FERTILIZER & LIME RESEARCH CENTRE

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA

Adding to the Knowledge Base for the Nutrient Manager

This document contains the abstracts of all papers that were presented at the 24th Annual FLRC Workshop held at Massey University on the 8th, 9th and 10th February 2011. 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

The correct citation for papers presented at this workshop is:

[Authors], 2011. [Title of paper]. In: *Adding to the knowledge base for the nutrient manager.* (Eds L.D. Currie and C L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 24. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. [No. of] pages.

Tuesday 8th February

Session 1

Tessa Mills, A Hoggard, L McKenzie and P Le Miere
Federated Farmers, Palmerston North
DOWN ON THE FARM – WHERE SCIENCE AND POLICY MEET PRACTICE

John Paterson and A Dewes ***(Invited Speaker)***
Bay of Plenty Regional Council, Whakatāne
THE STATUS OF NEW ZEALAND AGRICULTURAL SECTOR OWNED ENVIRONMENT MANAGEMENT SYSTEMS - ARE THEY A REALISTIC ALTERNATIVE TO AVERTING FURTHER ENVIRONMENTAL REGULATION?

Greg Carlyon
Horizons Regional Council, Palmerston North
THE NUTRIENT MANAGEMENT GAME IN THE HORIZONS REGION. THE ONE PLAN AND THE DAY-TO-DAY REALITY

Session 2

Genevieve Carruthers ***(Invited Speaker)***
Ecosure Pty Ltd, West Burleigh, Queensland, Australia
AUDITING AND CRITICAL REVIEW IN ENVIRONMENT MANAGEMENT SYSTEMS IN AGRICULTURE; IS THERE VALUE FOR SIMILAR APPROACHES IN NEW ZEALAND'S PROPOSALS FOR AUDITED SELF MANAGEMENT?

Megan Birchall and J Paterson
Okaro Catchment Lake Restoration Group, Lake Okaro
THE OKARO COMMUNITY LAKE RESTORATION GROUP - FARM AND CATCHMENT ENVIRONMENTAL ACCOUNTABILITY - WHAT ARE WE ACHIEVING?

Katie Milne
Dairy Farmer, Lake Brunner Catchment, West Coast
FARMING CHALLENGES IN A LAKE CATCHMENT – INCHBONNIE

Shirley Hayward
DairyNZ, Lincoln
IRRIGATION, WATER USE EFFICIENCY AND WATER QUALITY – WAIKAKAHI

Robert J Wilcock, G B van Assema, M A Bellingham, Ron Ovenden and K Müller
NIWA, Hamilton
BENEFITS OF WETLANDS IN FARMING LANDSCAPES – TOENEPI

Don Shearman and R J Wilcock
Taranaki Regional Council, Stratford
WATER QUALITY GAINS FROM RIPARIAN ENHANCEMENT – WAIOKURA

Mike Scarsbrook
DairyNZ, Hamilton
BEST PRACTICE DAIRYING CATCHMENTS
– WHAT WORKED, WHAT DIDN'T AND WHERE TO FROM HERE?

Poster Papers:

Reece Hill and D Borman
Environment Waikato, Hamilton
ESTIMATING PASTORAL LAND USE CHANGE FOR THE WAIKATO REGION

Lucy McKergow and C Tanner
NIWA, Hamilton
READING THE LANDSCAPE: SELECTING DIFFUSE POLLUTION ATTENUATION TOOLS THAT WILL MAKE A REAL DIFFERENCE

Archana Singh
URS New Zealand Limited, Auckland
REGULATORY AND NON REGULATORY OPTIONS IN ACHIEVING REDUCTION IN NON POINT SOURCE POLLUTION IN THE ROTORUA DISTRICT

M S Srinivasan and M J Duncan
NIWA, Christchurch
SUPPLY, RESTRICTIONS AND WATER USE: A SURVEY AT THE WAIMAKARIRI IRRIGATION SCHEME

M Hasinur Rahman, A W Homes, M A A Sarnaker, S Sabreen and A Okubo
PlusGroup Ltd, Tauranga
IMPACT OF IRRIGATION ON CARBON STRATIFICATION IN CALCAREOUS SOILS

Session 3

Keith L Bristow ***(Invited Keynote Speaker)***
CSIRO Land and Water, Townsville, Australia
IMPROVING NUTRIENT MANAGEMENT REQUIRES A SYSTEMS APPROACH

John Paul Praat and A Dewes
P.A. Handford and Associates Ltd, Te Awamutu
LAND AND WATER FORUM IN ACTION
- AN INTEGRATED APPROACH TO CATCHMENT PLANNING

Simon Park and P MacCormick
Headway Ltd, Tauranga
ROTORUA RURAL PROPERTY NUTRIENT ASSESSMENTS -CHALLENGES AND PROGRESS

Chris Palliser, K Rutherford and S Wadhwa
NIWA, Hamilton
USE OF A MODEL TO PREDICT THE EFFECTS OF
LAND USE CHANGES ON NITROGEN DELIVERY TO LAKE ROTORUA, ESPECIALLY THE LAGS INVOLVED WITH GROUNDWATER

Poster Papers:

David Houlbrooke, J Paton, T Styles, S Laurenson
AgResearch, Hamilton
REFINING THE PROCTOR COMPACTION TEST TO GUIDE
OFF-GRAZING MANAGEMENT DECISIONS

Patricia Burford
URS New Zealand Limited, Auckland
CONFINED ANIMAL OPERATIONS
- MINNESOTA MANURE MANAGEMENT REGULATIONS

David Horne, M R Bretherton, J A Hanly, D Houlbrooke and J Roygard
Fertilizer and Lime Research Centre, Massey University
THE FDE STORAGE CALCULATOR – AN UPDATE

Murray Perks
DairyNZ, Hamilton
CAN CHICORY BE USED TO REDUCE NUTRIENT LOADING ON THE EFFLUENT BLOCK?

Bob Longhurst and B Nicholson
AgResearch, Hamilton
RAPID METHOD OF ASSESSING NPK CONTENT OF DAIRY EFFLUENT FOR LAND APPLICATION

Kate Chatfield, H Mora and R Longhurst
Auckland Diocesan School for Girls, Auckland
"IT'S RAINING EFFLUENT", EFFECT OF HERD HOME SLURRY ON GROWTH OF MAIZE AND SORGHUM IN WAIKATO

Wednesday 9th February

Session 4

Doug Edmeades, M Robson and A Dewes
agKnowledge Ltd, Hamilton
SETTING THE STANDARD FOR NUTRIENT MANAGEMENT PLANS

Hilton Furness and J Richards
Seven Consulting Group, Auckland
ENHANCING SHAREHOLDER VALUE THROUGH LEADERSHIP ON NUTRIENT MANAGEMENT IN NEW ZEALAND

Estelle Dominati, A Mackay, S Green and M Patterson
Institute of Natural Resources, Massey University
THE VALUE OF SOIL SERVICES FOR NUTRIENTS MANAGEMENT

Sandy Elliot, A Semadeni-Davies and U Shankar
NIWA, Hamilton
CLUES CATCHMENT MODELLING - LESSONS FROM RECENT APPLICATIONS

Scott Fraser and Eva Vesely
Landcare Research, Hamilton
CONNECTING NORTH ISLAND HILL COUNTRY FARMERS NUTRIENT REQUIREMENTS WITH SOIL MAPPING UNITS

Brenda Rosser and C Ross
GNS Science, Lower Hutt
EROSION SOIL LOSS AND RECOVERY ON EASTERN NORTH ISLAND HILLCOUNTRY – IMPLICATIONS FOR NUTRIENT MANAGEMENT AND PASTURE PRODUCTIVITY

Coby J Hoogendoorn and B P Devantier
AgResearch, Palmerston North
LEACHING LOSSES OF NITROGEN AND CARBON FROM LOW AND MEDIUM SLOPED AREAS IN SHEEP GRAZED NORTH ISLAND HILL COUNTRY

Ronaldo E Vibart, I Vogeler, B Devantier, R Dynes, T Rhodes and W Allan
AgResearch, Palmerston North
IMPACT OF CARBON FARMING ON PERFORMANCE, ENVIRONMENTAL AND PROFITABILITY ASPECTS OF SHEEP AND BEEF FARMING SYSTEMS IN SOUTHLAND

Poster Papers:

M Hasinur Rahman, A W Holmes, M Deurer, S J Saunders, A Mowat and B E Clothier
PlusGroup Ltd, Tauranga
COMPARISON OF THREE METHODS TO ESTIMATE ORGANIC CARBON IN ALLOPHANIC SOILS IN NEW ZEALAND

M Hasinur Rahman, A W Holmes, M Deurer, S J Saunders, A Mowat and B E Clothier
PlusGroup Ltd, Tauranga
MODIFIED SOIL SAMPLING TECHNIQUE TO QUANTIFYCARBON SEQUESTRATION IN ALLOPHANIC SOILS UNDER KIWIFRUIT MANAGEMENT SYSTEMS

Ants Roberts, M White, H Lawrence and M Manning
Ravensdown, Pukekohe
WHEN MORE IS MORE – A PRÈCIS!

Gordon Rajendram and K Devey
Hill Laboratories, Hamilton
COMPARISON BETWEEN MID-INFRARED AND NEAR-INFRARED FOR SOIL ANALYSIS

Session 5

Cameron J P Gourley, S R Aarons, W J Dougherty and David M Weaver
(*Invited Speaker)*
Department of Primary Industries, Ellinbank, Australia
NITROGEN AND PHOSPHORUS BALANCES AND EFFICIENCIES ON CONTRASTING DAIRY FARMS IN AUSTRALIA

Christine Christensen, M J Hedley, J A Hanly and D J Horne
Fertilizer & Lime Research Centre, Massey University
NITRATE LEACHING AND PASTURE ACCUMULATION DURING TWO YEARS OF DURATION-CONTROLLED GRAZING IN THE MANAWATU

Mark Shepherd, P Phillips and V Snow
AgResearch, Hamilton
THE CHALLENGE OF LATE SUMMER URINE PATCHES IN THE WAIKATO REGION

Val Snow, M Shepherd, R Cichota and I Vogeler
AgResearch, Christchurch
URINE TIMING:
ARE THE 2009 WAIKATO RESULTS RELEVANT TO OTHER YEARS, SOILS AND REGIONS?

Richard W Muirhead and R M Monaghan
AgResearch, Mosgiel
MICROBIAL WATER QUALITY IMPACTS OF DIRECT INPUTS AND EFFLUENT MANAGEMENT

Poster Papers:

Ronaldo E Vibart, D Pacheco, K Lowe and B A Barrett
AgResearch, Palmerston North
PERFORMANCE, NITROGEN UTILISATION, AND GRAZING BEHAVIOUR FROM LATE-LACTATION DAIRY COWS OFFERED A FRESH ALLOCATION OF A RYEGRASS-BASED PASTURE EITHER IN THE MORNING OR IN THE AFTERNOON

Deborah Ballantine and Chris Tanner
NIWA, Hamilton
HOW CAN WE ENHANCE PHOSPHORUS REMOVAL IN CONSTRUCTED FARM WETLANDS?

James Sukias and C Tanner
NIWA, Hamilton
SURFACE FLOW CONSTRUCTED WETLANDS AS A DRAINAGE MANAGEMENT TOOL – LONG TERM PERFORMANCE

Allan Morton and D Woolley
Institute of Natural Resources, Massey University
FOLIAR UREA AS A SUBSTITUTE FOR SOIL APPLIED N: EFFECTS ON VEGETATIVE VIGOUR AND FRUIT QUALITY OF KIWIFRUIT

Laura Christianson, M Hedley, M Camps, H Free and S Saggar
Iowa State University and Fulbright Fellow, Massey University
INFLUENCE OF BIOCHAR AMENDMENTS ON DENITRIFICATION BIOREACTOR PERFORMANCE

M Hasinur Rahman, M Hara, A W Homes, M Deurer and T A Adjadeh
PlusGroup Ltd, Tauranga
EFFECTS OF SUBSOIL COMPACTION ON NUTRIENT ASSIMILATION AND TRANSLOCATION ABILITY IN THREE GRAIN LEGUME CROPS

Session 6

Dani Guinto
Bay of Plenty Regional Council, Tauranga
CHANGES IN TOPSOIL QUALITIES OF DRYSTOCK PASTURE AND KIWIFRUIT ORCHARD SITES IN THE BAY OF PLENTY

Weiwen Qiu, D Curtin and M Beare
Plant & Food Research, Lincoln
SPATIAL VARIABILITY OF AVAILABLE NUTRIENTS AND SOIL CARBON UNDER ARABLE CROPPING IN CANTERBURY

Seth Laurenson, N S Bolan, E Smith and M McCarthy
University of South Australia, Mawson Lakes, Australia
SOIL STRUCTURAL CHANGES RESULTING FROM IRRIGATING WITH A POTASSIUM RICH WINERY WASTEWATER

Robinson, C W N Anderson, O Knowles, J Gartler, D Portmann, A Contangelo and L M Clucas
Lincoln University, Canterbury
CLOSING THE LOOP: BIOSOLIDS TO REBUILD DEGRADED SOILS

Anwar Ghani, U Sarathchandra, S Ledgard, M Dexter and S Lindsey
AgResearch, Hamilton
BIOAVAILABILITY OF DISSOLVED ORGANIC CARBON AND NITROGEN LEACHED OR EXTRACTED FROM PASTURE SOILS

Chris Anderson, B Robinson and D West
Fertilizer and Lime Research Centre, Massey University
BIOFORTIFIED FODDER - AN ENVIRONMENTALLY SUSTAINABLE MECHANISM TO SUPPLEMENT LIVESTOCK WITH TRACE ELEMENTS?

Poster Papers:

Matthew Taylor, N Kim and R Hill
Environment Waikato, Hamilton
A TRACE ELEMENT ANALYSIS OF SOIL QUALITY SAMPLES FROM THE WAIKATO REGION

Shamima Sabreen, S Sugiyama, M H Rahman and S Saiga
Hirosaki University, Japan
CADMIUM ACCUMULATION AND TOLERANCE STRATEGIES IN INDIGENOUS FORAGE GRASSES

Gordon Rajendram, M Hawke, A MacCormick, L Matheson, L Butler and A Stafford
Hill Laboratories, Hamilton
WHAT DO HIGH OLSEN P VALUES MEAN ON PUMICE-GRAVEL SOILS IN THE ROTORUA DISTRICT?

Peter Bishop and M Manning
Bishop Research Ltd, Palmerston North
UREA VOLATILISATION: THE RISK MANAGEMENT AND MITIGATION STRATEGIES

Shuang Jiang and P Carey
Land Research Services, Lincoln
COMPARISON OF THREE PLANT GROWTH REGULATORS AND UREA ON A CANTERBURY DAIRY PASTURE

Mohammad Zaman, J D Blennerhassett and A J Croom
Ballance Agri-Nutrients, Tauranga
PASTURE DRY MATTER AND N UPTAKE AS INFLUENCED BY UREA APPLIED WITH AGROTAIN, ELEMENTAL S AND LIME

Session 7

Len Wassenaar and W T Baisden
Environment Canada, Saskatoon, Canada
USE OF DECADAL PATTERNS AND TRENDS IN GEOCHEMICAL AND ISOTOPIC TRACERS TO IDENTIFY AND MANAGE AGRICULTURAL NITRATE SOURCES: A COMPARISON OF CANADIAN AND NEW ZEALAND APPROACHES

W Troy Baisden, P Mudge, L Schipper, T Clough, N Wells, A Ghani, L Wassenaar and C Douence
GNS Science, Lower Hutt
PROGRESS IN THE DEVELOPMENT OF ISOTOPIC INDICATORS FOR LAND-TO-WATER NITROGEN TRANSFERS IN NEW ZEALAND

Karin Müller, M S Srinivasan, M Trolove and R W McDowell
Plant & Food Research, Hamilton
ROLE OF SUBSURFACE FLOW PATHS FOR PHOSPHORUS LOSSES IN A DAIRY-GRAZED HEADWATER CATCHMENT

Chris C Tanner, J P S Sukias, J Park, C Yates and T Headley
NIWA, Hamilton
FLOATING TREATMENT WETLANDS: A NEW TOOL FOR NUTRIENT MANAGEMENT IN LAKES AND WATERWAYS?

Iris Vogeler, R Cichota, V Snow and R Monaghan
AgResearch, Palmerston North
IMPACT OF CLIMATE ON THE EFFECTIVENESS OF DCD IN REDUCING N LEACHING

Donna Giltrap, S Saggar, J Singh, M Harvey, A McMillan and J Laubach
Landcare Research, Palmerston North
FIELD SCALE VERIFICATION OF NITROUS OXIDE EMISSION REDUCTION WITH DCD IN DAIRY-GRAZED PASTURE USING MEASUREMENTS AND MODELLING

Keith Betteridge, F Li, D Costall, A Roberts, W Catto, A Richardson, J Gates and C Brown
AgResearch, Palmerston North
TARGETING DCD AT CRITICAL SOURCE AREAS AS A NITROGEN MITIGATION STRATEGY FOR HILL COUNTRY FARMERS

Poster Papers:

Jiafa Luo, S Lindsey, B Wise and S Ledgard
AgResearch, Hamilton
NITROUS OXIDE EMISSIONS FROM A DAIRY FARMLET, AS AFFECTED BY USE OF A NITRIFICATION INHIBITOR AND A WINTER RESTRICTED GRAZING STRATEGY

Donna Giltrap, A Ausseil, K Thakur and Surinder Saggar
Landcare Research, Palmerston North
A FRAMEWORK TO ESTIMATE NITROUS OXIDE EMISSION AT REGIONAL AND NATIONAL SCALES

Dong-Gill Kim, T Palmada, P Berben, D Giltrap and S Saggar
Landcare Research, Palmerston North
SEASONAL VARIATIONS IN THE DEGRADATION OF A NITRIFICATION INHIBITOR DICYANDIAMIDE (DCD) IN A MANAWATU GRAZED PASTURE SOIL

Neha Jha, S Saggar, R W Tillman and D Giltrap
Institute of Natural Resources, Massey University
PRELIMINARY STUDIES TO MEASURE DENITRIFICATION ENZYME ACTIVITY AND DENITRIFICATION RATE IN NEW ZEALAND PASTURE SOILS

Amandeep Singh Ghatohra, S K Saggar, M J Hedley and C Ross
Institute of Natural Resources, Massey University
CARBON DIOXIDE EMISSIONS FROM SOILS FOLLOWING CONVENTIONAL-AND NO-TILL SEED BED PREPARATION UNDER CONTROLLED LABORATORY AND FIELD CONDITIONS

David Wheeler, S Ledgard and M Boyes
AgResearch, Hamilton
ENVIRONMENTAL FOOTPRINTING WITH OVERSEER® – 'THE WHOLE PICTURE

Bill Carlson, D Wheeler and S Ledgard
AgResearch, Hamilton
INTEGRATION OF DAIRY GOATS FARMING SYSTEMS INTO OVERSEER®

Laura Buckthought, V Snow, M Shepherd, T Clough, K Cameron and H Di
AgResearch, Hamilton
NITROGEN FERTILISER AND URINE PATCH INTERACTION – USE OF APSIM TO AID EXPERIMENTAL DESIGN

Mike Bretherton, D J Horne, D R Scotter and M J Hedley
Fertilizer and Lime Research Centre, Massey University
WATER UPTAKE BY HILL COUNTRY PASTURE – MORE THAN YOU THINK

Bert Quin
Quin Environmentals, Auckland
"GROUP ONE" – THE CASE FOR THE MIDDLE PATH

Thursday 10th February

Session 8

David Wheeler, R Cichota, V Snow and M Shepherd
AgResearch, Hamilton
A REVISED LEACHING MODEL FOR OVERSEER® NUTRIENT BUDGETS

David Wheeler and I Power
AgResearch, Hamilton
NUTRIENT USE EFFICIENCY ON FARM – LESSONS FROM OVERSEER® EXAMPLES

Kit Rutherford and D Wheeler
NIWA, Hamilton
ADDING WETLAND AND FILTER-STRIP MITIGATION OPTIONS TO OVERSEER

Emmanuel Chakwizira, J de Ruiter, H Brown, D Wheeler and M Shepherd
Plant & Food Research, Lincoln
PARAMETER DEVELOPMENT FOR ADDING FODDER CROP TO OVERSEER® NUTRIENT BUDGETS 1. KALE AND TURNIPS

Joanna Sharp, H Brown and S Thomas
Plant & Food Research, Lincoln
A VALIDATION OF APSIM NITROGEN BALANCE PREDICTIONS UNDER INTENSIVE CROPPING

Session 9

Ian Yule
NZ Centre for Precision Agriculture, Massey University
THE EFFECT OF FERTILISER PARTICLE SIZE ON SPREAD DISTRIBUTION

Miles Grafton, I J Yule and B W Rendle
Ravensdown, Wanganui
A REVIEW OF TECHNOLOGIES FOR IMPROVED FERTILISER APPLICATION ACCURACY

Miles Grafton, I J Yule and M Manning
Ravensdown, Wanganui
MODELLING FERTILISER BENEFITS FROM AERIAL TOPDRESSING

Rob Craigie and Nick Poole
Foundation for Arable Research, Lincoln
USE OF CROP SENSORS IN WHEAT AS A BASIS FOR APPLYING NITROGEN DURING STEM ELONGATION

Jemma Mackenzie, R Christianson, C Mackenzie and I J Yule
Agri Optics NZ Ltd, Ashburton
ADAPTATION OF OPTICAL SENSORS TO DETECT URINE AND DUNG PATCHES IN DAIRY PASTURE

Reddy Pullanagari, I Yule, M Tuohy, R Dynes and W King
NZ Centre for Precision Agriculture, Massey University
PASTURE QUALITY MEASUREMENT TOOLS FOR DECISION MAKING

Ian Yule, J Mackenzie, M Killick and C Mackenzie
NZ Centre for Precision Agriculture, Massey University
COMPARISON OF CROP SENSOR SYSTEMS FOR INFORMING FERTILISER PLACEMENT

Session 10

Markus Deurer, S Green, B Clothier and A Mowat
Plant & Food Research, Palmerston North
THE ORCHARD WATER FOOTPRINT OF NEW ZEALAND KIWIFRUIT – UPSCALING FROM THE ORCHARD TO THE COUNTRY

Gerald Rys
MAF Policy, Wellington
A NATIONAL CADMIUM MANAGEMENT STRATEGY FOR NZ AGRICULTURE

Mike Hedley, H Furness and J Fick
Fertilizer and Lime Research Centre, Massey University
NEW ZEALAND'S P FERTILISER DEMAND AND ASPECTS OF P RE-CYCLING FROM FEEDSTUFFS AND MANURES

Mark A Shepherd and G M Lucci
AgResearch, Hamilton
NITROGEN FERTILISER ADVICE –WHAT PROGRESS CAN WE MAKE?

Stewart Ledgard, M Boyes, S Payen and F Brentrup
AgResearch, Hamilton
LIFE CYCLE ASSESSMENT OF LOCAL AND IMPORTED FERTILISERS USED ON NEW ZEALAND FARMS

DOWN ON THE FARM
– WHERE SCIENCE AND POLICY MEET PRACTICE

Tessa Mills, Andrew Hoggard, Lachlan McKenzie and Paul Le Miere

Federated Farmers of New Zealand, PO Box 945, Palmerston North 4440

There is no disputing the place that farming has in both the hearts and the pockets of New Zealanders. Built on the promise that New Zealand will feed the British Empire, farming in New Zealand has a proud history. Those farming pioneers were tough and resilient. Not that much has changed, farmers are still tough, resilient and resourceful. However, the challenges that farmers face today look different from 100 years ago but are daunting nonetheless. Successful farming relies on many planets aligning. The obvious challenges of extreme weather and pest pressures are more obvious than other undercurrents including legislation, public perceptions and economic uncertainly that may also threaten the ability of farming in New Zealand to remain sustainable.

Adding to the Knowledge Base for Nutrient Managers is the worthy theme of this conference. The challenge of effective and efficient nutrient management in productive systems is central to the challenge of sustainable farm management in New Zealand. No longer is the focus solely on the provision of adequate nutrient for plant growth but must also address issues of efficient utilization and the minimization of any off- site impacts.

