P and $CaCl_2$ extractable P increased with P application rates. Dissolved reactive P (DRP) and dissolved organic P loads in leachate were greatest from the pH 4.5 treatment, with the pH 6.5 treatments losing the least DRP. Dissolved organic P (DOP) was also greatest from pH 4.5 treatments, but was not significantly different between pH 5.5 and 6.5 treatments. Soil fractionation data prior to leaching showed that most P was located in NH_4Cl- and $NaHCO_3$-extractable (and highly bioavailable) P forms. More P was extracted by HCl (thought to be Ca-P or possibly undissolved fertiliser) with increasing pH. Changes associated with leaching were largely due to decreases in bioavailable and HCl extractable pools, whereas NaOH extractable P (P associated with Al/Fe oxides and humic material) changed little. The findings of this study demonstrate that P losses were greatest from bioavailable pools in Organic soils. However, losses were moderated by incorporation of P into other pools as pH increased, due to the addition of lime. Furthermore, loses did not appear to be enhanced by mineralisation of organic material as originally hypothesized.

CAN LOW WATER SOLUBILITY PHOSPHORUS FERTILISERS DECREASE PHOSPHORUS LOSSES FROM AN ORGANIC SOIL?

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In areas of frequent surface runoff the risk of P loss can be decreased by using low-solubility forms of P fertiliser (e.g. reactive phosphate rock; RPR) instead of more soluble forms such as superphosphate. It is unclear if the same is true of leachate where P forms must first interact much more with the soil before being lost in, for example, artificial drainage to surface waters. RPR contains apatite which increases in solubility in low pH environments. Our hypothesis was that dissolved P losses in leachate from soils receiving RPR were similar to those receiving superphosphate at low pH, but were lower at greater pH.

An acid mesic Organic soil was collected (30-60 cm depth) from a single paddock, sieved (8 mm), and packed into lysimeters at field bulk density. Lysimeters received treatments of superphosphate (equivalent to 0, 50, 100 or 200 kg P/ha) and applications of lime to maintain an initial pH of 4.5, 5.5 or 6.5. Lysimeters were seeded with ryegrass, watered over 12 months with the equivalent mean annual rainfall volumes and rates as at the collection site and leachate was collected.

Loads of dissolved reactive and organic P (DRP and DOP) in leachate were greatest from the pH 4.5 treatment, with pH 6.5 treatments losing the least P over the trial. At pH 4.5 and 5.5 there were no significant differences in DRP or DOP loads lost from the RPR and superphosphate treatments. However, at pH 6.5 the loads of DRP and DOP lost from soils receiving superphosphate were greater than those of the equivalent RPR treatment when an application rate of 50 kg P/ha was exceeded. The results illustrate that the application of RPR to an acid Organic soil can result in DRP losses in leachate that rival those of superphosphate in soil pH ranges maintained for pasture production.

SOIL TYPE AND MOISTURE AFFECTS PHOSPHORUS LOSS PATHWAYS, FORMS AND AMOUNTS

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Soil moisture plays an important role in phosphorus (P) losses in runoff. Under wet anaerobic conditions, the reduction of Fe-oxides releases sorbed P into the soil solution that may be available for loss by transport processes in dissolved form. Under very dry conditions, soil hydrophobicity induced by soil organic C can exacerbate infiltration-excess surface runoff and soil erosion. Our hypothesis was that rainfall applied to dry soil would cause more P loss (especially as particulate P; PP) in surface runoff from an Organic (C-rich) soil than from a Brown soil of much lower soil C, but similar Olsen P concentration, due to hydrophobicity. However, at high soil moisture content, P losses would be largely dissolved and reflect the Fe concentration of the soil. An Organic and Brown soil with similarly low Olsen P concentrations were collected (10-17.5 cm depth) and placed in boxes designed to collected surface runoff and leachate. Superphosphate was applied to increase Olsen P levels to 15, 40, 60 and 80 mg P/L for each soil type, equilibrated for 3 months and then allowed to dry to two soil moisture contents (field moist or air-dry). After three weeks, artificial rainfall was applied to generate surface runoff and leachate.

The water drop penetration time for the Brown soil when dry was < 5 seconds, but > 3600 s for the Organic soil. Consequently, the greatest runoff volumes were measured as infiltration-excess surface runoff from dry Organic soil. Total P (TP) loads in surface runoff from both soils increased linearly with increasing Olsen P. However, surface runoff loads of TP and the relative proportion of TP as PP was much greater in the Organic than Brown soil. Under wet conditions the proportion of TP as DRP and dissolved organic P in leachate was much greater. Nevertheless, due to a much lower anion storage capacity the load of all P fractions was still much greater from the Organic compared to the Brown soil – irrespective of the loss pathways. The findings of this study indicate that soil moisture content influences loss pathways, but interacts with soil type to determine the form and quantity of P lost.

ROOTZONE REALITY - A NETWORK OF FLUXMETERS MEASURING NUTRIENT LOSSES UNDER CROPPING ROTATIONS

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Around New Zealand, regional authorities are responding to the National Policy Statement for Freshwater Management and developing plans to improve freshwater quality. A common theme is the requirement that farmers should, as a minimum, be applying agricultural good management practice (GMP) and developing farm environment plans to assess and manage the environmental risks associated with their farm business. It is expected that a farm nutrient budget will be part of the farm environment plan to provide a measure of the environmental performance of the farm. In most cases this will be an Overseer® nutrient budget.

Arable farmers have complex farm systems, they manage a number of crops and often have pastoral components to their farm businesses. They understand that there is a necessity to use models to develop nutrient budgets but they question whether these nutrient budgets are truly representing losses from their farms. They are right to be concerned because in reality there has been little measurement of nitrogen losses from the root zones of cropping rotations and we are short of data to calibrate the cropping components of the models. Having data to do this, is a good start to building farmer confidence in Overseer.

A new MPI Sustainable Farming Fund project “Rootzone Reality” will provide answers about nitrogen and phosphorus losses from the root zones of a range crops and cropping rotations. MPI, FAR, HortNZ, Ravensdown and five Regional councils (Canterbury, Horizons, Hawkes Bay, Waikato and Auckland) are partners in the project. Plant and Food Research is responsible for the delivery of the science programme and the interpretation of the data being collected.

The project is funding the installation of a permanent network of fluxmeters on commercial cropping farms in Canterbury, Manawatu, Hawkes Bay, Waikato and Pukekohe. Data from a diversity of arable and vegetable rotations will be collected, with crops including grains and seeds, onions, maize, potatoes, beetroot and process and green vegetables. The data is being collected over a number of years so the impact of stock grazing within the rotations will also be captured. As well as drainage and nutrient loss data, we will collect weather data, soil moisture and crop information including biomass accumulation throughout the season, final yield and the management practices associated with the crop production.

During the life of the project we will be running Overseer budgets for the crop system that the fluxmeters are under. The best outcome will be that the fluxmeter results fall either side of the modeled results, averaging out at about the same number over the long term.

SOIL NITROGEN AND SOIL WATER DYNAMICS IN ARABLE CROP ROTATIONS: ESTIMATION WITH THE MULTIPLE CROP SINGLE PURPOSE MODEL

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The objective of this study was to evaluate the Multiple Crop Single Purpose model (MCSP) for estimating nitrate leaching, soil nitrate and soil water content from crop rotation systems. MCSP is an APSIM crop model that allows the simulation of multiple crop types. It is based on the mechanisms and coefficients used in the OVERSEER® crop model and is intended for the single purpose of estimating the water and nitrogen uptake of crop rotations in New Zealand. Data for evaluation were from a 2004-2007 trial involving two crop sequences: Sequence 1 (potato-peas-potato-triticale) and Sequence 2 (potato-wheat-potato-triticale). The trial also included two irrigation treatments and three nitrogen treatments. In the trial, leachate was sampled at a depth 60 cm under the first potato crop and at 150 cm depth for the rest of the trial period. No leachate sampling occurred under the pea or wheat crop due to low rainfall amounts during this period.

Nitrate leaching was over-predicted during the first potato crop in both sequences. By contrast, predicted and measured nitrate leaching values were similar under the second crop except in Sequence 2 when drainage was over-predicted. A possible explanation for over-prediction under the first potato crop is that leachate sampling at 60 cm was affected by incomplete mixing of the leachate due to surface heterogeneity created by hilling. The association of over-predicted leaching and over-estimated drainage also reflected in Sequence1 under triticale crop could be attributed to a combination of over-estimation of drainage by the model and the inability to capture all drainage in the calculations.

In spite of the discrepancies observed in nitrate leaching, MCSP produced good estimates of total water content and total soil nitrogen in the profile during the trial period.

PRELIMINARY EVALUATION OF THREE METHODS FOR DETECTING URINE PATCHES IN THE FIELD

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Livestock urine patches are the major source of nitrogen-based emissions in grazed pastoral systems due to high concentrations of rapidly labile nitrogenous compounds, i.e. ammonium ions and the associated products of microbial transformation. These emissions include leached nitrate ions (NO_3^-) in soil solution, nitrous oxide gas (N_2O) and ammonia gas (NH_3), all of which have detrimental impacts on environments associated with intensive pastoral systems. To mitigate these emissions effectively and efficiently, the first challenge is locating the urine patches, given their small-scale nature and highly variable distribution across a recently grazed paddock. While the application of chemical formulations to inhibit the microbial transformation pathways has been a major focus of recent mitigation work, blanket application of such formulations is inefficient. Ideally these would be applied to individual patches, but this requires some means of patch detection and precise location. We conducted two field experiments to examine the potential for detection of animal urine patches after deposition. Patches were simulated with warm water or artificial urine applied to soil in amounts consistent with typical urine volume. Detection was by means of soil surface temperature measurements (via proximal infrared imaging), soil electrical conductivity (EC) measurements (via EC probes in the soil), and ammonia volatilisation measurements (via a portable gas analyser). All three techniques were successful at distinguishing simulated urine patches from non-patch areas, over varying periods of time post-deposition. Thermal measurements were effective for less than 40 minutes, EC measurements were effective for at least 7 days and ammonia volatilisation measurements were effective for at least 3 days, under the experimental conditions (autumn 2014 in Hamilton and Palmerston North). Further experimentation could usefully explore the range of conditions (soil type, pasture cover, moisture and temperature) under which this effectiveness extends. Practical considerations in the application of these approaches will dictate their utility.

NITROGEN CONCENTRATION IN PASTURE AS A TOOL FOR GUIDING FERTILISER REQUIREMENTS

Iris Vogeler and Rogerio Cichota

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Highly productive pasture systems require a regular supply of mineral nitrogen (N) to replace the N removed through the export of animal products and other loss pathways such as leaching and gaseous emissions. High spatial and temporal variability of both N supply by the soil and demand by the plant means that synchronising these is very challenging, and early indicators are lacking. A simulation study, using the Agricultural Production Systems Simulator (APSIM), aimed to verify the critical N concentration curve as an early indicator for guiding N fertilisation, which maximizes plant growth while minimising environmental impacts.

APSIM with a refined with a refined version of the pasture module (AgPasture) was used to determine average optimum fertilisation rates for different seasons for a ryegrass pasture in the Canterbury region of New Zealand. Simulations comprised 20 different fertilisation rates (ranging from 0 to 250 kg N/ha). Improvements in AgPasture included the definition of ideal N concentration for tissues of different ages (growing, mature, senescent and dead) and allowing nitrogen (N) remobilisation to occur from all the different tissue stages.

Highest pasture yields one month after fertilisation were achieved with N application rates of 20, 30, 140 and 160 kg N/ha for winter, autumn, summer and spring. The pasture N contents (%N) corresponding to the standing dry matter of the pastures in the different seasons were similar to the critical N curve when constant fertilisation rates were applied throughout the year, lower critical N concentrations were obtained for autumn and winter.

Before the critical N reference curve can be used to guide optimum N fertilisation for pastures further experimental studies and model testing and parameterisation is required. It is also possible that season specific critical N curves need to be established for pastures.

ON-FARM DRAINAGE REMEDIATION PROJECTS TO PROTECT WAIRARAPA MOANA

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The Wairarapa Moana Wetlands Project began in 2008 to enhance the native ecology, recreation and cultural opportunities and values on the public land in the area. This project was extended with funding from the Ministry for the Environment's Fresh Start for Freshwater Clean Up Fund in 2012 focusing on the helath of the edge wetlands that fringe the eastern shore of the lake. This has supported projects to both improve the quality of water entering Lake Wairarapa and enhancing biodiversity across farmland and the edge wetlands. Projects are co-funded by a range of partners, including landowners, and administered by the Greater Wellington Regional Council.

Projects have included riparian plantings, water conservation, improvement of effluent systems, optimisation of water use and irrigation, pest and weed control and modification of drainage. The work has also included surveys of fish and birds with some surprising results, removal of exotic fish and aerial application of herbicide on the extensive alder and willow infestations on the eastern lakeshore. A crucial component of the landowner engagement has been the technology transfer component of the project, which is ongoing.

A feature of the area is the extensive drainage network into the lake, including pumped drains. A particularly interesting project has been the construction of a wetland on a dairy farm adjacent to a remnant Kahikatea stand. In combination these areas will add significant biodiversity to the farm and the region as well as improving water quality by removing contaminants from farm drainage water.

CHANGES IN SOIL CARBON STOCKS OF NEW ZEALAND'S GRAZED PASTURE IN RESPONSE TO VARIATIONS IN MANAGEMENT AND ENVIRONMENTAL FACTORS

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Dairy farming is New Zealand's pre-eminent primary industry. It achieves large export earnings but is also responsible for a large proportion of New Zealand's greenhouse gas emissions. One of those greenhouse gases is CO_2 and in order to lower New Zealand's net greenhouse gas emissions, it is important to identify any management options that can lead to carbon sequestration in pasture soils. That would increase soil carbon stocks and thereby minimise net CO_2 emissions to the atmosphere. Equally important, it is necessary to understand what management options could lead to losses of soil carbon from pasture soils and add further to CO_2 emissions from pasture systems.

We addressed these questions by obtaining two years of observations from an eddy-covariance system on a dairy farm in the Waikato that provided half-hourly estimates of the exchanges of water and CO_2 between the pasture canopy and the atmosphere. We used CenW, a process-based ecosystem model, to describe these observations in terms of their biophysical drivers. Agreement between the model and observations was excellent, especially for evapotranspiration and net photosynthesis, for which 90% and 79% of observed daily variations could be explained by the model.

The validated model was then used to run different scenarios to assess the effect of changes in management options and environmental conditions on site carbon storage and milk production. Management options included application of fertiliser or irrigation water, and environmental changes included changing temperature and CO_2 concentration. The work showed the interactions between on-site carbon storage and carbon removal in grazing off-take and identified the risks and potential benefits of different environmental and management factors.

ON-FARM PRACTICES FOR MITIGATING N LOSSES TO WATER – IMPACTS ON DAIRY FARM SYSTEMS IN THE SOUTHERN SOUTH ISLAND

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Implementing farm system change to reduce N losses to water is complicated. Failure to consider likely farm system changes can put both the achievement of reduced nutrient loss and the financial viability of the dairy farm business at risk. As part of the Southern Wintering Systems project, six case study farms, operating a range of wintering systems, were selected. Comprehensive baseline information was collected for each farm and used to parameterise the Farmax and Overseer models. Discussions with farmers and rural professionals were used to develop and model three or four alternative operating scenarios for each. Modelling and assumptions were tested with groups of farmers who operate aligned systems. The objective of the modelling was to identify farm management practices that could reduce N losses to water with minimal impact on farm profitability.

