

# INMS 1.1.2 Dairy NUE

NERC 5276/6053 - Q4-T-2018 -  
2018:Q4 Progress Report and 1.1.2D3  
Meeting Report delivered.

17th December 2018



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## Task 1.1.2: Development of farm nitrogen budgets

### Task Output 1.1.2: Guidance Document on Dairy Farm Nitrogen Budgets

**Project title:** Development of nitrogen performance indicators for dairy production systems

## INTRODUCTION

Nitrogen performance indicators are useful tools to evaluate nitrogen (N) use outcomes of an agricultural system and/or the risk of N losses at the farm and paddock scale. Generally used approaches include N use efficiency (NUE), farm-gate and soil-surface N surplus calculations. Furthermore, component-based N indicators, which are applicable through the soil, pasture, animal product and excreta continuum, provide greater insights into key N fluxes and transformations impacting on N recovery and farm productivity and improving management decisions.

However, methodologies for calculating and utilising these indicators are often inconsistent and can vary between countries/regions and individual users. As a result, recommendations and decision-making on improved N management can be inconsistent.

Greater standardisation of within-farm N efficiency metrics and reporting frameworks will enable the broader agricultural sector and policy makers to: i) equitably benchmark systems in an international context; ii) identify systems and management decisions for improved farm productivity and reduced environmental losses; and iii) enhance between-region/country comparisons and allow tracking of performance improvements over time.

This requires the development of internationally recognised standards for quantification, including relevant data requirements, approaches for measurement and associated sensitivity, as well as application within decision support systems.

## PROJECT OUTCOMES

To improve the sustainable intensification of dairy systems, through greater international harmonization of relevant whole-farm and within farm N balance indicators.

### Science questions:

1. What are the key N performance indicators that inform and improve N management decisions and reduce N losses for dairy systems?
2. How should these be estimated?
3. What are realistic targets and performance guidelines?

## PROJECT OBJECTIVES

We will use this project to harmonise international expertise, knowledge and approaches and develop an appropriate set of indicators for practical application for dairy farming systems. Furthermore, the project will capitalise on the international datasets available to develop and test our set of indicators. NUE and N surplus targets will also be set in the context of other agro-environmental considerations such as nutrient loss pathways and greenhouse gas emissions (GHG) emissions.

## PROJECT TEAM

International Project team: The 18 project participants represent 7 international regions and 12 organisations.



Team members present at the December 2018 workshop

- Cameron Gourley (Joint Task Leader), Agriculture Victoria Research, Australia
- Tom Misselbrook (Joint Task Leader), Rothamsted Research, UK
- Sharon Aarons, Agriculture Victoria Research, Australia
- Gemma Heemskerck, Agriculture Victoria Research, Australia
- Cecile de Klein, AgResearch, New Zealand
- Tommy Dalgaard, Aarhus University DK
- Cláudia S C Marques-dos-Santos Cordovil, Instituto Superior de Agronomia, DCEB, Portugal
- Shabtai Bittman, Agriculture and Food Canada
- Yoshitaka Uchida, Hokkaido University Japan
- Karl Richards, Teagasc, Johnstown Castle, Wexford. Ireland
- John Lory, University of Missouri
- Lin Ma, The Chinese Academy of Sciences, China

Additional team members unable to attend.

- Zhaohai Bai, The Chinese Academy of Sciences, China
- Barbara Amon, Leibniz Institute for Agricultural Research, Germany.
- Karin Groenestein, Wageningen UR, The Netherlands
- Mark Shepherd, AgResearch, New Zealand
- Nick Hutchings, Aarhus University DK
- Marta Alfaro, INIA, Chile.



## REGIONAL WORKSHOPS

### Improving environmental outcomes for Intensive Animal Industries

Symposium 3 – 4<sup>th</sup> December 2018 Melbourne Australia.

Animal production systems are becoming more intensively managed in Victoria, Australia and globally as demand grows for food worldwide. It is important to understand global trends and changes in animal production systems, and approaches to improve environmental outcomes.

Agriculture Victoria hosted a two-day Symposium focusing on industry, science and policy engagement.

During the symposium, international and national scientists and industry specialists presented a total of 26 papers on the following topics:

- Changing nature of animal production systems, globally and locally
- Managing for greater nutrient fluxes and use efficiencies
- Improving water quality outcomes
- Manure management, gaseous emissions and land application
- International and local policy instruments and approaches

There were 148 registered participants at the event, with the audience representing industry partners (dairy, beef, chickens, pigs industries), industry consultants and some farmers, and government policy, government and university research organisations, catchment authorities, landscape planning and regulators, and EPA.

All presentations were video recorded, and the symposium presentations will be available in mid-December via the Agriculture Victoria Sustainable Agricultural Industries webpage links.



A 2-day symposium hosted by Agriculture Victoria

Dates: 3<sup>th</sup> - 4<sup>th</sup> December 2018

Venue: AgriBio, Centre For AgriBioscience, La Trobe University, 5 Ring Rd, Bundoora VIC 3083

Animal production systems are becoming more intensively managed in Victoria, Australia and globally as demand grows for food worldwide. It is important to understand global trends and changes in animal production systems, and approaches to reduce environmental impacts.

This two-day symposium will include presentations from international and local science, industry and policy experts, and interactive panel discussions.

For further details, contact:

Dr. Cameron Gourley, Agriculture Victoria  
cameron.gourley@ecodev.vic.gov.au  
Phone: 0417316251

Limited seating is available, so it is important to register.

To register go to: [https://intensive\\_animal\\_industries\\_symposium.eventbrite.com.au](https://intensive_animal_industries_symposium.eventbrite.com.au)

Economic Development,  
Jobs, Transport  
and Resources



Topics will include:

- The changing nature of animal production systems, globally and locally
- Managing for greater nutrient fluxes and use efficiencies
- Improving water quality outcomes
- Technological advances for manure management to reduce emissions and improve nutrient retention
- International and local policy instruments and approaches.

