Integrated Nutrient and Water Management for Sustainable Farming

This document contains the programme and abstracts of all presentations to the 29th Annual FLRC Workshop at Massey University on the 9th, 10th and 11th February 2016.

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 9th February

0915-1010 Registration and Morning Tea

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

Session 1 : The Bigger Picture

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

1020-1040 **Cameron Gourley and K J Stott** *Invited speaker*
DEDJTR, Ellinbank, Victoria 3821, Australia
THE IMPLICATIONS OF INTENSIFICATION ON NITROGEN USE AND RECOVERY IN AUSTRALIAN DAIRY FARMS

1040-1110 **Thomas Nemecek and Martina Alig** *Invited speaker*
Agroscope, Institute for Sustainability Sciences, Zurich, Switzerland
LIFE CYCLE ASSESSMENT OF DAIRY PRODUCTION SYSTEMS IN SWITZERLAND:
- STRENGTHS, WEAKNESSES AND MITIGATION OPTIONS

1110-1130 **Stewart Ledgard, J Chobtang, S Falconer and S McLaren** *Invited speaker*
AgResearch, Hamilton
LIFE CYCLE ASSESSMENT OF DAIRY PRODUCTION SYSTEMS IN NEW ZEALAND

1130-1140 **Steven Howarth and P Journeaux**
AgFirst Waikato, Hamilton
REVIEW OF NITROGEN MITIGATION STRATEGIES FOR DAIRY FARMS – IS THE METHOD OF ANALYSIS AND RESULTS CONSISTENT ACROSS STUDIES?

1140-1155 Discussion

1155-1200 Poster Paper Presentations

Jeerasak Chobtang, S Ledgard, S McLaren and D Donaghue
Institute of Agriculture and Environment, Massey University
LIFE CYCLE ENVIRONMENTAL IMPACTS OF FUTURE DAIRY FARMING INTENSIFICATION: A COMPARATIVE STUDY BETWEEN NITROGEN FERTILIZER-BASED AND MAIZE SILAGE-BASED SYSTEMS

Wei Yang and B Sharp
Department of Economics, University of Auckland
DAIRY YIELD RESPONSE TO INTENSIVE FARMING- A SPATIAL ANALYSIS OF THE NEW ZEALAND DAIRY INDUSTRY

1200-1300 Lunch

Session 2 : Nutrient Management Modelling

Chairman: **Dr Chris Anderson**
Fertilizer & Lime Research Centre, Massey University

1300-1310 **Warwick Murray, C Read, S Park and L Fietje**
BOP Regional Council, Whakatane
A COLLABORATIVE APPROACH TO GUIDANCE ON THE USE OF OVERSEER IN WATER MANAGEMENT

1310-1320 **Colin W Gray, D Wheeler, R McDowell and N Watkins**
AgResearch, Christchurch
OVERSEER AND PHOSPHORUS: STRENGTHS AND WEAKNESSES

1320-1330 **Phil Journeaux**
AgFirst, Waikato
VALUATION OF THE BENEFITS OF THE OVERSEER® NUTRIENT BUDGET MODEL

1330-1340 **Chris Glassey, D Selbie and D M Wheeler**
DairyNZ, Hamilton
INTERPRETING PASTURE EATEN AND PASTURE GROWTH ESTIMATES FROM OVERSEER AND WHAT TO LOOK FOR WHEN COMPARING THEM WITH OTHER MEASURED AND MODELLED ESTIMATES

1340-1350 **David M Wheeler, I Barugh and P Morel**
AgResearch, Hamilton
DESCRIPTION OF AN OUTDOOR PIG MODEL FOR OVERSEER

1350-1400 **Ian Barugh, D M Wheeler and N Watkins**
Institute of Vet., Animal and Biomedical Sciences, Massey University
CASE STUDIES USING THE OUTDOOR PIG MODEL IN OVERSEER

1400-1410 **Martha Trodahl and B Jackson**
Victoria University of Wellington
IMPROVING PREDICTIONS OF N & P EXPORT TO WATERWAYS FROM RURAL LANDSCAPES IN NEW ZEALAND USING LUCI

1410-1420 **Bethanna Jackson and M Trodahl**
Victoria University of Wellington
ADAPTION OF THE LUCI FRAMEWORK TO ACCOUNT FOR DETAILED FARM MANAGEMENT: A CASE STUDY EXPLORING POTENTIAL FOR NUTRIENT MITIGATION ON THE SOUTHLAND DEMONSTRATION FARM

1420-1435 Discussion

1435-1500 Poster Paper Presentations

Patrick C H Morel and J P Morel
Institute of Veterinary, Animal and Biomedical Sciences, Massey University
MODELLING NUTRIENTS FLOW FOR OUTDOOR PIG FARMS: EFFECT OF STOCHASTICITY

David M Wheeler
AgResearch, Hamilton
RELATIONSHIP BETWEEN SHOOT AND ROOT NUTRIENT CONCENTRATIONS FOR A RANGE OF TEMPERATE PASTURE AND CEREAL SPECIES

Iris Vogeler and R Cichota
AgResearch, Auckland
DETERMINATION OF NITROGEN FERTILISER REQUIREMENTS IN DAIRY PRODUCTION SYSTEMS BASED ON EARLY INDICATORS

Jane Chrystal, R Monaghan, M Hedley and D Horne
AgResearch, Mosgiel
DESIGN OF A LOW COST WINTER STAND-OFF PAD FOR REDUCING NUTRIENT LOSSES TO WATER FROM WINTER FORAGE CROPS GRAZED BY DAIRY COWS

Jane Chrystal, R Monaghan, M Hedley and D Horne
AgResearch, Mosgiel
VOLUMES AND NUTRIENT CONCENTRATIONS OF EFFLUENT PRODUCTS GENERATED FROM A LOOSE-HOUSED WINTERING BARN WITH WOODCHIP BEDDING

Nicole Schon, R A Gray and A D Mackay
AgResearch, Canterbury
AFTER FERTILISER APPLICATION EARTHWORMS REMAIN AN IMPORTANT COMPONENT OF OUR SOIL-PASTURE SYSTEM

Syrie Hermans, G Lear, F Curran-Cournane and M Taylor
School of Biological Sciences, University of Auckland
SOIL BACTERIAL COMMUNITIES ARE AFFECTED BY SOIL PH AND PHOSPHOROUS CONCENTRATIONS

Matthew Taylor, J Drewry, F Curran-Cournane, B Lynch, L Pearson and R McDowell
Waikato Regional Council, Hamilton
SOIL QUALITY TARGETS FOR OLSEN P FOR THE PROTECTION OF ENVIRONMENTAL VALUES

1500-1530 Afternoon Tea

Session 3 : Nutrient Loss and Attenuation

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

1530-1540 **David Burger, R Monaghan, N McHaffie, A Brocksopp and M Scarsbrook**
DairyNZ, Hamilton
POTENTIAL REDUCTIONS IN FARM NUTRIENT LOADS RESULTING FROM FARMER PRACTICE CHANGE IN THE UPPER WAIKATO CATCHMENT

1540-1550 **Ian Millner**
Hawkes Bay Regional Council, Napier
UTILITY OF ALLOCATION AS A MECHANISM TO MANAGE NITROGEN IN THE ABSENCE OF AN UNDERSTANDING OF ATTENUATION

1550-1600 **Stephen Collins, R Singh, A Rivas, A Palmer, D Horne, J Roygard and A Matthews**
Horizons Regional Council, Palmerston North
ASSESSMENT OF NITROGEN FLOW PATHWAYS AND ITS POTENTIAL ATTENUATION IN SHALLOW GROUNDWATERS IN THE LOWER RANGITIKEI CATCHMENT

1600-1610 **Aldrin Rivas, R Singh, D Horne, J Roygard, A Matthews and M Hedley**
Institute of Agriculture and Environment, Massey University
VARIABILITY IN DENITRIFICATION CHARACTERISTICS OF THE VADOSE AND SATURATED ZONES IN THE MANAWATU RIVER CATCHMENT

1610-1620 **Ahmed Elwan, R Singh, D Horne, J Roygard and B Clothier**
Institute of Agriculture and Environment, Massey University
EVALUATION AND DEVELOPMENT OF A RIVER LOAD CALCULATOR

1620-1630 **James Sukias, C Tanner and S Larned**
NIWA, Hamilton
CONSTRUCTED WETLAND ATTENUATION OF NUTRIENT INFLOWS TO TE WAIHORA / LAKE ELLESMERE

1630-1645 Discussion

1645-1700 Poster Paper Presentations

Clint Rissmann, K Wilson, B Hughes, E Rodway, M Beyer, R Millar, L Pearson, M Killick, J Hodgetts, R Hodson, A Akbaripasand, J Dare, T Ellis, M Lawton, N Ward, J McMecking, D May and L Kees
Environment Southland, Invercargill
PHYSIOGRAPHIC CONTROLS OVER SOUTHLAND'S GROUND AND SURFACE WATER HYDROCHEMISTRY AND QUALITY

Roland Stenger, S R Wilson, G F Barkle, M E Close, S J R Woodward, L F Burbery, L Pang, J Rekker, Th Wöhling, J C Clague, R McDowell, S Thomas, B E Clothier, L Lilburne and B Miller
Lincoln Agritech, Hamilton
TRANSFER PATHWAYS – NEW RESEARCH TO IMPROVE CONTAMINANT TRANSFER UNDERSTANDING

Simon Park, M Hope and A MacCormick
Landconnect Ltd , Tauranga
CONSIDERING SMALL BLOCKS IN CATCHMENT NITROGEN ALLOCATION

John-Paul Praat, J Sukias, A Bichan and T Faulkner
Groundtruth Ltd, Te Awamutu
CHANGES IN WATER QUALITY THROUGH A CONSTRUCTED WETLAND ON A WAIRARAPA DAIRY FARM – NUMBERS FROM THE FARM

John-Paul Praat and S Jacobs
Groundtruth Ltd, Te Awamutu
ORGANIC NO-TILL CROP ESTABLISHMENT – EARLY PROGRESS IN NEW ZEALAND

Wednesday 10th February

Session 4 : Soil Management and Critical Source Areas

Chairman: **Professor Richard McDowell**
AgResearch, Mosgiel

0840-0850 **Alec Mackay, A Collins and G Rys**
AgResearch, Palmerston North
FUTURE REQUIREMENTS FOR SOIL MANAGEMENT IN NEW ZEALAND

0850-0900 **James Barringer, L Lilburne, S Carrick and V Snow**
Landcare Research, Canterbury
WHAT DIFFERENCE DOES DETAILED SOIL INFORMATION MAKE? - A CANTERBURY CASE STUDY

0900-0910 **Colin Stace**
Opus International Consultants, Napier
FINE TUNING THE FARM PLAN: SOME REAL WORLD EXAMPLES OF PUTTING POLICY INTO PRACTICE

0910-0920 **Nicola McHaffie, M Highway, T Stephens, S Bowler, M Watts, T Cuthill and N Spencer**
DairyNZ, Hamilton
BRIDGING THE RIPARIAN DIVIDE: ONLINE RIPARIAN MANAGEMENT PLANS FOR ALL DAIRY FARMS IN NEW ZEALAND

0920-0930 **Brendan Powell**
Hawkes Bay Regional Council, Napier
TREATMENTS AND SIDE EFFECTS: - SUBSTITUTING ONE LOSS FOR ANOTHER

0930-0945 Discussion

0945-1000 Poster Paper Presentations

Neha Jha, T Palmada, P Berben, S Saggar, J Luo and A McMillan
Landcare Research, Palmerston North
LIME ENHANCES DENITRIFICATION RATE AND DENITRIFIER GENE ABUNDANCE IN PASTURE SOILS TREATED WITH URINE AND URINE + DCD

Kamal Adhikari, M Taylor, S Saggar, J Hanly and D Guinto
Institute of Agriculture and Environment, Massey University
ASSESSING THE RELATIONSHIP BETWEEN SOIL TOTAL RECOVERABLE Cu AND Zn STATUS AND SOIL UREASE ACTIVITY OF DAIRY-GRAZED PASTURE SOILS

Gina Yukich, Sumaraj, J Qi and L P Padhye
Dept of Civil and Environmental Engineering, University of Auckland
ACTIVATED CARBON'S ROLE IN CONVERTING NITROUS OXIDE TO NUTRIENTS

Bill Carlson, J Luo, B Wise and S Ledgard
AgResearch, Hamilton
NITROUS OXIDE EMISSIONS DURING FORAGE BRASSICA CROPPING AND GRAZING

Bill Carlson, J Luo and B Wise
AgResearch, Hamilton
NITROUS OXIDE EMISSIONS FROM ANIMAL EXCRETA DEPOSITED ON HILL COUNTRY SLOPES

Khadija Malik, P Bishop, S Saggar and M Hedley
Institute of Agriculture and Environment, Massey University
DEVELOPMENT OF MEASUREMENT PROTOCOLS FOR IDENTIFYING AMMONIA VOLATILIZATION LOSSES FROM THE HYBRID GRAZING/STANDOFF SYSTEMS BEING DEVELOPED IN NEW ZEALAND

1000-1030 Morning Tea

Session 5 : Hills and Catchments

Chairman: **Associate Professor David Horne**
Fertilizer & Lime Research Centre, Massey University

1030-1050 **Nathan Heath** *(Invited speaker)*
Hawkes Bay Regional Council
CHALLENGES FACED BY HILL COUNTRY FARMERS IN NEW ZEALAND – THE CURRENT ISSUES, THE STATE OF RESEARCH AND WHAT THE FUTURE MAY HOLD

1050-1100 **Lucy Burkitt, M Bretherton and R Singh**
Fertilizer & Lime Research Centre, Massey University
COMPARING NUTRIENT LOSS PREDICTIONS USING OVERSEER AND STREAM WATER QUALITY IN A HILL COUNTRY SUB-CATCHMENT

1100-1110 **Mike Bretherton, D Scotter, D Horne and M Hedley**
Fertilizer & Lime Research Centre, Massey University
FACTORING IN SOIL WATER REPELLENCY IN A HILL SLOPE SOIL WATER BALANCE MODEL

1110-1125 **Ian Yule and M Grafton**
NZ Centre for Precision Agriculture, Massey University
BRINGING FERTILISER APPLICATION INTO THE 21ST CENTURY

1125-1140 Discussion

1140-1200 Poster Paper Presentations

Sue Chok, M Grafton, I J Yule, M White and M Manning
NZ Centre for Precision Agriculture, Massey University
IMPROVING AERIAL TOPDRESSING IN NEW ZEALAND THROUGH PARTICLE BALLISTICS MODELLING AND ACCURACY TRIALS

Tommy Cushnahan, I J Yule, R Pullanagari and M Grafton
NZ Centre for Precision Agriculture, Massey University
IDENTIFYING GRASS SPECIES USING HYPERSPECTRAL SENSING

Jo-Anne Cavanagh, K Munir, C Gray, S Wakelin, O Chioma, J Jeyakumar, C Anderson, S Mamun and B Robinson
Landcare Research, Christchurch
ASSESSING THE SIGNIFICANCE OF CADMIUM IN NEW ZEALAND AGRICULTURAL SYSTEMS – PRELIMINARY RESULTS

Chioma Okafor, P Jeyakumar and C Anderson
FLRC, Institute of Agriculture and Environment, Massey University
DOES LAND APPLICATION OF DRILLING WASTE POSE A THREAT TO NEW ZEALAND AGRICULTURAL SYSTEMS

Paramsothy Jeyakumar and C Anderson
Fertilizer & Lime Research Centre, Massey University
RECENT METHODOLOGY DEVELOPMENTS IN SOIL FLUORINE ANALYSIS

Octavio Perez-Garcia and N Singhal
Dept. of Civil and Environmental Engineering, University of Auckland
PATHWAYS OF NITROGEN AND CARBON TRANSFORMATION IN SOILS AND WASTEWATER AS REVEALED BY MICROBIAL GENOMES: IMPLICATIONS FOR GREENHOUSE GAS EMISSIONS

Octavio Perez-Garcia and N Singhal
Dept. of Civil and Environmental Engineering, University of Auckland
ACTIVATING BIOCATALYST PRODUCTION TO ENHANCE THE REMOVAL OF VETERINARIAN ANTIBIOTICS FROM WASTEWATER

1200-1300 Lunch

Session 6 : Water and Irrigation Management

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

1300-1330 **Brent Clothier** *(Invited speaker)*
Plant & Food Research, Palmerston North
WATER: THE WORLD'S MOST VALUABLE NATURAL ASSET

1330-1350 **Andrew Curtis** *(Invited speaker)*
Irrigation NZ, Christchurch
GROWING IRRIGATED AGRICULTURE IN NEW ZEALAND

1350-1400 **Rogerio Cichota, F Kelliher, S Thomas, G Clemens, T Fraser and S Carrick**
AgResearch, Christchruch
EFFECTS OF IRRIGATION INTENSITY ON THE PREFERENTIAL TRANSPORT OF SOLUTES IN A STONY SOIL

1400-1410 **Steve Thomas, I Vogeler, T van der Weerden and S Carrick**
Plant & Food Research, Christchurch
IRRIGATION MANAGEMENT TO REDUCE NITROUS OXIDE EMISSIONS AND NITRATE LEACHING LOSSES

1410-1420 **Joanna Sharp and H E Brown**
Plant & Food Research, Canterbury
APPLICATION OF A SYSTEMS MODEL TO SPATIALLY HETEROGENOUS IRRIGATED AGRICULTURAL SYSTEMS

1420-1435 Discussion

1435-1500 Poster Paper Presentations

Wafa Al Yamani, S Green, R Pangilinan, S Dixon and B Clothier
Institute of Agriculture and Environment, Massey University
SUSTAINABLE IRRIGATION OF ARID FORESTS USING TREATED SEWAGE EFFLUENT

Ahmed Al Muaini, S Green, R Pangilinan, S Dixon, A Dakheel and B Clothier
Institute of Agriculture and Environment, Massey University
SUSTAINABLE IRRIGATION OF DATE PALMS USING SALINE GROUNDWATER

Steve Green, R Gentile, M Gitahi, M Kosgey, B Clothier, G Thorpe, B Fullerton and Mr Thomas
Plant & Food Research, Palmerston North
WATER AND NUTRIENT MANAGEMENT OF AVOCADOS IN THE CENTRAL HIGHLANDS OF KENYA

Roberta Gentile, B Fullerton, G Thorp, A Barnett, C Clark, J Campbell, M Gitahi and B Clothier
Plant & Food Research, Palmerston North
NUTRIENT MANAGEMENT OF AVOCADO TREES ON SMALL HOLDER FARMS IN THE CENTRAL HIGHLANDS OF KENYA

Hamed Khan, R Singh, T de Vries and B Clothier
Institute of Agriculture and Environment, Massey University
EVALUATION OF IRRIGATION EFFICIENCY AND SUSTAINABILITY IN THE WARABANDI SYSTEM OF PAKISTAN: A DIAGNOSTIC ANALYSIS OF HAKRA BRANCH CANAL COMMAND

Angela Lane, P G Peterson, C B Hedley, S T McColl and I C Fuller
Institute of Agriculture and Environment, Massey University
MAPPING OF ALLUVIAL SUB-SURFACE FEATURES USING GROUND PENETRATING RADAR TO IMPROVE IRRIGATION EFFICIENCY

Carolyn Hedley, P Roudier and P Peterson
Landcare Research, Palmerston North
GAMMA SOIL SURVEYS – INVESTIGATING SOIL PATTERNS FOR NUTRIENT AND WATER MANAGEMENT

Stewart Spilsbury and B F Quin
FOO Technologies, Newry, Victoria, Australia
CHANGING FARMER PERCEPTIONS AND PROFITABILITY ON VICTORIAN IRRIGATED DAIRY FARMS BY IMPROVING PASTURE UTILISATION EFFICIENCY

1500-1530 Afternoon Tea

Session 7 : Effluent Management

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

1530-1540 **Jeff Brown**
Fonterra, Palmerston North
IMPROVING NUTRIENT MANAGEMENT FOR DAIRY FACTORY WASTEWATER LAND TREATMENT SYSTEMS.

1540-1550 **Hamish Lowe, S Cass and J Horswell**
Lowe Environmental Impact, Palmerston North
THE CONUNDRUM OF REALISING FERTILISER BENEFITS OF WASTEWATER FOR GREATER SUSTAINABILITY – OPPORTUNITY VS REALITY

1550-1600 **Rogerio Cichota, J Chrystal and S Laurenson**
AgResearch, Christchurch
DESCRIBING N LEACHING FROM FARM EFFLUENT IRRIGATED ON ARTIFICIALLY DRAINED SOILS

1600-1615 Discussion

1615-1640 Poster Paper Presentations

Lisa Scott and R Wong
Environment Canterbury
DISSOLVED PHOSPHORUS IN CANTERBURY GROUNDWATER

Bert Quin, G Bates and L Nguyen
Quin Environmentals, Auckland
LOCATING FRESH COW URINE PATCHES; THE KEY TO COST-EFFECTIVE REDUCTION IN ENVIRONMENTAL N LOSSES AND IMPROVING N RECYCLING AND PASTURE GROWTH

Roshean Woods, K C Cameron, G R Edwards, H J Di and T J Clough
Faculty of Agriculture and Life Sciences, Lincoln University
DOES GIBBERELLIC ACID REDUCE NITRATE LEACHING LOSSES FROM ANIMAL URINE PATCHES?

Anna Carlton, K C Cameron, G R Edwards, H J Di and T J Clough
Faculty of Agriculture and Life Sciences, Lincoln University
THE EFFECT OF OPTIMUM VS. DEFICIT IRRIGATION ON PLANT NITROGEN UPTAKE AND NITRATE LEACHING LOSS FROM SOIL

Kyle Robertson, K Mason, K Müller and R Simpson
Plant & Food Research, Hamilton
RELATIONSHIPS BETWEEN ENZYME ACTIVITIES AND SOIL PROPERTIES IN RECENT AND PUMICE SOILS

Rogerio Cichota, I Vogeler, S Trolove and B Malcolm
AgResearch, Christchurch
DESCRIBING THE EFFECT OF GRAZING ON NITROGEN LEACHING IN WINTER FORAGE-RYEGRASS ROTATIONS

Melanie Bates
Foundation for Arable Research, Christchurch
PRODUCTIONWISE – ONLINE CROP MANAGEMENT

Danilo Guinto and W Catto
Ballance Agri-Nutrients, Tauranga
ANALYSIS OF THE RELATIONSHIP BETWEEN TOTAL NITROGEN AND AVAILABLE NITROGEN IN NON-PASTORAL TOPSOILS OF NEW ZEALAND FROM A LARGE SOIL TEST DATABASE

1640-1800 **Poster Papers on Display**
Informal Drinks In The Ag Hort Lecture Block

1815- **Workshop Dinner at Wharerata**

Thursday 11th February

Session 8 : Crops and Trees

Chairman: Dr Huub Kerkoff
Institute of Agriculture and Environment, Massey University

0845-0855 **Nick Pyke, R Chynoweth and D Mathers**
Foundation for Arable Research, Christchurch
THE POTENTIAL IMPACT AND OPPORTUNITIES FROM NUTRIENT MANAGEMENT REGULATION ON THE NEW ZEALAND HERBAGE SEED INDUSTRY

0855-0905 **Matt Norris, P Johnstone, S Green, G Clemens, C van den Dijssel, P Wright, G Clark, S Thomas, D Mathers and A Halliday**
Plant & Food Research, Havelock North
ROOTZONE REALITY – A NETWORK OF FLUXMETERS MEASURING NUTRIENT LOSSES UNDER CROPPING ROTATIONS

0905-0915 **Diana Mathers**
Foundation for Arable Research, Havelock North
MASS BALANCE BUDGETS FOR CROPPING SYSTEMS - THEIR ROLE IN NUTRIENT MANAGEMENT

0915-0925 **Dan Bloomer J Pishief and C Folkers**
Centre for Land and Water, Hastings
MONITORING & MAPPING CROP DEVELOPMENT

0925-0935 **Peter L Carey, K C Cameron, H J Di, G R Edwards and D F Chapman**
Faculty of Agriculture and Life Sciences, Lincoln University
CAN A WINTER-SOWN CATCH CROP REDUCE NITRATE LEACHING LOSSES AFTER WINTER FORAGE GRAZING?

