FERTILIZER & LIME RESEARCH CENTRE

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Advanced Nutrient Management

Gains from the Past – Goals for the Future

This document contains the abstracts of all papers that were presented at the 25th Annual FLRC Workshop held at Massey University on the 7th, 8th and 9th February 2012. They are printed here in the order of presentation at the workshop and may assist people who wish to search for keywords prior to accessing the individual manuscripts.

Individual manuscripts are available from the website at:

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

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Tuesday 7th February

Professor Mike Hedley
Director, Fertilizer & Lime Research Centre, Massey University
WELCOME AND INTRODUCTION

Farm and Nutrient Management

Stewart F. Ledgard, *(Invited Presentation)*
M Zonderland-Thomasen, M Lieffering and S McLaren
AgResearch - Ruakura, Hamilton
ROLE OF LIFE CYCLE ASSESSMENT IN AGRICULTURE FOR REALISING MARKET OPPORTUNITIES AND ENHANCING ON-FARM EFFICIENCY

Doug Edmeades
agKnowledge Ltd, Hamilton
DEVELOPMENTS IN THE MANAGEMENT OF SOIL FERTILITY AND PASTURE NUTRITION OVER THE LAST 20 YEARS

Mark Shepherd, D Wheeler and I Power
AgResearch - Ruakura, Hamilton
OVERSEER® NUTRIENT BUDGETS: THE NEXT GENERATION

Vaughan Templeton
Otaitai Dairys, Southland
NUTRIENT MANAGEMENT – A FARMERS PERSPECTIVE

Bob Longhurst, I Power, M Hawke and B Parker
AgResearch - Ruakura, Hamilton
REDUCING NUTRIENT LOSSES TO LAKE REREWHAKAAITU

Ian McIvor and G Douglas
Plant & Food Research, Palmerston North
POPLARS AND WILLOWS IN HILL COUNTRY
– STABILISING SOILS AND STORING CARBON

Dani Guinto
Bay of Plenty Regional Council, Whakatane
TEMPORAL CHANGES IN TOPSOIL TRACE ELEMENT CONCENTRATIONS IN THE BAY OF PLENTY

Malcolm Todd, W McKay, J Lissington and T Collis
Horizons Regional Council, Palmerston North
FAST FARM-SCALE SOIL MAPPING FOR SOIL AND NUTRIENT MANAGEMENT USING LIDAR IN THE MANAWATU

Siva Sivakumaran, I McIvor, A Gillum, S Sloan, P Jeyakumar, C van den Dijssel and D Hedderley
Plant & Food Research, Palmerston North
SOIL QUALITY IN PASTORAL HILL COUNTRY AS INFLUENCED BY THE PRESENCE OF WILLOW (*SALIX MATSUDANA × ALBA*) TREES

Nitrogen Management

Alison Dewes and J Bolt
Headlands Consultancy, Te Awamutu
MINIMAL FOOTPRINT OPTIMAL PROFIT FARMS
"TOMORROWS FARMS TODAY – UPPER WAIKATO CATCHMENT"

Christine Christensen, M J Hedley, J A Hanly and D J Horne
Fertilizer and Lime Research Centre, Massey University
THREE YEARS OF DURATION-CONTROLLED GRAZING: – WHAT HAVE WE FOUND?

Guna Magesan and G McFadden
NZ Biological Farming Systems Research Centre, Rotorua
NUTRIENT LEACHING UNDER CONVENTIONAL AND BIOLOGICAL DAIRY FARMING SYSTEMS

Greg Lambert, A Roberts and J Morton
Consultant, Halcombe
NITROGEN USE ON HILL COUNTRY: LESSONS FROM THE NATIONAL WISE N USE FOCUS FARM PROJECT

Brian Devantier, C Hoogendorn, P Theobold and S Bowatte
AgResearch - Grasslands, Palmerston North
EFFECT OF SLOPE CLASS ON SOIL NITRIFICATION POTENTIAL IN SHEEP GRAZED SUMMER MOIST HILL COUNTRY

Allan G Gillingham, S.F. Ledgard, S. Saggar, K. C. Cameron, H.J. Di, C. de Klein and M.D. Aspin
Research Consultant, Palmerston North
INITIAL EVALUATION OF THE EFFECTS OF DICYANDIAMIDE (DCD) ON NITROUS OXIDE EMISSIONS, NITRATE LEACHING AND DRY MATTER PRODUCTION FROM DAIRY PASTURES IN A RANGE OF LOCATIONS WITHIN NEW ZEALAND

Peter L Carey, S Jiang and A H C Roberts
Land Research Services, Lincoln
PASTURE DRY-MATTER RESPONSES TO THE USE OF A NITRIFICATION INHIBITOR: A SUMMARY OF A NATIONAL SERIES OF NEW ZEALAND FARM TRIALS

Frank Y Li and K Betteridge
AgResearch - Grasslands, Palmerston North
EFFECTIVENESS OF MITIGATING NITROGEN LOSS FROM CRITICAL SOURCE AREAS IN GRAZED PASTURE

Mark Shepherd, D M Wheeler and G Lucci
AgResearch - Ruakura, Hamilton
REVIEWING AND REVISING THE DCD MODEL WITHIN OVERSEER® NUTRIENT BUDGETS

Dong-Gill Kim, D Giltrap, S Saggar, T Palmada, P Berben and D Drysdale
Landcare Research, Palmerston North
FACTORS CONTROLLING DISAPPEARANCE OF NITRIFICATION INHIBITOR, DICYANDIAMIDE (DCD) IN A GRAZED PASTURE SOIL IN MANAWATU

Matt Wild
Ravensdown, Christchurch
THE USE OF DCD TO REDUCE NITROGEN LOSSES FROM INTENSIVE WINTER GRAZING BLOCKS

Brendon Welten, M Kear, M Dexter and A Judge
AgResearch - Ruakura, Hamilton
EXTRACTION EFFICIENCY OF DCD FROM SOILS

Sheree Balvert, A Judge, M Sprosen and S Ledgard
AgResearch - Ruakura, Hamilton
USING A LYSIMETER STUDY TO ESTIMATE N LEACHING UNDER GRAZING, AS AFFECTED BY MULTIPLE DCD APPLICATIONS

Farm Dairy Effluent

David Horne and J A Hanly
Fertilizer and Lime Research Centre, Massey University
FARM DAIRY EFFLUENT: ACHIEVEMENTS TO DATE AND FUTURE CHALLENGES

Bob Longhurst , D Houlbrooke, T Orchiston and R Muirhead
AgResearch, Hamilton
CHARACTERISING DAIRY MANURES AND SLURRIES

David Houlbrooke, R Longhurst, T Orchiston and R Muirhead
AgResearch, Hamilton
LAND APPLYING DAIRY MANURES AND SLURRIES: EVALUATING CURRENT PRACTICE

Seth Laurenson, D Houlbrooke, R. Monaghan, T Wilson and S Morgan
AgResearch - Invermay, Mosgiel
DEVELOPING BEST MANAGEMENT GUIDELINES FOR EFFLUENT APPLICATION IN HIGH RAINFALL REGIONS

Paul Johnstone, D Wallace, D Mathers and M Parker
Plant & Food Research, Hastings
INTEGRATED NUTRIENT MANAGEMENT STRATEGIES FOR DAIRY AND CROPPING FARMERS

David Wheeler, M Shepherd and I Power
AgResearch - Ruakura, Hamilton
EFFLUENT MANAGEMENT IN OVERSEER NUTRIENT BUDGETS

Wednesday 8th February

Water: Some Wider Perspectives

Robert Glennon *(Invited Presentation)*
Rogers College of Law, University of Arizona, USA
UNQUENCHABLE:- AMERICA'S WATER CRISIS AND WHAT TO DO ABOUT IT

Brent Clothier, M Deurer, S Green, I Herath and A Mowat
Plant & Food Research, Palmerston North
A HYDROLOGICAL APPROACH TO THE WATER FOOTPRINTING OF NEW ZEALAND'S FRUIT PRODUCTS

Indika Herath, B Clothier, S Green, D Horne, R Singh, A Marsh, A Buchanan and R Burgess
Institute of Natural Resources, Massey University
MEASURING THE GREY WATER FOOTPRINT OF POTATOES

W Troy Baisden and C Douence
GNS Science, Lower Hutt
FURTHER PROGRESS USING ISOTOPES TO TRACK THE SOURCES OF NITRATE IN SURFACE WATERS

Steve Green, C van den Dijjssel, G Dryden and P Davidson
Plant & Food Research, Palmerston North
GROUND WATER ABSTRACTION FROM THE WAIRAU PLAINS, MARLBOROUGH

Roland Stenger, J Clague, S Woodward, B Moorhead, L Burbery and H Canard
Lincoln Ventures, Hamilton
GROUNDWATER ASSIMILATIVE CAPACITY – AN UNTAPPED OPPORTUNITY FOR CATCHMENT SCALE NITROGEN MANAGEMENT?

Nutrient Use Efficiency

Robert E White *(Invited guest)*
L Balachandra, R Edis and D Chen
University of Melbourne, Australia
THE RELATIONSHIP BETWEEN GRAPEVINE VIGOUR AND THE N-MINERALIZATION POTENTIAL OF SOIL IN SELECTED COOL CLIMATE VINEYARDS IN VICTORIA, AUSTRALIA

Rob Craigie
Foundation for Arable Research, Lincoln
DOES ZONAL NITROGEN MANAGEMENT IN MILLING WHEAT PAY?

Peter W Clinton, J Xue, G Coker, S Smaill, M R Davis and T W Payn
Scion, Christchurch
PLANTATION NUTRITION MANAGEMENT IN NEW ZEALAND – 25 YEARS ON

Simeon Smaill
Scion, Christchurch
IMPROVING MANAGEMENT OF PLANTATION PRODUCTIVITY WITH A NUTRIENT BALANCE MODEL

Ronaldo Vibart, T White, D Smeaton, S Dennis, R Dynes and M Brown
AgResearch - Grasslands, Palmerston North
EFFICIENCIES, PRODUCTIVITY, NUTRIENT LOSSES AND GREENHOUSE GAS EMISSIONS FROM NEW ZEALAND DAIRY FARMS IDENTIFIED AS HIGH PRODUCTION, LOW EMISSION SYSTEMS

Nanthi S Bolan, R Naidu, S Shenbagavalli and S Mahimairaja
CERAR and CRC CARE, University of South Australia, Adelaide
BIOSOLIDS APPLICATION ENHANCES CARBON SEQUESTRATION IN SOILS

Stephen Trolove, J Reid, K Pyle and W Hall
Plant & Food Research, Havelock North
INVESTIGATING THREE METHODS FOR IMPROVING MAGNESIUM NUTRITION OF CITRUS GROWN ON YOUNG SEDIMENTARY SOILS

M Hasinur Rahman, P Mills, H Cameron, K Pellowe and A Holmes
PlusGroup Horticulture Ltd, Tauranga
THE IMPACT OF KIWIFRUIT MANAGEMENT ON ALLOPHANIC SOIL QUALITY: PHYSICAL, CHEMICAL AND HYDROLOGICAL PROPERTIES

Saman Bowatte, X Cheng, S Brock, P Theobald and P Newton
AgResearch - Grasslands, Palmerston North
GRASS SPECIES EFFECTS ON SOME SOIL PROPERTIES NOW AND IN THE FUTURE

Ivan Chirino, L Condron, R McLenaghen and M Davis
Faculty of Agriculture and Life Sciences, Lincoln University
EFFECTS OF PLANTATION FOREST SPECIES ON SOIL PROPERTIES

Weiwen Qiu, D Curtin, M Beare and E Gregorich
Plant & Food Research, Christchurch
TEMPERATURE SENSITIVITY OF ORGANIC MATTER MINERALISATION IN SOILS WITH CONTRASTING MANAGEMENT HISTORIES

Phosphorus

A tribute session to the late J Keith Syers,
Foundation Director of the Fertilizer and Lime Research Centre

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Rich McDowell *(Invited Presentation)*
AgResearch - Invermay, Mosgiel
CHALLENGES AND OPPORTUNITIES TO DECREASE PHOSPHORUS LOSSES

Russ Tillman, A Roberts and M Manning
Fertilizer and Lime Research Centre, Massey University
A RECONSIDERATION OF THE TARGET OLSEN P RANGES FOR DAIRY FARMS

Jim Moir, D Moot, P Jordan and R Lucas
Department of Soil and Physical Sciences, Lincoln University
PHOSPHORUS RESPONSE AND EFFICIENCY OF 12 NOVEL DRYLAND LEGUME SPECIES ON AN ACID HIGH COUNTRY SOIL

Gordon Rajendram, K Devey and S Unda
Hill Laboratories, Hamilton
SOIL CHEMISTRY WHICH INFLUENCES POTENTIAL P LOSS

James Hanly, J Leon, D J Horne and C Pratt
Fertilizer and Lime Research Centre, Massey University
REMOVING PHOSPHORUS FROM WASTEWATERS USING ANDESITIC TEPHRA SUBSOILS

Keith Betteridge, D Costall, S Martin, B Reidy, A Stead and I Millner
AgResearch - Grasslands, Palmerston North
IMPACT OF SHADE TREES ON ANGUS COW BEHAVIOUR IN SUMMER DRY HILL COUNTRY: GRAZING ACTIVITY AND NUTRIENT TRANSFER ISSUES

Ina Draganova and I J Yule
NZ Centre for Precision Agriculture, Massey University
THE COWS ROLE IN REDISTRIBUTING N AROUND THE DAIRY FARM

Seth Laurenson and D J Houlbrooke
AgResearch - Invermay, Mosgiel
RECOVERY OF SOIL PHYSICAL QUALITY FOLLOWING INTENSIVE GRAZING: COMPARING NATURAL RECOVERY AND MECHANICAL AERATION

Daniel Mason, M White, P Lorentz and J Waller
Analytical Research Laboratories, Napier
IMPROVED RELIABILITY OF SOIL PH MEASUREMENT USING MECHANICAL STIRRING

Charlotte Robertson, B Clothier, S Sivakumaran, A McLachlan, I McIvor and H Meikle
Plant & Food Research, Palmerston North
NITROGEN MANAGEMENT BY WATERCRESS (*NASTURTIUM OFFICINALE*) IN HYDROPONIC CONDITIONS

Nanthi S Bolan *(Invited guest)*
R Naidu and C Anderson
CERAR and CRC CARE, University of South Australia, Adelaide
MANAGEMENT OF PHOSPHORUS IN ORGANIC AMENDMENTS FOR SUSTAINABLE PRODUCTION AND ENVIRONMENTAL PROTECTION

Lindsay C. Campbell, G D Batten, J N A Lott and J Kolasa
University of Sydney, Australia
CAN OCEANIA RESPOND TO A P CRISIS?

Ravi Naidu, *(Invited guest)*
N S Bolan and J Gawandar
CERAR and CRC CARE, University of South Australia, Adelaide
RECOVERY AND REUSE OF PHOSPHORUS FROM WASTEWATER SOURCES

Marcio Chiba, R Cichota and I Vogeler
AgResearch - Grasslands, Palmerston North
CAN WE IMPROVE INTERPOLATION OF N_2O EMISSION MEASUREMENTS BY USING ENVIRONMENTAL FACTORS?

Weiwei Xia, Z Jia, S Bowatte and P Newton
Institute of Soil Science, Chinese Academy of Sciences, Nanjing, China
CHANGES IN SOIL MICROBIAL COMMUNITY STRUCTURE UNDER ELEVATED ATMOSPHERIC CO_2

Paramsothy Jeyakumar, K Müller, M Deurer, C van den Dijssel, K Mason, S Green and B Clothier
Plant & Food Research, Palmerston North
ROMA: A NOVEL LABORATORY APPLIANCE TO QUANTIFY HOW WATER REPELLENCY AFFECTS SOIL WATER DYNAMICS

Neha Jha, S Saggar, R W Tillman and D Giltrap
Institute of Natural Resources, Massey University
CHANGE IN DENITRIFICATION RATE AND N_2O/N_2 RATIO WITH VARYING SOIL MOISTURE CONDITIONS OF NEW ZEALAND PASTURE SOILS

Bob Longhurst, D Houlbrooke, M White, A McGowan, J Waller and R Stewart
AgResearch, Hamilton
SPATIAL VARIABILITY OF NUTRIENTS IN A HERDHOMES® ANIMAL SHELTER MANURE BUNKER

Thursday 9th February

Fertilisers and Application Technology

Warwick Catto
Ballance Agri-Nutrients, Tauranga
REFLECTIONS FROM 23 YEARS IN FERTILISER INDUSTRY

Pip McVeagh, I Yule and M Grafton
NZ Centre for Precision Agriculture, Massey University
PASTURE YIELD MAPPING FROM YOUR GROUNDSPREAD TRUCK

Colin Brown and R Saunders
TracMap, Mosgiel
PRODUCTIVITY DIFFERENCES DUE TO VARYING APPROACHES TO SPREADING - AN ANALYSIS OF 30,000 SPREADING MAPS

Colin Brown and L Nuttall
TracMap, Mosgiel
A FARMER FRIENDLY WAY OF ORDERING VARIABLE RATE FERTILISER APPLICATION USING GOOGLE EARTH

Miles Grafton and I J Yule
Ravensdown, Christchurch
PROGRESS TOWARDS BETTER PRECISION AND IMPROVED SAFETY

Peter Bishop, Tan Sy Pham, Linh Nguyen and B Quin
Advanced Agricultural Additives (NZ) Ltd, Palmerston North
THE USE OF POLY-CARBOXYLIC ACIDS AND SODIUM SILICATE TO INCREASE FERTILIZER P EFFICIENCY AND REDUCE LIME REQUIREMENTS ON ACID SOILS IN NEW ZEALAND AND VIETNAM

Bert Quin
Quin Environmentals, Auckland
SUPER, RPR AND LIQUIDS – OBSERVATIONS ON 40 YEARS OF SCIENCE AND SEMANTICS, ZEALOTRY AND BIGOTRY, REGULATION vs DEREGULATION, CONS OR COMMERCE, FACT OR MYTH, INTERPRETATION OR MISINTERPRETATION

Smart Tools

Raphael Viscarra Rossel *(Invited Presentation)*
CSIRO Land and Water - Black Mountain, Canberra ACT
THE ROLE OF REMOTE AND PROXIMAL SENSING OF SOIL PROPERTIES FOR BOTH NUTRIENT AND CARBON MANAGEMENT IN GRAZED PASTURE AND CROPPING SYSTEMS

Carolyn Hedley, J Ekanayake and P Roudier
Landcare Research, Palmerston North
WIRELESS SOIL MOISTURE SENSOR NETWORKS FOR PRECISION IRRIGATION SCHEDULING

Reddy Pullanagari, I J Yule, M Tuohy, R Dynes and W King
NZ Centre for Precision Agriculture, Massey University
SENSORS FOR ASSESSING PASTURE QUALITY

Keith Betteridge, G Siva, D Luo, K Kawamura, D Costall and R Yoshitoshi
AgResearch - Grasslands, Palmerston North
A METHODOLOGY FOR DETERMINING CRITICAL SOURCE AREAS IN GRAZED HILL PASTURES

Pierre Roudier, C Hedley and C Ross
Landcare Research, Palmerston North
FARM-SCALE MAPPING OF SOIL ORGANIC MATTER USING VIS-NIR SOIL SPECTROSCOPY

Water Quality

Bob Wilcock and A Wright-Stow
NIWA, Hamilton
DOES BEST MANAGEMENT PRACTICE ON DAIRY FARMS RESULT IN BETTER STREAM HEALTH?