## SYMPOSIUM PROGRAM

## Symposium Program

Improving Environmental Outcomes for Intensive Animal Industries  
3 - 4 December 2018, AgriBio, Bundoora, Victoria



## Monday 3 December 2018

Time	Speaker
9:00 - 9:50	Registration / coffee
<b>Opening Session</b>	
<b>Chair: Claire Flanagan-Smith, Principal, RMCG</b>	
10:00 - 10:05	Introduction Acknowledgment of Country <b>Claire Flanagan-Smith</b> RMCG
10:05 - 10:20	Welcome to Agriculture Victoria <b>Mike Goey</b> Agriculture Victoria
10:20 - 10:30	Welcome to AgriBio Overview of Agriculture Victoria Research and role in contributing to science and policy outcomes. <b>German Spangenberg</b> Agriculture Victoria
<b>Theme 1: Understanding the changing nature of animal production systems: locally, nationally and globally</b>	
10:30 - 10:45	<b>Facilitated audience discussion</b> • Participant aims and desired outcomes <b>Claire Flanagan-Smith</b> RMCG
<b>Policy overview</b>	
10:45 - 11:00	Changing nature of animal production systems in Victoria and Australia; intensification, diversification, de-intensification of production systems <b>Julie Simons</b> Agriculture Victoria
11:00 - 11:15	Changing expectations of community and challenge for animal industries in maintaining its social license <b>Kath Rowley</b> Victorian Department of Environment, Land, Water and Planning
<b>Industry overview</b>	
11:15 - 11:30	Poultry <b>Peter Scott</b> Scaexia
11:30 - 11:45	Beef and sheep <b>Des Rinehart</b> Meat and Livestock Australia
11:45 - 12:00	Dairy <b>Alison Kelly</b> Dairy Australia
12:00 - 12:15	Pigs <b>Grantley Butterfield</b> Australian Pork Limited
12:15 - 12:45	<b>Q &amp; As - All Speaker Panel</b> • What are the main environmental issues facing intensification of animal industries? • What is needed to progress industry towards a positive future? <b>Claire Flanagan-Smith</b> RMCG
12:45 - 13:30	<b>Lunch</b>

## Improving Environmental Outcomes for Intensive Animal Industries

3 - 4 December 2018, AgriBio, Bundoora, Victoria

### Monday 3 December 2018

Time				Speaker
<b>Changing nature of international animal production systems</b>				
<b>Chair: Joe Jacobs, Research Director, Agriculture Victoria Research, Agriculture Victoria</b>				
13:40	14:00	<i>International</i>	Livestock transition in China and global impacts	<b>Lin Ma</b> China
14:00	14:20	<i>International</i>	Changes in swine and poultry production systems in the USA	<b>John Lory</b> USA
14:20	14:40	<i>International</i>	Importance of quantifying nutrient fluxes, nutrient balances and efficiencies	<b>Cláudia Cordovil</b> Portugal
14:40	15:00	<i>International</i>	Recent trends in Hokkaido style dairy farming in Japan in relation to difficulties in nutrient budgeting	<b>Yoshitaka Uchida</b> Japan
15:00	15:20	<b>Q &amp; As - All Speaker Panel</b>		<b>Claire Flanagan-Smith</b> RMCG
15:20	15:50	<b>Afternoon tea</b>		
<b>Theme 2: Nutrient balances, use efficiencies and water quality</b>				
<b>Chair: Angela Avery, Research Director, Agriculture Victoria Research, Agriculture Victoria</b>				
15:50	16:10	<i>International</i>	Managing nutrient losses and water quality in Ireland	<b>Karl Richards</b> Ireland
16:10	16:30		A paradigm shift in managing dairy manure in Victoria	<b>Scott McDonald</b> Agriculture Victoria
16:30	16:50		Addressing the threat of excess nutrients and pathogens to waterways and groundwater	<b>Andrew Western</b> University of Melbourne
16:50	17:20	<b>Q &amp; As - All Speaker Panel</b>		<b>Claire Flanagan-Smith</b> RMCG
<ul style="list-style-type: none"> <li>• What are the innovations that will help industry and community to protect our waterways?</li> <li>• What are the proactive changes that are setting industry towards a positive future?</li> </ul>				
17:20	18:30	<b>Networking event</b>		





## Improving Environmental Outcomes for Intensive Animal Industries

3 - 4 December 2018, AgriBio, Bundoora, Victoria

### Tuesday 4 December 2018

Time				Speaker
8:45	9:00	<b>Recap Day 1</b>		Claire Flanagan-Smith
<b>Theme 3a: Manure: Management, gaseous emissions and odor</b>				
Chair: Terry Batey, Manager, Dairy Services, Biosecurity and Agriculture Services, Agriculture Victoria				
9:00	9:20	<i>International</i>	Managing nutrient and GHG emissions from ruminants and manure	Tom Misselbrook UK
9:20	9:40	<i>International</i>	Manure practices for reduced ammonia emissions in a largely unregulated environment	Shabtai Bittman Canada
9:40	10:00		Opportunities for biogas generation from manure	Stephan Tait University Southern Queensland
10:00	10:20	<b>Q &amp; As - All Speaker Panel</b>		Claire Flanagan-Smith RMCG
		<ul style="list-style-type: none"> <li>What is the one thing you would do/research/implement that will transform our environmental performance in reducing odor and GHG emissions?</li> </ul>		
10:20	10:45	<b>Morning tea</b>		
<b>Theme 3b: Manure: Enhanced nutrient capture, reuse and application technologies</b>				
Chair: Cameron Gourley, Senior Research Scientist, Agriculture Victoria Research, Agriculture Victoria				
10:50	11:05		Nutrient fluxes, spatial distribution and nutrient use efficiencies in dairy systems	Sharon Aarons Agriculture Victoria
11:05	11:20		Chemical and physical modification of manure to retain nutrients and reduce gaseous emissions	Bruce Shelley Agriculture Victoria
11:20	11:40		Current and future waste water treatment technologies for managing animal waste streams	Xiwang Zhang Monash University
11:40	12:00		Potential solutions for poultry waste streams	Byron Stein New South Wales Department of Primary Industries
12:00	12:20	<b>Q &amp; As - All Speaker Panel</b>		Claire Flanagan-Smith RMCG
		<ul style="list-style-type: none"> <li>What is the one thing you would do/research/implement that will transform our environmental performance in managing nutrients?</li> </ul>		
12:20	13:00	<b>Lunch</b>		