0935-0945 **Stephen Trolove, S Thomas, G Clemens and M Beare**
Plant & Food Research, Havelock North
THE EFFECT OF WINTER FORAGE CROP AND ESTABLISHMENT METHOD ON N LOSSES DURING DAIRY PASTURE RENEWAL

0945-0955 **Shirley Nichols and J Crush**
AgResearch, Hamilton
DEVELOPING NUTRIENT-EFFICIENT CLOVERS FOR NEW ZEALAND FARMERS

0955-1005 **Trevor Jones, I McIvor and M McManus**
Plant & Food Research, Palmerston North
DROUGHT TOLERANCE AND WATER-USE EFFICIENCY OF FIVE HYBRID POPLAR CLONES

1005-1015 **Hannah Franklin, D McEntee and M Bloomberg**
Faculty of Agriculture and Life Sciences, Lincoln University
THE POTENTIAL FOR POPLAR AND WILLOW SILVOPASTORAL SYSTEMS TO MITIGATE NITRATE LEACHING FROM INTENSIVE AGRICULTURE IN NEW ZEALAND

1015-1030 Discussion

1030-1100 Morning Tea

Session 9 : Soil Contaminants

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

1100-1115 **Christopher Anderson**
Fertilizer & Lime Research Centre, Massey University
TRENDS, OPPORTUNITIES AND RISKS FOR SOIL CONTAMINATION IN NEW ZEALAND

1115-1125 **Edward Abraham, J Cavanagh, P Wood, A Pearson and P Mladenov**
Dragonfly Data Science, Wellington
CADMIUM IN NEW ZEALAND'S AGRICULTURE AND FOOD SYSTEMS – AN UPDATE

1125-1135 **Aaron Stafford, C Anderson, M J Hedley and R McDowell**
Ballance Agri-Nutrients, Tauranga
CADMIUM ACCUMULATION BY FORAGE SPECIES USED IN NEW ZEALAND LIVESTOCK GRAZING SYSTEMS

1135-1145 **Mahdiyeh Salmanzadeh, A Hartland, C Stirling, M Balks, L Schipper, and E George**
University of Waikato, Hamilton
USE OF CADMIUM ISOTOPES TO DISTINGUISH SOURCES OF CADMIUM IN NEW ZEALAND AGRICULTURAL SOILS: - PRELIMINARY RESULTS

1145-1200 Discussion

1200-1300 Lunch

Session 10 : Technology

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

1300-1310 **Eva Schröer-Merker**
Institute of Agriculture and Environment, Massey University
STATUS AND FUTURE PERSPECTIVES OF SMART TOOLS AND APPS IN NUTRIENT AND WATER MANAGEMENT

1310-1320 **Wei Yang**
Department of Economics, University of Auckland
SPATIAL DEPENDENCE AND DETERMINATES OF DAIRY FARMERS' ADOPTION OF BEST MANAGEMENT PRACTICES FOR WATER PROTECTION

1320-1330 **Megan Cushnahan, B Wood and I J Yule**
NZ Centre for Precision Agriculture, Massey University
DISCOVERING THE VALUE OF HYPERSPECTRAL DATA FOR NEW ZEALAND AGRICULTURE

1330-1340 **Stu Bradbury, J Mulvihill, C Mackenzie, C Smith and P Whitehead**
Agri Optics North, Palmerston North
TECHNOLOGIES FOR IMPROVING NUTRIENT AND WATER USE EFFICIENCY

1340-1350 **Miles Grafton, D Izquierdo Acebes, I J Yule and L A Willis**
NZ Centre for Precision Agriculture, Massey University
MEASURING THE SPREAD PATTERNS OF SPREADERS UNDER NORMAL FIELD CONDITIONS COMPARED TO TEST CONDITIONS

1350-1400 **Dan Bloomer**
LandWISE, Hastings
ON-FARM FERTILISER APPLICATOR CALIBRATION

1400-1415 Discussion

1415-1430 Closing Remarks

1430 Afternoon Tea and depart

THE IMPLICATIONS OF INTENSIFICATION ON NITROGEN USE AND RECOVERY IN AUSTRALIAN DAIRY FARMS

Cameron J P Gourley[1] and Kerry J Stott[2]

[1]Agriculture Research and Development Division, Ellinbank Centre, Department of Economic Development, Jobs, Transport and Resources, Ellinbank, Victoria 3821
[2]Agriculture Research and Development Division, Parkville Centre, Department of Economic Development, Jobs, Transport and Resources, Carlton, Victoria 3053

There is increased international interest in the intensification of grazing-based dairy systems such as occur in Australia and New Zealand. However, associated with increased milk production is the potential for decreasing nitrogen (N) recovery and increased N losses to the environment. In this study we produced a 22-year time series of N recovery measures, for the entire Australian dairy industry and largest dairy producing State, Victoria, using a farm-gate N balance method and long-term farm survey data between 1990 and 2012. Nitrogen recovery measures included whole-farm N balance (kg N ha^{-1}), N use efficiency (%) and milk production N surplus (g N l^{-1} milk) and also total industry-wide N surplus (t N). On-going intensification in dairy production at both the national and state level has led to fewer and larger dairy farms, with increased stocking rates, reliance on imported feed, nitrogen fertiliser use and milk production per cow and per ha. All N recovery measures deteriorated markedly over the 22 year period examined, though the adverse trend has moderated somewhat since 2006. The Victorian industry was found to be higher-performing in terms of N recovery compared to the national dairy industry as a whole, though there has been some convergence in the last decade. The whole-farm N surplus for the 'industry average' Australian dairy farm has increased from 54 to 158 kg N ha^{-1} and from 38 to 136 kg N ha^{-1} yr^{-1} for the average Victorian dairy farm, between 1990 and 2012. Nitrogen use efficiency for the average Australian dairy farm has declined from 40 to 26% while for the average Victorian dairy farm, the decline was from 51 to 29%. Milk production N surplus increased from 10.2 to 17.3 and 6.9 to 15.2 g N l^{-1} milk, for the average dairy farm in Australia and Victoria, respectively. Total N surplus has also increased from 63,076 to 164,621 t N for the Australian dairy industry as a whole, despite a decline of 470,000 hectares in land used in dairying, suggesting a growing problem in terms of higher losses of reactive N. Looking to the future, we examined a scenario whereby N use efficiency for Victorian dairy farms increased to 35% by 2030, in accordance with national dairy industry sustainability goals. This turn-around rests on an anticipated improvement in milk yield per cow and per hectare, delivered through further improvements in forage yields, bovine genetics and feed conversion efficiency. We conclude that achieving this whole-farm N use efficiency will be challenging within current grazing-based dairy farming operations. Improvements in N recovery will more likely depend on significant on-farm mitigation strategies incentivised by cost-effective policy measures and future technological advances stemming from strong public and industry investment in research and development.

LIFE CYCLE ASSESSMENT OF DAIRY PRODUCTION SYSTEMS IN SWITZERLAND: STRENGTHS, WEAKNESSES AND MITIGATION OPTIONS

Thomas Nemecek and Martina Alig

Agroscope, Institute for Sustainability Sciences, LCA group, CH-8046 Zurich, Switzerland
Email: Thomas.nemecek@agroscope.admin.ch

The dairy sector is the most important agricultural sector in Switzerland, contributing about 1/3 to the economic return of Swiss agriculture. Over 70% of Swiss agricultural area consists of grassland, without counting the vast Alpine pastures.

We analysed the environmental impacts of Swiss dairy farms during three years by means of LCA, leading to the following conclusions: The environmental impacts per kg of milk vary widely between farms. These differences can only partly be explained by factors such as region (lowlands, hills and mountains), farming system (integrated or organic) or farm type. The environmental impacts per kg of milk tended to increase in the higher altitudes, due to less favourable production conditions (steep slopes, lower grass yields, longer winter feeding period). Increasing milk production per farm was related to a slightly lower global warming potential (GWP). Organic farms had lower ecotoxicity impacts, thanks to the ban of synthetic pesticides.

The comparison of Swiss dairy production to the neighbour countries Germany, France and Italy showed that the environmental impacts of Swiss milk and of cheese were generally lower or similar than in the other countries, despite the 2-3x lower input of concentrate feed in Switzerland. The result was explained by the relatively good conditions for grass growth, allowing to produce large amounts of high quality roughage and to achieve good milk yields with modest inputs of concentrates.

The full grazing system with block calving was compared to a total mix ration system in Switzerland. It had a lower energy demand, acidification and eutrophication potentials, ecotoxicity, resource consumption and deforestation, mainly due to lower concentrate inputs. On the other hand, the land occupation of the full grazing system was higher, due to lower yields and higher feed consumption. Furthermore, GWP and ozone formation were increased due to higher methane emissions.

Several mitigation options for the reduction of greenhouse gases (GHG) and other environmental impacts were analysed recently. The increase of the number of lactations per cow from 3.5 to 4.5 led to a general decrease of environmental impacts and was therefore one of the most promising GHG mitigation measure on Swiss farms.

LIFE CYCLE ASSESSMENT OF DAIRY PRODUCTION SYSTEMS IN NEW ZEALAND

Stewart Ledgard[1,3], Jeerasak Chobtang[1,2,3], Shelley Falconer[1] and Sarah McLaren[2,3]

[1]AgResearch, Ruakura Research Centre, Hamilton
[2]Institute of Agriculture and Environment, Massey University, Palmerston North
[3]New Zealand Life Cycle Management Centre, Massey University, Palmerston North

Life Cycle Assessment (LCA) is a standardised approach to evaluate resource use and environmental emissions of a production system or product. It covers multiple stages including raw material extraction, production of farm inputs and farm emissions (i.e. cradle-to-farm-gate stages), and can extend to milk processing, transport, consumer use and waste stages.

LCA has been applied in agriculture over the past decade to examine the total greenhouse gas (GHG) emissions associated with products such as milk. More recently it has been applied in assessing a range of environmental emissions. For example, the current European Product Environmental Footprinting initiative covers 15 environmental impact categories.

This paper reports on studies using LCA to evaluate effects of dairy intensification in New Zealand (NZ) covering cradle-to-farm-gate stages. Initial focus was on the carbon footprint of milk (total GHG emissions) and the effects of intensification using different brought-in supplementary feeds. This showed a large effect depending on type of feed, with highest emissions from use of palm kernel expeller. Results were compared with French dairy farm systems at varying levels of intensification using the same methodology (to provide an international comparison) and showed high efficiency of some NZ farm systems. Recent research extended the use of LCA to evaluate a wider range of environmental impact indicators (up to 12) across a range of farm intensification levels. This evaluation showed an increase in emissions per kg milksolids for the high intensification level compared to the low intensification level of 5-32% depending on the impact indicator, with the highest increase for Freshwater Ecotoxicity. The main factors affecting the different environmental impact indicators and mitigation benefits are discussed.

REVIEW OF NITROGEN MITIGATION STRATEGIES FOR DAIRY FARMS – IS THE METHOD OF ANALYSIS AND RESULTS CONSISTENT ACROSS STUDIES?

Steven Howarth and Phil Journeaux

AgFirst Waikato, Hamilton

Nitrogen leaching is fast becoming a major issue for New Zealand farms, Regional Councils are developing legislation to control nitrogen losses from the farm gate. This will impact farm management and economic viability. Nitrogen losses are impractical to measure for each farm, most councils are adopting a modelling approach using OVERSEER to quantify losses. There are a number of studies commissioned by industry and regional councils assessing nitrogen leaching mitigation and the economic impact.

This analysis considered twelve studies, with two methods of analysis identified:

- Single mitigation approach, defining the effectiveness and economics of each strategy in isolation.
- Combined mitigation approach, reaching a predefined reduction to assess the economic impact of meeting the legislation.

Single mitigation strategies showed large variation between studies for the same mitigation strategy, e.g changing to low protein feeds reduced nitrogen leaching by 3-42%. Differences were due to:

- Soil type and Climate
- Current farm system
- Current leaching loss
- Secondary changes (e.g. reduced nitrogen fertiliser impacts on production unless feed is sources elsewhere)
- Magnitude of change (e.g. quantity of nitrogen fertiliser removed)
- Definition of profit and consideration of capital

Combined mitigation strategies were well aligned (R^2 0.66). Studies showed leaching reductions of 0-20% resulted in no significant impact on profit; beyond this profit was exponentially negatively impacted. Overall there is a large number of mitigation strategies available (20 considered in this study) and there is no one size that fits all. All farms are different and the effectiveness of the strategy will depend on the individual farm situation.

Clear guidelines on each strategy and the impact it will have on nitrate leaching and profit would provide clarity for farmers. However this is required at a granular level to capture soil type and climatic differences, considering each farm system separately. Secondly a clear procedure on how to model and quantify each strategy is required as differing methods and assumptions were apparent. If consistent and realistic council policy, and messaging to farmers is to be delivered, studies need to be consistent.

LIFE CYCLE ENVIRONMENTAL IMPACTS OF FUTURE DAIRY FARMING INTENSIFICATION: A COMPARATIVE STUDY BETWEEN NITROGEN FERTILISER-BASED AND MAIZE SILAGE-BASED SYSTEMS

Jeerasak Chobtang[1,2,3], Stewart Ledgard[1,3], Sarah McLaren[2,3] and Daniel Donaghy[4]

[1]AgResearch, Ruakura Research Centre, Hamilton 3240
[2]Institute of Agriculture and Environment, Massey University, Palmerston North 4442
[3]New Zealand Life Cycle Management Centre, c/o Massey University
[4]Institute of Veterinary, Animal and Biomedical Sciences
Massey University, Palmerston North 4442

The New Zealand dairy sector has a goal to increase its production capacity to support the national economic growth agenda. Increased total milk production can be achieved by both farm expansion and farm intensification. The present study focused on environmental impacts associated with increased milk production through farm intensification in the Waikato region where two scenarios were compared: increased use of either (i) nitrogen (N) fertilisers to boost on-farm pasture production (increased N scenario) or (ii) off-farm maize silage (increased MS scenario). Twelve environmental impact indicators were assessed using a prospective attributional Life Cycle Assessment approach. The results showed that there were four impact indicators (Ozone Depletion Potential, Cancer Effects, Photochemical Ozone Formation Potential and Freshwater Eutrophication Potential) where the differences between the two scenarios were less than 2%. The increased N scenario had two impact indicators (Non-cancer Effects (6%) and Ecotoxicity for Aquatic Freshwater (20%)) that were lower than those derived from the increased MS scenario. In contrast, the increased N scenario had six indicators (Climate Change (8%), Particulate Matter (16%), Ionising Radiation (6%), Acidification Potential (16%), Terrestrial Eutrophication Potential (16%) and Marine Eutrophication Potential (11%)) that were greater than those derived from the increased MS scenario. The impact indicators for the increased N scenario were driven mainly by N-based emissions (e.g. ammonia, nitrous oxide and nitrate) resulting from the manufacturing and use of N fertiliser, whereas the indicators for the increased MS scenario were associated mainly with emissions of heavy metals from the manufacturing and use of phosphorus fertilisers and the use of pesticides in a maize silage production system.

DAIRY YIELD RESPONSE TO INTENSIVE FARMING- A SPATIAL ANALYSIS OF THE NEW ZEALAND DAIRY INDUSTRY

Wei Yang and Basil Sharp

Department of Economics, University of Auckland

Purpose: The New Zealand dairy industry faces the challenge of increasing productivity and dealing with public concerns over nutrient pollution. Effective policy needs to address regional differences in productivity and fertiliser use. This paper aims to investigate how spatial effects influence the relationship between dairy yields and intensive farming practices across regions in New Zealand.

Design/methodology: This paper employs spatial panel data models to establish whether unobserved spatial effects exist in the relationship between dairy yields and nutrient inputs regionally and nationally using 2002, 2007 and 2012 data from Statistics New Zealand and Dairy NZ.

Findings: Results show positive spatial spillovers for most intensive inputs. The high level of effluent use and estimated negative yield response to nitrogen suggests that an opportunity exists for greater use of effluent as a substitute for nitrogenous fertiliser. Substitution has the potential to reduce dependence on fertiliser and contribute to a reduction in nutrient pollution.

Originality/value: This paper is the first empirical application of spatial econometric methods to examine the spatial relevance of dairy yields and intensive farming in New Zealand. In particular, the spatial panel data model accounts for cross-sectional dependence and controls for heterogeneity. The results contribute to an understanding of how farmers can improve their management of intensive inputs and contribute to the formation of regional environmental policy that recognizes regional heterogeneity.

A COLLABORATIVE APPROACH TO GUIDANCE ON THE USE OF OVERSEER IN WATER MANAGEMENT

Warwick Murray[1], Caroline Read[2], Simon Park[3] and Leo Fietje[4]

[1]Bay of Plenty Regional Council; [2]OVERSEER Management Services Ltd
[3]Landconnect Ltd; and [4]Environment Canterbury
Email: Warwick.Murray@boprc.govt.nz

The 2014 National Policy Statement for Freshwater Management (NPS-FM) requires the maintenance or improvement of water quality. This is to be achieved through regional councils setting water quality objectives and limits. The process for setting objectives and limits requires information on current state and anticipated rates of contaminant losses to water. Farming is a significant contributor to water quality outcomes. OVERSEER is New Zealand's leading farm-scale nutrient modelling software and it enables quantification of nutrient inputs, outputs and flows based on farm system parameters.

In catchments where farm nutrient sources impact water quality, OVERSEER provides a potential tool to manage the effects of land use, rather than rules controlling farm inputs and practices. This effects-based approach offers flexibility for farmers to determine how they will reduce their nutrient losses and thereby supports innovation in the primary sector. With Councils starting to use OVERSEER in their planning and rule setting, the challenges and opportunities around using modelled information in regulation are being tested.

While Councils take different approaches to managing the specific risks in their regions, many face similar challenges in applying OVERSEER to generate nutrient loss information to use in an RMA rules framework. To address this, a collaborative project is now underway to provide guidance on the appropriate use of OVERSEER information in policy, planning and compliance.

Guidance will provide usage options alongside their policy implications, including:

- Management of version updates and output uncertainty
- Integration with other planning and modelling tools
- Data input, auditing and management considerations.

To ensure the guidance is widely applicable, development is governed by a project board of five regional councils, the Ministry for Primary Industries, the Ministry for the Environment, OVERSEER Management Services, Dairy Companies Association of NZ, Beef & Lamb NZ, HortNZ and the Foundation for Arable Research.

This presentation will provide an overview of the guidance development project and its outcomes to date.

OVERSEER AND PHOSPHORUS: STRENGTHS AND WEAKNESSES

C W Gray[1], D M Wheeler[2], R McDowell[3] and N L Watkins[2]

[1]*AgResearch, Lincoln Research Centre, Private Bag 4749, Christchurch, New Zealand*
[2]*AgResearch, Ruakura Research Centre, Private Bag 3123, Hamilton, New Zealand*
[3]*AgResearch, Invermay Agricultural Centre, Private Bag 50034, Mosgiel, New Zealand*

Increasingly decision support tools such as OVERSEER® Nutrient Budgets (OVERSEER) are being used by consultants and policy makers to estimate the likely effects of land management practices on off-farm losses of nutrients, for nutrient allocation, and decisions in policy relating to nutrient management. OVERSEER estimates phosphorus (P) loss, but the P model in OVERSEER has come under scrutiny. The aim of this paper is to highlight how well OVERSEER currently estimates phosphorus (P) loss from farming systems, along with comment on some of its perceived weaknesses and recommendations for improvements to P modelling in OVERSEER.

The core of the P loss submodel was developed and integrated into OVERSEER a decade ago. It accounted for most combinations of P loss from pastoral agricultural systems. However, some agricultural systems were not included due to a lack of data at the time of the submodel's development. Since then, new research has been undertaken on P loss from agricultural systems, some of which has been integrated into the P loss submodel. A number of additions and changes to other submodels in OVERSEER, which directly affect P loss have also occurred. Currently, comparison between measured P losses from 46 sites with different landuse (dairy, deer, forest, sheep/beef and mixed), at a range of scales (<1 ha plots to catchments) indicate OVERSEER can predict P loss reasonably well (R^2 >0.80; P<0.001).

However, despite the good prediction of P loss, there are modifications that could be made to OVERSEER to improve P loss estimates. It is recognised that some agricultural systems are currently inadequately modelled e.g. arable cropping, cut and carry, and fodder crop. Some individual components of farm systems could be considered for inclusion or updated in OVERSEER, for example losses from farm structures. There is also an opportunity for the standardisation of the estimation of P loss via runoff and leaching, and separate reporting of P losses via different pathways. Consideration of new features in OVERSEER could include a better estimation of P loss from sediment, estimation of P removal in wetlands, and for the model to increase its spatial and temporal capability.

VALUATION OF THE BENEFITS OF THE OVERSEER®

NUTRIENT BUDGET MODEL

Phil Journeaux

AgFirst, Waikato

This project endeavours to value the benefit of the use of the OVERSEER model, focusing around its use in three key areas:

(i) As a research tool

(ii) As a tool to assist the efficiency of fertiliser use, and

(iii) As a tool to assist in nutrient management on-farm, particularly around limits on nutrient discharges.

The benefit value was based on expert opinion; people from a range of different perspectives with expertise in agri-environmental issues and the use of OVERSEER were interviewed so as to develop “with versus without” scenarios, with the difference being used as a basis to estimate the value.

As could be anticipated, information in a number of areas was relatively sparse, and a range of assumptions have been made. Using these assumptions, estimates of the benefit value are:

(i) As a research tool: $51 million/year (range $26 - $102 million)

(ii) As a tool to assist the efficiency of fertiliser use: $107 million/year (range $54 - $161 million)

(iii) As a tool to assist in nutrient management on-farm: $113 million/year (range $73 - $137 million)

This gives an overall estimated value of $271 million/year (range $153 - $400 million)

These figures must be regarded as indicative only, given the range of assumptions and extrapolations that lie behind them. This is particularly so for the estimate of value in assisting with nutrient management, and further work is required to obtain a more definitive figure.

A second component, of the value of continuing to develop OVERSEER, is more problematic. It is inherent within the value of benefits calculated that they are ongoing, and inherent within this is that the model continues to be developed. In this sense the ongoing value of the current model is only valid if the model is keep up to date and new science incorporated. While future development of OVERSEER is therefore essential in maintaining the current benefit of the model going forward, the addition of new science and features also means that the benefit from the model would increase.

INTERPRETING PASTURE EATEN AND PASTURE GROWTH ESTIMATES FROM OVERSEER AND WHAT TO LOOK FOR WHEN COMPARING THEM WITH OTHER MEASURED AND MODELLED ESTIMATES

Chris Glassey[1], Diana Selbie[2] and David Wheeler[2]

[1]DairyNZ,Hamilton
[2]AgResearch, Hamilton

Background:
Overseer nutrient budgets for DairyNZ farmlet trials produced pasture eaten/ha and pasture growth/ha estimates that differed from actual measured estimates. We investigated what factors were important for generating these differences between estimates, and what assumptions and information needs to be checked for improving and verifying estimates.

Why is this important?
Nutrient loss predictions from Overseer are strongly linked to the volume of pasture and other feeds used per ha by the farm animals. Overseer users also potentially have a variety of other estimates of pasture use per ha available to them e.g. individual paddock yield measured on farm, DairyBase, and FarmMax modelling. Some of these estimates are made using similar model predictions. Overseer users are asking what degree of difference between estimates is tolerable, and which estimates can be used reliably for farm management purposes.

While it may not be possible to align all these estimates our view is that some key input assumptions should be checked for alignment between estimates before any conclusions are made on their reliability and accuracy.

Factors to check (from our experience):

Assumed pasture utilisation % . In our case pasture utilisation was different to the Overseer default.

Assumed wastage and utilisation of supplements

Quantity of supplements fed

Quality of supplements fed

Assumed energy (ME) profile of pasture

DESCRIPTION OF AN OUTDOOR PIG MODEL FOR OVERSEER

David M Wheeler[1], Ian W Barugh[2] and Patrick C H Morel[2]

[1]*AgResearch, Hamilton*
[2]*Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North*

To provide an estimate of nutrient flows within an outdoor pig farm, an outdoor pig sub-model has been developed that is consistent with the scope of OVERSEER® Nutrient Budgets (OVERSEER). In developing the model, the first consideration was estimating feed intake, in particularly the grass component and understanding the effect of management on nutrient flows. The primary focus was on nitrogen (N). Initial modelling indicated that the amount of excreta dung and urine was dependent on the amino acid composition of the feed, and that grass amino acid composition was close to optimum for minimising the amount of urine excreta N. Grass protein is poorly digested by pigs, leading to increased faecal excretion. However, feeding regimes are highly controlled as feed amount and quality, including amino acid composition, is critical for production. Given the controlled feeding regimes, management practices had the largest effect on nutrient losses, and the focus has been placed on modelling the latter.

The model is based on the number of animals and performance using standard industry inputs. The amount of feed brought in and its quality is user defined, and defaults are available. Utilisation (including bird loss) is defined by the feeding method. The outdoor pig unit is divided into management areas (areas for lactating, mating, and growers and finishers, and an acclimatisation area for replacements). Sows use huts, and can be placed in village's pre or post farrowing, and any pig class can be placed in sheds or barns as a means to reduce excreta deposition on the block. The model includes waste management options for the bedding and excreta from each form of housing. The nutrient flow and excreta deposited in each management area is estimated. For N, leaching losses where highly dependent on the stock density (the amount of feed intake) and the amount of pasture cover. Pasture cover is dependent on management (for example, stock density, placement and movement of troughs and huts, nose ringing) and hence pasture cover for each management area is an input.

This paper describes the developed outdoor pig model.

CASE STUDIES USING THE OUTDOOR PIG MODEL IN OVERSEER®

Ian Barugh[1], David Wheeler[2] and Natalie Watkins[2]

[1]*Institute Veterinary and Biomedical Sciences, Massey University*
[2]*AgResearch , Hamilton*

Regional Councils have signalled that the primary method of recording nitrogen leaching rates will be through the use of OVERSEER® Nutrient Budget (OVERSEER). While indoor pig farms in NZ can be modelled using OVERSEER®, outdoor bred pigs, which comprise 40% of NZ production, until recently could not. A NZPork and Sustainable Farming Fund funded project set out to integrate outdoor pigs into OVERSEER®. Outdoor farms require low rainfall and free draining soil and as such are situated in Canterbury. Farms are different for a variety of reasons including soil type, rainfall, farm and land area under pigs, stocking rate, ground cover, productivity and feed type. Development of the outdoor module required inputs limited to the key parameters that were easy to obtain, and where possible assumptions and default figures were used. Case studies were undertaken on two farms using a development version of OVERSEER. Farm 1 had total area of 196ha of which 65 ha running 900 sows, 106 ha pastoral with sheep and dairy grazers, 15 forestry and the balance being housing and sheds. The soil was Lismore silt loam, annual rainfall of 717mm and sow feed intake of 1.53 tonne /sow/year. OVERSEER determined a nitrogen (N) leaching rate of 14 kg N /ha over the whole farm and 33 kg N/ha under pigs.