John W Nagels, T James, R J Davies-Colley, A Fenemore, R Merrilees, A Burton, B Stuart, R Young and A Parshotam
NIWA, Hamilton
THE SHERRY RIVER - A SUCCESS STORY

Tanira Kingi, S Park and M Scarsbrook
AgResearch, Palmerston North
SOLUTIONS FOR A SUSTAINABLE LAKE ROTORUA: THE FARMERS' PERSPECTIVE

Bob Parker, B Longhurst, I Power, M Hawke and G Corbett
Fruition Horticulture, Tauranga
DEVELOPING A FARMER LED CATCHMENT PLAN FOR A ROTORUA LAKE WITH REGIONAL COUNCIL SUPPORT

Brendan Powell
Hawke's Bay Regional Council, Napier
LESSONS LEARNT FROM A COLLABORATIVE APPROACH TO NUTRIENT MANAGEMENT IN TAHARUA CATCHMENT

Steve Green, A Manderson, M Benson, A MacKay and B Clothier
Plant & Food Research, Palmerston North
CATCHMENT WIDE MODELLING OF LAND USE IMPACTS ON THE RUATANIWHA PLAINS

Melissa Robson, I Brown, R Ford, L Lilburne, N Norton and M E Wedderburn
AgResearch, Christchurch
SETTING CATCHMENT WATER QUALITY LIMITS AND IMPLICATIONS FOR NUTRIENT MANAGEMENT IN CANTERBURY

WELCOME AND INTRODUCTION

Mike Hedley

Director, Fertilizer and Lime Research Centre, Massey University

Welcome to FLRC's 25th Jubilee Workshop, "ADVANCED NUTRIENT MANAGEMENT - Gains from the Past - Goals for the Future". After organising 25 annual workshops, most themed with the focus of improving nutrient use efficiency in New Zealand agriculture, forestry and horticulture, or reducing adverse impacts of nutrient runoff from agriculture on the environment, "the committee" favoured a theme that allowed some reflection on what had changed, or had been achieved in those 25 years but still focused us on the "job in hand".

Mid-year plans to bring back the founder of the Fertilizer and Lime Research Centre were derailed when Keith Syers died of a heart attack at his home in Phitsanulok in Thailand on 15th July 2011. Nanthi Bolan, suggested we organize a tribute session on "Phosphorus" in memory of Keith's mentoring and research. The contributions to the Keith Syer's "Phosphorus" session on Wednesday afternoon are bang on our theme - learning from the past and the challenges at hand. Several of the presenters in that session, to be chaired by Paul Gregg and Alec Mackay, have been mentees, or influenced directly, or indirectly, by Keith's enthusiasm and style.

We had greater luck securing the presence of Bob White, who was the Director of FLRC when the first of the current series of FLRC workshops began in 1987. Bob, with his current passion for viticulture, will lead us into the nutrient use efficiency session.

It is very pleasing to see that you, sponsors, contributors and supporters, have really taken on board the theme. We have a great programme of 86 presentations ahead of us. I would like to thank our sponsors for assisting with costs for invited speakers, student registration and travel. Particular thanks to our overseas invited guests Robert Glennon, an AGMARDT Visiting fellow from the University of Arizona; Raphael Viscarra-Rossel, also supported by AGMARDT, from CSIRO Land and Water, Canberra; Ravi Naidu and Nanthi Bolan from CRC CARE, University of South Australia - and thanks also to other speakers who have travelled long distance and given up time from their busy schedules to be with us during the next three days.

Managing nutrients efficiently for effective productivity gain and environmental protection is the ultimate responsibility of the farmer or grower. To do this, guidance is offered by nutrient budgeting software such as Overseer. Overseer's scope and development is guided by its owners MAF, NZFMRA and AgResearch who are aware of international and national drivers, including consumer, retailer, resource management and electorate demands. The first session gives you a taste of these interactions. We have invited Stewart Ledgard, to open the batting by bringing us up to speed with the role of Life Cycle Assessment in product and farm foot printing; Doug Edmeades will remind us of Lance Cairn's "Excalibur"; Mark Shepherd will give us a "virtual" hat trick and Vaughan Templeton will tell us whether the team can perform on his "wicket".

ROLE OF LIFE CYCLE ASSESSMENT IN AGRICULTURE FOR REALISING MARKET OPPORTUNITIES AND ENHANCING ON-FARM EFFICIENCY

Stewart F. Ledgard[1], Marlies Zonderland-Thomasen[1], Mark Lieffering[2] and Sarah McLaren[3]

[1]AgResearch Ruakura, Private Bag 3123, Hamilton 3240, New Zealand
and New Zealand Life Cycle Management Centre
[2]AgResearch Grasslands, Private Bag 11008, Palmerston North, New Zealand
[3]NZ Life Cycle Management Centre, Massey University, Palmerston North, New Zealand
Email: stewart.ledgard@agresearch.co.nz

Life Cycle Assessment (LCA) is a key tool for evaluating the resource inputs and environmental emissions throughout the life cycle of a product so that the key 'hot-spots' can be identified and the most effective options for improvement defined. It covers a range of environmental issues and not just greenhouse gas (GHG) emissions.

An increasing number of major supermarket chains throughout the world are looking at either eco-labelling of products or requiring suppliers to have determined their environmental emissions (e.g. the carbon footprint of products) and have a reduction plan over time. At a national level, some governments have commissioned work to examine how reduced environmental targets can be achieved. For example, the United Kingdom has indicated the need for major cuts in GHG emissions and studies have examined how low they can go by modifying the food system. An LCA study revealed the need for a combination of dietary change, technical efficiency improvements, reduced waste and less fossil fuel use. The largest single reduction was from change to a no-meat diet.

Identification and development of low environmental impact agricultural systems have potential to provide a marketing advantage or opportunity in high-returning environmentally-sensitive markets. Studies in NZ on the carbon footprint and eutrophication potential of some meat products have shown dominance of the farm production stage to total emissions, a low contribution from shipping to overseas markets and relatively low total emissions compared to some overseas production systems.

Detailed analyses of individual dairy farms within regions of NZ have indicated an approximately two-fold variation in carbon footprint and five-fold variation in eutrophication potential. This highlights the potential for improving environmental efficiency on some farms.

DEVELOPMENTS IN THE MANAGEMENT OF SOIL FERTILITY AND PASTURE NUTRITION OVER THE LAST 20 YEARS

Dr D C Edmeades

Managing Director, agKnowledge Ltd, PO Box 9147, Hamilton 3240.
Email: doug.edmeades@agknowledge.co.nz

This paper documents some of the major developments in the management of soil fertility and pasture nutrition in New Zealand since 1990. The development of the dynamic nutrient models for P, K and S is the most significant advancement in the past 20 years, because these models are the basis of a) the econometric fertiliser decision support system and b) the nutrient budgeting system. The background to these developments is discussed elsewhere (Edmeades 1995). As originally conceived both systems were incorporated into one piece of software (OUTLOOK) but as further developments took place these systems were separated with much greater emphasis being placed on developing the nutrient budget system now called OVERSEER.

The development of the dynamic models was predicated by establishing a database comprising the records of all the past P, K and S fertiliser field trials (some 3000 trials); in itself quite an achievement. All of this research has now summarized and published in a series of review papers. Some of the highlights from these reviews include:

1. The application of Bayesian statistics to more precisely define the production functions relating soil Olsen P and relative pasture production for the major soil groups.
2. The development and calibration of a soil test (extractable organic S), which measures the contribution that the soil organic S pool makes to pasture S requirements.
3. The application of Bayesian statistics to define the probability of pasture responses to fertiliser K at increasing soil quick test K levels, for the major soil groups.
4. The evidence suggesting that the Reserve K does not improve the prediction of pasture responses to fertiliser K.
5. The conclusion that further efforts to improve the prediction of pasture responses to fertiliser P, K and S, needs to focus, not on new soil tests *per se,* but on a better understanding of how plant acquire nutrients.

It is suggested that the current dynamic nutrient models for P, K and S and hence the econometric fertiliser decision support system should be revised and updated based on the new evidence presented in these review papers.

OVERSEER® NUTRIENT BUDGETS: THE NEXT GENERATION

Mark Shepherd, David Wheeler & Ian Power

AgResearch Ltd, Ruakura Campus, Hamilton

OVERSEER® Nutrient Budgets (*Overseer*) was engineered as a decision support tool to illustrate nutrient flows around farm systems. It also includes maintenance fertiliser nutrient recommendations and is integrated with Fertiliser Company systems to provide fertiliser recommendations. Its strength is that the user is able to able to represent a farm system with a manageable amount of input data; the model then estimates nutrient flows around that farm system. This paper summarises the actions required to ensure that a tool such as *Overseer* remains useful to the agricultural industry as farming systems develop and evolve.

Maintain relevance to farming systems

- Why? - It is important that the user is able to correctly represent their farm in the model. Farming systems continually evolve in response to a range of factors.
- Solution – user feedback and industry intelligence on new farm managements. Try to add in before their absence is deemed a significant barrier to use.

Capturing new science

- Why? - Models are never perfect; scientific understanding is never perfect!
- Solution - best endeavours; document and explain assumptions; periodically review as new science becomes available.

Adding new features

- Why? - increases the usefulness for users or a group of users.
- Solution - whilst the emphasis always has to be on ensuring the model is fulfilling its core purpose well, there is scope for adding extra functionality if (a) it has synergy with the model's core purpose and (b) it can be based on much of the same input data.

Maintaining the software

- Why? - Reliability, usability. Maintenance is often underestimated as a model moves from a research project to a publically available decision support system.
- Solution – allocate sufficient resources (triple the number you first thought of – at least!). Use specialist support.

Managing the user

- Why? - ensure that the model is being used correctly, for its correct purpose, and within its limitations
- Solution - training, documentary evidence, regular interaction.

OVERSEER® is a registered trademark and is jointly owned by MAF, Fert Research and AgResearch. Funding for this work by MAF and Fert Research is gratefully acknowledged.

NUTRIENT MANAGEMENT – A FARMERS PERSPECTIVE

Vaughan and Megan Templeton

Otaitai Dairys, Riverton, Western Southland

Introduction:
425ha Dairy Farm - 905 Cross bred cows 365,000 kgMS, – semi self-contained
Located on the coast at Riverton, Western Southland.
Soils: 1/3 Waikiwi silt loam. 1/3 Well developed sandy loam. 1/3 Very light sandy loam.

History:
Grandfather leased property 100 years ago to harvest flax for rope and twine making. Father closed the mill in 1972 when prices became uneconomic and coastal swamps developed into an extensive sheep and brief property. Megan and I took over our ½ of the property in 1988 and converted to dairy in 2002.

Nutrient Management History:
Flax - Totally unfertilized; Sheep and Beef - 250 kg/ha super; Dairy 150N, 30-40P, 60K

Current Management:
- Annual soil testing of monitor paddocks.
- Highly mobile nutrients applied little and often.
- Effluent area expanded to 100 ha with a low rate application system, fertilized separately.
- Management of potential nutrient loss sources.

Uptake of Nutrient Management Best Practice:
For us this is driven by financial efficiency first and the environment second.
I see the barriers to farmer uptake being:
- Lack of understanding of the potential financial gains.
- Lack of farmer understanding of overseer.
- Variability between overseer prediction and soil testing results.
- The lack of a tool to show farmers the movement of nutrients around the farm.
- Some gaps in the science around nutrient losses, particularly around summer and winter brasicas.

The Future?
- Micro managing nutrient movement around the farm and within the paddock.
- Use of overseer to manage winter cropping nutrient requirement and mineral N test.
- Putting a $ value of predicted nutrient loss into strategic decision planning. Wintering sheds vs winter cropping.
- Regulation/Nutrient capping?
- Measuring productivity per unit of nutrient loss?

REDUCING NUTRIENT LOSSES TO LAKE REREWHAKAAITU

Bob Longhurst [1], Ian Power [1], Martin Hawke [2], Bob Parker [3]

[1]*AgResearch Ruakura, Hamilton*
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Lake Rerewhakaaitu is a mesotrophic shallow lake, unique amongst the Rotorua Lakes, for having a catchment comprising mostly dairy farms. Water quality, as measured by the trophic level index (TLI), has in recent years gone above the Bay of Plenty Regional Council's TLI target of 3.6. Farmers within the catchment are concerned about: 1) future condition of Lake and 2) possible imposition of constraints on their farming operations. During the past eight years SFF projects have been set up to address the water quality issues by identifying ways that pastoral management in the catchment could be changed to minimise the environmental impact on the Lake, while still allowing sustainable dairy farming to continue.

In Phase 1 a farmer survey was conducted and OVERSEER® nutrient budgets were compiled for each farm in Lake's catchment. Nitrogen management was the main priority. Phase 2 focused on phosphorus (P) management, identifying the main pollutant form of P so that appropriate on-farm P-mitigations could be demonstrated. In Phase 3 OVERSEER® nutrient budgets were again compiled for each farm as well as 'enviro walks' conducted to identify critical source areas for nutrient loss. On-farm mitigations have been identified for farmers to implement. The collective response of farmer mitigations has seen the annual N and P nutrient loadings to the Lake between 2002/03 and 2009/10 reduced by 18% and 28% respectively.

The success of the project has been the close interaction between the farmers and the science providers through frank discussions, regular newsletters and farmer meetings.

POPLARS AND WILLOWS IN HILL COUNTRY – STABILISING SOILS AND STORING CARBON

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Poplar and willow trees have proved effective in preventing or reducing a range of soil erosion processes on pastoral slopes. They achieve this through the development of an extensive root system which achieves its maximum potential when it interconnects with root systems of adjoining trees to form a reinforcing network across a slope. A consideration of spacing is important to achieve soil stability in the shortest possible time. The root systems of these trees increase with time and at a diameter at breast height of ~30 cm they are effective at stabilising soil to a radius of 10 m. With appropriate spacing the interlocking root systems of adjacent trees have been shown to reduce slippage during severe storms to negligible levels. At maturity poplar and willow trees will stabilise soil on slopes at a canopy cover less than 30%, the amount depending on the clone. These trees contribute soil carbon and are eligible for carbon credits under the Emissions Trading Scheme (ETS) where the area planted exceeds one hectare and the trees are sufficiently close to achieve 30% canopy cover. Total carbon pools in a mature poplar-pasture and open pasture systems have been measured at 55.5 t/ha and 44.0 t/ha respectively.

Trees vary in form so a consideration of canopy spread will assist in choosing appropriate species and clones for the complementary purposes of soil conservation and carbon storage. Trees planted to achieve 30% canopy cover will reduce pasture production by around 7-11% during the period the tree is in leaf. Pruning of the trees results in an increase in pasture production compared with unpruned trees.

Evidence of effectiveness of mature poplars and willows stabilising soil in pastoral hill country will be presented, as will data on potential carbon storage of these species in a pastoral context. Tree density and spacing required to achieve 30 % canopy cover based on a single measure of tree diameter at breast height (1.4 m above the ground) will be presented for both poplars and willows.

TEMPORAL CHANGES IN TOPSOIL TRACE ELEMENT CONCENTRATIONS IN THE BAY OF PLENTY

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Trace element sampling has recently been included in the Bay of Plenty's regular regional soil quality monitoring programme due to the potential risk of accumulation associated with some past and present-day land use practices such as fertiliser application and disease control. Topsoil (0-10 cm) samples from existing soil quality monitoring sites were analysed for the trace elements arsenic, cadmium, chromium, copper, lead, mercury, nickel, uranium and zinc in 2009 and 2010. Archived samples from previous samplings (since 1999) were also included in order to show trend s over time. The samples represented five land uses namely dairy, maize, sheep/beef, deer and kiwifruit.

The temporal changes in mean trace element concentrations for all land uses were not significant. Mean values for each sampling year were all below the environmental guideline values for each element. For dairy pasture sites, there were increasing trends in cadmium and zinc concentrations over a 10-year period (1999-2009) but these increases were not statistically significant. In fact, for cadmium, mean concentrations in 2004 (0.76 mg/kg) and 2009 (0.75 mg/kg) were almost identical suggesting that cadmium concentration has not increased since 2004. In kiwifruit orchard sites, copper and zinc concentrations appear to be increasing but the increases were not statistically significant due to the small sample size. Nevertheless, this will most likely pose a concern particularly for copper which is now a widely used spray to control the *Pseudomonas* disease (Psa) of kiwifruit vines.

FAST FARM-SCALE SOIL MAPPING FOR SOIL AND NUTRIENT MANAGEMENT USING LIDAR IN THE MANAWATU

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Soil information is very important to both farmers and resource managers such as regional councils. Soil characteristics influence farm management factors such as;

- whether the paddock is dry enough to graze without causing pugging or bypass flow to waterways;
- potential pasture or crop production;
- tillage costs –e.g. tractor energy and/or number of passes required to get a good seedbed;
- number of days after rain before the paddock is grazeable, plowable or able to be irrigated with shed effluent; and
- ability of the soil to store or filter nutrients.

Therefore good soil information is vital for sound nutrient management planning and grazing management. However, regional scale soil maps are often not accurate enough for use at farm scale, meaning that important soil units or critical nutrient hot spots may be missed. With soils frequently varying within paddocks, there is always tension between the need to minimise costs and the need for accuracy.

Horizons LIDAR derived elevation data was tested for its utility for predicting soil type on Tony Collis' cropping farm near Kairanga. Soil profiles were investigated at eleven sites on the farm; initially to determine the range of soil types on the farm and later to associate them with elevation ranges and check these for accuracy. Soil structure was also described using the VSA drop test method.

We found a good relationship between elevation and soil type and were able to quickly use the LIDAR to map soil units on the farm. Using the visual soil assessment data from this and previous surveys we were also able to demonstrate a relationship between soil type and soil physical quality; (aggregate size and visible porosity). This is important because structural vulnerability has been associated with potential for phosphate leaching.

There is scope for more work in this area;

- to confirm and document soil-elevation relationships in the Manawatu and around New Zealand, and
- to use this information to enable high resolution on-farm soil, farm and nutrient management plans to be delivered cheaply.

SOIL QUALITY IN PASTORAL HILL COUNTRY AS INFLUENCED BY THE PRESENCE OF WILLOW (*SALIX MATSUDANA* × *ALBA*) TREES

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The benefits of conservation poplars and willows for the stabilization of soil on New Zealand hill country are well recognised, but not so well understood is how these trees may influence soil quality. We tested the hypothesis that soil conservation trees growing on pastoral hill slopes would increase soil organic matter and change the physical properties that are influenced by organic matter (e.g., bulk density (BD)).

The study was conducted in December 2010 on hill country sheep and beef farmland approximately 10 km SSW of Waipukurau in Central Hawke's Bay. Transects from three 13-year-old willow trees were marked out in an area where there were no other trees found within 10 m. Intact soil samples (0-15 and 15-30 cm layers) were taken at 1, 2, 3, 4, 5, 7 and 10 m from each tree. Total carbon (C) and nitrogen (N) determined by (LECO Truspec C/N analyser). Labile C and N: extracted using hot (80ºC) water; C and N in extracts determined using a Shimadzu total organic carbon (TOC) analyser (5000A). Bulk density: estimated from the soil mass in the 0-15 and 15-30 cm cores.

There was a significant increase in bulk density with increasing distance from the base of the trees. There was also a significant decrease in organic matter with distance from the trees. On a logarithmic scale, HWC to 15 cm depth showed a significant linear trend with distance from the trees. At 15-30 cm soil depth, there was no biologically significant trend in HWC, despite the mean values acraigiet 1 m to 4 m from the tree being higher than values at greater distances. Hot water-extractable N in the 0-15 cm layer decreased significantly with distance from the trees but in the 15-30 cm layer, there was no statistically significant trend. The findings support the hypothesis that conservation trees on pastoral slopes can confer soil quality benefits by increasing soil organic matter over distances up to 10 m from the trees. It would be useful to repeat this study for conservation trees differing widely in age to better understand the rate of organic matter accumulation under trees.