Optimising pasture utilisation and per cow production improved profitability on all farms, but reductions in N loss to water were small, (less than 5%). Farmer feedback raised issues around managing pasture quality and seasonal variation in growth patterns at lower stocking rates.

When significant amounts of supplement were imported onto the farm, either for lactation or winter feeding, increasing the effluent area decreased N loss to water by up to 7%; the impact on profitability was dependent on effluent infrastructure availability.

Using facilities for duration controlled grazing during autumn showed a significant reduction in N loss to water (6-39%), with a positive impact on operating profit (not including capital cost of infrastructure). The impact on business profitability will be dependent on the ability of the owner to ensure pasture utilisation and quality remain high and on the availability and cost of infrastructure.

Utilising off-paddock facilities to winter animals showed significant reductions in N loss to water (up to 28%) due to the removal of winter cropping from the farm system. The impact on production and profit will be dependent on the number of other farm systems changes made and the cost of the infrastructure.

PROGRESS WITH OPERATING A DURATION CONTROLLED DAIRY GRAZING SYSTEM FOR PRODUCTIVITY GAIN AND FOOTPRINT REDUCTION

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The New Zealand dairy industry's goals are to increase productivity and profitability whilst decreasing the environmental footprint of dairy farming. Management strategies are required to reduce the inherent elevated losses to surface waters of nitrogen, phosphorus and faecal coliforms that are associated with urine and dung return to intensively grazed pastures. In addition, grazed pasture systems on fine textured soils (clay and silt loams) in regions with wet winter-springs and dry summers need strategies to prevent production losses due to tread-damaged pastures in winter-spring and to drought in summer.

Small plot and farmlet trials have shown that standing cows off pasture to ruminate and rest after grazing (Duration-controlled (DC) grazing) can reduce the treading damage of wet soils and contaminant losses to water. Objective 2 of the National P21 Research Programme is currently evaluating the benefits and operational requirements for practising DC grazing at farm scale.

The structural and operational components required to stand cows off pasture to reduce treading damage and contaminant loss to water are being evaluated in a paired farm systems trial under the climate and imperfectly drained soil regimes found on Massey University's No.4 Dairy farm, Manawatu, New Zealand. One 200 cow 'standard' herd (2.67 cows/ha) is managed according to typical regional practices i.e. 40% of cows are grazed off farm in winter and an uncovered concrete feedpad is used to feed maize and pasture silage (supplements constitute approximately 27% of annual diet). The feedpad offers limited capacity in avoiding the treading damage of saturated soils and the reduction of environmental impacts by standing cows off. The second 'housed' herd of 200 cows (2.82 cows/ha) utilises a freestall barn to winter all cows on-farm, and practises DC grazing to reduce excretal load on pastures in summer and autumn, and to reduce treading damage in winter. Both farms have the aim of utilising as much fresh pasture as possible. Supplements are imported as required to fill feed deficits and to feed cows standing off paddocks.

This paper presents a summary of the operational components and management protocols required in the current 2014-2015 lactation season to operate the grazing management, storage and supply of supplementary feed, and effluent generated during stand-off, as well as its "safe", handling, storage and re-application to soils.

AN ANALYSIS OF RECENT URINE PATCH NITROGEN RESEARCH

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The urine patch is the conduit through which the majority of nitrogen (N) is cycled in a grazed pasture system. Improving our understanding of N cycling processes in the urine patch is critical for modelling and managing N on farms. Since the early 1990s a significant amount of research has been undertaken on urine patch nitrogen dynamics including, more latterly, modelling. We have undertaken an analysis of articles published on the topic in peer-reviewed journals since 1940. The aims were to identify opportunities to improve modelling and management of N, and to identify knowledge gaps.

Findings from two literature reviews (Haynes & Williams, 1993 and Selbie et al., 2015) were used as well as a keywords search using the Scopus research article database (www.scopus.com), using the terms 'urine', 'soil', and 'nitrogen' (14 January 2015).

In 1993, Haynes and Williams identified the grazing animal as central to N cycling in grazed pasture systems due to the excretion of urine and dung in patches with high N loads. The review identified key challenges for managing grazed pasture systems, including: increasing environmental challenges, a need for more research into N leaching and nitrous oxide emissions, improved modelling, and a better understanding of the pathways and rates of processes within the N cycle in grazed pasture systems.

Since 1993, there has been increased focus on urine N, in particular, urine characteristics and N removal processes at the urine patch scale. The majority of the published work was carried out in New Zealand, and commonly in experiments using barrel lysimeters. A major driver for current research continues to be managing and mitigating N loss in order to farm within environmental limits. Major improvements have been made in N accounting using models, which are increasingly being used to estimate N losses at a range of scales (both spatially and temporally). Since 1993, urine N research has targeted leaching losses, pasture uptake and nitrous oxide emissions. There has been relatively less research into other N removal processes of immobilisation, and denitrification (other than nitrous oxide). By far the majority of urine N research has been dairy-focused compared to sheep, beef, deer or goats.

The main challenges ahead for modelling are: scaling up from urine patch to paddock and farm scale, and understanding the sensitivity of modelled estimates to highly variable urine patch characteristics. Improved management and mitigation of N in urine patches is on-going, however many mitigation strategies still at the proof-of-concept stage, need to be evaluated within a farm system context.

SOIL TOTAL N CONTENT INFLUENCES PASTURE FERTILISER N RESPONSE

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Soil nitrogen (N) supply, as one aspect of soil fertility, is important in determining the response of pasture to N fertiliser because fertiliser can be used to meet the shortfall between demand by the pasture and soil N supply. A series of sequential research projects have tested the hypothesis that N fertiliser response is negatively related to soil total N (TN) content, used as a surrogate measure of soil N supply.

In a series of glasshouse and national field trials, the variability in the TN in soils alone was able to explain between 30-70% variability in pasture dry matter yield. In spring fertiliser N response trials at Tokanui research farm, significantly more variation in pasture yield was explained by including TN in a linear combination with a scalar of N fertiliser applied in a Mitscherlich model than was by using fertiliser N alone. Consequently, the response to fertiliser N (difference between yield at 200 kg N/ha and nil-N applied) decreased with increasing soil TN concentration, with TN% explaining c. 53% of the variation in fertiliser N response ($P<0.001$); this increased to 72% when all N rates 0, 25, 50, 100 and 200) were included. A further series of national experiments comprising between 4 and 8 N fertiliser response trials per farm property generally indicated that N fertiliser response decreased at higher levels of soil TN, but was of less value comparing *between* farms, presumably due to climatic differences affecting growing conditions.

Combined, this research indicates that use of TN, as a surrogate estimate of soil N supply, can improve the estimate of pasture DM response to applied fertiliser N. Without being able to account for growing conditions, measurement of soil TN concentration probably best serves as a method to rank paddocks across a farm in terms of likely response to fertiliser N, i.e. more as a strategic tool for fertiliser N management and is not a tactical tool. Benefits will be greatest where large differences occur in soil TN across a farm. For comparisons between farms, some account of growing conditions will also be required. Further research is required to continue to develop and evaluate the approach.

DOES SIZE MATTER?

THE EFFECT OF URINE PATCH SIZE ON PASTURE N UPTAKE

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A urine patch can be considered as a wetted area, or as an 'effective area', which also includes a zone outside of the urine patch where the pasture is able to access urinary N by lateral growth of roots or diffusion of N. Size becomes important when considering edge contribution to uptake because the smaller the urine patch, the greater the relative contribution that edge uptake could make. The aim of this study was therefore to assess the interaction of urine patch size and N loading on pasture N uptake and, by inference, N leaching risk.

A plot study was set up in March 2014, where small pasture plots (representing urine patches) were divided into three zones: wetted, where urine was applied directly; edge, where there was a zone of visible extra growth adjacent to the wetted area (15 cm); and outer (unaffected) as a control. The experiment was a 3 x 3 factorial design with factors: wetted area size (0.2 m2, 0.36 m2 and 0.49 m2) and N loading rate (400 kg N ha-1, 700 kg N ha-1 and 1000 kg N ha-1) and five replicates per treatment. Net N uptake was expressed as the proportion (%) of applied N for edge, wetted and edge plus wetted zones, after correcting for the outer ('control') zone.

Contribution from the edge zone to the total net N uptake was only significantly affected by urine patch size, not N rate. About 40% of total net N uptake was from the edge zone in the small patch and c. 30% for the medium and large patches. Expressed relative to the wetted area, the edge area net N uptake was equivalent to 68% of the wetted area uptake for the small patch; and 43% and 40% for the medium and large wetted areas, respectively.

The implications of the results are that studies using lysimeters, which have a confined edge and which receive urine over the whole surface area (i.e. wetted area only), underestimate pasture N uptake and therefore potentially overestimate N leaching.

HOW EVENLY ARE N AND P LOADS FROM ANIMAL EXCRETA DISTRIBUTED ACROSS THE FARM LANDSCAPE?

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Nitrogen (N) and phosphorus (P) are key nutrients which drive production in grazing based dairy farms, but if not used efficiently can degrade water and air quality. Pasture and fertiliser management decisions often assume that nutrient loads are relatively uniform across the farm landscape. However, grazing cows excreta around 75 - 85% of ingested N and P and are significant contributors to nutrient fluxes within the farm. Cows visit and forage in some paddocks more frequently than others due to differences in pasture production, the conserving of pasture for silage and hay, and management convenience for the farmer. Cows can also spend a disproportionate amounts of times in sacrifice or holding paddocks, when soils are too wet for grazing or pasture growth is limited by dry conditions. Consequently, a greater understanding of cow location, cow excreta concentrations and expected patterns of within-farm nutrient distribution is important to improve N and P management decisions on dairy farms. This paper describes an approach to quantify nutrient loading rates from grazing-based dairy cows at the paddock and farm scale, using readily available information from dairy farms.

NITROGEN FERTILISER MANAGEMENT WITH ZONE CHARACTERISATION IN GRAZED PASTURE SYSTEMS

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Spatial information is frequently used for managing arable crops. The idea of developing management zones is often to enable accurate fertiliser supply for local crop needs. This helps avoid excessive introduction of nutrients, such as nitrogen, into the environment, and also to reduce fertiliser costs. Despite the success of this concept in arable farming, it is a poorly adopted practice for the management of grazed pastures.

Grazed pasture systems have an additional level of complexity compared to monoculture, annual crops. Pastures are typically perennial in nature with short intervals between harvests (by a grazing animal) and therefore require fertiliser applications to maintain biomass production. Additionally, pastures often consist of two or more desirable plant species and the distribution of waste from livestock results in many small patches of very high nutrient content.

We propose a concept to create management zones of grazed dairy pastures, using the spatial attributes of pasture paddocks. The target will be to identify zones of most likely high nitrogen availability and use this information to estimate the required local fertiliser target. The spatial information required for this approach may include: soil variation, irrigation, animal density, slope, farm infrastructure (i.e troughs and shelter) and previous pasture growth.

Using a geographical information system, the spatial information for an area can be utilised to create map layers. These layers can then be spatially related and zones for the application of varying amounts of fertiliser can be developed at the sub-paddock scale. We are in the process of deriving response curves for N-ramps on selected paddocks in NZ and Australia which have sufficient spatial variability of the mentioned site characteristics.

We undertook a theoretical feasibility study to compare both uniform and variable nitrogen fertiliser application as an initial investigation of the potential benefit of zone management. The integrated result (value of feed – cost of fertiliser – cost of environmental impact) of applying nitrogen variably across a paddock of dynamic soil using a non-linear response function was slightly lower than for uniform application. It is expected however, that increased understanding of spatial variables in pastures will increase the benefits of zone management.

MANAGEMENT ZONE DELINEATION IN ARABLE CROP SYSTEMS

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Management Zone Delineation (MZD) could be of increasing importance for its economic and environmental benefits through varying rates of crop inputs to meet site-specific demands across individual fields. However, research on MZD in arable cropping systems is limited in New Zealand. Previous work from Lincoln Agritech Ltd. presented the benefits of Precision Agriculture for large scale farmers and contractors using yield, soil and aerial images to adopt Variable Rate Application of seeds, fertilizer and agro-chemicals. Furthermore, improved irrigation efficiency in wheat and maize cropping systems and maize zone delineation using Active Light-Nitrogen sensor, NIR camera technology and SPAD chlorophyll meter, were studied. The objective of the presented project is to develop methods and tools to identify optimal N supply rate for maize production with the emphasis on management zones and site adapted plant population densities in New Zealand.

Two rain-fed maize fields from Waikato and one irrigated field from Canterbury were selected for field experiments. Yield and elevation data in 2013 and 2014 collected with a John Deer 7050 Series Self-Propelled Forage Harvester. Data analysis and mapping of management zone were done in Esri, ArcGIS 10.2.2. software. VESPER 1.6 free version from Australian Centre for Precision Agriculture was used to interpolate the data. Three management zones with low, medium and high yield potential were derived in the final map. Satellite images from Google Earth Archive of previous years were also used to delineate field boundaries and management zones. A strip-plot experimental design with 3 replicates was allocated to each management zone at each field. Three treatment levels of N fertilizer: farmer's best N-fertilization practice, +35% and -35% were applied using calculated N-fertilizer demand prescription maps with an 8- row VRA fertilizer spreader.

We expect that soil electrical conductivity field survey data, compatibility of yield data and prescription maps between different software packages, and the inclusion of annual yield data would improve the discriminating power of the various approaches.

UNDERSTANDING AND ENHANCING NUTRIENT ATTENUATION CAPACITY IN NZ AGRICULTURAL CATCHMENTS

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Productive farms and their associated processing industries are important for New Zealand's future economic and social welfare. The current view is that for New Zealand to make a sustainable future income, the profitability of grazed pasture systems needs to increase without grazed systems impacting negatively on the environment. A large research investment to date by government and rural industries has identified that ruminant grazed systems are inherently leaky with respect to nitrogen, the key nutrient implicated in the deterioration of surface and ground water quality in New Zealand's agricultural catchments.

Sophisticated nutrient budgeting software (Overseer NB) has been developed to assist farm managers to use nitrogen efficiently within their farming enterprise. Significant effort and investment is being devoted to the development and implementation of best management practices to reduce nitrogen leaching, and to manage and mitigate its likely impact on freshwater quality and ecosystem health. Current nitrogen management efforts, however, appear to be focused mainly within the farm boundary and concentrate on identifying and reducing nitrogen loss from the root zone of high nitrogen leaching farms so that they comply with some set limits. This approach ignores the transport and transformation of nitrate-nitrogen (NO_3-N) along pathways from farms to rivers and lakes. Little if any consideration is given to the attenuation capacity as NO_3-N passes from the paddock root zone to rivers and lakes. One reason these processes are not accounted for is that relatively little is known about them.