Farm 2 had 118ha, of which 13 ha was running 390 sows, cattle on 73.8 ha, fodder beet and green oats on 23.2 ha and lucerne on 6.5 ha. Timaru and Rakaia soils with average rainfall of 554mm and feed intake/sow/year of 1.45 tonne. The predicted whole farm N leaching rate was 25 kg/ha and under the pigs 71 kg/ha.

For these two farms the inputs were varied to highlight the key influencers on N leaching. These were ground cover, stocking rate and rainfall, followed by feed make up and usage, with productivity factors such as weaning weight, sow performance, replacement rates having less effect.

IMPROVING PREDICTIONS OF N & P EXPORT TO WATERWAYS FROM RURAL LANDSCAPES IN NEW ZEALAND USING LUCI

Martha Trodahl and Bethanna Jackson

Victoria University of Wellington

In New Zealand concern over the impact of rural land management and primary production on water quality is increasing, putting farmers and land managers under increased pressure to reduce nutrient losses to the environment while simultaneously ensuring production and profitability goals are met. Due to its fine spatial scale and focus on the rural environment, the Land Utilisation & Capability Indicator (LUCI) is well placed to help both farm and catchment managers quantify and explore spatially explicit solutions to these issues.

LUCI is a GIS framework that considers impacts of land use on multiple ecosystem services in a holistic and spatially explicit manner. A number of ecosystem services are supported within the framework, including water quality (N & P to water). Ecosystem service tools can be run for individual ecosystem service analysis and to analyse interrelationships between ecosystem services, identifying trade-offs and synergies between them. LUCI has been applied in a number of countries, but most extensively in the UK.

A collaboration between LUCI developers and Ravensdown has recently commenced. The aim of the collaboration is to develop a bespoke version of LUCI for the co-operative that will assist New Zealand farmers and other land managers with decision making around farm ecosystems, with a particular focus on water quality.

This talk will present catchment scale results based on work-to-date developing appropriate export coefficients for the New Zealand environment. N and P sources and sinks are discussed, trade-offs and synergies investigated, and implications for farm and catchment managers explored.

ADAPTION OF THE LUCI FRAMEWORK TO ACCOUNT FOR DETAILED FARM MANAGEMENT: A CASE STUDY EXPLORING POTENTIAL FOR NUTRIENT MITIGATION ON THE SOUTHLAND DEMONSTRATION FARM

Bethanna Jackson and M Trodahl

School of Geography, Environment & Earth Sciences, Victoria University of Wellington

This talk discusses recent progress in adapting the Land Utilisation and Capability Indicator (LUCI) framework to take account of the impact of detailed farm management on water, sediment and nutrient delivery to waterways.

LUCI is a land management decision support framework which examines the impact of current and potential interventions on a variety of outcomes, including flood mitigation, water supply, greenhouse gas emissions, biodiversity, erosion, sediment and nutrient delivery to waterways, and agricultural production. The potential of the landscape to provide benefits is a function of both the biophysical properties of individual landscape elements and their configuration. Both are respected in LUCI where possible. For example, the hydrology, sediment and chemical routing algorithms are based on physical principles of hillslope flow, taking information on the storage and permeability capacity of elements within the landscape from soil and land use data and honoring physical thresholds, mass and energy balance constraints. LUCI discretizes hydrological response units within the landscape according to similarity of their hydraulic properties and preserves spatially explicit topographical routing. Implications of keeping the “status quo” or potential scenarios of land management change can then be evaluated under different meteorological or climatic events (e.g. flood return periods, rainfall events, droughts), cascading water through the hydrological response units using a “fill and spill” approach.

Historically, LUCI has inferred land management from nationally available land cover categorisations, so lacked the capacity to discriminate between differences in more detailed management (tillage information, type of irrigation system, stocking numbers and type, etc). However, recently a collaboration with the Ravensdown cooperative has commenced. LUCI is being further developed within New Zealand to take in a range of more detailed management information, which can be entered directly to LUCI or easily integrated via an Overseer farm file. Example output and ongoing “validation” of LUCI’s performance at the farm scale will be presented using the Southland Demonstration Farm as a case study.

MODELLING NUTRIENTS FLOW FOR OUTDOOR PIG FARMS: EFFECT OF STOCHASTICITY

P C H Morel and J P Morel

Institute of Veterinary, Animal and Biomedical Sciences
Massey University, Palmerston North

This paper first briefly describes a nutrient partitioning model for outdoor pig farms. The model uses input parameters that are commonly available on outdoor pig farms. The mechanistic and dynamic model simulates both animal performances and nutrient losses to the environment based on dietary energy, protein amino acids and minerals intake and digestibility. The model outputs are feed wastage, bird losses, faecal and urinary excretion for Nitrogen, Phosphorus, Potassium, Sulphur, Calcium, Magnesium, Sodium as well as Total Volatile Solids. A simulation study was conducted to compare total farm Nitrogen excretions and losses obtained by a deterministic model (one average sow; N=1) or a stochastic model (a population of sows; N= 400, 900 and 1400). For the stochastic model the coefficients of variation (CV) were set to 0%, 5%, 10% and 15%. Each combination n x CV was run 10 times. Variation was applied to litter size at birth and weaning, daily feed intake, and maximum protein deposition rate. The number of litters per sow and year was set to 2.0, 2.2 or 2.4 and the number of sows per ha was kept constant at 13.9.

The results from the simulation study shows that overall, less of the N entering the farm as feed is lost to the environment when the number of litters per sow and year increases (79.5%, 77.5%, and 75.5% for 2, 2.2 and 2.4, respectively). The total amount of nitrogen lost to the environment was slightly higher with the deterministic than the stochastic models (+ 0.3 to 2.1 kg N /ha).

RELATIONSHIP BETWEEN SHOOT AND ROOT NUTRIENT CONCENTRATIONS FOR A RANGE OF TEMPERATE PASTURE AND CEREAL SPECIES

David M Wheeler

AgResearch, Hamilton

When modelling pasture uptake, there is little data on the contribution of roots to total nutrient uptake by the plant. This requires an estimate of root growth and root nutrient concentrations. A series of experiments have been undertaken for a range of temperate pastures species (grasses and legumes) and cereals grown in low ionic strength solution culture in which shoot and root nutrients concentrations have been measured. The relationship between shoot and root nutrients concentrations were determined using regression analysis. There were significant ($P<0.05$) differences in the relationships between the grass and cereal species (monocotyledons) and the leguminous species (dicotyledons). In general, for a given shoot concentration, grass and cereal species generally had higher root concentrations of magnesium (Mg), iron (Fe), and aluminium (Al), and leguminous species generally had higher root concentrations of nitrogen (N), sulphur (S), potassium (K), and manganese (Mn). All root nutrient concentrations increased linearly with shoot concentrations, except for K where there was a biphasic relationship. For both groups (temperature pasture and cereal species, and legumes), root sodium (Na) concentrations were higher than shoot concentrations, with the relationship between shoot and root concentrations depending on the form that Na was added. For legumes N, S, P, Mn, zinc (Zn), copper (Cu), and Fe concentrations, root concentrations for a given shoot concentration were lower when root K concentrations were <3%. Including other nutrients in the regression analysis did not significantly improve the relationship except in wheat, where increasing root Ca concentrations increased root Mg concentrations, and increasing root Ca concentrations increased root Mg concentrations. The results from this study give an empirical method of estimating the distribution of root and shoot nutrients when modelling nutrient flows in pasture.

DETERMINATION OF NITROGEN FERTILISER REQUIREMENTS IN DAIRY PRODUCTION SYSTEMS BASED ON EARLY INDICATORS

Iris Vogeler[1] and R Cichota[2]

[1]*AgResearch, Hamilton*
[2]*AgResearch, Lincoln*

Early estimates of nitrogen (N) fertiliser requirements are desirable to ensure an adequate N supply for targeted pasture growth, as well as to minimise N losses. 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. To manage this variability in N requirements by plants effectively, various methods have been developed to determine optimum fertiliser application rates based on the N nutrition status of the plant. The use of remote sensing for mapping spatial variations in crop N status offers potential for fertiliser management practices tailored to spatial variability in the field, which can improve nitrogen use efficiency and thus lead to environmental and economic benefits.

To determine optimum N fertilisation rates which will maximize plant growth based on the pasture N content and environmental conditions, a simulation study using the Agricultural Production Systems Simulator (APSIM), was set up. The APSIM model, with a refined version of the pasture module (AgPasture), which allowed N remobilisation to occur from all the different tissue stages, was used for an irrigated ryegrass pasture in the Canterbury region of New Zealand. Simulations comprised 10 different fertilisation rates (ranging from 10 to 100 kg N/ha), which were applied every month at alternating rates, resulting in 90 different fertiliser treatment combinations. These were run for 20 consecutive years, giving a total of 1800 combinations of pasture N contents and pasture growth responses for each month. Based on statistical analysis, the optimum N fertilisation rate dependent on pasture N content and environmental conditions was determined. For example in October, optimum fertilisation rates at which 90% of the maximum yield was achieved were estimated to be 160 kgN/ha if the pasture N content was below 2.4%. However, at much higher pasture N contents (between 3.6 and 4%) only 60 kg N/ha was required to obtain the same yield, reflecting the much higher supply of N by the soil.

The approach using pasture N content and environmental conditions as early indicators for guiding N fertilisation offers potential for improved management of the spatial and temporal variability in N demand and supply. Further model testing under different conditions and linked with experimental studies are required to test this approach.

DESIGN OF A LOW COST WINTER STAND-OFF PAD FOR REDUCING NUTRIENT LOSSES TO WATER FROM WINTER FORAGE CROPS GRAZED BY DAIRY COWS

J Chrystal[1], R Monaghan[1], M Hedley[2] and D Horne[2]

[1]*AgResearch, Invermay*
[2]*Massey University, Palmerston North*
Email: jane.chrystal@agresearch.co.nz

Dairy cow wintering in Southern New Zealand most commonly involves grazing brassica crops *in situ*. This system is relatively low-cost compared to alternative wintering systems, such as barns and wintering pads, due to: the low cost of the feed, low labour requirement, no structure needed, and no effluent storage required. However, grazing at high stocking densities during winter, combined with high winter rainfall and excessively free-draining soils or heavy soils and sloping land can result in high contaminant losses (N, P, *e.coli*, sediment) to water. This wintering practice is increasingly coming under scrutiny from those who are seeking alternatives to reduce these losses. Current alternatives are high cost and require feed to be brought to the animals at further cost. Therefore, a low-cost stand-off that reduces contaminant losses to water, whilst utilising the low cost brassica crop as a feed source, is urgently sought. This trial investigated the feasibility of a portable pad system that consists of an impermeable liner to capture effluent, overlain by a suitable surface for cow comfort and durability. Cows graze the brassica crop *in situ* and return to the portable pad for a proportion of the day. The portable pad has the ability to be moved around the farm in different years as the location of the forage crop paddock changes. Minimal effluent storage is required due to the application of the liquid effluent to a neighbouring pasture during winter using low rate and low depth application methods. This paper describes the first stage in the evaluation of this system where the objectives were (i) to determine if a portable pad could be constructed that captured the excreta and rainfall deposited on the pad surface and (ii) to find a readily-available commercial product suitable for the cow comfort layer. Of the 3 surfaces trialled, a geotextile 'carpet' was selected as the surface of choice to be used in further trials. The concept of effluent capture and the use of a low-cost plastic liner overlain with a cow comfort layer was a success and proved worthy of further investigation.

VOLUMES AND NUTRIENT CONCENTRATIONS OF EFFLUENT PRODUCTS GENERATED FROM A LOOSE-HOUSED WINTERING BARN WITH WOODCHIP BEDDING MATERIAL

J M Chrystal[1], R M Monaghan[1], M Hedley[2] and D Horne[2]

[1]*AgResearch, Invermay Agricultural Centre, Mosgiel, New Zealan*
[2]*Massey University, Palmerson North, New Zealand*
Email: jane.chrystal@agresearch.co.nz

In Southern New Zealand there has been an increase in the use of off-paddock wintering systems as an alternative to the traditional approach of grazing winter brassica crops. These off-paddock systems capture and store effluent products that differ in their characteristics depending on the particular system used. The volumes generated and nutrient characteristics of the effluents produced are poorly defined and this means that the associated nutrient values are not easily recognised. We monitored the volumes and nutrient concentrations of the effluents and manures produced by a loose-housed deep litter wintering barn utilising woodchip as a bedding material. Effluent and manure products from 5 sources were monitored: drainage through the barn bedding, solids scraped from the feeding alley, farm dairy effluent (FDE), leachate from the silage pad, and the used barn bedding. Total amounts of nutrient per cow from all captured effluent sources in the dairy farm system were equivalent to: 38.4 kg N cow^{-1} year^{-1}, 9.6 kg P cow^{-1} year^{-1} and 56.1 kg K cow^{-1} year^{-1}. This equates to an annual fertiliser value of \$140 cow^{-1}. The manure products with the highest nutrient concentrations were associated with dung and urine deposition in the feeding alley and on the barn bedding. The largest volumes of effluent were generated by the FDE and rainfall falling on the concrete area of the milking yard, feeding alley and silage pad. The total volume of effluent captured by the pond system was equivalent to 19 m^3 cow^{-1} year^{-1} and the volume of spent bedding represented 7.4 m^3 cow^{-1} winter^{-1}.

AFTER FERTILISER APPLICATION EARTHWORMS REMAIN AN IMPORTANT COMPONENT OF OUR SOIL-PASTURE SYSTEM

Nicole Schon[1], R A Gray[2] and A D Mackay[2]

[1]*AgResearch, Canterbury*
[2]*AgResearch, Palmerston North*

Greater emphasis is being placed on ensuring fertiliser application minimises losses to the environment and is nutrient efficient. Earthworms increase nutrient mineralisation and plant growth. The few studies which have explored the role of earthworms on plant growth after fertiliser application have found varying results depending on soil type as well as nutrient inputs. Here we investigate the contribution of deep burrowing earthworms to pasture growth at three field sites after the application of superphosphate and urea.

At each site we selected a site where the deep burrowing earthworm A. longa was present or absent. Pasture production was monitored throughout the year. At the sites where A. longa was present pasture production was greater and pasture quality was higher, especially increasing growth during autumn, winter and early spring when earthworms are most active. The application of both superphosphate and urea also increased pasture production. Earthworms had a larger influence on pasture production with superphosphate application. Even after the application of fertiliser earthworms contribute to the soil-pasture system and their importance for pasture production is highlighted in this study.

SOIL BACTERIAL COMMUNITIES ARE AFFECTED BY SOIL pH AND PHOSPHOROUS CONCENTRATIONS

Syrie Hermans, G Lear, F Curran-Cournane and M Taylor

School of Biological Sciences, University of Auckland

Soil bacteria are important for soil ecosystem health and functioning, but we lack knowledge on the composition of bacterial communities in New Zealand soils. To determine the relative influences of both natural and anthropogenic factors on bacterial community structure, bacterial DNA was sequenced from 1100+ samples collected in Auckland and Waikato. Soil variables explained more of the variation in bacterial community composition than either spatial or climatic variables. Additionally, a link between anthropogenic activity, soil variables and bacterial communities was established. Specifically, the pH of the soil and the concentration of available phosphorous strongly influenced the composition of bacterial communities in human impacted sites. This indicates that farming practises such as fertiliser use impact vital soil bacterial communities. These findings suggest that bacterial community data may be used to inform on the impact of anthropogenic activities, including fertiliser use, on the health and production potential of soils. Molecular (DNA-based) data offers multiple advantages as a biologically relevant indicator of soil condition, and could be used to help manage nutrient use and to ensure the long term sustainability of New Zealand's agricultural industries.

SOIL QUALITY TARGETS FOR OLSEN P FOR THE PROTECTION OF ENVIRONMENTAL VALUES

Matthew Taylor[1], John Drewry[2], Fiona Curran-Cournane[3], Barry Lynch[4], Lisa Pearson[5] and Richard McDowell[6]

[1]*Waikato Regional Council, Private Bag 3038, Waikato Mail Centre, Hamilton*
[2]*Greater Wellington Regional Council, PO Box 41, Masterton*
[3]*Auckland Council, 1 The Strand, Takapuna, Auckland*
[4]*Hawke's Bay Regional Council, Private Bag 6006, Napier*
[5]*Environment Southland, Corner of North Road and Price Street Waikiwi Invercargill*
[6]*Faculty of Agriculture and Life Sciences, Lincoln University*

Agricultural land contributes considerable amounts of nutrients to surface water in many regions throughout New Zealand, particularly land managed under intensive farming practices. Considerable focus has been on nitrogen (N) but, as the community continues to raise concerns about the health of streams and rivers, regional councils in New Zealand are increasing scrutiny on the role of phosphorus (P) in water quality. Historically, it has been assumed that P is not often transported through soil, but more recent work has shown subsurface flow can transport considerable amounts of P.

Several studies have shown the importance of soil P levels to subsequent P losses. Olsen P, a measure of plant available P, is a commonly used soil fertility and soil quality monitoring indicator. Low concentrations of Olsen P tend to inhibit production, while high concentrations have been associated with transfer of P to surface water. Avoiding both extremes is important in retaining soil quality, while avoiding excessive Olsen P is important in retaining water quality.

Soil quality indicators, like Olsen P, can be used to assess how land use and management practices influence soil for plant growth or for potential risks to the environment. Targets for indicators have been developed and are now commonly used by regional councils. Recommended upper Olsen P targets have often been exceeded by land under intensive agriculture and horticulture.

Regional councils are contributing to the development of the land-based component of the Environmental Monitoring and Reporting (EMaR) project with the Ministry for Environment and other agencies, and to generate information that will help inform the National Policy Statement for Freshwater Management process. In this paper we will discuss estimating potential P loss from different soils. We show that there are substantial soil Order and slope effects on P loss risk. It appears that although the risk of P loss is less on flatland, it can still be considerable and we present data showing the movement of P down the soil profile.

POTENTIAL REDUCTIONS IN FARM NUTRIENT LOADS RESULTING FROM FARMER PRACTICE CHANGE IN THE UPPER WAIKATO CATCHMENT

David Burger[1*], Ross Monaghan[2], Nicola McHaffie[1], Adrian Brocksopp[1] and Mike Scarsbrook[1]

[1]DairyNZ, Private Bag 3221, Hamilton 3240, New Zealand
[2]AgResearch, Private Bag 50034, Mosgiel 9053, New Zealand
**Email: david.burger@dairynz.co.nz*

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 were offered one-on-one advice and support via the development of a farm-specific DairyNZ Sustainable Milk Plan (SMP). All actions were recorded and coded into specific management categories to provide a more comprehensive analysis of the likely impacts of successful implementation on farm contaminant losses. In this paper we estimate potential reductions in farm nutrient losses for 594 farms which have completed the full SMP process. For each farm, nitrogen (N) and phosphorus (P) reductions were derived from individual farm Overseer® Nutrient Budget information and assumed nutrient reduction efficacy rates assigned to each specific mitigation strategy. Given the uncertainties and variability associated with quantifying efficacy rates attributable to different mitigation strategies, several approaches were trialled using a combination of Overseer modelling, existing studies published in the scientific literature and expert opinion. Mean reductions in farm nutrient losses for actions already completed are estimated to be 5% for N and 12% for P. These reduction estimates are expected to increase to 8% for N and 21% for P once all actions across all 642 SMP farms are fully implemented.

UTILITY OF ALLOCATION AS A MECHANISM TO MANAGE NITROGEN IN THE ABSENCE OF AN UNDERSTANDING OF ATTENUATION

Ian Millner

Hawkes Bay Regional Council, Napier

The allocation of nitrogen losses to land is seen as a necessary practice within nitrogen management frameworks. Allocation of a "number" to a hectare of land has variously been advocated as providing certainty and equity between land users. However, allocations are typically done in a manner that average nitrogen attenuation between the root zone and an instream monitoring point at 50%.

This analysis looks at the 50% assumption and compares it to other assumptions to test its usefulness as a nitrogen management framework.

Changing the assumption pertaining to attenuation and the effect that has on the utility of allocation as a nitrogen management framework is discussed as well as corresponding effect on the notion of certainty and equity.

Suggestions are made as to how the resource management field can avoid short term limitations in knowledge about attenuation while still reducing N loss to water.

ASSESSMENT OF NITROGEN FLOW PATHWAYS AND ITS POTENTIAL ATTENUATION IN SHALLOW GROUNDWATERS IN THE LOWER RANGITIKEI CATCHMENT

Stephen Collins[1,2], R Singh[2], A Rivas[2], A Palmer[2], D Horne[2], J Roygard[1] and A Matthews[1]

[1]Horizons Regional Council
[2]Institute of Agriculture and Environment, Massey University

A sound understanding of the sources, transport, transformation and fate of the nitrogen and phosphorus lost from farms is a key component of managing and mitigating the likely impacts of these nutrients on water quality and ecosystem health in agricultural catchments. We assessed surface water and groundwater interactions, and nitrogen flow and its potential attenuation in shallow groundwater in the lower Rangitikei catchment. The study area covers about 850 km^2 between the townships of Bulls and Sanson in the east, Tangimoana in the south and Santoft in the north.

A piezometric map, developed from measured depths to groundwater in about 100 wells in October 2014, suggests that groundwater flow, and in particular the movement of shallow groundwater (<30 m), is heavily influenced by the regional topography. Shallow groundwater flows mostly from elevated areas, such as Marton, in a south-westerly direction towards the Rangitikei River. Groundwater discharges to the river upstream and downstream of Bulls, while groundwater recharge or no interaction with the river is more likely to occur near the coast. The groundwater redox characterisation, based on sampling and analysis of 15 groundwater wells suggests that in general terms the groundwater across the lower Rangitikei catchment is anoxic/reduced. The groundwater typically has low dissolved oxygen concentrations (<1 mg/L) and levels of electron donors (particularly DOC and Fe^{2+}) that are suitable for denitrification. We further measured nitrate-nitrogen attenuation in shallow groundwater piezometers (3-6 m bgl) using the single-well push-pull tests. The push-pull tests showed nitrate-nitrogen reduction at four of the five piezometers, with the rates of reduction varying from 0.036 mg N L^{-1} hr^{-1} to 1.158 mg N L^{-1} hr^{-1}.

Our results suggest that groundwater is likely to be connected with some reaches of the lower Rangitikei River. However, nitrate-nitrogen concentrations in the river and groundwater were generally low, especially for the river at low flows, which is surprising given the land use intensity in this region. This suggests nitrate-nitrogen may be undergoing reduction within shallow groundwater before it has a chance to seep into the river. This is evident in the redox characterisation of reduced groundwater and observed nitrate-nitrogen reduction during the push-pull tests conducted. However, more spatial and temporal surveys and *in-situ* measurements of denitrification occurrence in the shallow groundwater of the study area are required.

VARIABILITY IN DENITRIFICATION CHARACTERISTICS OF THE VADOSE AND SATURATED ZONES IN THE MANAWATU RIVER CATCHMENT

Aldrin Rivas[1], Ranvir Singh[1], David Horne[1], Jon Roygard[2], Abby Matthews[2] and Mike Hedley[1]

[1]Fertilizer & Lime Research Centre, Massey University
[2]Horizons Regional Council

Investigating the denitrification characteristics of the subsurface environment is important to an understanding of the capacity of this zone to reduce nitrate contamination of groundwater and surface water. However, there are limited studies of the denitrification properties of both the vadose and saturated zones. The objective of this study is to quantify denitrification in the vadose and saturated zones at selected sites in the Tararua Groundwater Management Zone (TGWMZ) of the Manawatu River catchment.

Measurements of denitrification were conducted in the summer of 2014/2015 and the winter of 2015 at three locations in the TGWMZ namely, Pahiatua, Woodville, and Dannevirke. These sites were selected to represent areas with either oxidising or reducing shallow groundwater. The denitrification potential of the vadose zone was determined in the laboratory by assays measuring the denitrifying enzyme activity (DEA) in soil samples collected along the vertical profile (surface to 1.95 m bgl). Shallow groundwater denitrification rates were measured *in situ* using the single-well push-pull tests from two to three piezometers at each site with depths varying from 4.4 m to 7.5 m bgl.

Results of the denitrification assays show that the denitrification potential is highest in the surface soil at all sites and that this dentrification potential was similar across all of the surface soils. Denitrification potential decreased with depth, particularly at the Dannevirke site. For shallow groundwater, denitrification was clearly apparent at both test times at the Woodville site which has reduced groundwater. In contrast, there were no clear indications of denitrification at the oxidised Pahiatua site at either test time. Mixed results were obtained at the Dannevirke site where denitrification seemed to occur in the deepest piezometer during the summer test but was not evident during the winter measurements. Given that the DEA measurements for vadose zone samples involved the addition of an electron donor in the denitrification assays, results of the push-pull tests provide a better indication of the denitrification capacity of the study sites. Quantification of the denitrification potential of the study sites has important implications for nutrient management on farms.

EVALUATION AND DEVELOPMENT OF A RIVER NUTRIENT LOAD CALCULATOR

Ahmed Elwan[1], Ranvir Singh[1], David Horne[1], Jon Roygard[2] and Brent Clothier[3]

[1]*Institute of Agriculture and Environment, Massey University, Palmerston North*
[2]*Horizons Regional Council, Palmerston North*
[3]*Plant and Food Research, Palmerston North*

Accurate estimates of river nutrient loads are required for better management of water quality at a catchment level. In most catchments, there are continuous measurements of river flow but only infrequent measurements of water quality parameters. Thus, a number of methods have been developed to estimate the annual river loads using various temporal resolutions of river flow and nutrient concentrations.