To give regard for the high-level requirements of sustainable management within the RMA context it is important to accept that the criteria that determine sustainable management will change as knowledge improves. With increasing knowledge the solutions to provide for sustainable management become increasingly complex. In addition sustainable management as a goal is difficult to achieve as it is a poorly defined endpoint open to interpretation. Models that describe the dynamics of nutrients in productive systems and which predict the impact of poorly managed nutrients on the surrounding environments have developed significantly in the last 20 years. Issues such as degrading water quality due to nutrient enrichment has simulated public interest in New Zealand fresh water resources and aspirations for water quality by communities have evolved. Community aspirations must be aligned with the other goals that are served through the use of on-farm nutrients notably the economic prosperity of all New Zealanders. On-Farm challenges for nutrient management into the future include the ongoing provision of robust and relevant tools which describe and predict productive sector nutrient dynamics. These must be coupled with legislation permissive of innovation and an effective partnership with regulatory authorities and other stakeholder groups including the public. Good farm management also requires economic considerations to be effectively addressed with an understanding that optimization of resource use demands that all facets of the sustainability challenge are rated.

Here we explore, from a farming perspective, what this space looks like out the kitchen window of farmhouses throughout New Zealand and pose some challenges for science and policy providers.

THE STATUS OF NEW ZEALAND AGRICULTURAL SECTOR OWNED ENVIRONMENT MANAGEMENT SYSTEMS (EMS) - ARE THEY A REALISTIC ALTERNATIVE TO AVERTING FURTHER ENVIRONMENTAL REGULATION?

John Paterson[1] and Alison Dewes[2]

[1] Bay of Plenty Regional Council *Email: john.paterson@envbop.govt.nz*
[2] Agribusiness Consultant *Email: dewesam@gmail.com*

The environmental sustainability of intensified New Zealand pastoral farming activities is now both measurable and questionable. Intensification of land use and consequent diffuse nutrient loss can now be irrevocably linked to water quality degradation in some Lakes and lowland rivers. With increasing confidence in the use of OVERSEER®, there is increasing ability to both measurably quantify the impact and address the issue.

Two laudable initiatives are challenging land users towards improving water quality goals; the Primary Sector Water Partnership and The Land and Water Forum. Good management practices and audited self management are a principle recommendations in both of these initiatives.

The present status of three New Zealand pastoral industry Environment Management System's (EMS's) are reviewed for their adequacy to demonstrate effective self management and achieve the goals and targets outlined in both the Partnership and Forum initiatives. The review will compare these New Zealand systems with international best practice principles that include demonstrable 'continuous improvement'. Reference will be made to Australian dairy industry 'self management' programmes and their relative effectiveness.

Key challenges for the primary sector EMS's facilities will be the ability of these programmes to demonstrate; widespread uptake, credibility, transparency, audit ability and continuous improvement that is underpinned by either incentives or penalties.

There are clear challenges for the existing pastoral sector systems in New Zealand to satisfy wider community expectations for improved water quality. There are also some specific obligations in relation to co-management of catchments under the new Waikato River Settlement Act.

Provided these challenges can be met, there is a real and exciting potential for positive and collaborative change in NZ water and land resource management - a 'fresh start for Freshwater' - perhaps.

THE NUTRIENT MANAGEMENT GAME IN THE HORIZONS REGION. THE ONE PLAN AND THE DAY-TO-DAY REALITY

Greg Carlyon

Horizons Regional Council, Palmerston North

It is timely to reassess where the Manawatu-Wanganui region has got to with the management of nutrients over this past five years. Much has happened. The Regional Council has proposed the One Plan (a consolidated regulatory framework for sustainable management), heard evidence and released decisions. We now have the joy of the appeals phase.

But, in the real world, things carry on and there is a great deal of work in progress on nutrient management. The regional practice in relation to effluent management has changed markedly, and the shift to whole farm nutrient management planning is occurring. The development of new tools is also changing the way we manage nutrients. We are also acutely aware of the impacts our decision-making has on the wallet, the ratepayer, and the environment.

Discussions and debate needs to take place in the context of the science and what it is telling us. There are many views held on this but the one thing that is undeniable is that the effects of our decision-making over time is coming home to roost. We have an enormous challenge in the nutrient management space and it will only get bigger unless we make decisions sensitive to those impacts and adapt accordingly.

All the more important we share the common goal of growing sustainable agriculture within the region while we maintain and improve the quality of our water bodies. Naturally, the economy does not stop growing and the effects do not stop occurring if we dither.

This presentation explores those issues and updates industry professionals on what has occurred and what is to come in this space

AUDITING AND CRITICAL REVIEW IN ENVIRONMENT MANAGEMENT SYSTEMS (EMS) IN AGRICULTURE; IS THERE VALUE FOR SIMILAR APPROACHES IN NEW ZEALAND'S PROPOSALS FOR AUDITED SELF MANAGEMENT?

Genevieve Carruthers

EMS Principal Consultant, Ecosure Pty. Ltd.
PO Box 404 West Burleigh, Queensland, Australia 4219
Email: gcarruthers@ecosure.com.au

Farmers and other land managers around the world appreciate the need to minimise environmental impact and respond to concerns from consumers and the community regarding environmental stewardship and sustainability. In some cases, Environmental Management Systems (EMS) have been adopted by land managers to meet their own business management needs by stream-lining processes, saving resources and input costs, and obtaining marketing advantages over competitors. The international EMS standard, ISO 14001, has been employed by land managers in Australia, New Zealand, the US and Europe. Many farmers also use such systems to 'showcase' their good environmental works and effectively communicate their 'sustainability story'.

This paper outlines the 'Plan, Do, Check, Act' cycle of management, underpinned by critical reflection on progress toward environmental, social and economic goals involved in EMS. Case studies presented illustrate the benefits derived from EMS and highlight the need for robust self-reflection and auditing. I discuss the critical factors in developing a self-review process, internal audits, and if needed external auditing. The paper concludes that adoption of an EMS will address key recommendations made in '*A Fresh Start for Freshwater - Report of the Land and Water Forum'* which was released for review in New Zealand.

THE OKARO COMMUNITY LAKE RESTORATION GROUP- FARM AND CATCHMENT ACCOUNTABILITY - WHAT ARE WE ACHEIVING?

Megan Birchall and John Paterson

Okaro Catchment Lake Restoration Group,
774 Okaro Rd, RD 3, Rotorua. New Zealand.
Email: meganbirchall@hotmail.com
john.paterson@envbop.govt.nz

Lake Okaro is one of the twelve Rotorua Lakes that is monitored by the Bay of Plenty Regional council, and one of the five lake catchments where land owners have been regulated with a nutrient loss cap applying to both Nitrogen and Phosphorous levels from land use activities (Rule 11). Lake Okaro is thirty one hectares in size and has a 367 hectare catchment, 90% of which is farmland. It is the most polluted lake in the Rotorua Lakes district with a current Trophic Level Index (TLI) of 5.3, recently improved from 5.5 in 2009, and has a target TLI of 5.0.

In 2009 all seven landowners within the Okaro Catchment formed the Okaro Catchment Lake Restoration Group to try and reduce the impact of their farming operations. The group is supported with funding from the Sustainable Farming Fund (SFF). The land owners are taking a proactive approach to increasing Lake Okaro's water quality by investigating their environmental performance, primarily by utilising Overseer® and are considering the use of Environmental Management Systems (EMS) to demonstrate improvement and environmental accountability.

A private consultant was employed to run each of the properties through Overseer® to calculate the nutrient losses for the 2008-2009 and 2009-2010 seasons and compare these to their benchmarked levels (the average nutrient loss that occurred during 2001-2004). Within the Okaro catchment, Nitrogen loss has increased 4%, and phosphorus loss has decreased 44% compared to the benchmarked years. The group aims to further reduce these levels, so a Whole Catchment Nutrient Plan has been developed outlining further steps the land owners will take. Collective performance will continue to be assessed using Overseer®.

The origins of this project are unique in that the entire farming community has now agreed that their primary goal is to work in collaboration with each other, the wider community and the Regional Council to improve the water quality in Lake Okaro. This is a concerted attempt to 'take ownership' with a demonstrable environment management system and to have a directive role in the long-term measures that will be needed to restore Lake Okaro.

FARMING CHALLENGES IN A LAKE CATCHMENT – INCHBONNIE

Katie Milne

Dairy Farmer, Lake Brunner Catchment, West Coast

A presentation providing on the ground insight into the challenges facing farmers who farm in sensitive catchments.

Environmental challenges e.g.:

- Extreme rainfall (from 3.5 meters right up to 7 meters!)
- Free draining soils
- Many streams, creeks and drains on farms

Nutrient challenges e.g.:

- Stocking rates
- Fertiliser inputs
- Effluent

Regulatory challenges e.g.:

- Permitted activity rule changes
- Farm plans
- Political influences

Economic challenges e.g.:

- Bridges, culverts, fencing
- Herd homes, effluent systems up grades
- Grazing off, resale values

Educational challenges e.g.:

- Data interpretation
- Maintaining “buy in” to progress forward
- Blame game / finger pointing

The Lake Brunner catchment is a highly visible one with one of the main highways, and the rail link from Christchurch to Greymouth running through it. This brings the added pressure of many untrained eyes making judgements daily on farming practices seen. Local councils have a strong focus on this area as it has its own chapter in the regional plans governing the West Coast.

IRRIGATION, WATER USE EFFICIENCY AND WATER QUALITY – WAIKAKAHI

Shirley Hayward

DairyNZ, Canterbury Agriculture & Science Centre, Gerald Street, Lincoln

The Waikakahi catchment is one of the five Best Practice Dairying Catchments, but differs from the others in that dairy farming in the catchment depends on irrigation water. Farms are supplied with irrigation water via the Morven Glenavy Ikawai irrigation scheme (MGI), which takes water from the adjacent Waitaki River and distributes it via a canal system to irrigate over 18,000 ha. Waikakahi Stream is one of several small catchments within this scheme area.

The MGI irrigation scheme was originally developed for border-dyke irrigation. In recent years, some conversion to spray irrigation, re-bordering and laser levelling of borders has resulted in improved efficiency of water use, enabling irrigation of more land. Consequently, the irrigation company had to recently renew its water take and use consents, and included a proposal to develop an 'Environmental Management Strategy' for the company operations and require individual farms supplied with scheme water to prepare and implement 'Farm Management Plans'. This includes most farmers in the Waikakahi catchment. New irrigators (or farms with new areas of irrigation) are required to develop farm management plans first, followed in successive years by existing irrigated farms.

Auditable farm management plans as a requirement of irrigation water supply arrangements provides leverage for driving good farm planning and practices beyond that of voluntary measures. Good progress has been made in the Waikakahi catchment to address community concerns around poor water clarity and sediment inputs on a voluntary basis by farmers, with significant reductions in sediment loads to the stream through fencing and planting efforts. Furthermore, instream concentrations of phosphorus and E. coli concentrations have remained steady despite increased production in the catchment over the past decade (~40% increase in milk solids/ha). However, nitrate loads have increased over the past decade. Therefore, the voluntary measures of farmers in the catchment can be considered as successfully improving some aspects of water quality, but it is likely that greater incentives will be required to drive further improvements.

BENEFITS OF WETLANDS IN FARMING LANDSCAPES – TOENEPI

**Robert J Wilcock[1], Gareth B van Assema[1], Margaret A Bellingham[1]
Ron Ovenden[1] and Karin Müller[2]**

[1]NIWA, Hamilton, [2]Plant and Food Research Limited, Ruakura

The Toenepi catchment study (1995-97) was the first to look exclusively at the effects of pastoral dairy farming on water and soil. The success of that study can be gauged by the number of studies that followed and the almost continuous monitoring of the catchment outlet since studies began there. Currently, Toenepi is one of the five best practice dairying catchments and results show that the stream has undergone substantial improvements in water and habitat quality as a result of fencing (>85%) and a major change in disposal of treated FDE from predominantly pond discharge to land irrigation. A riparian wetland near the top of the catchment has been monitored recently for it capacity to remove nutrients and faecal bacteria (*E. coli*). Three weirs and five samplings were used to monitor flow and water quality changes, respectively, over three years. Prevailing oxidising conditions meant that little denitrification occurred within the wetland and hence, little net N removal. However, the wetland removed about 95% total P and particulate C, and 70% each of particulate N and *E. coli*. A combination of oxidising conditions favouring phosphate sorption, and the long, narrow shape of the wetland, providing good conditions for trapping particulate material, achieved high removal rates. Dissolved P was mostly transformed to plant and microbial particulates forms whereas a sizeable fraction of N was converted to dissolved organic N and nitrate, neither of which was retained by the wetland. Wetlands like this one are common in the headwaters of dairy catchments in the Waikato region and can provide a useful means of mitigating catchment loads, particularly if coupled with down-slope wetlands where denitrification may occur to a significant extent.

WATER QUALITY GAINS FROM RIPARIAN ENHANCEMENT - WAIOKURA

Donald W Shearman[1] and Robert J Wilcock[2]

[1]Taranaki Regional Council
Private Bag 713Stratford 4332, New Zealand
Email:don.shearman@trc.govt.nz
[2]National Institute of Water and Atmospheric Research Limited
P.O. Box 11-115Hamilton, New Zealand
Email:b.wilcock@niwa.co.nz

The Resource Management Act 1991 is the key statute for managing New Zealand's freshwater resources. In its Regional Policy statement, the Taranaki Regional Council has identified the intensification of agriculture contributing to diffuse source pollution of waterways as an issue. Policy has been developed to address this issue and a riparian management strategy implemented in 1993 to achieve the outcomes. Delivery of the non-regulatory programme includes the provision of information, advice and advocacy, but has a particular focus on individual property planning and ongoing, one-on-one contact with landholders to implement riparian management. The customization of GIS technology and the introduction of the Dairying and Clean Streams Accord have accelerated plan preparation to the extent that 95% of dairy farms now have a riparian management plan in place. The early development of Council's native plant tender scheme has made riparian planting affordable with 1.9 million native plants established. The implementation of riparian management in the Waiokura Catchment was adopted as the main vehicle for achieving the objectives of "best practice dairy catchments project". Trend analysis of concentration time series data (2001-2008) showed that significant improvements occurring since 2001 may be attributed to changes in farming practices and riparian management. In particular, yields of filterable reactive P, total P and suspended solids (SS) declined by 25-40%. Median annual *Escherichia coli* concentration declined to 116 per 100 ml per year. These marked improvements in water quality are attributed to (a) improved riparian management, and (b) a major switch from pond discharge of farm dairy effluent (FDE) to the Waiokura Stream to land irrigation. Loads of sediment and P declined during 2001-08 even though water yields increased in the same period.

BEST PRACTICE DAIRYING CATCHMENTS – WHAT WORKED, WHAT DIDN'T AND WHERE TO FROM HERE?

Mike Scarsbrook

DairyNZ, Hamilton

Lowland wetlands, streams, lakes and groundwaters are the front line in the conflict between intensive agriculture and community expectations for waterway health. Lowland areas contain our most productive soils and, as a consequence have been progressively developed for intensive agriculture over the last 150 years. Not surprisingly, waterways in these areas have been significantly modified and, as our understanding of agriculture's impacts on these systems has grown, so too has the need to identify cost-effective mitigation and rehabilitation strategies. The dairy industry initiated the Best Practice Dairy Catchments programme in 2001 to help improve our understanding of the link between dairying and environmental outcomes and provide farmers with mitigation options. Since 1995 the industry has committed to long-term monitoring and research in Toenepi Stream (Waikato), but assistance from Sustainable Farming Fund, Regional Councils and FRST allowed expansion to four catchments in 2001, with a fifth added in 2004. Amongst the range of benefits provided by the catchments, perhaps the greatest value has been in providing evidence linking farmer practice change to water quality outcomes at the catchment scale. This evidence gives the dairy industry and regulators confidence that policies and plans aimed at increasing adoption of good practice on farm will contribute to the water quality outcomes the wider community is asking for. Increasingly, development of policies for farmer practice change are being based on outputs from farm and catchment-scale models and the regions where these requirements are being implemented do not overlap with the Best Practice Dairy Catchments. This leaves us with a dilemma regarding the future of the Catchments. On one hand we have a highly valuable knowledge base that is used extensively for research and industry State of the Environment reporting, but on the other hand, we have priority regions for driving farmer adoption of good practice that don't overlap with most of the existing catchments. Solving this dilemma will require industry and key stakeholder to redefine objectives for a much-needed monitoring programme that links farmer practice change to water quality outcomes.

ESTIMATING PASTORAL LAND USE CHANGE FOR THE WAIKATO REGION

Reece Hill and Dan Borman

Environment Waikato
PO Box 4010, Hamilton East, Hamilton

The Waikato Region covers much of New Zealand's central North Island and has a land area of about 2.5 million hectares, a little more than half being in pastoral land use. Maintaining the soil resource and water quality is vital to the Waikato Region's prosperity. Safeguarding the soil and water resource requires knowledge of where land use pressures are and how they may be changing.

Over the past decade the Waikato Region has experienced to conversion from plantation forestry to pastoral land conversions, higher stocking rates and more intensive farming practices. Soil and water quality trends for the Waikato Region are indicating pressures and trends consistent with increased agriculture intensity above and beyond any improvements made through good management practise. Fundamental to understanding these trends is having a spatial "picture" of the land use change. Comparing land use change patterns with the existing New Zealand Land Use Capability classification (LUC) provides an assessment of land use pressure. This paper presents a method for analysis and describes pastoral land use change relative to land use capability to assess pastoral land related pressures across the Waikato Region.

Analysis of pastoral land conversion (plantation forest to pasture) used interpreted land cover data from Land Cover Database 2 (2002 data) and LUCAS land use map version 3 (2008 data). Analysis of pastoral intensification used existing Waikato regional land use indicator stock density classes and Agribase data for 2001 and 2008. Pastoral intensification was classed as moderate if there was a single class increase and major for an increase of two or more classes.

Regionally, about 37,357 hectares of plantation forest was converted to pastoral land use from 2002 to 2008 compared with 5142 hectares for the 1989 to 2002 period. From 2001 to 2008 the amount of the Waikato's pastoral land indicating moderate and major intensification was estimated at 18% (about 242,000 hectares) and 5% (about 69,000 hectares) respectively.

Pastoral land conversion has predominantly been in the upper Waikato River catchment. A greater portion of the conversion occurred on LUC class 6 land. Pastoral intensification was greatest in the upper Waikato, Waihou-Piako and Waipa catchments whereas a decline in stock density was observed for the Lake Taupo catchment. Intensification has predominantly occurred on LUC class 6 land. The most common pastoral intensification resulted from a farm change from either plantation forest to dairy or sheep and beef to dairy. The amount and location of pine to pasture conversion and pastoral land use intensification over the past decade has increased the potential risk of soil degradation and decline in water quality.

READING THE LANDSCAPE: SELECTING DIFFUSE POLLUTION ATTENUATION TOOLS THAT WILL MAKE A REAL DIFFERENCE

Lucy McKergow[1] and Chris Tanner[1]

[1]NIWA, PO Box 11-115, Hamilton

Riparian fencing and planting, grass filter strips and constructed wetlands some of the common attenuation tools farmers can use to improve farm water quality. But can Farmer J. Bloggs or their farm advisor pick the best attenuation tools for the landscape? Probably not. Existing environmental guidelines do not provide information or tools to help farmers/land management officers/farm advisors compare the real world applicability of attenuation tools or match suitable attenuation tools with major pollutant flowpaths. In addition we scientists tend to focus on and promote our own favourite attenuation tool, process or pollutant, barely stopping to consider how to best use a range of attenuation tools/processes at the farm and catchment scales. This paper presents a hydrology based framework for guiding the selection of attenuation tools. The method requires a site inspection equipped with an aerial photograph/map. During the site inspection three basic steps are required. Firstly, the framework guides the user and farmer through a series of landscape related questions to identify dominant runoff generation processes. Then the active flow network is defined and finally existing and additional attenuation tools are evaluated.

REGULATORY AND NON REGULATORY OPTIONS IN ACHIEVING REDUCTION IN NON POINT SOURCE POLLUTION IN THE ROTORUA DISTRICT

Archana Singh

URS New Zealand Limited, Auckland

Intensive agricultural activities have attributed to an increased contribution of nonpoint source pollution. In particular the transfer of nutrients (nitrogen and phosphorus) from land to waterways has resulted in the impairment of water quality. The major pressure is from the intensification of farming activities which accounts for 75% of nitrogen and 46% of phosphorous entering the lakes in Rotorua. The water quality of the lakes has been declining for at least 30 to 40 years. This has resulted in eutrophication and increasing occurrence of toxic blue green algal blooms which are of particular concern.

The Rotorua's regulatory councils (Rotorua District Council (RDC) and Environment Bay of Plenty (EBOP)) have been implementing management options to improve the water quality of its lakes since the 1990's.

This poster will provide background information on some of the options being used in Rotorua mainly focusing on the joint Rotorua Lakes Protection and Restoration Programme. This programme sets out overall management strategies and the vision, goals and tasks set out in the non statutory strategy. RDC, EBOP and Te Arawa Maori Trust Board are members of the Joint Strategy Committee established to monitor implementation of the restoration programme. Some examples of the regulatory and non regulatory options from other countries from a literature review conducted as part of a post graduate study course will also be presented.

SUPPLY, RESTRICTIONS AND WATER USE: A SURVEY AT THE WAIMAKARIRI IRRIGATION SCHEME

M S Srinivasan and M J Duncan

National Institute of Water & Atmospheric Research Limited
10 Kyle Street, Christchurch
Email: m.srinivasan@niwa.co.nz

Irrigation is the single largest user of freshwater in New Zealand and in Canterbury. While consented volumes are known, there is uncertainty about how much water is actually used for irrigation, because water use has not been widely and routinely measured. Also, there is little institutional knowledge in New Zealand on how to interpret water use data in the context of water resources management. The recent installation of water meters in the Waimakariri Irrigation Scheme, Canterbury, offered the opportunity for NIWA to explore water use data. We studied water use data from fourteen dairy farms from January to April 2009 and September 2009 to April 2010. These selected farms use as much as 21% of all irrigation water abstracted by the scheme. Generally, irrigation up to November was limited due to sufficient rainfall to meet evaporative demand, and was limited in March due to low flows in the Waimakariri River. Very little evidence for excessive irrigation was found, and it appeared that most users should be applying more irrigation than was measured. Detailed analysis showed that many farms appeared to build up large soil moisture deficits, and the soil moisture levels were often less than optimum for pasture growth. The low soil moisture levels were not primarily due to the lack of water availability from the scheme. Spatial and temporal analyses of historical rainfall and evaporation data across the irrigation scheme highlighted the presence of large soil moisture deficit gradients, indicating a divergent water need across the scheme. Thus, there appears to be a need to monitor soil moisture and crop needs and schedule irrigations accordingly, rather than following scheme level supply schedule. However, adoption of such monitor-and-irrigate approach would also require that farms need to develop supplementary water sources such as on- or off-farm storage, to schedule irrigation effectively.

IMPACT OF IRRIGATION ON CARBON STRATIFICATION IN CALCAREOUS SOILS

M Hasinur Rahman[1]*, Allister W Holmes[1], M Abbas Ali Sarnaker[2], Shamima Sabreen[3], Atsushi Okubo[3]

[1]*PlusGroup Ltd., Newnham Park, Tauranga, New Zealand*
[2]*Department of Soil, Water and Environment, University of Dhaka, Bangladesh*
[3]*Faculty of Agriculture and Life Science, Hirosaki University, Hirosaki, Japan*
**E-mail: hasinur65@yahoo.com; technical@plusgroup.co.nz*

Human activities contribute to the production of greenhouse gases through higher use of technology and industrialization and increased inputs in production in agricultural sectors. Agriculture releases three primary greenhouse gases (CO_2, CH_4 and N_2O) to atmosphere which are responsible for climate change. The proper agricultural management systems can be a sink for CO_2 through C sequestration into organic matter through biomass production. Irrigation may or may not change of soil carbon in a desirable direction. We measured soil organic carbon (SOC) and soil inorganic carbon (SIC) in irrigated and non irrigated calcareous soils for better understanding of the altering of soil carbon. Soil samples were collected from three soil series: Sara (Silt to Silt loam), Gopalpur (Silt loam to Silty clay loam) and Ishurdi (Silt loam to clay), located in same catena at 0-25 cm, 25-50 cm, 50-75 cm and 75-100 cm depth of irrigation project as well as adjoining non irrigated area of Ganges-Kobadak of Bangladesh. Soil organic carbon increased in irrigated soils but decreased in non irrigated soils. The opposite trend was observed for SIC. Soil organic carbon density was in the order of Sara>Goplapur>Ishurdi and SIC while in case of SIC it was in the order of Sara<Gopalpur<Ishurdi, regardless of management practices. Stratification ratios of total carbon were higher in non irrigated than irrigated soils. Stratification ratios of soil total carbon were 0.88, 0.70 and 0.56 under irrigated soils and 0.92, 1.07 and 0.72 under non irrigated soils in Sara, Gopalpur, and Ishurdi series, respectively. Our result indicated that irrigation practices may increase SOC carbon but decrease in SIC in calcareous soil. Therefore, the ways to change of carbon levels depend on forms of carbon and the overall impact of irrigation in calcareous soil is negative on soil carbon storage.