MINIMAL FOOTPRINT OPTIMAL PROFIT FARMS

"TOMORROWS FARMS TODAY – UPPER WAIKATO CATCHMENT"

Alison Dewes and Jesse Bolt

Headlands Consultancy, Te Awamutu

The first 100 K of the Waikato River is of critical importance for the amenities it provides, especially that of tourism. The farmer group is between Taupo Gates via Orakei Korako and Atiamuri. This is cited by WRC to be a "high value water body" which means it has priority status. There are around 200 farms, in the sub catchment on pumice soils.

30% of the farmer group of 25 are already demonstrating low impact farm systems leaching less than 28kg N/ha on pumice soils. (Central Plateau Average 39 kg N/Ha: Dairy NZ Regional Data 2011). Some of these farms are demonstrating high levels of profitability (> 8% return on Total Dairy Assets) and productive with lower than average impacts (< 28 kg N leached)

The farmer group is supportive of the co management of the river, but wish to understand how this may influence agriculture in the future. As a group already demonstrating unique interest in stewardship, they have requested more information about the policy directions, co governance, and improved performance of their businesses. This will be achieved by looking in detail at a range of farm systems, and quantifying their physical and financial performance, and their relative environmental impact ("footprint").

For each farmer, this has involved two funded visits to assess both economic (Red Sky) and environmental performance (Overseer + some environmental indicators). An environmental scorecard has been developed for this purpose.

Business performance is confidential to the farmer and the consultant, but joined to an anonymous database, so only each farm business knows their own figures, against that of the group in the local area.

Awareness occurs as a result of self-assessment, and group interactions. There are two community focus/farm groups each year, to tie the individual information into the wider farmer group.

Initial data from this benchmarking exercise has revealed that with a mix of mitigations in place, some farming systems can demonstrate strong levels of productivity, efficiency and profitability while having lower than average impacts on the receiving environment.

THREE YEARS OF DURATION-CONTROLLED GRAZING: WHAT HAVE WE FOUND?

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The practice of standing cows off pasture is used on dairy farms throughout New Zealand and globally to protect cows from adverse climatic conditions, increase production, reduce treading damage to pasture and soil, and minimise the loss of nutrients to waterways.

At Massey University's No. 4 Dairy Farm, the effects of standing cows off pasture year-round is being investigated, using Duration-controlled (*DC*) grazing. The effects of *DC* grazing on pasture accumulation, and the concentrations of nitrogen (N), phosphorus (P) and faecal microbes in mole and pipe drainage and surface runoff water have been measured from 14 pasture plots since June 2008. Seven plots were managed under *DC* grazing (4 hour graze, day or night) and seven plots under 'standard' grazing (*SG;* 7 hour day graze, 12 hour night graze). Slurry was returned to the *DC* plots in the first season with a nutrient loading equivalent to approximately the amount of nutrients produced in slurry from about 18 months of *DC* grazing. Consequently, no slurry was applied during the second lactation season. Four more dilute applications of slurry were applied to *DC* plots in the third season.

The average quantities of drainage over the three drainage seasons studied (2009, 2010 and 2011) were 373, 316 and 329 mm, respectively. The quantities of nitrate (NO_3^-) lost in drainage from the *SG* plots during these seasons were 13.1, 8.0 and 20.9 kg NO_3^--N/ha, respectively. Drainage NO_3^- losses from the *DC* plots were 43, 65 and 53% lower, respectively, compared with the *SG* grazing plots for the three seasons.

Pasture accumulation measured over the three lactation seasons (2008/09, 2009/10, and 2010/11) was 15212, 12778, and 14990 kg DM/ha per year, respectively, for the *SG* plots. There was no significant difference seen in pasture accumulation on *DC* plots for the first season; however there was a 20% and 9% reduction seen for the second and third seasons respectively. The smaller pasture accumulation achieved on the *DC* plots in the second season was likely due to less dung and urine deposited during grazing and the nil slurry return. It is anticipated that emphasis on frequent slurry return to pasture (e.g. earlier spring applications) can be used to further minimise differences.

Over three seasons, *DC* reduced NO_3^- leaching by more than 50%, which supports the proposal that *DC* could play a very important role in mitigating nutrient losses from dairy farms in some parts of New Zealand. However, slurry should be regularly applied throughout the lactation season if pasture growth is to be optimised under *DC* grazing management.

NUTRIENT LEACHING UNDER CONVENTIONAL AND BIOLOGICAL DAIRY FARMING SYSTEMS

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Interest in, and support for, biological farming systems is growing in New Zealand. This is because some farmers are anxious about the increased use of synthetic fertilisers that has caused both economic (e.g. increase in fertiliser costs) and environmental concerns (e.g. water quality). In the Central North Island, New Zealand, nutrient leaching has become a risk to the viability of many farming ventures as farmers are compelled to reduce nutrient losses.

The Rotorua Lakes and Land Trust (RLLT) – a joint venture between Te Arawa Federation of Maori Authorities and Rotorua/Taupo Province of Federated Farmers – is interested in exploring if biological farming systems can be used to achieve the same financial results as current farming practices while lowering nutrient leaching. Recently, the RLLT organised a national conference on biological farming systems, and announced the formation of NZ Biological Farming Systems Research Centre.

Farmers using biological farming systems have observed positive changes to soil, and improvements in plant and animal health. Scientific investigation is warranted to establish the mechanisms and processes responsible for these observed improvements in economic and environmental performance and to ensure that potential benefits can be more widely adopted.

The RLLT set up two experimental sites, one at Reporoa and one at Edgecumbe. At each site sets of 12 drainage flux-meters were installed on a biological and a neighbouring conventional dairy farm. The drainage flux-meters were used to measure amounts of drainage and nitrate concentrations in the soil water. In addition to nitrate, concentrations of ammonium, dissolved organic nitrogen and dissolved organic carbon were also measured in the soil water.

Here, we report preliminary leaching results from two experimental sites. The results showed that, in general, the biological farms had significantly lower nitrate concentrations than the conventional farms in both farms. In Edgecumbe site, which had biological farming for a longer period, the leaching of dissolved organic carbon was greater in the biological farm than in the conventional farm. We will share up-to-date leaching results at the conference.

NITROGEN USE ON HILL COUNTRY: LESSONS FROM THE NATIONAL WISE N USE FOCUS FARM PROJECT

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Consultant, Halcolme

The focus farm component of the programme ran for 3 years, during which time local community groups designed, implemented, monitored and reported on 31 demonstrations on 16 commercial sheep & beef farms throughout New Zealand. The demonstrations were mainly paddock scale and mainly ran from pre-lamb to weaning. Nitrogen application treatments (range of 19 to 260, average of 90 kg/ha/yr) were compared with no N controls, and pasture and animal measurements were made.

- Pasture production responses ranged from 7 to 55 kg and averaged 22 kg DM/kg N; ryegrass content was increased and clover content decreased
- Animal production was greater, mostly through a higher base ewe stocking rate, and more grazing for finishing cattle; lambing % and ewe and lamb liveweights were generally not affected
- A comprehensive review concluded any potential direct effects of N-boosted pasture on animal health would be insignificant compared to the advantages of increased animal nutrition
- Estimated net economic benefit of N use ranged from -$322 to +$221/ha, and averaged +$35/ha; lower rates of N application were generally most profitable
- Factors influencing profitability are: the cost of the extra feed generated; the timing of that feed; the % of the extra feed harvested; and the efficiency of conversion of that feed
- N fertiliser application can be used to reduce risk, through tactical application to generate feed to fill in seasonal feed deficits
- Where N is used strategically to increase whole-farm stocking rate, production risk is increased and careful feed planning and management are required
- The key to effective use of fertiliser N is feed budgeting to identify where feed deficits are likely to occur and to assist in identifying ways of mitigating these
- The most likely future use of fertiliser N on hill farms will involve tactical applications at low rates on parts of the farm to generate feed to increase feeding levels of responsive stock and to fill identified seasonal feed gaps

IMPACT OF TOPOGRAPHY ON SOIL NITRIFICATION RATE IN SHEEP GRAZED SUMMER MOIST HILL COUNTRY

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Nitrate (NO_3^-) is a major source of nitrogen (N) loss from grazing systems via leaching and denitrification. In grazed pastures soil NO_3^- is produced through a key process called nitrification, whereby ammonium (NH_4^+), primarily derived from urine deposits, is oxidised to nitrite (NO_2^-) and then to nitrate (NO_3^-). The nitrification process is influenced by soil and environmental factors, namely: NH_4^+ substrate supply, and soil temperature, moisture and pH. A grazing trial was initiated in September 2010 to investigate the impact of topography (low slopes (0 - 12°), medium slopes (13 – 25°) and high slopes (>25°)) and grazing intensification (8 vs. 14 SU/ha) on aspects of nitrogen cycling in sheep grazed summer moist hill country. In June 2011, a short term (16 h) nitrification assay was conducted on soil samples taken at two depth increments (0-10 and 10-20 cm) from each of the three topographical areas and to a 20-30 cm depth increment, in LS areas only.

Our hypothesis was that short term nitrification rate (SNR) would be higher in low compared to medium and high slope areas, due to more favourable conditions for nitrification in low slope areas. We also hypothesised that soils from areas grazed at the greater stocking intensity would have a higher SNR due to the greater availability of NH_4^+ substrate.

Topography had a highly significant impact on 16 h nitrification rate, with mean nitrification rate of soils from low slope areas nearly 8x that from medium slope areas at the 0-10 cm depth increment (0.421 vs. 0.056 µg NO_3-N gained/g dry soil/h, respectively). Soils from high slope areas had a very low SNR (0.003 µg NO_3-N gained/g dry soil/h). Grazing intensity differences in the previous 10 months did not have a significant impact on SNR. Short term nitrification rate decreased markedly in soils from 10-20cm compared to the 0-10 cm depth increment for the low and medium slope areas. Significant nitrification activity was also present at the 20-30 cm depth increment in low slope areas (0.086 µg NO_3-N gained/g dry soil/h). Our results suggest that LS areas in grazed hill country are potential critical source areas for N loss.

INITIAL EVALUATION OF THE EFFECTS OF DICYANDIAMIDE (DCD) ON NITROUS OXIDE EMISSIONS, NITRATE LEACHING AND DRY MATTER PRODUCTION FROM DAIRY PASTURES IN A RANGE OF LOCATIONS WITHIN NEW ZEALAND

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Dairying is New Zealand's second largest export industry (to Tourism; Statistics NZ). Cattle urinations deposit about 700-1000 kg N/ha at each site, and it is the fate of such urine that is subject to much research and industry scrutiny. Urine and dung deposited by grazing livestock are the single largest source of nitrous oxide (N_2O) emissions in New Zealand. N_2O emissions increased by 23% between 1990 and 2009, mainly due to a sharp increase in fertiliser-N use with intensification, largely on dairy farms, and a consequent increase in excretal-N. Urine leaching into soil can directly contribute nitrate, and indirectly contribute N_2O, to ground water systems that eventually lead to lakes or rivers. These environmental concerns have stimulated research into the effects of nitrification inhibitors (NI). The general theory of using these inhibitors is that they slow down N turnover by slowing the oxidation of N to nitrate, causing N to stay in the more immobile ammonium form. The longer residence time of N in the ammonium form may contribute to additional pasture growth.

One of the NI's that has been studied in New Zealand for several years is dicyandiamide (DCD). The application of DCD has been shown to reduce N_2O emissions and nitrate leaching, and, in results from Canterbury, has been shown to consistently stimulate additional pasture growth. Considering the implications of DCD use for both possible environmental and production benefits, a trial series was implemented to study DCD in a wider range of environments. This was a collaborative project funded by MAF, Fonterra, Dairy NZ and FMRA and managed by the Pastoral Greenhouse gas Research Consortium (PGgRc).

A three year research programme, commencing in autumn 2009, was established in each of the Waikato (Tokanui), Manawatu (Massey), Canterbury (Lincoln) and South Otago (Telford) regions. At each location there was a grazing trial to measure the effect of DCD treatment on pasture dry matter (DM) response, small plot trials to measure effects of DCD on pasture DM response, nitrous oxide emissions, and soil DCD movement beneath cattle urine (artificial) patches, and in years 2 and 3, measurement of the effects of DCD application on nitrate leaching.

Results from these trials are discussed and conclusions drawn.

PASTURE DRY-MATTER RESPONSES TO THE USE OF A NITRIFICATION INHIBITOR: A SUMMARY OF A NATIONAL SERIES OF NEW ZEALAND FARM TRIALS

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The use of a nitrification inhibitor, such as eco-n™, to reduce nitrate leaching and nitrous oxide emissions in grazed pastures has become increasingly commonplace, especially on NZ dairy farms. Reducing these types of N losses has a potential benefit to boost dry-matter production but results have varied. We collated pasture response data from a national series of farm trials conducted in 132 paddocks on 37 farms in the North (NI) and South (SI) Islands of New Zealand where paddocks were randomly split into two halves and one half treated with eco-n whilst the other half was not. Measurements were made using pasture plate meters and conformed to a strict protocol.

There was a highly significant overall DM response to eco-n use of 19% across all trials (14% NI; 21% SI) although full year responses were more variable between NI regions (4-27%) than SI regions (12-31%). Generally, DM responses were greater than those demonstrated by previous small-scale experimental trials and this may indicate the influence of a farm-system effect. We speculate several reasons for this effect but further research is required to identify the factors involved.

Keywords: dicyandiamide, grazing, N cycle efficiency, farm system, grassland, eco-n

EFFECTIVENESS OF MITIGATING NITROGEN LOSS FROM CRITICAL SOURCE AREAS IN GRAZED PASTURE

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Application of the nitrification inhibitor, DCD, is a promising technology to reduce N loss from grazed pastures, but its application over the whole the farm may not economically justified. Critical sources areas (CSAs) created by grazing animals (e.g. campsites) and management (strip grazed areas), represent the areas of high N loss risk and thus possibly high efficacy of the mitigation strategy. We explored the effects of DCD application in mitigating N leaching on these CSAs using grazing systems on two soils in the Lake Taupo catchment.

Based on the observation of urination events of GIS-tracked grazing cattle, with assumption that 30% of urination events are deposited on 3% of the land area, the modelled urinary N deposition rates are 115 and 1694 kg N/ha, and estimated N leaching rates are 31 and 929 kg N/ha, on main gazing and campsite areas respectively. The weighted average N leaching loss from whole paddock would be 58 kg N/ha, which is 35% higher than the estimation assuming a random distribution of urination events on whole pasture area.

Aggregation of urinary N at, and the increase in N leaching from campsites does not necessarily imply a high efficacy of DCD mitigation on these CSAs, particularly in zones of overlapping urine patches. Holding urinary N as ammonium for a few weeks following DCD application may not result in this N being taken up by plants as their uptake potential is likely to have been exceeded in soils where urine patches overlap. The effectiveness of DCD application on CSAs with varying levels of urinary N aggregation is modelled. DCD application on camp area with 'moderate aggregation' of urinary N has the highest mitigation efficacy. Furthermore, as DCD both degrades and leaches over time, its application on temporally aggregated urinary N, such as in strip-grazed areas, is more effective than on urine patches spatially aggregated within campsites where timing of DCD application is less well matched with deposition of urine, at least in set-stocked pastures.

REVIEWING AND REVISING THE DCD MODEL WITHIN OVERSEER® NUTRIENT BUDGETS

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The OVERSEER® nutrient budgeting tool ('*Overseer*') allows users to assess the impacts of potential farm management changes on the resultant farm nutrient budget and, therefore, the efficiency of nutrient use on the farm. One of these management options is the use of the nitrification inhibitor Dicyandiamide (DCD) applications in autumn and late winter.

The aim of this project was to review the original DCD model that was implemented in *Overseer* v 5.4 in 2007/08. To do this, we collated over 80 published papers and reports, which covered all aspects of DCD use on pasture. The relevant reports of experiments covered 110 separate treatments, with the majority of these measuring effects at the individual urine patch effect. The reports covered one or more of N leaching; N_2O emissions and/or pasture growth.

Our assessment was that there was insufficient new data for *Overseer* to significantly change its current modelling approach. Because much of the data are based on measurements at the urine patch scale, the challenge for *Overseer* is to scale up these results to the paddock, block and farm. This requires up-scaling of the urine patch principles to a complex farm system with multiple grazing events through the whole year; the DCD effect will be variable on these urine deposits.

Our conclusions were:

- The empirical approach to modelling DCD effects is still appropriate, using rainfall/drainage and temperature after application as the main drivers to estimate efficacy.
- To make further progress, more understanding around the DCD mode of action and the ability to model the process based effects is required, for example using APSIM, but this is probably a long-term goal.
- A further review should be undertaken after the completion of the current MAF-industry funded Nitrous Oxide Mitigation Research (NOMR) experimental series is completed.

OVERSEER® is a registered trademark and is jointly owned by MAF, Fert Research and AgResearch. Funding for this work by MAF and Fert Research is gratefully acknowledged.

FACTORS CONTROLLING DISAPPEARANCE OF NITRIFICATION INHIBITOR, DICYANDIAMIDE (DCD) IN A GRAZED PASTURE SOIL IN MANAWATU

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Nitrification inhibitors (NIs) including dicyandiamide (DCD) slow nitrogen (N) turnover by retarding the oxidation of ammonium (NH_4^+) to nitrate (NO_3^-), providing more time for plant uptake of NH_4^+. While studies evaluating the efficacy of DCD on reducing nitrous oxide (N_2O) emissions have been widely conducted, the characteristics of biophysical disappearance of DCD (i.e., biological decomposition, plant uptake and physical loss through surface run-off and leaching) and its longevity in soil are not well understood. The objectives of this study were to improve our understanding of seasonal variations in the biophysical disappearance of DCD in soil and the key control factors regulating the variations. Changes in DCD concentrations in soil and plant canopy were measured following its application in dairy-grazed pasture soil. The treatments included two levels of DCD alone (10 and 20 kg ha^{-1}) applied to non-grazed pasture field plots and a single level DCD (10-kg ha^{-1}) applied with urine and with urea fertiliser. DCD (10-kg ha^{-1}) was also applied in grazed farmlets following grazing. Our measurements show 4 to 40% of applied DCD was intercepted and stayed on plant canopy from <6 up to 16 days, depending on timing and intensity of rainfall following DCD application. In this poorly drained soil <10 % of applied DCD leached below 10 cm depth. Our results suggest that neither the level of DCD nor the N source had any significant effect on the half-life of DCD in soil. Seasonal variations in soil temperature affected the half-life of DCD in soil. The DCD half-life showed a linear decrease with increased temperature over the observed range of average seasonal temperatures (10.7 to 16.5°C). The results suggest that to sustain an optimum effective DCD concentration in soil different DCD application rates and frequency may be required in different seasons.

THE USE OF DCD TO REDUCE NITROGEN LOSSES FROM INTENSIVE WINTER GRAZING BLOCKS

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The intensification of modern pastoral systems has led to increased nitrate (NO_3^-) leaching and nitrous oxide (N_2O) emissions from animal grazing. The use of nitrification inhibitor technology in New Zealand dairy pastoral systems has been proven to reduce NO_3^- and N_2O emissions from animal urine patches. The objective of this study was to review recent trial data to evaluate the effectiveness of using dicyandiamide (DCD) to reduce N losses from urine patches deposited during winter grazing of forage crops.

Three main intensive winter grazing trials have been conducted using field lysimeters comparing four general treatments: (i) control (i.e. no urine), (ii) control + DCD, (iii) urine, and (iv) urine + DCD. Urine was typically applied at an N loading rate of 300 kg N ha^{-1} for sheep, 580 kg N ha^{-1} for beef cattle and dairy cattle at 1000 kg N ha^{-1}. DCD was applied at the recommended rate of 10 kg ha^{-1} using a fine suspension spray for liquid applied DCD or as a granular DCD applied at 15 kg N ha^{-1}.

The results from these initial trials show that the use of DCD under intensely grazed winter forage systems can be an effective way to reduce nitrogen losses. Reductions of between 39 and 70% in NO_3^--N leaching and over 70% in N_2O emissions have been measured from animal urine patches in these winter grazing block studies.