We assessed the uncertainty in estimated annual river-nutrient loads as a function of sampling frequency and load estimation methods for the Manawatu River catchment. The true river loads of "soluble inorganic nitrogen (SIN), total nitrogen (TN) and dissolved reactive phosphorus (DRP)" were calculated using the daily measurements of both river flow and nutrients concentrations at the Manawatu Teachers College monitoring site for the 2010/2011 year. We considered three sampling frequencies (weekly, fortnightly and monthly). For each sampling frequency, river nutrient load was estimated using four load estimation algorithms (Global mean "GM", Ratio estimator "RE", Flow-stratified "FS", and Flow-weighted "FW"). The resulting estimated annual nutrient loads for all sampling frequencies and load estimation algorithms were compared to the true loads and the bias (a measure of the accuracy) and the root mean square error (RMSE; a measure of both the accuracy and the precision) were calculated.

Our results showed that the bias decreased, for all load-estimation algorithms except the GM, from weekly to fortnightly sampling frequency. However, the bias increased from fortnightly to monthly sampling frequency. On the other hand, the root-mean square error (RMSE) was found to have an inverse relationship with the sampling frequency, as it increased from weekly to monthly for all load estimation algorithms, except the GM. The GM was found to underestimate the river annual load for all water quality parameters used in the study regardless of sampling frequency. The FW and RE gave the same results for all water-quality parameters. In general, FW and RE were found to perform better than the FS. However, the FS performed better than FW and RE only for SIN at fortnightly sampling frequency. From these results we recommend the use of either FW and/or RE to estimate annual river nutrient loads in the study area.

CONSTRUCTED WETLAND ATTENUATION OF NUTRIENT INFLOWS TO TE WAIHORA / LAKE ELLESMERE

James P S Sukias, Chris C Tanner and Scott Larned

NIWA, Hamilton

Diffuse nutrient losses from agricultural land often require integrated approaches to manage and mitigate effects. Wetlands can be a useful tool to land owners due to their natural capacity to reduce nutrient fluxes to downstream water bodies by capturing phosphorus and removing nitrogen via denitrification. In the Te Waihora/Lake Ellesmere catchment (Canterbury), extensive drainage to facilitate agricultural land use has resulted in substantial loss of these natural wetlands from the landscape. Ongoing drainage and stream channelization has lowered water tables and disconnected many of the remaining wetlands from the drainage system, reducing their ability to intercept and attenuate the flux of sediments and nutrients into Te Waihora. NIWA was commissioned to undertake an assessment of the areas of wetlands in the catchment that would be needed to meet nitrogen load reduction targets of 20% and 40% in the 9 major surface inflows to the lake. Modelling predicted a total of 593 ha of suitably-designed wetland would be needed to reduce the annual nitrogen loads by 20% and 1,782 ha of wetland to reduce the annual load by 40%. Substantial reductions in sediment and phosphorus microbial contaminant loads would also be achieved. Such wetland areas intercepting major inflows before they entered the lake, would occupy less than 0.3% and 0.9%, respectively, of their apparent catchment areas. Required areas of wetland for different inflows ranged from 16–142 ha for 20% TN load reduction, and from 44–324 ha for 40% TN load reduction. Appropriate areas of potentially suitable land for wetland creation were able to be identified near the outlets of major inflows to the lake edge and/or in shallow littoral areas of the lake. Surface-flow wetlands strategically located in these areas offer feasible, low-risk options to reduce nutrient loads and change the freshwater landscape of Te Waihora.

PHYSIOGRAPHIC CONTROLS OVER SOUTHLAND'S GROUND AND SURFACE WATER HYDROCHEMISTRY AND QUALITY

Clint Rissmann, K Wilson, B Hughes, E Rodway, M Beyer, R Millar, L Pearson, M Killick, J Hodgetts, R Hodson, A Akbaripasand, J Dare, T Ellis, M Lawton, N Ward, J McMecking, D May and L Kees

Environment Southland, Invercargill

The Physiographic Project is a component of Environment Southland's Water and Land 2020 and Beyond (WAL2020) programme, and their response to the National Policy Statement for Freshwater Management (NPS-FM) 2014. The physiographic work is a novel approach, which characterises the landscape based on water origin, soil type, geology and topography to provide a better understanding of the relationships between these factors and the drivers of water quality and hydrochemical variability. Nine "physiographic zones" were identified during this work. Hydrochemistry and water quality outcomes differ in each of these zones due to their unique physiographic features and the interaction between the main "drivers" of water quality. Chemical analysis of precipitation, soil, soil water and ground and surface waters was used to determine the drivers. These have been identified as: precipitation source; recharge mechanism; geology and soil age/parent material composition and finally soil and aquifer redox characteristics. This study was approached in two different ways. Firstly a "Bottom Up" approach, which is based upon a large hydro-biogeochemical and isotopic dataset (26,615 samples) and aims to let the water tell the story of its evolution. The hydrochemical data were complimented by a strong conceptual understanding of the physical hydrology and hydrogeology developed over the last 20 years by staff at the Southland Regional Council. Secondly, the "Bottom Up" approach was complimented by a "Top Down" approach to mapping the units spatially. This involved using soil, geological, hydrological and topographical information to generate mapping rules that could be applied in an objective manner to classify Southland into 9 unique "Physiographic Zones" whilst adhering to the results of the "Bottom Up" approach. The mapped zones are to be used within a planning framework as a way of developing plans that are targeted and relevant to the specific zones and water quality concerns within these zones.

TRANSFER PATHWAYS – NEW RESEARCH TO IMPROVE CONTAMINANT TRANSFER UNDERSTANDING

Roland Stenger[1], S R Wilson[1], G F Barkle[2], M E Close[3], S J R Woodward[1], L F Burbery[3], L Pang[3], J Rekker[1], Th Wöhling[1,4], J C Clague[1], R McDowell[5], S Thomas[6], B Clothier[6],L Lilburne[7] and B Miller[1]

[1]Lincoln Agritech Ltd, [2]Aqualinc Research Ltd, [3]Environmental Science and Research, [4]Technische Universität Dresden, [5]AgResearch Ltd, [6]Plant and Food Research Ltd, [7]Landcare Research Ltd

Land use (source) can only be defensibly linked to an effect on a receiving water body (recipient) if the critical transfer pathways and the hydrological and biogeochemical processes that occur along them are understood. Depending on the natural setting of the catchment and the contaminant concerned, surface runoff, interflow, artificial drainage, shallow and deep groundwater may be critical pathways. The time it takes a contaminant to move from source to recipient ('lag time') is one of the key hydrological characteristics of each transfer pathway. Amongst the biogeochemical processes, those that result in contaminant attenuation (e.g. denitrification of nitrate) are of greatest relevance. Failing to explicitly consider both types of processes concurrently will inevitably result in poor contaminant transfer understanding. For example, the effects of long lag times can easily be misinterpreted as indication of high attenuation rates and vice versa.

The Transfer Pathways Programme, which was successful in the MBIE 2015 investment round, has therefore been developed to quantify pathway-specific transfers of nitrogen (N) and phosphorus (P) that take lag times and attenuation potentials of the different pathways into account. The multi-disciplinary research team will be working closely with industry (DairyNZ) and council partners (Waikato Regional Council, Environment Canterbury, Marlborough District Council), as well as iwi on achieving the programme's aims.

By 2018 we will have established how N and P transfer is partitioned across the pathways relevant in four case study areas (Wairau Aquifer, Ashley-Waimakariri, Upper Waikato, Hauraki). A catchment typology scheme will facilitate the application of transfer pathway understanding in other, less well studied catchments. Concurrently, we will apply an iterative modelling framework to integrate existing data of different types and quality, identify knowledge gaps, characterise and quantify fluxes, analyse uncertainty, and ultimately derive simplified models for management purposes.

The research will help to maximise economic outcomes on the land while achieving the water quality targets mandated by the community.

CONSIDERING SMALL BLOCKS IN CATCHMENT NITROGEN ALLOCATION

Simon Park[1], Maggie Hope[1] and Alastair MacCormick[2]

[1]Landconnect Ltd; [2]Bay of Plenty Regional Council
Email: Simon.Park@xtra.co.nz

Large reductions in nitrogen (N) losses from rural land are needed to meet Lake Rotorua's sustainable N load target of 435 tonnes by 2032. New rules have been developed which allocate N to all rural properties in the catchment, in addition to establishing an incentives scheme and engineering actions to achieve the N target.

There are about 1400 small rural blocks under 40 ha in the Lake Rotorua catchment and about 160 rural properties over 40 ha. Conversely, the aggregate N contribution to the lake from small blocks is far less (~10%) than from large farms due to smaller aggregate area and generally smaller per hectare losses (except for septic tank "point source" N losses). The small block sector is a diverse group of landowners, from lifestylers seeking a quiet rural experience on the outskirts of Rotorua city, to commercially-focused drystock grazing enterprises.

There has been considerable political debate on the fairness and effectiveness of the new N rules, especially for small block owners in the Lake Rotorua catchment. This paper will describe catchment small blocks (0-40 ha) in terms of area, land use, valuation and economic activity.

The new rules will generally require reductions in N loss rates relative to losses that occurred between 2001 and 2004. While 2001-2004 OVERSEER-based "Rule 11" assessments were completed for almost all properties over 40 ha, relatively few properties under 40 ha were assessed. While not necessarily representative, this small block Rule 11 dataset enabled qualified predictions to be made of the potential N reductions expected from small blocks under the new rules. This analysis recently informed policy discussion on pragmatic permitted activity thresholds for small blocks in the Lake Rotorua catchment.

The practical implications for small blocks will be discussed, including the use of OVERSEER, stocking rate tables and compliance requirements. Broader comment is made on small block owner input to policy development and the communication challenges associated with a large and diverse group of landowners.

CHANGES IN WATER QUALITY THROUGH A CONSTRUCTED WETLAND ON A WAIRARAPA DAIRY FARM – NUMBERS FROM THE FARM

John-Paul Praat[1], James Sukias[2] Aidan Bichan[3] and Tony Faulkner[4]

[1]Groundtruth Ltd, Te Awamutu
[2]NIWA, Hamilton
[3]Kaiwaiwai Dairies Ltd
[4]Greater Wellington Regional Council, Masterton

A constructed wetland was installed on a Wairarapa dairy farm in October 2014. The wetland features a serpentine flow at three levels in the landscape and has a permanent metered inflow and is planted with native aquatic plants. As such it demonstrates an ideal design as described by the Overseer® wetland module. The quality of the water entering and leaving the wetland has been monitored on a monthly basis since February 2015. The quantity of Nitrate-Nitrogen and Total nitrogen leaving the farm has been reduced. This water quality benefit is estimated to reduce leaching value for the farm from 14 down to 13 kg N/ha/yr which equates to a reduction of around 7% for an investment of at least $55000. Measured data from the wetland will be compared with values predicted by Overseer to improve the level of knowledge on the performance of this nutrient loss mitigation technique.

ORGANIC NO-TILL CROP ESTABLISHMENT

– EARLY PROGRESS IN NEW ZEALAND

John-Paul Praat[1] and Sarel Jacobs[2]

[1] *Groundtruth Ltd, Te Awamutu*
[2] *Cameron Family Farm, Featherston*

There is a tension between no-till and organic cropping. On one hand no-till relies on herbicides to control weeds but looks after soil structure and soil life (micro-organisms) whereas organic cropping relies on cultivation to control weeds but destroys soil structure, kills earthworms and other soil biota, burns up soil organic matter (carbon) and uses more diesel. Several technologies have been brought together on a South Wairarapa Farm which provide an opportunity for a significant change and offer a solution for this tension.

Linseed and Hemp crops have been established by no-till (direct drilling) into a crimp-rolled ryecorn cover crop. The quality of crop established achieved has been encouraging and have indicated some key considerations. These considerations include the nature of the cover crop and evidence that preparation and planning in the previous season is likely to determine success in the current season.

FUTURE REQUIREMENTS FOR SOIL MANAGEMENT IN NEW ZEALAND

Alec Mackay[1], Alison Collins[2] and Gerald Rys[3]

[1]*AgResearch, Palmerston North*
[2]*Landcare Research, Palmerston North*
[3]*Ministry for Primary Industries, Wellington*

A review commissioned by the Ministry for Primary Industries identifies the most significant pressures on the soil resource result from:

- Intensification: the addition of more chemicals, irrigation and inadequate vegetation cover
- Land use change: fragmentation and urban expansion, as well as poor matching of land use to inherent capacity
- Legacy: impact of past deforestation and pests and diseases.

These pressures result in a range of proximal (effect on soil stocks including availability and condition) and distal (effect of the loss of soil function on the condition of other resources) impacts. The scale (national, regional or local) and magnitude (high, medium or low) of these impacts varies according to the ability to mitigate or reverse the impact and the social acceptability of impacts.

To address these pressures and impacts will require appropriate capability within and outside of the science system. This readiness will also require addressing significant gaps in coverage, scale or utility of nationally-agreed underpinning resource information and ensuring it is easily accessible to a range of users.

The study also reveals:

- Complexity in the governance of soil in New Zealand, reflecting ownership and iwi and the involvement of a diverse range of organizations, sectors and individuals in decision-making
- That while the primary sector practises a number of soil management approaches to address these pressure, it is difficult to determine their effectiveness
- Greater attention is needed within our policy and planning framework to protect soil functional capacity, reduce the fragmentation of land and loss of versatile soils. This includes the development of regulatory and non-regulatory measures to ensure the full range of services provided by soils is sustained into the future.

As a result of this study a *National Soil Management Group* is to be established and work towards the development of Aotearoa's Living Soil Action Plan. The Action Plan will incorporate the recommendations of this study to unlock and realise the full potential of New Zealand's soils.

WHAT DIFFERENCE DOES DETAILED SOIL MAPPING INFORMATION MAKE? A CANTERBURY CASE STUDY

James Barringer[1], Linda Lilburne[1*], Sam Carrick[1] and Val Snow[2]

[1]*Landcare Research, Lincoln, New Zealand*
[2]*AgResearch, Lincoln, New Zealand*
**Corresponding author Email: LilburneL@landcareresearch.co.nz*

This study is based on 120 hectare farm on the Canterbury Plains. We compare soil maps and soil data from:

- the Fundamental Soils Layer (FSL – https://lris.scinfo.org.nz /layer/137-fsl-south-island-all-attributes/);
- S-map (http://smap.landcareresearch.co.nz/);
- a detailed farm-scale soil series map at approximately 1:10,000 scale, and
- S-map sibling data associated with a survey of 723 auger holes across the farm.

Auger holes were on an approximate grid with 40 metre separation (approximately 7 auger holes/hectare). For comparative purposes the soil series identified in the FSLs and farm-scale soil maps have been recorded in the S-map database as siblings. At the different map scales the study area is represented by: four soil siblings in the FSL; by 12 soil siblings in S-map (7 dominant and 5 subdominant soil siblings across the map units); by 9 soil siblings in the farm-scale map; and by over 200 different soil siblings in the auger dataset. Different interpolations of soil properties were also generated, each using different sub-samples of the auger dataset, to visualise variation in representation of soils with different auger sampling densities.

The auger points give an idea of the variability in texture, horizon thickness, and depth to stones within a single S-map sibling, as well as within soil mapunits from different scales. The impact of this spatial variability on estimates of profile available water, drainage and nutrient losses from each soil mapunit, farm block and whole farm is determined and graphed. We also discuss the different costs of soil sampling and mapping at each scale, along with some general recommendations.

FINE TUNING THE FARM PLAN: SOME REAL WORLD EXAMPLES OF PUTTING POLICY INTO PRACTICE

Colin Stace

Opus International Consultants, Napier

Over the last twenty years issues arising from farm nutrient discharge to waterways has driven a substantial body of research in New Zealand, along with a raft of national and regional policy for protecting and improving surface water quality. An extensive and assorted box of management tools has been produced and continues to be developed. Application of the toolbox in the variability of real world situations requires an element of translation, and what ultimately results on the farm is likely to be a pragmatic combination of policy and tools, site conditions, advisory know-how and prevailing farm management.

The Farm Plan continues to serve as a primary mechanism for delivery of Regional Policy at farm scale. The contemporary farm plan addresses nutrient budgeting and fertiliser management, critical source areas (CSAs) for potential P discharge and best-practice waterway management. For regional council staff and consultants delivering farm plan advice the challenge is to build a property-based programme that will satisfy policy and comply with Regional rules as required, while proving the landowner with practical and meaningful options.

While components such as nutrient budgeting are generally addressed ‘at the kitchen table’, and/or in consultation with the landowners fertiliser advisor, field inspection is required to assess CSA and waterway risks and management options. Broadly, CSA assessment is based around surface drainage pattern, soil disturbance levels and soil characteristics. Waterway evaluation focusses on sediment/particular P discharge risk related to waterway connectivity, farm management practice and best-fit solutions for specific site conditions.

Examples are drawn from advisory field inspections to illustrate end user application (and interpretation of) research and policy, to identify and develop appropriate management options for CSAs, waterway and riparian issues and erosion risk. Farm plan solutions to meet Regional policy and rules include on-ground works and specified management practices, and are underpinned by targeted recommendations and information resources to support on-going landowner adaption.

BRIDGING THE RIPARIAN DIVIDE: ONLINE RIPARIAN MANAGEMENT PLANS FOR ALL DAIRY FARMS IN NEW ZEALAND

Nicola McHaffie, Matt Highway, Tom Stephens, Sarah Bowler Margaret Watts, Tom Cuthill and Nick Spencer

DairyNZ, Hamilton

Under the Sustainable Dairying: Water Accord all dairy farms in New Zealand need a riparian management plan by 2020. To support this target Landcare Research and DairyNZ, with input from farmers, rural professionals, regional councils and academic experts, have developed the "Riparian Planner" – a flexible, user-driven and comprehensive online tool to automate and regionalise farm plans.

Barriers to successful riparian management on-farm include a lack of planning tools and support as well as insufficient understanding of what actions to pursue, where, in what order and over what timeframe. When used alongside DairyNZ and regional council resources, the Riparian Planner will help minimise these barriers. At the heart of the Riparian Planner is the farmer making informed decisions on merit and cost.

In this presentation, you will be taken through the journey of successful riparian planning with the Riparian Planner, ahead of its release this year. You will be introduced to the four-step process for riparian planning: (1) map out and describe waterways or wetlands; (2) plan actions, including planting and weed control; (3) cost actions over a reasonable timeframe; and (4) summarise these in a farmer-friendly plan.

The Riparian Planner uses intuitive geographic information system tools to capture waterway information and actions on a farm map. It is free and secure, enabling rural professionals and farmers to revisit, review or update any plan. This flexibility helps future proof farm plans should changes to the farm, regional policy, or environment occur.

The Riparian Planner improves planning by breaking riparian management down into achievable, farmer-agreed actions. While water quality problems are complex, the Riparian Planner simplifies and speeds up the process of effective riparian management on-farm. The Riparian Planner is a valuable new tool for riparian management planning and will help dairy farmers and the industry to achieve the Sustainable Dairying: Water Accord.

TREATMENTS AND SIDE EFFECTS:

SUBSTITUTING ONE LOSS FOR ANOTHER

Brendan Powell

Hawkes Bay Regional Council, Napier

Some of the strategies that have been suggested to manage nutrient losses to water, have involved shifting an activity from one place to another. An example of this is off-farm stock wintering for N management. Are these sorts of strategies solutions, or do they shift problems to another place, or transform one problem into a different one to be dealt with in the future?

This paper will discuss these issues in relation to the example of use of stony soils for feedlots and intensive wintering.

Past research efforts by CRIs and communication efforts by regional councils drew attention to the need to protect vulnerable soils from pugging and associated structural damage. Pugging damage reduced productivity and led to sediment runoff to streams. These risks are high in winter when soils are more likely to be waterlogged.

Many farmers have identified areas of stony soils, or river gravel areas with little soil development as areas of value for intensive winter management of cattle. These offer alternative feeding areas to avoid pugging other more vulnerable areas of their farms. This has led to an increased use of these areas for growing winter crops and for use as feedlots. In feedlots, supplements are brought on to these areas and fed to cattle which are kept at high stocking rates (eg. 70 s.u./ha) for long periods.

In Southland alone, roughly 19, 000 to 25, 000ha of stony soils are estimated to be used for winter cropping. In Hawke’s Bay some areas have been identified in the Tukituki plan as priority sub-catchments due to elevated nutrient levels. Winter feedlot operations in these sub-catchments have been identified as potential critical source areas for P and N loss, but tools to quantify these losses are not available.

LIME ENHANCES DENITRIFICATION RATE AND DENITRIFIER GENE ABUNDANCE IN PASTURE SOILS TREATED WITH URINE AND URINE + DCD

Neha Jha[1], Thilak Palmada[1], Peter Berben[1], Surinder Saggar[1], Jiafa Luo[2] and Andrew M S McMillan[1]

[1]Ecosystems and Global Change, Landcare Research, Palmerston North
[2]AgResearch, Hamilton

Denitrification is one of the major soil processes that produce nitrous oxide (N_2O) in grazed pastures. Year-round grazing, animal excretion, heavy rainfall, and the use of nitrogen fertilizers lead to high denitrification rates in grazed pastures. Complete denitrification produces harmless dinitrogen (N_2) as its end product, whereas N_2O is produced by incomplete denitrification as a potent greenhouse and ozone-depleting gas. Soil pH is one of the key factors controlling denitrification end-products. Soil pH below 6.5 leads to higher N_2O emissions than N_2. Liming of soils to raise its pH and enhance denitrification activity has therefore been suggested to reduce N_2O to N_2. Application of the nitrification inhibitor dicyandiamide (DCD) to urine-affected soils offers another mitigation strategy to reduce N_2O production from soils.

We incubated two soils at three liming levels amended with deionised water only, water + cattle urine (600 mg-N kg^{-1} soil), and water + cattle urine (600 mg-N kg^{-1} soil) + DCD (10 mg kg^{-1} soil) at saturated soil water content, at 10°C and 15°C, for 42 days. We tested the influence of liming-induced pH increase on denitrification and denitrifier gene abundance in amended soils.

We observed higher denitrifier gene abundance in the lime-applied soils than in the soils where no lime was applied. We did not find any significant change in the denitrifier gene abundance with either of the urine amendments in two soils. The addition of urine along with water increased cumulative N_2O-emissions and denitrification in soils, and these increases were higher in the urine-amended limed soil than the urine amended un-limed soils. DCD with urine reduced cumulative N_2O emission (62% for allophanic soil and 48% for fluvial soil at 15°C) and denitrification (48% for allophanic soil and 40% for fluvial soil at 15°C) in urine-amended limed soil. These reductions were either low or not significantly different among liming treatments when soils were incubated at 10°C. Our results indicate liming could offer a mitigation option to increase denitrifier population in soils and reduce N_2O production from grazed pasture soils.

ASSESSING THE RELATIONSHIP BETWEEN SOIL TOTAL RECOVERABLE Cu AND Zn STATUS AND SOIL UREASE ACTIVITY OF DAIRY-GRAZED PASTURE SOILS

Kamal Adhikari[1], Matthew Taylor[2], Surinder Saggar[1, 3], James Hanly[1] and Danilo Guinto[4]

[1]Soil & Earth Sciences Group, Institute of Agriculture and Environment, Massey University, Palmerston North
[2]Waikato Regional Council, Private Bag 3038, Hamilton
[3]Ecosystems & Global Change, Landcare Research, Palmerston North
[4]Ballance Agri-Nutrients Limited, Tauranga
Email: Kamal.Adhikari.1@uni.massey.ac.nz

Intensification of dairy farming in New Zealand over the last three decades has resulted in a substantial increase in use of urea nitrogen (N) fertiliser and, as a consequence, higher ammonia (NH_3) emissions. The annual loss of NH_3 is estimated to be worth about $30 million (Ballance Agri-Nutrients; Press Release 31 March 2015). The urease inhibitor, N-(n-butyl) thiophosphoric triamide (nBTPT)) sold under the trade name Agrotain® is one of the more promising approaches for reducing NH_3 emissions by inhibiting soil urease activity when applied with urea fertiliser or cattle urine. However, nBTPT inhibition of soil urease activity and NH_3 emissions is short-lived (7-14 days) requiring repeated applications immediately after each grazing for effective reduction in NH_3 loss from urine spots. Micronutrients such as Cu and Zn also have potential to inhibit soil urease activity and reduce NH_3 emissions over a longer duration than nBTPT at concentrations within the normal range found on dairy farms.

Here, we present the results of preliminary investigations on inherent soil urease activity levels of 24 dairy farm soils from the Waikato region representing low, medium, high, and very high total acid recoverable Cu and Zn levels. We observed a significant positive correlation of urease activity with total soil carbon (C) levels. However, soil urease activity was not related to inherent soil total recoverable Cu and Zn levels. The lack of such a relationship is attributed to the inability of the acid recoverable Cu and Zn levels to adequately represent their bioavailability for microorganisms and plants. We propose the measurement of bioavailable Cu and Zn levels in future work to better understanding of relationship between soil urease activity and bioavailable Cu and Zn levels.