IMPROVING NUTRIENT MANAGEMENT REQUIRES A SYSTEMS APPROACH

Keith L Bristow

CSIRO Sustainable Agriculture National Research Flagship, CSIRO Land and Water, PMB Aitkenvale, Townsville, QLD 4814 Australia

A key challenge facing the world, especially with a changing climate, is how to increase productivity of our agricultural systems while halting and reversing current unprecedented levels of environmental degradation. Seeking continual improvement in the way water and solutes (salts, nutrients and agrochemicals) are managed is essential to address these challenges.

In this paper I discuss the need to think across spatial (soil aggregates to catchments) and temporal (days to months) scales, the need to manage water and nutrients together rather than one separate from the other, and the challenge of addressing the 'conflict' between nitrogen and salt management, where the aim is to retain nitrogen within the root zone while exporting salt from it. I also draw on lessons learned from recent experience with the Australian Cooperative Research Centre's System Harmonisation Program to highlight the need for a 'systems approach' to achieve better on-farm and environmental outcomes.

LAND AND WATER FORUM IN ACTION - AN INTEGRATED APPROACH TO CATCHMENT PLANNING

John Paul Praat[1] and Alison Dewes[2]

[1]P.A. Handford and Associates Ltd, Te Awamutu
[2]Consultant, Cambridge

The peat lakes of the Waikato are generally under threat from a range of factors including shrinkage of the peat as a result of continual drain deepening within the catchment. The loss of open water habitat due to the invasion of willow and other weed species, treading and browsing damage from livestock encroachment and nutrient enrichment of the lake from non point source runoff from the surrounding catchment also reduce water quality and biodiversity. New Zealand Landcare Trust initiated a catchment plan for a Waikato Shallow Lake lakes as part of a three year Sustainable Management Fund (SMF) project looking into raising awareness of and how communities can improve water quality in these lakes . The aim is to integrate whole farm plans and an overall catchment action plan into an easy- to-use plan that is able to be followed by all parties involved. In this example these parties include landowners, sharemilkers, the regional council and the Department of Conservation.

The concept of doing both whole farm level planning as well as a catchment plan was to identify the key risks presented to the receiving environment. These structured plans provide evidence of how economic, environmental, social and cultural issues associated with the land are managed.

Even though the example lake was arguably so severely degraded, it is past the point of remediation, the catchment was chosen as there were two landowners motivated to attempt to make some attempts to both understand the status of the lake, make an effort give it some protection and contribute to its improved health where they can. Also a protected reserve exists on one of the properties and the prospect of lake quality being monitored on a five yearly basis meant that success or otherwise of any actions for improvements can be measured and demonstrated.

Issues including landownership, risk profile, priorities and barriers to implementation will be discussed.

ROTORUA RURAL PROPERTY NUTRIENT ASSESSMENTS - CHALLENGES AND PROGRESS

Simon Park[1] and Penny MacCormick[2]

[1]Headway Ltd, Tauranga;
[2]Bay of Plenty Regional Council, Whakatane

The Bay of Plenty Regional Water and Land Plan includes nutrient capping regulations, known collectively as “Rule 11”, which apply to rural properties in the catchments of five degraded Rotorua lakes: Okaro, Okareka, Rotoehu, Rotoiti and Rotorua. Preventing increases in the nutrient load from rural land is a key initial step towards eventual lake water quality improvement. Rule 11 directs landowners to provide specific property information for the three years from July 2001 to June 2004. Overseer® is then used to calculate a “nutrient benchmark” in terms of the average annual nitrogen and phosphorus loss. Current and future land uses that stay within the nutrient benchmark are permitted, whilst a discretionary resource consent is needed to exceed the benchmark.

Nutrient benchmarking efforts initially focused on the three smallest lake catchments, reflecting practical logistics and the need to fully develop systems before tackling the larger Lake Rotorua catchment. In late 2009, Councillors directed that by mid-2011 staff should benchmark the “top 100” Lake Rotorua properties in terms of likely nutrient loss i.e. dairy farms and large dry stock farms. By the end of 2011, about 40% of Lake Rotorua’s pastoral land had been benchmarked, with mean nutrient loss rates of: 16.2 kgN/ha/yr and 2.2 kgP/ha/yr for dry stock farms (n=16); and 51.1 kgN/ha/yr and 3.3 kgP/ha/yr for dairy farms (n=5). Factors impacting these loss rates and how they relate to other initiatives (ROTAN catchment modelling and farmers’ own nutrient assessments) are discussed.

The use of Overseer® within a regulatory context has been endorsed by the Environment Court in the interim Taupo Variation decision, at least for nitrogen. Some benchmarking challenges for Lake Rotorua properties are canvassed, including: the deadline for providing benchmark information; lack of records; landowner cooperation; phosphorus losses; issues arising from lease blocks, farm sales and subdivision; and the evolving policy framework.

USE OF A MODEL TO PREDICT THE EFFECTS OF LAND USE CHANGES ON NITROGEN DELIVERY TO LAKE ROTORUA, ESPECIALLY THE LAGS INVOLVED WITH GROUNDWATER

Chris Palliser, Kit Rutherford and Sanjay Wadhwa

NIWA, PO Box 11115, Hamilton 3251

NIWA has developed a catchment-scale model for nitrogen (ROTAN = ROtorua and TAupo Nitrogen) to aid land use planning and lake restoration in Lake Rotorua. Baseflow nitrate concentrations in major streams draining into Lake Rotorua have increased significantly over the period 1968-2003 (Rutherford 2003). As a result, the nitrogen input to Lake Rotorua from streams is now significantly higher than the 'target' load set for the lake. Groundwater in some parts of the catchment is several decades old (Stewart & Morgenstern 2001). There was a period of land clearance in the 1940s and a surge of agriculture in the 1970s. It has been hypothesised that current trends in stream concentration are the effects of historic land use change making their way slowly through the groundwater (Williamson et al. 1996). Estimates have been made of how long the increasing trends in nitrate concentration are likely to continue in the Rotorua streams and the steady-state loads (Morgenstern & Gordon 2006). The ROTAN model aims to complement Morgenstern & Gordon's work by taking into account temporal and spatial variations in rainfall, land use and nitrate leaching. ROTAN is a GIS-based, daily-weekly time step, conceptual land use-surfacewater-groundwater-nitrogen model.

Firstly ROTAN was fitted to flow and nitrogen concentration data using historical land use data, rainfall and leaching rates. This included ensuring that ROTAN was giving a satisfactory water balance for the lake. Groundwater lag times as estimated by Morgenstern & Gordon (2006) were also used. The historical leaching rates were obtained using Overseer® with agricultural statistics being used to determine the required input variables. Recent leaching rates used both Overseer® and the advice from an expert group of local agriculture consultants, farmers and Bay of Plenty Regional Council staff.

ROTAN was then used to predict the effect of a variety of future land use changes on nitrogen loads to the lake. Climate change was incorporated into these predictions. Five scenarios were simulated. A "do-nothing" one both with and without climate change. These two scenarios assumed that the current land use continues into the future. The other three scenarios, all with climate change, had some dairy farming areas in the catchment being converted to drystock farming and some drystock farming areas being converted to forestry.

REFINING THE PROCTOR COMPACTION TEST TO GUIDE OFF-GRAZING MANAGEMENT DECISIONS

David Houlbrooke[1], Jim Paton[2], Tash Styles[2] and Seth Laurenson[2]

AgResearch, Ruakura, Private Bag 3115, Hamilton 3240.
AgResearch, Invermay, Private Bag 50034, Mosgiel 9053.

Increasing grazing intensity both by increased number of animals per unit area and weight of grazing animals has placed more stress on soil, therefore, testing its resistance and resilience to compaction forces. To date, much effort has been put into management strategies to remedy the effects of soil compaction in order to return it to its full productive capacity. However, such an approach is akin to parking an ambulance at the bottom of the cliff. In more recent time, the use of off-grazing management facilities has become more prevalent within the dairy industry. This infrastructure can provide multiple benefits to a farm system such as temporally controlled nutrient management and effluent returns, feed supply, thermal stress control and decreased soil damage from animal treading. However, little guidance is available in order to specifically make accurate decisions designed to decrease the likelihood of either compaction or pugging damage.

The proctor test using confined uniaxial compression has been used to assess changes in bulk density on undisturbed soil under varying soil moisture contents and compactive forces. This approach can be used to determine the critical moisture content (CMC) at which the greatest level soil compaction can be achieved. For the Timaru silt loam (Typic Fragic Pallic) this value has been identified as being 33% g/g. We hypothesis that avoiding cattle grazing of pasture when the soil moisture content is greater than the CMC will increase the long-term soil macroporosity under intensive land use for soils prone to structural degradation. We describe a grazing trial that has been established under irrigated cattle grazing land use in the North Otago Rolling Downloads to test this hypothesis.

CONFINED ANIMAL OPERATIONS - MINNESOTA MANURE MANAGEMENT REGULATIONS

Patricia Burford

URS New Zealand Limited, Auckland

The state of Minnesota (MN) has regulated the management of confined animal feeding operations (CAFOs) since the 1980s with expansion of the programme in 2000 to include comprehensive requirements for manure management. This poster provides some of the consenting and manure management planning requirements that may generate some discussion in terms of their applicability in NZ.

MN is a state with many similarities to New Zealand. It has a large agricultural sector, has a population of about 5 million people and, although landlocked, has lots of water with over 12,000 lakes, 148,000 km of streams/rivers and 3.8 million hectares of wetlands. MN also has more than 30,000 registered feedlots, ranging in size from small farms to large-scale commercial livestock operations. Nutrient management from these feedlots is therefore important for protection of its freshwater resources.

With the exception of very small operations, CAFOs are required to develop a manure management plan that shows how nitrogen and phosphorus will be managed to control impacts on groundwater and surface water. The availability and suitability of land for manure application is required as part of this planning. Manure management plans must meet regulatory requirements for storage, monitoring, application and other aspects of manure management.

This poster will focus on aspects of the regulation that are in place to prevent nutrients from impacting surface water quality. Regulatory requirements for management of manure in sensitive areas will be presented as will an example permit used for regulation of CAFOs.

THE FDE STORAGE CALCULATOR – AN UPDATE

Dave Horne[1], M Bretherton[1], J Hanly, D Houlbrooke[2] and J Roygrad[3]

[1]*Fertilizer and Lime Research Centre, Massey University*
[2]*AgResearch, Hamilton*
[3]*Horizons Regional Council*

Adequate storage is the foundation of successful land treatment systems for Farm Dairy Effluent (FDE). The 'FDE Storage Calculator' has been developed to identify the unique storage volume required on a dairy farm. The Calculator uses farm specific information, including a soil risk factor, along with 30 years of daily climate data to determine the necessary storage volume. The Calculator predicts the volume of FDE generated on a daily basis and identifies suitable days for irrigation using a soil water balance. The scheduling of irrigation is also dependent on irrigator type and management.

Some recent developments to the Calculator will be discussed along with plans for future improvements, including its use as a management tool for scheduling FDE irrigation.

CAN CHICORY BE USED TO REDUCE NUTRIENT LOADING ON THE EFFLUENT BLOCK?

Murray Perks

DairyNZ, Private Bag 3221, Hamilton 3240

Many farmers are considering growing crops on farm dairy effluent blocks to reduce the nutrients that have accumulated in the soil over time. Elevated soil potassium (K) status is common on effluent blocks because farm dairy effluent (FDE) is K rich. High levels of soil K can result in metabolic health problems for cows. A common crop choice for effluent blocks is maize for silage. This is because it extracts considerable amounts of soil K due to its high yield potential. However, growing maize on the milking platform means less pasture area is available during summer, which effectively increases the stocking rate over the remaining farm area. This can create a feed deficit, particularly on non-irrigated, summer-dry farms. As a result, growing maize on the milking platform is often not profitable due to lost pasture production and consequent milk production. Conversely, growing a summer forage crop, such as turnips or chicory, would provide feed when it is needed the most, whilst having a similar (if not better) ability to reduce soil nutrient levels due to their deeper rooting properties. The cows grazing the crop then transfer the nutrients to other areas of the farm through excreta. However, the More Summer Milk programme (1994-1997) demonstrated that turnips are not often a profitable crop to grow on Waikato dairy farms. In comparison, chicory can provide cheap feed right through the summer, at around 8 c/kg DM on effluent blocks (where no fertiliser is required). In addition, feed quality is high (12.5-13 MJME/kg DM), and chicory is able to remove excess nutrients from the soil due to its deep tap root (up to 1 m in length) which also provides drought tolerance. Effluent can continue to be applied once it is established as well. Chicory is therefore a viable crop option for effluent blocks.

RAPID METHOD OF ASSESSING NPK CONTENT OF DAIRY EFFLUENT FOR LAND APPLICATION

Bob Longhurst[1] and Brian Nicholson[2]

[1]AgResearch, Ruakura Research Centre, Hamilton
[2]Hi-Tech Enviro Solutions, Morrinsville

Land application is the preferred method of effluent treatment on New Zealand dairy farms. Intensification in the dairy industry since 2000 has meant that higher concentrated effluents are now being generated from dairy shed/feed pads. Farmers are being urged to have effluent storage ponds so that daily spray irrigations to land can be avoided when soil conditions are wet. Various land application systems now exist to effectively apply the dairy effluent. However, vital pieces of information are missing for appropriate land treatment as farmers/contractors are faced with not knowing: 1) nutrient concentrations from different effluent sources, and 2) subsequent nutrient loading when effluents are applied to land.

Two rapid, on-farm methods were evaluated in 2010, throughout the Waikato, on 51 samples from five different effluent sources. Results have shown that one method provides highly significant estimates of NPK concentrations.

IT'S RAINING EFFLUENT", EFFECT OF HERD HOME SLURRY ON GROWTH OF MAIZE AND SORGHUM IN WAIKATO

Kate Chatfield[1], Helen Mora[2] and Bob Longhurst[3]

[1]*Year 13, Auckland Diocesan for Girls, Auckland*
[2]*LENScience, Liggins Institute, University of Auckland*
[3]*AgResearch Ruakura, Hamilton*

There has been unprecedented growth in the dairy industry in New Zealand over the last 15 years, with increases in average dairy size and cows per hectare, making it necessary to look at the way in which effluent on farms is being managed. One potential solution for effluent that has accumulated from areas such as dairy sheds and herd homes is to apply it to crops as a fertiliser.

The problem with this treatment method is that over-application can result in runoff of effluent into waterways. This practise is a relatively new concept and some difficultly in implementing sustainable land application systems has been experienced by farmers. The purpose of this project was to measure plant growth from two different application rates of herd home slurry, compared to control, on two supplementary feed crops currently used in the Waikato, maize and sorghum. Data on yield, % dry matter, leaf count and height was collected at three different stages of plant growth. Additionally, soil and plant chemical analysis was undertaken on the sorghum to create a nitrogen budget.

SETTING THE STANDARD FOR NUTRIENT MANAGEMENT PLANS

Dr D C Edmeades[1], Dr M Robson and Dr A Dewes

agKnowledge Ltd, PO Box 9147, Hamilton 3204
Email: doug.edmeades@agknowledge.co.nz

Nutrient Management Planning (NMP) is a relatively new concept in New Zealand and it is likely to become mandatory, at the individual farm level, within the next 5-10 years. In this paper we attempt to define the minimum requirements of a NMP. First we define nutrient management and set out the legal requirements for NMPs and discuss the context and purpose of NMPs. Based on these considerations we then describe the technical and non-technical attributes which we believe are essential in a NMP.

ENHANCING SHAREHOLDER VALUE THROUGH LEADERSHIP ON NUTRIENT MANAGEMENT IN NEW ZEALAND

Hilton Furness and J Richards

Seven Consulting Group, Auckland.

Agricultural sectors are facing the challenge of increasing their output to meet food and economic expectations while at the same time responding to increasing demands to deal with adverse impacts of nutrient use.

These types of challenges are not unique to nutrient use or agriculture and have been successfully addressed by other industries. This has involved a three phase process:

- Improving efficiency by focusing on cost and risk reduction. This is often in response to regulatory or public pressure. Action taken is usually internal to the company or sector. Essentially this involves doing the same things as usual but doing them better.
- Innovation and transformation. This involves a future focus and a change in thinking and the way things are done. Rather than reducing waste the focus is on a better process that doesn't produce waste or using waste as a raw material for new products.
- Collaborating to avoid fragmentation and confusion. This is particularly relevant to industries and sectors rather than individual companies.

These phases are discussed in relation to current nutrient management in New Zealand. Suggestions are made as to how they can be implemented in New Zealand, emphasising collaboration and leadership, in a way that enhances shareholder value while meeting regulatory and public expectations.

THE VALUE OF SOIL SERVICES FOR NUTRIENTS MANAGEMENT

E Dominati[1], A Mackay[2], S Green[3] and M Patterson[4]

[1]*Institute of Natural Resources, Massey University*
[2]*AgResearch, Palmerston North*
[4]*Plant and Food Research, Palmerston North*
[4]*Ecological Economics Research Centre, Palmerston North*

This paper shows how a framework for classifying and quantifying soil natural capital and ecosystem services was implemented to value the ecosystem services provided by an Allophanic soil (Horotiu silt loam), under a typical Waikato dairy farm. A process-based model, the SPASMO model from Plant and Food Research, with the inclusion of additional functionality, was used to quantify each of the ecosystem services provided by the Horotiu silt loam. These included the provision of food, which includes the supply of water and nutrients and physical support to plants, the provision of support for human infrastructures and animals, flood mitigation, the filtering of nutrients and contaminants, detoxification and the recycling of wastes, carbon storage and greenhouse gases regulation, and the regulation of pests and diseases populations. Neo-classical economic valuation was then used to put a dollar value on these services.

On the dairy farm considered, rain fed pasture is grazed *in situ* with no irrigation or artificial drainage. Pasture silage is made from the farm and fed as supplements. There is no feed-pad available and no grazing off the farm. The SPASMO model was used to explore the dynamics of soil properties and processes regulating each of the soil services and to quantify these services every year, for 35 years between 1975-2009, using climate records from the Waikato. This quantitative information was then used to place a monetary value on each service with the sum of the services an estimate of the value of soil natural capital as it provides services to the dairy operation.

This valuation approach provides for the first time farmers with an indication of the total value of the soil natural capital of their farms and economists and policy makers an approach for estimating the value of the country's soil natural capital under a range of land uses. In the paper, the calculated values of soil natural capital to a dairy operation are also compared with current land values.

CLUES CATCHMENT MODELLING - LESSONS FROM RECENT APPLICATIONS

Sandy Elliott, Annette Semadeni-Davies and Ude Shankar

NIWA, Hamilton

CLUES is a GIS-based catchment model for predicting water quality and socio-economic indicators as a function of land use in New Zealand. The model has been applied recently in several catchment studies in New Zealand, for purposes of identifying of critical source areas, the relative contribution of various land uses, effect of land use change, and the effect of mitigation measures for nutrients. This paper summarises these applications, strengths and weaknesses identified through the use of the model, and areas where CLUES can be improved. Strengths of the model include: the ability to import land use layers to reflect local data and land-use scenarios developed externally to CLUES; rapid assessment of mitigation measures through interactive tools; flexibilty of results display through use of standard GIS software; and flexible assessment of mitigation measures and land use intensification through data import facilities. We identified the need to check data inputs such as point source data as they were sometimes inaccurate or out of date. Considerable discrepancies between model predictions occurred in some cases, particularly for concentrations. This partly reflecting the underlying variability and uncertainty in parameter estimates, with local values of yields for uniform land uses differing from national values used in CLUES. Also, the assumptions used in the simplified versions of leaching models used in CLUES were sometimes inappropriate. The flows used to convert loads to concentrations sometimes differed from measured values, leading to errors in the predicted concentration. In other cases, there were clear interactions with groundwater that were not captured by the model. Some of the parameters in the standard CLUES model have been modified as a result of these experiences. In other cases, we adjusted the local values of CLUES parameters to reduce consistent regional biases, either by altering the parameter files or applying mitigation factors. We conclude that CLUES predictions should be used with due regard to local influences and knowledge of the catchment, and that re-calibration should be considered to improve model performance if suitable data is available. In the future, we plan to incorporate more regional council monitoring data into the calibration of the national model to capture more regional variability.

CONNECTING NORTH ISLAND HILL COUNTRY FARMERS NUTRIENT REQUIREMENTS WITH SOIL MAPPING UNITS

Scott Fraser and Eva Vesely

Landcare Research, Hamilton

Agricultural primary production accounts for almost 50% of New Zealand's export earnings, with approximately 37% of New Zealand's land area under pastoral land uses. The North Island (NI) accounts for approximately 43% of the total pastoral land area in New Zealand, and approximately 30% - 3.5 million ha, of NI pastoral land is hill country. New Zealand soils generally have low natural nutrient status and tend to be acidic; therefore fertiliser and lime additions are vital to improving and maintaining pastoral production. As fertiliser costs are often the single largest annual expenditure on hill country farms, profitability could be improved significantly with more efficient fertiliser use through technologies that allow fertiliser placement to be targeted to areas where the greatest benefit may be achieved.

This paper will discuss how NI hill country farmers could realise potential productivity gains from their land through improved soil spatial information. A cost benefit analysis for new soil information draws on soil information gathered from a NI hill country farm and from literature data to demonstrate how improved productivity leading to increased farm cash surplus could be achieved. While improved soil information may lead to greater farm profitability, this will be conditional upon the availability of a value chain that encompasses the development of, access to and implementation of the new soil information in conjunction with other sources of information and emerging technologies. However, market failure needs to be addressed as this may be a barrier to successful uptake of new information and technologies by farmers.

EROSION SOIL LOSS AND RECOVERY ON EASTERN NORTH ISLAND HILLCOUNTRY – IMPLICATIONS FOR NUTRIENT MANAGEMENT AND PASTURE PRODUCTIVITY

Brenda Rosser [1,2] and Craig Ross [1]

[1]Landcare Research, Palmerston North
[2]GNS Science, Lower Hutt (current employer)

Landslide scars previously dated (1977, 1961, and 1941) and sampled by Lambert et al. (1984) for pasture production and topsoil characteristics were re-sampled. Pasture dry matter production and selected soil properties were re-measured on the same scars and uneroded control sites for two years, from 2007 to 2009. Results show that after a further 25 years of recovery, no significant increase in pasture production had occurred on the 1941 and 1961 slip scars. Average dry matter pasture production on eroded sites increased from 63% to 78% of pasture production levels on uneroded sites, but improvement was restricted to the youngest 1977 slip scars, where dry matter production increased from 20% to 80% of uneroded levels. Maximum pasture recovery occurred within about 20 years of landsliding and further recovery beyond 80% of uneroded level was unlikely.

The recovery of pasture production on slip scars follows similar recovery to soil physical (e.g. soil depth, particle density, bulk density) and chemical properties (e.g. total-C, total-N). Topsoil depths on eroded sites were roughly a third of topsoil depths on uneroded sites, indicating reduced profile available water capacity on eroded soils. We were unable to determine if total C would recover to uneroded levels because of the high variability in total C at eroded sites. However, given that uneroded soils were formed under native forest and that new soils are forming under pasture (over a shorter period of time), it is unlikely that total C will recover to uneroded soil levels.

This research verifies the conclusion of Lambert et al. (1984) that it is unlikely pasture production on slip scars will return to production levels on uneroded sites in human time scales. The sustainability of pastoral agriculture on steeper slopes in soft-rock hill country comes increasingly under threat from the progressive reduction of pasture production from cumulative erosion.

The permanent loss in productivity on erosion scars due mainly to changes in profile available water capacity also has implications for aerial topdressing fertiliser application rates in highly eroded hill country and suggests that rates of fertiliser application should be reduced on highly eroded slopes to match the lower productivity. Over-application of nutrients on highly erodible land with lower expected production yields can lead to increased runoff of nutrients to water bodies.