The economic benefit of reducing nitrogen losses with the application of DCD to winter grazing blocks will be discussed in the latter part of the paper.

EXTRACTION EFFICIENCY OF DCD FROM SOILS

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The soil nitrification inhibitor, dicyandiamide (DCD), has gained increasing attention in New Zealand pastoral agriculture as a mitigation strategy to reduce nitrogen losses to the environment. Quantifying the amount of DCD present in soil is critical in the assessment of DCD effectiveness to inhibit nitrification. Currently the DCD content in soil is determined by a water extraction method and reported in kg ha^{-1} which accounts for the soil depth, bulk density and moisture factor. However, research has suggested that DCD interacts with soil organic matter reducing the recovery of DCD in water extractions. A laboratory study was undertaken to assess the variability in extraction efficiency of DCD across nine soil profiles covering different soil groups throughout New Zealand to ascertain if a correction factor is warranted in the calculation of soil DCD content. DCD was added to field-moist soil at rates between 0 and 40 µg DCD g^{-1} OD soil, the soil was then extracted with water for DCD analysis and the recovery was calculated as a percentage of DCD applied. The extraction efficiency of DCD was variable across soils, ranging from 65 to 94% in the top soil (0-10 cm), and generally increased with soil depth. A pooled regression analysis revealed that the extraction efficiency of DCD was strongly correlated to the soil organic matter content (R^2 = 0.81; $P < 0.001$). The inverse linear relationship indicates that an increase in soil organic matter results in a decrease in the recovery of the DCD applied. Given the organic matter content of a soil the following linear equation has been proposed to obtain a precursory estimate of the recovery of DCD; *DCD recovery (%) = -0.823 x soil organic matter (%) + 95.6*. This study highlights the importance of using a correction factor when measuring soil DCD to adjust for incomplete recovery, particularly in soils with high organic matter.

USING A LYSIMETER STUDY TO ESTIMATE N LEACHING UNDER GRAZING, AS AFFECTED BY MULTIPLE DCD APPLICATIONS

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The loss of nitrogen (N) from grazed pasture systems by nitrate leaching and the dominance of animal urine as the main source of leaching has been well documented. Nitrification inhibitors, such as Dicyandiamide (DCD), have been shown to be an effective tool in mitigating N loss, particularly from urine patches. As part of the NOMR (Nitrous Oxide Mitigation Research) programme, a series of coordinated mowing and grazing trials were carried out throughout New Zealand to determine how DCD can be most effectively used. This lysimeter study was aligned to the Waikato grazing trial site. The purpose of this study was two-fold: 1) to measure the effect of multiple DCD applications on nitrogen leaching from urine patches, and 2) to estimate total nitrogen leached under a grazing system through an entire leaching season.

Forty-five lysimeters (Otorohanga Silt Loam) were collected from a dairy pasture in the Waikato. Urine was applied to each lysimeter at a rate of 700 kg/ha in either February, March or April, followed by nil, 2 or 3 DCD applications (10 kg/ha).

N leaching results from the lysimeters showed that 3 DCD applications were more effective than only 2 applications. Three applications resulted in an average of 39% reduction in N leached, however 2 applications showed no significant reduction.

Combining this lysimeter data with urine-N return data from grazed pasture to estimate N leached under grazing, showed an apparent reduction in total N leached over the leaching season of 4 or 32% with 2 or 3 DCD applications, respectively.

FARM DAIRY EFFLUENT:

ACHIEVEMENTS TO DATE AND FUTURE CHALLENGES

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For a number of reasons, the treatment of farm dairy effluent (FDE), particularly via land application, has been difficult on many of New Zealand's dairy farms. Many farmers still struggle to comply with their resource consents, thereby tarnishing the image of dairying both locally and internationally.

A substantial amount of research and investment by the industry has resulted in: the development of design standards for FDE irrigation systems, identification of 'best management practices', and the production of 'decision support' tools to help farmers manage FDE on a daily basis. Furthermore, there are a number of initiatives in place to improve the design of FDE systems and encourage the adoption of these BMPs.

FDE contains a large quantity of nutrients. It is important that these nutrients are re-used efficiently and that losses to the environment are kept to a minimum. The role of FDE in nutrient management plans has not received the attention that it deserves.

The importance and value of FDE to the farm system is likely to increase in the future. The most influential factor here is the likely increase in the quantity of FDE produced as a result of greater use of animal shelters and feedpads.

CHARACTERISING DAIRY MANURES AND SLURRIES

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The rapid intensification on dairy farms in New Zealand since 2000 has increasingly focused attention on issues relating to effluent management. Increased cow numbers, greater use of fertiliser N and higher supplementary feed inputs on dairy farms has resulted in marked changes in the volume, content and types of effluent produced. Concurrently, more management options for removing stock from paddocks are also being practiced to protect pastures and soils from stock damage. Furthermore, best management practices for land application of farm dairy effluent are now often resulting in solid separation. With all of these system changes, farmers are faced with handling more concentrated high solid content effluents and manures while coming under increased scrutiny from regional councils concerned about deteriorating water quality. Both the dairy industry and regulatory authorities have not had sufficient New Zealand based information with regards to these solid effluent types in order to help progress or confirm robust management practices designed to provide agronomic and environmental benefit and the development sound regulatory policy.

This project examined 22 different case studies to characterise and compare the variability of slurries and manures from different farm and effluent management systems. From this data set some averaged values for dry matter %, Total N, mineral N, P, K, S, Organic C, C/N ratio and % mineral N are presented

LAND APPLYING DAIRY MANURES AND SLURRIES: EVALUATING CURRENT PRACTICE

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The intensification of New Zealand dairy farms over the past ten years has resulted in a greater proportion of animal excreta ending up in an effluent management system rather than being directly excreted back onto paddocks. Much of the additional animal excreta collected is captured from animal off-grazing facilities where nutrient concentrations are higher and volumes lower than traditional wash down farm dairy effluent (FDE). The resulting more solid dairy manures and slurries require different management (storage, handling, application and timing) than liquid FDE in order to achieve outcomes that are both agronomically and environmentally positive. This paper reports on a two year programme that investigated current on farm management practices for land application of dairy manures and slurries and discusses recommended management practise based on international research combined with New Zealand farming system requirements. Best management practice for manures and slurries needs to take into account the timing of land application with respect to short-term climate and time of year. From a nutrient use efficiency point of view, the application of slurries and manures in late spring provides the optimum window to utilise nutrients for plant growth. Direct loss of P, N and faecal microbes is likely to be greatest during winter and early spring when soils are regularly wetter than field capacity causing drainage and runoff events. Volatilisation losses from surface applied N (not immediately incorporated) will be highest during summer and early autumn when sunshine hours and air temperatures are high. Indirect drainage loss of N from nitrate leaching will be greatest from autumn applied slurry and manure that has only minimal plant growing days prior to the commencement of the winter/spring drainage period, a season when much of the resident soil nitrate N moves below the plant rooting depth, and is therefore lost to the wider environment.

DEVELOPING BEST MANAGEMENT GUIDELINES FOR EFFLUENT APPLICATION IN HIGH RAINFALL REGIONS

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Two- (or more) pond treatment systems have traditionally been used for farm dairy effluent (FDE) management on the West Coast, with many existing systems discharging directly into high volume, short reach rivers. This practice has come under recent scrutiny due to the potential effects of soluble P on the water quality of Lake Brunner. Application of FDE to land at a suitable irrigation depth and rate is an alternative option that can likely mitigate surface water pollution and recycle valuable nutrients. However, this approach does present some challenges because high annual rainfall (i.e. approx 4.8m per annum) results in a large volume of water collected from the dairy shed catchment areas while also limiting the development of soil water deficits that are large enough to safely apply FDE to land.

Many West Coast soils would be defined as 'high risk' due to poor natural drainage or the hump and hollow drainage systems. In most regions of New Zealand, it is not advisable to apply FDE to high risk soils at a depth greater than the soil water deficit. On the West Coast, however, deferring FDE applications until these soil conditions occur is impractical as it would require extremely large pond storage capacities and an unrealistically large effluent block size (i.e. greater than whole farm). It therefore appears that the West Coast will require a unique set of best management practices based on regionally-specific data.

Description of a field trial, recently established within the Lake Brunner Catchment, will be presented. Here, FDE will be applied using low rate effluent applicators, to a Hari Hari silt loam soil with a hump and hollow drainage system. Nutrient losses from this low rate application of effluent will be compared against those from the direct discharge from two pond systems over the course of the milking season.

INTEGRATED NUTRIENT MANAGEMENT STRATEGIES FOR DAIRY AND CROPPING FARMERS

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Integrated nutrient management strategies for dairy and cropping farmers offer economic and environmental benefits to both sectors. Farmers can use crops to recover nutrients from depth on higher fertility blocks that have had a long history of shed effluent irrigation and permanent pasture. Strategic use of shed effluent can also markedly reduce the need for fertiliser nutrient inputs on lower fertility cropping blocks.

Over the past 5 years we have conducted numerous on-farm trials to investigate these strategies. Results from nine field trials have shown that typically there are sufficient amounts of nitrogen, phosphorus and potassium (NPK) in higher fertility effluent blocks to maximise maize silage yields with no further fertiliser application in the first season of summer cropping. Where tested, we also found there was sufficient nutrient availability for a second consecutive season of summer cropping with no further fertiliser application. In these cases total crop N uptake across both growing seasons was between 580 and 657 kg N/ha, which was supplied entirely from the soil reserves. Seven additional field trials have also shown that applying shed effluent to cropping blocks can produce maize grain yields that equal those achieved with standard fertiliser practices. In most cases about 20–40% of the total applied N was recovered by the end of the first season following application. Understanding longer term N release dynamics, the role of initial effluent characteristics and seasonal loss pathways is therefore critical to optimising the use of this resource.

An overview of key results and critical findings will be presented.

EFFLUENT MANAGEMENT IN OVERSEER® NUTRIENT BUDGETS

David Wheeler, Mark Shepherd & Ian Power

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OVERSEER® Nutrient Budgets (*Overseer*) calculates the movement of nutrients around a farm. This includes accounting for excreta deposited on hard surfaces or in structures such as feed pads, wintering pads, etc, which is then collected and dealt with as effluent. *Overseer* deals with nutrient loads in the effluent, not volumes of effluent. Accounting for effluent nutrients is an essential part of the nutrient budget and enables adjustment of fertiliser rates on effluent blocks, as well as calculating the required effluent block area required to meet annual N loading limits.

The challenges for the decision support tool are:

(a) having the ability and the flexibility to allow the user to input data that correctly describes the effluent system on the farm and

(b) being able to adequately model the nutrient flows through the systems, accounting for transformations and losses.

This paper describes how effluent is dealt with in Overseer and uses examples to show the implications of different management approaches on calculated nutrient transfers.

OVERSEER® is a registered trademark and is jointly owned by MAF, Fert Research and AgResearch. Funding for this work by MAF and Fert Research is gratefully acknowledged.

UNQUENCHABLE:

AMERICA'S WATER CRISIS AND WHAT TO DO ABOUT IT

Robert Glennon

Rogers College of Law, University of Arizona, USA

Deep in the Mojave Desert sits Las Vegas. The desert is a dry, torrid place that can quickly kill a person without water, but in Sin City a torrent of water flows freely in massive fountains, pirate lagoons, wave machines, and casinos. Meanwhile, across the United States in places that are not particularly dry or hot, communities, farmers, and factories are struggling to find water, and even running out altogether.

America's self-inflicted water crisis is coming.

In a book that is both frightening and wickedly funny, acclaimed author and expert Robert Glennon has captured the tragedy—and irony—of water in America. From the Vegas Strip to faux snow in Atlanta, from our supersized bathrooms to mega-farms, from billion-dollar water deals to big time politics and personalities, *Unquenchable: America's Water Crisis and What To Do About It* reveals the heady extravagances and everyday waste that are sucking the nation dry.

Our water woes will get worse before they get better because we are slow to change our ways, and because water is the overlooked resource. It's happening again: Washington's love affair with biofuels will turn to heartbreak once America realizes that thousands of gallons of water are required to produce one gallon of fuel. Glennon tells how a celebrated, new ethanol plant in Minnesota—The Land of 10,000 Lakes!—is already sucking local wells dry.

Glennon argues that we cannot engineer our way out of the problem with the usual fixes or the zany—but very real—schemes to tow icebergs from Alaska or divert the Mississippi River to Nevada. America must make hard choices—and Glennon's answer is a provocative market-based system that values water as a commodity and a fundamental human right.

Island Press is proud to have published Robert Glennon's thought-provoking exposé on our water crisis. *Unquenchable* illustrates the urgency of this problem and the need for action on multiple fronts to solve it.

Robert Glennon is the Morris K. Udall Professor of Law and Public policy in the Rogers College of Law at the University of Arizona. He is the author of many articles and books, including the acclaimed *Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters.*

A HYDROLOGICAL APPROACH TO THE WATER FOOTPRINTING OF NEW ZEALAND'S FRUIT PRODUCTS

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Water footprints are mooted as indicators of the influence of primary products on water scarcity and water quality. We evaluated two approaches for how the green, blue and grey water footprints represented these impacts. These issues pose methodological challenges for the footprinting community.

We used the net change of soil water, and the net groundwater recharge, over a yearly timeframe as indicators for the impact on water scarcity. We found a negligible net annual change in soil water, as the freshwater in the soil is replenished, year-on-year, by rain. A net depletion of groundwater resources occurs only in two kiwifruit-growing regions. It seems that kiwifruit production in New Zealand is in general positive, or at least no adverse impact on freshwater scarcity.

We suggest discarding the green water footprint. The blue water footprint describes the influence of kiwifruit on water scarcity in aquifers. We tested two approaches. In Approach I the blue water footprint quantifies the net change of groundwater recharge and includes all hydrological processes. In Approach II, that of the Water Footprint Network, only the consumption of the groundwater is considered while the recharge of the aquifer by rain is neglected. We recommend adopting Approach I as it is hydrologically rational. The resulting regional product-based blue water footprint is a useful metric that can be directly related to the regional groundwater recharge. A negative water footprint indicates a positive hydrological outcome, as the catchment's water resources are being recharged.

The grey-water footprint is an indicator of the influence on water quality. The absolute value is sensitive to the choice of background and maximum admissible concentration value. We recommend that this information must always be given in addition to the grey water footprint value

We conclude that blue water footprints must be derived by a hydrologically rational approach. The grey water footprinting metric must also be rationally referenced. We also caution against the addition of the blue and grey water footprints to form a single number, for although they might have the same units, management and policy to protect water quantity and water quality require separate considerations.

MEASURING THE GREY WATER FOOTPRINT OF POTATOES

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As the dominant land use in New Zealand, agriculture has the most widespread impact on freshwater quality and quantity. The grey water footprint is proposed as an indicator of the impacts of land use on the quality of fresh water resources. It is expressed as the volume of fresh water that is required to assimilate the load of pollutants, and is based on the natural background concentrations and water quality standard values. Previous studies have shown that in crop production systems, the grey water footprint is dominated by nitrate leaching. The source of this nitrogen (N) is either added fertilizer or mineralization of N in the soil. Due to the complexity in assessing nitrate leaching and contamination of water resources, most of the grey water footprint calculations of cropping systems are currently based on the single assumption that on average 10% of the applied nitrogen fertilizer is lost through leaching. This is a very rough estimation which obviously excludes relevant factors such as soil types, agricultural practice, soil hydrology and interaction between different chemicals in the soil. Validation of the grey water footprint is therefore imperative if it is to be taken seriously. Measurements and modeling are needed to ecoverify the grey water footprint.

We have installed 12 tension fluxmeters (six in the row and six in the interrow) below the root zone in two potato fields on Manawatu sandy loam soils. The leachate was collected for the analysis of nitrate and ammonium. We discuss nitrate leaching considering both soil N mineralization and fertilizer application. At one site, which was planted early (3rd October 2011) there was significant spring rainfall and, on average, about 90% of total rainfall had drained during the nine weeks after planting. At the other site, about 40% of the total rainfall drained and this crop was planted later on 31st of October 2011. Rainfall here was less over this period. This year was very wet and the weather needs to be put in context. To this end, the second step of our analysis will be to model leaching losses by considering a 37-year period of annual weather data to calculate the average grey water footprint and assess its variability. We will also suggest how the grey water footprint can be minimized. Eventually we will also consider the whole supply chain of potatoes including seed–potato production, potato cultivation, and the water use in the pack-house so as to quantify the total water footprint of a kilogram of potatoes.

FURTHER PROGRESS USING ISOTOPES TO TRACK THE SOURCES OF NITRATE IN SURFACE WATERS

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New Zealand's intensive pastoral agricultural systems have a significant impact on water quality due to nitrogen loading in rivers. Efforts to cap the total loads of N entering water places a strong focus on developing indicators to support N budgets at farm and catchment scales. We present an additional year of progress developing isotopic techniques to trace the sources of nitrate in New Zealand's surface water.

Previously we reported over one year of measurements from the Upper Manawatu Catchment, where we have measured over a year of monthly $\delta^{15}N$ and $\delta^{18}O$ in NO_3 from over 15 Horizons monitoring stations. The annual averages span a range of $\delta^{15}N$ and $\delta^{18}O$ of 7‰, and spread approximately along a 1:1 'denitrification line' with the unimpacted site at the Tararua Forest Park boundary on the lower end of the range, and the mainstem of the Manawatu River exiting the catchment at Hopelands on the upper end. Monthly data throughout the year display movement almost entirely along the 1:1 denitrification line in some catchments, but display more complex patterns indicating multiple complex sources in other catchments, including the Manawatu at Hopelands. The data and related research suggested a need for substantially improved laboratory precision and detailed study at smaller scales. We have also focused on approaches to separate pastoral agricultural sources from other nitrate sources, such as sewage or animal processing effluent, nitrate fertilizer applied to crops. To undertake this, we are developing a new stream of work in the Wairarapa.catchment.

Laboratory precision has been improved over threefold from approximately ~1‰ to <0.3‰ for both $\delta^{15}N$ and $\delta^{18}O$ in NO_3. Another year of monitoring data in the Upper Manawatu catchment is yielding similar but more precise conclusions. The $\delta^{15}N$ and $\delta^{18}O$ in NO_3 in some streams follows a simple denitrification line while others show more complex behavior. Monitoring of 4 sewage treatment plant (STP) effluents suggest these have variable but often distinct signatures. Stream stations showing relatively complex behavior may be related to groundwater/ surface water interactions. A major goal of our Mangatarere investigation is to track groundwater sources and delays in the hydrologic system at a smaller scale and where more previous work has been carried out. In this work, we are finding benefits in using H and O stable isotopes in H_2O to track the sources of water contributing to streamwater. Within this catchment, a bifurcation in $\delta^{15}N$ and $\delta^{18}O$ in NO_3 is observed in the upper catchment and this may be explained by seasonality and flowpaths. Accounting for these factors and local hydrogeology lead to expectations that the isotope tracer will yield significant insights into the contributions of piggery effluent and STP inputs to the Mangatarere catchment following this year's summer and winter monitoring campaigns.

GROUND WATER ABSTRACTION FROM THE WAIRAU PLAINS, MARLBOROUGH

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The Marlborough District Council (MDC) is currently seeking to define the volumes of water used for irrigation of wine grapes. This information is needed to establish sustainable limits for groundwater abstraction. A measurement and modelling approach was adopted for this task. Seasonal irrigation records (November to April) and soil moisture readings were assembled from a large number of monitor sites (> 300 vineyards) between the years 2004 and 2011. Modelling was carried out using Plant and Food Research's SPASMO model (Soil Plant Atmosphere System Model) that simulates the daily water and nutrient balance for a given land use, soil type and microclimate.