## Tuesday 4 December 2018

Time				Speaker
<b>Theme 4: Policy instruments and regulations</b>				
Chair: Mike Gooley, Executive Director, Agriculture Victoria				
13:00	13:20	<i>International</i>	The intersection between science and policy in defining guidelines and regulations for intensive animal industries	<b>Tommy Dalgaard</b> Denmark
13:20	13:40	<i>International</i>	Policy approaches for improving farm production and environmental outcomes in New Zealand	<b>Cecile De Klein</b> New Zealand
13:40	14:00		Tools to improve environmental performance – what motivates their uses?	<b>Joanne Campbell</b> Agriculture Victoria
14:00	14:30		Victorian land use planning and environmental protection reforms	<b>Andrew Gear</b> Victorian Department of Environment, Land, Water and Planning <b>Paula Bradshaw</b> Environment Protection Authority Victoria
14:30	15:15	<b>Facilitated Q &amp; A panel discussion:</b>		<b>Claire Flanagan-Smith</b> RMCG
		<ul style="list-style-type: none"> <li>• Are the international learnings adaptable to Australian intensive livestock issues?</li> <li>• What are the logical next steps for Australia to support these industries?</li> <li>• What are the main R&amp;D gaps supporting intensive animal agriculture?</li> </ul>		
15:15	15:30	<b>Closing Remarks</b>		
				<b>Mike Gooley</b> Agriculture Victoria



## SPEAKER DETAILS

## Symposium Key Speakers

3 - 4 December 2018, AgriBio, Bundoora, Victoria

**Mike Gooley**

Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, Australia

Mike is the Executive Director of Agriculture Policy, Agriculture Victoria, in the Department of Economic Development, Jobs, Transport and Resources. He is a senior executive with more than 20 years of experience in the public sector. He has deep expertise in corporate strategy, strategic policy, policy and program development – particularly in agriculture, environment, natural resource management and rural development. He has delivered a variety of flagship initiatives for government, and his leadership experience includes portfolios with more than 200 staff and budgets of over \$200M. He has strong skills in stakeholder engagement, program delivery and business development.

**Dr Julie Simons**

Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, Australia

Julie Simons is the Director Agriculture Industry and Rural Transition, Agriculture Victoria in the Department of Economic Development, Jobs, Transport and Resources. She is an experienced representative of the Victorian Government with expertise in policy formulation and implementation, industry research and development, and agricultural and stakeholder engagement.

Julie's portfolio of responsibilities includes land-use planning policy, drought and natural disaster policy, rural women and young farmer programs. Julie is also a director on the Dairy Food Safety Victoria board, and a member of the National Centre for Farmer Health's Advisory Committee.

**Professor German Spangenberg FTSE PSM**

Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, Australia

Professor Spangenberg is Deputy Secretary, Agriculture Research for Agriculture Victoria; Professor (Plant Genetics & Genomics) and Head of School of Applied Systems Biology with La Trobe University; and Director of AgriBio, Centre for AgriBioscience. Professor Spangenberg is also Director and Chief Scientific Officer of the agricultural biotechnology company Phytogene Pty Ltd. He was elected Fellow of the Australian Academy of Technological Sciences and Engineering in 2007 and was the recipient of the Australian Thinker of Year 2006 Award. He is past President of the International Association for Plant Biotechnology. In 2017, Professor Spangenberg was awarded the Public Service Medal for outstanding public service through scientific research programs in the agricultural sector in Victoria.

**Kath Rowley**

Department of Environment, Land, Water and Planning, Victoria, Australia

Kath Rowley is Executive Director of the Climate Change Division in Victoria's Department of Environment, Land, Water and Planning (DELWP). She leads the Department's work on climate change, environment protection, and waste and resource recovery policy.

Kath joined DELWP in April 2016, after three years at the Climate Change Authority, advising the Australian Government on policies to reduce Australia's greenhouse gas emissions. She has been working on climate change and environment policy since 2004, including leadership roles in the Department of Climate Change in Canberra and the global think tank, the Climate Policy Initiative, in San Francisco.





## Key Speakers

3 - 4 December 2018, AgriBio, Bundoora, Victoria



**Professor Lin Ma**  
Chinese Academy of Sciences, China

Professor Lin Ma is a Professor at the Chinese Academy of Sciences in the Group of Coupling of Food, Environmental protection and Resource use (COFER), Center for Agricultural Resources Research, Institute of Genetic and Developmental Biology. He has a keen interest in the integrated assessment of nutrient flows in the food production and consumption chain of China. His research includes database and model development, scenario analyses and integrated assessment of nutrient management options at regional and national level. He has authored and co-authored about 40 publications, 20 in international peer reviewed journals.



**Associate Professor John Lory**  
University of Missouri, United States of America

Associate Professor John Lory has a Commercial Agriculture extension/ research appointment in environmental nutrient management with the University of Missouri, based in Columbia, Missouri. John received his PhD in Soil Science from the University of Minnesota in 1993. His research and extension objective is to promote the efficient use of nutrients from manure and other sources for crop production in a manner that protects water and other natural resources. John is a leader in nutrient management in the US, has jointly developed national tools and nutrient management guidelines, and works closely with government and industry organisations, particularly the swine and grazing industries.



**Professor Cláudia Marques-dos-Santos Cordovil**  
University of Lisbon, Portugal

Professor Cláudia Marques-dos-Santos Cordovil is an agronomist and soil scientist. She is a Professor at the Biosystems Engineering Department at the School of Agronomy, University of Lisbon where she teaches residue and effluent management, environmental policy, environmental pollution and agronomic valorization of residues from energy production. She has been involved in and has coordinated national and international projects. She is an independent expert for the European Commission, for the Polish Scientific Foundation, for the Science Foundation from Argentina, and for the Portuguese Science Foundation. Her areas of interest are soil fertility in grainfed and extensive agriculture, conservation agriculture, organic and food waste recycling, and rural and social development. She is the co-chair of the UNECE Task Force on Reactive Nitrogen, she is part of the Nutrient Cycles of the Livestock Environmental Assessment and Performance Partnership of the Food and Agriculture Organization of the United Nations, and of the Grazing for Carbon focus group of the European Union.