LEACHING LOSSES OF NITROGEN AND CARBON FROM LOW AND MEDIUM SLOPED AREAS IN SHEEP GRAZED NORTH ISLAND HILL COUNTRY

Coby J Hoogendoorn and Brian P Devantier

AgResearch Limited, Grasslands Research Centre, Palmerston North

A recent review of carbon (C) and nitrogen (N) cycling in New Zealand hill country pastures identified critical gaps in information which restricts current ability to adequately evaluate the environmental implications of land use intensification in this environment. A 3 ½ year grazing trial has been initiated to look at the impacts of grazing intensification, in two distinct topographical categories (low slopes (0 - 12°) (LS) and medium slopes (13 – 25°) (MS)), in sheep grazed hill country on: inorganic N (ammonium N and nitrate N) and dissolved organic N (DON) and C (DOC) leaching at 300 mm below the soil surface. The trial consists of 6 paddocks (0.7 ha each) with similar aspect and mix of slope classes, arranged in three blocks. Sixteen lysimeters (150 x 300 mm) were installed in each paddock; 8 in each slope class. Two grazing intensity treatments were imposed in August 2010; an extensive (8 SU/ha) and an intensive (14 SU/ha) grazing regime. Rainfall from April 1 2010 – January 12 2011 totalled 1084 mm, with approximately 60 and 80% measured as drainage from LS and MS areas respectively ($P < 0.005$). Pasture covers in early January 2011 were 1325 and 2000 kg DM/ha for the intensive and extensively grazed treatments respectively. Leaching results obtained in both the pre-differential (April 1 – August 30 2010) and differential grazing treatment period (Sept 1 – Jan 12 2011) highlight topographical differences in nutrient leaching from 300 mm below the soil surface, with no significant differences in nutrient leaching detected to date between the two grazing intensity treatments. Mean values for nitrate N leached from April 1 2010 – Jan 12 2011 were 63 and 9 kg N/ha from LS and MS areas respectively ($P < 0.001$). Leaching of DON and DOC, for the period April 1 – September 21 2010, from LS and MS areas respectively totalled 44 and 9 kg DON/ha ($P < 0.02$) and 124 and 76 kg DOC/ha ($P > 0.05$). The results reported are of the first 9 months of a 3 ½ year grazing trial, and must therefore be interpreted with caution.

IMPACT OF CARBON FARMING ON PERFORMANCE, ENVIRONMENTAL AND PROFITABILITY ASPECTS OF SHEEP AND BEEF FARMING SYSTEMS IN SOUTHLAND

Ronaldo Vibart[1], Iris Vogeler[1], Brian Devantier[1], Robyn Dynes[2], Tony Rhodes[3] and Wayne Allan[4]

[1]AgResearch Grasslands Research Centre, Palmerston North
[2] AgResearch Lincoln Research Centre, Christchurch
[3]PGG Wrightson Consulting, Dannevirke
[4]Allan Agricultural Consulting Ltd., Christchurch

As New Zealand's agriculture moves steadily towards implementing the Kyoto protocol, a better understanding of, and methods to reduce or offset, on-farm greenhouse gas (GHG) emissions become increasingly important. This study used whole-farm system models, FARMAX® and OVERSEER®, to examine feed flow, nutrient balance, livestock emissions and profitability from sheep and beef farming scenarios in Southland (Breeding and Finishing, Beef + Lamb New Zealand). Nine farm scenarios were explored including three levels of intensification (by altering stocking rate, N application and reproductive efficiencies) across three proportions of cultivatable land to hill land (90:10, 70:30, 50:50; land-use capability levels). In addition, within each of these simulated farms, three levels of forestry (*Pinus radiata*) were included attempting to offset livestock emissions liability (no trees, and 10- and 20-ha blocks located in the hill areas). All farms were equally sized and all feed was produced on-farm.

Increasing level of intensification resulted in greater amounts of beef, and to a lesser extent wool, produced per ha. This was associated with substantial increases in feed conversion efficiency (kg dry matter intake per kg animal product) and farm profit, although these results varied with land-use capability. Intensifying production was also associated with increased methane (CH_4) and nitrous oxide (N_2O) emissions at a farm level; CO_2 equivalents per stocking unit (kg CO_2-e/SU), however, was similar among all scenarios, and CO_2 equivalents per unit of production (t CO_2-e/t produced) decreased with intensification. Annual inventory-based emissions (CH_4 + N_2O) ranged from 2763 to 4434 kg CO_2-e/ha. Carrying capacity was minimally altered by adding forest blocks; stocking rates were altered by less than 3% (i.e. 7.5 to 7.3 SU/ha for the 50:50 land-use capability level). Assuming credits from forestry accumulate at a rate of 22 tonnes CO_2-e/ha/yr, preliminary findings suggest that a new 20-ha block of Radiata pines would be able to meet liability for livestock emissions from the most intensified farming scenario until 2031. Physical and financial indicators were largely in response to pasture harvesting efficiency and maintenance of healthy swards; the achievement of high amounts of pasture production was a key driver of performance and financial efficiency.

COMPARISON OF THREE METHODS TO ESTIMATE ORGANIC CARBON IN ALLOPHANIC SOILS IN NEW ZEALAND

M Hasinur Rahman, Allister W Holmes, Markus Deurer, Steven J Saunders, Alistair Mowat and Brent E Clothier

The Carbon in Orchard Soils Team (COST), Plus Group Ltd., Horticulture Innovation Centre, Newnham Park, Te Puna, Tauranga, New Zealand
E-mail: technical@groplus.co.nz

Soil sequesters large amounts of carbon derived from organic and inorganic sources. Soil organic carbon (SOC) has to be measured periodically for the study of climate change. Carbon in soil samples are converted to carbon dioxide which is measured directly or indirectly by different methods. Many methods are involved in estimating SOC and those methods are relatively time consuming and costly. Quantitative methods for the determination of SOC are based on titration or gravimetric, volumetric, spectrophotometric and chromatographic methods. Loss-on-ignition (LOI) has been considered as a rapid, inexpensive and convenient method for estimating SOC, which involves the dry combustion of samples at high temperature in a muffle furnace. The LECO Carbon Analyzer for SOC determination is capable of complete recovery and high precision, and is recommended primarily for total C analysis of soils. The objective of this study was to establish a NZ kiwifruit-specific regression equation to estimate SOC from LOI. We collected 121 allophanic soil samples from 0-100 cm depth from three regions of kiwifruit orchards in the Bay of Plenty area with organic, biological and integrated management systems. Soils were analysed using LOI to determine organic matter by combinations of three different ignition temperatures and four time durations. Results were compared with two other methods viz. wet acidified rapid dichromate oxidation, Walkley-Black method (organic carbon) and dry combustion technique, (LECO; total organic carbon) and a regression equation was established to estimate SOC in allophanic soil. A NZ kiwifruit-specific regression of SOC measured by LOI (300^{o}C, 2 h) versus LECO which was assumed here to have no error yields for the topsoil (0-50 cm) an R^2 of 0.944 and for the subsoil (50-100 cm) an R^2 of 0.45. The regression of SOC for 0-15 cm soils established by LOI (400^{o}C, 3h) had an R^2 of 0.903. On the other hand, regressions established by LOI (300^{o}C, 3h) for SOC of 15-30 cm and 30-90 cm of soils had R^2 of 0.777 and 0.748, respectively. This analysis shows that the LOI method is well suited as a cost-effective method for the analysis of SOC in NZ kiwifruit systems, and other allophanic soils, especially for topsoil with higher accuracy than subsoil.

MODIFIED SOIL SAMPLING TECHNIQUE TO QUANTIFY CARBON SEQUESTRATION IN ALLOPHANIC SOILS UNDER KIWIFRUIT MANAGEMENT SYSTEMS

M Hasinur Rahman, Allister W Holmes, Markus Deurer, Steven J Saunders, Alistair Mowat and Brent E Clothier

The Carbon in Orchard Soils Team (COST), Plus Group Ltd., Horticulture Innovation Centre, Newnham Park, Te Puna, Tauranga, New Zealand
E-mail: technical@groplus.co.nz

Due to differences among soil types combined with different research aims there is no specific strategy for collecting soil samples. However, having a precise technique of soil sampling would help to meet specific research goals. This study was undertaken to compare a new, less invasive technique for measuring soil organic carbon (SOC) of a low bulk density soil (Andisol: Allophanic soils) to 100cm depth accurately, quickly and inexpensively; and to evaluate how the new technique compares with digging a large pit affect carbon stocks in Allophanic soils. The advantages and disadvantages of the new technique are also discussed. Soil was collected from kiwifruit orchards by the existing method of opening a pit 1.5m x 1.0m, a technique that causes much concern amongst orchardists; and by the new modified technique of digging a small hole 5cm and 2.5cm diameter for undisturbed and disturbed samples, respectively. Results show that bulk density (BD) and concentration of soil organic carbon (SOC) were higher in wheel tracks followed by grass alley and the lowest was in vine row in all depths irrespective of methods. Regardless of sampling position, the bulk density showed slightly higher value with the coefficient of variations of 3.04, 3.53, 2.57 and 5.72% for depth of 0-10, 10-30, 30-50 and 30-90cm, respectively, measured by the new technique as compared to the existing method. Soil organic carbon measured by different techniques did not show any definite trends. The variations in SOC stock were 2.33, 2.93 and 1.25% for grass alley, wheel track and vine row, respectively, measured between two methods. Regardless of sampling position, the average variation between two methods for SOC stock in 0-100cm depth of soil profile was 2.19%. Our findings show that it is possible to use the new, modified method to accurately determine SOC and BD, rather than the traditional time-consuming and hugely disruptive pit methodology. Using the new methodology will allow soil sampling to occur on a wider range of properties and crop types, to determine many variables including SOC and nutrient status of soils, and allow BD to be determined to calculate results on a per hectare basis.

WHEN MORE IS MORE – A PRÈCIS!

Ants Roberts[1], Mike White[2], Hayden Lawrence[3] and Mike Manning[1]

[1]Ravensdown, P O Box 608, Pukekohe, 2340
[2]ARL, P O Box 989, Napier 4140
[3]Niaruo Farm, 217 Rawhitiroa road, R D 18, Eltham

Fertiliser applications historically have being relatively ‘uniform’ in rate and type such that soil fertility could be expected to be uniform across the farm. In reality, this is seldom the situation for many reasons including soil type, topography, animal behaviour, paddock history, fertiliser spreading patterns. With current costs of fertiliser relative to farm returns, pasture performance in relation to soil fertility should be maximised as the most economic use of fertiliser dollars. This can be achieved by quantifying the variability of soil fertility across the whole farm, through soil testing all or many more paddocks than usual, so that differential rates of fertiliser/lime can be applied. This will allow either increased productivity in low fertility areas where appropriate and financial savings where less or no fertiliser may be required. In the 2009/2010 dairy season, all the paddocks on Niaruo dairy farm, Eltham, Taranaki were sampled and fertiliser was applied differentially. This paper reports on the pasture production and soil fertility changes between the 2008/2009 and 2009/2010 dairy seasons when the change from uniform application of fertiliser to differential application was instituted.

COMPARISON BETWEEN MID-INFRARED AND NEAR-INFRARED FOR SOIL ANALYSIS

Gordon Rajendram and Kyle Devey

Hill Laboratories Ltd, Hamilton, New Zealand

This study attempts to build calibrations using 500 New Zealand soils for total nitrogen and total carbon using NIR and MIR instruments. The soils are from around New Zealand and include a wide range of different soil types, and cover a range of total nitrogen and total carbon values.

The NIR analysis was measured using the 2 mm fraction of soil scanned on a Bruker Matrix. The MIR analysis was measured using the fine-ground fraction and scanned on a Bruker Alpha MIR unit.

There was little difference between the predictive powers of the two techniques. Near infrared had the advantage that fine grinding of the soil was not necessary.

NITROGEN AND PHOSPHORUS BALANCES AND EFFICIENCIES ON CONTRASTING DAIRY FARMS IN AUSTRALIA

Cameron J P Gourley[1], Sharon R Aarons[1], Warwick J Dougherty[2], and David M Weaver[3]

[1]*Future Farming Systems Research Division, Ellinbank Centre, Department of Primary Industries, Ellinbank, Victoria 3821 AUSTRALIA*
[2]*NSW Department of Industry and Innovation, Richmond, NSW, 2753 AUSTRALIA*
[3]*Centre for Ecohydrology, Department of Agriculture and Food, Albany, Western Australia 6330 AUSTRALIA*

E-mail: cameron.gourley@dpi.vic.gov.au

Nitrogen (N) and phosphorus (P) imports, exports and within-farm flows were measured during a standardised production year on 41 contrasting Australian dairy farms, representing a broad range of geographic locations, productivity, herd and farm size, reliance on irrigation, and soil types. The amount of N and P imported varied markedly, with feed and fertiliser generally the most significant contributors and principally determined by stocking rate and type of imported feed. Whole-farm N surplus ranged from 47 to 600 kg N/ha/year and was strongly ($P < 0.01$) and linearly related to the level of milk production. Whole-farm N use efficiency ranged from 14 to 50%, with a median of 26%. Whole-farm P surplus ranged from -7 to + 133 kg P/ha/year, with a median of 28 kg/ha. Phosphorus use efficiencies ranged from 6 to 158%, with a median of 35%. The poor relationship between P fertiliser inputs and milk production from home-grown pasture and crops reflected the high soil P levels measured on these farms.

The N and P intakes of each dairy herd, the locations the cows visited and the time they spent there, were also determined during five visits throughout the year. As N and P intakes increased so did excreted N and P, with use efficiencies generally less than 20%. On average 432 g N and 61 g P were excreted by each lactating dairy cow/day. Overall, cows spent a small proportion of their time in the milking parlour (2%) and yards (9%) where dung and urine were generally collected, however greater time was spent on feedpads (11%) and holding areas (26%) where manure was not routinely collected. The largest amounts of excreted N and P were deposited by cows in grazed paddocks but particularly those closest to the milking parlour.

Key opportunities to improve N and P use efficiency within grazed dairy systems include reducing unnecessary nutrient intake, improved spatial and temporal movement of animals within dairy farms to reduce heterogeneous N and P deposition, increasing the capture, storage and redistribution of excreted N and P in non-productive areas, and more strategic fertiliser and effluent applications.

NITRATE LEACHING AND PASTURE ACCUMULATION DURING TWO YEARS OF DURATION-CONTROLLED GRAZING IN THE MANAWATU

C L Christensen, M J Hedley, J A Hanly and D J Horne

Fertilizer and Lime Research Centre, Massey University

Duration-controlled grazing practices, in conjunction with increased use of cow housing or feedpad facilities, are used in New Zealand to reduce treading damage to pastures during wet periods. Removing cows from pasture also reduces the excreta load returned to the pasture. Simulation models suggest that if the excreta captured on the standoff facility during duration-controlled grazing is stored and uniformly re-applied to paddocks, then this can lead to subsequent reductions in nitrogen (N) leaching.

A large-scale grazing trial has been in operation at Massey University No. 4 Dairy Farm since June 2008, to investigate the effect of duration-controlled grazing on the concentrations of N, phosphorus (P) and faecal microbes in drainage and surface runoff from grazed pasture. Pasture accumulation between grazings is also being assessed. The experimental area has 14 grazing/drainage plots (each ~850m^2), which provides facilities for continuous monitoring of volumes and flow rates of mole and pipe drainage, and surface runoff water. Seven of these plots are managed under 'duration-controlled' grazing (*DG*; 4 hour day or night graze) and the other seven plots under 'standard' grazing (*SG*; 7 hour day graze, 12 hour night graze). Plots are grazed alternatively between morning and night grazings. Slurry was returned to the *DG* plots in the first season, with a nutrient loading equivalent to approximately the amount of nutrients produced in slurry from about 18 months of *DG* grazing. Consequently, no slurry was applied during the second lactation season.

The results presented in this paper indicate *DG* has a major impact on reducing nitrate-N leaching losses, achieving an average reduction over the two seasons of more than 50%. This demonstrates that *DG* is a mitigation strategy available to farmers to assist them in achieving the dairy industry's target of reducing nitrate leaching by 50%, by the year 2020.

Pasture accumulation was similar for both treatments during the 2008/09 lactation season, however, in the 2009/10 lactation season, a 17% reduction in pasture accumulation was observed on the *DG* plots compared with the *SG* plots. This was likely due to less dung and urine deposited during grazing combined with no slurry being returned. However, slurry applications managed over subsequent seasons will help to establish whether pasture differences between the treatments can be minimised, whilst continuing to reduce nitrate leaching losses.

THE CHALLENGE OF LATE SUMMER URINE PATCHES IN THE WAIKATO REGION

Mark Shepherd[1], Paula Phillips[1] and Val Snow[2]

AgResearch Ltd, [1]Ruakura Campus, East Street, Private Bag 3123, Hamilton 3240;
[2]Lincoln Research Centre, Private Bag 4749, Christchurch 8140

Two experiments (2009 and 2010) have now been undertaken at DairyNZ's Scott farm in the Waikato to test the relative importance on N leaching of timing of urine N deposition from late-summer to spring. Results for 2009 were reported at last year's FLRC workshop. Here we focus on data from 2010, which show similar results but this year provide additional information on the interaction of timing and rate of urine N application.

Artificial urine (800 or 400 kg N/ha) was applied to separate replicated plots at monthly intervals from February to July 2010. Nitrogen loads leached below 60 cm during the drainage period were calculated using porous ceramic cups installed in each plot. Supplementary data were also collected on dry matter production and N uptake and soil mineral N.

Drainage of 465 mm was measured between early June and early October. Mineral N leached predominantly as NO_3-N. There was a significant ($P < 0.01$) interaction of time and rate of urine application on the amount of mineral N leached during the drainage period. There was a tendency for N leaching to increase linearly between the February and May applications. Leached N values for the February and May applications were 317 and 445 kg N/ha (800 rate) and 83 and 173 kg N/ha (400 rate); thus the contribution to N leaching from February deposited urine can be large, especially at higher urinary N concentrations. Halving the N load in the urine patch more than halved N leaching from the patch. Nitrogen leaching from applications after May decreased because not all of the urine N had been eluted from the profile by the time drainage stopped in October. Losses were 212 and 86 kg N/ha (800 rate) and 84 and 48 kg N/ha (400 rate) for applications in June and July, respectively

Combined, data from experiments in 2009 and 2010 indicate a significant contribution to N leaching from urine deposited in February/March and, by extrapolation, months before this – especially at the 800 kg N/ha rate (equivalent to a dairy cow urine patch).

We should not be surprised by these data: N leached from the urine patch is a balance between the amount deposited and the amount removed from the leachable pool by pasture uptake plus gaseous losses and immobilisation into the soil biomass. Further experimental and modelling work are required to extend these data to different soils and regions (climatic conditions) and to also test the effects on N leaching of urine deposited before February.

URINE TIMING: ARE THE 2009 WAIKATO RESULTS RELEVANT TO OTHER YEARS, SOILS AND REGIONS?

V O Snow[1], M A Shepherd[2], R Cichota[3] and I Vogeler[3]

AgResearch: [1]Lincoln Research Centre, Private Bag 4749, Christchurch 8140; [2]Ruakura Research Centre, 3123, Hamilton 3240; [3]Grasslands Research Centre, Private Bag 11008, Palmerston North 4442
Email: Val.Snow@agresearch.co.nz

Effective mitigation of N leaching must target the critical times of year that produce the greatest risk of leaching. Historically, much research has concentrated on the winter as that critical time. More recently, modelling results have suggested that the greatest leaching risk in New Zealand might be from urine patches deposited in late summer rather than winter. In response, a field trial was conducted on the Horotiu silt loam in the Waikato in 2009 to examine the effect of urine deposition time on N leaching. The 2009 Waikato results generally confirmed the earlier exploratory modelling and also provided a validation dataset to test the modelling. This paper compares model results to the trial data, examines if the 2009 Waikato trial was likely to be representative of other years in the Waikato and then examines if the trial results are likely to be representative of other regions and soil types.

The comparison between the experimental and modelled results showed good general agreement. The model reflected well the measured trend of N leaching with time of deposition. The deviation between modelled measured leaching ranged between -5 and +13% of the applied N, with no relationship between the deviation and deposition date. A sensitivity analysis showed that, whilst some parameters (particularly those associated with nitrification rate, urine deposition depth and rooting depth) had a strong effect on the amount leached, none of them changed the pattern of leaching with time of urine deposition.

To explore the possible effects of soil and region, simulations replicating the 2009 Waikato trial were performed across 36 years of climate data for the Waikato (Horotiu and Oropi soils) and Canterbury (Templeton and Lismore soils, both irrigated). In all cases the leaching risk peaked in summer and declined through winter to spring. However, the trend between timing of urine deposition and N leached was considerably muted in Canterbury and showed wider year-to-year variability. Some of this variability might be attributed to irrigation effects. More work is required to fully understand implications for regional differences between N leaching risk and time of urine deposition.

MICROBIAL WATER QUALITY IMPACTS OF DIRECT INPUTS AND EFFLUENT MANAGEMENT

Richard Muirhead and Ross Monaghan

AgResearch, Invermay, Private Bag 50034, Mosgiel 9053, New Zealand.
E-mail: richard.muirhead@agresearch.co.nz

The quality of water in streams and rivers draining agricultural dominated catchments needs to improve. There have been a number of (BMPs) that have been promoted as having the potential to reduce faecal indicator organism (FIO) losses from farms. However, the effectiveness of these microbial BMPs needs to be quantified. We describe an approach to predict the effectiveness of BMPs to achieve water quality targets under base-flow conditions. Microbiological data is inherently inconsistent driven by the variability in the loads of FIOs excreted by animals and influenced by the growth or die-off of these organisms that can occur between deposition and delivery to the stream network. This variability can be captured by the use of a Monte Carlo simulation framework that models distributions rather than averaged values. The other key advantage of a Monte Carlo simulation approach is the ability to make comparisons between (a) relatively consistent inputs (i.e. a continuously discharging effluent pond) and (b) sporadic inputs (i.e. a spray irrigation effluent system). Continuous inputs, such as from effluent pond discharges, increased the expected median concentrations of *E. coli* in the stream. Sporadic inputs, such as from direct faecal inputs to the stream or losses from effluent irrigation systems, increased the upper percentiles of expected *E. coli* concentrations. Our analysis suggests that implementing currently available good environmental practice, as proposed in the "Clean streams accord", should improve microbial water quality in agricultural catchments during base-flow conditions.

PERFORMANCE, NITROGEN UTILISATION, AND GRAZING BEHAVIOUR FROM LATE-LACTATION DAIRY COWS OFFERED A FRESH ALLOCATION OF A RYEGRASS-BASED PASTURE EITHER IN THE MORNING OR IN THE AFTERNOON

Ronaldo Vibart, David Pacheco, Kate Lowe and Brent Barrett

AgResearch Grasslands Research Centre, Palmerston North

The consumption of a more balanced fermentable carbon to nitrogen (C to N) ratio from fresh forages can potentially enhance dry matter (DM) intake, lactation performance, and N utilisation in dairy cows, particularly those in late lactation. Eighty lactating cows were used to examine the effects of allocating a morning (~0730 h, AM; two groups) vs. an afternoon (~1530 h, PM; two groups) fresh strip of a ryegrass-based pasture on lactation performance, nitrogen utilisation, and grazing behaviour. The trial was conducted at the Massey University N^{o} 4 Dairy farm during April, 2010. Cows grazed on the same strip for a 24-hour period, and were offered the same daily DM allowance.

Pasture composition differed among treatments; forage from the PM treatment had greater DM (19.0 vs. 16.9%; P = 0.04) and water soluble carbohydrate concentrations (10.9 vs. 7.5%; P < 0.001), primarily at the expense of crude protein (20.3 vs. 22.2%; P < 0.001) and ash (10.6 vs. 11.2%; P < 0.001). Estimates of DM intake, from pre- and post-grazing herbage masses (HM), did not differ among treatments. Similarly, daily milk yields were similar among treatments, but trends towards greater fat and protein yields resulted in greater daily milk solids (MS) yields for cows on the PM treatment (1.23 vs. 1.13 kg MS/cow; P = 0.08). Estimates of urinary N excretion (g/d) and urinary N concentration (g/L) did not differ among treatments; urinary N concentration was greater in samples collected during the morning (6.2 vs. 5.0 g/L, P < 0.001). Initial HM available (kg DM/ha) and instantaneous HM disappearance rates (kg DM/ha and per hour) did not differ among treatments, but disappearance rates (0.56 vs. 0.74%/hour for AM vs. PM treatments, respectively) differed among treatments (P < 0.001). Despite similar partitioning of N towards urine, given similar amounts of herbage allocation, a simple change in management practice such as allocating a fresh strip later in the day resulted in moderate increases in N captured in milk and MS yields in late-lactation dairy cows.

HOW CAN WE ENHANCE PHOSPHORUS REMOVAL IN CONSTRUCTED FARM WETLANDS?