For the purpose of calculation, the land area under vineyard production was identified using a GIS map of vineyard property boundaries. The corresponding soil series under each vineyard was identified from the Functional Soil Layer map (Landcare Research). The physical and hydraulic properties were deduced from soil profile descriptions provided in the New Zealand Soils database. Daily climate data (1972-2011) were assembled on a 5 km grid using NIWA's Virtual Climate Network of stations. The crop factor for wine grapes, that relates actual vine water use to the evaporative demand (ET_o, mm/day), was derived from >10 years of sap flow data from grape vines from Marlborough.

Grower records and model outputs of irrigation use were grouped according to the nearest climate station and the representative soil type. Daily values of irrigation were summed up on a monthly basis to generate two estimates of water take from each aquifer zone. Our analysis revealed large differences in irrigation use across the plains that could be explained by differences in soil water holding capacity and summer rainfall. More importantly, we found that grape growers, on average, are using substantially less water than they have been allocated on a seasonal basis. These findings will enable the Council to draw conclusions about current water allocation policies and also to assess the sustainability of water takes for irrigation of wine grapes cf. aquifer recharge of the Wairau Plains.

GROUNDWATER ASSIMILATIVE CAPACITY – AN UNTAPPED OPPORTUNITY FOR CATCHMENT-SCALE NITROGEN MANAGEMENT?

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Not all nitrate leached out of the soil zone ultimately pollutes the groundwater system and groundwater-fed surface waters; some nitrate can be assimilated in the subsurface environment. How much nitrate can be assimilated without exceeding water quality limits depends on a combination of biogeochemical and hydrological factors.

Denitrification, i.e. the conversion of nitrate to gaseous forms of nitrogen (N_2, N_2O), is the key process determining the biogeochemical component of a catchment's assimilative capacity for nitrate. Denitrification is the only attenuation process that actually removes nitrogen from the subsurface rather than just storing or diluting it. Saturated zone denitrification is an environmentally benign process, as it predominantly returns inert N_2 to the atmosphere.

The second major attenuation process at the catchment scale is the dilution of nitrate-rich groundwater, typically recharged from agricultural land, with clean groundwater originating from low land use intensity areas (e.g. mountains, forests).

Provided the groundwater flowpaths and the biogeochemical processes occurring along them were known, this knowledge could be used to optimise spatial land use intensity patterns in a catchment within agreed water quality limits. Rather than relying on root zone leaching estimates alone, the acceptable land use intensity for a given piece of land would take the subsurface system's assimilative capacity into account. Consequently, land uses with higher nitrate leaching losses would be possible where the assimilative capacity allows, while only lower losses would be acceptable on land with lower assimilative capacity.

It is anticipated that this approach would result in spatial land use intensity patterns that better protect environmental, economic, social, and cultural values than current practice and recently introduced approaches that are exclusively based on root zone leaching estimates. Statutory environmental standards and nutrient limits will in the future constrain development in some catchments. Comprehensive assimilative capacity assessments across catchments or sub-catchments would thus help to guide investment in land development and to allocate clean-up funding more effectively, and enable land to be directed to its optimum use.

THE RELATIONSHIP BETWEEN GRAPEVINE VIGOUR AND THE N-MINERALIZATION POTENTIAL OF SOIL IN SELECTED COOL CLIMATE VINEYARDS IN VICTORIA, AUSTRALIA

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Excess vigour is a problem affecting fruit quality in vineyards on deep fertile soils in some cool climate regions of south-eastern Australia. A possible cause is the naturally high nitrogen (N) fertility of the soils. To investigate this possibility, vine vigour and N fertility of paired vineyard sites deemed to be of low and high vigour by vineyard managers were identified in the King Valley, Yarra Valley and Mornington Peninsula.

To test for internode length as an index of vine vigour, the length of the fifth internode from the shoot tip was measured on the low and high vigour blocks between flowering and early fruit set. Petiole samples were also collected and analysed for N to assess the N status of the vines. Soil samples were collected at depths of 0-10 and 10-20 cm from each of the low and high vigour blocks and analysed for total soil C and N, and subjected to an anaerobic incubation for 7 days at constant temperature to determine the potentially mineralizable-N (N_o). No N fertilizer was applied at these sites.

For all sites, N_o was strongly correlated with total soil N at both sampled depths, but especially so in the 0-10 cm soil layer. The C:N ratio of these soils ranged from 13.8 to 18, indicating that conditions were favourable for net mineralization of soil N in these vineyards. That all the vines were adequately supplied with N was confirmed by the petiole N concentrations, which ranged between 1.4 and 1.8% N. Mean internode lengths of the vines were consistent with the managers' assessments of site vigour and so could be used as a surrogate for vine vigour. Mean internode length was well correlated with N_o, but the slope of the relationship was different for the three vineyards, being more definitive at Hoddles Creek than at Whitlands. These results suggest that the potential vigour of a site can be inferred from the total soil N content, specifically in the topsoil. Potentially mineralizable N is a more exact indicator of vigour than total soil N, but the relationship between vine vigour and N_o must be determined for each soil-site combination.

DOES ZONAL NITROGEN MANAGEMENT IN MILLING WHEAT PAY?

Rob Craigie

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Is there value in variable rate nitrogen (N) management of a wheat crop with variable soil properties and variable potential yield? Specifically, can the N rate be reduced in zones with lower potential yield with no loss of yield? A nitrogen trial was set up in a paddock of irrigated autumn sown milling wheat cv Sage at Methven as part of a MAF SFF funded crop sensing project. Two N response trials were established in different yield potential zones of the paddock based on soil texture. Lighter and heavier soil zones were selected as identified by an EM survey of the paddock. A desktop comparison of variable rate N based on the optimal N rate for each of the two zones with one rate applied to the paddock was made.

PLANTATION NUTRITION MANAGEMENT IN NEW ZEALAND – 25 YEARS ON

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It is more than 25 years since Graham Will's cornerstone work 'Nutrient deficiencies and fertiliser use in New Zealand exotic forests' was published. This FRI bulletin, focussing primarily on radiata pine, summarised over 30 years of research and trial results on the nutrition of plantation forests in New Zealand, and also presented recommended nutritional management strategies.

Since this time a substantial amount of research on forest nutrition, soil quality, nutritional genetics and wood quality has been undertaken and although reported in various journals and unpublished reports there has been no attempt to integrate this new knowledge into a useful format until recently with the publication of "Plantation Forest Nutrition". Another development has been the establishment of a national foliage nutrition database with more than 60,000 records collected over 30 years that allows us to determine nutritional trends in space and time and aid in better focussed fertiliser prescriptions.

Current research is examining in more detail the relationships between soil properties and productivity, wood properties, the influence of genetics, symbiotic relationships and environmental controls on plant responses to fertiliser application. The environmental fate of N fertilisers has also been a current focus along with the role of rhizobacteria in producing plant growth promoting substances and the influence of forest management practices on this activity as well as soil carbon sequestration. Finally, nutritional data has recently been developed into a software tool now being adopted by the forest sector to aid planning and management of nutrition and fertiliser use, saving time and effort while maximising economic returns.

IMPROVING MANAGEMENT OF PLANTATION PRODUCTIVITY WITH A NUTRIENT BALANCE MODEL

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Forest managers are required to maintain the productivity and profitability of plantation management while simultaneously minimising the negative ecological effects associated with forest operations. NuBalM (from Nutrient Balance Model) was developed to function as a decision support tool to assist forest managers in meeting these requirements in *Pinus radiata* D. Don (radiata pine) plantations over single or multiple rotations. NuBalM was initially conceived to provide forest managers with predictions of the optimum time for fertiliser application by identifying when nutrient demand would outstrip supply, then modelling the likely effects on growth. This information allows managers to more accurately determine when fertilisation events will provide the greatest benefits, and the extent of fertiliser addition required to achieve the optimum return.

The capability of NuBalM to accurately predict the effect of nitrogenous fertilisation on wood production and nitrogen pools has been tested over a wide range of locations, with generally satisfactory results. Across the majority of locations predicted stem wood masses underestimated observed masses by a mean value by approximately 2% (R^2 =0.98, n =92) over masses ranging from 1 – 320 t ha^{-1}. The only exception were locations treated with ultra-high doses of fertiliser, as predicted stem mass values at these sites were underestimated by approximately 36%. However, as the fertiliser application rates at these locations were much greater than would ever be used in conventional forestry, this inaccuracy was not considered a substantial issue. NuBalM also provided accurate projections of nitrogen pools in soil, overestimating pool sizes by approximately 3% over a range of sites and management regimes, including fertilisation. The nitrogen leaching and weed growth components of NuBalM are yet to be rigorously tested, but both will be examined in a project commencing in 2012. From the results to date, we conclude that NuBalM can be used with a reasonable degree of confidence to provide meaningful projections of the effects of fertiliser application on growth and nitrogen pools in New Zealand radiata pine plantations.

EFFICIENCIES, PRODUCTIVITY, NUTRIENT LOSSES AND GREENHOUSE GAS EMISSIONS FROM NEW ZEALAND DAIRY FARMS IDENTIFIED AS HIGH PRODUCTION, LOW EMISSION SYSTEMS

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Dairy farming in New Zealand (NZ) is under increasing scrutiny due to growing environmental concerns. Consequently, considerable investment has been channelled into the search for sustainable land management options and opportunities for mitigation of greenhouse gas (GHG) emissions and nutrient losses. Improved feed conversion efficiency (FCE) without an increase in animal numbers, has proven an effective mitigation strategy. The objective of this scoping study was to identify dairy farms that were both highly productive and profitable while maintaining reduced stock numbers (i.e. less than 3.3 cows/ha) leading to reduced GHG emissions. Two suitable farms in the Waikato and two in Southland were identified. The whole-farm system models FARMAX® and OVERSEER® were used to examine feed flow and nutrient balances, as well as profitability, of these systems.

Although differing in size, all farms tended to be reliant on home grown feeds with only small quantities of purchased feed; imported feed ranged from 2.2 to 9.7% of feed consumed. All farms were classified as Production System 2 (DairyNZ). Stocking rates (SR) at peak lactation ranged from 2.5 to 3.3 cows/ha, comparative SR ranged from 88.3 to 94.6 kg liveweight/tonne of available feed, and annual production ranged from 377 to 464 kg MS/cow. Wintering policies (i.e. the use of an off-farm block of land for wintering and young stock), however, differed between farms; the Waikato farms used these blocks only for young stock whereas the Southland farms used them for young stock and dry cows. Despite these differences, emissions intensity ranged from 8.4 to 9.6 kg CO_2-e/kg MS, and compared favourably with the average NZ farm range (11 – 13 kg CO_2-e/kg MS). Lower emissions intensity farms tended to be more profitable and achieve greater FCE (kg MS/kg DM consumed). Although low stocked dairying often requires a high level of managerial skill to be successful, these systems were associated with high levels of home-grown herbage intake and farm profitability.

Keywords: diary, livestock emissions, stocking rate, profitability.

BIOSOLIDS APPLICATION ENHANCES CARBON SEQUESTRATION IN SOILS

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Carbon (C) sequestration in soil has been recognised as one of the possible measures through which greenhouse gas emissions can be mitigated. Strategies for increasing C sequestration in soils include conservation tillage, application of organic amendments such as biosolids and composts, and improved crop rotation involving cover crops. However, capitalising on this potential climate-change mitigation measure is complicated by the fact that intensive farming practices generally lead to the depletion of C from soil, thus reducing its capacity to act as a C sink.

Applying organic amendments including biosolids and composts to agricultural land could increase C storage in soils and contribute significantly to the reduction of greenhouse gas emissions. These organic amendments can contribute to both restoring soil quality and sequestering C in soils. Although a number of studies have examined the potential value of biosolids as a nutrient source, there has been only limited work on the potential impact of biosolids application on C sequestration in soils.

The objective of this study was to examine the potential value of biosolids in C sequestration in soils. Two types of experiments were conducted to examine the effect of biosolids application on C sequestration. In the first laboratory incubation experiment, the rate of decomposition of various organic amendments including biochar, biosolids and green waste composts was examined using soil samples collected from different land-use practices. In the second field experiment, the effect of biosolids on the growth of *Arundo donax* (giant reed), *Brassica juncea* (Indian mustard) and *Helianthus annuus* (sunflower) on a landfill site was examined in relation to biomass production and C sequestration. The rate of decomposition varied amongst the organic amendments and also soil types. Biosolids application increased the biomass of all three plant species, thereby increasing the C input to soils. The rate of net C sequestration resulting from biosolids application was higher for giant reed than mustard and sunflower.

INVESTIGATING THREE METHODS FOR IMPROVING MAGNESIUM NUTRITION OF CITRUS GROWN ON YOUNG SEDIMENTARY SOILS

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Magnesium (Mg) deficiency is widespread in citrus grown in young sedimentary soils such as those found in Gisborne. The use of fertiliser to overcome the deficiency has been unsuccessful, and foliar sprays have been only partly successful, with a number of sprays causing only a small increase in leaf Mg concentration. This paper reports on three trials aimed to improve plant Mg status. Three techniques were investigated: fertiliser, foliar sprays or trunk injection. Fruit were also analysed to determine if these amendments affected fruit quality. The fertiliser trial compared Mg chloride or Mg sulphate at 850gMg/tree applied for two seasons. Neither fertiliser treatment increased leaf Mg concentrations compared with the control (no Mg) treatment in either the first or second season.

The foliar spray trial used four sprays of Mg nitrate at concentrations of 1 – 2% at a high water rate, or 5% Mg nitrate plus adjuvants at one-fifth water volume (to give the same Mg rate per ha as the 1% Mg high water volume treatment). These rates are higher than recommended for many commercially available products, but 1% Mg nitrate has been recommended in scientific studies. The results showed that Mg nitrate at 1 – 2% increased leaf Mg concentration and did not cause leaf burn. Leaf Mg concentration increased as spray Mg concentration increased, with 2% Mg giving leaf Mg concentrations 0.6g/kg higher than the control treatment. The use of 5% Mg nitrate plus adjuvants in one-fifth water volume may give a greater increase in leaf Mg concentration than a high water volume without adjuvants and will allow five times more area to be covered on the one tank. However, this time saving will need to be weighed against the additional cost of the adjuvants.

The trunk injection trial compared Mg in four forms, as a sulphate, nitrate, citrate or glycate injected at 1.5gMg/tree, and a high rate of Mg sulphate at 3 gMg/tree. The results showed that only Mg citrate caused a significant (although small, 0.3g/kg) increase in leaf Mg concentration.

In all trials there was no indication that increased plant Mg status improved fruit quality.

THE IMPACT OF KIWIFRUIT MANAGEMENT ON ALLOPHANIC SOIL QUALITY: PHYSICAL, CHEMICAL AND HYDROLOGICAL PROPERTIES

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Management of kiwifruit-producing soils in New Zealand varies widely with special techniques depending on agro-ecological zones. The diverse kiwifruit management systems can have significant impacts on soil quality indices. We hypothesised that physico-chemical indicators of soil quality would be higher in soils under shaded kiwifruit management systems compared to the grassland management system. In order to assess the impact of land use on soil quality properties in a kiwifruit ecosystem of New Zealand, soil samples were collected at 0-100cm depth from a kiwifruit orchard of vines aged seven years old and thirty years old. Soil samples were collected from grassland adjacent to the kiwifruit as paired samples. The study site was on allophanic orthic pumice soil (Vitrads/Vitriccryands Andisol, USDA; Mollic Andisol FAO) formed from volcanic parent material. Land management resulted in bulk density being highest in grassland followed by 7-year-old kiwifruit vines and the lowest in 30-year old kiwifruit vines. In grassland soils, higher values for sand content and lower values for silt and clay content were recorded in comparison to kiwifruit soils. Higher sand content combined with poorer aggregation could account for the higher bulk density under grassland in comparison with the kiwifruit soils. The decrease in silt+clay content in grassland soils is likely a result of the removal of fine particles by accelerated water erosion. Total organic C and N, soluble and aggregate protected C, EC, maximum water holding capacity, field water holding capacity and hygroscopic moisture all increased under kiwifruit vine managed soils. The 30-year-old vine soils have higher nitrogen and carbon contents in comparison to the other soils, as it is permitted to grow nitrogen fixing cover crops. Lower pH values were observed in the grassland management system than that of 30-year-old kiwifruit soils. In grassland soils, the intense leaching of basic cations during irrigation and/or precipitation is the likely contributing factor to lower pH levels. Additionally, the input of lime has contributed to the higher pH in kiwifruit soils. The overall improvement of soil properties under the kiwifruit management systems indicate that expansion of well-adapted and rapid-growing agro-forest species can gradually improve soil quality and ameliorate degraded soils.

GRASS SPECIES EFFECTS ON SOME SOIL PROPERTIES NOW AND IN THE FUTURE

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New Zealand pastures contain a range of C3 grass species that fill different ecological niches. A frequent case is the presence of species that are found in low and high fertility situations. Examples of these are the low fertility species *Agrostis capillaris* (browntop) and the high fertility species *Lolium perenne* (ryegrass). We expect the different traits expressed by these species to result in different soil properties. Consequently, it is of interest to know how these species will respond to a future climate as there are potential consequences for ecosystem functions such as C and N cycling.

We measured soil carbon (C), nitrogen (N) and microbiological properties in rhizosphere soil taken from browntop and ryegrass under ambient and elevated CO_2 from the New Zealand Free Air Carbon Dioxide Enrichment (FACE) experiment at Flock house, Bulls (40°14' S, 175°16' E) where pastures had been exposed to elevated atmospheric CO_2 from 1997.

The total C, total N, soil pH, net nitrogen mineralisation and nitrification potential of two rhizosphere soils were significantly different. The effects of grass species on dissolved organic C, dissolved organic N, microbial biomass C, microbial biomass N and total number and diversity of ammonia oxidising bacteria were significantly interacted by the level of atmospheric CO_2.

Our results indicate that pasture species play key roles in soil C and N cycling and the potential changes in botanical composition under climate change can influence these soil functions.

EFFECTS OF PLANTATION FOREST SPECIES ON SOIL PROPERTIES

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Recent large scale afforestation of grasslands represents a major land use change in New Zealand. Some studies have shown that land-use changes have significant long-term impacts on the quantities, dynamics and bioavailability of soil P, which is a limiting of primary productivity. The objective of this study was to investigate the effects of afforestation on soil P dynamics and bioavailability after 10 years of establishment in order to understand the impacts of land use change. A large-scale replicated field trial was established in 1999 at Orton Bradley Park on Banks Peninsula, New Zealand, comprising 4 replicate plots of three commercial tree species (*Pinus radiata*, *Eucalyptus nitens* and *Cupressus macrocarpa*). Samples of mineral topsoil (0-5cm) were taken from five sites randomly located in the middle of each replicate plot in September 1999 (at trial establishment), September 2004 (5 years after planting) and November 2009 (10 years after planting). Various forms of inorganic and organic P were determined using sequential extraction of soil with 1M NaCl, 0.5M $NaHCO_3$, 0.1M NaOH (NaOH I), 1M HCl and 0.1M NaOH (NaOH II). Analyses of samples showed that changes in soil P with time were similar to all three tree species. Results for comparison between samples taken in 1999, 2004 and 2009 revealed that total extractable soil P decreased by 16% from 568µg g^{-1} in 1999 to 474 µg g^{-1} in 2009. Significant decreases in NaCl, $NaHCO_3$ and NaOH I-extractable organic P pools occurred between 1999 and 2009. Depletion of topsoil P over 10 years following establishment of plantation forest was mainly attributed to enhanced mineralisation of readily extractable organic P due to a combination of factors including decomposition of pasture residues, tree uptake, and the action of mycorrhizal fungi associated with tree roots. These findings confirm that afforestation of grassland has a major short-term impact on soil properties and processes.

Key words:
Grassland afforestation, soil fertility, soil P dynamics and bioavailability.