**Associate Professor Yoshitaka Uchida**  
Hokkaido University, Japan

Dr Yoshitaka Uchida is an Associate Professor at Hokkaido University, Faculty of Agriculture. Yoshi completed his PhD at Lincoln University New Zealand in 2011, studying carbon and nitrogen cycles under cow urine patches in New Zealand grazed pastures. Yoshi and his students currently undertake extensive research at a range of scales from soil microbiology to farm level nutrient budgeting, especially targeting dairy farms at Hokkaido. Yoshi also coordinates several projects in countries in Africa, including Zambia, Malawi and Kenya, targeting soil degradation issues in agricultural fields.





## Key Speakers

3 – 4 December 2018, AgriBio, Bundoora, Victoria



**Dr Karl Richards**  
Agriculture and Food Development  
Authority, Teagasc, Ireland

Dr Karl Richards is a Principal Research Officer and head of the Environment Soils and Land-Use Department based at Teagasc, Johnstown Castle, Ireland.

He leads a team investigating nitrogen dynamics in soil, nitrate leaching and denitrification in croplands and grazed grasslands soils. His research has focused on the investigation of options to mitigate nitrous oxide from soils; understanding landscape scale nitrogen dynamics; investigating nitrogen partitioning in soils and aquifers and ammonia emissions from pasture-based systems.



**Scott McDonald**  
Department of Economic Development,  
Jobs, Transport and Resources,  
Agriculture Victoria, Australia

Scott McDonald is a Dairy Development Specialist with Agriculture Victoria's Biosecurity and Agriculture Services.

He has an established reputation as one of Australia's leading technical experts in dairy effluent system design and is a national trainer with over 29 years' experience. He has performed 1,800 farm site assessments and plans and has 38 publications ranging from state guidelines, training packages, online planning tools and technical notes. Scott's current body of work is focused on intensive livestock systems, providing technical support to a range of government agencies and Australian livestock producers establishing intensive farming systems or transitioning from partial mixed ration systems to fully housed dairy production systems.



**Professor Andrew Western**  
University of Melbourne, Australia

Professor Andrew Western of the University of Melbourne has more than twenty-five years' experience in catchment and waterway research, teaching and consulting. He is now the

Deputy Head of Department of Infrastructure Engineering at the University of Melbourne. He has undertaken major field programs in Australia and New Zealand investigating catchment behaviour and has made leading contributions to spatial analysis in hydrology, particularly the area of spatial soil moisture variability, patterns and processes. Professor Western is currently working on water quality, groundwater analytics, flood modelling, and understanding and predicting the impacts of prolonged drought and climate change on catchment response.



**Professor Tom Misselbrook**  
Rothamsted Research, England

Professor Tom Misselbrook is a Senior Research Scientist in the Sustainable Agricultural Sciences Department at Rothamsted Research, based at the North Wyke site in South West England.

He graduated from Reading University with a Bachelor of Science in Agriculture in 1987 and gained a PhD with Plymouth University on ammonia emissions from agriculture in 2005. He now leads a research team on atmospheric emissions and mitigation, covering ammonia and greenhouse gas emissions from agriculture, aspects of livestock and other organic residue management and more generally nitrogen cycling within agricultural systems. He leads the compilation of the UK agriculture ammonia and greenhouse gas emission inventories, required for reporting under international legislation, and works collaboratively nationally and internationally in seeking solutions to these issues as part of developing more sustainable agricultural systems.





## Key Speakers

3 - 4 December 2018, AgriBio, Bundoora, Victoria



**Dr Shabtai Bittman**  
Agriculture and Agri-Food, Canada

Dr Shabtai Bittman has conducted research on forage systems for extensive beef operations and intensive dairy operations across Canada. Over the past decade his work has focussed

on nutrient use and, particularly, manure efficiency. His work has included improved application technology for forage and corn, involving improved infiltration and nutrient balancing strategies. His primary focus currently is improving efficiency and sustainability of intensive dairy systems on limited land base considering the field, farm and regional perspectives, the latter involving multiple ecosystems including urban. His work includes nutrient budgets. Dr Bittman has also developed models used to estimate ammonia emissions across Canada and has supported the UNECE Convention on Long-Range Transboundary Air Pollution through co-chairing the Expert Panel on Agricultural Nitrogen.



**Dr Stephan Tait**  
Centre for Agricultural Engineering,  
University of Southern Queensland,  
Australia

Dr Stephan Tait is a Research Fellow at the Centre for Agricultural Engineering, University of Southern Queensland, Toowoomba. He is a chartered Chemical Engineer and a Registered Professional Engineer in Queensland. Stephan has a 10-year history in research and engineering of biogas and wastewater treatment systems, and is probably most well-known for his role in facilitating uptake of biogas technology in the Australian Pork sector via a Pork Cooperative Research Centre funded program. He is passionate about making environmental sustainability profitable.



**Dr Sharon Aarons**  
Department of Economic Development,  
Jobs, Transport and Resources,  
Agriculture Victoria, Australia

Dr Sharon Aarons is a Senior Research Scientist in the Agriculture Resources branch of Agriculture Victoria Research.

Sharon received her PhD in Soil Science from the University of Minnesota, 1990. Sharon has expertise in soil chemistry, fertility and microbiology. Dr Aarons' research activities focus on nutrient cycling and improving nutrient management in grazing-based and intensifying dairy systems. Her research aims to improve productivity while minimising environmental consequences through an understanding of the return and recycling of nutrients by grazing animal.