Deborah J Ballantine and Chris C Tanner

NIWA, PO Box 11115, Hillcrest, Hamilton
Email: d.ballantine@niwa.co.nz

Constructed and restored wetlands have significant potential to reduce nutrient losses in drainage waters from New Zealand farms. While both types of wetland show reasonably good nitrogen removal efficiencies, they are not always so effective at phosphorus (P) removal and their flooded topsoils can be net sources of P. Wetland P removal efficiency could be enhanced, either by adding a P-retentive amendment to the soil in the bottom of the wetland, or installing a porous filter with a high P adsorbency and retention capacity at the end of the wetland.

A review was carried out to evaluate a range of materials reported in the scientific literature as having the ability to remove P from water. Materials reviewed included (1) naturally occurring materials, such as soils, sands, clays and aggregates, (2) processed and modified materials, and (3) waste materials. The reported performance of the materials reviewed varied widely. A simple scoring system based on P removal characteristics, availability, likely cost and potential reuse or disposal on saturation was used to identify the materials with most promise as soil amendments or filters for constructed wetlands. Allophane, Papakai tephra, limestone and alum were judged as materials with the most potential as soil amendments, while limestone, slag, seashells, shell-sand and tree bark had most potential as filter materials. Another possible approach is to use subsoil or a mix of subsoil and topsoil as the growth media in the base of the wetland to avoid P release on flooding of P-rich agricultural topsoils.

Field and lab tests are now underway to determine which of the above materials might be most suitable to enhance P removal in constructed farm wetlands.

SURFACE FLOW CONSTRUCTED WETLANDS AS A DRAINAGE MANAGEMENT TOOL – LONG TERM PERFORMANCE

James Sukias and Chris C Tanner

NIWA, PO Box 11115, Hillcrest, Hamilton

Subsurface tile drains are used extensively throughout many agricultural areas of New Zealand to reduce excessive wetness from grazed pastures. Along with water, subsurface drains also transport nutrients which have leached from the soil, bypassing natural attenuation processes in shallow groundwaters and riparian zones. These nutrients have the potential to cause excessive "weedy-ness", algal growth, oxygen depletion and alterations to natural ecological processes. Surface flow constructed wetlands intercepting and treating these drainage waters before discharge into surface waters are one tool employed by the agricultural community. This paper quantifies long-term drain yields and nutrient removals associated with 2 constructed wetlands (situated in Waikato and Southland) planted with native bulrushes (raupo). Removal of TN ranged between 18 and 43% of influent loading annually, and was negatively associated with wetland N mass loadings. In contrast, mean annual flow-proportional TP concentrations increased (by up to 115%) after passage through the wetlands in most years monitored. These results demonstrate the need for research into reducing nutrient leaching from soils and improved nutrient attenuation within wetlands, particularly for phosphorus.

FOLIAR UREA AS A SUBSTITUTE FOR SOIL APPLIED N: EFFECTS ON VEGETATIVE VIGOUR AND FRUIT QUALITY OF KIWIFRUIT (*Actinidia deliciosa* cv. Hayward)

Allan Morton and David Woolley

Institute of Natural Resources,Massey University

The use of foliar sprays of nitrogen (N) in perennial fruit crops can reduce the risk of nitrate (NO_3^-) leaching and vegetative vigour compared to soil applied N. To compare the effects of foliar N with soil applied N, eleven 1% urea sprays were applied at 10 day intervals from 20 days before fruit set to the canopy of six mature kiwifruit vines cv.'Hayward' supplying N at a rate approximately equivalent to 80 kg N ha^{-1}. Another six vines were not given foliar N. Three of the foliar treated vines and three of the untreated vines were also given calcium nitrate applied to the rootzone at a rate approximately equivalent to 80 kg N ha^{-1}. Vegetative vigour of the vines given soil N was more than doubled compared to vines only given foliar N. Leaf N% in January was not significantly increased by the foliar N treatments but was by the soil applied N ($P<0.05$). Fruit from vines given foliar N but not soil N was 9% heavier ($P<0.05$) than that from vines given neither soil nor foliar N. Fruit weight from vines given soil N and soil N plus foliar N was not significantly different to other treatments and there were no significant differences between the treatments in fruit dry matter concentration. Foliar N may be a useful substitute for soil applied N for kiwifruit orchards allowing fruit quality to be maintained while reducing vegetative vigour and NO_3^- leaching.

INFLUENCE OF BIOCHAR AMENDMENTS ON DENITRIFICATION BIOREACTOR PERFORMANCE

Laura Christianson[1], Mike Hedley[2], Marta Camps[2], Helen Free[2] and Surinder Saggar[3]

[1]*PhD candidate, Iowa State University and Fulbright Fellow, Massey University*
LauraEChristianson@gmail.com
[2]*Massey University Soil and Earth Sciences Group and*
New Zealand Biochar Research Centre
[3]*Massey University Soil and Earth Sciences Group and Landcare Research*

As a soil amendment, biochar can provide environmental benefits like increased soil cation exchange capacity, microbial growth and soil water retention, in addition to its role as a long-term store of carbon in terrestrial ecosystems. This suggests that biochar can also be a useful addition to treatment systems aiming to reduce nutrient loadings in agricultural drainage. One possible such application for biochar is inclusion as fill denitrification bioreactors for agricultural drainage, where woodchips (carbon source) allow enhanced denitrification as drainage water laden in nitrate (electron acceptor) flows through the woodchip bioreactor. It was hypothesized that biochar additions could improve nitrate removal and decrease ammonium losses from woodchip denitrification bioreactors. This was explored with lab-scale column experiments consisting of woodchips mixed with two application rates of biochar (7% and 14% biochar by dry weight) which was produced from *Pinus radiata* feedstock. Biochar was pyrolysed at a peak temperature of either 380°C or 550°C to investigate effects of different temperature-derived chars on nitrate removal (i.e. more labile carbon remaining in lower temperature char). A nitrate solution was pumped through the columns and outlet stream samples were analysed for ammonium-N and nitrate-N while head space samples were analysed for nitrous oxide. Initial results indicated that there was no observable difference in nitrate removal between the woodchip control and the woodchip plus biochar columns. The columns containing biochar also seemed to release more ammonium upon start-up than the woodchip control though this trend was not significant ($p=0.36$).

EFFECTS OF SUBSOIL COMPACTION ON NUTRIENT ASSIMILATION AND TRANSLOCATION ABILITY IN THREE GRAIN LEGUME CROPS

M Hasinur Rahman[1*], Michihiro Hara[2], Allister W Homes[1], Markus Deurer[3] and Thomas A Adjadeh[4]

[1]PlusGroup Ltd., Newnham Park, Tauranga, New Zealand
[2]Faculty of Agriculture, Iwate University, Morioka, Japan
[3]The Plant and Food Research Institute Ltd., Palmerston North, New Zealand
[3]Department of Soil Science, School of Agriculture, University of Ghana, Accra, Ghana
**E-mail: hasinur65@yahoo.com*

Subsoil compaction affects all aspects of soil quality and persistent than that of surface compaction. An experiment was conducted in a phytotron using a randomized block design to evaluate the effects of different levels of compaction on legume crops viz. soybean, chickpea and lentil in an Andisol. A clay loam Andisol was used to grow the legume crops at different levels of surface and subsoil compaction as no compaction (0 J), medium compaction (500 J) and high compaction (1000 J). In this experiment, the effects of soil compaction on soil physical properties, plant development and nutrient assimilation and translocation ability by soybean, chickpea, and lentil were investigated. The bulk increased substantially with increased compaction. The dry weight of the plants differed in both surface and subsoil compacted soils. Shoot and root weights of the plants were higher at 0 J than the other compaction levels indicating that soil compaction hampered normal plant growth. Furthermore, the yields of plants tended to decrease with increasing of soil compaction from 500 J to 1000 J for both surface and subsoil compaction. However, this tendency was not always statistically significant. The results obtained in the study revealed that apart from Ca uptake by roots, compaction hampered nutrient assimilation in both shoot and root of all the crops. Similarly, the translocation of nutrients in the shoot of the plants were adversely affected by compaction. In general, the effect of compaction on the growth and levels of both macro-and micro- nutrients in soybean was the least pronounced. The severity of the detrimental effect of compaction on dry matter production could be presented as chickpea > lentil > soybean. This study also revealed that for all the measured parameters, the effect of surface soil compaction was severer on the crops than that of subsoil compaction.

CHANGES IN TOPSOIL QUALITIES OF DRYSTOCK PASTURE AND KIWIFRUIT ORCHARD SITES IN THE BAY OF PLENTY

Dani Guinto

Bay of Plenty Regional Council, Tauranga

Temporal changes in topsoil (0-10 cm) qualities of drystock (sheep/beef and deer) and kiwifruit orchard sites were monitored periodically over a 10-year period. Results indicate that for the land uses considered, many of the topsoil quality indicators were being maintained and these are within the provisional target values set by Landcare Research for production and/or environmental criterion. However, the current high level of anaerobically mineralisable N (close to 200 mg/kg) in the drystock sites will need to be monitored closely because further increase could lead to significantly higher nitrate leaching and subsequent eutrophication of water bodies. In the case of kiwifruit land use, there was an increasing temporal trend in Olsen P values. The current Olsen P mean value exceeded the 100 mg/kg target and is a cause for concern because high Olsen P levels could lead to P-laden sediment polluting streams and other water bodies. Since kiwifruit does not require high P input for high productivity, application of P fertilisers can be reduced significantly.

SPATIAL VARIABILITY OF AVAILABLE NUTRIENTS AND SOIL CARBON UNDER ARABLE CROPPING IN CANTERBURY

Weiwen Qiu, Denis Curtin and Mike Beare

Plant and Food Research, Private Bag 4704, Christchurch

Soil properties can vary spatially due to differences in topography, parent material, climate or land management. The objective of this study was to quantify the spatial variability of available nutrients and organic matter within a 10.4 ha paddock (predominantly Templeton silt loam; flat topography) at Lincoln that had a long-term history of arable cropping. Samples (0-7.5cm depth) were collected in a grid pattern (35 m sampling intervals; total of 91 samples) for determination of mineral N, anaerobically mineralisable N (AMN), Olsen P, total C and total N. The data were evaluated using geostatistic as well as classical statistical methods, and geographic information system was used to produce nutrients and organic matter maps. Although the paddock had even topography and had been managed uniformly for many years, nutrients levels exhibited substantial variability. For example, Olsen P ranged from 14 to 53 µg/g (mean 20 µg/g) and AMN ranged from 37 to 83 µg/g (mean 50 µg/g). Soil organic matter also showed significant spatial variability, with total C ranging from 19 to 31 µg/g (mean 27 µg/g). All measured variables except mineral N showed moderate to strong positional dependence. Semivariogram models showed that for Olsen P the autocorrelation distance was 72 m, compared with 460 m for AMN, and 430 m for total C. We examined the relationship between soil texture and organic matter using samples collected along two perpendicular transects within the paddock. Soil C showed a strong positive correlation (R^2=0.79; n=17) with the amount of clay plus fine silt (<5 µm fraction) and a negative correlation (R^2 = 0.81) with sand content. These results suggest that textural variation was the major factor influencing within-paddock variability in soil organic matter at this study site.

SOIL STRUCTURAL CHANGES RESULTING FROM IRRIGATING WITH A POTASSIUM RICH WINERY WASTEWATER

S Laurenson[1,3], N S Bolan[1,3], E Smith[1,3] and M McCarthy[2]

[1]*Centre for Environmental Risk Assessment and Remediation, University of South Australia*
[2]*Viticulture Division, South Australian Research and Development Institute, Nuriootpa, South Australia.*
[3]*Co-operative Research Centre for Contamination Assessment and Remediation of the Environment, South Australia.*

In many parts of Australia and New Zealand, reusing wastewater, including recycled municipal water and winery wastewater, for irrigation has become increasingly commonplace as an efficient use of water and effective means of disposal. These water sources are rich in monovalent cations, including sodium (Na^+) and potassium (K^+). One major agricultural concern related to their use is the potential for these monovalent cations to accumulate in the soil profile, and subsequently, cause clay fractions to disperse. This invariably leads to changes in many key soil properties such as hydraulic conductivity, infiltration rate, bulk density and soil aeration.

Research on the soil structural effects of K^+ in irrigation wastewaters has received limited attention due to the typically low abundance in most waters. Winery processing wastewater however tends to have elevated concentrations of both K^+ and Na^+. This study investigated the contrasting cation dynamics under municipal and winery wastewater following irrigation to a heavy clay soil. Accelerated annual irrigation, drying and rainfall cycles enabled long-term predictions to be drawn.

Despite the higher Na^+ concentration in winery wastewater, irrigation caused a significant increase in the exchangeable potassium percentage of the soil indicating preferential retention of K^+ over Na^+. Generally, clay dispersion was greater in soils irrigated with wastewaters relative to those receiving mains water or without irrigation. Importantly however, this was greater under municipal wastewater relative to winery wastewater due to the higher dispersive potential of Na^+ over K^+. Soils receiving municipal wastewater also required a greater concentration of electrolytes to maintain flocculation. It is thought that the influence of wastewater on soil pH plays a significant role in the dispersion of clays by increasing cation exchange capacity whereby greater retention of monovalent cations occurs.

CLOSING THE LOOP:
BIOSOLIDS TO REBUILD DEGRADED SOILS

Brett Robinson*, C W N Anderson, O Knowles, J Gartler, D Portmann, A Contangelo and L M Clucas

**Department of Soil and Physical Sciences, Lincoln University, Canterbury*

Countries with sewage treatment plants produce some 27 kg of dry biosolids per person per year (Bradley, 2008). Biosolids represent a valuable source of soil nutrients, including phosphorus, of which global supplies are dwindling. Their addition to soil can improve fertility and store carbon that may otherwise be emitted into the atmosphere and exacerbate climate change. However, biosolids contain heavy metal and organic contaminants as well as pathogens. Prolonged addition of biosolids to soil may result in the accumulation of these contaminants to levels that pose a risk to human health and the environment. Therefore, their addition to fertile productive lands is not widely accepted.

We propound that biosolids be applied to degraded soils with the aim of restoring fertility and producing products that contain high concentrations of the essential micronutrients zinc and copper. Zinc and copper are the two most prevalent heavy metals in biosolids are Zn and Cu. Worldwide, some 35% of children and 20% of adults suffer from Zn deficiency (White and Broadley, 2005). Biosolids addition to soil may thus be a means of producing crops that are “biofortified” with these elements. Biosolids addition to degraded soil represents a closing of the loop, returning nutrients that have been removed in through degradation.

Unlike using biosolids as a fertiliser on productive soils, rebuilding degraded soils requires biosolids addition at a relatively high rate. This is because the role of the biosolids is to provide soil organic matter, rather than solely supplying nutrients. However, high application rates may result in excessive nitrate leaching and subsequent groundwater contamination or eutrophication of nearby lakes and rivers.

We hypothesised that some of the negative environmental effects associated with biosolids addition to soil could be mitigated by mixing the biosolids with biochar, a form of charcoal that is added to soil (Lehmann and Joseph, 2009) often with the goal of reducing impacts of greenhouse gas emissions (Clough & Condron, 2010). Biochar can improve porosity, surface area, and structure. Chemically, biochar may mitigate contaminants of biosolids through increased cation and anion exchange capacity, as well as increase soil pH. Soil microbes may also benefit from applications of biochar (Clough & Condron, 2010).

We aimed to determine the effect of biosolids and biochar addition to the uptake of Zn by crop plants and investigate the effects of biochar addition on Zinc uptake and nitrate leaching from biosolids amended soil. Here, we present the results of experiments that demonstrate that soils amended with both biosolids and biochar produce biofortified crops while avoiding excessive nitrate leaching.

BIOAVAILABILITY OF DISSOLVED ORGANIC CARBON AND NITROGEN LEACHED OR EXTRACTED FROM PASTURE SOILS

Anwar Ghani, U Sarathchandra, S F Ledgard, M Dexter and S Lindsey

AgResearch, Ruakura Research Centre, Private Bag 3123, Hamilton

The general perception is that leachable dissolved organic carbon and nitrogen (DOC and DON) from agricultural soils are predominantly recalcitrant, hence their movement from soil beyond the rooting depth and into ground water is considered of little concern environmentally. Soils from temperate regions under grazed pastures tend to lose significant amounts of C and N as DOC and DON through leaching or runoff. Literature suggests 100 to 1600 kg C ha^{-1} yr^{-1} as DOC and 5 to 120 kg of N as DON ha^{-1} yr^{-1} can be lost through leaching from some New Zealand pasture soils. If these compounds are amenable to microbial decomposition then this could have important environmental consequences.

In two laboratory experiments, bio-decomposability of dissolved organic matter (DOM) extracted and leached from pasture soils was examined. The first experiment examined decomposition rate of extractable DOM from two soils (pumice and allophane) treated with and without animal excreta. The DOM from these soils was extracted with cold-water (20°C for 30 minutes) and non-amended soils were also extracted with hot-water (70°C for 16 hrs). The second experiment studied decomposition of DOM collected as leachates from outdoor lysimeter trials, representing four different soils. A set volume of extracted or leached DOM was added into Schott bottles, which were air-tight and had outlets for periodic gas and liquid sub-sampling. The bottles were placed on an orbital shaker at 60 shakes per minute at 20°C and concentrations of DOC, DON, NH_4, NO_3 were measured at various time intervals up to 49 days. Loss of dissolved C through microbial respiration (CO_2) and N as denitrification (N_2O) were also measured periodically.

Our results clearly show that DOC and DON components of the DOM whether extracted or leached, are highly decomposable and bioavailable. These findings warrant more in-depth studies to understand the role of DOM in regulating the ecosystem functions and nutrient balance in grazed pasture systems.

BIOFORTIFIED FODDER - AN ENVIRONMENTALLY SUSTAINABLE MECHANISM TO SUPPLEMENT LIVESTOCK WITH TRACE ELEMENTS?

Christopher Anderson[1], Brett Robinson[2] and David West[3]

The New Zealand Biofortification Initiative
[1]Fertilizer and Lime Research Centre, Massey University
Private Bag 11-222, Palmerston North 4442, New Zealand
Email: c.w.n.anderson@massey.ac.nz
[2]Agriculture and Life Sciences Division, Lincoln University, Christchurch
[3]Institute of Veterinary, Animal and Biomedical Sciences
Massey University, Palmerston North

New Zealand agriculture utilises trace element supplements to protect livestock from fungal infection. For example Zinc (as zinc oxide) administered as an oral drench or intraruminal bolus, is used extensively to protect sheep and cattle from facial eczema. A large percentage of administered Zn is however excreted in faeces and there is published evidence to show that Zn levels in pastoral soils are increasing with time. The long-term environmental affect of this ongoing Zn input to soil is unknown.

In this paper we describe research into the efficacy of fodder with an elevated Zn concentration as a potential prophylaxis against facial eczema in sheep relative to a conventional drench. Our hypothesis is that Zn protection afforded by biofortified fodder may be realised at a relatively lower dose, thus limiting transfer of Zn into the pastoral environment. This may represent a more environmental sustainable mechanism to supplement livestock with trace elements than conventional options. Our mechanism of Zn administration can be described as the biofortification of food with essential trace elements.

During a controlled feeding trial, 20 sheep were administered one of four Zn treatments over seven days (conventional drench or biofortified / non-biofortified fodder). Blood and faecal samples were taken regularly and analysed for the constituent Zn concentration. Prescribed threshold levels for Zn in blood serum and faeces were used to gauge the likely effect of treatments in protecting against facial eczema. Both conventional ZnO drench and biofortified fodder (willow) increased the Zn concentration in blood and faeces. The drench increased serum levels to above the threshold level for protection, however Zn was rapidly excreted, and after a very short time levels had dropped to below the prescribed concentration. In comparison, serum and faeces Zn levels in the animals fed biofortified willow increased throughout the feeding period. The total amount of Zn administered to animals via willow was significantly lower than that administered via drench, and consequently serum and faeces concentrations did not increase above the prescribed threshold level. However, our results do show that biofortification has potential as a mechanism to deliver trace elements to animals. Research from 2011 will build upon our initial findings in 2010.

A TRACE ELEMENT ANALYSIS OF SOIL QUALITY SAMPLES FROM THE WAIKATO REGION

Matthew Taylor, Nick Kim and Reece Hill

Environment Waikato, Hamilton

EW monitors 144 soil quality sites to determine the extent and direction of changes in soil properties. Sampling sites were chosen to cover a representative range of land uses and Soil Orders. A subset of samples were analysed for the trace elements arsenic, cadmium, chromium, copper, lead, mercury, nickel, uranium and zinc, to provide measures of defuse contamination. There were data for three years and these provide indicative trends. Native and forestry sites had low concentrations of all trace elements measured, while other land uses showed enhancement of some elements. Annual cropping sites were significantly ($p<0.05$) enhanced in arsenic, cadmium, copper, chromium, mercury, nickel, uranium and zinc. Horticultural sites were significantly enhanced ($p<0.05$) in arsenic, cadmium, copper, uranium and zinc, while dairy and other pasture sites were significantly enhanced ($p<0.05$) in cadmium, copper, uranium and zinc. No sites were significantly enhanced with lead.

A separate land use category “conversion pasture” was developed to include a cluster of outliers that had been converted from production forestry to pasture. These sites have only been in pasture 2-3 years and still have trace element concentrations close to background. Further monitoring over 2-3 years is required before a trend can be deemed genuine. Changes in land use are likely to lead to alterations in the trace element status of the soil.

CADMIUM ACCUMULATION AND TOLERANCE STRATEGIES IN INDIGENOUS FORAGE GRASSES

Shamima Sabreen[1], Shu-ichi Sugiyama[1], M Hasinur Rahman[2] and Suguru Saiga[3]

[1]*Faculty of Agriculture and Life Science, Hirosaki University, Hirosaki, Japan.*
[1]*PlusGroup Ltd., Newnham Park, Tauranga, New Zealand*
[3]*Faculty of Agriculture and Life Science, Iwate University, Morioka, Japan*

Excessive toxic metal levels in soils pose considerable hazards to human and animal health. Cadmium (Cd) is considered an important environmental soil pollutant as it is readily absorbed by plants and has the potential to enter the food chain. Cadmium levels have increased in soils throughout the world including USA, New Zealand and Japan, where great quantities of phosphate fertilizer are required for intensive cultivation. Grasses are excellent candidates for phytoremediation because of their high biomass production, high adaptability and low management costs. Few studies of phytoextraction of Cd have been undertaken for interspecific variation among grasses. Because Cd hyperaccumulation is an unusual biological phenomenon and the ecological significance of this trait remains largely obscure, this study was therefore, conducted to assess interspecific responses and phytoextraction abilities of C_3 grass species for Cd applications in hydroponics to clarify their potential for phytoremediation of Cd. Populations of 30-day-old C_3 grass species, i.e., *A. alba*, *A. odoratum*, *D. glomerata*, *F. arundinacea*, *F. pratensis*, *L. multiflorum*, *L. perenne*, and *P. pratensis* were grown hydroponically for 15 days with different concentrations of Cd (0, 5, 10 and 50 µ*M*). For each species, shoot biomass, the proportion of growth inhibition (GI, %), shoot Cd concentration and accumulation, shoot nutrient uptake, and the proportion of uptake inhibition (UI, %) of nutrient minerals were evaluated. Effects of Cd application included stunted growth. The GI was increased 16% to 70% with increasing Cd concentrations. For all Cd treatments, *L. multiflorum* showed the highest shoot dry biomass. Shoot Cd concentrations negatively influenced mineral nutrient uptake. The highest Cd treatment caused UI of various elements by 40% to 95%. At 50 µM Cd treatment, Cd accumulation varied by twenty times among species, and *L. multiflorum* showed the highest Cd accumulation (116.46 $\mu g \cdot plant^{-1}$). Our results indicate that *L. multiflorum* exhibited high degrees of both Cd tolerance and phytoextraction among grass species.

WHAT DO HIGH OLSEN P VALUES MEAN ON PUMICE-GRAVEL SOILS IN THE ROTORUA DISTRICT?

Gordon Rajendram[1], Martin Hawke[2], Alastair MacCormick[3], Lee Matheson[4] Louise Butler[1] and Aaron Stafford[5]

[1]Hill Laboratories, [2]Bay of Plenty Pastoral Research, [3]Environment Bay of Plenty, [4]Farm consultant, [5]Ballance Agri-nutrients

To achieve maximum pasture production on pumice soils, Olsen P levels of 35-45 mg/L is required. However, soils derived from the Tarawera eruption and associated soils require Olsen P level of approximately 90 mg/L to maintain maximum pasture production.