TEMPERATURE SENSITIVITY OF ORGANIC MATTER MINERALISATION IN SOILS WITH CONTRASTING MANAGEMENT HISTORIES

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Temperature is a key regulator of the mineralization of soil organic matter (SOM). Concern over climate change has stimulated interest in the temperature-dependence of SOM mineralization. Loss of soil organic C induced by a warmer climate could provide a positive feedback and accelerate the rate of global warming. Kinetic theory suggests that the temperature dependence of mineralization is greater for recalcitrant than for labile forms of SOM, but little experimental evidence exists to support this hypothesis. A strong temperature-dependence for recalcitrant SOM, which makes up the bulk of the SOM in soils, would mean that the size of the feedback to global warming may be larger than predicted by current models.

The purpose of this study was to quantify the impacts of temperature on mineralization of SOM fractions in selected treatments from the Millennium Tillage Trial. The trial was established in 2000 on a Wakanui silt loam at Lincoln to identify the effects of management on SOM following the conversion of long-term pasture to arable cropping. The following treatments were sampled in 2011 (0-7.5 cm): (1) long-term ryegrass-cover pasture; (2) arable cropping rotation, managed using no-tillage; and (3) chemical fallow, plots maintained plant-free since 2000 using herbicides. Three size fractions (>50; 5-50, and <5 µm) were isolated using standard sieving and sedimentation methods after dispersion by overnight shaking with glass beads in deionized water. Carbon mineralization (respiration) was determined by incubating subsamples of the fractions at three temperatures (5, 15, 25°C) for 98 d (water potential adjusted to -60 k Pa).

The results confirmed that that the particulate organic matter (POM, i.e., >50 µm fraction) was most labile and the clay-associated (<5 µm) organic matter least labile. In all fractions, mineralization increased exponentially with temperature (Q_{10} values ranged from 1.92-2.64). The temperature dependence of mineralization (expressed as the absolute increase in CO_2-C evolution between 5 and 25^oC) was large for POM, intermediate for the 5-50 µm fraction and low for clay-associated organic matter. This sequence is the reverse of what would be predicted by kinetic theory.

CHALLENGES AND OPPORTUNITIES TO DECREASE PHOSPHORUS LOSSES

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Phosphorus (P) loss from land, due to agricultural intensification, can impair water quality. However, there is concern that we may not be able to decrease current losses, let alone mitigate greater losses due to intensification. Research over the past three decades has revealed the soil and climatic factors and management practices that affect P loss. Put simply, the quantity of P lost is a function of runoff (surface runoff or sub-surface drainage) and availability, which is affected by inputs and the ability of the soil to retain P. Losses are exacerbated if surface runoff or drainage occurs soon after P inputs (e.g. fertiliser and/or manure and dung).

Strategies to decrease P losses depend on the farming system. Providing a range of fully costed options gives flexibility when matching strategies to a system. Furthermore, to maximise their effectiveness, mitigation strategies are best used in areas that lose the most P, but occupy little of the farm or catchment's area. Focusing on these areas, termed critical source areas, is more cost-effective than farm- or catchment-wide strategies.

Although strategies may be effective at decreasing P loss, there is a lot of uncertainty over whether or not this will result in the desired (or required) improvement in water quality. Some of this uncertainty surrounds what background and human-influenced losses are. Not all human, or anthropogenic losses, will be mitigated. Hence, the concept of a manageable loss is introduced as the maximum quantity of P loss mitigated with current knowledge. The question is: will this be enough?

A RECONSIDERATION OF THE TARGET OLSEN P RANGES FOR DAIRY FARMS

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Maintaining an appropriate Olsen phosphorus (P) level on a dairy farm is important for several reasons. Firstly, if the Olsen P level is too low there is an opportunity cost to the farmer, through loss of potential pasture production. Secondly, if the Olsen P level is too high there is an unnecessary cost to the farmer and a potential environmental cost from P runoff into rivers and lakes. The current recommended target ranges for Olsen P on dairy farms are based in part on P response curves derived in 1999 from a large database of historical P response trials. From these response curves, “critical” Olsen P values required to achieve a relative yield of 97% were estimated to be 20 and 22 for sedimentary and volcanic soils respectively. Based on this information, and taking account of other factors that influence the financially optimum Olsen P value (e.g. fertiliser price, milk solid payout and intensity of the farming operation), the current target ranges for Olsen P on sedimentary and volcanic soils are 20-30 for most dairy farms and 30-40 for high producing dairy farms.

Since these recommendations were first formulated, the database of P response trials has been re-analysed and other P response trials have been conducted. This later work has suggested that “critical” Olsen P values corresponding to 97% relative yield may be higher than 20 and 22 for sedimentary and volcanic soils respectively. This paper re-evaluates the target ranges for Olsen P on dairy farms in the light of this later work. It also investigates how the uncertainty associated with measured Olsen P values and P response curves affects the financially optimum Olsen P value.

As a consequence of this re-evaluation it is recommended that the current “dual target range” (20-30 or 30-40, depending on production) for Olsen P in sedimentary and volcanic soils be replaced with a single target range (25-40) accompanied by a simple checklist identifying when Olsen P values near the top of this range are appropriate.

PHOSPHORUS RESPONSE AND EFFICIENCY OF 12 NOVEL DRYLAND LEGUME SPECIES ON AN ACID HIGH COUNTRY SOIL

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High country soils are typically acidic and have low fertility compared with intensive high fertility low land systems. Pasture legumes commonly used in New Zealand perform poorly in these environments. The optimum soil P status for growth of many potential alternative legume species for this environment is unknown.

Twelve legume species were grown under glasshouse conditions at Lincoln University in an acidic high country soil (Ashwick stoney / boldery silt loam) from the Lees Valley (North Canterbury). Phosphorus was applied at eight rates (0, 10, 30, 60, 100, 250, 500, 1500 mg P kg^{-1} soil). Plants were harvested monthly post establishment and the yield determined. Annual species grew on average for 25 weeks, while perennial species grew for 42 weeks. Herbage was analysed for macro and micro element content and uptake. Soils were analysed for available P content at the end of the experiment.

Phosphorus increased the yield of both annual and perennial legume species through the increase in plant available P. Optimum Olsen P for maximum yield differed between species as did P use efficiency. Persian clover was the highest yielding annual species (13.6 g DM pot^{-1}) followed by subterranean clover > arrowleaf clover > balansa clover, while gland clover was the lowest yielding annual species (1.2 g DM pot^{-1}). Lotus was the highest yielding perennial species (15.0 g DM pot^{-1}) followed by tagasaste > lucerne > Caucasian clover > falcata lucerne > strawberry clover, while white clover was the lowest yielding perennial species (8.2 g DM pot^{-1}). As a measure of P use efficiency, the Olsen P at which biological optimum (97%) yields were achieved varied between species, ranging from 21 µg ml^{-1} (tagasaste) to 174 µg ml^{-1} (gland clover). Gland, balansa and arrowleaf clovers had the lowest P use efficiency, while tagasaste, white and Persian clovers had the highest. Arrowleaf, subterranean and balansa clovers gave the greatest increase in yield at low P inputs (100 mg P kg^{-1}). Further research using field trials is required to confirm these results under natural climatic and physical conditions.

SOIL CHEMISTRY WHICH INFLUENCES POTENTIAL P LOSS

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Previous studies have found dissolved reactive P (DRP) in drainage flow to be strongly related to calcium chloride extractable DRP in soil. The objective of this study was to identify soils which were potentially at risk of losing P via subsurface drainage. This was done by using soil tests or markers which could predict the potential release of P from soil to soil solution.

Fifteen hundred soils were tested for 0.01 M $CaCl_2$ extractable P, Olsen P, P retention and C on the <2 mm fraction of dried soil. Relationships between 0.01 M $CaCl_2$ extractable P and the other tests were established and the findings will be presented.

REMOVING PHOSPHORUS FROM WASTEWATERS USING ANDESITIC TEPHRA SUBSOILS

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Many rivers and streams within the Manawatu-Wanganui region experience blooms of periphyton growth during periods of high sunlight intensity and extended periods of stable flows. Phosphorus (P) enrichment promotes the growth of aquatic weeds and algae when P is growth-limiting. Point-source discharges, primarily from domestic sewage treatment plants (STPs), are a major cause of elevated dissolved reactive phosphorus (DRP) concentrations during low flow conditions at many river-monitoring sites within the Manawatu-Wanganui region. The removal of DRP from domestic sewage is problematic, particularly for smaller towns, as many wastewater treatment options for DRP are either cost-prohibitive or largely ineffective. Therefore, there is a need for a new, cost-effective method for DRP removal at STPs.

Soils and parent materials derived from andesitic tephra with relatively high P absorbing capacities have potential as relatively low cost substrates for use in active filters for P removal. Soils formed from andesitic tephra are abundant in the central North Island. In addition, once the P adsorbing capacity of tephra is exhausted, it has potential for re-use as a soil amendment.

The P absorption capacities of a range of different tephra subsoils have been measured. Of the tephra assessed, the Okato tephra (<2 mm particle size fraction), collected from the North West of the Taranaki Region, had the highest P absorbing capacity, absorbing nearly 8 g P/kg tephra with an average removal efficiency of 97%. For a STP servicing a community the size of Taihape, it is estimated that a filter with 232 m^3 of Okato tephra would have the potential to remove approximately 1,670 kg P from wastewater, which corresponds to treatment of about 18 months of discharge. If DRP removal was only required during the summer and early autumn months, then the life of the filter could be extended to about 3.5 years. Future research at a pilot scale is being conducted to further assess the feasibly of tephra filtration systems.

IMPACT OF SHADE TREES ON ANGUS COW BEHAVIOUR IN SUMMER DRY HILL COUNTRY: GRAZING ACTIVITY AND NUTRIENT TRANSFER ISSUES

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Increased farm production is often at the expense of trees that limit pasture growth, hinder stock mustering and impede pivot irrigator movement. Further, some farmers believe that if animals use trees for shade they will reduce intake and production. This trial quantified grazing time of cows in paddocks with and without space-planted willows that provide shade in summer. Cow movement was determined by GPS, activity (walking, standing, grazing, lying) by Icetag®, and dorsal skin temperature with a button temperature logger. Button loggers were also placed on the tree trunk (shade) and in full sun. Cow movements, fence lines and water sources were displayed on GIS map layers overlying the farm's aerial photograph to show trees in the 'shade' treatment. Time spent by cows within 0-5 and 5-10 m zones centred on the trees was determined as an indicator of shade usage. Paddocks of 6–20 ha, with trees (2) or without trees (2), formed two reps. Each grazed 6 monitored cows with others to standardise stocking at 2.1 cows/ha. The trial ran from 26 February to 16 March 2010 on a hill farm near Porangahau. Shade reduced maximum ambient temperature by 10˚C on days where screen temperature ≥25˚C. Average temperature on the cow's back at 2 PM was 40.8˚C for 'no shade' and 36.8˚C for cows with 'shade'. Most grazing was between sunrise and sunset, with short bouts during the night. Cows often used shade from ~9 AM. Between 10 AM and 4 PM, between 30 and 70% of lying and 20 and 60% of standing time was within 10 m of the tree trunk. On days when the maximum temperature exceeded 25˚C, 'shade' cows grazed for 30-40 minutes longer than 'no shade' cows. As trees will potentially create critical source areas of nutrient and faecal pollution, judicious selection of tree species and their placement away from streams within paddocks should minimise pollution of waterways while potentially increasing animal performance through reduction of heat stress.

THE COWS ROLE IN REDISTRIBUTING N AROUND THE DAIRY FARM

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Intensification and scale of production are increasing in the livestock industries in New Zealand. This could lead to negative environmental impacts due to increased fertiliser inputs and runoff, and consequent increased return of animal excreta to water. Of particular concern in New Zealand is the high level of nitrogen (N) pollution arising from dairy farms due to the inhomogeneous nature of bovine urine patches. This study aimed to provide baseline knowledge on the distribution of urine by dairy cows in regard to environmental and management factors. Seventeen cross-bred dairy cows in late lactation, in a herd of 180, were fitted with global positioning system (GPS) collars, IceTag3D® activity sensors and urine sensors for seven consecutive days. The herd was milked twice a day and rotationally grazed, without supplements. Animals were at pasture from 06:00 h to 14:00 h (AM grazing) and from 15:00 h to 05:00 h (PM grazing). Cows were rotated through 12 paddocks of ~1.1 ha. The majority of urine (85% of total) was deposited on pasture, while 10% of total urine deposits were captured in the holding yard and milking shed (5%). Kernel density estimates showed that urine patch distribution was inhomogeneous, thus there was an aggregation of urine patches within specific areas of the paddocks. Moderate correlations between the time spent in a location and urine patch density provided preliminary evidence that the time spent in a particular location was the main factor affecting the density of urine patches. Paddock characteristics did not play a major role in determining urine distribution patterns in this study. Understanding excreta distribution may have application in farm management strategies aimed at managing loss of nutrients and pasture utilisation.

RECOVERY OF SOIL PHYSICAL QUALITY FOLLOWING INTENSIVE GRAZING: COMPARING NATURAL RECOVERY AND MECHANICAL AERATION

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The North Otago Rolling Downlands (NORD) has undergone considerable land-use change and intensification following a greater use of irrigation and increased pasture production, fertiliser input and animal stocking rates of both cattle and sheep. A decline in soil physical quality associated with livestock grazing has been reported in a number of studies that have been based in this region. Once compacted, soil structure may be restored through a process of natural recovery facilitated by wetting and drying, freeze-thawing, pasture growth and earthworm activity. These processes however tend to be limited to the top 0-5 cm of soil where moisture fluctuations, pasture root growth and biological activity are often greater than at lower soil depths. Mechanical aeration has been used to ameliorate the adverse effects of soil compaction by loosening topsoils to greater depth within the soil profile. Here we report findings from a trial that was established in the NORD region to compare the rates of soil recovery (as determined by increases in soil macroporosity values) via natural or mechanical means. This assessment was made at a trial site where four years of winter forage cropping under cattle or sheep grazing had caused a significant amount of soil compaction.

Six months after mechanical aeration to 20 cm soil depth, soil macroporosity levels at depths of 0-5 and 5-10 cm were significantly greater in aerated soils relative to the non-aerated treatment. This was evident under both cattle and sheep grazed pastures. Significant differences were no longer evident eighteen months after aeration, however. Throughout the three year monitoring period, a gradual decline in macroporosity for the aerated soils was matched by an opposite trend of improved macroporosity in the non-aerated soils, whereby similar macroporosity values were eventually reached for each treatment. This trend was most evident in soils grazed by cattle where the initial compaction of the soils was greatest. Consistently higher pasture growth rates were evident in the aerated treatment during the first year following aeration. Results indicate that mechanical aeration can provide an immediate improvement in porosity of compacted soils, although this benefit appears to be short-lived.

IMPROVED RELIABILITY OF SOIL PH MEASUREMENT USING MECHANICAL STIRRING

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Does it make sense for New Zealand laboratories servicing the agricultural sector to adopt a single, referenced procedure for the measurement of soil pH?

A review of the analytical methodology to determine soil pH adopted by the various agricultural laboratories in New Zealand demonstrated that no single procedure is currently adopted. Differences in procedures include; the settling time, manual versus robotic reading, pH probe types, position of probes during measurement and stirring vs. not stirring while reading. Test measurement trials where soil pH readings were taken using four different probe positions (within the soil supernatant, soil/supernatant interface, directly in the soil sediment and at a set height in a stirred soil/water slurry), showed these factors had a marked affect on measurement uncertainty.

The practice of stirring the samples while taking pH measurements creates a homogeneous soil suspension and resulted in greater measurement reliability and precision. It is proposed that these improvements will also lead to an improved alignment of results between different laboratories.

The adoption of a single, referenced procedure for the measurement of soil pH using mechanical stirring while readings are taken is recommended for New Zealand agricultural laboratories.

NITROGEN MANAGEMENT BY WATERCRESS (*NASTURTIUM OFFICINALE*) IN HYDROPONIC CONDITIONS

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Many New Zealand waterways are polluted by excess nitrogen (N) from farm runoff and by human activities. Watercress (*Nasturtium officinale*), an edible aquatic herb, is a 'luxury feeder' that can grow rapidly and take up nitrogen in excess of its growth requirements. It could therefore be an ideal plant to remove excess N from waterways. We quantified how much nitrate the watercress plants could take up from a hydroponic solution over 10 weeks, in order to determine the potential for watercress to be used to manage nitrogen pollution in waterways. Germinated watercress was grown in a glasshouse hydroponically in a sterile Grodan® (rockwool) medium. A constant nutrient concentration and pH was maintained throughout the experiment. This involved regular determination of the nutrient conductivity factor in the solution, and addition of nutrients to compensate for plant uptake. The hydroponic solution was analysed weekly for nitrate-nitrogen using an RFA-300. Each week, 10 plants were removed for dry matter determination and total nitrogen (TN) analysis (LECO Truspec).

The distribution of TN throughout the plant was not uniform. The TN content was highest in the leaves and least in the roots. Plant dry matter and TN content both increased in a similar and logistic way between Days 28 and 56. Rate of increase in plant mass and rate of N uptake slowed after Day 56. However, TN mass continued to increase as plant biomass increased. As long as the plant was actively growing, it took up N. Leaf TN concentration peaked at 6–7% at Day 21, and slowly decreased to just over 4% on Day 70. To maximise TN removal, watercress should be harvested when the rate of nitrate uptake is at its maximum. In this experiment, this was within the range of Day 32 – Day 42. This study requires investigation of watercress within polluted waterways.

MANAGEMENT OF PHOSPHORUS IN ORGANIC AMENDMENTS FOR SUSTAINABLE PRODUCTION AND ENVIRONMENTAL PROTECTION

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The use of organic amendments such as biosolids, poultry and animal manures and farmyard compost in agriculture holds dual benefits for the waste producing industry and primary producers. For waste producing industries, land application provides a primary avenue for safe and beneficial recycling of these resource materials. For agricultural producers, these organic amendments are an alternative source of nutrients, thus the traditional routes of disposal for these valuable resources such as land-filling, incineration and ocean dumping are avoided. These organic amendments can also be used to enhance the rehabilitation of fragile disturbed lands such as mine sites.

Optimum use of these byproducts requires knowledge of their composition in relation to beneficial uses and environmental implications. Most of the environmental problems associated with land application of organic amendments have centered on potential contamination of ground and/or surface water with major nutrients, nitrogen (N) and phosphorus (P). The application of organic amendments as a nutrient source is generally based on N input which is likely to provide more of other nutrients (especially P) than is required by crops.

Cost-effective and innovative solutions are needed to expand the range of acceptable options in the management of nutrients, especially P in organic amendments. This will involve refining feed rations to animals, using feed additives to increase P absorption in animals, managing and recovering P in organic amendments, moving organic amendments from surplus to deficit areas, finding alternative uses for organic amendments, and targeting conservation practices to critical areas of P export during land application. This paper gives an overview of various strategies used in managing P in organic amendments in relation to its disposal through land application with particular emphasis on potential for surface and ground water contamination.

CAN OCEANIA RESPOND TO A P CRISIS?

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Food security is dependent on many factors, one of which is the availability of phosphorus (P) either from the soil resources or applied fertilizers. Much of the total land area in Oceania has soils that are responsive to P fertilizers but it is not necessarily economic to apply P. Of the global production of P, Oceania uses about 4.3% of the world's usage. Australia and New Zealand [ANZ] combined account of more than 99% of the P used in Oceania. On a per capita basis, Australia and New Zealand consume P at almost 9 times the world average; most of this P is from North Africa, China and the USA. This is not going unnoticed in world circles. As a consequence, many will say that ANZ are inefficient users of P and therefore should cease or reduce agricultural activities. This paper will refute these global assertions.

ANZ are exporters of several important staple foods and other agricultural commodities. These agricultural products vary in their P density and hence the rate at which they drain P reserves. Thus it is essential to develop balance sheets for P as a prerequisite to assess the impact of P shortages and sustainability of an industry. Furthermore, the economic value of nutrients, especially P, in exported foods needs greater recognition. The long term effects of a negative P balance are likely to be relatively severe for the small islands of Oceania as well as some pastoral industries in Australia.