Preliminarily analysis in the Manawatu River catchment suggests that nitrogen loads measured in the river are significantly smaller than the estimates of nitrogen leached from the root zone. The on-going field observations, surveys and experiments indicate denitrification as a key NO_3-N attenuation process in the catchment. This nitrogen attenuation capacity appears to vary among the sub-catchments of the catchment. Further understanding of this nitrogen attenuation capacity in NZ agricultural catchments is important for a number of reasons. Firstly, we may be able to manage or enhance the 'hot spots' and 'hot moments' of this attenuation process. Secondly, by taking a catchment perspective, we may be able to redesign landuse practices in a coordinated fashion that increases agricultural production while reduces nitrogen loss from the catchments, i.e. 'matching landuse practices with nutrient attenuation capacity'. This will be crucial to identify the most critical areas for investment and development of innovative solutions to reduce high nitrogen loads to rivers and lakes.

AN ASSESSMENT OF THE DENITRIFICATION POTENTIAL IN SHALLOW GROUNDWATERS OF THE MANAWATU RIVER CATCHMENT

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Denitrification in shallow groundwaters is an important nitrate attenuation process which is dependent on the characteristics of the contributing surface and subsurface environment. Little is known about the spatial variability and factors contributing to denitrification potential in shallow groundwater systems in the Manawatu River catchment. The objectives of the study, therefore, are (1) to determine the spatial variability of the denitrification potential in shallow groundwater, (2) to identify the factors affecting this denitrification potential, and (3) to quantify denitrification in selected sites in the catchment.

A groundwater survey was carried out during February-March 2014 sampling a total of 56 wells and piezometers well spread across the Tararua Groundwater Management Zone (TGWMZ), located in the eastern portion of the Manawatu River catchment. Preliminary analysis of groundwater hydrochemical parameters reveals significant variability in the potential of groundwater to denitrify. Anoxic groundwaters in the middle and northern portion of the TGWMZ were found to have the potential to denitrify, in contrast to the oxic groundwaters mostly found in the southern portion. Factors affecting the denitrification potential of groundwater are being assessed using statistical analysis of hydrochemical data. Initial results from the statistical analysis show a negative correlation between nitrate and silica, indicating that relatively older groundwater may have better denitrification potential. Further analysis is required to determine the role of other possible factors such as geology and overlying soil types on the denitrification potential of shallow groundwater in the area.

We have established four detailed study sites in the catchment wherein three piezometers are installed to different depths and selected parameters are monitored monthly to obtain indications of temporal variability of denitrification characteristics. Moreover, push-pull tests are being conducted at these sites to quantify denitrification in shallow groundwater. Preliminary analysis of two push-pull tests conducted on one of the study sites during May and July 2014 support the occurrence of denitrification in shallow groundwater, with denitrification rates measured at approximately 0.5 mg N L^{-1} h^{-1}.

NITROGEN ATTENUATION FACTOR:
CAN IT TELL A STORY ABOUT THE JOURNEY OF NUTRIENTS IN DIFFERENT SUBSURFACE ENVIRONMENTS?

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Catchment characteristics such as; landuse, topography, rainfall, soil texture and rock affect the nutrient concentrations of surface and ground waters. Therefore, it is important to identify these characteristics for an improved understanding of the spatio-temporally variations in nutrient concentrations and their influence on water quality at a catchment scale. Many studies have investigated the relationship between water quality parameters (mainly nitrate concentration) and catchment characteristics. However, none of these studies have investigated the relationship between the nitrogen attenuation factor (decrease in nitrogen leaving the root zone, by different processes in the subsurface environment, to the river sampling site at the outlet of the catchment) and catchment characteristics. There is considerable interest in nitrogen attenuation in the 'sensitive' catchments of the upper Manawatu River such as the Tararua Groundwater Management Zone (TGWMZ). Few studies have calculated the for specific catchments and there is no study which determines the spatial distribution of the throughout the TGWMZ.

The main objectives of this study were (1) to define the spatial distribution of the throughout the TGWMZ; and (2) to evaluate the relationship between and catchment characteristics of the TGWMZ. A total of 16 water quality monitoring sites in TGWMZ were used in ArcMap to delineate the contributing area 'sub-catchments' upstream of these sites. The shapefiles resulting from delineation were then used to extract the key characteristics of each catchment. We calculated the based on the root zone load (adding up the landuse area multiplied by the leaching rate of each landuse in the catchment) and the river load (Flow-stratified average method "FS"). Finally, we evaluated the relationship between various catchment characteristics and the using regression analysis.

MULTI-PRONGED APPROACH TO ELUCIDATE NITRATE ATTENUATION IN SHALLOW GROUNDWATER

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It is increasingly being recognised in New Zealand that denitrification occurring in the groundwater zone can result in a substantial reduction of the nitrate load leached from agricultural land before this load can reach water supply wells or discharge into groundwater-fed surface water bodies. This natural attenuation process provides an ecosystem service with regard to the protection of the quality of our freshwater resources that to date has not been adequately accounted for. This is largely due to the major challenges involved in trying to understand and quantify the denitrification occurring in a particular water management zone.

Based on the example of research conducted at the 'Waihora' site in the Lake Taupo catchment, we demonstrate a multi-pronged approach to elucidate the biogeochemical and hydrological controls on denitrification. The site is unique in New Zealand inasmuch as it has allowed investigating shallow groundwater underlying a pastoral hillslope in great detail using 11 multi-depth well clusters (comprising 26 wells in total).

As denitrification is only active under mildly reduced conditions, a systematic approach to characterise redox conditions based on measured concentrations of dissolved oxygen, nitrate, dissolved manganese, dissolved iron, and sulphate provided fundamental initial information on the denitrification potential of the groundwater system.

Determining stable isotope signatures of nitrate ($\delta^{15}N$, $\delta^{18}O$) and excess N_2 dissolved in the groundwater can help differentiate between denitrification potential and denitrification that has actually occurred in a given groundwater sample. As the interpretation of these data is strongly dependent on the understanding of the temporal and spatial variation of groundwater flows at the site, hydrological understanding proved critical.

Given that most biogeochemical and hydrological parameters analysed showed substantial spatial variation, hydrological modelling of the hillslope proved the only promising way to ascertain the overall effect denitrification may have on the groundwater nitrate discharges from this site.

MONITORING STREAM SEDIMENT, NITROGEN AND PHOSPHORUS CONCENTRATIONS IN GRAZED HILL COUNTRY IN THE MANAWATU REGION

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Hill country represents approximately 60% of New Zealand's landscape and supports major agricultural industries such as sheep and beef production. With such a large area providing catchments for many of New Zealand's major rivers and water bodies, pastoral hill country plays a vital role in the quality of these water systems which is a critical issue facing New Zealand agriculture. Despite this, information regarding water quality in hill country areas used for sheep and beef production is lacking, particularly in the Manawatu Region. This study monitored nutrient and sediment concentrations in selected streams and a seepage wetland on Massey University's Agricultural Experimental Station at Tuapaka, Palmerston North since April 2013. Data to date indicates that dissolved reactive P (DRP) concentrations are consistently below our limit of laboratory detection (<0.02 mg/L). Nitrate-nitrogen concentrations are also generally low (<0.25 mg NO_3-N/L), with the exception of cases where water sampling coincided with aerial application of urea (2 mg NO_3-N/L) and when cows were grazing in the paddocks where streams were sampled (~1 mg NO_3-N/L) in winter 2013. Total P and N concentrations are generally low (<0.03 mg P/L and <1 mg NO_3-N/L), with the exception of sampling periods when suspended sediment concentrations were elevated (i.e. summer 2014). Mean suspended sediment concentrations were generally low (<20 mg/L).

Monitoring of water entering and leaving a seepage wetland on the experimental station has indicated that nitrate-nitrogen concentrations are generally below our limit of laboratory detection (<0.25 mg NO_3-N/L). However, where nitrate-nitrogen concentrations can be accurately measured, there is a trend for lower nitrate-nitrogen concentrations leaving the wetland compared to concentrations entering the wetland. Further studies on this seepage wetland will focus on understanding and enhancing denitrification processes to attenuate nitrate-nitrogen loads from hill country farms.

REALISING THE VALUE OF REMNANT FARM WETLANDS AS ATTENUATION ASSETS

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Wetlands are one of the tools farmers can use to intercept and attenuate diffuse losses of sediments, nutrients, and faecal contaminants. Attenuation is the loss or temporary accumulation of contaminants along the transport pathway from where they are generated to where they have impacts on the water quality of a stream, lake or estuary. With the co-operation of farmers within the Waituna catchment and Environment Southland, we undertook an assessment of potential sites for implementation of constructed wetlands to reduce nutrient and sediment flux to the Waituna lagoon. We found re-plumbing of wetlands into the highly modified Waituna mole and tile drainage system was challenging, often requiring significant excavation of wetlands to maintain drain function in surrounding areas. However, an extensive range of potentially viable wetland sites were able to be identified, particularly located in natural swales and gullies in the upper catchment. Such wetlands were estimated to be able to intercept 60-90% of the surface and subsurface run-off from the catchment. Wetlands occupying 2-3% of the contributing subcatchments were predicted to be able to reduce annual nitrate-N losses by ~30-40%. Suspended solids and particulate P loads would also be substantially reduced. However, a major constraint identified was that many of the most feasible areas identified for wetland construction were former wetlands that had been recently drained – many in the last 5 years or less. Farmers were understandably less than keen to convert such areas back into wetlands. Given the frequent need for extensive excavation, the cost of constructing (or re-constructing) wetlands is relatively high at around \$100-200 K/ha (lowest for larger-scale systems), with implementation costs of around \$2K-5K per ha of farmed catchment. Farmers often spend substantial amounts of hard work and money on draining persistent small remnant areas of wetland on their farms, frequently with marginal financial returns. With the transition towards farming under environmental limits, the potential value of maintaining and enhancing such remnant wetland areas on farms need to be reassessed. In many cases these relatively small natural wetlands can provide important attenuation assets, markedly reducing export of contaminants from the catchment.

THE ROLE OF CURRENT AND FUTURE GROUNDWATER RESEARCH IN COLLABORATIVE MANAGEMENT OF WATER QUALITY

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New Zealand has embarked on a process of fresh water management reforms. Each region has a differing approach, but all must comply with national standards and bottom lines. Collaborative processes are increasingly being adopted in water management, in planning, setting limits and in catchment-scale implementation. These reforms have created extraordinary demands on science, but more so on groundwater understanding. Collaborative management requires all participants to share a common platform of understanding of the biophysical world and the legislative framework.

This presentation will look at what we know, what we need to know, and how current research is addressing the gaps. From the experiences with the Canterbury Regional Water Management Strategy, the Land and Water Forum and subsequent development of policies and regional plans, some of the limitations imposed by insufficient knowledge of groundwater processes will be discussed. The cause and effect relationships between land use practices and receiving water quality are managed using tools that are “best we’ve got” but what else do we need? How will groundwater research address those needs? Another consideration is the increasing acceptance that water, even in New Zealand, is not a limitless resource, and that water quality is emerging as a primary constraint to further agriculture development. Land users are expected to manage to limits, but do they have sufficient or appropriate tools to achieve those limits? What is the role of the regulators, the regional councils? How will the relationship between regulator and land user change over time? How can science support and enable water management to achieve the multiple and sometimes competing demands of cultural, social, environmental and economic values?

SOUTHLAND GRAVEL PITS CONVERSION TO WETLANDS: A WIN-WIN FOR FARMERS AND THE ENVIRONMENT

James Sukias[1], Katrina Robertson[2], Warren Tuckey[2], Chris Tanner[1]

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In certain areas of Southland gravel is extracted from below the top soil for on-farm use. Gravel is extracted down to the groundwater level (or just below), leaving open pits, frequently with open water areas. With a lack of suitable material at hand to re-fill them, they are often left as open pits. The feasibility of developing them into wetlands is currently being investigated by Environment Southland with advice from NIWA.

Constructing wetlands to reduce nutrient losses from farmland to natural waterways has a number of hurdles. Firstly there is the excavation cost as well as loss of potentially productive land. Another barrier to uptake of this technology may be the farmer having undertaken great efforts to drain wetlands on their farm. However, with dis-used gravel pits, the excavation costs are minimal and the farmer has already accepted the loss of grazing land at that location. Thus cost to achieve this conversion are much lower than constructing a wetland from scratch, with potential environmental benefits if such a pit can be connected to existing farm drainage systems resulting in a win:win for farmers and the environment.

Potential environmental benefits are reduced losses of sediments and nutrients from farmland to natural waterways, and providing locations for the protection of natural biodiversity. The level of treatment these systems might provide depends on their size relative to the drainage catchment feeding them. The NZ Guidelines for constructed wetland treatment of tile drainage (Tanner, Sukias et al. 2010) gives likely levels of treatment for wetlands occupying between 1% and 5%. If the gravel pit/wetland is smaller than 1%, it is unlikely to give substantial benefits with regards to removing dissolved nutrients. However they may still provide effective removal of suspended solids. In addition, if they are developed in an appropriate manner, they will provide biodiversity benefits. Thus it was recognised by Environment Southland that assessing the benefits of such systems will require a more holistic approach than simply measuring inflow and outflow water quality.

WATER QUALITY IMPACTS OF CRASH GRAZING A HILL COUNTRY WETLAND

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Due to the steep and complex terrain which is unique to hill country, wetlands can form in the bottoms of valleys. These areas receive water from both surface and subsurface flow and commonly remain wet all year. Grazing wet areas can result in treading damage and urine and dung deposition which increases the risk of sediment and nutrient loss. Grazing pressure can increase during dry periods, when these wet areas are the only sources of green feed available to stock. If these areas are fenced from stock, farmers can crash graze (high stocking rates over a short period of time) to remove excess vegetation and provide extra feed for animals. To study the impact of crash grazing on P, N and sediment loss from a seepage wetland, two crash grazing events were conducted with sheep for a period of 4 hours each, in February and June 2014.

Crash grazing had no discernible effect on nitrate, ammonium or dissolved reactive P concentrations, with concentrations mostly below the limit of detection. In contrast, total N, P and sediment concentrations leaving the wetland increased in response to animal grazing. During the 4 hour grazing event, mean suspended sediment concentrations leaving the wetland were 4 and 36 times higher than those entering the wetland for the summer and winter grazing, respectively. Mean total N concentrations leaving the wetland during the grazing event were 2 and 5 times higher in summer and winter, respectively. A similar trend was observed for Total P, however total P concentrations entering the wetland were generally below the limit of detection, making differences more difficult to quantify. Although higher total N, P and sediment concentrations were measured in winter, concentrations rapidly decreased to background concentrations within 2 hours of the sheep being removed from the wetland. This suggests that water quality impacts in winter, are short lived. In contrast, total N, P and sediment concentrations remained elevated for at least 2 hours following stock removal in summer. Total N and P concentrations were closely related to sediment concentrations, with stronger relationships measured with total N (r^2 = 0.94 and 0.68) compared to total P (r^2 = 0.88 and 0.48), for summer and winter respectively.