**Bruce Shelley**  
Department of Economic Development,  
Jobs, Transport and Resources,  
Agriculture Victoria, Australia

Bruce is a Senior Research Scientist in the Agriculture Resources branch of Agriculture Victoria Research. Bruce

has expertise in Analytical Chemistry, Agricultural and Environmental Chemistry and leads the AVR soil chemistry laboratory. He is an active participant on a number of national committees including being a technical assessor for NATA and Standards Australia Committee for analysis of Soils and Biota and the Australasian Soil and Plant Analysis Council. His current research interests include; improved knowledge of the chemical and physical characteristics and within storage transformations of dairy cow excreta fractions, including gaseous losses and odour generation, to achieve greater nutrient capture and reduced environmental impacts; and use of soil proximal sensing technologies that help farmers better understand and manage spatial variation for productivity gain.



## Key Speakers

3 - 4 December 2018, AgriBio, Bundoora, Victoria



**Professor Xiwang Zhang**  
Monash University, Australia

Professor Xiwang Zhang is Professor of the Department of Chemical Engineering at Monash University and the Director of the Australian Research Council (ARC) Research Hub for

Energy-efficient Separation. Professor Zhang has over 15 years' industry and academic experience in water and wastewater treatment. He has authored and co-authored more than 120 peer-reviewed journal papers. In the past decade, he has attracted more than \$15 million of research funding from government and industry.

Professor Zhang was the recipient of the prestigious ARC Australian Research Fellowship and a Monash Larkins Fellowship. He was also awarded the International Water Association (IWA) East Asia & Pacific Applied Research Honour Award and the Institution of Engineers Singapore (IES) Prestigious Engineering Achievement Award.



**Byron Stein**  
Department of Primary Industries,  
New South Wales, Australia

Byron Stein works for the New South Wales (NSW) Department of Primary Industries as a Poultry Meat Industry Development Officer. He has a Masters

Degree in Agriculture, majoring in Animal and Poultry Science. As an Industry Development Officer, Byron deals with a broad range of industry challenges and opportunities in NSW. Byron is responsible for supporting industry development in NSW by liaising with the industry about planning and policy issues. Given the technical and unique structure and requirements of the industry, Byron seeks to help industry by liaising with state and government agencies that have a poor understanding of the industry and its needs. As such, Byron is involved in local development applications and assessments, regional and strategic planning and development of policy and industry liaison with all levels of government. "In many ways, I consider myself as an industry broker," says Byron. "My job is to help industry find solutions to enable ongoing investment in NSW".



**Professor Tommy Dalgaard**  
Aarhus University, Denmark

Professor Dalgaard is a professor of the Department of Agroecology, Agricultural Systems and Sustainability, Aarhus University, Denmark. Professor Dalgaard has a keen interest in

Agroecology, scaling and interdisciplinarity research. His interests and expertise include comparisons of organic and conventional farming systems, effects of policy measures on nitrogen pollution of the aquatic environment, biofuels and bioenergy value chains and sustainability assessment methodologies. Professor Dalgaard was a leader in the NitroEurope Project (2007-2011), 'Impact assessment of multifunctional agriculture' (MEA-scope, 2004-2007), and 'Sustainability Impact Assessment of Multifunctional Land Use in European Regions'.



**Dr Cecile de Klein**  
AgResearch, New Zealand

Dr Cecile de Klein is an internationally recognised expert on nitrogen cycling and GHG emissions from pastoral systems. Born and educated in The Netherlands, she came to New Zealand

in 1995 following a postdoc in Cambridge, UK. She is a Principal Scientist with AgResearch and a Principal Investigator of the NZ Agricultural Greenhouse Gas Centre (NZAGRC). Cecile has led many national and international nitrogen research programmes, including a Global Research Alliance project on developing and revising guidelines for measuring N<sub>2</sub>O emissions; the NZAGRC nitrous oxide mitigation research programme; and a programme on delivering solutions for low N leaching livestock productivity systems. Cecile is also working closely with the agricultural sector to help develop tools, knowledge and training for building a GHG capable workforce, and to review and assess the suitability of OVERSEER as an on-farm GHG accounting tool.



## Key Speakers

3 - 4 December 2018, AgriBio, Bundoora, Victoria

**Jo Campbell**

**Department of Economic Development,  
Jobs, Transport and Resources,  
Agriculture Victoria, Australia**

Jo is a Senior Knowledge Broker in the Dairy Production Sciences branch of Agriculture Victoria Research.

Jo specialises in governance, user context, content analysis, science-based tool design and digital development processes. Jo has worked with a range of research scientists, technical experts and industry personnel for the last 15 years. Jo has also analysed, designed and developed more than 20 industry extension programs and has developed numerous print based, user-friendly best practice guidelines and other extension tools for programs including InCalf, Cool Cows, Dairy Cow Nutrition and automated milking systems & antimicrobial resistance guidelines. In addition, Jo has developed two QA/food safety programs for Victorian milk companies and has been a Director of the West Gippsland Healthcare Group.

**Andrew Gear**

**Department of Environment, Land,  
Water and Planning, Victoria, Australia**

Andrew Gear RPIA (Fellow) is the Executive Director of Planning and Heritage in the Victorian Department of Environment, Land, Water & Planning

(DELWP). The role is within the Planning Group of DELWP and encompasses planning systems and Heritage Victoria. He joined DELWP from the South Australian Department of Planning, Transport and Infrastructure in 2016.

Andrew has held senior positions in various Councils within South Australia and the Local Government Association of South Australia. He holds qualifications in Urban and Regional Planning and has nearly four decades experience in planning (strategy/policy/assessment), development (building/subdivisions/civil engineering), governance, community development, emergency management and natural resource management including statutory and non-statutory board appointments.

**Paula Bradshaw**

**Environment Protection Authority,  
Victoria, Australia**

Paula is an environment leader with over 20 years' experience in environmental management and compliance assurance in support of business

results. She has a track record in helping executives and management effectively understand environmental compliance and risk mitigation. Paula is passionate about the implementation of environmental thinking in the planning and development stages of projects to effect environmental risk mitigation at operational and corporate level.