As P is a non-renewable resource, strategies for efficient P utilization and recycling should be developed. This is irrespective of the timing of peak P. Implications for restricted P supply or price spikes on food security are discussed.

RECOVERY AND REUSE OF PHOSPHORUS FROM WASTEWATER SOURCES

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There is no known substitute for phosphorus (P) in agriculture. If soils are deficient in phosphorus, food production is restricted unless this nutrient is added in the form of fertilizer. With the increased demand for P coupled with dwindling sources of phosphate rock, world may soon run out of P based fertilizers. In an excellent article on “The disappearing Nutrient” Gilbert (2009) states that “ Every year, China, the United States, Morocco and other countries mine millions of tonnes of P from the ground, the bulk of which is turned into fertilizer for food crops. But such deposits are a finite resource and could disappear within the century.” Clearly, the diminishing supply of phosphate rock is the ticking time bomb that if not managed will severely impact on sustainable food production and through this global food security. Optimizing agricultural practices while exploring innovative approaches to sustainable use of P can reduce environmental pressures and enhance the long-term supply of this important plant nutrient.

In many parts of the world, continued extraction of freshwater for various activities including irrigation, declining rainfall trends and increased portioning of water for eco-system servicing have led to unsustainable rates of water consumption. Farmers are under significant pressure to improve water-use efficiency and better utilize alternative water supplies including recycled wastewater sources for irrigation purposes.

Wastewaters derived from a number of sources for irrigation has many beneficial effects, including groundwater recharge and nutrients, but also some detrimental effects, such as the build-up of salts, pesticides and heavy metal(loid)s, and soil degradation.

In this paper we address major opportunities for enhancing the continued supply of rock phosphate by developing strategies that minimise the use of P based fertilizers. We also discuss the recovery and reuse of P from municipal and other wastewater sources in relation to agricultural production and environmental protection.

References

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CAN WE IMPROVE INTERPOLATION OF N_2O EMISSION MEASUREMENTS BY USING ENVIRONMENTAL FACTORS?

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Determining nitrous oxide (N2O) emissions is highly uncertain due to their large spatial and temporal variability. This variability is caused by the large variation in biological processes involved, each responding in a different way to environmental conditions, and it is often associated with non-linear relationships to gaseous emissions. The objective of this study was to analyse N2O emission from a recently set up New Zealand N2O database and verify the possibility of using environmental factors to improve its linear interpolation. This repository comprises a collection of data from 21 trials carried out in New Zealand since 2000, under different climates, with different soils and N loads and sources. Gaseous and soil data collection were performed according to MAF protocols. In this work, we analyzed all data from urine patches treatments (N application ranging from 49 – 1,000 kg/ha) using stepwise multiple regression to select significant variables and to determine their relationship with N2O emissions. Daily measurements of soil water-filled pore space, volumetric water content, soil porosity, sum of rain recorded in the two previous days of gas measurement, soil temperature, air temperature, solar radiation as well as soil organic carbon content and inorganic soil N content were used as environmental variables. Prediction of N2O emission using environmental parameters resulted in a poor agreement when fitting was done using the whole dataset (R2=0.10). Improvement of fitting (R2=0.37 for overall data) was achieved after filtering the data according to the soil's nitrate content (soil NO3 content higher than 70% of total inorganic N). This separates the N2O values obtained when denitrification was the dominating process on the production of N2O. For the remaining data, the emissions come from both nitrification and denitrification, and could not be related to environmental factors with in a more precise way. Next the data were analysed region specific. For the Waikato region, stepwise regression indicated that four variables as significant: rainfall, air temperature, radiation, soil's clay content, and NO3 amount; while for Otago only rainfall and NO3 amount were significant. Predicitive functions based on these variables were used to interpolate N2O emissions and these were compared with the IPCC's interpolation approach. Preliminary results suggest that the above procedure is promising and specific tests will be carried out in the future. The relationship between estimated gaseous emission and environmental factors at the time of high ammonium contents also need to be further investigated.

CHANGES IN SOIL MICROBIAL COMMUNITY STRUCTURE UNDER ELEVATED ATMOSPHERIC CO_2

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The response of soil microbes to elevated atmospheric CO_2 is fundamental to understanding future global carbon and nutrient cycling. Here, we investigated soils that had been exposed to the ambient atmospheric CO_2 concentration or to 12 years of elevated atmospheric CO_2 in a Free Air Carbon Dioxide Enrichment (FACE) experiment in New Zealand. Through pyrosequencing, we obtained an average of 3,458 sequences per soil. We then assigned the sequencing data of 16S rRNA genes to RDP taxonomical hierarchy based on nomenclatural taxonomy and Bergey's Manual with a minimum support threshold of 80%. The result of classification at different levels (such as phylum-, class-, subclass-, order-, suborder-, family- and genus-level) showed that the diversity and dominance of bacterial communities was altered by elevated CO_2 but the major effects were on the relative abundance of each community. Compared with ambient, for example, *Actinobacteria* and *Planctomycetes* were stimulated, *Proteobacteria* was unchanged and *Frimicutes* decreased. Changes in the relative abundance of microbes have the potential to alter soil processes and this is an area for future research.

ROMA: A NOVEL LABORATORY APPLIANCE TO QUANTIFY HOW WATER REPELLENCY AFFECTS SOIL WATER DYNAMICS

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Soil water repellency (SWR) is a surface property of soil particles that reduces or prevents the infiltration of water into soils. SWR often leads to severe run-off and erosion, rapid leaching of surface applied agrochemicals, plus losses of water and nutrient availability for crops. We developed a laboratory-scale run-off measurement apparatus (ROMA) to quantify directly the impact of SWR on run-off and drainage simultaneously from undisturbed soil slabs. We tested and evaluated the performance of ROMA in multiple consecutive run-off experiments with water followed by a fully-wetting liquid, namely an ethanol solution. We found that a 30% (v/v) ethanol solution was needed to ensure soil hydrophobicity had no influence on the penetration rate of the liquid.

We evaluated that the run-on rate of both water and the ethanol solution under an equivalent rainfall rate of 60 mm/h. Within each experiment, the deviations of the 10-minute intervals ranged from 0 to 1.5% for water and 0.06 to 1.78% for the ethanol solution. In addition, the reproducibility of the experiment was high.

We also found that the run-off rates for water and the ethanol solution were constant during the duration of an experiment. Within each experiment, the values of the 10-minute intervals deviated by only 0.01 to 0.83% for water and by 0.08 to 0.90% for the ethanol solution. In addition, the reproducibility of the experiment was high.

After calibrating the ROMA for constant water and ethanol solution run-on rates, experiments were conducted with soil slabs. The homogeneity and reproducibility of flow rates produced by ROMA were confirmed by running repeated run-on tests in between any consecutive run-off experiments with soil slabs. These tests were conducted without soil slabs.

In conclusion, the ROMA was thoroughly tested ROMA for homogeneity and reproducibility of run-on and run-off rates with water and ethanol solution. We have developed a robust and reproducible method, and the ROMA performs at a high standard with methodological errors below 1%.

CHANGE IN DENITRIFICATION RATE AND N_2O/N_2 RATIO WITH VARYING SOIL MOISTURE CONDITIONS OF NEW ZEALAND PASTURE SOILS

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Denitrification is a microbially mediated process of dissimilatory reduction of nitrogen (N) oxides (nitrate NO_3^-, and nitrite NO_2^-) that may ultimately produce inert nitrogen (N_2) through a series of intermediate gaseous N oxides such as nitric oxide (NO) and nitrous oxide (N_2O). It accounts for 60% of the total N_2O emissions globally and is the primary process of N_2O production in New Zealand pasture soils. There are various soil and environmental factors affecting the denitrification rate (DR) and N_2O/ N_2 ratio. Soil moisture is one of the important factors that affect the DR and the relative proportion of N_2O/N_2 produced during the process. The DR has been found to increase and N_2O/N_2 ratio to decrease with increasing soil water content. The influence of changing moisture on DR and N_2O/ N_2 ratio will vary with soil type, soil texture, nutrient status and management practices followed on the farm. The interactions between these factors are still not very well understood. Therefore, the current study was planned to investigate the effect of soil moisture on DR and the N_2O/ N_2 ratio in five different New Zealand pasture soils with varying physical and chemical characteristics and denitrification potentials. The experiment involved incubation of surface (0-10cm) and subsurface (10-20cm) soil samples at field capacity (FC) and complete saturation at constant temperature (25^{o}C). DR and N_2O/N_2 ratio were estimated using an acetylene inhibition (AI) technique of measurement of denitrification.

Denitrification rates were higher in soils incubated at saturation than in soils incubated at FC. Similarly, the N_2O/N_2 ratio decreased in soils when incubated at saturation as compared to FC. The DR and the amount of N_2 produced during these incubations increased with increasing moisture content in all the soils however, the level of increase varied among the soils. Soils with higher denitrification potential showed higher DR and more N_2 production as compared to the soils with lower denitrification potential. As denitrification is a microbial process, along with chemical and gaseous measurements there is also a need to study the change in microbial (denitrifier and denitrifier enzyme) activities in variety of soils, to get in depth knowledge about the process for its mitigation. Further attempts will be made to establish relationship between DR and N_2O/ N_2 ratio and relative abundance of denitrifier enzymes encoding genes in various New Zealand pasture soils using molecular based techniques.

SPATIAL VARIABILITY OF NUTRIENTS IN A HERDHOMES® ANIMAL SHELTER MANURE BUNKER

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As dairy intensification has taken place within the dairy industry over the past decade has been the desire to protect pastures and soils from stock treading damage. Amongst the wintering options being practiced in New Zealand for removing stock from paddocks is the use of HerdHomes Shelters®. These plastic-roofed structures allow stock to be stood-off pastures and feed in sheltered conditions. Captured excreta is collected and stored in an under-floor manure bunker for later removal and land application when soil conditions are appropriate. A dairy farm in the Waikato with one 60m long HerdHomes Shelter® was intensively sampled to determine the spatial variability of solids content and nutrient concentrations that may occur within the manure bunkers. The study also sort to identify where and how many manure samples are required to obtain a truly representative sample.

REFLECTIONS FROM 23 YEARS IN FERTILISER INDUSTRY

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Ballance Agri-Nutrients, Tauranga

Over the past 20 years there has been slow but significant change within the fertiliser industry. This change covers the progression from a number of regional fertiliser SSP based companies to today's duopoly. The fertiliser products supplied have not changed significantly in terms of base products but the complexity of blends continues to increase as farmers and advisors move to more site specific advice. This is now being taken further and depending on the integration and ease of use of technologies will accelerate putting pressure onto logistic and service providers.

Product use has seen a dramatic increase in nitrogen use in the diary sector. The views often espoused about nitrogen today by dry stock farmers was typical of dairy farmers in the early 1990's. The expected increase in N use by dry stock farmers will create some tensions about nutrient loads from farm systems depending on how water quality or N leaching is considered at the farm level.

The external drivers will now focus the industry on efficiency of fertiliser use in terms of the external effects, namely greenhouse gas and nutrient loss from farms.

Finally, scribbling a fertiliser recommendation on a soil test is no longer adequate today even if the product recommendation is the same the context of its use and defensibility has created a huge increase in workload for fertiliser advisors.

Although often seen as a mature industry the fertiliser industry is continuing to innovate and morph as farms and wide stakeholder expectations and needs change.

PASTURE YIELD MAPPING FROM YOUR GROUNDSPREAD TRUCK

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There is considerable interest from farmers in measuring their pasture production. Dairy farmers in particular want to improve feed budgeting as well as increasing the efficiency of fertiliser use. While many have shown interest by investing in technology such as the C-Dax pasture meter, others are resistant to spending time on this task. One possible solution is to utilise the fact that a fertiliser spreading truck travels over the farm on a regular basis and at crucial periods where decision around fertiliser application are being made.

Pasture biomass can be estimated by using a VIS/NIR sensors, this type of non contact, optical sensor is used to produce a measurement called NDVI (Normalised Difference Vegetation Index), a surrogate of it or an alternative ratio of reflectance in the visible and near infrared ranges of the spectrum. There are a number of manufactured sensors available, the sensor used in this trial was the CropSpec™ from Topcon. These sensors can be fitted to the roof of the truck and linked directly to the GPS navigation assistance system of the vehicle.

This initial work examined the performance of the sensor and discuss the feasibility of using this approach. The possible uses of the technology are to provide pasture cover maps for the farmer and provide the basis for variable rate application of N fertiliser. This would be done by either reducing or eliminating further application of nitrogen fertiliser once the NDVI reached predetermined levels.

PRODUCTIVITY DIFFERENCES DUE TO VARYING APPROACHES TO SPREADING - AN ANALYSIS OF 30,000 SPREADING MAPS

C Brown[1] and R Saunders[2]

[1]TracMap, Mosgiel, [2]Otago Polytech, Dunedin.

In 2011 we analyzed the maps that were processed through the TracMap database. Of these, 19,000 were retained after filtering for only those who were carried out by contractors on blocks of over 3 hectares at an average speed of over 10km/hr and spread width of greater than 5 metres.

The resulting analysis showed significant differences in spreading efficiency, measured in average number of hectares spread per hour. The mean was 17.2 ha/hr, with 50% falling between 12.8ha/hr and 20.8 ha/hr

There was a strong correlation between spreading efficiency and job size up to 50Ha. A great deal of that variation can be attributed to time spent starting and finishing a job, which comprises a greater percentage of time on small jobs. For jobs in the size range of 10 ha to 20 ha, the mean spreading efficiency was 15.7 ha/hr, whereas for jobs 50 ha to 60 ha in size, the mean was 20.5 ha/hr

Spread width and percentage of time spent spreading vs non-spreading were also factors, as expected.

However, there were significant differences between spreading companies which cannot be attributed to geographic location or farm type. There can also be significant differences between efficiency of drivers within an individual business, with those differences typically being 3 to 4 ha/hr.

This paper presents a range of graphs and data which show the impact small changes in application methodology can have on spreading efficiency.

A FARMER FRIENDLY WAY OF ORDERING VARIABLE RATE FERTILISER APPLICATION USING GOOGLE EARTH

C Brown and L Nuttall

TracMap, Mosgiel

There is growing interest by farmers in achieving greater match between the variation in soil/plant needs across a farm, and actual fertiliser application rates. For example, the ability to target superphosphate on to portions of hill country that have high quality pasture species, but suffer from a high degree of nutrient loss (for example, steeper faces on hill country sheep pastures.)

One of the main constraints to achieving adoption has been access to tools which make it easy to

a - identify the target areas

b - convey that information to the spreading contractor

c - the spreading contractor being able to implement the plan

With increasing numbers of farmers becoming familiar with Google Earth, and it being relatively easy to access and to use, TracMap have implemented a web based system that allows farmers to easily specify fertiliser treatments for different areas of the farm, even if they do not have a farm map. That application map is then transmitting to the truck by cellular modem, and the resulting coverage map is transmitted by the same method back to the server so that farmers can see what has been applied and where.

This information, along with updated soil tests and local knowledge is then used as a basis for future application decisions.

The ability for farmers to specify different rates for different areas and have that be automatically applied by the truck as it drives around is presently being worked on, and will be available later in 2012.

This paper illustrates how the process works through a series of screen shots.

PROGRESS TOWARDS BETTER PRECISION AND IMPROVED SAFETY

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Safety and product placement precision is reviewed in this paper from the perspective of modifying materials applied by agricultural aircraft. It discusses methods and costs to overcome the problems outlined.

Improved safety of bulk solid fertilisers can be gained by ensuring the materials supplied for aerial application are free flowing. Mass flow rates of free flowing materials are predictable as they obey the "Beverloo equation". Not all products delivered from aircraft are free flowing; the most problematic is agricultural limestone (lime).

Applying lime from fixed wing aircraft on hill country pasture in New Zealand has incurred a disproportionate number of accidents. Most lime is hammer milled to meet the Fertmark® standard, which requires that 95% by weight must pass through a 2mm (10 mesh) diameter screen and 50% by weight through a 0.5 mm (35 mesh) screen. The resulting product is cohesive, with varying bulk densities, both within and between quarries. Inconsistent flow properties have led to difficulties discharging lime from aircraft.

The problem is caused by a large range of particle sizes which are able to pack and form cohesive bridges preventing discharge. A free flowing non compactable product may be produced by having a narrow particle size range or by removing most of the particles below 0.5 mm. The cost of producing such lime products is discussed.

There are two other products; di-calcic phosphate and reactive phosphate rock which are also commonly applied with a high proportion of fines. Because of their high drag coefficient particles below 0.5 mm in diameter cannot be modelled predictably as to where they will deposit, which makes precision application impossible.

THE USE OF POLY-CARBOXYLIC ACIDS AND SODIUM SILICATE TO INCREASE FERTILIZER P EFFICIENCY AND REDUCE LIME REQUIREMENTS ON ACID SOILS IN NEW ZEALAND AND VIETNAM

Peter Bishop, Tan Sy Pham, Linh Nguyen and Bert Quin

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The application of poly- carboxylic acids (PCA) to acid soils has been shown in field trials in the Mekong delta of Vietnam to increase rice production by up to 557 kg ha^{-1} when applied in association with di-ammonium phosphate (DAP) compared to DAP alone. In New Zealand soils trials have shown that the application of a low cost PCA AlpHa™ has been able to increase production in acid soils by reducing aluminium toxicity and may be an alternative to lime application in reducing metal toxicity in pastures.

SUPER, RPR AND LIQUIDS
– OBSERVATIONS ON 40 YEARS OF SCIENCE AND SEMANTICS, ZEALOTRY AND BIGOTRY, REGULATION *vs* DEREGULATION, CONS OR COMMERCE, FACT OR MYTH, INTERPRETATION OR MISINTERPRETATION

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The author blames the late Professor Keith Syers for the author's 'pit-lane' entry into fertiliser and soil fertility research in 1974. The author had intended, after completing a Ph.D in biogeochemical exploration under the late Robert Brooks, to take up a post-doctorate fellowship in lake geochemistry in Canada. Robert, about to commence a sabbatical in the UK in 1973, asked his friend Keith, who had recently taken up the position of Professor of Soil Science at Massey, to 'look after me'. Well, he did more than that. He got the author hooked on using my analytical chemistry training and perspective to develop agricultural production in New Zealand. This lead to being offered a position with MAF to set up a laboratory at the Winchmore Irrigation Research Station in mid-Canterbury, and that was that.

With such a different background to the agronomy focus of most of his MAF peers, the author tried to immerse himself in the MAF's soil fertility philosophy. Tried but mostly failed. The author came to the conclusion that some issues were not even being identified, let alone understood, because they were essentially chemical in nature, not 'agronomic', and partly because of an almost religious faith in the superiority of the current system.

These issues are looked at from five different perspectives, *viz*

* Science and semantics – what exactly is superphosphate, an RPR, a liquid?
* Zealotry and Bigotry – the evil twins
* Regulation *vs* Deregulation – where is the compromise?
* Cons or Commerce – where is the line?
* Fact or Myth? Repetition blurs the difference
* Interpretation or Misinterpretation – we see what we want to see.

Suggestions for future research are made, along with a plea to revisit key research of past decades, but with a modern perspective on what to look for in the results.

THE ROLE OF REMOTE AND PROXIMAL SENSING OF SOIL PROPERTIES FOR BOTH NUTRIENT AND CARBON MANAGEMENT IN GRAZED PASTURE AND CROPPING SYSTEMS

Raphael Viscarra Rossel

CSIRO Land and Water - Black Mountain, Canberra ACT

Editor's Note:
Extenuating circumstances did not allow an abstract to be available for publication. The following is a brief biography of the author and his recent achievements.

Raphael Viscarra Rossel grew up in Coroico, a small town near La Paz in Bolivia. He completed his undergraduate and postgraduate studies at the University of Sydney, before moving to CSIRO Canberra in 2008 to take up the position of Principal Research Scientist in the Soil and Landscape Science Dept.