ASSESSMENT OF POTENTIAL BIOFILTER MATERIALS TO MITIGATE METHANE EMISSIONS

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Previous laboratory and field studies demonstrated the ability of volcanic pumice soil to mitigate both high and low rates of CH_4 where both type I and type II methane oxidising bacteria (MOB) present were responsible for removing CH_4. However, limited global availability of volcanic pumice soil necessitated the need to bio-remediate to assess other potentially suitable, economical and widely available biofilter materials. We mixed small part of the inoculum (volcanic soil) with larger part of the potential biofilter materials, viz. in situ soil (isolated from the effluent pond bank area), pine biochar, garden waste compost, fresh and weathered pine bark mulch. The efficiency of these materials to remove CH_4 was monitored over 6 months at 25^{o}C with periodical feeding of CH_4 and O_2 to support microbial growth and activity. All materials (except fresh mulch) supported the growth and activity of methanotrophs. However, the efficiency of CH_4 removal in all the materials fluctuated between no or low CH_4 removal and high CH_4 removal phases, indicating the disturbances in the community. Among these, soil and biochar removed > 80% CH_4 and was more resilient to changes in the community. Amendment of soil and biochar with micro-quantities of macro- and micro-nutrients (nitrate mineral salts) enhanced the stabilisation with CH_4 removal of up to 99%. This study demonstrated that (1) other soils and cheaply available materials can be used as a biofilter material by spiking with CH_4 enriched medium, and (2) nutrient additions enhance the growth and activity of MOB in the biofilter materials.

NITROUS OXIDE EMISSIONS DURING MAIZE CROPPING

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The objectives of this study were to conduct field measurements of nitrous oxide (N_2O) emissions through various stages during the production of maize silage (i.e. cultivation of permanent pasture to maize) relative to land maintained in permanent pasture. The research was carried out on a Horotiu soil on the former Ruakura Number 1 Dairy Research farm, Hamilton. The treatments were: Pasture control, fertilized pasture, maize control and fertilized maize. Soil temperature, moisture and inorganic nitrogen (N) content were monitored and N_2O emissions were measured using a closed chamber technique.

Soil temperature was generally lower, and soil water filled pore space (WFPS) was generally higher, in the soil under the closed maize canopy than under the adjacent pasture sward. Cultivation for maize crop establishment resulted in elevated soil nitrate levels. The addition of fertiliser N (177 kg N ha^{-1}) enhanced soil nitrate levels until maize harvest time. However, increases in soil ammonium due to cultivation or the application of fertiliser only lasted for relatively short periods (up to 35 days).

For about 2 months following initial cultivation for maize establishment, the daily soil N_2O emissions from the cultivated control (without any N input) were between 0.017 and 0.419 mg N m^{-2} hr^{-1}. These rates were generally higher than those in the pasture control treatment, which ranged between 0.004 and 0.027 mg N m^{-2} hr^{-1}.

In the cultivated maize growth area the total N_2O emissions during the maize growth period (131 days) were 1.44 kg N_2O-N ha^{-1} in the control and 1.62 kg N_2O-N ha^{-1} in the fertilised treatment. During the same period, the permanent pasture had significantly ($P<0.05$) lower total emissions, with values of 0.293 and 0.423 kg N_2O-N ha^{-1} for the pasture control and fertiliser treatments, respectively. The N_2O emission factor (EF1) (% of fertiliser N emitted as N_2O) during the maize growth period was 0.10%. The EF1 for fertiliser on the pasture was 0.16%. The EF1 values obtained were below the default IPCC value of 1% for applied fertilizers.

IDENTIFYING IMPROVEMENTS REQUIRED TO SIMULATE NH_3 VOLATILISATION FOLLOWING URINE OR UREA APPLICATION USING NZ-DNDC

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Correct simulation of ammonia (NH_3) loss through volatilisation is important for process-based models of soil N cycling as this can have a significant effect on the soil mineral-N concentration and subsequent N-transformation processes. In addition, volatilised NH_3 represents a significant loss of N from pasture soils, and can act as a secondary source of nitrous oxide (N_2O) emissions when redeposited on soil.

In this study we use data from two field experiments on the same soil (Tokomaru silt loam) to test the process-based NZ-DNDC model. In the first experiment, cattle urine was applied at 530 kg N ha^{-1}, and NH_3 emissions, soil pH and mineral-N were monitored over 30 days. In the second experiment, urea was applied at either 0 (control), 30 or 60kg N/ha. The urea was followed by either 5 mm, or 10 mm of irrigation applied after a delay of 8, 24, or 48 hours. NH_3 emissions and soil mineral N were collected for 2 weeks following urea application.

Both these data sets revealed processes within the NZ-DNDC model that need improving. For the urine application, the model over-estimated the increase in the soil pH (simulated maximum ~8.7 compared with observed 6.7) and of the NH_3 emissions. Modifying the model to use observed pH changes improved the simulated NH_3 loss. For the urea plus irrigation experiments, the model simulations showed a much lower effect for irrigation timing on NH_3 EF compared with the experiments. This is because NZ-DNDC does not simulate the physical transport of urea down the soil profile.

Our model results show that to improve simulated NH_3 emissions from urine patches and applied urea the simulation of pH in NZ-DNDC needs to be improved and to account explicitly for the different buffering capacities of soils. Meanwhile, a urea transport process needs to be added to simulate the potential mitigation of NH_3 emissions by irrigation. These improvements are the focus of future work.

ROUTES OF DCD UPTAKE IN PASTURE PLANTS:

A PRELIMINARY GLASSHOUSE STUDY

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The nitrification inhibitor, dicyandiamide (DCD) can mitigate nitrate leaching and nitrous oxide emissions in New Zealand pastures and was commercially available to farmers (as spray suspension or granular formulations) until January 2013, when its use was suspended due to detection of traces of DCD found in exported milk. It is evident that DCD in the milk must have entered into the ruminant's body via ingested pasture and/or soil adhering to the pasture. The question is: did the DCD originate solely from the leaf surface or was it absorbed into leaf tissues? Alternatively, was the DCD taken up by the roots and translocated to the shoots? We investigated these routes of DCD into the plant by separately examining leaf uptake and root uptake in two glasshouse experiments. In experiment 1, DCD (at 10 kg/ha) was sprayed onto the foliage of ryegrass/clover growing on an intact soil core, off which 41–64% was intercepted. Surface residues of DCD were quantified periodically by thorough rinsing of the foliage, which decreased (P <0.005) over 21 days. The foliar uptake (absorbed DCD) quantified by analysing the DCD content of a blended extract of the rinsed plant material ranged between 2.7 and 5.2% of the DCD applied and did not change over time. Experiment 2 quantified the root uptake of DCD in two soils of contrasting drainage by analysing the blended extract of the foliage for DCD over 37 days. The DCD uptake in the foliage was between 2.6 and 6.3%, which increased over time (P <0.001) in both the soils. During the second harvest (97 days after DCD application), 1.2–2.2% of the DCD was detected in the foliage but no DCD was found in both the soil and roots. Interestingly, there was little pasture growth during the study period. This preliminary study raises several questions: is the DCD protected from decomposition in both the pasture shoot and root or in the rhizosphere for continuous uptake? Are these results reproducible and can these estimates be extrapolated to field conditions? Will similar levels of DCD be taken up under lower interception by the foliage/soil?

LAB ASSESSMENT OF NITROGEN MINERALISATION FROM FARM DAIRY EFFLUENT, SLURRY AND MANURES

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To 'close the loop' on the farm nutrient cycle and improve nutrient use efficiencies an increasing proportion of effluents, which include farm dairy effluents (FDE), slurries and manures, are being recycled to crops. Nutrient loading rates of these effluents are typically based on Total N content (i.e. inorganic and organic forms) and assume that all of the N in these effluents will be mineralised and available for plant uptake within a short period of time. However, a range of physical and chemical effluent characteristics can have a significant effect on the net mineralisation of N and need to be considered when applying these effluents to ensure that the potential risks associated with over and under supply of nutrients are minimised. There is currently no simple or rapid method for a farmer to assess the rate of mineralisation of N from individual effluents.

We report preliminary results from an N mineralisation study using eighteen effluents collected from various dairy farms and applied to a long term cropping soil. The effluents were classified as liquid, slurry or solid manures based on their solids content and were characterised for total N, P, K, and C, Na, Mg, Ca, pH, ammonium, nitrate, dissolved organic carbon and nitrogen, anaerobically mineralisable N and hot-water extractable N and C. These effluents were applied at c.100 kg N/ha into soil columns, incubated at 20°C at 85±3% of water holding capacity and periodically leached with one pore volume of distilled water over the 182 day study period. Leachates collected were analysed for nitrate, ammonium and dissolved organic N as indicators of net N mineralisation.

Rates of N mineralisation from the effluents were highly variable. Average leachate N concentrations were in the order of slurry > manures > liquids. Hot water extractable and anaerobically mineralisable N in effluents correlated better with N release from effluents than Total N.

IMPROVING THE EFFICIENCY OF FERTILISER UREA ON PASTURE WITH ONE*system*®

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Granular urea is by far the most widely used nitrogen (N) fertiliser in New Zealand, with an estimated 750,000 tonnes (345,000 tonnes N) applied annually, most of which goes on dairy farms. Anecdotal evidence suggests that approximately 50% is spread by contractors (mainly with ground-spreading trucks), with the remaining 50% spread by farm owners and sharemilkers.

The main reason many farmers choose to spread their own urea is not so much to save the spreading cost (which in fact is generally quite low at $8-$12/ha), especially considering the value of their own time, but rather the importance they place on getting the urea applied at the best time to optimise pasture growth, generally 1-3 days after grazing.

Given the importance many farmers place on optimising the pasture response to urea, there has been surprisingly little effort to improve its performance by the main fertiliser manufacturers and suppliers. In fact, the only performance-orientated modified urea sold in significant quantities is SustaiN®, which is granular urea treated with the urease inhibitor nbpt. This product was introduced by Summit-Quinphos in 2002. It is now estimated to comprise 30% of urea sold by Ballance Agri-Nutrients, or 20% of total New Zealand urea sales. It is sold at a $50/t (8.5%) premium to standard granular urea.

This poster presents results from one of two field trials, in mid-Canterbury on an irrigated dairy farm on Lismore stony silt loam, a Yellow Grey earth classified as an *Ustrochrept* under USDA Soil Taxonomy. The second trial was on a dairy farm near Morrinsville, Waikato. Both trials were conducted under grazing.

Results from the mid-Canterbury site have very significant positive implications for both the economics and environmental impacts of fertiliser N use in New Zealand. Preliminary results from the Waikato trial suggest an only slightly less impressive result.

THE ECONOMIC IMPACT OF WATER QUALITY REGULATION IN NEW ZEALAND

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Abstract. New Zealand (NZ) pastoral agriculture is facing a momentous challenge in terms of bolstering its current strength, amidst societal pressure to reduce contaminant loss to water ways. For the near future, industry groups will be engaged in participatory processes associated with water reform driven by regional and national government. Underlying these difficult discussions are important questions surrounding the potential economic impact of limits placed on agricultural intensity.

Within regional processes, economic models are being broadly applied at the catchment level to assess the implications of alternative water quality limits. These frameworks integrate information from a broad range of sources, focusing primarily on land use heterogeneity and how it impacts cost-effective mitigation. The foundation of these models is the relationship between profit and contaminant loss within different agricultural industries.

The primary objective of this presentation is to outline the current state of knowledge regarding the potential economic impact of water-quality limits on NZ grazing systems. This will draw on the author's experience in modelling these impacts, both at the farm and catchment level. Much of the work is drawn from a five-year research programme performed with industry to establish system models that provide a reasonable description of grazing behaviour, especially in the context of limits being placed on farming systems. Key ways forward for both economists and scientists are discussed.

THE REAL (RATHER THAN MODELLED) COST OF MEETING N LIMITS – PART 1: AN ONGOING CASE STUDY OF A CANTERBURY DAIRY FARM

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Most of the analysis considering both the implications, and opportunities to farm within lower nutrient losses, is based on modelled datasets. Limited data is available from commercial size farms, or full system research whereby management practices have changed to farm within lower (estimated) nutrient losses.

Lincoln University Dairy Farm (LUDF) is an exception, having modified farm management part way through the 2013-14 production season, specifically to lower the predicted N-loss. Additional changes have been implemented for the 2014-15 season, seeking further reductions in N-losses while regaining some of the profitability lost in the previous season.

The farm is a well-known, frequently visited commercial demonstration farm, operated by the South Island Dairying Development Centre (SIDDC) to showcase best practice sustainable, profitable farming. Annual benchmarking indicates the farm operates in the top 2-3% based on profitability.

The self-imposed (2013-14 season) target to hold nitrogen losses within historical levels achieved the desired reduction in N-loss but eroded profitability by over $80,000 ($500/ha), providing a real example or case study of an option to reduce N-loss and its associated cost. If extrapolated across the Canterbury region's 1000 dairy farms, this impact would markedly change the local economy.

Uncomfortable with the impact on profitability, yet seeing potential legislative reductions in N-loss effective in its local catchment from 2017, LUDF is voluntarily changing its management for the 2014-15 season to operate with lower N-loss. The farm is adopting research undertaken within the Pastoral 21 (P21) research programme whereby farm systems research with self-contained farmlets has shown an irrigated nil-infrastructure, low input (N-fertiliser and supplement) system is theoretically as profitable as the previous system at LUDF, yet should further reduce the catchment nutrient loss.

Details of the 2013-14 season changes and results to date for 2014-15 will be presented, highlighting the actual costs and implications of farming within nutrient loss restrictions.

LESS COWS, MORE PROFIT, BETTER ENVIRONMENT

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The Horizons One Plan recognises the significant impact that nutrient discharges from agricultural activities can have on water quality and regulates existing intensive farming activities for individual farms including dairy in targeted catchments. This is achieved by allocating nitrogen leaching allowances based on Land Use Capability class (LUC). Existing dairy farms in target water management sub-zones will either meet nitrogen (N) leaching targets (Limits), according to the Land Use Capability (LUC) of the farms or, where they cannot, then a consent will be granted subject to a reduction in nutrient loss from farm land.

The Grazing Systems Limited Linear Program (GSL LP) is a bio-economic model in that resources have economic values that drive optimisation, and provides an opportunity to distinguish the changes that are required to optimise operating surplus, this is where marginal cost equals marginal revenue (MC=MR) and to minimise N-loss of the farming system.

The results showed that six of the nine runs out performed the base system with farm surplus and eight out of nine runs showed lower N-loss than the 20 year N-loss limit, with run five giving the highest profit and run ten the lowest N-loss. Run five reduced cow numbers by 23% to 2.2 cows/ha, removed imported supplements, N fertiliser and 15 ha of winter Oats. The results showed run five increased profits by 14% and decreased N-loss by 43% over the base system; this would make the farm meet the 20 year set limit imposed by the One Plan by 39% (N-loss).

The research highlights that the farm system needs to de-intensify, reduce stocking rate, remove or reduce imported supplements and remove or reduce nitrogen fertiliser, thus increasing profitably of the farm system and reducing the environmental impact.

This study found that the GSL LP whole farm modelling tool to be very effective when used with Overseer®, to identify profitable options for reducing N-loss off the case study farm.

IMPACT OF ON-FARM BUILT INFRASTRUCTURE INVESTMENTS ON THE PROVISION OF ECOSYSTEM SERVICES: IRRIGATION FOR DAIRY SYSTEMS IN NEW ZEALAND

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Many on-farm built infrastructure investments to increase production address a direct lack of provision of the required ecosystem services from soil's natural capital. Investment in irrigation immediately removes water as one of the major constraints to pasture growth by compensating for a lack of soil water holding capacity, in addition to a lack of seasonal rainfall. This study explores the changes to the provision of all ecosystem services from a dairy grazed system following an investment in irrigation infrastructure.