Forty-one sites from the Bay of Plenty region were sampled to a depth of 7.5 cm. The soils included Tarawera Gravel (11), Matahina Gravel (10), Rotomahana Mud (7), Oropi Sand (4), Taupo Ash (7) and Te Pepe (2).

The amount of gravel, which did not pass through a 2 mm sieve for the Tarawera and Matahina gravel soils, ranged from 24-67% and 9-29% respectively. For the other soils there were minimal amounts, which did not pass through the 2 mm sieve. Olsen P, P retention, total P and Cd were measured on the <2 mm fraction, gravel only and a mixture of the two fractions which was naturally found in the field.

This study showed that the exclusion of the gravel fraction prior to analysis (common laboratory practice) would have lead to the higher Olsen P values required to maintain maximum pasture production when pasture growth trials were conducted. The exclusion of gravel will also have implications on other chemical tests such as Cd levels in the soil.

UREA VOLATILISATION: THE RISK MANAGEMENT AND MITIGATION STRATEGIES

Peter Bishop[1] and Mike Manning[2]

[1]*Bishop Research 2008 Ltd, PO Box 97 Tokomaru 4864, New Zealand*
Email: bishopresearch@slingshot.co.nz
[2]*Ravensdown Fertiliser Co-operative, PO Box 1049 Christchurch, New Zealand*

A review of international ammonia volatilisation trials from surface applied urea, showed the potential risk from ammonia volatilisation to be in the range of 0 to 65% of applied N, dependent on soil properties (Martens et al., 1989; Watson, 1990). Martens et al. (1998) and Watson (1990) showed that in 20 Iowa and 20 Irish soils respectively, the maximum volatilisation (V_{max}) of urea was negatively affected by cation exchange capacities (CEC), exchangeable acidity and buffering capacity but increased with calcium carbonate equivalence and soil pH in 0.1 M KCl (pH-KCl).

In addition to soil properties the realisation of V_{max}, under field condition was mainly dependent on climatic and management practices which assist the migration of urea into the soil profile. The main climatic effect was rainfall greater than 16 mm, occurring shortly after surface application and in terms of crop management the placement of urea below 30 mm at seeding (Cornell et al. 1979), avoiding post planting urea applications.

From the assessment of field trial data the losses of N from agricultural applications of urea is globally 10% (Turner et al., 2010) which is similar to the results from nine New Zealand field trials dependent on the methodology used. Trials in which rainfall was allowed to influence the measurements (metrological and rain compensated chamber methods) the observed mean was significantly lower than (mean 10.4%, SD 4.6) the covered chamber methods (mean 27.1%, SD 6.9). The results show average ammonia volatilisation from urea application in New Zealand has little economic importance given the cost of mitigation, as long as urea is not surface applied to soils with high V_{max} potential without impending rainfall.

In terms of mitigation of urea volatilisation the use of management tools, mainly timing of broadcast applications and placement/incorporation of urea at planting are the most cost effective strategies. The use of urease inhibitors mainly NBPT has proven, in eight international field trials to reduce ammonia volatilisation by between 28 to 88%. However this may represent a mean saving of only 2.8% to 8.8% of applied N.

COMPARISON OF THREE PLANT GROWTH REGULATORS AND UREA ON A CANTERBURY DAIRY PASTURE

S Jiang and P L Carey

Land Research Services, Lincoln

Two NZ-available plant growth regulator products (PGR-1 & PGR-2) and a new Ravensdown product (PGR-R), all based on gibberellic acid, were applied to a Canterbury dairy pasture in late winter (August) and early spring (September) and measured for their effect on dry-matter (DM) production. PGR treatments were compared with both a single application of liquid urea (20 kg N/ha) and a urea plus PGR-R treatment.

In the first harvest of both winter and spring trials, a month following PGR application, the PGR treatments produced significant increases in DM production ranging from 23-41%. None of these increases extended to the second harvest in either trial for any of the PGR agents. The application of urea increased production in the 1st harvest by ~30% in both trials but this was increased to over 60% when combined with PGR-R. No effect of the PGR was apparent in the second harvest when the urea treatment alone was the highest DM producer.

There trials showed some benefit in the use of PGR products when there is a need to boost pasture growth in early spring but these benefits largely disappeared after the first month following application. Some future research may be useful to further optimise parameters for the use of PGR products

PASTURE DRY MATTER AND N UPTAKE AS INFLUENCED BY UREA APPLIED WITH AGROTAIN, ELEMENTAL S AND LIME.

M Zaman*, J D Blennerhassett and A J Croom**

**Ballance Agri-Nutrients Limited New Zealand. Tauranga, New Zealand.*
***Summit-Quinphos (NZ) Ltd, Tauranga, New Zealand.*
Email: zamanm_99@yahoo.com

Granular urea applied onto pastures has lower N response efficiency (NRE) compared to other chemical fertilizers. Improving N use efficiency of applied urea is therefore critical for sustainability and to minimise its adverse effects on the environment. Two field trials were set up on permanent dairy pastures in Lincoln and Ashburton to investigate the effect of applying granular urea coated with urease inhibitor, [N-(n-butyl) thiophosphoric triamide (NBPT) or “Agrotain”], elemental sulphur (S) and lime (PhasedN) on pasture dry matter and NRE during 2009-2010. The five treatments: control (no N or S), S only, urea + S, urea + Agrotain + S and PhasedN were applied at the rate of 25 kg N/ha after every 3 pasture cuts. Each treatment had 5 replicates. The results showed that PhasedN consistently improved annual pasture N response by exhibiting significantly higher pasture dry matter yield, NRE and pasture N uptake compared to urea + S treatment in both trials. These results suggest that there is considerable potential for improving farm production and profitability by treating urea with Agrotain, elemental S and lime.

USE OF DECADAL PATTERNS AND TRENDS IN GEOCHEMICAL AND ISOTOPIC TRACERS TO IDENTIFY AND MANAGE AGRICULTURAL NITRATE SOURCES: A COMPARISON OF CANADIAN AND NEW ZEALAND APPROACHES

Len Wassenaar[1] and W T Baisden[2]

[1]Environment Canada, Saskatoon, Saskatchewan, Canada
[2]National Isotope Centre, GNS Science, Lower Hutt

Nitrate contamination of surface and ground water is a global problem, caused by sewage and septic waste, agricultural activity and exacerbated in some regions by atmospheric deposition. We emphasize the example of a transboundary aquifer spanning the US-Canada border, and describe how political concerns initiated intensive scientific studies. The studies identified agriculture as a dominant source. Agricultural beneficial management practices (BMPs) were implemented as a means to reduce nitrate contamination through producer optimized management of inorganic fertilizer and animal manure inputs. In this study, decadal trends (1991-2010) in nitrate concentrations in conjunction with $^{2}H/^{2}He$ groundwater ages and nitrate stable isotopes ($\delta^{15}N$, $\delta^{18}O$) were examined to determine whether voluntary BMPs aimed at reducing nitrate contamination in the transboundary Abbotsford-Sumas aquifer, Canada and USA were effective. A general trend of increasing nitrate concentrations in young groundwater (<5 yr) suggested that the voluntary BMPs were not having a positive impact in achieving groundwater quality targets. While the stable isotope data showed that animal manure was and remains a historical and prevalent source of nitrate in the aquifer, a decrease in $\delta^{15}N$ of recent nitrate indicated a shift away from the use of animal wastes towards inorganic fertilizers. The coupling of long-term monitoring of nitrate concentrations, nitrate isotopes, and $^{2}H/^{2}He$ age dating proved to be invaluable, and should be considered in future assessments of the impact of BMPs on nutrients in aquifers. The findings also revealed that BMPs should be better linked to ongoing soil and groundwater nutrient monitoring programs in order to more quickly identify BMP deficiencies, and to dynamically adjust nutrient loadings to help achieve water quality objectives. These Canadian examples contrast with New Zealand's contemporary approaches, within which the delineation of Regional Councils has prevented transboundary water issues from developing political focus. New Zealand has seen less development of stable isotope tracers and small-scale studies; a greater focus has been placed on water dating (^{3}H) and regional monitoring. In contrast to BMPs as a management tool, New Zealand has emphasized nutrient budgeting and the development of 'cap and trade'. Ultimately, both approaches have limitations that may limit their success in achieving outcomes.

PROGRESS IN THE DEVELOPMENT OF ISOTOPIC INDICATORS FOR LAND-TO-WATER NITROGEN TRANSFERS IN NEW ZEALAND

W Troy Baisden[1], P Mudge[2,3], L Schipper[2], T Clough[4], N Wells[4], A Ghani[3], L Wassenaar[5] and C Douence[1]

[1]National Isotope Centre, GNS Science, Lower Hutt
[2]University of Waikato, Hamilton, [3]AgResearch, Hamilton, [4]Lincoln University, Lincoln
[5]Environment Canada, Saskatoon, Saskatchewan, Canada

New Zealand's intensive pastoral agricultural systems have a significant impact on water quality due to nitrogen loading in rivers. New Zealand's preference for capping 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 progress to date on the development soil N isotopes and O and N isotopes in streamwater NO_3 as quantitative indicators to support N budgets.

The development of an indicator based on soil $\delta^{15}N$ values relies on the expectation that the ability of pasture soil to continue to store, rather than release, added N is related to the duration and intensity of past agricultural land use. Work to date from a range of long-term experiments demonstrates that soil $\delta^{15}N$ increases with both the duration and intensity of agricultural use, implying that this indicator provides the needed means to classify sites in the 'developing', 'developed' and 'highly developed' categories presently used in Overseer™.

Development of indicators for the percent of NO_3 from known sources and percent of NO_3 lost to denitrification during transport (attenuation) are more complex and rely on critical assumptions we have been testing. Our assumptions about the isotope systematics describing the sources of N and O isotopes in soil-derived NO_3 appear to be well supported within the precision of measurements. An assumption found to be problematic is that the N and O isotope shift associated with denitrification observed in the field can be estimated using laboratory 'batch' experiments that measure the isotope fractionation associated with denitrification biochemistry. Mathematical modeling demonstrates that diffusion of NO_3 into the anoxic sediments required for denitrification suppresses the isotope fractionation observed in flowing oxygenated typical of streams, drains and rivers. The model explains field data and implies that an isotope indicator for the percent attenuation due to denitrification will need to be calibrated in the field, and will be environment specific.

Results are presented from our primary study catchment, the Upper Manawatu.
Overall, our work to date has pointed to the need for intensive calibration studies in smaller catchments, including individual springs and drains. To undertake this, we are developing a new stream of work in the Wairarapa, focusing on the Mangatarere catchment.

ROLE OF SUBSURFACE FLOW PATHS FOR PHOSPHORUS LOSSES IN A DAIRY-GRAZED HEADWATER CATCHMENT

K Müller[1], M S Srinivasan[2], M Trolove[3], R W McDowell[4]

[1]The NZ Institute for Plant & Food Research,
Ruakura Research Centre, Private Bag 3230, Hamilton
[2]National Institute of Water & Atmospheric Research Limited, Christchurch
[3]AgResearch Limited, Ruakura Research Centre, Hamilton
[3]AgResearch Limited, Invermay Agricultural Centre, Mosgiel

The objective of this study was to identify flow pathways and link them to phosphorus (P) transport in the 8.7-ha Kiwitahi dairy-grazed pastoral catchment, Waikato. Our hypothesis was that P transport is equally influenced by saturation-excess (SE) and infiltration-excess (IE) runoff during stormflow and by shallow subsurface flow or in-stream exchanges during baseflow. The occurrence of surface runoff was ascertained by localized surface runoff samplers, and the dynamics of the shallow subsurface flow system during and between rainfall events were captured by continuously recording shallow groundwater levels in five shallow wells installed at 2, 4, 8, 15 and 25 m distance from the stream along a transect perpendicular to the stream. Stream flow was continuously recorded at the outlet of the catchment. In monthly intervals, grab samples from the stream and the shallow wells were collected. Additional flow-proportional stream-water samples were taken during storm events. All samples were analyzed for reactive phosphorus (DRP) and total phosphorus (TP) concentrations. In the year December 2007 to December 2008, P losses totaled 695 g ha^{-1} TP and 169 g ha^{-1} DRP. The dynamics of the shallow groundwater table and the occurrence of SE areas were influenced by proximity to the stream. The limited presence of the water table at the surface and the limited extent of impervious areas generating IE runoff (<0.1% of total catchment area) indicated that flow sources and transport of P during rainfall events was not limited to surface runoff. In fact, subsurface flow appeared to dominate both storm and base flow periods. Baseflow accounted for 42% of annual flow, and contributed 37 and 52% to the DRP and TP loads, respectively. The match in P concentrations between groundwater and stream samples during baseflow inferred the importance of shallow groundwater for stream flow, but also the role of exchange via the hyporheic zone. Management strategies should focus at decreasing Olsen P to minimize leaching of P via subsurface flow to streams. Research is needed for both, quantifying the role of subsurface flow and expanding management strategies to include P transport during stormflow and baseflow conditions.

FLOATING TREATMENT WETLANDS: A NEW TOOL FOR NUTRIENT MANAGEMENT IN LAKES AND WATERWAYS?

Chris C Tanner, James P S Sukias, Jason Park, Charlotte R Yates and Tom R Headley

NIWA, Hamilton

Floating treatment wetlands (FTWs) employing emergent aquatic plants growing on a buoyant mat are an innovative new tool for nutrient management in ponds, lakes and slow-flowing waters. Plant roots hang beneath the floating mat providing a large surface area for nutrient assimilation, growth of biofilms and entrapment of fine suspended particulates. By shading the surface and buffering water turbulence they can also promote settling of suspended algae and solids beneath the mats. Microbial nutrient removal processes, such as nitrate conversion to N gases via denitrification, may also be stimulated through creation of localized anoxic zones. The ability of FTWs to be used on the top of deep water and to tolerate wide fluctuations in water depth, means they can be used to retrofit a wetland treatment component into existing treatment ponds, or used directly as nutrient management tools in lake embayments and waterways. As there is little quantitative information on the performance of FTWs in these situations, we have undertaken trials to evaluate their treatment performance. Results of trials conducted in 1 m^2 experimental tanks and at pilot-scale in modified shipping containers will be summarized and practical applications discussed.

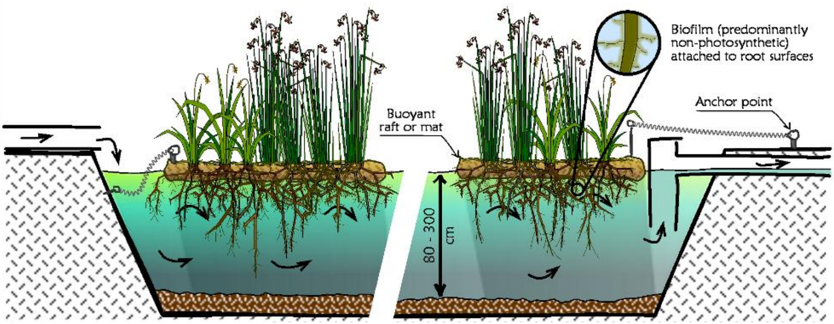

Figure 1: Cross-section of FTWs deployed in a treatment pond.

IMPACT OF CLIMATE ON THE EFFECTIVENESS OF DCD IN REDUCING N LEACHING

Iris Vogeler, Rogerio Cichota, Val Snow and Ross Monaghan

AgResearch, Private Bag 11008, Palmerston North, New Zealand
AgResearch, Private Bag 4749, Lincoln, New Zealand
AgResearch, Private Bag 50034, Invermay, New Zealand

The use of nitrification inhibitors, such as DCD, has been shown to reduce N leaching losses. However, its effectiveness has been seen to vary considerably with location and month of application. Developing guidelines for a widespread use of DCD as a mitigation tool requires better quantitative understanding of the influence of environmental variables on the effectiveness of DCD. The effectiveness is dependent on the residence time of DCD in the soil, which in turn is influenced by DCD leaching and degradation, and thus ultimately by rainfall and temperature.

To investigate the influence of rainfall and temperature on DCD effectiveness we used the APSIM model with a module accounting for nitrification inhibition by DCD. Simulations were run for key dairy regions of NZ (Southland, Canterbury, Manawatu, Waikato and Northland), with three different soil types (clay loam, silt loam, and sand), with and without irrigation for Canterbury, Manawatu and Waikato, and without irrigation for Northland and Southland, and over a period of 33 years. Deposition of a urine patch was simulated by applying an equivalent of 750 kg N/ha, and these depositions were, in separate simulation runs, done for every month and year of application. The total amount of N leached was summed over three years following the urine deposition.

Of the 750 kg N/ha applied, on average over all years and deposition months between 50 and 500 kg N/ha leached. In general, leaching was lowest in Southland and increased with locations further north. DCD decreased N leaching in average by 8-26%, and was most effective in Southland, with decreasing effectiveness further north. For the irrigated sites, rainfall amount and pattern explained 15% of the variation in DCD effectiveness. When considering temperature as well, the variation explained increased to 25%. The influence of rainfall and temperature conditions on DCD effectiveness varied across application month and with soil type, e.g. for silt loam explaining from 2% in September to 71% in May. These modelling results have provided insights to help explain the variation observed in DCD effectiveness. More detailed observations and modelling are needed to help develop improved usage guidelines that are tailored to local soil and weather conditions.

FIELD SCALE VERIFICATION OF NITROUS OXIDE EMISSION REDUCTION WITH DCD IN DAIRY-GRAZED PASTURE USING MEASUREMENTS AND MODELLING

Donna Giltrap[1*], Surinder Saggar[1], Jagrati Singh[1,2], Mike Harvey[3], Andrew McMillan[3], Johannes Laubach[4]

[1]*Landcare Research, Private Bag 11052, Palmerston North, New Zealand*
[2]*University of Melbourne, Melbourne, Australia*
[3]*NIWA, P.O. Box 14-901, Wellington, New Zealand*
[4]*Landcare Research, P.O. Box 40, Lincoln, New Zealand*
[*]*Corresponding author. Email: GiltrapD@landcareresearch.co.nz*

Nitrous oxide (N_2O) from agricultural soils is a major source of greenhouse gas emissions in New Zealand. N_2O is produced by the microbial break-down of animal excreta and fertiliser N applied to agricultural soils. Nitrification inhibitors are seen in New Zealand as a potential technology to reduce N_2O emissions from agricultural soils. A review of lysimeter and field studies using the nitrification inhibitor dicyandiamide (DCD) in New Zealand reported an average reduction of 67 ± 6% in N_2O emission from animal urine (Kelliher et al. 2007). In these studies DCD was directly applied to urine. However, farmers apply DCD to grazed pastures shortly before or after grazing rather than specific application to the urine patches. The objective of this study was to test whether the same level of N_2O reduction is achieved under grazed conditions where excretal-N is non-uniformly deposited and then apply the process-based NZ-DNDC model to simulate the effect of DCD on emission reductions. Two circular 1250-m^2 treatment plots at Massey University Dairy Farm 4 were grazed simultaneously for 4 h, by 20 cattle on each. The following day, DCD was applied to one of the plots at 10 kg ha^{-1} in 800 L water. N_2O emissions were measured periodically for 20 days following a grazing event, and soil and environmental variables were monitored.

The cumulative N_2O emissions were 220 ± 90 g N_2O-N $ha^{-1}$and 110 ± 20 g N_2O-N ha^{-1} for the untreated and DCD treated areas respectively. Therefore the reduction in N_2O emission from DCD application was ~50 ± 40%. NZ-DNDC simulated N_2O emissions of 181 g N_2O-N $ha^{-1}$and 77 g N_2O-N $ha^{-1}$for the untreated and DCD treated areas respectively, corresponding to a reduction in N_2O emissions from DCD application of 57%.

A sensitivity analysis was conducted on the NZ-DNDC model to find the variability in the predicted N_2O emissions that would result from uncertainty in the input parameters. Varying the parameters' initial soil NO_3^- and NH_4^+, soil organic carbon and bulk density within plausible ranges resulted in N_2O emissions from the no-DCD area ranging from 117 to 244 g N_2O-N ha^{-1}.

Both the measured and modelled results for the grazed system found an emissions reduction from DCD application consistent with the results from urine patches.

TARGETING DCD AT CRITICAL SOURCE AREAS AS A NITROGEN MITIGATION STRATEGY FOR HILL COUNTRY FARMERS

Keith Betteridge[1], Frank Li[1], Des Costall[1], Ants Roberts[2], Warwick Catto[3], Alec Richardson[4], Jo Gates[4] and Colin Brown[5,]

[1]AgResearch, [2]Ravensdown, [3]Ballance AgriNutrients, [4]Farmers Lake Taupo catchment and [5]Tracmap Ltd.

The nitrogen (N) discharge allowance (NDA) imposed on Taupo farmers prevents on-going increases in stocking rate to cover ever increasing costs of production unless effective N leaching mitigation tools are found. The nitrification inhibitor DCD applied to pastures over winter will reduce N leaching, but economics are questionable on sheep and beef farms, especially on hill country. This research relies on the fact that 50% of all urination events of cattle are concentrated a) into the 5-10% of small flat stock camp areas of hill pastures or, b) all urine is excreted within the areas of winter strip-grazed crops or pasture. Two farmers on the western side of Lake Taupo applied DCD to pastures from May/June until end of August. DCD applications were mapped with a Tracmap GPS logger and data were downloaded into a database via internet. Soil samples were taken and analysed for nitrate-N, ammonium-N and DCD to characterise DCD efficacy at five depths, twice in 2010. Six cattle fitted with GPS collars were tracked through several large hill paddocks over six weeks to determine on which contour class they camped. DCD resulted in elevated concentrations of NH_4-N in the upper soil profile and in most cases lowered NO_3-N concentrations compared to Control. Control had higher NO_3-N and lower NH_4-N concentrations. Leaching of NO_3-N was most dominant but both NH_4-N and DCD also leached down the profile. Strip-grazed crops had substantially higher concentrations NH_4-N and NO_3-N than strip-grazed pastures, as animals fed crops were not back-fenced and crop density (kg DM/ha) offered was much greater than pasture density. A preliminary economic evaluation is presented. Tracking of GPS-monitored cows did not identify obvious campsites as the hill paddocks were only moderately steep and contained many relatively flat areas.

NITROUS OXIDE EMISSIONS FROM A DAIRY FARMLET, AS AFFECTED BY USE OF A NITRIFICATION INHIBITOR AND A WINTER RESTRICTED GRAZING STRATEGY

Jiafa Luo, Stuart Lindsey, Bridget Wise and Stewart Ledgard

AgResearch Ruakura, Hamilton, New Zealand

Experimental farmlets at DairyNZ's Prototype Farm near Hamilton were used to determine potential reductions in nitrous oxide (N_2O) emissions from use of a nitrification inhibitor and a restricted grazing regime. A control farmlet was managed under a conventional rotational grazing regime, while a "tight nitrogen" farmlet was managed under a similar grazing regime to that on the control farmlet, except during the non-lactating period between winter and early spring when cows grazed for about 6 hours per day on pasture with the remaining 18 hours in a herd home (e.g., a stand-off or restricted grazing regime). A nitrification inhibitor (dicyandiamide, DCD) was applied onto the "tight nitrogen" farmlet on 2-3 occasions immediately after grazing through winter and early spring. A soil chamber technique was used to measure N_2O emissions from each farmlet during three contrasting periods of each year for three years. In addition, the New Zealand IPCC (International Panel for Climate Change) inventory methodology was used to calculate total greenhouse gas emissions.

During winter/early spring in 2007, 2008 and 2009, N_2O emission rates were lower in the "tight nitrogen" farmlet than in the control farmlet. The use of a restricted grazing regime and a nitrification inhibitor reduced N_2O emissions from the dairy farmlet by 43-55%, 64-79% and 45-60% during the winter/early spring seasons, respectively. During late spring/summer and autumn periods, N_2O emission rates were generally similar between the two farmlets. The difference in the annual N_2O emission rates between the control and the "tight nitrogen" farmlets was not significant in the first study year. However, in the second and third study years between 39% and 50% lower annual N_2O emission rate from the "tight nitrogen" farmlet than from the control was found. For the three study years, an average of 20% lower annual N_2O emission rate from the "tight nitrogen" farmlet than from the control was observed.

Total calculated annual emissions for the sum of the three major greenhouse gases, N_2O, CH_4 and CO_2, were 11,524 and 10,871 kg CO_2-equivalent per hectare from the control and "tight N" dairy farms, respectively. The total greenhouse gas emissions from the tight nitrogen dairy system were 6% lower than those from the control system.

Acknowledgements: Thanks to PGGRC for funding this study and DairyNZ and Chris Glassey for access to the dairy farms and farm management information.