ACTIVATED CARBON'S ROLE IN CONVERTING NITROUS OXIDE TO NUTRIENTS

Gina Yukich, Sumaraj, Jing Qi and Lokesh P Padhye*

Dept of Civil and Environmental Engineering, University of Auckland
**Corresponding author Email: l.padhye@auckland.ac.nz*

The potential for enhanced nitrous oxide adsorption on activated carbon surfaces was explored through a range of secondary treatments and an adsorption experiment under nitrous oxide flow. Modification of activated carbon surface properties was carried out through liquid oxidant treatment (H_2O_2, HNO_3), standard heat treatment (800 °C, 600 °C), and microwave heat treatment, with characterisation of the surface properties using XPS, SEM, FT-IR, BET, and Boehm titration. Heat treatment caused the most drastic changes to surface morphology of the carbon, with graphitisation of carbon observed for the 800 °C treatment and an abnormal surface structure after microwave treatment. Liquid oxidant treatment caused decreasing microporosity to different degrees, alongside an increase in oxygen functional groups on the carbon surface. Nitric acid proved to be a stronger oxidant than hydrogen peroxide, with results showing a high acidity and no detectable basic groups on the surface after treatment. The XPS characterisation of the carbon surface before and after the adsorption experiment showed definite increases in the nitrogen content on all activated carbon samples, excluding that treated at 800 °C. The greatest surface nitrogen content after adsorption was viewed on the 600 °C treated sample and the nitric acid treated sample. The mechanisms behind nitrous oxide adsorption are therefore complex and related to both the surface texture and area, and the chemical nature of the surface functional groups on activated carbon. Based on our previous published work, we hypothesize that adsorbed nitrous oxide is converted to nitrite and nitrate through hydroxylamine pathway. Further work to prove this hypothesis is underway in our laboratory.

NITROUS OXIDE EMISSIONS DURING FORAGE BRASSICA CROPPING AND GRAZING

B Carlson, J Luo, B Wise and S Ledgard

AgResearch, Ruakura Research Centre, Private Bag 3123, Hamilton, New Zealand

The objectives of this study were to conduct field measurements of changes in nitrous oxide (N_2O) emissions through various stages during the establishment and utilisation of a forage rape (Brassica *napus* subspecies *biennis*) crop on land that had been in permanent pasture. This work was carried out on a free-draining volcanic soil at the former Ruakura Number 1 Dairy Research Farm, Hamilton. This research provides field data for use in system models for the New Zealand situation.

N_2O emissions during the establishment, growth and management of the forage rape crop, followed by re-establishment of permanent pasture by direct-drilling, were evaluated and compared with that from established permanent pasture. Treatments on the rape and pasture plots were nitrogen (N) fertiliser application (0 versus 80 kg N ha^{-1}) and management (grazing versus cutting).

N_2O emissions were measured using a closed chamber technique.

Production of a forage rape crop resulted in higher N_2O emissions compared with leaving the area in pasture. The total N_2O emission from the forage rape, including fertiliser and grazing, was 5.59 kg N_2O-N ha^{-1} over the 10 month measurement period. This compares with 0.64 kg N_2O-N ha^{-1} from the adjacent fertilised and grazed permanent pasture over the same period.

Application of urea-N at 80 kg N ha^{-1} on the forage rape crop significantly ($P<0.05$) increased the N_2O emissions from 0.45 kg N_2O-N ha^{-1} to 1.45 kg N_2O-N ha^{-1}. Application of urea-N on the permanent pasture increased the N_2O emissions from 0.14 kg N_2O-N ha^{-1} to 0.21 kg N_2O-N ha^{-1}, but this increase was not statistically significant ($P>0.05$).

Grazing of the forage rape or the permanent pasture significantly ($P<0.05$) increased total N_2O emissions, compared with those from the ungrazed forage rape or pasture controls. The largest contribution to the difference in the amounts of N_2O produced was from the 6 weeks following the grazing of the forage rape.

NITROUS OXIDE EMISSIONS FROM ANIMAL EXCRETA DEPOSITED ON HILL COUNTRY SLOPES

B Carlson, J Luo and B Wise

AgResearch, Ruakura Research Centre, Private Bag 3123, Hamilton, New Zealand

The objectives of this study were to conduct field measurements of nitrous oxide (N_2O) emissions caused by deposition of sheep and beef cattle dung and urine on hill country pasture. This work was carried out on a free-draining volcanic soil at the Whatawhata Research Farm in the Waikato region as part of a series of field trials nationwide conducted in 2014 and 2015. This research provides field data to determine background N_2O emissions and emission factors (EF_3, % of the applied excreta N emitted as N_2O) for animal excreta deposited in the autumn-winter on steep (>25^o) and moderate(12-25^o) slopes . N_2O flux measurements were made using a closed chamber technique.

N_2O fluxes from controls on both medium and steep slopes were less than 0.55 mg N_2O-N m^2 hr^{-1} through the four month (winter/early spring) measurement period. Greater variability in background emissions was exhibited on the steep slopes than on the medium slopes. There was a slight trend for higher total background N_2O emissions from medium (0.035 kg N_2O ha^{-1}) compared to steep slope areas (0.021 kg N_2O ha^{-1}), but the difference was not significant (P>0.05).

Application of either animal urine or dung increased N_2O fluxes, but the patterns and magnitudes of the increases were not consistent between excreta types and slope classes. Changes in the fluxes were not significantly correlated to changes in soil moisture levels, mineral nitrogen (N) concentrations or temperature. EF_3 for all excreta types were generally very low, with the averages being less than 0.3% for urine and dung sources, and highly variable. There was a trend for higher EF_3 values on the medium slope than on the steep slope, with beef cattle dung on the medium slope having the highest EF_3 value and sheep dung on the steep slope having the lowest EF_3 value. There was no relationship between EF_3 and soil properties, including soil Olsen P, moisture and mineral nitrogen levels. The EF_3 values in the hill country appear to be affected by a complex range of physical and biological factors.

DEVELOPMENT OF MEASUREMENT PROTOCOLS FOR IDENTIFYING AMMONIA VOLATILIZATION LOSSES FROM THE HYBRID GRAZING/STANDOFF SYSTEMS BEING DEVELOPED IN NEW ZEALAND

Khadija Malik, P Bishop, S Saggar and M Hedley

Institute of Agriculture and Environment, Massey University

Dairy industry intensification in some areas of NZ has led to increased N loss to water. Practising duration controlled grazing, using hybrid grazing- temporary housing systems, is capable of reducing urinary load to paddocks and N loss to water. There is concern that ammonium-N losses to atmosphere during housing, manure storage and re-application to pasture simply results in pollution swapping i.e. increasing the greenhouse gas emission footprint of dairying. Methods that are appropriate for measuring ammonia losses in the hybrid grazing (housing) systems have been developed and are discussed with respect to the characteristics of the source and emission surface, namely: i) deposition of urine and dung on the floor ii) transfer to the collection channel iii) storage pond and finally iv) the reapplication of the manure to the land. The respective methods involve i) in situ chambers (Static with acidified filter paper trap or 7L dynamic chambers connected to compressed air and 0.05M H_2SO_4 acid traps) ii) 8 L ammonia sampling bag technique iii) and (iv) combination of Sonic anemometers (to measure wind speed and direction in the barn and field) and acid scrubbers (by using aquarium pumps and 0.5 M H_2SO_4 acid traps) positioned on masts. The efficiency of ammonia recovery or measurement is reported for all methods.

CHALLENGES FACED BY HILL COUNTRY FARMERS IN NEW ZEALAND – THE CURRENT ISSUES, THE STATE OF RESEARCH AND WHAT THE FUTURE MAY HOLD

Nathan Heath

Hawkes Bay Regional Council, Napier

I have this nostalgic image of an oil-skin clad farmer, riding their horse, with a team of dogs, moving old ewes bound for the local works, off an eroded gully with Ponga's in the base and an easterly drizzle in their face. For me, this epitomises what hill country farming used to be about.

In essence, man, animal, land, climate and market in an intimate systemic relationship.

Today this image and identity is increasingly challenged by emerging and compounding factors that make these systems more complex and volatile: globalised markets; a changing climate; increased community expectations for stewardship of natural capital; the health, safety and welfare of people; food and animals, and; of particular interest to this conference, freshwater reforms.

There has been considerable emphasis in New Zealand on the deterioration of freshwater quality as a result of intensive land uses. The response to this has been an approach that seeks certainty through the achievement of water quality limits over specific timeframes. This is often prescribed with limited information, tools and engagement with those most affected.

The process that drives this is largely adversarial, with national issues and arguments around the trade-offs between the environment and economy fought out at a local scale.

This can lead to a disconnect between what is desired through plans and policy and what is actually possible in practice.

The ability to adapt to change in hill country farming is influenced by a significantly different range of natural, social, human, financial and infrastructural capitals than that of the more intensively farmed parts of the landscape.

A different approach to natural resource management is required in hill country, one that is more in tune with the realities of change, the need to be adaptive, and also considers the needs of our communities that depend on hill country for their livelihoods and wellbeing.

COMPARING NUTRIENT LOSS PREDICTIONS USING OVERSEER AND STREAM WATER QUALITY IN A HILL COUNTRY SUB-CATCHMENT

Lucy Burkitt, Mike Bretherton and Ranvir Singh

Fertilizer and Lime Research Centre, Massey University
Email: L.Burkitt@massey.ac.nz

Hill country represents a significant proportion of our water catchment areas, particularly in the Manawatu region (75%). Soil and nutrient management in pastoral hill country plays a vital role in the management and mitigation of water quality impacts. Improving our understanding of nutrient loss and nutrient attenuation in pastoral hill country will be essential in assisting beef and sheep farmers adapt to inevitable nutrient loss restrictions in the future. However, there is currently very limited monitoring and quantification of nutrient loss and its potential attenuation in pastoral hill country catchments.

We have established an ongoing water quality study, monitoring nutrient and sediment loads in selected streams and a seepage wetland, on the Massey University Agricultural Experimental Station at Tuapaka, Palmerston North. The largest area currently being monitored is an 84.7 ha sub-catchment, which incorporates both rolling and steep hill terrain, a number of seepage wetlands, and a range of different soil types. Detailed Overseer modelling of this sub-catchment has been undertaken and nutrient loads estimated using monitored stream flow and water quality. These findings, along with a comparison of historic (1976) nutrient loss data measured from a larger catchment on the same farm, will be presented and discussed.

FACTORING IN SOIL WATER REPELLENCY IN A HILL SLOPE SOIL WATER BALANCE MODEL

Mike Bretherton, Dave Scotter, Dave Horne and Mike Hedley

Fertilizer & Lime Research Centre, Massey University

The incidence of soil water repellency (SWR) in New Zealand hill country (particularly on the North Island East Coast) increases the potential for runoff during the late spring through to late autumn seasons, thereby reducing the effective rainfall depth for pasture growth.

A modified soil water balance model for sloping land incorporating the infiltration restrictions imposed by SWR is presented. Detailed rainfall and runoff data collected at Alfredton in northern Wairarapa were used to develop a 2-tier daily soil water balance model - the first tier incorporating the top 50 mm soil layer, and the second tier incorporating the whole root zone. The reference crop evaporation was estimated using the FAO56 version of the Penman-Monteith equation after incoming solar radiation had been adjusted for slope and aspect. Repellency-induced runoff is only simulated to occur if two conditions are satisfied:

1) The top 50 mm soil layer is drier than a certain trigger water content value, and
2) The rainfall intensity is greater than a certain threshold value.

The model's input variables and shortcomings associated with SWR are discussed and the outputs matched against stream flow data gathered from a catchment near Waipawa in southern Hawkes Bay.

Some suggested uses of the model in terms of the management of SWR are presented.

BRINGING FERTILISER APPLICATION INTO THE 21ST CENTURY

Ian Yule and Miles Grafton

NZ Centre for Precision Agriculture, Massey University

Ten years ago it was pointed out that "Field CV" that for both aircraft and ground spreaders was significantly worse than the "Tested CV". This tested CV is the result of a transverse spread pattern test conducted under controlled conditions used to determine bout width to attain minimum standards of spread pattern uniformity. There was a big misconception that somehow the tested CV's were transposed to field performance, indeed in the majority of agronomic studies assume perfectly uniform spreading which is unobtainable. This led to a lack of interest in this matter. The advent of GPS and GIS helped researchers measure "Field CV" and results for ground spread equipment from around the world have been fairly consistent, that "Field CV" is around double the "Test CV". Results obtained by the authors have shown that aircraft "Field CV" is higher. These factors create far greater economic loss from uneven spreading than previously imagined and underline the fact that achieving targeted variable rate application to achieve precision agriculture was a forlorn hope.

The last decade has seen considerable advances in both ground spread equipment and aerial topdressing to a point where considering targeted and variable rate application is now a realisable goal.

What we need to turn our attention to now is how we can apply the principles of precision agriculture to fertilising our hill country in an appropriate way in order to achieve greater efficiencies, and achieve improved financial and environmental goals. Historically it has always been difficult or too labour intensive and expensive to gather sufficient data from this sector to make informed decisions. The advent of improved information gathering through remote sensing technology of both spatial and temporal information has the potential to better inform our nutrient management strategies. We now have the necessary equipment to deliver the right product to the right place at the right rate at the right time. Earlier financial studies indicated that this technology could benefit an under pressure hill country sector.

IMPROVING AERIAL TOPDRESSING IN NEW ZEALAND THROUGH PARTICLE BALLISTICS MODELLING AND ACCURACY TRIALS

Sue Chok[1], M Grafton[1], I Yule[1], M White[2] and M Manning[2]

[1]*New Zealand Centre for Precision Agriculture, Massey University*
[2]*Ravensdown Limited, New Zealand*

Fixed wing aircraft are utilised in New Zealand to apply dry bulk fertiliser on hill country farms. The fertiliser is most often applied manually as a blanket rate over the entire farm. Previous study indicates that this yields a field application coefficient of variation (CV), which is the standard deviation over the mean application rate, of 63 – 70%. The CV decreased to 44% when the hopper door was automatically controlled using aircraft installed global positioning system (GPS) in lieu of manual intervention by the pilot. This is comparable to fertiliser application by fully GPS enabled truck spreaders. Spreadmark® specifies that the transverse overlap CV should be 15% for nitrogen-based fertilisers and 25% for all other products; however transverse overlap tested CV is considerably different to “Field CV”. Variation in aerial topdressing is a barrier to achieving these CV. These variables include wind conditions, topography, aircraft speed and fertiliser properties.

Ravensdown Limited is upgrading their topdressing aircraft fleet with differential rate application technology (DRAT), which uses the automated hopper door and GPS to apply various application rates over specified target areas within a farm. The advantage of this system is that fertiliser can be applied to these areas with the largest potential benefit in terms of increase pasture productivity and reduced environmental impact. Two trials utilising cone shaped collectors were carried out at coastal sheep and beef farms to determine the DRAT system’s accuracy when applying two application rates. Proof of release maps, which is deduced from aircraft recorded data, showed the system was able to vary rate. The CV ranged between 34% and 56%. The CV can be further improved by using a granular fertiliser ballistics model that predicts the transverse and longitudinal spread patterns based on wind conditions, fertiliser properties and aircraft operation. Validation data for this model was collected in validation trials for superphosphate, urea and di-ammonium phosphate. A validated model can provide guidelines on the optimum conditions and settings for aerial topdressing.

IDENTIFYING GRASS SPECIES USING HYPERSPECTRAL SENSING

Tommy Cushnahan, I J Yule, R Pullanagari and M Grafton

New Zealand Centre for Precision Agriculture, Massey University

Current hill farming practices rely on the skill of the farmer and previous experience to guide key elements of the operation such as stocking rates. The use of remotely sensed hyperspectral data raises the possibility to reduce some of the guesswork from the system by identifying pasture species being farmed and use that information to raise net returns. The diurnal and seasonal variations in plant reflectance were investigated using hyperspectral proximal sensing, this paper examines if these techniques were sufficiently robust to be practically useful.

The primary difficulty in application of remote sensing technology to the hill farm environment is the potential spatial and temporal variability of species in different regions of New Zealand. Monoculture plots of a number of turf species were used to ascertain the level of daily and seasonal variability within the species groups and to investigate how it might impact species identification.
Data was collected from the plots using an ASD FieldSpec® with CAPP over a one year period. The species on the chosen plots were monocultures of 7 species with different cultivars for two species. Linear discriminant analysis (LDA) and partial least squares regression (PLSR) were carried out on the full spectrum data.

A U-Test was used to identify the most effective bands to use where data reduction was necessary; however where data processing is less limited the optimum number of band s for discrimination was identified. Where the instrument collecting the data is not limited there is an advantage in using a larger number of wave bands. In this experiment it was found that including up to 400 wavebands over the VIS/NIR SWIR range was useful.

The techniques used were successful in identifying the grass species with a high level of accuracy. The diurnal changes within the plants were clearly detectable by LDA although they did not affect the ability to discriminate between species.

ASSESSING THE SIGNIFICANCE OF CADMIUM IN NEW ZEALAND AGRICULTURAL SYSTEMS – PRELIMINARY RESULTS

Jo-Anne E Cavanagh[1], Kiran Munir[1], Colin Gray[2], Steven Wakelin[2], Okafor Chioma[3], Jeya Jeyakumar[3], Chris Anderson[3], Shamim Al Mamun[4] and Brett Robinson[4]

[1]Landcare Research,Christchurch
[2]AgResearch, Hamilton
[3]Fertilizer and Lime Research Centre,Massey University
[4]Lincoln University, Canterbury

The New Zealand economy relies heavily on the primary production sector and the use of phosphate fertilisers. Cadmium (Cd) occurs naturally in the phosphate rock used to produce phosphate fertilisers and is present in fertiliser at varying levels. A preliminary assessment of the significance of soil Cd concentrations in New Zealand agriculture was undertaken by assessing the uptake of Cd in economically important cultivars of wheat, potatoes, onions and leafy green vegetables and important pasture and forage crops, and assessing effects on soil rhizobia. Crop species, cultivar and soil properties were all shown to affect Cd uptake in the crops and pasture investigated. Within a species, the relative order of Cd uptake by individual cultivars was often not consistent between different sites, suggesting an interaction between Cd uptake by an individual cultivar and soil properties. The relative significance of Cd at a given site was assessed using a plant uptake factor (PUF), which is the ratio of plant Cd concentration: soil Cd concentration. The PUF varied between sites and between different crops, with sites with low soil Cd concentrations often having a higher PUF (i.e. plants take up a greater proportion of the soil Cd) for a given crop in the range of soils tested. This indicates that soil Cd concentration alone is not sufficient to assess the risk of non-compliance with food standards of agricultural crops. Taking current soil Cd concentrations into account and using the measured PUFs, for the soils tested, a 1.3- to 2-fold increase and >2.5-fold increase in current soil Cd concentrations were suggested to potentially lead to non-compliance with food standards for wheat and other crops respectively – assuming soil properties do not change. Potential effects on pasture productivity and quality were indicated by effects of Cd on rhizobia and white clover being observed although this was at concentrations higher than current environmental concentrations. Compost addition to soil was demonstrated to reduce phytoavailable Cd and plant uptake of Cd in pot trials, providing a potential mitigation strategy.

DOES LAND APPLICATION OF DRILLING WASTE POSE A THREAT TO NEW ZEALAND AGRICULTURAL SYSTEMS?

Chioma MaryAnn Okafor, Paramsothy Jeyakumar and Christopher W N Anderson

Fertilizer and Lime Research Centre, Institute of Agriculture and Environment, Massey University Palmerston North New Zealand

Land application of drilling waste is a trending activity in Taranaki region New Zealand aimed towards a natural bioremediation of hydrocarbon-containing waste from oil exploration and production industry. The drilling muds are incorporated into re-shaped sand dunes and used for pasture growth. However, there is a rising concern from the public and dairy industries on potential heavy metal accumulation in soil and risk of transfer to food chain from land application of drilling waste. It was proposed that growing industrial hemp as a new and valuable commercial crop could provide an economic and sustainable environmental option for Taranaki landfarming.

This study investigates and compares heavy metal (Cd, Zn, Cu, Ni, and Co) accumulation in soil and their concentration in hemp and ryegrass from four different soil treatments comprising 100% drilling waste, landfarm-impacted soil, a 50:50mix of drilling waste and control soil, and control soil to determine potential threats of heavy metal from land application of drilling waste. Heavy metal concentrations measured in soil or waste treatments did not exceed the soil toxic limits. In addition, heavy metal concentration in hemp and ryegrass in all soil treatments were within tolerable limits for agronomic crops except for Zn, Cu and Co concentrations in some treatments. The Zn, Cu, and Co concentrations in hemp grown in 100% drilling waste were 145, 38 and 29 mg/kg, respectively. These concentrations in ryegrass were 129, 26, 24 mg/kg, respectively. There was no difference between heavy metal accumulation by hemp and ryegrass in landfarm-impacted soil and control soil. This suggests no benefit for hemp as a potential plant for phytoremediation in landfarm impacted soil. However, hemp as a non-food product with limited metal exposure pathways to animals could be planted at an early stage of landfarm, harvested and utilised for its fibre quality prior to pasture growth.

RECENT METHODOLOGY DEVELOPMENTS IN SOIL FLUORINE ANALYSIS

Paramsothy Jeyakumar and Christopher W N Anderson

Fertilizer and Lime Research Centre, Institute of Agriculture and Environment, Massey University, Palmerston North

New Zealand research into soil fluorine (F) has been hampered by lack of a reliable and simple test for soil F. The accuracy of different methods to quantify the presence of F in analytical preparations (soil extracts or solid-phase samples) is dependent on interfering elements such as the aluminium (Al) content of the sample; Al cations form very strong complexes with fluoride ions in acidic conditions. The routine analytical methodology of NaOH fusion is used to release F ions in the ion-selective electrode methodology. This technique is time consuming, expensive and is very dependent on the abilities of the operating technician. This technique is not ideal for environmental monitoring. We assessed the accuracy of several alterative techniques relative to the standard fusion protocol. We found that simple extraction of soil with dilute NaOH (4M) consistently reported 80% of the total soil F (measured by both in-house and international laboratories with fusion method) for allophanic soils. This soil order generally represents the soil order with the greatest history of build-up of soil F (and Cd) from superphosphate application as allophanic soils constitute much of New Zealand most fertile land. This paper discusses the further development in reliability of the NaOH extraction technique to quantify soil F, with specific focus on the relative accuracy of this technique between different soil orders.

PATHWAYS OF NITROGEN AND CARBON TRANSFORMATION IN SOILS AND WASTEWATER AS REVEALED BY MICROBIAL GENOMES: IMPLICATIONS FOR GREENHOUSE GAS EMISSIONS

Octavio Perez-Garcia and N Singhal

Dept. of Civil and Environmental Engineering, University of Auckland

This poster shows the combined use of omics technologies and computational analysis to decipher mechanisms of production of greenhouse gases in agricultural soils and wastewater systems. An analysis of microbial genomes suggests that over 25 enzymatic reactions can influence N_2O formation in these systems. Computational modelling allows us to explore how carbon and nitrogen inputs in farm soils and wastewater influence enzymatic reactions that affect greenhouse gas formation by microbes, in contrast to the "black box" approach traditionally adopted for such estimates. The analysis reveals that the biodegradability of soluble carbon sources as well as the profile of nitrifying and denitrifying microbial species significantly influence the rate of reactions producing N_2O. Also the analysis identifies carbon and nitrogen input strategies as well as target chemical reactions to reduce N_2O formation.

ACTIVATING BIOCATALYST PRODUCTION TO ENHANCE THE REMOVAL OF VETERINARIAN ANTIBIOTICS FROM WASTEWATER

Octavio Perez-Garcia and N Singhal

Dept. of Civil and Environmental Engineering, University of Auckland

Data around the world shows that antibiotics in farm and municipal wastewater are a serious ecotoxic threat to receiving water bodies. Here, preliminary results from a new treatment process to remove veterinary antibiotics (i.e. trimethoprim, sulfamethoxazole and tylosin) from wastewaters are presented. The treatment process focuses on degrading pharmaceuticals by controlling the production and activation of microbial peroxidases and glucosidases in dairy farm and municipal wastewater. Enzymes production induction is done by maintaining dissolved oxygen concentration low (at 0.5 0.1 mgDO/L) and adding hard to degrade organics (lignin) to wastewater sludge cultivated in laboratory sequential batch reactors. Dairy farm runoff is seen to contain microbial populations capable of consistently reducing antibiotics influent concentration by 60 to 90%. This is likely due to adaptation from prior exposure to the antibiotics in the farm run off environment.

WATER: THE WORLD’S MOST VALUABLE NATURAL ASSET

Brent Clothier

Plant & Food Research, Palmerston North

The soil and plant-based ecosystems which cloak the lands of our earth are the planet’s critical zones. They provide valuable ecosystem services. Through these soil and plant systems on the earth’s surface, there are massive fluxes and storages of mass and energy. These flows and storages provide valuable ecosystem goods and services. Water is the prime natural capital stock. Water is the world’s most valuable natural asset. We are vitally dependent on the myriad of ecosystem services that water delivers to us via our plants and soils.

There is only much water on earth as there was when the world began. Yet, there is far greater competition for it nowadays.

There is already great pressure of our water resources. Furthermore this is being exacerbated by the intensification of our primary production systems, rising population numbers, and climate change.

In thinking about the sustainability of our water resources, it is of heuristic value to consider the three water colours of green, blue and grey. Blue water is that which is in the surface bodies of our streams, rivers and lakes, along with that contained in our groundwater reserves. Green water comes from the rain that falls onto the earth’s surface and is stored there, either to be used by plants, evaporated from the soil surface, or drained through the vadose zone to receiving waters. Grey water is the water that leaves our soils with a changed quality due to dissolved or entrained substances, or it is that can be that which is discharged, with, or without, treatment from urban sites or industrial processes.