The introduction of irrigation to a permanent pasture grazed by dairy cows, together with higher stocking rates, generate changes to soil natural capital stocks and thereby the provision of ecosystem services. The changes in the flow of services, including food quantity and quality, support for human infrastructures and farm animals, fresh water availability, flood and drought mitigation, filtering of nutrients and contaminants, decomposition of wastes, net carbon storage, greenhouse gases regulation, and regulation of pests and diseases, were quantified using soil and pasture data collected from irrigated and rain fed pastures over several years, as well as Overseer®. Neo-classical valuation techniques such as market prices, provision and replacement costs and defensive expenditure were then used to determine the economic value of services.

An investment in irrigation on a 250ha dairy farm in the manawatu sand country increased stocking rate from 2.5 cows/ha to 3 cows/ha, and milk production from 875 KgMS/ha/yr to 1200 KgMS/ha/yr. It also increased the value of the ecosystem services provided from $5,288 /ha/yr to $7,678/ha/yr. Simultaneously, N losses from the newly irrigated paddock increased from 33 kgN/ha/yr to 61 kgN/ha/yr. The cost benefit analysis (BCA) of an investment in irrigation revealed that the net present value (NPV) of the investment over 10 years was positive. However, when the costs of mitigating the additional losses to the environment associated with the introduction of irrigation were factored in the BCA the NPV of the investment became negative. Adding the economic value of the ecosystem services provided to the BCA kept the NPV positive even after factoring mitigation costs.

BIG STORMS CAN COST FARMERS BIG DOLLARS

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One of the worst storms in decades hit Hawke's Bay on 26 and 27 of April, 2011, generating significant soil erosion and flooding in coastal southern Hawke's Bay and a coastal area north of Wairoa. The storm damage affected 110 farms.

Questionnaires were distributed to affected farmers and 60 interviews were done on the farm, 39 in southern Hawke's Bay and 21 in Wairoa.

Information was collected on stock losses, stock movements, infrastructure damage and repairs, effectiveness of mitigation measures to combat erosion, and future planned mitigation measures.

Twelve stock classes were represented in stock deaths. Stock losses were reported on half the farms. Stocks losses were valued at $495,000.

Stock trading losses affected the majority of farms at a net cost per farm of $94,600, generally as a result of loss of grazing due to slips and silting.

All farms had to restore infrastructure at a mean cost of $84,250. At the completion of the questionnaire this mean cost accounted for ~80% of repairs.

When conservation trees were present, farmers reported that erosion damage was considerably reduced. Effectiveness ratings of excellent or good were given for 94% of pine plantations, 76% of poplar plantings and 73% of willow plantings.

Mean recovery costs per farm resulting from the storm event were $207,200. With just over 80% of infrastructure repairs completed, only half of the farms had mitigation practices in place or planned at an annual cost of $1540 per year.

A storm equally damaging could affect any locality in New Zealand.

YOUR SOIL IS VALUABLE – PLANT TREES TO KEEP IT!

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Soil performs four important functions: it is a medium for plant growth; it stores, supplies and purifies water; it is a modifier of the atmosphere; and it houses organisms that decompose organic matter and release mineral nutrients for plant growth.

Soil is a finite resource. We must conserve it for the future. Soils on pastoral hill slopes need tree protection. Particular attributes (ease of establishment, quick growth, extensive lateral root system, response to management, fodder value, deciduous character) of poplars and willows make them very suitable for soil conservation in pastoral hill country.

As a general rule, the bigger the tree, the more soil it protects from slipping. A tree protect more soil when it is close to other trees. Evidence of the effect of trees in reducing slipping on hill sites compared to pasture-only hill sites is given. Evidence that larger trees provide more protection from slipping than smaller trees is also presented

Bigger trees have bigger root systems and protect more soil. The intermeshing of root systems of adjoining trees increases the reinforcement of soil and provides greater resistance to slippage of saturated soil on slopes.

Trees planted for soil conservation should be planted close together, and the spacing increased as the trees grow, by the removal of excess trees.

Conservation trees can be managed so that the loss of pasture through tree shading is minimised. Trees can be pollarded to reduce the canopy size and increase light to pasture. Trees can be pruned so that the shadow is cast further away from the tree allowing more light to the pasture. This also disperses camping stock and animal manure.

In the long term, the loss of pasture production due to the presence of conservation trees is offset by the benefits of erosion reduction, stock shading, shelter and fodder

MEASURING THE COMPARATIVE COST OF ENVIRONMENTAL COMPLIANCE AND MITIGATION OPTIONS FOR WAIKATO DAIRY FARM SYSTEMS

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In the Waikato, regulation has been used as a means to limit and mitigate the negative environmental impacts of dairy under the National Policy Statement for Fresh Water. The regulation has predominantly focused on effluent storage and application as well as allocation of water. To date it has not shaped how Waikato dairy farm systems are implemented. It is likely that future regulation for the Waikato will include nitrogen loss limits. Management of nutrient cycles will therefore become a high priority for effective farm management as well as being used to inform the adoption of changes to farming systems. This research investigated the effect on N leaching and economic farm surplus (EFS) per hectare of four nitrogen (N) loss mitigation strategies for Waikato dairy farm systems of low, medium and high input.

Modelling through OVERSEER indicated that reductions in N leaching for farm environmental compliance were able to be achieved through farm management practices as well as through additional farm infrastructure. Destocking resulted in a 20% reduction in N leaching and a 1% increase in EFS. Cow housing decreased leaching by 17% and an 11% increase in EFS. Winter grazing off-farm decreased leaching (9%) but was associated with a 4% decrease in EFS. Increased effluent management facilities decreased N leaching (8%) and had no effect on EFS. The respective capital implications are shown to be an influencing factor for implementation of mitigation scenarios, relative to the farm specific debt loading.

It is likely that as N loss limits are used to generate future regulation for the Waikato region that farm nutrient budgets will be used to inform the implementation of changes to farming systems. At this point there are efficiencies to be gained through lower input and lower footprint farm systems as well as through high input farms with sufficient mitigation strategies in place.

SPATIAL VARIABILITY OF NITROGEN SUPPLY ASSESSED USING SOIL AND PLANT BIOASSAYS

Weiwen Qiu, Paul Johnstone, Dirk Wallace, Nathan Arnold, Bruce Searle, Joanna Sharp, Mike Beare and Denis Curtin

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Knowledge of spatial patterns in soil nitrogen (N) availability is a pre-requisite to delivering more precise N fertiliser management practices at a sub-paddock scale. The objective of this study was to quantify spatial variability in soil N mineralisation in a paddock with a history of arable cropping and identify soil chemical or physical properties that could help predict these patterns. The trial was conducted in 2012 using soil samples (0-15 cm depth) collected from a 30 ha paddock near Otane in the Hawke's Bay. The grid pattern (45m sampling interval) was used to collect a total of 105 individual soil samples. In the 4 years preceding the sampling, the crop rotation included wheat, peas, squash, barley and winter grass.

Total N (and C), anaerobically mineralisable N (AMN) and mineral N were determined on all samples using standard methods. A six month plant bioassay was used to quantify the N supplying capacity of the soils (expressed as net N mineralisation, converted to kg N/ha). This was evaluated by subtracting measurements of soil mineral N and seed N at sowing from whole plant N uptake and soil mineral N at harvest. Pots were watered every 1-3 days depending on evapotranspiration losses. The sink crop grown was oats (*Avena sativum*).

Indicators of soil N supply in the paddock exhibited substantial variability. Total N (TN) ranged from 1.6 to 3.2 g/kg (CV 14%), AMN from 38 to 176 µg/g (CV 27%) and mineral N from 20 to 108 µg/g (CV 29%). Net N mineralisation calculated from the bioassay also showed significant spatial variations, ranging from 10 to 225 kg N/ha (CV 47%). Except for mineral N, other indicators on N supply showed moderate to strong spatial dependence. The semivariograms for AMN, TN and net N mineralisation were well fitted by spherical and Gaussian models. Correlation of AMN (R^2=0.32, ρ<0.001) with net N mineralisation was similar to TN and net N mineralisation (R^2=0.44, ρ<0.001) suggesting that the AMN test did not provide a better estimate of N supplying potential in the experimental paddock.

The relationship between soil texture and indicators of N supply was also examined using 25 samples collected along two perpendicular transects within the paddock. TN and net N mineralisation were both positively correlated with clay content (R^2=0.72, P<0.001 and R^2=0.48, P<0.001 respectively). This result suggests that textural variation may be a useful factor in identifying potential variability in N supply patterns. Further work is needed to test these observations on a wider range of soils and conditions.

HIGH RATE LAND PASSAGE STRUCTURES FOR ATTENTUATION AT HIGH RISK LAND APPLICATION PERIODS

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High Rate Land Passage (HRLP) structures have been designed as an alternative to direct discharge of treated wastewater to surface water. A piped discharge directly to a waterway has been the historical means of surface water discharged used by many councils and industry. Land application of wastewater is an alternative, but saturated soil conditions and inadequate storage can limit year round land application. Combined Land and Water Discharges (CLAWD) are a solution.

Consultation with local iwi and the wider community has demanded improvements to municipal and industrial wastewater management. An objective often sought is land passage prior to eventual surface water discharge, especially when used as part of a CLAWD system. Rather than a direct pipe discharge to a surface waterbody recent consultation has helped to refine site specific land passage structures before wastewater is discharged to surface water. Every site is different and it is important that a variety of options for land passage and discharge are presented to stakeholders for their consideration prior to establishing a preferred option.

HRLP and discharge structures need to be designed within the constraints of the site and aim to spread the wastewater evenly over the structure with preferential flows being avoided, thereby maximising residence time and providing for greater contact with the land and vegetation. There is no significant treatment effect should be expected, but there are significant cultural and social benefits.

THE EFFECTS OF CLIMATE CHANGE ON NITROGEN AND SULPHUR LOAD IN PERCOLATION WATER FROM AGRICULTURE LANDSCAPE

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Global and climate changes influence the basic conditions for agriculture. Therefore there is not only a demand for a consequent climate protection but also for an adaptation of agriculture to changing conditions. For a study region of 60x40 km within the moraine landscape of North-East Germany, mainly used for agriculture, water balance, nitrogen and sulphur loads as well as crop yields are calculated for the actual and for a possible future situation. The comparison between the Scenario 2050 and the initial Situation 2000 reveals significant changes of the water balance (decrease in percolation water, increase in actual evapotranspiration) as well as of the concentration of nitrogen and sulphur in the percolation water. For the study region the crop yields decrease only slightly if the CO_2 fertilizing effect is taken into account. Adaptation measures in reaction to the changing climate conditions to achieve an economically secured and sustainable agriculture are recommended.

NITROGEN FERTILISER USE EFFICIENCY ON WEST COAST HUMPS AND HOLLOWS

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The practise of humping and hollowing is widespread on the South Island's West Coast to improve drainage and enable more intensive dairying. Humps and hollows are designed to overcome drainage and aeration issues primarily to enable greater pasture growth and provide physical support for livestock. However, there is very limited information on how the resulting "new" soils function. Of particular agronomic interest is how soil fertility and fertiliser requirements change as the soils develop.

Initially after formation the topsoil of the humps and hollows has low fertility and high nutrient inputs are required. Soils tend to have high carbon to nitrogen ratios and pasture production is strongly limited by nutrient availability, especially nitrogen. To overcome this, initially high rates of fertiliser and lime are applied. Excretal returns from animal and pasture residues lead to improved soil fertility resulting in rapid increases in total soil organic matter and reductions in soil carbon to nitrogen ratios. As the modified soils "develop" fertility improves, greater pasture production is sustained and fertiliser inputs are reduced.

In this paper we present data from field trials and soil surveys that demonstrate how fertility changes as hump and hollow soils develop, including differences in nutrient responses between the humps and hollows. We will address how the tactical application of fertiliser may increase overall herbage production and provide economic benefits. This is further explored in a companion paper (Horrocks *et al.*, 'Developing guidelines for fertiliser spreading on West Coast humps and hollows', FLRC proceedings 2015).

NITROGEN LEACHING FROM CUT-AND-CARRY LUCERNE

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Water in Lake Taupō is deteriorating due to increasing nitrogen levels. To maintain water quality, the Waikato Regional Council's Regional Plan (which outlines the nitrogen discharge allowance for each farm in this region) has adopted a target of a 20% reduction in manageable-N entering the lake. The target is challenging and farmers are now looking for economically viable, low N-loss options for land use.

Overseer® V5 is the model used to obtain nitrogen discharge from farming platforms; however, when the target was established Overseer® did not contain a module for cut-and-carry lucerne. While published data for N-leaching under lucerne range between 5 and 26 kg/N/ha/y, Waikato Regional Council allocated 19 kg/N/ha/y to lucerne. This constrains use of the crop if the actual leaching values are lower.

As a consequence, Lake Taupō Protection Trust is currently funding a 3-year trial on N-leaching under cut-and-carry lucerne. Since lucerne is a deep-rooting plant, Overseer® requires leachate to be collected at a 1.5-m depth and the size of lucerne plants means large diameter barrels are required. Twelve barrel lysimeters (1-m diameter × 1.5-m high) were installed around an underground facility. The lysimeters have 50-cm-long hanging fibreglass wicks installed at the base of the soil to maintain soil suction within the lysimeter. The lysimeters are not stocked and urine returns are absent. Four replicates of ryegrass/clover are harvested on a similar rotation to the farm grazing, while the eight replicates of lucerne are harvested at 10% flowering. Four of the lucerne replicates have been amended with biochar incorporated into the topsoil at a rate of 10 t/ha. Fertiliser is applied to both crops based on soil and foliage tests. N leaching from the ryegrass/clover is low, as expected at less than about 5 kg/N/ha/y. As a result of cultivation there was a spike in N leached under lucerne, which started and finished in the year following cultivation, of about 20 kg/N/ha. Nitrogen leaching from the lucerne is now similar to that of the ryegrass/clover.

Future work will examine N leaching from lucerne with urine inputs to simulate grazing.

SOIL QUALITY MONITORING ACROSS LAND USES IN FOUR REGIONS: IMPLICATIONS FOR REDUCING NUTRIENT LOSSES AND FOR NATIONAL REPORTING

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This paper reports on indicators of soil nutrients and soil compaction from soil quality monitoring undertaken as part of State of the Environment monitoring by regional councils in the Auckland, Waikato, Hawkes Bay and Wellington regions of New Zealand. Several regional councils have been monitoring soil quality since 2000. This paper presents soil quality data for land uses including drystock, dairy, market gardening (vegetable production), cropping (arable), horticulture orchards, exotic forest and indigenous vegetation at sites sampled to 2014. To avoid any confounding effects of changes in land use, sites that had land use changes were excluded from the analysis.

Indicators of soil nutrients included anaerobic mineralisable N (AMN), total nitrogen, C:N ratio, Olsen P, total carbon and for some regions extractable NO_3-N and NH_4-N. Other soil quality indicators included the soil physical indicators of bulk density and macroporosity (-10 kPa). Several soil nutrient indicators had some values outside recommended target values. For example, many of the intensive land use sites (e.g. market gardens and dairy) had soil chemical and physical indicator values outside recommended targets. This may represent an increased risk of soil nutrient loss from land to water via surface runoff.