A FRAMEWORK TO ESTIMATE NITROUS OXIDE EMISSIONS AT REGIONAL AND NATIONAL SCALE

Donna Giltrap*, Anne-Gaëlle Ausseil, Kailash Thakur and Surinder Saggar

Landcare Research, Private Bag 11052, Palmerston North, New Zealand
**Corresponding author. Email: GiltrapD@landcareresearch.co.nz*

The current method for calculating direct nitrous oxide (N_2O) emissions from agricultural soils in the National Inventory uses a constant emission factor (EF) multiplied by the nitrogen (N) input from fertiliser and animal excreta. However, N_2O emissions are actually the result of complex soil microbial processes, and soil properties, climate conditions and management practices can also influence emission levels. The National Inventory method is therefore limited in its ability to account for regional differences in N_2O emissions resulting from differences in soil, climate and management practices.

An alternative approach to estimate emissions is the use of the process-based DeNitrification DeComposition (DNDC) model. This model has been modified by taking account of New Zealand soils, climate, and grazed pasture management (NZ-DNDC), and used to estimate anthropogenic N_2O emissions in the Manawatu-Wanganui region. However, the model takes a long time to run when simulating a large number of points as it simulates a large number of soil properties at daily time step, and it is not easily integrated into GIS software. Further model simplification is therefore necessary to upscale NZ-DNDC to regional to national scales.

Here, we propose a framework whereby multi-year NZ-DNDC simulations are used to generate EFs (with uncertainties) over the range of soils, climates and farm systems and management practices occurring in New Zealand. The soil types are based on the New Zealand Soil Classification (NZSC) and climate zones determined from LENZ level 2 data. The framework will initially be based on 'average' farm management practices of dairy, intensive sheep and beef, hill-country sheep and beef, and deer farms, but will have the provision to accommodate other farm types, new management practices and mitigation strategies (e.g., the use of nitrification inhibitors, stand-off paddocks). This framework will be used to estimate the impacts of land use, grazing regime, land-management practices and mitigation strategies on N_2O emission in a fast and efficient way, enabling stakeholders to explore future scenarios for land management.

SEASONAL VARIATIONS IN THE DEGRADATION OF A NITRIFICATION INHIBITOR, DICYANDIAMIDE (DCD), IN A MANAWATU GRAZED PASTURE SOIL

Dong-Gill Kim, Thilak Palmada, Peter Berben, Donna Giltrap and Surinder Saggar*

Landcare Research NZ Ltd, Palmerston North, New Zealand
**Presenting author. Email: Saggars@landcareresearch.co.nz*

Nitrification inhibitor dicyandiamide (DCD) slows N turnover by slowing the oxidation of N to nitrate (NO_3^-) while retaining nitrogen (N) in soil in the ammonium (NH_4^+) form, providing more chance for plant uptake of NH_4^+. It thereby reduces N loss through leaching and the emission of the greenhouse gas nitrous oxide (N_2O) by 30 to 80% (Di et al., 2007; Akiyama et al., 2010). While studies evaluating the efficacy of DCD on reducing N_2O emissions have been widely conducted, the characteristics of DCD degradation and its longevity in soil are not well known. The objectives of this study were to examine seasonal variations in the degradation of DCD and to determine the major control factors for the variation. Two different DCD treatment levels (10 and 20 kg ha^{-1}) were assessed. In addition, a 10-kg ha^{-1} DCD treatment level with two different types of N (urine and synthetic fertilizer) was tested. The study was conducted on a Manawatu grazed pasture soil. Soil microclimate was measured at the site. The half-life of DCD varied with seasonal variation in soil temperature and moisture (longer in winter and shorter in spring and autumn) and soil temperature had a significant negative relationship with half-life. The half-life of DCD was affected by neither the rate of DCD application nor the type of N input. The results suggest that to maximise the effectiveness of DCD, different DCD application rates and frequency may be used in different seasons.

PRELIMINARY STUDIES TO MEASURE DENITRIFICATION ENZYME ACTIVITY AND DENITRIFICATION RATE IN NEW ZEALAND PASTURE SOILS

Neha Jha[1], Surinder Saggar[2], Russ Tillman[1] and Donna Giltrap[2]

[1]*Institute of Natural Resources, Massey University, Palmerston North, New Zealand*
[2]*Landcare Research, Palmerston North, New Zealand*

Denitrification is a microbially mediated process in which nitrate is reduced to a number of gaseous products, including N_2O and N_2. It contributes about 60% of the total N_2O emissions globally and is the primary process of N_2O production in New Zealand pasture soils. In soils actual and potential denitrification rates are determined by acetylene (C_2H_2) inhibition (AI) of N_2O reduction and by measuring denitrification enzyme activity (DEA) respectively. A review of published papers on these methods raised some concerns about the effect on measured denitrification rate of nitrification inhibition caused by C_2H_2, and also the effect of high concentrations of chloramphenicol, (added during the DEA assay) on the activity of the various reductase enzymes involved in denitrification. Therefore, preliminary studies were conducted to investigate these effects and to standardise these methods for future use. The experiments involved incubations in an N_2 atmosphere (O_2 free) with and without C_2H_2, and DEA measurements with varying chloramphenicol concentrations (0-100 ppm). Also, AI technique was used to assess denitrification in samples of surface and sub-surface pasture soils from control sites and from corresponding sites to which urine had been applied, in order to observe the change in denitrification rate with incubation time, urine application and soil depth.

The results of the preliminary experiment showed denitrification rate and DEA were higher for the soils incubated with C_2H_2 than without C_2H_2 and suggested C_2H_2 had little effect on $N_2O + N_2$ production (denitrification) during the measurement period. There was no significant effect of <10 ppm chloramphenicol concentration on DEA, however higher concentrations caused a reduction in measured DEA. Application of urine-N increased denitrification rate up to 24 hours of incubation followed by slower or no increase, in the surface and sub-surface soil. The findings of these preliminary experiments were used to develop the protocols for these methods for future use in research.

CARBON DIOXIDE EMISSIONS FROM SOILS FOLLOWING CONVENTIONAL- AND NO-TILL SEED BED PREPARATION UNDER CONTROLLED LABORATORY AND FIELD CONDITIONS

Amandeep Singh Ghatohra[1], Surinder Saggar[2], M J Hedley[1] and C Ross[2]

[1]Institute of Natural Resources, Soil and Earth Sciences, Massey University,
[2]Landcare Research, Palmerston North

Rising atmospheric concentrations of carbon dioxide (CO_2) and associated global climate change has raised interest in developing strategies to mitigate these emissions. Land use and tillage practices contribute 20.1% of CO_2 emissions to total annual global anthropogenic GHG emissions (IPCC Report 2007). Conservation tillage namely no-tillage (NT), a seeding technique with least soil disturbance, has been recommended to reduce CO_2 emissions from cultivated soils (Ussiri and Lal 2009). However, there is little New Zealand data comparing the CO_2 emissions from conventional tillage (CT) and no-tillage (NT) on a range of soils. We report the results of CO_2 emission from NT (using Cross Slot opener which causes least amount of soil disturbance) and CT (using rotary tiller to 10 cm depth) treatments under controlled laboratory and field conditions.

Carbon-dioxide (CO_2) emissions were measured in the laboratory from four soils varying in physical-chemical properties and one soil in the field using the alkali trap method for up to 3-months following NT and simulated CT (ST) treatment. The total amount of CO_2 emitted under laboratory conditions from the four soils ranged between 1066 and 3077 kg CO_2-C ha^{-1} for ST, 924 and 2679 kg CO_2-C ha^{-1} for NT treatment. In general all the soils lost more CO_2 from ST (between 22 and 398 kg CO_2-C ha^{-1}) than NT treatment. Similarly, in field conditions total CO_2-C emissions were significantly higher under CT (2591 kg CO_2-C ha^{-1}) than NT (2226 kg CO_2-C ha^{-1}) treatment.

Carbon dioxide measurements taken from both the field chambers and field in-situ soil cores following CT/ST or NT treatments were similar in magnitude (~2500 kg CO_2-C ha^{-1}). The CO_2 emissions were significantly higher from CT/ST than NT treatment. In the field NT treatment produced 365 kg CO_2-C ha^{-1} or 1.3 t CO_2 ha^{-1}lower emissions than CT.

Overall the results of laboratory and field studies suggest that, depending soil type and the amount of crop residue, NT can conserve up to 1.5 t CO_2 ha^{-1}.

ENVIRONMENTAL FOOTPRINTING WITH OVERSEER® – 'THE WHOLE PICTURE'

David Wheeler, S Ledgard and M Boyes

AgResearch, Hamilton

The inputs into OVERSEER® Nutrient Budgets (*Overseer*) allow farm-specific greenhouse gas emissions (GHG) to be estimated. Since development of the original model, international Life Cycle Assessment (LCA) standards have been developed for reporting greenhouse or carbon footprints (e.g. PAS 2050) and increasingly, GHG for a unit of product (kg milk solids, kg meat, and kg wool) are required. *Overseer* required GHG footprint reports to cover on-farm-specific emissions and to provide carbon footprint of products from the 'cradle-to-farm-gate'.

Greenhouse gas emissions, converted to CO_2 equivalents on a 100-year basis, include methane, nitrous oxide and embodied GHG associated with inputs (fuel, electricity, fertilisers, supplements, chemicals, etc.) used on the farm and off-farm components such replacement animals grazed off-farm. Embodied emissions are determined using an LCA approach. Embodied GHG depend on the source of the inputs. However, when farmers purchase inputs the source is not always known. Therefore, typical average values are used to estimate embodied GHG to a primary depot or warehouse, and then farm specific information is applied. The GHG can be estimated with no additional inputs to the model, using defaults; alternatively, the user can input key information such as fuel and electricity use, transport distances, and fertiliser application methods. Changes in soil or plant carbon stocks are not included in the model.

The design of the model means that emissions can be allocated to individual animal types and then used to produce two distinct GHG footprints reports based on either area or product. Animals, supplements, and effluent can be moved between farms. Procedures were adopted to ensure that area footprints can be additive across farms.

The animal-based GHG are allocated to give output product (e.g. milk, meat, wool, velvet) footprints to the farm gate. In undertaking this analysis, emissions associated with breeding animals are allocated to output products (milk, wool or velvet), meat production and to breeding animals for meat production. This allows the possibility of total product emissions for meat to be built up from contributing farms.

The poster outlines the framework for the GHG footprint reports within *Overseer* that will be available in the next release of *Overseer*.

INTEGRATION OF DAIRY GOAT FARMING SYSTEMS INTO OVERSEER®

Bill Carlson, David Wheeler and Stewart Ledgard

AgResearch Ruakura, Hamilton

New Zealand has a long established dairy goat industry, which although relatively small is dynamic and innovative. Dairy Goat Co-operative (N.Z.) Ltd (DGC) is the main producer of products from goat milk in New Zealand. The product range from DGC is focused on nutritional products for infants and young children. These capitalise on the unique nutritional advantages of goat milk, and the New Zealand origin of the milk. Because of the nature of the product, and the sophistication of the market, quality systems are paramount. This begins with on-farm practices including environmental standards. In light of this, DGC and MAF (Sustainable Farming Fund) supported development of a dairy goat module within the OVERSEER® Nutrient Budget Model (*Overseer*) to enable farmers to understand and better manage nutrient losses and greenhouse gas emissions.

The development of an *Overseer* module for dairy goats requires an understanding of dairy goat farming systems as well as model input data specific to dairy goats. In comparison to dairy cow farming there is little published information about dairy goat farming systems in New Zealand.

Information collected by the DGC in its annual survey of farmer practices was used to identify five dairy goat farms in the Waikato area as study farms for use in the collection of information and data. These five study farms were selected to be "typical" and did not necessarily represent the full range of management types among dairy goat farms in the country. Two of the study farms manage goats outdoors on pasture all year, while the other three study farms operate fully indoor systems with cut-and-carry pasture and brought-in feed. In addition, data collected from three other indoor farm systems was used to provide a wider sample base.

The study farmers provided access to records and documented management practices. Samples of feed inputs and effluent outputs were collected and analysed for nutrient contents at regular intervals over time.

The dairy goat module was developed based on this survey and literature data, and will be available in the next release of *Overseer*.

NITROGEN FERTILISER AND URINE PATCH INTERACTION – USE OF APSIM TO AID EXPERIMENTAL DESIGN

Laura Buckthought[1,3], Val Snow[2], Mark Shepherd[3], TimClough[1], Keith Cameron[1] and Hong Di[1]

[1]Dep. of Soil and Physical Sciences, Lincoln University, Lincoln;
[2]AgResearch Ltd, Lincoln Research Centre, Private Bag 4749, Christchurch;
[3]AgResearch Ltd, Ruakura Campus, East Street, Private Bag 3123, Hamilton

Previous studies have shown that both leaching and gaseous (N_2O) losses from pasture-based systems occur predominantly from urine deposited by grazing animals, but also occur following fertiliser application. However, there is limited understanding of the interaction and fate of urinary N and fertiliser N.

The objective was to use APSIM modelling software to generate pre-experimental data to help determine hypotheses, and aid with the design of a lysimeter experiment to study the interactions of fertiliser N and urinary N on N leaching and N_2O emissions.

APSIM simulations were run to explore the likely fate of several combinations of urine and fertiliser N under experimental conditions normally imposed on lysimeters, using the weather record for Hamilton from 1972 to 2009. The soil type was the Horotiu silt loam, the urine patch was 800 kg ha^{-1} and fertiliser rates of 0, 200 and 400 kg N ha^{-1} yr^{-1} were used. The modelling suggested that:

- N leaching losses without fertiliser addition under autumn-deposited urine could be greater (74 – 327 kg N ha^{-1}) than under spring-deposited urine (0 – 133 kg N ha^{-1}).
- N leaching could increase with increasing fertiliser rate but differentially such that about 9% of the fertiliser applied to the autumn-deposited urine could leach but 28% of the fertiliser applied to the spring-deposited urine could leach.

Based upon prior knowledge and examination of data from the pre-experimental modelling, it is *hypothesised* that: N leaching losses will be greater under autumn-deposited urine than spring-deposited urine; there will be an additional effect on N leaching from fertiliser applied over the urine patch; the size of the additional effect will increase with increasing fertiliser rate and will be greater when applied to a spring urine patch than an autumn urine patch. The pre-experimental modelling suggested that the effects of fertiliser at 0, 200 and 400 kg N ha^{-1} yr^{-1} would be sufficiently different for the measured leaching to support or reject the hypotheses. The lysimeter trial, to commence in February 2011, will test these hypotheses.

WATER UPTAKE BY HILL COUNTRY PASTURE – MORE THAN YOU THINK

Mike Bretherton, D Horne, D Scotter and M Hedley

Fertilizer and Lime Research Centre, Massey University

Hill country pasture production on the east coast of the North Island is often constrained by moisture deficits during the summer and autumn months. To date, little has been published about the soil water balance of New Zealand hill country under pasture. It has been suggested that hill country soils have a small water storage capacity with moisture uptake limited to a depth of 150 mm, and that pasture growth is much more dependent on rainfall frequency than total annual rainfall (less than 50% of the annual rainfall is used to replenish the root zone moisture pool).

In this study, a trial site was established (April 2006) at Pori Station (22 km SSE of Pahiatua). Runoff plots (2 x 1 m) and climate stations have been installed on; both a steep (30^o) and shallow (20^o) slope of a north facing aspect, a steep and shallow slope of a south facing aspect, and two east facing aspects (steep slopes). Soil cores were taken at approximately monthly intervals for gravimetric water contents and bulk density data was used to convert these to volumetric water contents. Climatic data was gathered using a combination of a manual rain gauge and a NIWA meteorological station approximately 5 km distant.

Our research suggests that significant water extraction occurs to a depth of at least 350 mm and that between 65 and 80% of the annual rainfall contributes to the available soil moisture pool. A simplified water balance model based on the work of Bircham and Gillingham (1986) is described and discussed. It is hoped that this model will provide further impetus to research into the soil water balance of New Zealand hill country pasture systems and assistance to those people who manage these systems.

“GROUP ONE” – THE CASE FOR THE MIDDLE PATH

Dr Bert F Quin

Quin Environmentals (NZ) Ltd, PO Box 125 122, St Heliers, Auckland 1740, NZ.
Email: quinfert@xtra.co.nz, Web: www.groupone.co.nz

The fertiliser industry in New Zealand is controlled by a duopoly which comprises over 90% of the total market. These companies have both built enormous infrastructures throughout New Zealand, and are consequently extremely dependent on maximizing sales tonnages, particularly single superphosphate (SSP), potash, DAP and urea. Their research input is focused on pasture production, and more recently, means of reducing nitrogen (N) loss, but curiously almost entirely that from animal urine patches, not from urea fertiliser. There is little or no investigation into reducing P losses into waterways.

Increasing numbers of farmers are expressing concern regarding deterioration in soil ‘health’, aka soil biological activity. Compaction from over-stocking, reduction in clover vigour and N fixation from both increased shading from fertiliser N-fed ryegrass, and increasing numbers of, and susceptibility too, clover pests and diseases are some reasons. The two major companies have adopted a ‘not our problem’ policy with respect to these increasing problems, despite being owned by the very farmers who look to them for means of optimizing their soils’ productivity.

This ‘vision vacuum’ regarding farmers’ concerns together create opportunities for a second generation of ‘muck and mystery’ merchants, all claiming to have the ‘silver bullet’ farmers want. Thee companies are normally big on advertising but provide no useful hard data.

There are companies however that have good, promising products, developed on entirely rational grounds, which have the potential to greatly improve nutrient efficiency and/or improve soil biological activity.. However, because these companies are generally poorly resourced, they have very little ability to compete in the advertising and distribution worlds, or compete for Government funding. Consequently, they struggle to afford to carry out scientifically robust field trials at a range of locations.

“GROUP ONE” as been set up primarily to help these companies and their products, services and opinions a real voice in New Zealand agriculture.

A REVISED LEACHING MODEL FOR OVERSEER®
NUTRIENT BUDGETS

David Wheeler[1], Rogerio Cichota[2], Val Snow[3] and Mark Shepherd[1]

[1]*AgResearch Ltd,* [1]*Ruakura Campus, East Street, Private Bag 3123, Hamilton 3240;*
[2]*Grasslands Research Centre, Private Bag 11008, Palmerston North 4442;*
[3]*Lincoln Research Centre, Private Bag 4749, Christchurch 8140*

OVERSEER® Nutrient Budgets (*Overseer*) is an accounting tool for on-farm nutrient management. It calculates budgets for a range of nutrients (N, P, K, S, Mg, Ca and acidity) on the farm. Increasingly important features of the model are that (a) the budget includes robust estimates of nutrients losses by leaching/run-off and (b) it is able to calculate the effects of farm management practices on mitigation of these losses. *Overseer* continually undergoes development to ensure the most recent science is encapsulated in the model and that it is able to accurately represent a farm system. Consequently, the N model within *Overseer* has needed to develop from the original annual calculation basis to a monthly time-step to be able to better describe the interactions between urine deposition timing and load for the wide variety of climates and soils in New Zealand. This paper provides an overview of the revised N leaching model that is being implemented for the next *Overseer* release.

The approach was to set up and run APSIM (a more detailed process-based model) to simulate N leaching from a urine patch. Thousands of simulations were run for combinations of soils and climates across New Zealand. This firstly allowed the identification of key factors that *Overseer* needed to capture to adequately describe the movement of N through the soil profile. It was determined that the major soil property that affected leaching was the plant available water capacity.

Based on the APSIM simulations, a transfer function or ‘breakthrough curve’ was identified, which defined the relationship between cumulative N leached (relative to the maximum amount of leachable urine N for that system) and cumulative soil water drainage expressed as pore volumes (PV) drained. The curve could be defined by three points: the PV to the start of N leaching (PV_1); the PV where maximum leaching was reached (PV_3); and a mid-point (PV_2) which describes the degree of curvilinearity. We have developed relationships between annual precipitation and soil properties to describe the values of PV_1 to PV_3.

The revised model combines this transfer function with other subroutines that calculate the total urinary N pool in the soil and its partitioning to other processes (uptake, immobilisation, gaseous loss), and is currently being implemented for the next *Overseer* release (version 6).

NUTRIENT USE EFFICIENCY ON FARM – LESSONS FROM OVERSEER® EXAMPLES

David Wheeler and I Power

AgResearch, Hamilton

OVERSEER® Nutrient Budgets (*Overseer*) is a whole-farm nutrient budgeting tool. A large number of farms already have an *Overseer* analysis. Questioning at *Overseer* courses and meetings, and our analysis of some files indicates a trend is emerging on nutrient use efficiency: the need for attention to detail in farm management.

For nitrogen (N), N use efficiency can be defined as:

N use efficiency = product N / N input

N use efficiency typically varies from less than 25% to greater than 40%. High N use efficiency does not always imply lower per ha discharges. However, on farms with similar productivity and site characteristics, higher N use efficiency usually equates with lower discharges per ha.

N use efficiency can be improved by improving the conversion of N inputs into product. Optimising the use of effluent and improving timing and application rates of N fertiliser are two of the more obvious solutions. The use of high energy low N feeds also improves N efficiency. However, we receive a number of enquiries around *Overseer* calculating negative pasture production, or under-estimating pasture growth when supplements are feed out. This suggests that, practically, that supplement utilisation on many farms could be improved, with resultant benefits to calculated N efficiency. N use efficiency can also be reduced by other factors that reduce animal performance. Hence, optimising animal performance through animal health or genetics, and grazing management should not be overlooked. These are examples of attention to detail.

Some of efficiency in nutrient use is associated with inefficient use of N in dung or urine. N use efficiency can be improved by housing animals and then controlling the distribution of effluent back on the paddock. However, this may not always improve nutrient use efficiency, as there can be large losses, e.g. volatilisation and denitrification of N from stored manure, with associated potential increase in greenhouse gas emissions. This option may also increase the risk of larger losses from large point sources or during the re-application process.

We provide examples to illustrate these points.

ADDING WETLAND AND FILTER-STRIP MITIGATION OPTIONS TO OVERSEER

Kit Rutherford[1] and Dave Wheeler[2]

[1]NIWA, Hamilton and [2]AgResearch, Hamilton

Both artificial and natural wetlands have the potential to reduce N and P loadings from agricultural land. Notably denitrification in wetlands is known to reduce nitrate through denitrification. Grass filter strips have the potential to trap particulate N and P. A recent release of Overseer includes modules for these mitigation measures but feedback indicates that few people are comfortable using these new features. We describe the changes that had to be made to the hydrology module so that wetlands and filterstrips could be modelled using a daily timestep. Simplified models are used for wetlands and filter strips which require the user to provide input data based on local knowledge - data which some have found difficult to estimate. We discuss the strengths and weaknesses of the wetland and filterstrip models.

PARAMETER DEVELOPMENT FOR ADDING FODDER CROP TO OVERSEER® NUTRIENT BUDGETS
1. KALE AND TURNIPS

E Chakwizira[1]*, J de Ruiter[1], H Brown[1], D Wheeler[2] and M Shepherd[2]

[1]The New Zealand Institute for Plant & Food Research Limited, Christchurch
[2]AgResearch, Ruakura Research Centre, Hamilton
***Email: Emmanuel.Chakwizira@plantandfood.co.nz*

The OVERSEER® nutrient budgets program is a decision support model that helps users to account for inputs of nutrients and transfers and losses of nutrients within farming systems.The current version of the model covers the three main farming systems: pastoral, arable and horticultural cropping. However, the arable and horticultural cropping modules have not been as widely tested or improved as frequently as the pastoral module because of the lack of appropriate long-term data available to quantify nutrient balances under these two cropping systems. Forage brassicas account for nearly two-thirds of the land under crops every year (~300,000 ha) throughout New Zealand so the incorporation of data into the OVERSEER® nutrient budgets program for these crops is important. The parameters were derived from published papers. Where no published data could be found, data from experiments conducted by The Institute for Plant & Food Research Limited (Plant and Food Research; PFR) and expert opinion were used. The information we analysed suggested that mean dry matter yields for kale crops were around 12 t/ha while those for turnip crops were 6–8 t /ha. The data also suggested that plant tissue macro-nutrient concentrations of roots and residues were generally lower than those of the potentially grazed tops, except for phosphorus (P). For example, the nutrient concentrations of 4% nitrogen (N), 0.3% P and 4% potassium (K) for the grazeable tops compared with 2.5% N, 0.3% P and 2% K for the residues for kale crops. Crop utilisation decreased with increasing yields because higher yielding crops are more likely to have greater trampling losses. The lower utilisation for the higher yielding kale crops could also be attributed to higher stem: leaf ratios associated with increased dry matter yields. Although data from sales literature suggest differences in turnip DM yields and ME in favour of globe cultivars compared with `Barkant'; available literature and data at PFR from replicated experiments show no differences in these attributes. We suggest treating all turnip cultivars as similar until we have enough data to distinguish parameters for them. These parameters will be used by AgResearch scientists to develop fodder crop modules for incorporation into the OVERSEER® nutrients budgets.