We outline the imperative to minimise abstraction from our blue water reserves such we seek to use this water to achieve the best outcome for the least use. Efficiency is a flawed metric when considering blue water use. Further, we need to ensure that we make the best use of our green water resources, and this is especially so for the developing world where there is not the infrastructure to enable the use of blue water. As for the grey water discharged as leachate from farms and orchards, we need to develop sustainable land-management practices to protect the quality of the water in our blue-water reserves. Where the grey water is discharged from cities or factories we need to ensure that its treatment enables its re-use. Examples of all of these are given.

GROWING IRRIGATED AGRICULTURE IN NEW ZEALAND

Andrew Curtis

Irrigation NZ, Christchurch

Irrigation development is critical to NZ agriculture. Climate change predictions and current weather events are driving the need for a reliable water supply for irrigation.

However, lower commodity prices are making short-term affordability challenging. Add to this the future uncertainty, but the likely increased investment required around farm nutrient management expectations, alongside the need for catchment scale environmental mitigation infrastructure to be developed in parallel, and life can become daunting for some.

So what's the answer? Drivers for uptake have never been greater, just ask a north Canterbury farmer whether he'd like water for irrigation at the farm gate – this is not the issue!

The challenge is overcoming uptake affordability issues and the associated financing challenges this can create for scheme development.

The reality is all new infrastructure pushes risk appetite to its limits. The question potential irrigators now ask is 'how am I going to intensify my farm system so I can service the increased debt whilst meet my future nutrient limits, when I'm not 100% sure what future expectations will be?'

Some of the answer lies in proponents better communicating the alternate futures. There's risk in a future with or without irrigation, the status quo today is not the status quo tomorrow, from both a regulatory and climatic perspective. You're going to be impacted which ever route you go down. Many don't understand this so there's a need for investment in this message.

There's also considerable investment required in the shareholder engagement process, to work through their opportunities and help narrow down feasible options. Despite this being a complex task, schemes, with support from the banking and other sectors, are starting to do a great job in this space.

For environmental infrastructure there's a need to better understand who is going to be responsible for it, what's the structure that's going to drive its investigation, development and operation, and importantly who is going to pay for it? A simple 'where do the benefits lie' will help determine this.

As for environmental limits, they are what they are. Most have become accepting that post the challenges of the plan process a successful future is about practice change, the clear articulation of Good Management Practice expectations and beyond.

EFFECTS OF IRRIGATION INTENSITY ON THE PREFERENTIAL TRANSPORT OF SOLUTES IN A STONY SOIL

Rogerio Cichota[1], Francis M Kelliher[1], Steve M Thomas[2], Gina Clemens[2], Patricia M Fraser[2] and Sam Carrick[3]

[1]AgResearch, Lincoln Research Centre, Lincoln, New Zealand
[2]Plant & Food Research -Lincoln, New Zealand
[3]Landcare Research, Lincoln, New Zealand

The use of irrigation has been increasing in New Zealand over the past 20 years; linked to the intensification of farming systems and particularly to the expansion of dairy farming. Most of the irrigated land is located in the South Island, the Canterbury region representing about 60% of the total area. The predominant irrigation system is the centre-pivot, considered an effective method for applying water uniformly. However, the instantaneous intensity of application varies considerably along its length, and by the end of the irrigation line it is far greater than that of typical rainfall. When irrigation intensity exceeds the soil infiltration capacity, water is likely to flow preferentially down cracks and large pores. If this occurs, the transport of solutes through the soil will involve only a fraction of pore space, increasing the rate of leaching. Determining this fraction is, therefore, crucial to evaluate the risk of leaching losses. Stony soils, considered vulnerable to nutrient leaching losses, are common in Canterbury and are present where most of the irrigation expansion is occurring.

To evaluate whether irrigation intensity has an effect on preferential solute flow in a stony soil, an experiment was performed at Lincoln using 12 steel-encased lysimeters with a Lismore Stony Silt Loam soil under two irrigation intensities, 5 and 20 mm/h. Drainage water was collected at regular intervals and the concentration in the leachate of two non-reactive tracers, bromide and chloride, was determined. The Burns' equation was then fitted to these data, to estimate the fraction of the soil's water involved in solute transport. The results from the chloride data indicate that irrigation intensity affects preferential solute transport and an exponential function can be used to describe this relationship. The data from bromide leaching suggest that antecedent soil moisture may also be important. Implications for management and further studies of nutrient leaching will be discussed.

IRRIGATION MANAGEMENT TO REDUCE NITROUS OXIDE EMISSIONS AND NITRATE LEACHING LOSSES

Steve Thomas[1], Iris Vogeler[2], Tony van der Weerden[3] and Sam Carrick[4]

[1]Plant and Food Research, Private Bag 4704, Christchurch 8140
[2]Agresearch, Ruakura Research Centre, Hamilton 3214
[3]Agresearch, Invermay Agricultural Centre, Private Bag 50034, Mosgiel 9053
[4]Landcare Research, P.O. Box 69040 Lincoln 7640

While the benefits of irrigation for dairy production are well established the environmental consequences are not well quantified. In particular how irrigation management practices affect losses of nitrous oxide (N_2O) to the atmosphere and nitrate (NO_3) to groundwater.

We used the APSIM (Agricultural Production Systems Simulator) model to simulate the effect of six different irrigation management scenarios on N_2O emissions from urine patches and non-urine areas on pasture of three different soil types. These were deep poorly drained (Otokia), deep well drained (Templeton) and shallow well drained (Eyre) soils. The effects of different climate and rainfall regimes were simulated using 20 years of data from two climate stations (Lincoln and Hororata, Canterbury). Simulation outputs included irrigation amounts, N_2O emissions, NO_3 leaching losses and pasture production.

Soil type, urine and the timing of urine application had the greatest influence on the variation of N_2O emission and NO_3 leaching. Greatest N_2O emissions were predicted from the Otokia soil, while emissions tended to be similar from the well drained soils. More frequent irrigation resulted in the largest N_2O emissions and NO_3 leaching losses. Greatest NO_3 leaching losses were predicted from the Eyre soil with the higher rainfall regime. Least were predicted from the Otokia soil with the lower rainfall. Pasture production was largely unaffected by irrigation management, except for the shallow Eyre soil when some loss of production was predicted from the two less frequent irrigation scenarios.

Based on the model simulations and supporting field experiments, N_2O emissions and NO_3 leaching can be reduced without penalising production by irrigating less frequently and maintaining soil water deficits. The contribution of indirect N_2O emissions (produced from leached NO_3) will be greater from shallow well drained soils compared to deeper (poorly or well drained) soils.

APPLICATION OF A SYSTEMS MODEL TO SPATIALLY HETEROGENOUS IRRIGATED AGRICULTURAL SYSTEMS

J M Sharp and H E Brown

Systems Modelling, Sustainable Production, Plant and Food Research, Lincoln
Email: joanna.sharp@plantandfood.co.nz

Although New Zealand is water-rich, many of the intensively farmed lowland areas suffer frequent summer droughts. This has seen a 70% increase, to 750,000 ha, in irrigated land over the last 8 years and is expected to increase by a further 350,000 ha by 2035. The production and economic benefits are substantial; in the summer of 2011/12 irrigation contributed $NZD 2.17 billion to GDP. Lateral or centre pivot sprinklers make up 74% of irrigation systems, with many using VRI, and these provide greater sophisticated control of water application.

Tools to enable irrigation practices that improve water use efficiency, reduce run-off, drainage, and subsequent nutrient losses, are seen as an essential component of achieving freshwater policy targets. To consider both water dynamics and profitability of these irrigated cropping systems, a framework for the existing systems model APSIM was constructed that could capture the variability in soil, cropping systems, and irrigation application observed under a single irrigator with constrained water and infrastructure availability.

An advanced irrigation module was built to translate irrigator specifications into spatial and temporal application events. To consider the multiple layers of variability in soil, crop, landscape position and infrastructure present under a single irrigator, a multiple patch approach was required. Thus a set of methods to create multiple patch simulations, with patches that were spatially aware, interconnected and could run concurrently was developed. These patches may have differing soil characteristics, crop management, slope and position in the landscape but were controlled by overarching management routines. These routines determined application depth and timing of irrigation, based on the irrigator specifications, soil water, infiltration capacity, and irrigation application rate. This system also allowed placing limitations on fixed resources, such as water and infrastructure, to enable scenario analysis in a constrained system. Outputs from the simulations, such as water application, yield, drainage, profitability and WUE, can then be mapped spatially.

While at the early application stage, the framework can model the water dynamics and profitability of different irrigation options and will be used to conduct scenario analyses to determine guidelines for irrigation requirements on landscapes with differing extents of variability.

SUSTAINABLE IRRIGATION OF ARID FORESTS USING TREATED SEWAGE EFFLUENT

Wafa Al Yamani[1,2], Steve Green[3], Rommel Pangilinan[1], Steve Dixon[4] and Brent Clothier[3]

[1]*Environment Agency Abu Dhabi, United Arab Emirates*
[2]*Institute of Agriculture and Environment, Massey University*
[3]*Plant & Food Research, Palmerston North*
[4]*Maven Consultants, Wellington*

In the 1970s, the late Sheikh Zayed bin Sultan Al Nahyan, the founding father of the United Arab Emirates, embarked on a programme of greening of the desert. The forests planted provide a variety of provisioning, regulating and cultural ecosystem services. However, the forests need to be irrigated. They are in a hyper-arid environment where annual evapotranspiration exceeds 1900 mm/yr and rainfall is less than 60 mm/yr. The source of the water for irrigation is currently groundwater. So low is the recharge of the aquifers some 76% of the groundwater currently extracted for irrigation comes directly from the depletion of the groundwater reserves. And the groundwater supply is becoming more saline. Treated sewage effluent (TSE) is being considered as an alternative to groundwater (GW)

The first challenge is to establish how much water these arid-forest trees use when irrigated by groundwater (GW), and to establish the minimum amount of water that is needed that will maintain a leaching fraction that will flush salts from the rootzone. The next challenge is to determine what level of the 'treated sewage effluent (TSE) can be used to replace saltier GW.

Experimental plots have been set up at Madinat Zayed in the western desert of Abu Dhabi. Field experiments have already been going for over a year on Al Ghaf (*Prosopis cineraria*) and Sidr (*Ziziphus spina-christi*) trees. There are 12 trees in each plot, and six are being irrigated with GW and six with TSE. The GW has a salinity of around 8-10 dS/m, whereas the TSE is less than 1 dS/m.

We have installed heat-pulse devices to provide continuous monitoring of the trees' transpiration. Time domain reflectometry rods have been installed in the drip zone, and nearby, to monitor the soil's changing water content. Both Sidr and Al Ghaf have significantly deciduous behaviours and we have found this reduces their water requirements well below what a calculation based on ETo would suggest. In addition, the low salinity of the TSE is showing beneficial effects on the growth rates of both Sidr and Al Ghaf, especially so the Sidr. We are using the light stick we have developed to provide monitoring of the changing leaf area of the trees' canopies. The goal is to develop a forest irrigation management tool to tailor irrigation practices to soil type, species, and groundwater source.

SUSTAINABLE IRRIGATION OF DATE PALMS USING SALINE GROUNDWATER

Ahmed Al Muaini[1,2], Steve Green[3], Rommel Pangilinan[1], Steve Dixon[4], Abdullah Dakheel[5] and Brent Clothier[3]

[1]*Environment Agency, Abu Dhabi, United Arab Emirates*
[2]*Institute of Agriculture and Environment, Massey University*
[3]*Plant & Food Research, Palmerston North*
[4]*Maven Consultants, Wellington*
[5]*International Center for Biosaline Agriculture, Dubai, United Arab Emirates*

The United Arab Emirates annually produces nearly 1 million tonnes of dates, which is nearly 12% of the world's production. Date palms (Phoenix dactylifera L) cover nearly 200,000 hectares. The UAE is in a hyper-arid region where potential evapotranspiration (ETo) is about 1900 mm/yr, and rainfall is just 60 mm/yr. Irrigation is therefore essential. Groundwater is used for irrigation, and date palms account for one third of the water allocated for irrigation. However, 64% of the groundwater extracted is drawn from aquifers that are not renewed. Furthermore, the groundwater supplies are becoming more saline, and date palms are sensitive to salinity. Sustainable irrigation practices need to be developed. The prime requirement is to determine the water requirements in relation to the various date cultivars as a function of the salinity of the groundwater.

In 2014, a pilot experiment was set-up at the International Center for Biosaline Agriculture (ICBA) near Dubai. The focus was to determine the water use of the cultivar Lulu being irrigated twice daily with with 5 dS/m water. Tree water-use was measured directly using sap-flow sensors placed in the tree trunks, and indirectly using time domain reflectometry in the root-zone. Local weather data were used to calculate the hourly and daily ETo, and derive an appropriate value for the crop factor, Kc. Our data showed the water use of the palm trees to be less than half the amount suggested by the FAO-56 guidelines. Furthermore, much of the irrigation water was seen to be rapidly lost by deep drainage through the highly permeable sands.

In 2015 a comprehensive project commenced on two additional cultivars (Shahlah and Khalas), as well. The experiments were extended for all cultivars to irrigation with 15 dS/m water. We present initial results. We have measured a decline in tree transpiration in relation to the irrigation water salinity, and for the cultivar Lulu, the increase in salinity from 5 to 15 dS/m results in a halving of the daily water use. Part of this drop is due to the impact that salinity has had on the leaf area of the canopy. Our measurements with the 'light stick' that we have developed shows that the salinity rise has reduced the Lulu canopy area by only 25%. Other processes must be involved, and these likely involve stomatal control of transpiration as affected by salinity. A decision support tool for date palm irrigation will be developed.

WATER AND NUTRIENT MANAGEMENT OF AVOCADOS IN THE CENTRAL HIGHLANDS OF KENYA

Steve Green[1], R Gentile[1], M Gitahi[2], M Kosgey[2], B Clothier[1], G Thorpe[3], B Fullerton[4] and Mr Thomas[5]

[1] Plant & Food Research Limited, Private Bag 11 600, Palmerston North 4442, NZ
[2]Olivado Kenya (EPZ) Ltd, Murang'a area, Kenya
[3]Plant & Food Research Australia Pty Ltd, Level 14, 97 Creek St, Brisbane, Australia
[4]Plant & Food Research Limited, 120 Mt Albert Road, Auckland 1025, NZ
[5]Mitero, near Mang'u, Kenya
Email: Steve.Green@plantandfood.co.nz

Plant and Food Research (PFR) are working in the central highlands of Kenya on an NZ Aid programme with a New Zealand-born company Olivado which produces the world's leading brand of extra virgin avocado oil. We are working alongside local farmers and horticultural research/extension organisations to improve the supply of high quality organically-grown fruit. The goal of the programme is to more than double the average return to small-holder famers over 10 years through increased plantings, enhancing grower production capability, improved postharvest handling systems, and enhancing national horticultural research and extension capability to support the industry. One of our research activities is to better understand the water and nutrient status of avocados grown under current dry-land farming practices. Field experiments have been set up near Murang'a to monitor changes in tree water-use and soil water content over the course of a growing season. Sap flow sensors were installed in trees of different sizes (ages) to measure tree water use, TDR (time domain reflectometery) probes were installed in the root-zone to monitor changes in soil water contents, and a weather station was installed to monitor the microclimate and assess the potential evaporative demand (ETo, mm/day). We have also carried out regionally based soil and leaf analyses to determine plant nutrient status and help identify target nutrients for remediation. These results are supporting the development of a model to assess the potential water requirements and yield gains that might be achieved from optimised irrigation.

NUTRIENT MANAGEMENT OF AVOCADO TREES ON SMALL HOLDER FARMS IN THE CENTRAL HIGHLANDS OF KENYA

R Gentile, B Fullerton, G Thorp, A Barnett, C Clark, J Campbell, M Gitahi and B Clothier

Plant & Food Research, Palmerston North

Plant and Food Research are working on a NZ Aid project in Kenya in partnership with the company Olivado EPZ which produces avocado oil from over 1300 small-holder farmers. In the project, we are developing sustainable production systems to improve the supply of high quality organically-grown avocados. Improved avocado production will increase the revenue stream for these small-holder farmers. One of our research activities is to better understand the nutrient status of avocados grown under current farming practices. We have surveyed soil and plant nutrient contents in the main avocado production regions to assess the current fertility status of the farms. Soils in this region are classified as Nitisols and have low levels of organic matter and low pH. Soil and leaf nutrient analyses of monitoring farms revealed similar trends in nutrient availability. Low levels of the macronutrients nitrogen and phosphorus and the micronutrient boron were found in these soils. These nutrients are essential for avocado growth and production. One challenge to improve avocado productivity is finding ways to improve soil nutrient availability and tree nutrition under organic production practices. We are developing simple nutrient budgets for these avocado trees using yield and fruit nutrient concentration data to assess the quantity of nutrients being exported off-farm in the harvested crop. Using the nutrient concentrations of locally available organic amendments, we can provide recommendations on the amount of organic material needed to sustain soil fertility. For example, manure from a single cow may replace the nitrogen exported by 39 avocado trees or the phosphorus removed from the farm by 46 trees. These simple nutrient balances will be incorporated into a Decision Support Tool to assist small-holder farmers in enhancing their soil and plant nutrition. These budgets will be improved by further characterising the nutrient composition and quantities of available organic matter amendments in the region.

EVALUATION OF IRRIGATION EFFICIENCY AND SUSTAINABILITY IN THE WARABANDI SYSTEM OF PAKISTAN: A DIAGNOSTIC ANALYSIS OF HAKRA BRANCH CANAL COMMAND

Hamed Khan[1], Ranvir Singh[1], Tonny de Vries[2] and Brent Clothier[3]

[1]Soil & Earth Sciences, Institute of Agriculture and Environment, Massey University
[2]Department of Civil and Natural Resources Engineering, University of Canterbury
[3]Plant & Food Research, Food Industry Science Centre Palmerston North

The agricultural sector in Pakistan is a significant contributor to Pakistan's economy and social welfare. Despite its importance the productivity in the Pakistani agriculture sector is low, and has declined over the past decades. Nearly 85% of agriculture in Pakistan is irrigated. The major driving force behind irrigated agriculture in Pakistan is the large Indus-basin irrigation system, which was developed in the late nineteenth century. Warabandi systems supply a fixed amount of canal water proportionate to the size of the farm. Problems are often caused by poor and inefficient irrigation and crop management. This can result in soil salinization, water logging or declining groundwater levels, depleted soil fertility and a reduction in productivity.

We present a diagnostic analysis of crop water-demand and supply, equity in canal water distribution, groundwater recharge and discharge, plus water-use efficiency in irrigated agriculture. This is applied to the Hakra Branch Canal command area, covering nearly 200 thousand hectares in the Bahawalnagar district of Punjab Province in Pakistan. The analysis is presented at both spatial (canal command, distributaries, head, middle and tail reaches) and temporal (daily, weekly, monthly and seasonal) scales. The results show that canal water supplies are significantly less compared to crop water demands. Further, the analysis reveals that not only are the actual canal water supplied discharges are less than the crop water demand, but also that the design canal water discharges of the distributaries are considerably less than the potential crop water demands. There is also considerable inequity canal water distribution across the irrigation system, as the head-reach distributaries get more canal water per unit area than the distributaries in the middle and at the tail-end of the system. This reveals inequities in the allocation of canal water available. The water-use efficiency and water productivity are low for the whole command area.

This analysis reveals that irrigation management strategies are required to ensure equity, increase productivity and minimize losses in the system. We propose to develop and integrate irrigation scheduling and soil-water-crop modelling with geographical information to further assess and improve the efficiency and sustainability of irrigation practices in the system.

MAPPING OF ALLUVIAL SUB-SURFACE FEATURES USING GROUND PENETRATING RADAR TO IMPROVE IRRIGATION EFFICIENCY

Angela L Lane[1], Paul G Peterson[2], Carolyn B Hedley[2], Samuel T McColl[1] and Ian C Fuller[1]

[1]*Institute of Agriculture and Environment, Massey University, Palmerston North*
[2]*Landcare Research Limited, Palmerston North*
Email: angelalane.nz@gmail.com

Soil drainage information is vital for determining smart irrigation practices. Predicting soil drainage requires knowledge of the spatially varying subsurface features, e.g. soil-thickness, flow pathways, and depth to groundwater table. Obtaining information about these features rapidly and non-invasively requires the use of geophysical techniques like ground penetrating radar (GPR). While applications of GPR are diverse, ranging from geotechnical to archaeological investigations, to mineral and groundwater exploration, GPR has not been extensively applied in soil mapping for agricultural purposes. The potential use of GPR for identifying subsurface features, such as depth to gravel and groundwater table which influence soil drainage, could benefit future developments in irrigation practice. To assess applicability of GPR for this purpose, research work was conducted on the alluvial soils at Massey No. 1 Dairy Farm, Palmerston North. Radargrams were collected on two 0.4 ha plots, one arable and one pasture using 200 MHz antennae, in a 2-m grid pattern. Radargrams were ground-truthed with 13 soil cores and 21 auger holes, targeting different layers detected by GPR. The soil cores were analysed for bulk density, soil moisture and particle size. Several transect lines using a 100 MHz antenna were also conducted in the pasture plot to determine soil layering and subsurface features at greater depths than what was achieved with the 200 MHz antenna. The soil types present at these sites are the Manawatu silt loam over sand, Manawatu fine sandy loam, and the Rangitikei silt loam, which overlay Manawatu River gravels that occur at depths ranging from 0.7-3 metres. The average subsoil dry bulk density ranged from 1.30 g/cm^3 to 1.35 g/cm^3 and was consistent with previously mapped soil types. Initial validation of radargrams with soil core samples indicates that GPR can obtain meaningful results from alluvial sediments ranging from sandy loams to silt loams. The use of GPR for delineating sub-surface features in alluvial soils is a promising tool that could assist with informing irrigation practice.

GAMMA SOIL SURVEYS – INVESTIGATING SOIL PATTERNS FOR NUTRIENT AND WATER MANAGEMENT

Carolyn B Hedley, Pierre Roudier and Paul Peterson

Landcare Research, Palmerston North
Email: hedleyc@landcareresearch.co.nz

Real-time management and accurate modelling of spatially and temporally variable drainage events is a challenging research topic for New Zealand's soil scientists. A new gamma soil survey system is therefore being trialled to investigate its potential to collect fine-scale soil information rapidly and affordably to improve dynamic management and modelling of nutrient and water management. The system consists of a GPS-enabled gamma sensor mounted on a quad bike, with on-board information system to collect soil geophysical survey data.

This proximal soil sensor detects gamma ray photons emitted naturally from the soil, and a typical spectrum has four 'regions of interest" (ROIs): total counts, and peaks relating to Potassium, Uranium, and Thorium. Gamma-ray spectrometry has been reported to be a valuable soil surveying tool because different parent materials contain varying amounts of these three predominant radioisotopes, as do the soils that weather from them. The spectrometry potentially compliments electromagnetic (EM) soil survey data, which respond to soil texture and moisture differences in non-saline conditions; the two sensors can be used simultaneously to improve soil prediction models.

We conducted a pilot study at Massey University No.1 Dairy Farm (160 ha) in 2015. Four gamma ROI maps were used with an existing EM map (5-m pixel resolution) to investigate relationships of sensor data to a soil drainage toposequence.

The drainage toposequence at this farm is from well-drained loamy gravels, sands, and sandy loams, through imperfectly drained sandy loams and silt loams to very poorly drained silt loam Gleys. Soils tend to become less freely draining and older with distance away from the river. The Gleys are exceptions to this rule, as they occur adjacent to a tributary stream in a frequently inundated area. Gamma ROI values are smallest for the loamy gravels, and tend to increase with this drainage and soil development sequence. The exception is the Gley soil, which has low total counts, potentially due to lack of weathering in these saturated soils, and the gamma signal may also be attenuated by the soil wetness.

Future research is planned to investigate the use of gamma survey data with and without other high resolution soil data, such as EM and Lidar, to improve spatial modelling of soil attributes, including drainage class, stoniness, clay content, available water storage, and carbon.

CHANGING FARMER PERCEPTIONS AND PROFITABILITY ON VICTORIAN IRRIGATED DAIRY FARMS BY IMPROVING PASTURE UTILISATION EFFICIENCY

Stewart Spilsbury and Bert Quin

FOO Technologies, Newry, Victoria, Australia

Much research has been conducted into finding ways to both improve and measure the profitability of dairy farms, yet in Victoria Australia at least, the latest Dairy Farm Monitor report shows no improvement in farm EBIT over the past decade. In fact in Victoria, one of our two demonstration farms has announced it will close this year; the second made a loss during and since the record milk price year, and has advised it needs financial assistance to continue.

However there are some farms that have increased both MOAF and EBIT substantially over the past 3 to 4 years, despite declining milk prices. This poster provides information on those farms, and describes the technologies and pasture management used to achieve this.

These improvements have only been possible because the farmers involved consciously made the decision to change (and/or outsource) their grazing management practises in order to optimise home grown DM consumption and quality. The system used is based around the LUDF "golf-ball grazing" system, modified for Australian consumption. Making that decision was for many of the farmers the easiest part of the journey. The discipline involved in adopting the changes has for some been very much harder.

It is the authors' view that getting the farmer to change his or her perception of how the farm needs to be managed is the biggest barrier to improving profitability. It is human nature for many of us to try the same unsatisfactory but familiar methods over and over again, rather than set out on a new and frighteningly different course, with all the associated fears of financial ruin.

This poster presents the system currently used by nine irrigated dairy farms in the MacAlister Irrigation District of East Gippsland, Victoria and the results they have achieved by adopting the NZ grazing system developed at Lincoln, but adapted for Australian conditions.