Regional councils are contributing to the development of the land-based component of the Environmental Monitoring and Reporting (EMaR) project with the Ministry for the Environment and other agencies. The EMaR project relates to legislation called the Environmental Reporting Bill that was introduced to Parliament in 2014. In this paper we highlight some observations and recommendations of interpretation and methods between regional councils which should be considered for robust nationally-based analyses and reporting.

COST AND EFFECTIVENESS OF MITIGATION MEASURES FOR REDUCING EMISSIONS TO WATER AND AIR FROM PASTORAL FARMS IN SOUTHLAND, NEW ZEALAND

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Using a novel approach that links geospatial land resource information with individual farm-scale simulation, we conducted a regional assessment of nitrogen (N) and phosphorous (P) losses to water and greenhouse gas (GHG) emissions to air from the predominant mix of pastoral industries in Southland, New Zealand. An evaluation of the cost and effectiveness of several nutrient loss mitigation strategies applied at the farm-scale, set primarily for reducing N losses and grouped by capital cost and potential ease of adoption, followed an initial baseline assessment. Grouped nutrient loss mitigation strategies were applied on an additive basis on the assumption of full adoption, and were broadly identified as 'improved nutrient management' (M1), 'improved animal productivity' (M2), and 'restricted grazing' (M3). Estimated annual nitrate-N leaching losses occurring under representative baseline sheep and beef (cattle) farms, and representative baseline dairy farms for the region were 10±2 and 32 ± 6 kg N/ha (mean ± standard deviation), respectively. Both sheep and beef and dairy farms were responsive to N leaching loss mitigation strategies in M1, at a low cost per kg N-loss mitigated. Only dairy farms were responsive to N leaching loss abatement from adopting M2. Dairy farms were also responsive to N leaching loss abatement from adopting M3, but this reduction came at a greater cost per kg N-loss mitigated. Only dairy farms were responsive to P-loss mitigation strategies, in particular by adopting M1. Only dairy farms were responsive to GHG abatement; greater abatement was achieved by the most intensified dairy farm system simulated. Overall, M1 provided for high levels of regional scale N- and P-loss abatement at a low cost per farm without affecting overall farm production, M2 provided additional N-loss abatement but only marginal P-loss abatement, whereas M3 provided the greatest N-loss abatement, but came at a large financial cost to farmers, sheep and beef farmers in particular. The modeling approach provides a farm-scale framework that can be extended to other regions, capturing the interactions between farm types, land use capabilities and production levels, as these influence nutrient losses and GHG emissions and the effectiveness of mitigation measures.

NITROGEN USE EFFICIENCY IN DIFFERING DAIRY WINTERING SYSTEMS IN CANTERBURY

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Intensification of dairying in the South Island due to irrigation and high fertiliser inputs has led to excess nitrate leaching to ground water. The contribution of winter support blocks to the whole system environmental footprint varies with the type of system and the intensity of feeding on land or on feed pads. Commonly, non-lactating dairy cows are grazed off the milking platform on high yielding forage crops during winter with potential for high N returns. Alternatively, effluent capture and dispersal may be required in future to reduce the potential N loss.

Three dairy farm systems, all on light free-draining Lismore soils, were compared for efficiency of nitrogen cycling over two seasons. These included System A (DairyNZ System 2), representing relatively low inputs with all cows grazed 'off-farm' on forage crops during June and July; System B (DairyNZ System 4), a system whereby greater than 90% of supplement was fed on a large feed pad (also used as a stand-off area), and animals were wintered off farm on forage crops; and System C (DairyNZ System 5), a full indoor housed system where animals were inside year round with the feed sourced from an accompanying support block and imported supplements.

OVERSEER® nutrient budgets were used to define N cycling at the paddock level and for overall system level performance. Nitrogen leaching losses at the system level were highest in System B at 47.5 kg N/ha/an, approximately 9 kg N/ha/an higher than System A, and lowest in System C at approximately 26 kg N/ha/an. Stocking densities during wintering of System B were greater than in System A, leading to higher losses from the wintering system alone of 65 kg N/ha/y compared with System A losses of 50 kg N/ha/an. Losses beneath fodder beet (System A) were 44.5 kg N/ha/an. Nitrogen conversion efficiency at the whole farm system level was highest for System C at 39%, while the efficiencies of Systems A and B varied between 25 and 33%. Corrected annual amounts of N returned to support land were 74 kg N/ha in System B (over 50 ha) compared with 243 kg N/ha in System C distributed over 80 ha.

The mean cost of wintering was defined as the value of N lost in emissions and leaching on a per cow per day basis. Values were standardised for hectares grazed and cow number per paddock. Costs were $0.44 and $0.43/cow/d for respective years in System A, $0.46 and $0.34/cow/d in System B, and only $0.03/cow/d for System C. The housed system, therefore, showed significant environmental benefits when effluent was captured and distributed in a controlled way. These data may be used as a bench mark for comparing similar wintering systems and potential environmental impacts on commercial farms in the South Island.

IMPACT OF CLIMATE SCENARIOS ON SOYBEAN YIELDS IN SOUTHERN BRAZIL

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Soybean is a very important crop,cultivated mainly as feedstock for animalproduction, but also for other uses like biodiesel. Brazil is the second largest producer of soybeans, and the main exporter. About 10% of the Brazilian total production is aimed for biodiesel production. The aim of this work is to assess the impact of climate changescenarios on soybean yield and evaluate two simple adaptation strategies: cultivar and planting date. Tests were done for soilprofiles from two important producing regions: Chapecó – Red Oxisol, and Passo Fundo – Rodic Hapludox. Two commercial soybean cultivars (CD202 and CD204) and seven regional circulation models (RCM) were used. All simulations were done with DSSAT. After model alibration, eleven planting dates were run for two periods (2011-2040 and 2071-2100) using the RCM`s. The cultivars did not showed differences among them. For Chapecó, the majority of RCM`s projected yieldreductions, with few RCM`s projecting increments, and for only few planting dates(November). The pattern of response for both time periods was identical, although the end-of-century period presented a further yield reduction. The main reason is due reduced water holding capacity from soil, high temperatures and changes in rainfall distribution along the cropping season. For Passo Fundo, 2011-2040yields are distinct, depending on the RCM.

Simulated yields tend to follow the actual yield pattern along the different planting dates, besides discrepancies. For 2071- 2100, all but one RCM indicate yields equal or lower to actual levels. Regarding planting dates, no significant changes were identified, although reductions are observed in the early planting dates (August-September). The scenarios suggest that soybean yields will be reduced, jeopardizing the viability of this crop and biodiesel production in the studied regions.

MAIZE FOR ETHANOL PRODUCTION: REGIONALIZATION OF RESPONSES TO CLIMATE SCENARIOS, N USE EFFICIENCY AND EFFECTIVENESS OF ADAPTATION STRATEGIES

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Maize, besides a source of food, is also a source of energy. As any other crop, maize yield – and therefore the ethanol produced – is a response to environmental factors such as soil, weather and management. In a context of climate change, understanding responses is crucial to determine mitigation and adaptation strategies. Crop models are an effective tool to address this. The objective is to present a procedure to assess the impacts of climate scenarios on N use efficiency, yield, so as the effect of crop variety (n=2) and planting date (n=5) as adaptation strategy. The study region is Santa Catarina State, Brazil, where maize is cultivated in more than 800000 ha (average yield: 4,63 ton ha-1). Besides not yet expressive in the region, there is a growing tendency for using maize as biofuel source. Allocation of crop land was done using satellite data, allowing the coupling of weather and 253 complete soil profiles in single polygons (n=4135). DSSAT crop model was calibrated and validated using field data (2004-2010 observations). Weather scenarios generated by RCMs were selected according capability of reproducing observed weather. Simulations run for the 2012-2040 period (437 ppm of [CO2]) without adaptation strategies showed reductions of 12.5% in maize total production. By only using the best maize variety for each polygon (soil + weather), total production was increased by 6%; when using both adaptation strategies – variety and best planting date – total production was increase by 15%. The modeling process indicates N use efficiency increment ranged from 1 – 3% (mostly due [CO2] increment, but also due soil properties and leaching). This analysisshowed that N use efficiency rises in high [CO2] scenarios, so as that crop variety and planting date are effective tools to mitigate deleterious effects of climate change, supporting energy crops in the study region.

DEVELOPING GUIDELINES FOR FERTILISER SPREADING ON WEST COAST HUMPS AND HOLLOWS

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The practise of humping and hollowing has become widespread on the South Island's West Coast as a way of improving drainage and has enabled a growth in dairying in the region. Fertiliser spreading patterns on humps and hollows differ from those on the flat. To improve the efficiency of fertiliser spreading on these unique landforms, fertiliser distribution patterns (of urea and superphosphate) for two types of commonly used spreaders (Coombridge & Alexander SAM and Robertson® Transpread) and three different widths of humps and hollows (30-, 40- and 60-m) were determined. A total of 48 single-pass tests using collector trays (0.5 m x 0.5 m) were conducted across the humps and hollows for the different spreader and fertiliser types and a statistical model was used to fit distribution curves to the spreading pattern data.

Bout widths and driving positions resulting in the most uniform fertiliser application on these land forms are discussed. Bout widths and driving positions required for more strategic fertiliser distribution on these landforms are also considered based on recent field trials which indicate that there can be greater responses to fertiliser placed on the lower slopes than on the upper slopes in some hump and hollow systems (Thomas *et al*., 'Nitrogen fertiliser use efficiency on West Coast humps and hollows', FLRC proceedings 2015).

WHOLE FARM TESTING: A REVIEW OF DATA

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Traditionally, fertiliser plans have been generated by sampling a limited number of paddocks to represent the soil type and farm use of the whole farm. In more recent times, intensive soil testing has taken place over the whole farm, so that the fertiliser plan can be tailored to the specific nutrient requirements of each paddock. By using this approach the soil fertility variation between paddocks can be narrowed. Ravensdown has been offering whole farm testing since 2012 and couples this with paddock specific fertiliser application, to help farmers optimise their nutrient investment. ARL provides the soil analysis component of this offering. This report is a review of the whole farm testing data collated by ARL.

Since 2012 more than 300, predominately dairy farms, have participated in whole farm testing and then adjusted their fertiliser applications based on the results. Approximately 15% of these farms have completed a second round of whole farm soil testing. For this report we have used a sub set of data comprising dairy farms that have applied paddock specific fertiliser rates and have completed at least two rounds of whole farm testing. We have aggregated the data across pH, Olsen P, potassium and magnesium and evaluated the results.

As the overall data set is reasonably small, it is difficult to draw conclusions, but trends have been identified. It is encouraging to see that, for all components, the spread of results has reduced. This suggests that more fertiliser has been applied to the areas of lower fertility and less to the areas of higher fertility.

EFFECTS OF HOLDING TIME AND TEMPERATURE ON *E. COLI* AND TOTAL COLIFORMS IN SURFACE WATER SAMPLES

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Total coliform and Escherichia coli (*E. coli*) counts are routinely used as microbiological indicators of water quality. For Laboratory results to be compliant with APHA (American Public Health Association), samples must be held at less than 10°C, for a maximum transit period of 6 hours and processed at the lab within 2 hours. With samples taken in many locations in New Zealand it is unlikely that they will reach a laboratory within the time frame to meet the compliance standard.

In an effort to understand the effects of both temperature and storage conditions on Total coliform and *E. coli* recoveries a case study was performed by analysing surface water samples.

Samples were collected from five sites across Hawkes Bay targeting different waterways and transported back to the laboratory within the compliance timeframe. All sites were then analysed in duplicate. The remaining samples from each site were stored in three different conditions either resting at ambient temperature (within the Laboratory), in chilly bins with ice bricks or in the fridge. Samples were analysed over a period of five days at 0, 24, 48, 72 and 96 hours after sample collection. The method used for the analysis was the IDEXX Colilert-18 test kit, which simultaneously detects total coliforms and *E. coli*.

The results obtained for Total Coliform counts across all the sites showed that no substantial difference was observed from the initial zero hour up to 72 hours across all storage conditions. *E. coli* counts showed a sharp drop between the initial testing and 24 hours. This is consistent with work conducted by NIWA (Crump, 2011).

Further analysis is required to expand on this work, in particular additional resolution on the impact to *E. coli* numbers within the first 24 hours post sampling.

IMPROVING THE WATER USE EFFICIENCY OF CROP PLANTS BY APPLICATION OF MYCORRHIZAL FUNGI

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In an eight year (2007-2014) lysimeter experiment we investigated the influence of a commercial mycorrhiza inoculum on the water use efficiency and biomass production of the 'energy plants': Maize, Sunflower, Sweet clover and Sweet sorghum, when exposed to high or low ground-water levels. *Silphium perfoliatum* and the Szarvazi-1" energy grass were additional included in the experiment in 2012.

The lysimeters used, were undisturbed soil monoliths (surface area 1 m^2 and 1.5 m deep) with different low-level moors, half-bogs, humus gley, sand gley as well as loamy substrates.

Per plant system two different ground water levels were applied, high with 40 cm below surface and low with 100 cm below surface. A commercial mycorrhiza product was applied to each ground-water treatment according to the manufacturer's instruction. Lysimeters without mycorrhiza inoculation served as controls. The ground water levels were kept stable and the water input and output was recorded daily. Plant biomass, specific water use efficiency, water balance, mycorrhizal colonization and mycorrhiza spore abundance were determined.

Results showed that the different plant species responded differently to the application of mycorrhizal fungi. Over the eight-year trial period sunflower clearly benefited from mycorrhiza application. The total biomass in mycorrhiza treated lysimeters was significantly higher than in untreated ones and also the colonization degree of the roots with mycorrhiza. This result was not only found at low ground water levels (100 cm) but also at high levels (40 cm). Interestingly, at low groundwater levels the sunflowers in mycorrhiza treated lysimeters utilized less water than the untreated lysimeter but produced more biomass. A higher biomass at high ground-water levels was also observed for Sweet clover with mycorrhiza application, but the differences between treated and untreated plants were less pronounced. In contrast, Sweet sorghum developed a higher biomass in untreated soil compared to the mycorrhiza treatment, especially at low ground water levels which represents drought stress. Depending on the year the effects varied for maize, Silphie and Szarvazi gras. The results indicate that biomass production and water efficiency depends on plant species, cultivar, soil type, ground-water levels and degree of mycorrhization.

MYCOGRO AG®

- A MYCORRHIZA PRODUCT MADE IN NEW ZEALAND

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Changes in environmental policies are forcing plant producers worldwide to reduce the input of agrochemicals and demand alternative solutions for sustainable plant production. Accordingly, there is much interest in the use of arbuscular mycorrhizal fungi (AMF) as biofertilisers across both agriculture and horticultural systems. However the adoption of AMF-based biofertilisers has been hampered due to the prevalence of poor quality commercial products on the market. These claim to have high propagule numbers but laboratory analysis often find low to no viable AMF. Rather chemical fertiliser compounds are often present, and these support short-term plant growth. New Zealand farmers should not miss out on gains in fertiliser use efficiency and plant health that can be achieved by the use of AMF fungi. With financial support of the Royal Society, MBIE, Grasslanz Technology Ltd, AgResearch Ltd, and German industry and research partners, a mass production system for high quality, NZ-sourced mycorrhizal fungi has been developed, and the product MycoGro Ag® is currently under evaluation in various commercial field trials. The application of MycoGro Ag® in plantain (*Plantago lanceolata* cv. Lancelot) resulted in 118 % dry matter increase compared to the fertiliser control (P=0.0005). Further field and pot trial results will be presented at the workshop. A primary issue associated with commercial AMF products remains quality assurance. To ensure MycoGro Ag® meets or exceeds customer’s expectations, our inoculum undergoes extensive testing for presence of the correct fungal strains, propagule numbers and viability.