Paula currently manages the team that works with Victoria's largest and most complex projects to identify and manage potential environmental risks. The role requires a strong understanding of environmental issues associated with major projects, the measures to protect the environment and an understanding of environmental management systems and processes for environment protection.

## DAIRY N USE EFFICIENCY WORKSHOP

This 3-day International Nitrogen Management Systems (INMS) workshop was held at the Agriculture Victoria Ellinbank Dairy Research Institute, West Gippsland, Victoria.

Workshop activities focussed on international harmonization of relevant whole-farm and within farm N balance and indicator approaches to improve the sustainable intensification of dairy systems.

Specifically, the international project team worked towards INMS Project 1.1.2. project deliverables: namely a draft version of the guidelines document and selection of international case studies.

Nominated team members lead discussions in specific theme areas which aligned with the structure of the guidance document. Other activities included commercial dairy farm visits, and a tour of the AVR Ellinbank research facilities. The workshop program is outlined below.

The project team will meet again in China in September 2019.

### Program for INMS 1.1.2 Ellinbank workshop

	8:30 am session	10:30 am session	1:00 pm session	3:30 pm session
<b>Wed 5<sup>th</sup> Dec</b>	<b>Introductions</b> - Project deliverables - Guidance document - Workshop themes  Leads: C Gourley, T Misselbrook	Travel to farms	Dairy farm visit #1	Dairy farm visit #2
<b>Thurs 6<sup>th</sup> Dec</b>	<b>Theme 1.</b> Whole farm N use efficiency.  Lead: C de Klein (L), M Alfaro	<b>Theme 2.</b> Home-grown feed N use efficiency.  Lead: K Richards (L), C Cordovil, Y Uchida	AV Ellinbank research farm tour	<b>Theme 3.</b> Animal intake N use efficiency.  Lead: S Aarons (L), Lin Ma, T Dalgaard
<b>Fri 7<sup>th</sup> Dec</b>	<b>Theme 4.</b> Manure reuse efficiency.  Lead group: S Bittman (L), J Lory, T Misselbrook	Case study data sets	<b>Conclusions</b> Deliverables, actions, timelines  Leads: C Gourley, T Misselbrook	Departures



## AGREED STRUCTURE OF GUIDELINES DOCUMENT

Preface

Executive Summary

1. Introduction (Cameron, Tom)
  - 1.1. Background
  - 1.2. Document purpose and intended users
  - 1.3. Scope and proposed impact
  - 1.4. How to use this document.
2. Global dairy production systems (Gemma, Cameron and team)
  - 2.1. Diversity of systems
  - 2.2. Trends in intensification
3. Nitrogen flows in dairy production systems (Zhaohai, Lin, and team)
  - 3.1. Describing N cycles and key components
  - 3.2. Describing system boundaries
  - 3.3. Definitions of N performance indicators
4. Whole-farm N use efficiency (**Cecile**, Marta, Tommy, Karl, Cameron)
  - 4.1. Calculating N inputs and outputs
    - 4.1.1. Tier 1
    - 4.1.2. Tier 2
    - 4.1.3. Tier 3
  - 4.2. Dealing with externalised inputs (e.g. imported feed) and outputs (e.g. exported manure).
  - 4.3. Dealing with uncertainties
  - 4.4. Impact of management practices on N performance (summary, with sign-posts to existing documents and guidelines)
5. Dairy cow product N use efficiency (**Sharon**, Nick H, Zhaohai, Karin G)
  - 5.1. Calculating N inputs and outputs
    - 5.1.1. Tier 1
    - 5.1.2. Tier 2
    - 5.1.3. Tier 3
  - 5.2. Dealing with externalised inputs
  - 5.3. Dealing with uncertainties
  - 5.4. Impact of management practices on N performance (summary, with sign-posts to existing documents and guidelines)
6. Manure reuse N use efficiency (**John/Shabtai**, Tom, Barbara, Claudia, Lin, Sharon)
  - 6.1. Calculating N inputs and outputs
    - 6.1.1. Tier 1
    - 6.1.2. Tier 2
    - 6.1.3. Tier 3

- 6.2. Dealing with externalised inputs
- 6.3. Dealing with uncertainties
- 6.4. Impact of management practices on N performance (summary, with sign-posts to existing documents and guidelines)
7. Home-grown forage N use efficiency (**Karl**, Claudia, Yoshi, John, Mark S)
  - 7.1. Calculating N inputs and outputs
    - 7.1.1. Tier 1
    - 7.1.2. Tier 2
    - 7.1.3. Tier 3
  - 7.2. Dealing with externalised inputs
  - 7.3. Dealing with uncertainties
  - 7.4. Impact of management practices on N performance (summary, with sign-posts to existing documents and guidelines)
8. Combined framework for reporting and interpreting N use efficiency indicators
9. Case studies (Tom, Cameron, Gemma, Miquel?)
  - 9.1. Benchmarking (spatial: farm-systems, regions, national, international; temporal: changes over time)
  - 9.2. Interpretation of results and lessons learnt
  - 9.3. Targets (for different productions systems and in context of inherent conditions)
10. Recommendations (for policy or industry)

References

Appendices

## PROPOSAL FOR SHARING THE WORKLOAD AMONGST TEAM MEMBERS

- Each theme was been allocated a lead group and a theme leader (L) as indicated in the workshop program provided above. Lead group members were nominally assigned to a theme based on their expertise - but this can be reallocated on request.
- Each lead group provided an introductory presentation at the beginning of each theme discussion.
- Introductory presentations aimed to outline the issues to be included and guide further discussions. Issues included: descriptions of N flows, scale and boundaries, definitions used, examples of relevant NUE indicators, inconsistencies in previous approaches, challenges in measurements and interpretation guidelines.
- The theme lead group was responsible to taking notes during the discussions and post-the workshop will provide a summary of outcomes, including agreed approaches, identified gaps in knowledge, and required further activities.
- While all team members will be able to contribute to the various chapters within the guidance document, it is proposed that the theme lead group coordinate the preparation of the relevant chapter.