A VALIDATION OF APSIM NITROGEN BALANCE PREDICTIONS UNDER INTENSIVE CROPPING

Joanna Sharp, Hamish Brown and Steve Thomas

New Zealand Institute of Plant and Food Research, Lincoln, New Zealand

There is a growing need within New Zealand for systems models to address the implications of management decisions on nutrient cycling and leaching. The Agricultural Production Systems sIMulator (APSIM) is a systems model which, through a suite of modules, enables the simulation of systems that cover a range of plant, animal, soil, climate and management interactions. While there has been extensive testing and calibration of the plant and soil modules of APSIM in Australian conditions, they have not been extensively tested in New Zealand conditions. In this paper we report a test of APSIM to simulate nitrogen dynamics by comparing with data from a three-year field experiment, designed to measure the effects of irrigation, fertiliser and crop rotation management on nitrogen losses.

Observed data were collected from a field trial with a factorial combination of crop rotation, nitrogen fertiliser rate and irrigation management. Main plots were established in spring 2004 with four replicates of two crop rotations (potatoes-winter wheat-winter fallow-potatoes and potatoes-winter fallow-spring peas-winter fallow-potatoes). Each main plot was split into two different irrigation rates (optimum and either increased frequency or increased amount), and these sub-plots were split again into three different nitrogen fertiliser rates (nil, optimum and excess). Measurements of soil mineral nitrogen, crop nitrogen and leachate nitrogen concentration were made at regular intervals throughout the trial.

Results showed that APSIM was successful at simulating the nitrogen balance of each of these treatment combinations. However, questions are raised about APSIM's estimates of nitrogen mineralisation, and percolation of mineral nitrogen through the soil profile. Possible causes for the differences between the simulated outputs and measured values will be discussed, and suggestions proposed for possible modifications to APSIM to better suit the soil and climate conditions present within New Zealand.

THE EFFECT OF FERTILISER PARTICLE SIZE ON SPREAD DISTRIBUTION

Ian Yule

NZ Centre for Precision Agriculture, Massey University, Palmerston North.

Delivering a consistent and accurate fertiliser spread pattern is key requirement for the spreading industry in order to meet current farming requirements and expectations. A large number of factors have been identified as having an effect on the distribution of fertiliser particles from a centrifugal spreader, these can be broken down into three main categories relating to; the environment where the spreading is taking place, the machine being used to spread the fertiliser and the fertiliser's physical characteristics. This paper will concentrate on the physical characteristics of the fertiliser material, with particular reference to particle size distribution within the material and the effect on spread pattern.

Due to the significant financial implications of inaccurate spreading, a great deal of scientific effort has been devoted to analyse and mathematically model the fate of fertiliser from a spinning disc. A number of approaches have been taken and these are reviewed to explain overall behaviour. Very little field work has been completed that would help explain and quantify what is happening.

A field study funded by FMRA to investigate issues around spreading blended fertilisers was used to attempt to analyse the fate of particles of different sizes from a Superphosphate Potassium Chloride blend. Two loads of the blend were used and the Superphosphate used was found to have differing physical characteristics and this was used to form an estimate of the effect of changes in particle size. A total of 1700 tray samples were analysed in detail and the particle size distribution of their contents measured, allowing the spread distribution of each particle size to be recorded. To allow for the fact that different amounts were being captured within individual transect tests the percentage of the particle sizes captured was calculated, transects from both loads were compared and found to be reasonably consistent. This information was then used to simulate different materials to estimate the effect of changes in particle size distribution on spread pattern.

A REVIEW OF TECHNOLOGIES FOR IMPROVED FERTILISER APPLICATION ACCURACY

Miles Grafton[1], Ian Yule[2] and Brian Rendle[1]

[1]Ravensdown Fertiliser Co-op Ltd, 32 Oxford Terrace, Christchurch, New Zealand.
[2]NZ Centre for Precision Agriculture, Institute of Natural Resources,
Massey University, Palmerston North, New Zealand..

There are a number of factors which contribute to the variability of fertiliser application in the field. Earlier work has highlighted the potential for high levels variability associated with the spreading vehicle and its operating environment. In response a number of technologies have been identified as potentially helpful in reducing this variation. This paper compares the technologies used in ground-spread application and the cost versus benefits difference expressed as an estimate of financial return in terms of pasture response for systems in common use.

From previous work, sources of error due to inaccurate driving, causing poor positioning of the vehicle, inaccurate repositioning post vehicle starts and stops, and the inability to control flow with variable vehicle speed have all been identified as contributing to ”in-field” error. As a result of driver error being identified as a significant contributing factor, many operators have installed GPS guidance assistance to their vehicles to improve accuracy. Unless differential correction is used to improve the positioning to within 0.2 m then there may be little benefit from GPS as potential positioning errors (± 8m) are about equal to the standard deviation in spread pattern. The model developed to measure in-field CV is therefore not applicable, as it requires accurate measurement of application tracks so that spread patterns can be accurately combined to spatially model the application rate.

Through further economic modelling it is suggested that using differential correction, automated flow control and automatic shut off to prevent multiple application provide economic benefits greater than the cost of application on high fertility dairy farm situations which respond in line with the Ball and Field (1982) Nitrogen response curve.

MODELLING FERTILISER BENEFITS FROM AERIAL TOPDRESSING

Miles Grafton[1], Ian Yule[2] and Mike Manning[1]

[1]Ravensdown Fertiliser Co-op Ltd, 32 Oxford Terrace, Christchurch, New Zealand.
[2]NZ Centre for Precision Agriculture, Institute of Natural Resources, Massey University, Palmerston North, New Zealand.

This paper draws on data provided through an earlier case study to quantify the costs and benefits of fulfilling the fertiliser (nitrogen and phosphate) needs of a property using either DAP, or, urea and superphosphate. The performance of the application of nitrogen and phosphate on Limestone Downs is based on data of the aerial spread achieved in August 2005, whilst sowing di-ammonium phosphate (DAP).

The spread operation was heavily monitored and the data set came from point data collected from the topdressing aircraft. The hopper openings were recorded using a potentiometer, alongside the location data recorded from differential global positioning system (DGPS). The hopper openings and flow rates were measured statically at Ravensdown, Aramoho store in order to calculate fertiliser application rates.

Geostatistics were applied to the point data to establish a CV for the spreading operation over every square meter of the property; and this approach was taken to model a hypothetical application based upon this CV, but varying the product applied and the response models. Nitrogen response is measured in kilograms of dry matter per kilo of elemental nutrient supplied. Nitrogen was measured against a response curve; and also using a decision tree model. Phosphate response was quantified using a decision tree model. The data set suggests that the difference between modelled actual application accuracy and targeted application is between $34 and $41 per hectare per application, although there is still an actual net benefit of applying fertiliser. This benefit is between 2 to 2.5 times greater than the cost of application. This suggests there is an opportunity to improve fertiliser response by applying fertiliser more accurately.

The best results are obtained by applying DAP a high analysis fertiliser which applied the targeted nitrogen and phosphate in one application in August. The returns are reduced by applying phosphate as superphosphate and nitrogen as urea in separate applications, a necessity by aircraft. The main reason for this is that the cost of separate applications is greater; and the cost of off target application is cumulative.

It would appear that applying low analysis fertiliser such as superphosphate (P, 9.1%) by aircraft is more costly than applying high analysis fertiliser, which although more costly to apply per tonne, is cheaper per kilogram of nutrient. However, this ignores the pasture response from the sulphur and calcium content of superphosphate applied in the form of calcium sulphate. It has been found that in some pasture which has received little or no sulphur for some years; the response to sulphur is greater than the response to phosphate.

USE OF CROP SENSORS IN WHEAT AS A BASIS FOR APPLYING NITROGEN DURING STEM ELONGATION

Rob Craigie and Nick Poole

Foundation for Arable Research (FAR), PO Box 80, Lincoln, Canterbury, New Zealand

Wheat crops are responsive to the application of nitrogen (N) fertiliser typically increasing yield by 40% in FAR trials over unfertilised crops. Currently, most growers calculate their N requirements with a nutrient budget using soil mineral N test results and potential yield. This practice may result in insufficient or excessive N fertiliser rates in any given year and across a paddock with variable soil mineral N and yield. Therefore, a more accurate estimate of plant N requirements is required for economic and environmental sustainability.

Measurement of canopy reflectance with crop sensors has the potential to use the plant as an indicator of N requirements. In wheat crops N is typically applied in two or three applications. It is envisaged that normalised difference vegetation index (NDVI) may be used to better assess N requirements at the second and third applications to determine which zones will or won't respond to further applications of N. Therefore, crop sensors, measuring the reflectance from the cereal crop canopy, may offer a better opportunity of matching crop needs to nitrogen input, when combined with GPS technology.

The objective of this study was to determine if crop sensing could be used to assess the in-season plant N status of wheat under different sites, environmental conditions and cultivars. For two seasons, crop NDVI has been collected with a Greenseeker optical sensor as a measurement of crop N status and dry matter production. Following the application of N, a significant and strong curvilinear relationship was found between N uptake and NDVI.

ADAPTATION OF OPTICAL SENSORS TO DETECT URINE AND DUNG PATCHES IN DAIRY PASTURE

Jemma Mackenzie[1], Reid Christianson[2], Craige Mackenzie[1] and Ian Yule[2]

[1]Agri Optics NZ Ltd, 337 Reynolds Rd, RD 6, Ashburton, Canterbury, New Zealand.
[2]NZ Centre for Precision Agriculture, Institute of Natural Resources, Massey University, Palmerston North, New Zealand.

Nitrogen leaching from dairy pasture continues to be a major concern. Nitrogen from urine patches has been identified as making a significant contribution to N losses through leaching, due to high nitrogen loadings and the plant's inability to utilise that nitrogen before winter drainage. A typical dairy cow will urinate approximately 11 times a day, each urine patch is estimated to cover 0.3m^2 and therefore at stocking rates of approximately 100 cows per hectare significant parts of the paddock will be under urine patches after each grazing. Therefore does it make sense to continue to add additional nitrogen in the form of nitrogen fertiliser if it can be avoided?

Fertilising urine patches on dairy farms leads to luxury levels of nitrogen being present which further increases the risk of leaching as well as reducing the nutrient use efficiency of the fertiliser. A system called Smart N® has been developed that applies liquid nitrogen to pasture but avoids application to the urine and dung patches. The system uses four Trimble WeedSeeker® optical sensors in a system modified to detect the existence of urine and dung patches and controls the spray unit. These sensors were originally designed to sense weeds in a fallow field and activate the application of herbicide, in this pasture application the technology has been adapted to sense grass patches that are "greener" than surrounding pasture. This precision fertiliser application will help in reducing excessive application, produce more even growth while reducing overall fertiliser application as well as reducing nitrogen leaching as the majority of N leached from pasture is already coming from urine patches.

A modified system was developed to record activation of the system to test the ability to identify and omit urine patches from fertiliser treatment. In order to log the data for analysis, a data acquisition systems was built to record and log results (with GPS location) to a field computer.

The initial research had two phases: First, a trial was set up to look at pasture response over time after fertilization, which is intended to be a patch simulation. Second; was a paddock scale trial which manually logging urine and dung patches with an RTKDGPS system and comparing these with the levels of detection achieved by the Smart N® system. Preliminary results indicate that sensor calibration is key to the success of the system.

PASTURE QUALITY MEASUREMENT TOOLS FOR DECISION MAKING

Reddy Pullanagari[1], Ian Yule[1], Mike Tuohy[1],·Robyn Dynes[2] and·Warren King[3]

[1]New Zealand Centre for Precision Agriculture, Institute of Natural Resources, Massey University, Palmerston North, New Zealand.
[2]AgResearch Limited, Lincoln Research Centre, Lincoln, New Zealand
[3]AgResearch Limited, Ruakura Research Centre, Hamilton, New Zealand.

Pasture quality is an important component in grazing and livestock management and a key driver of animal performance. Accurate, real-time information on pasture quality can help farm managers in decision making. This study investigated the potential applicability of optical sensors to estimate pasture quality parameters in the field, these have been trialled as part of the P21 Feed Programme, (FORST Contract number: C10X0604). This paper summarises two spectral approaches which have been taken to investigate the potential:

1) The Multispectral approach is where sensing devices (Crop Circle and Crop Scan) have a limited number of spectral bands, around the VIS and NIR parts of the spectrum with broad spectral resolution, these can be used to estimate pasture quality parameters such as crude protein.
2) A Hyperspectral approach provides fine resolution, using reflectance data spanning from 350 nm to 2500nm, to derive estimates of crude protein, acid detergent fibre, neutral detergent fibre, metabolisable energy, lignin and organic matter digestibility.

To extract spectral information and to correlate with reference values, various statistical tools (univariate and multivariate techniques) were used. All in-field measurements were supported by an extensive programme of laboratory NIR and wet chemistry measurements for calibration and validation. Initial results suggest that pasture quality parameters such as crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF), ME, ASH, lignin and OMD can be accurately estimated using optical sensors and associated statistical methods, providing a useful management tool for farmers.

A COMPARISON OF CROP SENSOR SYSTEMS FOR INFORMING FERTILISER PLACEMENT SYSTEMS

Ian Yule[1], Jemma Mackenzie[2], Michael Killick[1] and Craige Mackenzie[2]

[1]*NZ Centre for Precision Agriculture, Massey University, Palmerston North*
[2]*Agri Optics NZ Ltd, 337 Reynolds Rd, RD 6, Ashburton, Canterbury*

A number of optical devices have been available to farmers to measure the development of growing crops such as cereals, brassica, maize and ryegrass for seed production. These vehicle mounted sensors are linked to GPS so that the position of the readings is recorded and can be accurately mapped in order to inform variable rate fertiliser or growth regulator application. Estimates of crop biomass are made using optical sensors which operate at discrete wavelengths in the visible and near infrared region of the electromagnetic spectrum. The most usually accepted method is to use the Normalised Difference Vegetation Index (NDVI) of the crop and relate that to biomass.

Under the Sustainable Farming Fund Project, Crop Sensing for Improved Nitrogen Use Efficiency, managed by the Foundation for Arable Research, three commercial systems which are available to farmers in New Zealand were used and their results compared with cut samples. The systems were; Greenseeker® from Trimble, Crop Circle® from Holland Scientific, and CropSpec® from Topcon. Each sensor uses at least two wavebands, with one in the visible range and the other in the near infrared, the Crop Circle sensor used (Crop Circle 470) had a third channel. Two main questions were considered. What is the level of accuracy of these sensors and, to what extent are the results from one sensor comparable to another system?

The systems were tested in a range of crops on farms in both the North and South Islands over a range of crop growth stages. The systems operate at slightly different wavebands and have slightly different sampling footprints but are intended for the same purpose. The collected data was mapped in a GIS package and the geo-referenced data was analysed to determine the relationships between sensors in the different crops, as the crop development was tracked. The results of one season's data collection and analysis are presented from the sites measured under the project.

THE ORCHARD WATER FOOTPRINT OF NEW ZEALAND KIWIFRUIT – UPSCALING FROM THE ORCHARD TO THE COUNTRY

Markus Deurer[a], Steve Green[a], Brent Clothier[a] and Alistair Mowat[b]

[a]Production Footprints Team, The New Zealand Institute for Plant & Food Research, Palmerston North, New Zealand
[b]ZESPRI International Limited, Mount Maunganui, New Zealand

A water footprint (WFP) assesses the impact of the life cycle of a product on the scarcity and quality of water resources. The WFP can be used as one indicator for environmental sustainability. Supermarket chains (e.g. Walmart) increasingly demand from suppliers the 'eco-verification' of their products in their quest to attract more consumers. WFPs are also already used by companies to enhance their 'green' branding (e.g. Unilever), and as a planning tool, for example, to identify the best region or supply chain for their future expansion.

In an ongoing project funded by ZESPRI and MAF and in cooperation with Landcare Research and AgriLink we are assessing the WFP of New Zealand's ZESPRI GREEN kiwifruit.

In the project we had to overcome two upscaling issues for the orchard phase of the life cycle. Firstly, how can we derive a WFP for the national scale, and, secondly, how can we guarantee a robust result that is not biased by particular weather events? We developed the following three-step strategy. (1) We used measurements from orchards to parameterize and validate the SPASMO model for simulating kiwifruit production including soil-plant-atmosphere water dynamics. (2) We then simulated kiwifruit production separately for each kiwifruit growing region in NZ using the region-specific soils, climate, and irrigation management. We avoided the bias of climatic fluctuations by simulating over a 30-year climate record and taking the average. (3) We weighted the regional WFPs by their contribution to the national kiwifruit harvest.

We will present and discuss our upscaling strategy and the WFPs for NZ's ZESPRI GREEN kiwifruit for the orchard phase of their life cycle for the various regions and for New Zealand.

A NATIONAL CADMIUM MANAGEMENT STRATEGY FOR NEW ZEALAND AGRICULTURE

Gerald Rys on behalf of the Cadmium Working Group

Ministry of Agriculture and Forestry, 25 the Terrace, Wellington
Email: gerald.rys@maf.govt.nz

Cadmium is a naturally occurring heavy metal in soils. Current dietary surveys for New Zealander's indicate that the daily intake of cadmium is lower than the World Health Organisation (WHO) tolerable monthly intake guidelines. It is unlikely that at current food cadmium levels there are any adverse health implications for the New Zealand population. However, there is potential for the intake guidelines to change in the future with new science, and there is a need for continued vigilance.

Phosphate fertiliser is the primary source of cadmium accumulation in agricultural soils, and the fertiliser industry has imposed a voluntary limit on the levels of cadmium in fertilisers since 1995. However, low cadmium sources of phosphate rock are limited in supply. There are no commercially viable processes for removing cadmium from rock phosphate. The gradual accumulation of cadmium in NZ soils is therefore likely to continue in the immediate future.

In response to concerns about the continued accumulation of cadmium, the Chief Executive Environmental Forum (CEEFs) established the Cadmium Working Group (CWG) supported through the Ministry of Agriculture and Forestry in 2006. The Working Group was tasked with assessing the potential risks of cadmium in New Zealand's agriculture and food systems, and to develop responses.

This paper presents the final of three reports, endorsed by the CEEFs, which sets out the CWG's strategy for managing cadmium over the long term. It is intended to stand for the next seven years whilst information is collected and research undertaken to fill key knowledge gaps, with the aim of a review at the end of the period to determine progress and future directions.

The strategy's objective is "***To ensure that cadmium in rural production poses minimal risks to health, trade, land use flexibility and the environment over the next 100 years."***

The strategy presents an exemplar of industry / regional and central government cooperation in the development of a voluntary approach to address the accumulation of an element that has the potential to be an issue in the long term.

NEW ZEALAND'S P FERTILISER DEMAND AND ASPECTS OF P RE-CYCLING FROM FEEDSTUFFS AND MANURES

M J Hedley[1], H Furness[2] and J Fick[3]

[1]Fertilizer and Lime Research Centre, Massey University, New Zealand
[2] Seven Consulting Group. New Zealand.
[3] PIANZ, Wellington New Zealand

Ninety five percent of P applied in New Zealand is used to maintain productivity of the more productive legume-based pastures of dairy, sheep and beef and deer farms. Past variations in the amounts of P applied can be explained by the volatile profitability of the export sheep and beef industry. Analysis of fertiliser recommendations for the pastoral industries indicates that the current (2009/10) amount of P applied, 108 x 10^3 t P/y, is 40 x 10^3 t P/y less than the application rate required to maintain soil P fertility status.

The financial outlook for sheep and beef farms is relatively stable, whereas dairying is predicted to expand with the market place continuing to support increasing prices for milk products. Current and future expansion of dairying is predicted to take a larger share of the P applied. The opportunities for further replacing imported P fertiliser with organic P recycled from farm effluents and urban wastes are limited because low amounts of P are contained in such wastes, which with the exception of sewage are already applied to land, some being accounted for in farm nutrient budgets.

Given that the current amount of P applied nationally is calculated to be below "maintenance" levels for pastoral farms, then both future fertiliser recommendations, and the finances of the overall pastoral industry (led by dairying), should support a slow recovery in the amounts of P applied to maintenance levels of approximately 174 x 10^3 t P/y. This expectation is predicated on the fact that increases in farm income will stay apace with increases in farm costs, including fertiliser. Increased farm costs are expected from the introduction of a greenhouse gas (GHG) emissions trading scheme (NZETS) for agriculture from 2015 onward. It is expected that this will be managed carefully as exports of agricultural produce currently return 48% of New Zealand's export revenue.

NITROGEN FERTILISER ADVICE
– WHAT PROGRESS CAN WE MAKE?

Mark A Shepherd and Gina M Lucci

AgResearch Ltd, Ruakura Campus, East Street, Private Bag 3123, Hamilton 3240

Fertiliser N use has increased in recent years in New Zealand, especially in the dairy sector. As the pastoral sector strives for productivity gains with smaller environmental impact, efficient use of N fertiliser inputs becomes critical. The aims of this paper are to provide a stock take of current knowledge, and to identify areas of possible improvement in N fertiliser recommendations for pasture.

Although there is a need for a strategic farm plan around N fertiliser use (e.g. site potential for pasture production, annual feed requirements and balance between pasture supply and use of supplements), farms continually need to make tactical decisions around the next N fertiliser application in response to weather conditions and production requirements.

Whist the general principles and key drivers of N response are understood, the challenge is converting the knowledge into specific (tactical) recommendations. Case studies from the UK and Australia confirm the challenge is not unique to New Zealand, and also show that different countries adopt different approaches to advice. However, what is common to both UK and Australian examples is that N fertiliser recommendations are well documented in advisory literature.

Data collected from 80 years of N fertiliser trials throughout New Zealand have shown that only weak relationships between environmental factors and pasture N response can be determined using the entire dataset. However, once trials are separated into regions and seasons, clearer relationships are seen - which can be used to generate more specific recommendations. A limitation is that previous experiments have been unevenly distributed throughout the country and by season.

Suggestions for improved advice include:

- Better synthesis and utilisation of existing data to support on-farm decisions
- Development of specific decision support tools for N fertiliser management
- Exploration of on-farm monitoring of environmental conditions to support decisions around N fertiliser timing and rates
- A focus on critical periods, early spring and autumn/winter

LIFE CYCLE ASSESSMENT OF LOCAL AND IMPORTED FERTILISERS USED ON NEW ZEALAND FARMS

Stewart Ledgard[1], Mark Boyes[1], Sandra Payen[2] and Frank Brentrup[3]

[1]AgResearch Ruakura Research Centre, Hamilton, New Zealand
[2]INRA, France
[3]Yara GmbH & Co. KG, Postfach 1464, D-48235 Duelman, Germany
Email: stewart.ledgard@agresearch.co.nz

Life Cycle Assessment (LCA) refers to a methodology for determining the total use of resources and environmental emissions throughout the life cycle of a product or system. In recent years its use has focused a lot on the total amount of greenhouse gases (GHGs) emitted throughout the life cycle (commonly called a 'carbon footprint').

In New Zealand (NZ) agricultural systems, fertilisers represent a critical input to achieve long-term productivity. The production and use of fertilisers are associated with the utilisation of a range of important resources and include some environmental emissions.

The purpose of this study was to apply LCA to examine the energy use and GHG emissions for a range of the main fertilisers used on NZ farms. The study was supported by MAF, FertResearch, Ballance Agri-nutrients and Ravensdown.

The research illustrated differences in the "hot-spots" for resource use and environmental emissions throughout the life cycle of various fertilisers and results from this will be presented. For example, most energy use and GHG emissions for urea were associated with the manufacturing stage, whereas for superphosphate they were associated with the transportation of raw materials to the manufacturing plant (e.g. phosphate rock from North Africa and sulphur from central Canada).

Results were determined for the average energy use and GHG emissions for some different fertiliser products, including NZ superphosphate and imported triple superphosphate. Data was collected from all NZ superphosphate manufacturing plants and used to determine a weighted-average. Results indicated that NZ superphosphate is produced with lower total energy use and GHG emissions per kg P at an NZ plant or port compared to imported triple superphosphate based on an average for European manufacturing and the main countries from which it is sourced (including shipping to an NZ port).

Results will also be presented on the contribution of fertilisers to the total energy use and GHG emissions throughout the life cycle of milk produced on NZ farms through to the farm-gate stage.