Dr Viscarra Rossel was senior research fellow working within the Faculty of Agriculture, Food and Natural Resources at The University of Sydney. Here he worked on the development of new technologies and innovative methodologies for proximal soil sensing and the development and use of pedometrics (mathematical and statistical techniques to describe, model and understand soil). Specifically his research included development of

- techniques for proximal soil sensing
- high resolution digital soil mapping
- use of chemometric techniques to analyse soil spectra
- precision agriculture.

He is now actively involved in the International Union of Soil Sciences initiatives, which includes being Chair of the Proximal Soil Sensing Working Group; active contributor to the IUSS Digital Soil Mapping project and creator and convenor of the Global Soil Spectroscopy Group. As creator of The Global Soil Spectroscopy Group his aims are to develop a global soil spectral library and to establish a community of practice for soil spectroscopy. The Group is tackling the following topics:

- Can global soil diversity and variation be characterised using diffuse reflectance spectra?
- Can soil spectral calibrations be used to predict soil properties globally?
- Is soil spectroscopy a useful tool for digital soil mapping?

Dr Viscarra Rossel and co-authors were awarded best paper in Pedometrics in 2003 and 2007 by the International Union of Soil Sciences Commission on Pedometrics.

WIRELESS SOIL MOISTURE SENSOR NETWORKS FOR PRECISION IRRIGATION SCHEDULING

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Advanced nutrient management aims both to optimise plant nutrient use and to minimise deleterious environmental effects. This is being addressed at high spatial (<10 m) and temporal resolution through cost-effective, smart technology. One example is the use of wireless sensor networks (WSNs) for site-specific real-time soil monitoring, where WSN nodes are positioned in soil management zones derived from high resolution digital soil variability maps produced by electromagnetic (EM) survey. This aims to monitor the full range of any specific soil attribute within a landscape unit, for precise management. For example, WSNs provide real-time soil moisture status information for optimising the land management decisions: timing, amount and placement position for nutrients and/or irrigation.

Three WSNs have been installed on irrigated farms (one Ashburton cropping, two Manawatu pastoral farms) to assist farm management decisions for precision irrigation scheduling. The WSNs consist of a network of between eight and twelve nodes placed in soil management zones. Sensors are attached to each node at two depths (15 cm and 50 cm) to monitor volumetric soil moisture and matric potential simultaneously, with a maximum communication range between any two nodes of one kilometre. The WSNs also monitor rainfall and irrigation at each farm. To conserve power the nodes act as sleeping routers, but activate to relay data to the base station every 15 minutes, via other nodes using the most energy efficient route. Data are processed in real-time, converted to the necessary format, and immediately made accessible through a cellular or ADSL modem via the Internet to a web page, available for simultaneous remote access by researchers, agricultural consultants, farm managers, and irrigator software controller packages.

The WSN web pages provide powerful visualisations of continuous (every 15 minutes) soil moisture data streams through the irrigation season at two depths in each soil management zone, indicating when stress point has occurred, and whether drainage is occurring during rainfall and irrigation events, allowing fine-tuning of irrigation scheduling. The discoverable, accessible and processible nature of the WSN data by human and machine end users makes the soil moisture data available for fully automated geo-information processing chains.

SENSORS FOR ASSESSING PASTURE QUALITY

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There are a number of sensing technologies which are being researched to assess pasture quality. Recent efforts have concentrated on non-destructive methodologies that give farmers access to near real-time information to assist in informing pasture management decision making. Previously, only time consuming and destructive sampling has been employed with assessment of quality being completed through wet chemistry or laboratory based VIS/NIR techniques. This paper summarises the work where a variety of optical sensors were used to sense pasture quality parameters such as: crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF), ash, dietary cation-anion difference (DCAD), lignin, lipid, metabolisable energy (ME) and organic matter digestibility (OMD) was evaluated. In situ canopy spectral reflectance was obtained from mixed pastures, under commercial farm conditions in New Zealand.

The approach was to use a hyper-spectral (ASD Field Spec® Pro) sensor and a 16-channel multi-spectral sensor (MSR 16R, Cropscan, Inc.) for predicting the pasture quality parameters. A three channel sensor (Crop Circle™; Model- ACS470, Holland Scientific) was also used to assess dry matter (DM) and crude protein availability (CPA).

The statistical methods were employed to establish a relationship between reflectance measurements and wet chemistry. In all cases these sensors showed that a number of the pasture quality parameters could be assessed with reasonable levels of explanation. For the multispectral sensor acceptable levels of explanation could be obtained and could be improved through season-specific models.

A METHODOLOGY FOR DETERMINING CRITICAL SOURCE AREAS IN GRAZED HILL PASTURES

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Critical source areas (CSAs) are minor parts of a catchment or farm that contribute a disproportionately large amount of contaminants to the environment. These areas could be camp sites that receive large amounts of nitrogen (N) from urine and N, phosphorous (P) and faecal microbes from faeces. These sites may emit N gases directly, but usually require water to transport N, P and faecal coliforms in overland flow or as N leachate to groundwater, to pollute larger water bodies. If CSAs can be identified from landscape and management activities then strategies could possibly be targeted to these areas to mitigate the contaminants. This paper draws on a spatial datasets from a hill country cattle grazed pasture in which cows wore a GPS collar to track their movement over several days. Cows were also fitted with a urine sensor to locate urine patches and a motion sensor to differentiate between walking, grazing, standing and lying. GIS maps were used to show distribution patterns of cow movement, urine deposition, and paddock slope, aspect and elevation. With time spent in a given area of a paddock (greatest when lying down) being correlated with urine distribution (r = 0.75), lying time was used as a proxy for urine distribution. Of several modelling approaches evaluated, the Generalised Additive Model (GAM) best predicted where cows would lie, using independent variables slope, elevation and aspect of 25 m^2 grid cells overlying the paddock map. Aggregates of “cells” with high densities of urine patches are considered to be potential CSAs. This model will be revised as new data become available and by inclusion of farm features such as trees, shelter belts water troughs and gateways around which animals typically congregate.

FARM-SCALE MAPPING OF SOIL ORGANIC MATTER USING VIS-NIR SOIL SPECTROSCOPY

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There is a need to develop new methods to assess soil carbon stocks and stock changes within the landscape, taking into account spatial and temporal variability. Visible/near-infrared spectroscopy (Vis-NIR) is a non-destructive and cost-efficient field and laboratory method for estimating soil attributes, and has been used in this project with electromagnetic (EM) survey data to develop a total soil organic carbon (SOC) mapping method.

EM surveying was used to quantify soil variability at high resolution (5 m) in a 90-hectare field located near Bulls, Manawatu. The resulting EM map has been used to target positions (n = 100) for soil sampling and Vis-NIR scanning. At each position a 0.3 m soil core was scanned in the field at 1-cm intervals. Three depth samples (0 – 0.1 m, 0.1 – 0.2 m, 0.2 – 0.3 m) were taken back to the laboratory for SOC analysis. Terrain attributes were extracted from the digital elevation model (DEM) derived from EM survey data.

Partial least squares regression (PLSR) was used to predict SOC from Vis-NIR data. To estimate the number of physical samples needed to provide an accurate estimation based solely on Vis-NIR spectra the model performance was repetitively assessed using between 10 and 80% of soil analyses for calibration. Our results indicate that Vis-NIR could accurately predict SOC using only 40% of the soil samples as a calibration set.

The SOC map produced from actual soil carbon measurements (classic approach) was compared with the one produced from the Vis-NIR-based soil carbon estimates (Vis-NIR approach). EM and terrain attributes were used as co-variates in both approaches in a random forest regression at each depth interval. For both approaches, the modelling step is repeated 10 times.

Results show that, in this paddock, the mean estimation of SOC (0 - 0.3 m) using the cost-efficient Vis-NIR approach is comparable to the result obtained using the classic lab-based approach, (2.29% difference: 3476.2 T for the lab-based approach and 3555.73 T for the Vis-NIR-based approach with lab analysis reduced by 60%), which illustrates the potential of field Vis-NIR technology to support traditional soil sampling for soil carbon accounting.

DOES BEST MANAGEMENT PRACTICE ON DAIRY FARMS RESULT IN BETTER STREAM HEALTH?

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The Best Practice Dairy Catchments study (2001-2011) has provided an invaluable data set describing water quality from five monitored catchments located in Waikato, Taranaki, Canterbury, Southland and West Coast. While there have been some improvements in water quality resulting from increased stream fencing and greater use of irrigation for effluent disposal, N concentrations have increased as dairy farming has continued to intensify. However, trend analysis has shown that suspended sediment concentrations have declined significantly in all five streams, most likely in response to greater use of fences for stock exclusion. Biological assessments of aquatic invertebrates (as indicators of stream health) and stream habitat indicated improved stream health in four of the five catchments, as a response to the reduced sediment (and related pollutant) concentrations. Macroinvertebrate Community Index (MCI) scores increased in four of the five catchments, indicating the presence of a greater number of invertebrate species that are sensitive to organic pollution and general improvement in stream health. The pattern was not seen in the Southland sites, possibly due to on-going forestry operations in the upstream catchment. The provisional results suggest that actions leading to reduced loss of sediments from land (viz. stock exclusion) result in healthier and more diverse aquatic ecosystems. Other factors likely to affect stream health and habitat are the frequency of floods causing biological disturbance (as indicated by the FRE3 flood frequency statistic) and the degree of riparian shading (temperature, C inputs). The provisional results nonetheless suggest that actions leading to reduced loss of sediments from land (stock exclusion from riparian areas) result in improved streams health and more diverse aquatic ecosystems.

THE SHERRY RIVER - A SUCCESS STORY

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Water quality (WQ) monitoring in the Motueka Integrated Catchment study (ICM) in 2000-2001 revealed mainly good water quality throughout this catchment. However, during the initial phases of the study the Sherry River showed consistently high E. coli concentrations, even under base-flow conditions. This was linked to frequent dairy herd crossings to and from the twice-daily milking by a field study (Davies-Colley et al. 2004). Dairy farmers responded rapidly to the findings of this study by building bridges to eliminate crossings and consequent dairy cow access. Continued monitoring at four sites in the Sherry River has demonstrated that bridging had much improved microbial water quality although the river was still not suitable for swimming.

The landowners in the Sherry River catchment wished to achieve contact recreational water quality standards in the river. The NZ LandCare Trust and other agencies (through the Motueka ICM programme) and with intensive farm planning by Tasman District Council, (TDC), have assisted towards that goal.

The WQ monitoring was extended to include a study of all the tributaries in 2007 (by TDC), and a year of special storm sampling in 2008 (by NIWA).

This was done to measure loads of diffuse pollution from this catchment, and gauge future decreases in loads. We hope to document improvements in water quality (in future studies), with improved total catchment land management and thus impacts on downstream waters.

The WQ monitoring that is continuing, is described and summarised. As at September 2011, the analysis of the E.coli trends in the Sherry River (seasonal Kendal test with flow adjustment) showed a reduction in E. coli concentrations to levels indicating that the Sherry River is consistently meeting contact recreational/bathing water standards.

This achievement is the outcome of significant on-farm best management practices (BMP's) being progressively installed and implemented.

SOLUTIONS FOR A SUSTAINABLE LAKE ROTORUA:

THE FARMERS' PERSPECTIVE

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The Government's Freshwater National Policy Statement requires all regional councils to establish environmental limits for significant waterways. Parallel signals from Cabinet papers and the Land and Water Forum have emphasised collaborative approaches and potential for industry-led audited self-management. The Lake Rotorua catchment provides a useful case study for the practical application of these approaches. Lake Rotorua water quality has deteriorated in recent decades due to elevated nitrogen and phosphorus levels. Improved management of farm nutrient losses is a key method to achieve community expectations for lake water quality.

The Bay of Plenty Regional Council (BoPRC) has already regulated Rotorua farms by capping nutrient losses to no more than the average that occurred from 2001 to 2004, based on Overseer® analyses. BoPRC has also signalled its intent to reduce annual catchment nitrogen losses by about 300 tonnes through prioritising land use change over management change.

Rotorua dairy farmers collaborated informally for several years before establishing the Lake Rotorua Primary Producers Collective in June 2011. Membership is expanding to drystock farmers so that the Collective can represent the owners of 80% of pastoral land in the catchment, including land managed by the Maori Trustee. The Collective also has a Memorandum of Understanding with the Lakes Water Quality Society, the leading local environmental group.

The Collective aims to be at the forefront of sustainable nutrient management in New Zealand by putting farmers at the centre of nutrient policy development and implementation whilst also protecting members' economic interests. The Collective presented its preferred path on nutrient management to BoPRC in October 2011, emphasising:

- Acceptance that the pastoral sector contributes to Lake Rotorua's nitrogen load and that the sustainable annual nitrogen load target is 435 tonnes;
- Farmer responsibility to achieve defined nutrient best practices at their own cost;
- Pastoral sector nitrogen reductions should be a three-way mix of nutrient management best practice, major farm system changes and land use change;
- Broad collaboration on policy development, funding and implementation that will give an enduring and cost-effective package to achieve a clean lake with better economic, social and cultural outcomes.

DEVELOPING A FARMER LED CATCHMENT PLAN FOR A ROTORUA LAKE WITH REGIONAL COUNCIL SUPPORT

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Lake Rerewhakaaitu is a predominantly pastoral catchment, mostly in dairy farming. Over the last nine years have been looking at ways to improve water quality in the lake while maintaining a profitable farm business.

In 2002 farmers initiated a SFF project to identify the impacts of farming in the waterways and lake. This was followed in 2006 by a second SFF project looking at on-farm mitigations.

At the final meeting in 2009 the CEO of Bay of Plenty Regional Council offered financial and technical support for the farmers to write the catchment plan for Lake Rerewhakaaitu. This was readily accepted by the farmers. The goal was to maintain the three year average TLI for the lake at 3.6 or below.

Firstly farmers set up the project. Some of the outcomes of this were: a set of principles on how everyone would work together, setting an action timeline, setting five years as the timeframe and forming a committee. A mission statement was developed. Six months after the start of the new phase a third SFF was won.

The strategy was for each farmer to prepare a farm NMP with support of AgResearch using OVERSEER® and an Envirowalk. The draft was then discussed and finalised with the farmer who committed to carry it out. Collectively all the farm NMP's will become the basis of the catchment plan.

Trust between farmers and council has remained strong despite some of the unknowns that face the project. Communication through personal contact, hall meetings and newsletters has been critical in achieving this. In addition and outside the SFF project work has continued on developing some macro mitigations involving installing sediment traps and dams in some of the dry streams. These will mitigate the runoff of phosphate during heavy rain events which contribute a large component of the phosphate that gets in the lake and waterways.

Technical details on progress are in the poster paper "Reducing Nutrient Losses to Lake Rerewhakaaitu".

The three projects have been funded by MAF Sustainable Farming Fund, Bay of plenty Regional Council, Dairy NZ, Dairy Insight and Fertresearch.

LESSONS LEARNT FROM A COLLABORATIVE APPROACH TO NUTRIENT MANAGEMENT IN TAHARUA CATCHMENT

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Hawke's Bay Regional Council

Taharua catchment is a microcosm of many of the issues facing New Zealand. These are compressed in both time (a relatively short history of development ~30years from native vegetation) and space (a small catchment of ~13500ha).

This headwater sub-catchment of the Mohaka River has received increased public attention as intensification of land use has correlated with increasing N levels in the Taharua stream, nuisance algae in the upper Mohaka and adverse impacts on the outstanding trout fishery recognised by water conservation order. Two monitoring sites immediately downstream of two of the catchment's three dairy farms have the highest nitrate levels of any stream sites monitored in Hawke's Bay.

Council began meetings in the catchment to discuss water quality monitoring results with landowners and Fish and Game in 2007. A broader working group of key stakeholders was formed in November 2009 (Taharua Stakeholders Group -TSG) to develop enduring solutions.

Work with individual landowners and the TSG has so far resulted in:

- Acceptance of the issues and a commitment to working on solutions
- Agreement on desired outcomes for the catchment
- Provisional (subject to economic evaluation) agreement on making land management changes within 10 years to reach desired water quality target within 15yrs.
- On-farm changes to reduce nutrient losses.
- A significant decline in P levels in the Taharua stream.

The National Policy Statement for Freshwater management 2011: Implementation Guide, advocates collaborative work at the catchment level. This paper outlines some of the key elements of success along with challenges and issues for securing future sustainable management of the catchment.

CATCHMENT WIDE MODELLING OF LAND USE IMPACTS ON THE RUATANIWHA PLAINS

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The Hawkes Bay Regional Council (HBRC) is currently undertaking a water storage project for the Ruataniwha Plains. They are seeking information to define the potential volumes of water that are needed, now and in the future, to irrigate a range of agricultural and horticultural enterprises. In addition, the Council are also seeking information to help assess the potential effects of land use change on surface and groundwater quality as a result of irrigating from stored water. In this paper we discuss the modelling approach that is being used to simulate irrigation demand plus N and P loads from a range of land use activities.

The current land use has been identified (using the Agribase and recent ortho-corrected aerial photography) as a mix of dryland sheep and beef, extensive arable, some dairy and finishing farms and a small amount of horticulture. Model outputs have been simulated for these farming enterprises. The provision of a reliable supply of irrigation water is expected to change the mix and intensity of land uses as well altering the environment impacts. We are running simulations for a number of future farm scenarios that have been identified by a team of expert farm management consultants who inspected the Ruataniwha area, visiting typical farms to analyse current farming systems, production and profitability and engaging with farmers to understand their mindset.

Modelling is being carried out in two stages. Firstly, at the enterprise scale, we are using Plant and Food Research's SPASMO model (Soil Plant Atmosphere System Model) to simulate the daily water and nutrient balance for a range of land uses, soil type and microclimate. Model outputs from SPASMO are then being used by AgResearch's GIS landscape modelling tools to aggregate the water and nutrient balances across a number of sub-catchments (irrigation zones). The task of the modelling is to assess the impacts of land use intensification on the water balance and nutrient fate. Some preliminary results will be presented for selected farming enterprises.

SETTING CATCHMENT WATER QUALITY LIMITS AND IMPLICATIONS FOR NUTRIENT MANAGEMENT IN CANTERBURY

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The management of agricultural diffuse pollution is at the heart of a debate facing Canterbury between pressure to intensify agricultural production and the effects on the region's water resources.

In recognition that existing policies did not deal adequately with diffuse pollution, Environment Canterbury initiated a collaborative pilot project in 2009 to devise a 'preferred approach' for managing the cumulative impacts of land use on water quality. The outcome was a set of general principles that underpin the process of setting catchment water quality and quantity limits with the local community and for the continuing task of managing to the limits.

While overall responsibility for setting limits and ensuring compliance rests with Environment Canterbury, the 'preferred approach' relies on the relevant Canterbury Water Management Zone Committee having a central role in all aspects of the process. The involvement of the Zone Committees in this way is critical to ensure integrated water management in the region. Communities of interest and key stakeholders also have an important role to play by participating in the process and ensuring that a strong focus on community-agreed outcomes is maintained.

Once limits are set the challenge is managing to these limits. The preferred approach empowers those responsible for, or who benefit from, the use of land to develop their own property-specific or collective means to deliver on the agreed catchment objectives. At the farm level, a key component will be farm nutrient discharge allowances (NDAs). The impact of introducing NDAs at farm level will depend on the scale, nature and intensity of the operation. A nutrient allocation system based on 'averaging' is likely to be recommended for over-allocated catchments.

The 'preferred approach' is markedly different to current management of diffuse pollution in Canterbury. It is a resource intensive process initially and will need to deal with challenges and conflicts. However, the combination of a technically-informed collaborative approach, community agreed outcomes, and management to limits represents a big step forward in the sustainable management and use of resources in Canterbury. This is expected to deliver cost effective management of diffuse pollution in the long term.