## USEFUL DOCUMENTS

1. de Klein CAM, Monaghan RM, Alfaro M, Gourley CJP, Oenema O, Powell JM (2017). Nitrogen performance indicators for dairy production systems. *Soil Research* 55(6) 479-488.
2. Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A., (eds), 2014, Options for Ammonia Mitigation: Guidance from the UNECE Task Force on Reactive Nitrogen, Centre for Ecology and Hydrology, Edinburgh, UK.
3. Aarons SR, Gourley CJP, Powell JM, Hannah MC (2017). Estimating nitrogen excretion and deposition by grazing lactating cows for improved nutrient management. *Journal Soil Research* 55(6) 489-499.
4. Rugoho I, Lewis H, Islam M, McAllister A, Heemskerk G, Gourley ADP, Gourley CJP (2017). Quantifying dairy farm nutrient fluxes, balances and environmental performance. *Animal Production Science*. *Animal Production Science* 57, 858-876.
5. Gourley CJP, Aarons SR and Powell JM (2012). Nitrogen use efficiency and manure management in contrasting dairy production systems. *Agriculture Ecosystem and Environment* 147: 73 – 81.
6. Powell JM, Gourley CJP, Rotz CA and Weaver DM (2010). Nitrogen Use Efficiency: A Measurable Performance Indicator for Dairy Farms. *Environmental Science and Policy* 13: 217-228.
7. EU Nitrogen Expert panel (2015) Nitrogen Use Efficiency (NUE) - an indicator for the utilization of nitrogen in agriculture and food systems. Wageningen University, Alterra, PO Box 47, NL-6700 Wageningen, Netherlands.
8. EU Nitrogen Expert panel (2016) Nitrogen Use Efficiency (NUE) - Guidance Document for assessing NUE at farm level. Wageningen University, Alterra, PO Box 47, NL-6700 Wageningen, Netherlands.
9. Hristov AN, Hazen W, Ellsworth JW (2006) Efficiency of use of imported nitrogen, phosphorus and potassium and potential for reducing phosphorus imports on Idaho dairy farms. *Journal of Dairy Science* 89, 3702–3712.
10. Ma L, Velthof GL, Wang FH, Qin W, Zhang WF, Liu Z, Zhang Y, Wei J, Lesschen JP, Ma WQ, Oenema O, Zhang FS (2012) Nitrogen and phosphorus use efficiencies and losses in the food chain in China at regional scales in 1980 and 2005. *Science of the Total Environment* 434, 51–61.
11. Norton R, Davidson E and Roberts E (2015) Position Paper Nitrogen Use Efficiency and Nutrient Performance Indicators. A Publication of the Global Partnership on Nutrient Management.
12. Núñez RP, Demanet R, Alfaro M, Mora ML (2010) Nitrogen soil budgets in contrasting dairy grazing systems of southern Chile, a short-term study. *R.C. Suelo Nutr. Veg.* 10, 170–183.
13. Oenema O, Witzke HP, Klimont Z, Lesschen JP, Velthof GL (2009) Integrated assessment of promising measures to decrease nitrogen losses from agriculture in EU-27. *Agriculture Ecosystems & Environment* 133, 280–288.
14. Nutrient Flows and associated environmental impacts in livestock supply chains. Guidelines for assessment (2018). (<http://www.fao.org/partnerships/leap/en/>).

15. FAO. 2016. Environmental performance of large ruminant supply chains: Guidelines for assessment. Livestock Environmental Assessment and Performance Partnership. FAO, Rome, Italy. (<http://www.fao.org/3/a-i6494e.pdf>).
16. Nannan Zhang, Zhaohai Bai, Jiafa Luo, Stewart Ledgard, ZhiguoWud, Lin Ma (2017). Nutrient losses and greenhouse gas emissions from dairy production in China: lessons learned from historical changes and regional differences. *Science of the Total Environment* 598 (2017) 1095–1105.
17. Environmental impacts and resource use of milk production on the North China Plain, based on life cycle assessment (2018). XiaoqinWang, Stewart Ledgard, Jiafa Luo, Yongqin Guo, Zhanqin Zhao, Liang Guo, Song Liu, Nannan Zhang, Xueqin Duan, Lin Ma. *Science of the Total Environment* 625 (2018) 486–495.
18. J Mark Powell (2015). The need for more uniform terms and measures of nitrogen use efficiency in agricultural production. *JOURNAL OF SOIL AND WATER CONSERVATION* JULY/AUGUST 2015—VOL. 70, NO. 4.
19. Nitrogen and Phosphorus Use Efficiencies in Dairy Production in China (2012). Z.H. Bai, L. Ma, O. Oenema, Q. Chen, and F.S. Zhang. *Journal of Environmental Quality* doi:10.2134/jeq2012.0464.