SERUM AND FAECAL ZINC CONCENTRATIONS IN SHEEP FOLLOWING LOW DOSE ORAL ZnO TREATMENT

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Facial Eczema (FE) is a fungal disease in farm animals caused by *Pithomyces chartarum*. In New Zealand, high dosages of ZnO and $ZnSO_4$ are used as a prophylaxis against FE. High doses of Zn may cause negative effects on animal health and the accumulation of Zn excreted by animals in soil is threatening environmental quality guidelines in some regions. Ongoing research at Massey is investigating if Zn-enriched fodder can protect animals against FE (biofortification) at lower total Zn intake. This would have benefits for both animal and soil health.

To investigate if faecal and serum Zn concentration can be separately manipulated through oral Zn supplementation, an experiment was conducted with nine sheep at Massey University. The sheep were organised into three groups of three and each group was orally treated with 3 different treatments of ZnO: 5 mg Zn/kg/day for three days (3 doses), 5 mg Zn/kg /12-hr for three days (6 doses) and 10 mg/kg Zn at time zero as a single dose. These doses are all significantly lower than those administered to animals in the field. Blood and faeces were sampled at four-hour intervals and analysed for Zn.

Single dose treatment rapidly increased the Zn concentration in faeces, but this reduced after 24 hours. The Zn concentration in faeces gradually increased in the sheep treated twice a day and remained significantly elevated for longer than those treated once a day and above the threshold for protection (250 mg/kg fresh weight). All treatments increased the blood serum Zn concentration to the established threshold (18 µM Zn) 8 hours after commencing the experiment, however the serum Zn concentration thereafter reduced below the threshold level.

The regular administration of low-level zinc had limited effect on the serum Zn of the sheep, but had a major effect of their faeces Zn. This experiment therefore proved that serum and faeces Zn concentration can be separately manipulated.

CAN I FARM WITHIN A PHOSPHORUS LIMIT?

R W McDowell

AgResearch, Invermay Agricultural Centre, Mosgiel and Lincoln University, Lincoln

The national policy statement on freshwater management requires Regional Councils to manage or improve water quality above a national set of bottom lines for specific objectives. One of these objectives is periphyton (algae) growth in streams and rivers.

Periphyton growth is linked to phosphorus concentrations in the water column and other factors. As such, some Councils are considering or have imposed limits on phosphorus emissions to water. Here I explore the link between periphyton growth and phosphorus losses, highlighting the processes and pathways relevant to the mitigation of phosphorus emissions. I then ask:

1. should a limit be set and what should it be;
2. where should it occur;
3. when should it come into effect and be re-evaluated; and most importantly
4. what can I do to meet it – or can I farm within a phosphorus limit?

SOIL WATER REPELLENCY: INVESTIGATING POTENTIAL BIOLOGICAL DRIVERS AND CONSEQUENCES FOR APPLIED PHOSPHATE

R. Simpson, K. Mason, C. Robertson, K. Müller

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Soil water repellency (SWR) is generally thought as a significant problem affecting large areas of land throughout the world, and is found in natural, intensively managed and man-made ecosystems. SWR reduces water infiltration and increases surface runoff. This can lead to nutrient losses and leaching of agrichemicals, as runoff decreases absorption of the chemicals into the soil. There is universal agreement that SWR is caused by the formation of hydrophobic organic surfaces on minerals and soil aggregates. The organics implicated to be involved include waxes, aromatic oils, resins, fatty acids, lignin and fungal hyphae proteins. Ligninolytic enzymes such as phenol oxidase and peroxidase are important catalysers, creating hydrophobic and aromatic compounds. Glycosyl hydrolases are enzymes involved in carbohydrate utilisation are unusually found in within cells, their presence in soil extracts imply cell degradation. These organic compounds can result from the degradation of recalcitrant soil compounds such as lignins and the debris associated with bacterial and fungal decomposition. In this study we hypothesized that enzymatic activity could act as indirect indicators of the accumulation of hydrophobic substances causing SWR. To this end, intact soil blocks were collected from a Pumice soil along the ridges and gullies of a hill slope on a Taupo beef farm in February 2014. These were divided into 1 or 2 cm thickness bands down to 10 cm depth, passed through a 2-mm sieve and used to measure water drop penetration times, contact angles, enzyme activities and Bradford-reactive soil protein levels. While there were some clear correlations between soil depths and phenol oxidase activity, these did not correlate with SWR; other indicators showed a similar lack of correlation with SWR

THE TIERED FERTILISER MANAGEMENT SYSTEM FOR MANAGING SOIL CADMIUM IN AGRICULTURAL SOILS IN NEW ZEALAND

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Soil cadmium levels are gradually increasing in agricultural soils around the world due to the natural trace levels which are found in phosphate rock from which phosphate fertiliser is manufactured. Trace levels applied to soil will accumulate in the surface soil bound to organic matter and soil colloids with accumulation rates dictated by the cadmium content in phosphate products and the rate of phosphate fertiliser applied over the long term.

Soil cadmium levels in New Zealand do not currently present a risk to human health, trade or the environment and in order to control soil cadmium and maintain acceptable levels of soil cadmium over the long-term the Cadmium Management Group has been charged with the role of implementing an agreed Cadmium Management Strategy.

One integral component of the Cadmium Management Strategy for New Zealand is the Tiered Fertiliser Management System for the application of phosphate fertilisers. This system, developed by the fertiliser industry, was endorsed and adopted by the Cadmium Management Group as an appropriate means to ensure soil cadmium remains within acceptable limits over the next 100 years at least. It provides an upper threshold in agricultural soils, where no further soil cadmium accumulation will occur unless there is a detailed site specific investigation to identify risks and pathways for potential harm.

The Tiered Fertiliser Management System requires monitoring of soil cadmium with a series of soil cadmium trigger values prompting increasingly stringent controls on the soil cadmium accumulation through choice and rate of phosphate fertiliser products. At all tier levels, soil and crop management options are available to influence bio-availability and exposure pathways. New Zealand specific research will inform and contribute to further development and enhancement of the Tiered Fertiliser Management System for controlling soil cadmium accumulation in New Zealand's agricultural soils.

DEVELOPING SOIL GUIDELINE VALUES FOR THE PROTECTION OF SOIL BIOTA IN NEW ZEALAND

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To assist in managing soil quality, different policy and regulatory approaches have been implemented in recent years. From an agricultural perspective the National Cadmium Management Strategy was released in February 2011 and includes a Tiered Fertiliser Management System to assist in reducing cadmium accumulation on agricultural land over time; from a contaminated land perspective, the *National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health* (the NES) came into effect on 1 January 2012. Additionally, guidelines are currently being developed for the management of the disposal of solid waste to land, and the beneficial use of organic waste (updating the Biosolids guidelines) that also are designed to prevent the negative impact of contaminants on the environment.

Under the Resource Management Act, regional councils and unitary authorities have responsibilities for soil quality and land management to safeguard the life-supporting capacity of soil and ecosystems, and ensure any adverse effects on the environment are avoided or mitigated. Fundamental to ensuring regional councils can fulfil these responsibilities is the need for a clear understanding of how hazardous substances potentially affect soil organisms (microbes, macrofauna and plants), and higher organisms (livestock, wildlife). Soil guideline values developed to protect soil biota (Eco-SGVs) provide a useful means to readily assess potential environmental impact. Further, the soil Cd concentrations currently used as trigger values in the TFMS are from a variety of sources, although the development of risk-based soil guideline values specific to New Zealand, in line with a review of the strategy in 2017 , is identified as part of the Governance work programme (MAF 2011). New Zealand derived cadmium Eco-SGVs provide one such risk-based soil guideline value.

However, a consistent methodology for deriving such criteria for use in New Zealand has not been agreed. A two-year Envirolink project commenced in July 2014 aimed at helping regional councils develop soil guideline values for the protection of ecological receptors (Eco-SGVs). As Eco-SGVs can differ in their level of protection depending on their context, feedback will be sought from industry and other stakeholders regarding their application and to achieve agreement on the derivation methodology. This paper provides an update on the status of this ongoing project.

SPATIAL DISTRIBUTION OF SOIL CADMIUM IN TWO LONG-TERM DAIRY FARMS

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Cadmium (Cd) accumulation in New Zealand agricultural soils has been linked primarily to phosphorus (P)-fertiliser application history. Land that has traditionally been intensively farmed with a rich history of P-fertiliser inputs is therefore likely to have the most enriched soil Cd concentrations.

As a consequence, long-term dairy farms represent a land use likely to be most impacted by the introduction of the Tiered Fertiliser Management System (TFMS). However, there is little information available regarding spatial variability of soil Cd within these farm systems. Without this knowledge, it is difficult to implement a soil sampling strategy with confidence that it will reliably represent a properties true soil Cd 'tier-status' within the TFMS. Furthermore, knowledge of soil Cd spatial variability is likely to be important to farmers and advisors since this may influence management and/or mitigation options and costs.

Soil Cd spatial distribution has been mapped for two long-term dairy properties under contrasting soil types; a Waikato property with predominantly Allophanic and Gley soils, and a Canterbury property with predominantly Gley and Peaty-Gley soils. This spatial variability information will provide the platform for further research including assessment of Cd accumulation in selected animal forage species under different soil, soil Cd concentration and environmental conditions.

CADMIUM IN THE DIET: UPDATING AND EXPANDING THE EXPOSURE MODEL FOR NEW ZEALAND CONSUMERS

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The New Zealand Total Diet Study (NZTDS) has been used as the primary monitoring tool to determine trends in cadmium exposure through the New Zealand population. In the most NZTDS (2009) the estimated cadmium exposures were 22-46% of the JECFA Provisional Tolerable Monthly Intake for different population age/gender groups.

In the 2009 NZTDS the simulated diet used to estimate exposures was based on the 1997 New Zealand National Nutrition Survey. Due to drift in consumption trends the use of a 12 year old diet could be under- or over-estimating current exposures. In 2008/9 the Ministry of Heath ran the latest New Zealand Adult Nutrition Survey. However due to the time taken to collate the over 100,000 food records from this survey the calculated consumption habits for New Zealand were not available for use in the 2009 NZTDS.

As a result of the 2008/9 nutrition survey becoming available for analysis MPI commissioned an extended and updated dietary modelling exercise for cadmium from the 2009 NZTDS results. This dietary modelling of cadmium calculated that exposures are 28-34% lower for adults groups and 3-15% lower for children when using the latest consumption values compared to those estimated in the 2009 NZTDS. The basis of the decrease is a reduction in consumption quantities of potato based foods and white bread. However these two foods still make up the majority of the contribution to exposure with 28-43% contribution for potatoes and 13-18% contribution for bread. Additionally oyster consumption has significantly dropped. Exposure contribution through oysters, estimated at 26% for adult males in the 2009 NZTDS, is now estimated as being at 3%. Comparison of these results to those calculated overseas shows that mean consumption values for all age groups are similar.

The results of this work feed into MPIs continuing risk management on cadmium in the diet and inform the planning of the forthcoming 2015/6 NZTDS.

PRACTICAL USES OF SMART TECHNOLOGIES

Jim Wilson

Soilessentials, Hilton of Fern, Brechin, Scotland

(Extract from the website soilessentials.com):

A leading figure In Precision Agriculture Jim Wilson is both a farmer and the Managing Director of Soilessentials Ltd. He has been running the family farm at Hilton of Fern in Angus, Scotland since the early eighties. A typical Scottish Arable Farm, it has hugely variable land, both in terms of soil type and topography. In 1996 he began collating data collected from a variety of sensors and input sources which helped quantify in field spatial variability in both map and economic terms. This information, when demonstrated to local farmers was the starting point for a long journey into the world of Precision Agriculture.

Soilessentials was set up in 2000 with 2 business partners, both farmers, who were equally interested in creating useful, meaningful, practical and ultimately user friendly hardware and software based on sound agronomy practices.

Over the years he has been an invited speaker at many conferences and congresses including: ECPA Greece, Precision farming Workshops and Conferences at Massey University NZ and University of Sydney, The American Society of Agronomy 103rd Congress in San Antonio Texas and the Sino UK Workshop on Geospatial technologies for Precision Agriculture held in Qingdao, China.

His passion for finding user friendly, practical applications for Precision Agriculture Technology is what drives him. Maintaining an active role in the farm allows him to test first hand any new developments.

VARIABLE RATE FERTILISER APPLICATION ON PASTORAL HILL COUNTRY - A SIMPLE AND EFFECTIVE SYSTEM

Colin Brown

TracMap, Mosgiel

It has long been know there are significant productivity gains or fertiliser savings available from differential application of fertiliser to pastoral hill country. This is to account for the variation in productivity potential due to slope and aspect, combined with the impact of nutrient transfer by grazing animals.

This need has long been known by farmers, and documented by researchers - for example, Gillingham A G, During C; Pasture production and transfer of fertility within a long established hill pasture*. New Zealand Journal of Experimental Agriculture 1973, p227-232.*

However, unlike the broadacre cropping sector, adoption of variable rate application by pastoral farmers has been limited by a lack of tools and systems capable of being used by those farmers, their advisors, and the spreading industry.

With this in mind, in 2013 TracMap started developing a system that would be simple enough to be used by most farmers and fertiliser reps, would work with the spreading technology used by the industry, and deliver the productivity gains expected.

The system uses simple mapping tools on the TracMap Online website to split a farm into Management Zones based on aspect, contour, and location of subdivision fences. The result is stored as a Variable Rate Base map. At the time of creating a job order the target rate for each zone is specified. These target rates accompany the map which goes to the TracMap unit in the truck, which in turn controls the existing rate controller in the truck to automatically apply the target rate as the truck drives around the farm.

Feedback from farmers and spreading operators who have piloted the system has been very positive. A typical example is where instead of applying super at 230 kg/ha over and area of 43 ha, a farmer was able to apply no fertiliser to 9 ha, only 100 kg/ha to 8 ha, and 350 kg/ha to the remaining 26 ha, which achieved the nutrient input needed for full pasture maintenance.

PRECISE SURVEYING OF SOIL PRODUCTIVITY INDICATORS USING ON-THE-GO SOIL SENSORS

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Current soil sampling methods, such as conventional and hectare grid sampling, do not provide a cost effective way in which to gather G.P.S. referenced data at an adequate frequency.

Various on-the-go soil sensing methods have been attempted to try and combat this. One such method is the Veris Mobile Sensor Platform (MSP-3). This method combines the mapping of soil texture via electrical conductivity (E.C.), organic matter (O.M.) percentage, using near infra-red light reflectance and soil pH levels, using ion-selective electrodes, along with topography data.

The concept of direct measurement of soil pH, texture (via EC) and O.M. percentage, all geospatially referenced, has allowed for a substantial increase in measurement density.