IMPROVING NUTRIENT MANAGEMENT FOR DAIRY FACTORY WASTEWATER LAND TREATMENT SYSTEMS

Jeff Brown

Fonterra, Palmerston North

Nutrient rich wastewater, containing milk residues and cleaning agents, is generated during dairy processing. Wastewater treatment systems for Fonterra's 26 milk processing facilities vary between full biological treatment and land treatment systems (LTS, with and without pre-treatment) involving irrigation on to productive farms. Biological treatment involves high initial capital and running costs, but the treated wastewater is of sufficient quality for direct surface water discharge. LTS involves less initial capital outlay and may be viewed more favourably by regional councils. However large daily wastewater volumes (2,000-10,000 m^3/day, August-May/June) make storage difficult resulting in irrigation outside traditional irrigation periods.

The recent expansion of Fonterra's Pahiatua factory shows how changing public expectations and environmental regulations significantly influenced the resource consenting process and the overall wastewater treatment/nutrient management system installed. The factory and associated LTS lie in a 'Sensitive 'Water Management Zones' (SWMZ) where significant improvements in water quality are required by Horizons One Plan. Under this regional plan, the LTS farms require a 'consent to farm' under which staged decreases in nitrogen leaching must be demonstrated. This is additional to the full discretionary activity resource consent for the 'discharge of wastewater to land' under the RMA 1991.

A combination of treatment and farming system changes were proposed to satisfy the regulatory requirements, key amongst these were full biological wastewater treatment and storage for 100,000 m^3 of treated wastewater 130 ha irrigation area expansion and implementing a 'low impact' dairying system on two Fonterra owned irrigation farms. Predicted nitrogen losses from the four LTS farms decreased by 48% to 28 kg N/ha/yr and a 35 year irrigation resource consent was granted. Conditions specific to nitrogen management included:

1. Nitrogen loading limit of 250 kg N/ha/yr from all sources
2. Combined average annual nitrogen leaching rate across the four farms of 28 kg N/ha/yr calculated as a five year rolling average.

An issue with having nutrient loss targets written into a consent conditions is that Overseer version changes result in a risk of non-compliance from significantly changed leaching estimates (for the same input parameters). The Overseer 6.1 to 6.2 upgrade and the new irrigation sub-routines resulted in major leaching increases. Fortunately the irrigation resource consent allowed for review if this occurred and the limit of 28 kg N/ha/yr has now been reviewed in conjunction with Horizons Regional Council to 35 kg N/ha/yr.

THE CONUNDRUM OF REALISING FERTILISER BENEFITS OF WASTEWATER FOR GREATER SUSTAINABILITY – OPPORTUNITY VS REALITY

Hamish Lowe[1], Sian Cass[1] and Jacqui Horswell[2]

[1]Lowe Environmental Impact, PO Box 4667, Palmerston North 4442
[2]Lowe Environmental Impact, Wellington
Email: hamish@lei.co.nz

Land application of nutrients in municipal effluent (ME) and farm dairy effluent (FDE) have the potential to support the New Zealand agricultural industry by reducing reliance on fertiliser, contributing to removing nutrients from waterways and sustainably recycling nutrients. However, these positives have to be weighed against perceived negatives, including: "not in my back yard", "it smells", "it contaminates groundwater", "it carries terrible chemicals" and "the products can't be consumed". It's not easy being green!

The discharge of FDE has changed from approximately 100 % to water to almost 100 % to land in 15 years. This change has come from better irrigation practices and greater awareness of water quality impacts. ME has traditionally been discharged to waterways, but like FDE, has the potential to benefit productive land and contribute to improved waterway quality. However, the uptake of ME to land has not been as successful, with less than 5 % currently applied to land.

Nationally New Zealand municipal wastewater treatment plants generate approximately 12,000 tonnes of N and 2,400 tonnes of P annually. This compares to 41,000 tonnes N and 6,500 tonnes P from dairy farms. The ME volume is 480 M m^3 annually compared to 93 M m^3 of FDE. At a N loading rate of 150 kg N/ha, this equates to 79,000 ha of land needed for ME and 270,000 ha for FDE. Applying an annual application of 400 mm irrigation would require 120,000 ha and 23,000 ha for ME and FDE respectively.

Environmental lobby groups and some government departments support land application of ME. But limitations have emerged with industry bodies (potential negative impact on market access) and other government departments (generation of contaminated sites).

Resource vs water quality vs adverse perception. What a conundrum! This paper identifies the opportunity of two key wastewater resources and the disparity, with reasons, between their use.

DESCRIBING N LEACHING FROM FARM EFFLUENT IRRIGATED ON ARTIFICIALLY DRAINED SOILS

Rogerio Cichota[1], Jane Chrystal[2] and Seth Laurenson[1]

[1]*AgResearch, Lincoln Research Centre, Lincoln, New Zealand*
[2]*AgResearch –Invermay Agricultural Centre, Mosgiel, New Zealand*

Dairy farming generates a considerable amount of effluent which has to be stored and treated, representing both labour and cost requirements. Application of farm effluent to land via spray irrigation is the preferred option in New Zealand. This practice enables a better utilisation of nutrients in the effluent, but can have an adverse impact on the environment if poorly managed. Managing the application of farm effluent can be a major challenge in farms with poorly drained soil, as it can generate surface runoff in undrained soils and leaching losses in artificially drained soils. Because of this, irrigation of effluent over the winter months is not permitted in some regions. The increasing practice of housing animals over the winter months, especially in South Island, results in the collection of larger volumes of effluent that need storage and disposal, representing more costs to farmers. The potential for applying effluent over winter months, reducing the need for large storage ponds, is thus appealing to farmers, but the risks of nutrient losses need to be better understood before this practice can be implemented.

In this study the Agricultural Production Systems Simulator (APSIM) was setup to describe the fate of nitrogen (N) applied as effluent irrigated to artificially drained soils. The system described consisted of a dairy farm where the cows are wintered in an off-paddock system where effluent is captured and returned to land during winter. The applications use a low rate, low depth system and that happens daily unless large rainfall (>4.0 mm) occurs, thus minimal storage is needed. The modelling setup was refined and evaluated using data collected in field trials at Lincoln University's Telford Farm, in Balclutha. This simulation setup was then used to extrapolate the trial results to different soils and climates of South Island in order to assess the potential risks for N leaching losses. Implication on the practicality of applying effluent irrigation over winter are discussed.

DISSOLVED PHOSPHORUS IN CANTERBURY GROUNDWATER

Lisa Scott and Ray Wong

Environment Canterbury, PO Box 345, Christchurch, 8140
Email: lisa.scott@ecan.govt.nz

Phosphorus-enriched groundwater could cause adverse effects if discharging to surface waterways. Environment Canterbury holds nearly 2000 records of Dissolved Reactive Phosphorus (DRP) concentrations in groundwater samples taken from over 900 wells in Canterbury over the past 20 years. From this dataset the regional median DRP concentration is 0.007 mg/L and the 95th percentile, 0.078 mg/L. Over 15% of our shallow wells (<30 m) had median DRP concentrations above 0.026 mg/L, a threshold that would be considered 'excessive' for surface waters.

We have limited long-term records for DRP in groundwater for trend analysis, but 9 wells with more than 10 years of data showed no increasing trends. We also found DRP concentrations in around 290 wells in 2014 were very similar to what they were when last sampled in 2007/2008. More long-term monitoring is needed to confirm that DRP trends are stable.

We see higher DRP in groundwater along the Canterbury coast, both north of Amberley and South of Timaru than on the Canterbury Plains, which we think is mostly due to natural geological sources (soils and rocks). Wells screened in older formations (e.g., Kowai, Taratu, Mount Harris) can also have higher concentrations of soluble phosphorus than wells screened in Quaternary age sediments.

Shallow wells with DRP concentrations above 95th percentile are typically surrounded by sheep/beef/deer, dairy or other pastoral land uses and lifestyle blocks. Median DRP is also higher under these land uses, but only when the groundwater is sub-oxic. There does not appear to be a strong relationship between mapped soil phosphorus leaching risk and measured groundwater DRP for shallow groundwater under pastoral farming or lifestyle blocks. But we need more groundwater data from intensive land uses on very gravely thin soils near rivers where the risk is highest.

Redox status appears to be the overriding factor affecting groundwater DRP concentrations. Most of Canterbury's groundwater is oxic, limiting phosphorus mobility. Where sources of phosphorus are present, high DRP concentrations are more likely to arise if the groundwater is, or becomes, anoxic. This behaviour is broadly the inverse of nitrate, which is removed by denitrification in low oxygen environments.

LOCATING FRESH COW URINE PATCHES; THE KEY TO COST-EFFECTIVE REDUCTION IN ENVIRONMENTAL N LOSSES AND IMPROVING N RECYCLING AND PASTURE GROWTH

Bert Quin, Geoff Bates and Long Nguyen

Quin Environmentals, Auckland

The new Spikey® detection and treatment of fresh urine patches provides the means of not just treating fresh (invisible) cow urine patches with urease inhibitor and the nbpt growth promotant (ORUN®) to reduce nitrate leaching and greenhouse gas losses, the technology provides the platform to amend the urine patch soil-pasture environment in other ways as well.

For example, once it is proven that DCD, when applied to urine patches only, and only shortly after grazing, does not result in the presence of DCD residues in cow milk, DCD or DCD plus nbpt may be preferable to nbpt (Zaman et al. 2010).

Recent work indicates that on some dairying soils, nitrate concentrations are markedly attenuated below the root zone, presumably through either denitrification, particularly where a clay layer is present. The size of these reductions indicate this deep-soil denitrification may be equally important to denitrification in shallow groundwater.

While this denitrification is good for reducing nitrate leaching, it raises the important question of whether this denitrification is going through to N_2 production, or is leading to greater losses of N_2O.

In situations where undesirably high losses of N_2O are occurring, Spikey® permits the targeted application of products to reduce this, such as sources of readily mineralisable carbon.

Recently, Selbie et al. 2015 have provided confirmation that the process known as co-denitrification, the reaction of NO species (produced from urea-sourced NH_4^+) with soil amides, is a major source of N loss as N_2 from urine patches. While not an environmentally harmful mechanism, it can be a major economic loss, requiring more fertiliser N inputs to maintain a given level of production. This loss can be reduced with DCD (Selbie et al. 2015).

Regardless, increased focus needs to be placed on increasing plant N recovery from urine patches. The Spikey® technology provides the platform to achieve this.

DOES GIBBERELLIC ACID REDUCE NITRATE LEACHING LOSSES FROM ANIMAL URINE PATCHES?

R R Woods, K C Cameron, G R Edwards, H J Di and T J Clough

Faculty of Agriculture and Life Sciences, Lincoln University

In New Zealand, the urine deposited by dairy cows onto the paddock while grazing year-round represents an input of nitrogen (N) into the soil-plant system greater than what the plants can use. The nitrogen which is not taken up by the pasture is often lost from the soil in drainage water. For this reason, N leaching is a significant environmental concern in intensively grazed NZ pasture-based systems.

One mitigation approach could be to apply gibberellic acid (GA) to increase the uptake of N by pasture, particularly during the cooler seasons where risk of leaching is high. GA is a plant hormone which occurs naturally in most plants and is responsible for stem elongation and leaf expansion. It is currently used by some farmers to stimulate dry matter (DM) production under rotational grazing when cool soil temperatures limit natural pasture growth rates. We hypothesized that application of GA to pasture in the autumn would increase pasture growth and uptake of urinary N during this time, and subsequently reduce N leaching loss.

A lysimeter study was conducted to measure pasture growth, N uptake, and N loss to water beneath pasture urine patches treated with, and without, GA. Results showed there was no significant difference in annual pasture DM yield, N uptake or N leaching loss between the urine + GA treated lysimeters compared with the urine-only lysimeters. These results suggest that, at the urinary N rate of 700 kg N ha^{-1} used in this trial, an application of GA would not reduce N leaching loss. However, pasture treated with N fertiliser (50 kg N ha^{-1}) has previously been shown to have an additive DM response to a GA application. Therefore future research could determine the GA response rate when applied to lower rates of urine-N to investigate whether a reduction in N leaching loss would occur.

THE EFFECT OF OPTIMUM VS. DEFICIT IRRIGATION ON PLANT NITROGEN UPTAKE AND NITRATE LEACHING LOSS FROM SOIL

A Carlton, K C Cameron, G R Edwards, H J Di and T J Clough

Faculty of Agriculture and Life Sciences, Lincoln University

Nitrate (NO_3^-) leaching associated with urine nitrogen (N) deposition during grazing is recognised as a significant environmental problem. In this study it was hypothesised that optimum irrigation can increase plant growth and uptake of urine deposited N thereby reducing NO_3^- leaching over winter. The objective of this research was therefore to determine the effect of optimum vs. deficit irrigation regimes on N uptake and dry matter yield from diverse and standard pasture species and its effect on annual NO_3^- leaching loss from the soil.

In this study urine was applied at two rates of nitrogen, 500 and 700 kg N ha^{-1} to soil monolith lysimeters in late spring. Urine was labelled with ^{15}N stable isotope at 5 atom% prior to application. Irrigation water was applied at optimum vs. deficit rates. Measurements of NO_3^- leaching, ^{15}N abundance and pasture N uptake were taken for a 10 month period following urine application.

RELATIONSHIPS BETWEEN ENZYME ACTIVITIES AND SOIL PROPERTIES IN RECENT AND PUMICE SOILS

Kyle Robertson, Karen Mason, Karin Müller and Robert Simpson

Plant & Food Research, Hamilton

Soils of the Recent and Pumice soil orders are relatively young, typically only one to three thousand years old. Recent soils are weakly developed, although they have a distinct topsoil layer; despite this they are usually fertile, with good water storage capacity and a facility for deep rooting. Pumice soils, derived from volcanic eruptions, have low soil strength, but like Recent soils have both good water storage and deep rooting facility. Pumice soils have low levels of some major nutrients and trace elements, limiting fertility of unamended soil. These two soil orders share many properties, including their susceptibility to soil hydrophobicity, a potential problem for runoff and fertiliser loss. We hypothesized that at least some of these common properties may be related to biological activity rather than the soil type. Recent soil was collected from three farms (sheep or mixed sheep and beef) east of Waipukurau, in the foothills of the Ruahine Ranges. Pumice soil was collected from three farms (mixed sheep and beef) northeast of Napier. Six samples were taken from a single paddock on each farm, maintaining a similar geographic aspect for each farm, but attempting to take samples with varying hydrophobicity. Soil properties measured included pH, total carbon and nitrogen, mineral nitrogen, hot and cold water extractable carbon, bulk density, gravimetric water content and actual and potential hydrophobicity. Enzyme activities measured included general dehydrogenase, glucosidase, galactosidase, cellobiohydratase, xylase, N-acetylglucosaminidase, tyrosinase, peroxidase, arylsulphurtase and monophosphatase. These enzymes are involved in general oxidation of potential toxins, the breakdown of complex carbohydrates such as starch, cellulose, hemi-cellulose, pectin, chitin and humic acids found in plant and fungal cell walls, and the release of phosphate and sulphur found in organic molecules. Relationships between the enzyme activities and chemical/physical properties were tested statistically, to discover any correlations; especial attention was given to links between hydrophobicity within a single soil order and other properties. These precursory results emphasize the complex nature of interactions between biological activity and physical properties found in soil.

DESCRIBING THE EFFECT OF GRAZING ON NITROGEN LEACHING IN WINTER FORAGE-RYEGRASS ROTATIONS

Rogerio Cichota[1], Iris Vogeler[2], Stephen Trolove[3] and Brendon Malcolm[4]

[1]*AgResearch, Lincoln Research Centre, Lincoln, New Zealand*
[2]*AgResearch –Ruakura Research Centre, Hamilton, New Zealand*
[3]*Plant & Food Research - Havelock North, New Zealand*
[4]*Plant & Food Research -Lincoln, New Zealand*

Animal feeding over the winter is a critical phase of pasture-based dairy farming with important influence on animal performance. An increasingly common management practice in New Zealand is wintering pregnant non-lactating cows on forage crops, thus avoiding damaging the pasture during wet periods. It is also a potential source of income for non-pastoral farms. Due to the high productivity of forages, cows are typically grazed on blocks or strips where stocking densities can be as high as 300-600 cows/ha. Grazing at high stocking densities cause the return large amounts of excreted nitrogen (N) to the paddock during winter when risk of losses are high. The high stocking densities can also cause soil compaction, exacerbating denitrification losses and potentially reducing growth of upcoming pasture. While the area used for winter grazing is relatively small, these winter forage grazing paddocks are believed to contribute a disproportionately large part of annual farm nutrient losses. Identifying good management for wintering systems is, however, not an easy task. Several forage crops can be used, the grazing management can vary, as well as the land use after grazing. Computer simulation models are a crucial tool for evaluating management strategies for wintering systems under different climates and soils. In this study the Agricultural Production Systems Simulator (APSIM) was setup to describe the growth and grazing of winter forages followed by the establishment of ryegrass pasture. Firstly, data from trials in the Canterbury region were used to guide model refinement and assess its performance for wintering systems. Changes made to APSIM included forage crop parameters and the dynamic change of soil physical properties, such as macroporosity, bulk density and hydraulic conductivity, in response to animal trampling. This setup was then used to analyse scenarios where the fate of urine-N post-grazing winter forage was determined considering the effects of soil moisture during grazing, variations in stocking density and duration, and the fallow period after grazing.

PRODUCTIONWISE – ONLINE CROP MANAGEMENT

Melanie Bates

Foundation for Arable Research, Christchurch

Record keeping and traceability are increasingly important for the primary industries, including reporting of nutrient inputs. FAR, New Zealand's levy funded crop research and extension organisation, have been working with Grain Growers Ltd, Australia in developing a comprehensive system for growers.

ProductionWise is an integrated online farm management system that allows you to map your paddocks, record management practices and inputs, to automatically generate specific reports and gross margins. It is also expected to improve the efficiency and profitability of farmers and help with nutrient reporting and traceability. ProductionWise functionality includes:

1. **Farm Mapping –**digital paddock mapping, topographic paddock information, general soil characteristics and grain infrastructure configuration.
2. **Paddock Diary –** Paddock record keeping of all crop management practices and inputs by date including all nutrient sources; fertiliser, effluent and supplemental feed, using pre-defined lists.
3. **Mobile App –** mobile device available from Apple and Google Play app stores, for real time data entry.
4. **Reporting –** Auto-created traceability reporting, nutrient use reporting, comprehensive operation, input and grain storage reporting,
5. **Grain Storage –** record keeping, contracts and sales management,
6. **Gross margins –** Automatically generates gross margins and cost of production.
7. **Advisor Functionality** –Connects to growers, assists with farm planning, to assist individual day to day paddock activities and input recommendations.

The system is simple for data entry, layered features for farm mapping, date range and selector options for reporting, plus a mobile app for easy data entry. The Grain Store section displays the complete history of the grain from paddock to buyer, which will provide a complete grain traceability for farmers. ProductionWise could link to nutrient management models, such as APSIM or Overseer, to reduce the data entry and improve the accuracy of data entered.

As well as providing growers with information on their cropping operation, ProductionWise assists FAR in capturing cropping information to be used for benchmarking assessment. This will enable the relationships between productivity and inputs, such as nutrients, to be defined at sub-regional, regional or national scales and to provide reports back to growers to aid them to improve and refine practices.

ANALYSIS OF THE RELATIONSHIP BETWEEN TOTAL NITROGEN AND AVAILABLE NITROGEN IN NON-PASTORAL TOPSOILS OF NEW ZEALAND FROM A LARGE SOIL TEST DATABASE

Danilo Guinto and Warwick Catto

Ballance Agri-Nutrients Ltd., Tauranga, Bay of Plenty

Using a large soil test database, the relationship between total nitrogen and available nitrogen (measured as anaerobically mineralisable nitrogen) in non-pastoral topsoils (0-15 cm) of New Zealand was analysed by linear regression, grouping the data into 14 regions. For most regions, a statistically significant relationship between total N and available nitrogen exists (P values <0.001). Furthermore, six regions exhibited good R^2 values (range 0.48 to 0.79, P values <0.0001). These include the Bay of Plenty, Canterbury, Gisborne, Hawke's Bay, Wellington and the West Coast. For these regions, total nitrogen analysis can be useful to predict topsoil available nitrogen with a good degree of confidence that can serve as useful guidance in fertiliser nitrogen recommendations.

THE POTENTIAL IMPACT AND OPPORTUNITIES FROM NUTRIENT MANAGEMENT REGULATION ON THE NEW ZEALAND HERBAGE SEED INDUSTRY

Nick Pyke, Richard Chynoweth and Diana Mathers

Foundation for Arable Research
PO Box 23133, Templeton, Christchurch, New Zealand

New Zealand herbage seed growers will need to ensure their farm management practices do not result in nutrient losses that exceed limits. Unlike many countries New Zealand has adopted limits for nutrient loss based on outputs, with no limit on the application (input) of nutrients. As it is not currently possible to measure outputs across a number of paddocks or farms, management within the limits will rely on the use of models which accurately estimate losses for a farm system averaged over a reasonable time frame. Herbage seed crops offer both opportunities and problems to growers when minimising nutrient losses. Excellent research has provided growers with good information on the N requirements of grass seed crops to maximise productivity and, if Nitrogen Use Efficiency is high, minimising the risk of nitrogen losses through leaching or volatilisation. As grass seed production is a minor crop research has not been undertaken to measure actual losses. The Overseer® model is likely to be used to estimate nitrogen losses from the farm system and reports of losses in relation to different inputs and its applicability to herbage seed cropping systems is discussed.

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

M Norris, P Johnstone, S Green, G Clemens, C van den Dijssel,
P Wright, G Clark, S Thomas, D Mathers and A Halliday

Plant & Food Research, Havelock North

Nutrient losses are an important economic and environmental consideration across the wider cropping sector in New Zealand. Between August 2014 and May 2015 we established a network of passive-wick tension fluxmeters in commercial cropping farms in the Canterbury, Manawatu, Hawke's Bay and Matamata/Pukekohe regions to measure nutrient concentrations of nitrogen (N) and phosphorus (P) in drainage water under good management practices. Results from this study will provide farmers and regional authorities with measurements of nutrient losses from cropping farms across sites and seasons, and will be the basis for ongoing extension efforts to ensure good management practices are widely accepted and adopted by farmers.

The experimental design across the network includes the four monitor regions, three sites per region and twelve fluxmeters per site. Sites provide a range of cropping systems, soil types, climatic conditions and management practices relevant to each region. Fluxmeters were installed to collect drainage water at a depth of 1 m. In this paper we summarise activity for the period between fluxmeter installation and 30 September 2015.

MASS BALANCE BUDGETS FOR CROPPING SYSTEMS

- THEIR ROLE IN NUTRIENT MANAGEMENT

Diana Mathers

Foundation for Arable Research, Havelock North

Overseer has become the model of choice for most regional councils to assist their understanding of nutrient losses at farm-scale. The farm Overseer nutrient budget numbers for nitrogen and phosphorus are used to gauge the farm's environmental performance with catchment limits.

Arable and vegetable cropping farmers continue to face a number of challenges when having Overseer budgets prepared for their farm systems. These relate to the dynamic and complex nature of many cropping farms, as the complexity of the system increases, the ability to model it decreases and confidence in the output reports may be low. Farmers and regional council land managers have asked if there is an alternative approach to an Overseer nutrient budget or arable systems.

In this work, we explore the concept of using a pre-season, crop mass-balance budget as a nutrient management tool as a substitute for a retrospective Overseer nutrient budget

Historical data sets for maize and potatoes which included nitrogen budgets prepared from pre-season and post-harvest nitrogen soil tests, fertiliser rates and crop yield responses were used to compare mass-balance budgets and Overseer nutrient budgets.

The uncertainties involved in developing a mass balance budget include; estimating the soil nitrogen supply, the fertiliser efficiency and the crop yield. If these uncertainties can be reduced, then a mass balance budget for a crop will provide a level of confidence that fertiliser applications are being applied to meet the crop demand with a minimal surplus.

In long term crop rotations certainty that losses were being controlled and minimised could be achieved if the cropping rotation was managed with the consistent use of mass balance budgets for all the crops, including the pasture and forage crops in the rotation. But without a measure of how well the system is performing, neither the Regional Council nor the farmer can gauge the success of the farm fertiliser management practices.

MONITORING & MAPPING CROP DEVELOPMENT

Dan Bloomer, Justin Pishief and Chris Folkers

Centre for Land and Water, Hastings

In 2015 we reported on the use of geo-referenced smartphone photos processed to assess onion crop canopy size and variability. Preliminary results showed promise for zoned nutrient planning and variable rate application based on predicted spatial crop yield.

Within paddock yield variability is a challenge for increased profitability of onion production that may only be addressed through spatially varying management. That requires a way to monitor and measure crop variation digitally.

A new project “Enhancing the profitability and value of New Zealand onions” (SFF Project No. 408098) extends our earlier work. An onion crop is being assessed with a range of sensors mounted on a range of vehicles. Data is geo-referenced and maps prepared. Plant & Food Research has detailed crop monitoring plots within the crop with data being compared to the mapped information.

Paddock scale data captured to date include Dual EM (soil conductivity), elevation, tractor mounted GreenSeeker (NDVI) and smartphone CoverMap (% ground cover), UAV mounted DJI (RGB) Altus MicaSense (RGB, NIR + Red-edge) and high resolution satellite (RGB + NIR).

Data have been processed using ArcGIS and Quantum GIS. Maps prepared from these data include soil zones, topography, canopy cover, NDVI and other canopy spectral indices. Information is presented on-line at: http://microfarm.landwise.org.nz /research/onion-variability/. Examples of the layers, their strengths, weaknesses and frustrations will be presented and links to physical plant and canopy measurements explored.