In this paper, we discuss various case studies and investigate:

1. Variable rate lime prescription rates, generated from on-the-go pH measurements and how it can result in the improved prediction of liming requirements compared to the conventional and grid sampling methods.
2. Mapping soil texture via EC and using GPS references to provide dense data coverage to delineate soil boundaries more accurately than currently available data and existing soil maps, including S-Map.
3. Accurate mapping of soil O.M. Soil O.M. affects the chemical and physical properties of the soil and its overall health. It is a key component of structure and porosity, affecting moisture holding capacity/nitrogen leaching, the diversity and biological activity of soil organisms, and plant nutrient availability.
4. Acquiring precise topographical measurements simultaneously and geo-referenced to proximal soil sensor readings. Topography and landscape position frequently exert a significant influence on soil properties and productivity.

MONITORING AND MAPPING CROP DEVELOPMENT

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In an attempt to understand variability in crops, smartphone photos were processed to assess canopy size. By geo-referencing such images, they can be used for spatial analysis. Preliminary results show considerable promise and the hope is that a tool can be made developed and made widely available.

A potential use is for detailed nutrient planning and variable rate application, which requires spatial knowledge of final yield. Onions grown in New Zealand have a potential yield of around 100t/ha. However industry statistics show the mean national yield in a good year is about 50 t/ha and in an average year only 35t/ha.

An onion crop planted on 7 June 2014 at the LandWISE MicroFarm at the Centre for Land and Water was followed to assess the viability of photographic images to assess canopy size and estimate final yield potential. Yields before curing within this 1ha paddock ranged from 0 – 85 t/ha.

Fertiliser was applied at three intervals, 2 August, 27 September and 24 October 2014. Overhead photos of the crop were taken across 18 crop beds on 1 October, 28 October and 14 November 2014. The images were processed to determine the percentage of green pixels as an estimate of ground cover. The crop was lifted on 8 January 2015 and fresh weights taken from each bed. These final yield results were compared to the images taken during crop development.

To investigate the potential to create canopy maps, we automatically captured GPS referenced images. The images were processed to determine ground cover and displayed on Google Earth.

There was a strong spatial pattern that could allow variable rate application. The accuracy of the smartphone GPS may be adequate for large scale assessment of crops in big paddocks. However, it was not able to correctly locate the images and subsequent ground cover factors within the correct onion bed. Our next step is to capture images with a device connected to an accurate GPS signal to better locate each image point.

We thank the LandWISE MicroFarm sponsors Ballance AgriNutrients and BASF Crop Protection and MicroFarm supporters for access to the onion crop.

FARM SYSTEM RISK ANALYSIS: BUILDING A FARM RISK PROFILE TO IMPROVE FARM ECONOMIC OUTCOMES

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Agricultural production systems are subject to a multitude of risks which must be managed or mitigated by farmers. Traditionally, a farm budget is fixed, and is based on expected farm outcomes. Limited variance analysis takes place, if so, usually around price of outputs and a limited number of inputs such as interest rates and perhaps some major expenses like fertiliser or grain drying which varies with autumn rainfall.

A budget does not describe the financial risk profile of a farm production system at all well. There are always a number of factors which have an influence on a farm's bottom line, climate, for example has a huge influence on yield, price and the quantity, components, timing and cost of many inputs. Sometimes there is a correlation between factors which improve farm incomes and *vice versa*.

Frequent summer - autumn rainfall events, for example, generally allow sheep and beef farmers to finish more stock, reduces the cost and increases the production of feed, will help maintain pasture cover and reduce weed germination and, or invasion, and prevent rye grass staggers. Whereas a drought will decrease income and increase expenses. The impacts are greatest if wet summers and droughts are felt on a national, rather than a regional scale.

Palisade @Risk software, is a risk profiling plug in tool for Microsoft Excel. It undertakes Monte Carlo simulations on inputs and outputs, based on the distribution type and parameters selected by the profiler. This paper runs simulations on model farm budgets for a typical Western Lower North Island sheep and beef property and a Canterbury dairy farm to demonstrate the risk profile of each farm type and the value of using this technique in farm planning.

ON-FARM FERTILISER APPLICATION CALIBRATION

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The Sustainable Farming Fund "On-Farm Fertiliser Applicator Calibration" project arose from repeated requests by farmers for a quick and simple way to check performance of fertiliser spreading by themselves or contractors. They wanted to know that spreading was acceptable.

Fertiliser applicator manufacturers provide guidelines to calibrate equipment but usually only the bulk application per hectare is determined, not the uniformity of application. This is a critical omission, as poor distribution significantly impacts yield and increases risk of leaching losses.

A calibration check includes assessment and correcting of both application rate (kg/ha) and uniformity (CV). Farmers indicate determining the rate is reasonably easy and commonly done. Very few report completing any form of uniformity assessment.
Fertiliser application calibration procedures suitable for farmers applying nutrients with their own equipment will allow on-farm checks to ensure and demonstrate application equipment is performing to expectations. They may also aid the self-audit component of *Spreadmark®*.

There are many protocols internationally relating to the spreading of fertiliser products. Lawrence (2007) compared six test methods. Most used 0.5 m trays organised in a single transverse row to capture the spread pattern of the spreader. No account is taken of the longitudinal variation between individual rows when multiple tests are carried out. The results of the test are given as the bout width where the coefficient of variation (CV) does not exceed a specified level. In all cases the maximum allowable CV is 15% for nitrogenous fertilisers and 25% for low analysis fertilisers.

Uniformity requires collection of samples from a spreading event and calculation of a uniformity value. It will involve either physical or theoretical over-lapping of adjacent swaths.

Test spread-pattern checks performed to date show there is a need for wider testing by farmers. Unacceptable CVs and incorrect application rates are the norm.

The SFF project is co-funded by the Foundation for Arable Research and the Fertiliser Association.

ACTIVE LIGHT SENSING OF CANOPIES IN CROP MANAGEMENT: PASTURES AND ARABLE CROPS

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A field spectrometer with an active light source was tested as a potential canopy sensor for dairy pastures ('TEC-5', YARA). Commercial units of this system are designed for sensing arable crops to estimate the required amount of nitrogen fertiliser and are well-established in intensive arable cropping systems in Europe. Indices calculated from the reflection levels of the crop canopies are used to determine site specific rates of nitrogen fertiliser. These are based on calibration curves provided from research. Though, such sensor systems are not yet commercially available for pastures.

The spectrometer provides an artificial light source and multispectral light in a range between 650 to 1,100 nm and offers sensors in four wavelength channels (730, 760, 900, 970 nm). Using the reflection data of these channels, spectral vegetation indices can be calculated.

To study the applicability of the sensor on pasture for the intensive radiation conditions of NZ we conducted two sensitivity experiments. These experiments investigated the influence of the spectrometer angle and height above a ryegrass pasture. Three angle settings were investigated, as well as nine heights from 50 to 250 cm over the two experiments. The results of the sensitivity analysis show that height and angle of the spectrometer can have an effect on the reflection of some of the four wavelengths.

A plot experiment was designed to calibrate sensors on ryegrass and white clover canopies fertilised with five different nitrogen amounts. The pasture plots were sensed with the spectrometer and results compared with measured biomass amount and nitrogen content. For a typical grazing period, the variation of the canopy dry matter could be attributed to 62.7% of the 'water index', when calculated from two NIR-wavelengths (900 nm, 970 nm).

These preliminary results are promising, however further work is required to determine the influence of urine patches on the measured reflection values and the non-uniformity of pastures under practical conditions. In addition, calibration procedures for grazed pastures need to be developed.

ASSESSING BIOMASS YIELD OF KALE (B*RASSICA OLERACEA VAR. ACEPHALA L.*) FIELDS USING MULTI-SPECTRAL AERIAL PHOTOGRAPHY

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Aerial images were taken in June 2014 with a multispectral VIS/NIR camera of the canopy from 14 kale (Brassica oleracea var. acephala L.) fields in Canterbury, New Zealand before this forage was grazed by cows. Images were taken at 716m and at 1,372m flying altitude. Calculating the *Green Normalised Difference Vegetation Index (GNDVI)* from green and NIR channels proved to be the best representation of yield (dry matter) variation from manual biomass cuts in these fields. Several hundreds of individual images covering parts of the fields were semi-automatically stitched to composite images covering full blocks of fields. Highest coefficients of variation (CV) of GNDVI values in a field are linked with low yield averages, often found at vary patchy fields (CVs of 20%). High yielding fields were less patchy and had CVs of less than 8%.

A non-linear calibration curve was derived from the presented data. This functional relationship can explain 70% of the variance of the measured biomass yield data with reflection data of the canopy from these fields. This explaining power does not change when data from aerial images from higher altitudes were analysed. This independency of the preliminary model from height will allow using such an approach with standard high resolution cameras from various platforms (e.g. conventional aircraft, UAV/ RPAS).

Grouping the GNDVI data also allows delineating zones of similar yield levels within the forage fields. Such zoning enables farmers to adapt fertilizer application to the yield expectation of such zones or to manage the feed provision for their grazing cows in a spatial variable way across and between fields. The zones can be used for directing the manual sampling of biomass in cases when farmers deem estimations of biomass yield from aerial imagery to be inaccurate. For all these steps higher resolutions - associated with lower flying altitudes - are necessary.

LOW-COST DETECTION AND TREATMENT OF FRESH COW URINE PATCHES

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Leaching of nitrate-nitrogen (NO_3-N) from cow urine patches is the most serious threat facing the future viability – environmental and possibly economic – of grazed dairy farms in New Zealand. Proposed solutions to this problem are focused mainly on changing the fundamental basis of the NZ year-round grazing model to one extent or another, all requiring increased capital expenditure on and maintenance of housing or stand-off pads, and capital and running costs on collecting and distribution of manure.

Solutions that permit full-time grazing have focused mainly on better matching the energy and protein ratio of the feed to the cow's intake requirements, such as by the use of different plant species, or mixes of crops and pasture. These will require much research, and new skills to be learnt by farmers.

Previous published attempts to reduce losses from the actual urine patch include (i) the 'Taurine' tail-activated N-inhibitor dispensing device (still in development), and (ii) sensing where urine patches are likely to be with chlorophyll level assessment in pasture. However, by the time significantly greater growth can be assessed, most of the urine-N is already present as nitrate.

This paper describes the development – to the farm-tested working prototype stage – of relatively inexpensive and easily manufactured vehicle-towed equipment which uses the measurement of surface-soil electrical conductivity to detect fresh urine patches with very high accuracy ('Spikey', patent application 617342). The equipment simultaneously sprays the urine patch with 'ORUN', a mix of the commonly used urease inhibitor NBPT and gibberellic acid (GA_3), and where more dissolved organic carbon (DOC) is required, the carboxylate polymer AlpHa® as well ('ORUN', patent applied for). This mix is assessed as having the capability to reduce nitrate leaching as much as DCD (now removed from the New Zealand market).

If coupled with high-efficiency nbpt-treated wetted prilled urea application (ONE*system*®) on a follow-the-cows basis, the *combined* operation would cost less than just achieving the same increase in pasture production with granular urea.

While initial equipment will be towed by manned vehicles, a robotised vehicle currently under development (Mini-ME™, patent applied for) is designed to take over this and other tasks (including micro-precision nutrient assessment and application), thereby releasing farm labour.

USING FERTIGATION AS A TOOL TO MITIGATE NITROGEN LEACHING UTILISING THE INCREASED EFFICIENCIES OF WATER AND NUTRIENTS

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A study of past & current international research was conducted to show how this will be achieved in New Zealand farming conditions.

Nitrogen leaching is one of the biggest issues facing farming in NZ today. With more land being irrigated, we need to find a solution to this problem, not just for dairy but for arable farming as well. This will allow farmers to continue to grow food in a sustainable & profitable manner. Fertigation has being used extensively overseas to grow all types of crops from Pastures & Lucerne in Middle East to Potatoes in the Mid West, USA & Sugar Cane in Australia. Universities across the globe have completed numerous research papers showing the benefits of growing crops utilising fertigation to obtain the same yield with less water & nutrients, resulting in "Maximum Economic yield." Combining the research papers and practical in field experience, this paper will outline how fertigation along with other existing technology already effectively operating in agriculture, can provide a real solution to the N leaching problem whilst keeping NZ farming sustainable and profitable.

SMART IRRIGATION

Andrew Curtis

Irrigation New Zealand, Christchurch

SMART stands for Sustainably Managed, Accountable, Responsible and Trusted.

SMART Irrigation has been designed to allow irrigators to meet community expectations around sustainable water management whilst also maintaining their own future financial viability.

INZ's SMART Irrigation strategy is to develop practical and achievable standards for irrigators that add value behind the farm gate. These can also be used in planning processes overseen by regional authorities. This will ensure that transparent and consistent policy and regulations develop around irrigation practice.

Importantly, SMART Irrigation provides a brand for the irrigation sector that will help communicate the need for irrigation, its positive impact and ultimately contributing to winning support from the New Zealand public. The SMART Irrigation public website will be launched at the INZ conference in April 2014.

Importantly the expectations of the SMART Irrigation framework are complementary to improved production (both quality and quantity – through uniformity of application and appropriate application depths and timing), minimised operating costs (through hydraulic design and scheduling, and thus profitability) and importantly improved environmental performance (through less water being abstracted, less drainage and/or surface run-off, and less energy being used per hectare of irrigated land).

The requirements of SMART Irrigation are simple -

1. The Irrigation System Can Apply Water Efficiently

   Industry codes of practice and standards provide minimum design performance levels

   Once installed the performance is checked annually

2. The Use of Water for Irrigation is Justified

   There was a valid reason why I applied irrigation today

3. Proof Can Be Provided

   I am accountable for my actions

These points will be expanded on in the presentation.

SENSORS – WHAT HAVE WE GOT AND WHERE ARE WE HEADED

Ian Yule

NZ Centre for Precision Agriculture, Massey University

There are now an increasing number of platforms that may be available to farmers, regional councils, other land owners and rural professionals. Sensors can be mounted on satellites, carried in aircraft, carried using a UAS or RPAS, vehicles have been used for some time and an increasing number of handheld sensors are on the market. As well as sensing platforms, end users now have a choice of sensor or imaging systems. Many of the remote sensors rely on light reflectance from the target, and there is a range of choice in terms of spectral and spatial resolution. This paper explores the range of sensors available.

Sensors have a range of abilities in terms of what they can sense, the more sophisticated hyperspectral imaging systems are capable of determining the nutrient (N, P, K, S) concentration as well as nutritional qualities. This is currently being employed in the PGP "Pioneering to Precision" project jointly funded by Ravensdown and the Ministry of Primary Industries (MPI). This sensor can also discriminate between plants and different varieties and cultivars of the same plant.

Other sensors have high spatial resolution, for example, UAS mounted systems such as the Trimble UX5 which generates 16 million points per hectare. Although this gives a very high quality image, it has a significant data processing and storage overhead. These very high quality images create an expectation in terms of presentation of results and put considerable demands on the rural ICT infrastructure for delivery of service, as do other methods such as machine vision. Adoption by farmers has been slow in the past, there is the possibility that increasingly complex systems will put the information produced by these sensors out of reach for many farmers. These issues are also discussed.