A prototype yield monitor in development is not complete. The monitor is anticipated to enable paddock scale capture of crop yield and size distribution. This is the “end point” against which the various canopy development assessments can be compared.

This work is funded by the MPI Sustainable Farming Fund and Onions New Zealand.

Thanks to: AgriOptics (EM maps and GreenSeeker Sensor), BioRich Compost (providing a tractor), Altus UAS (capturing and processing UAV imagery) and ASL Software (CoverMap app and image processing). Thanks also to MicroFarm sponsors Ballance AgriNutrients, BASF Crop Protection, FruitFed Supplies, Mark Redshaw, Gerry and John Steenkamer for support growing the onion crop.

CAN A WINTER-SOWN CATCH CROP REDUCE NITRATE LEACHING LOSSES AFTER WINTER FORAGE GRAZING?

P L Carey[1], K C Cameron[1], H J Di[1], G R Edwards[1] and D F Chapman[2]

[1]Faculty of Agriculture and Life Sciences, Lincoln University, Lincoln 7647, New Zealand
[2]DairyNZ, P.O. Box 85066, Lincoln University, Lincoln 7647, New Zealand.

Direct grazing of winter forage crops to feed non-lactating, pregnant dairy cows prior to calving is a common management practice in the New Zealand South Island. However, the high crop yields per hectare grazed, combined with a high stocking density of cows, means this potentially leads to large amounts of urinary nitrogen (N) deposited on bare, wet soil, that in turn, could lead to high nitrate leaching losses. We undertook a study to simulate a winter forage grazing (WFG) event using field lysimeters planted with a kale (Brassica oleracea L.) crop. We report the effect of delaying sowing a "catch crop" of oats (Avena sativa L.) following simulated WFG on nitrate leaching losses from urine applied at different times throughout the winter.

Measurements showed a catch crop sown between 42 and 63 days after urine deposition in early winter reduced N leaching losses from urine patches by 39% (22-65%) over the winter-spring period, and 26% (18-46%) overall, compared with no catch crop. Generally, the sooner the catch crop was sown following crop harvest, the greater the uptake of N by the catch crop and the greater the reduction in nitrate leaching losses.

The results indicate that sowing of a catch crop following winter crop grazing could be an effective management strategy to reduce nitrate leaching as well as increase the N use efficiency of dairy winter feed systems.

THE EFFECT OF WINTER FORAGE CROP AND ESTABLISHMENT METHOD ON N LOSSES DURING DAIRY PASTURE RENEWAL

Stephen Trolove[1], Steve Thomas[2] Gina Clemens[2] and Mike Beare[2]

[1]Plant and Food Research, Private Bag 1401, Havelock North 4157
[2]Plant and Food Research, Private Bag 4704, Christchurch 8140
Email: stephen.trolove@plantandfood.co.nz

There is concern over the fate of mineral nitrogen (N) during winter in dairy systems, particularly from grazing of winter forages during pasture renewal. An experiment was conducted on a poorly drained soil in Canterbury to investigate the effects of renewal via a crop of winter rape, or direct to pasture. Two different tillage techniques were compared, intensive cultivation (inversion ploughing) or direct drilling. Plots were further split into with and without treading, and with and without urine-amended plots.

Nitrate concentrations measured in suction cups multiplied by drainage modelled by APSIM gave leaching losses ranging from 18–30 kg N/ha. Leaching losses were greatest in the untreaded treatments and lowest the treaded treatments. APSIM modelling suggested that this difference was because treading enhanced denitrification losses. A simple mass balance of N inputs less N measured in the plant, soil or lost through leaching suggested that gaseous losses were the main loss pathway in this poorly drained soil. Tillage technique had no significant effect on N losses.

DEVELOPING NUTRIENT EFFICIENT CLOVERS FOR NEW ZEALAND FARMERS

Shirley Nichols and Jim Crush

AgResearch, Hamilton

Repeated selection for higher rates of white clover shoot growth in New Zealand breeding programmes over the last 85 years, has been accompanied by a 10% increase in internal phosphate (P) use efficiency (PUE), with PUE defined as shoot dry weight per unit total plant P uptake. The agronomic significance of this change in PUE is unknown because no P response field trials involving contemporary clover cultivars have been reported, that we are aware of. There are obviously limits to how far internal PUE can be increased because of the role of P in many plant metabolic processes. Having some inorganic P held in reserve in the cell vacuoles is probably a good insurance against short term fluctuations in P supply from the soil. Our current strategy is focussed more on improving phosphate acquisition efficiency (PAE) in white clover, though any coincidental gains in PUE are welcome. Introgression of traits from some of white clover's close wild relatives into adapted cultivars provides access to more variation than is found in the white clover gene pool alone. For example, *Trifolum uniflorum*, a Mediterranean wild clover has several characteristics indicating adaptation to low fertility soils. If it is crossed with white clover, and the hybrid progeny is then crossed again with white clover, the backcross (BC1) progeny are genetically 75% white clover and above ground they resemble typical white clovers. Under controlled conditions, some of these BC1 hybrids grow better than white clover in soils with Olsen P values in the 10 – 20 range. Of more importance may be their characteristic of investing heavily in root growth in lower P soils i.e. scavenging for P when it is in short supply. As soil P increases they switch over to shoot growth, but unlike white clover they accumulate P in their roots where it is protected from grazing, and made progressively available for shoot growth over a longer period. This trait would be particularly valuable in clovers for hill farming where P fertiliser inputs are less frequent than for lowland systems.

DROUGHT TOLERANCE AND WATER-USE EFFICIENCY OF FIVE HYBRID POPLAR CLONES

Trevor Jones[1], Ian McIvor[1] and Michael McManus[2]

[1]*Plant & Food Research, Palmerston North*
[2]*Massey University, Palmerston North*

The soil water deficits that occur in drought conditions are a major factor limiting the survival and growth of poplar trees for soil conservation in New Zealand. Poplars are among the fastest growing trees under temperate latitudes, but their high productivity is associated with a dependency on water availability. There is wide variability in the drought tolerance and water-use efficiency of poplar species and hybrids, and potential for the selection of poplar clones with improved adaptability to drought conditions.

The physiological responses to soil water deficits of four new experimental hybrid poplar clones of *Populus trichocarpa* x *P. nigra* and *P. maximowiczii* x *P. trichocarpa*, and the *P. deltoides* x *P. nigra* 'Veronese' poplar clone that is widely used for soil conservation in New Zealand, were evaluated in a greenhouse pot trial, with well-watered, moderate and severe (90, 60 and 40% of field capacity) soil water deficit treatments. The biomass growth and water-use efficiency of the poplar trees, leaf stomatal conductance, water potential, chlorophyll content and antioxidant enzyme activity were measured to determine the drought tolerance of the poplar clones.

The four new experimental hybrid poplar clones were not as drought tolerant as the 'Veronese' poplar clone, showing a less conservative response to the soil water deficits, but they had the advantage of better biomass growth and water-use efficiency under drought conditions. The 'Veronese' clone appears well adapted for drought-prone areas, where the survival of the trees during periods of severe soil water deficits is a constraint. In contrast, the new hybrid poplar clones appear better adapted to moderately drought-prone areas, where there is an advantage in combining high productivity and high water-use efficiency to better utilise the available water during the growing season.

THE POTENTIAL FOR POPLAR AND WILLOW SILVOPASTORAL SYSTEMS TO MITIGATE NITRATE LEACHING FROM INTENSIVE AGRICULTURE IN NEW ZEALAND

Hannah Franklin[1], Dale McEntee[2] and Mark Bloomberg[2*]

[1]*Faculty of Agriculture and Life Sciences, Lincoln University*
[2]*Faculty of Agribusiness and Commerce, Lincoln University*
**Corresponding author Email: mark.bloomberg@lincoln.ac.nz*

In New Zealand, nitrate (NO_3^-) leaching is a major environmental problem associated with intensive agriculture. Research suggests that plants with deeper roots and high evapotranspiration rates, such as poplar (*Populus)* and willow *(Salix)*, may reduce NO_3^- leaching. In New Zealand, willow and poplar have largely been studied in relation to their soil conservation benefits, use as stock fodder, biomass production and phytoremediation of contaminated soil. This review compiles information on the use of poplars and willow in agricultural systems and explores their potential application to the management of NO_3^- leaching. Studies show reduced NO_3^- leaching under short rotation coppice willows. However, the establishment and harvesting phases are risk periods for nitrate leaching and nitrogen application should be avoided. A case study has identified a potential for role of poplar and willow silvopastoral systems on intensively-managed irrigated farms of the Canterbury Plains. Height restrictions due to overhead irrigation, stock fodder value and the need to restrict light competition with pastures suggest *Salix viminalis* (with annual coppicing) as the most suitable species for integration into these farms. Further research is needed to quantify both the possible reduction in N losses possible and the additional on and off-farm benefits of poplar and willow silvopastoralism in the context of intensive farming in New Zealand.

TRENDS, OPPORTUNITIES AND RISKS FOR SOIL CONTAMINATION IN NEW ZEALAND

Christopher Anderson

Fertilizer and Lime Research Centre, Massey University, Palmerston North

Society is today very aware of the dangers of contaminants in food. Stories of heavy metal, pesticide and agrichemical levels in food products are common in media. While New Zealand does not have a legacy of extensive soil contamination from industrial sources, agricultural practices have introduced contaminants such as DDT, Cd and As in the soil environment. Many of the contamination pathways are/were diffuse and accurate knowledge of the specific location of contaminated land is often poor.

The growth of major New Zealand cities into what has traditionally been rural land has seen the transfer of land use from agricultural production to residential housing or lifestyle blocks. This is particularly true for Hamilton and Christchurch; the former due to the Auckland housing boom and the later a consequence of the 2011 earthquake. There are regular stories of new housing developments being sited on historic landfills or sheep-dip sites, where soil contamination levels exceed National Environmental Standards.

Understanding the relationship between the NES and urban development is an important area for New Zealand environmental management. There is good opportunity for research and teaching in this space to increase the capability of environmental professionals to provide sound environmental advice. The risk of contaminant concentrations above NES guidelines can be mitigated by timely environmental assessment, appropriate consideration of alternative land-use options, and, where necessary, soil amendment and/or remediation.

This paper will present an overview of topical contamination issues with New Zealand soil, and review specific case studies for As and DDT contamination at historic sheep dip sites, Cd contamination of pastoral land, and dioxin contamination of soil and sediments.

CADMIUM IN NEW ZEALAND'S AGRICULTURE AND FOOD SYSTEMS – AN UPDATE

E Abraham[1], J Cavanagh[2], P Wood[3], A Pearson[4] and P Mladenov[5]

[1]Dragonfly Data Science, PO Box 27535, Wellington 6141
[2]Landcare Research, Gerald Street, PO Box 69040, Lincoln 7640
[3]QCONZ, 62 Wake Street, PO Box 12316, Chartwell Square, Hamilton 3248
[4]Ministry for Primary Industries, PO Box 2526, Wellington 6140, Wellington
[5]Fertiliser Association of NZ, L2, 58 Victoria Street, PO Box 11519, Wellington 6142
Corresponding author E-mail: philip.mladenov@fertiliser.org.nz

This presentation summarises up-to-date data and trends for key information related to the management of cadmium in New Zealand's agriculture and food systems, including:

- The results from statistical modelling of soil cadmium concentrations from more than 7000 nationally available soil samples collected by the fertiliser industry, regional councils and other researchers between 2007 and 2015 from across a broad range of land uses and soil types;
- Trends in levels of cadmium reported in phosphatic fertilisers used in New Zealand since 1995, with a comparison to agreed voluntary limits;
- Trends in soil cadmium accumulation from the long-term flood irrigated fertiliser trials at the Winchmore Research Station in Canterbury, New Zealand
- Trends in cadmium levels in food from the 1990, 2004 and 2009 New Zealand Total Diet Surveys, with a comparison to international standards.

The results of this work will feed into the multi-stakeholder Cadmium Management Group's continuing risk management of cadmium in New Zealand's agriculture and food systems, and inform the planning for the forthcoming review of the national Cadmium Management Strategy in 2017.

CADMIUM ACCUMULATION BY FORAGE SPECIES USED IN NEW ZEALAND LIVESTOCK GRAZING SYSTEMS

Aaron Stafford[1], Chris Anderson[2], Mike Hedley[2] and Richard McDowell[3]

[1]Ballance Agri-Nutrients, Private Bag 12503, Tauranga 3143, New Zealand
[2]Institute of Agriculture and Environment, Massey University, Palmerston North
[3]Land & Environment, AgResearch, Invermay Agricultural Centre, Mosgiel
Email: Aaron.Stafford@ballance.co.nz

Little data exists on cadmium (Cd) accumulation in many plant species now commonly used as animal forages in New Zealand livestock grazing systems. A glasshouse trial was undertaken on 12 forage species to address this knowledge gap. Mean tissue Cd concentration decreased in the order chicory > plantain > turnip > lucerne > sheep's burnet > strawberry clover > kale > perennial ryegrass > haresfoot trefoil > red clover > crimson clover > white clover. Chicory and plantain had significantly greater mean tissue Cd concentrations (1.639 and 0.734 mg kg^{-1} DM, respectively) than all other species. Cadmium in ryegrass and white clover (0.103 and 0.035 mg kg^{-1}, respectively) was similar to that reported in other field and laboratory studies.

A survey undertaken across a range of commercial farms with varying soil type, land use and phosphorus (P)-fertiliser history validated the results of our glasshouse trial; chicory had a mean Cd concentration of 1.82 mg kg^{-1} (range 0.40-4.50 mg kg^{-1}) and plantain had a mean Cd concentration of 0.80 mg kg^{-1} (range 0.23-2.40 mg kg^{-1}).

Modelling of lamb kidney Cd accumulation indicated that food standard maximum levels may be exceeded in animals younger than the current meat industry 30 month offal discard age. With increased use of chicory and plantain as specialist forage crops in New Zealand, this information will be important for improving livestock Cd accumulation risk assessment models.

USE OF CADMIUM ISOTOPES TO DISTINGUISH SOURCES OF CADMIUM IN NEW ZEALAND AGRICULTURAL SOILS: PRELIMINARY RESULTS

M Salmanzadeh, A Hartland, C Stirling, M Balks, L Schipper and E George

University of Waikato, Hamilton

In New Zealand soils, cadmium (Cd) is mainly derived from phosphate fertiliser application. In 1997, the NZ fertiliser industry changed the main source of phosphate fertilisers from Nauru to Morocco, which has a lower concentration of Cd. Research on the concentration of Cd in soils from the Winchmore research farm (Canterbury) demonstrated that Cd accumulation rates started to slow in the period since 1997. We investigate the hypothesis that the decrease in the rate of Cd accumulation is linked to the lower Cd inputs in the contemporary P fertiliser supply.

The objective of this research is to assess the potential of Cd stable isotope ratios ($\varepsilon^{114/110}$Cd) to distinguish sources of Cd in Winchmore soil samples and pre- and post-1997 superphosphate fertilisers. Ten soil samples were selected from Winchmore research farm. Two replicate dried and sieved (< 2mm) soil samples from each of the years 1959, 1967, 1979, 1993 and 2002 were analysed. After determination of the total concentration of Cd, samples were transferred to Otago University for Cd isotope analysis using double-spike methods and multiple-collector ICP-MS.

Results showed a linear relationship ($R^2 = 0.9451$) between the total Cd concentration and isotope ratios of Cd. This surprising result may suggest that the amount of fertiliser-derived Cd might be determinable from an isotope mixing approach. A two end-member mixing model based on estimated native and fertiliser Cd isotope ratios was applied to the data set. However, the measured and calculated values did not show a good relationship for all years. Therefore, for the next step of research we are analysing more samples from Winchmore farm, historical and contemporary superphosphate fertilisers, and rock phosphate to better constrain the isotope composition of source materials.

STATUS AND FUTURE PERSPECTIVES OF SMART TOOLS AND APPS IN NUTRIENT AND WATER MANAGEMENT

Eva Schröer-Merker

Centre of Excellence in Farm Business Management
Institute of Agriculture and Environment, Massey University

The pace of technological development is vast, and exponentially increasing. Scientific projections show that this will also have an ever increasing impact on agriculture, with the deployment of drones and sensors as just the beginning.

Farms are highly complex systems, and they operate differently from any other form of enterprise. The demand for formal controlling, especially in the field of nutrient and water management, has increased greatly in recent years. This was promoted, in part, by an increased awareness / concern about impacts on the environment and subsequent legislation.

The Centre of Excellence in Farm Business Management (OneFarm) is a Joint Venture by Lincoln and Massey Universities and is funded by DairyNZ and RMPP via the Primary Growth Partnership. It is an independent source for information on recent developments in farm management related topics. Providing an overview on resources is the Toolbox which contains reviews of Apps, websites and other helpful tools available in the marketplace. The website also delivers commentary on recent developments via blogs and supports the industry with research on current farm business management topics.

Our research into decision making and information management has shown that formalisation and the use of software solutions / apps is largely driven by compliance requirements arising from this. Another driver for adoption is the perceived value add. A number of apps are already available to farmers with respect to nutrient and water management, such as AgHub and SmartMaps. Other examples for smart tools and apps currently used in the field of nutrient management are Overseer (compliance), FieldMAP (precision irrigation), FarmIQ (holistic approach), Harvest Electronics (holistic approach).

Albeit, or because of, the large number of smart tools available to farmers, a wholly different set of challenges arises, namely connectivity / rural broadband and the perceived overload of data / single solutions. In the future, New Zealand farmers will have to be able to be connected to stay on top. Smart systems will start ‘talking’ to each other in order for collected data to be useful to the end-user and to have the biggest impact on their business (the Internet of Things).

SPATIAL DEPENDENCE AND DETERMINATES OF DAIRY FARMERS' ADOPTION OF BEST MANAGEMENT PRACTICES FOR WATER PROTECTION

Wei Yang

Department of Economics, University of Auckland

Purpose: This paper aims to explore determinants of dairy farmers' willingness to adopt Best manamgment practices (BMPs) for water quality protection. In addition, except for testing the commonly used determinants, such as farm characteristics, it will test for the hypothesis that spatial effects influence farmers' choices.

Design/methodology: Bayesian spatial Durbin (SDM) probit models are applied to survey data collected from dairy farmers in the Waikato Region of New Zealand. Firstly, spatial effects will be modelled according to the distance from farm to the nearest water bodies. It is assumed that dairy farmers whose farms are located close to water bodies are more inclined to be willing to adopt BMPs. Secondly, spatial effects will be presented as the existence of spatial interdependency in dairy farmers' decision-making. It is hypothesised that dairy farmers observe or learn from nearby farmers thereby reducing the uncertainty of the performance of BMPs since BMPs are information-intensive farming techniques.

Findings: Results show that farmers located in close proximity to each other exhibit similar choice behaviour indicating that access to industry information is an influential determinants of dairy farmers' adoption of BMPs. In addition, these findings address the importance of farmer interactions in adoption decisions as participation in dairy-related activities are identified as an extension of information acquisition. Financial problems are considered a significant barrier to adopting BMPs. Overall, the study highlights the importance of accounting for interdependence in farmers' decisions, which emerges as important in the formulation of agricultural-enviornmental policy.

Originality/value: The results contribute to assist policy makers to specify water protection strategies. An understanding of dairy farmers' drivers and barriers to adopting BMPs could assist policy makers to deliver support to solve the problems that are badly in the need of help. Besides, the importance of information availability in the neighbourhood network and social activities for the farmer's decision-making suggests that extension activities that address the whole community may be more efficient than targeting individual farmers to induce behavioural changes in adoption of BMPs.

DISCOVERING THE VALUE OF HYPERSPECTRAL DATA FOR NEW ZEALAND AGRICULTURE

Megan Z Cushnahan, B A Wood and I J Yule

NZ Centre for Precision Agriculture, Massey University

Agricultural science in New Zealand has traditionally been well served by the classical science model. The model has enabled specialist agricultural research teams to extrapolate results from small samples to produce a significant knowledge return on investment. The advent of big data in agricultural science is producing a radical transformation in the way value is generated from scientific research. Hyperspectral imaging technology (HIT) is used by Massey University's New Zealand Centre for Precision Agriculture (NZCPA) in a variety of applications. Unlike traditional agricultural research, HIT produces superabundant, multi-layered data early in the science process. The study explores how the NZCPA is adapting its science processes in order to capitalise on the possibilities generated by the new data economy. The paper documents the iterative, cyclical science process being developed by NZCPA in order to refine value from the superabundant, versatile data. An example of how this non-linear process and a multidisciplinary approach, including farmers and scientists from other fields, have been used to extract unplanned value from hyperspectral imaging data is provided. The study highlights the need for agricultural science to adapt in order to maximise the value refined from the new data economy.

TECHNOLOGIES FOR IMPROVING NUTRIENT AND WATER USE EFFICIENCY

Stu Bradbury[1,3], Jemma Mulvihill[2], Craige Mackenzie[2], Chris Smith[2] and Paul Whitehead[3]

[1]Agri Optics North, Palmerston North
[2]Agri Optics NZ Ltd, Methven
[3]Lindsay NZ, Palmerston North

New Zealand agriculture and the technology we use within it to make farming easier, more accurate and more profitable is evolving at a fast pace, both in the technology itself and also how we adapt and use it on farm. Of high importance currently are tools that help improve nutrient and water use efficiency. Some of these tools are:

- Electro-magnetic (EM) surveying
- Variable Rate Irrigation
- Soil moisture probes

These tools and Precision Agriculture (PA) management techniques can be inter-linked to provide a very strong on-farm understanding of the current state of nutrient and water use. They can then be used as a platform to implement further fine tuning to boost nutrient and water use efficiency.

EM Surveying provides a method to map and measure the conductivity of the soil, which in NZ strongly correlates to texture and water-holding capacity. When the survey is completed accurately it can be then used to create a water-holding capacity map which can then be used for scheduling irrigation, in particular with variable rate irrigation. An EM survey is primarily completed (in NZ) using a device known as a DualEM. It provides a range of measured attributes from each survey which can then be post–processed into a wide range of different maps including soil variability, elevation, slope, and watershed modelling using GIS software. Once high quality data is collected and maps of the required attributes are produced the information is then ready to be implemented on farm using variable rate irrigation software with soil moisture probes employed to create a feedback loop.

Currently in NZ we are only scratching the surface with the adoption and use of these tools. Precision Agriculture techniques and technologies are providing an effective way to map, measure and manage more precisely the way in which we farm to ensure that the use of water and nutrients is maximised to increase farm efficiency and help maximise productivity from current input levels while reducing environmental risks. Precision Ag can easily be incorporated into Farm Environment Plans and Overseer modelling by using the information gathered to break the farm into different management areas and inputs varied accordingly to help improve farm management. Ultimately this helps to provide incentive to increase water and nutrient use efficiency for all of NZ agriculture.

MEASURING THE SPREAD PATTERNS OF SPREADERS UNDER NORMAL FIELD CONDITIONS COMPARED TO TEST CONDITIONS

Miles Grafton, D Izquierdo Acebes, I J Yule and L A Willis

New Zealand Centre for Precision Agriculture, Institute of Agriculture and Environment, Massey University, Palmerston North, New Zealand

The Fertiliser Quality Council, Ravensdown and the Fertiliser Association commissioned Massey University to conduct some fertiliser spreading trials over the summers of 2013 – 2014 and 2014 – 2015. This work was undertaken to provide a better understanding of the effects of field conditions on spread patterns for some commonly applied fertilisers, which were provided by Ravensdown and Ballance for the work.

This work was commissioned to help understand which factors effect spreading accuracy in actual application conditions. The work provides some science around this topic which has had fertiliser suppliers being blamed for poor spread outcomes by spreaders claiming the products are not of a suitable physical standard to spread accurately.

This work identified the following factors which reduce spreading accuracy which effects in field CV are poorly understood for ground-spread:

- Border spreading (non migration past border target)
- Variable rate application within paddocks
- Headland control (spreading around corners)
- Effects of slope, hills and uneven surfaces
- The effect of wind
- Other changes in operating conditions, temperature, humidity, height of crop

The effect some of these variables have on in-field CV and the importance in terms of bout width distances to meet Spreadmark standards are measured. The paper finds that the effect of slope has a marked negative impact on application rate and spread pattern. The effect of wind is also negative but can be mitigated. Border spreading is possible if the spreader is correctly set up. Variable rate application and changes in crop height, temperature and humidity were not tested.

ON-FARM FERTILISER APPLICATOR CALIBRATION

Dan Bloomer

LandWISE, Hastings

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.

Farmers and agronomists had noticed striping in crops, especially when spreading bout widths increased to match wide sprayer bouts. Visible striping is indicative of very significant non-uniform distribution and yield loss.

Fertiliser applicator manufacturers provide guidelines to calibrate equipment and some newer machines automatically adjust to correct distribution pattern based on product properties and comparing a test catch with "factory" test data.

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 have been developed. Guidelines and a web-based calculator (see www.fertspread.nz) support on-farm checks to ensure and demonstrate application equipment is performing to expectations. They also aid the self-audit component of *Spreadmark®*.

FertSpread calculates uniformity from data from a single pass and mathematically applies overlap using both to and fro and round and round driving patterns. Weighing samples involves very small quantities so scales weighing to 0.01g are required. Satisfactory options are readily available at reasonable price.

An alternative approach uses small measuring cylinders or syringe bodies to compare applied volumes. While not able to assess alternative driving patterns, this can give a direct and very visual immediate view of performance.

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 efficiency of catch trays is called into question. While we believe the collection tray data is acceptable to assess evenness of application, the application rate should be determined by direct measurement of weight applied to determined area.

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