USEFUL FIGURES

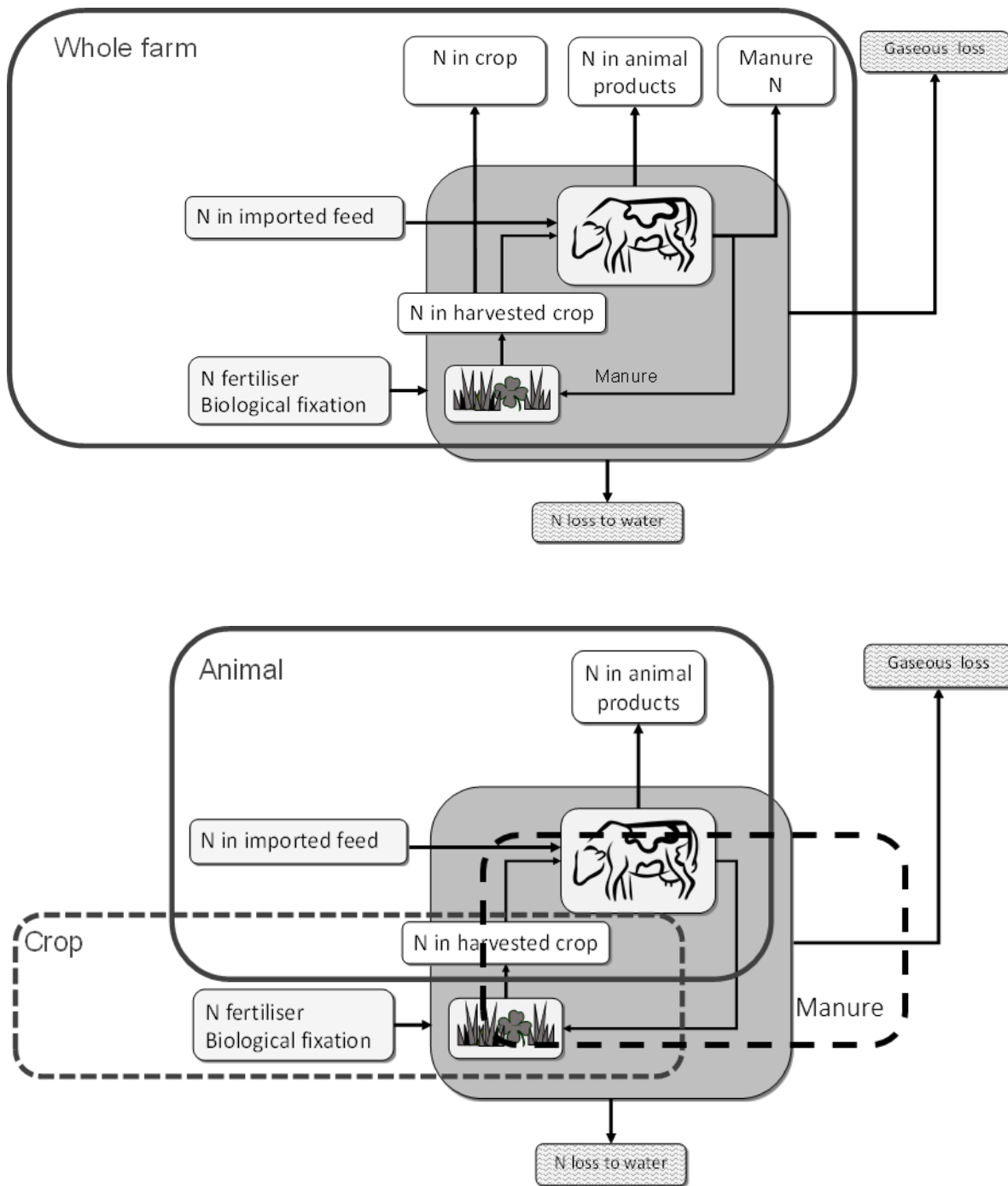


Figure 1. Representation of the N inputs and outputs that are typically included in the calculation of (A) Whole farm NUE and N surplus values and (B) component efficiency assessments for Crop/home-grown forage, Animal and Manure reuse.

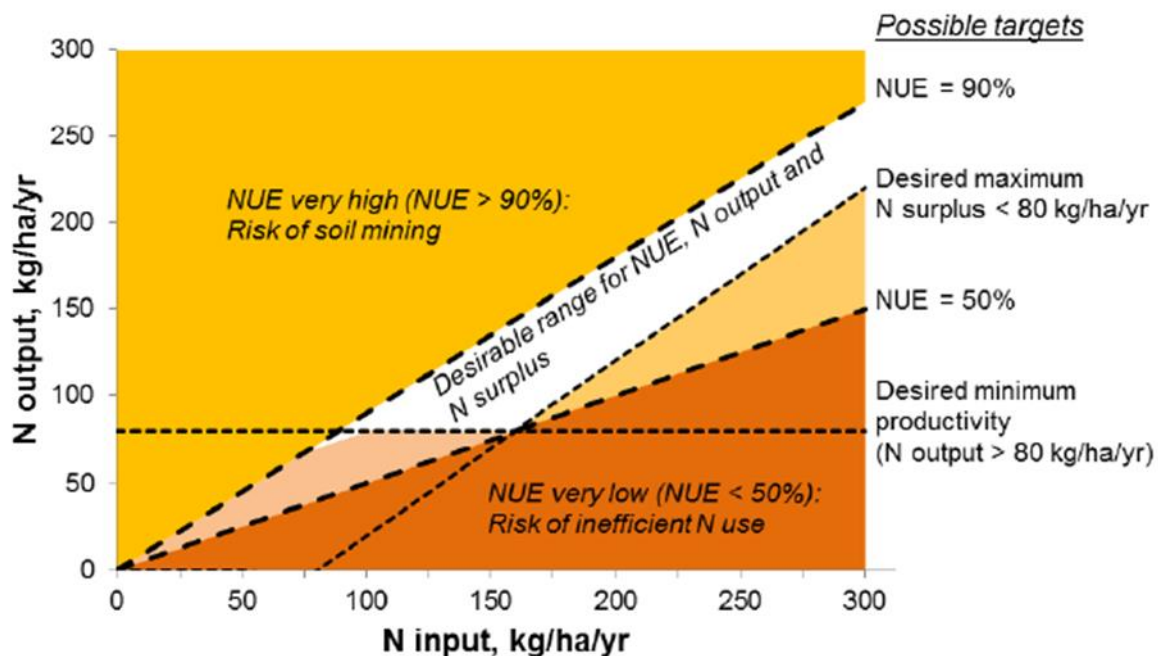


Figure 2. Conceptual diagram of the Nitrogen Use Efficiency (NUE) indicator framework developed by the EU Nitrogen Expert Panel (2015). The numbers shown are illustrative of an example system and will vary according to context (soil, climate, crop). The slope of the diagonal wedge represents a range of desired NUE values between 50% and 90%; lower values are likely to exacerbate N pollution and higher values risk mining of soil N stocks. The horizontal line is a desired minimum level of productivity for the example system. The additional diagonal line represents a limit related to maximum N surplus to avoid substantial pollution losses. The combined criteria serve to identify the most desirable range of outcomes and is represented by the un-shaded part of the Figure.

## FUTURE ACTIVITIES

- **July 2019** – Draft version of guidelines document and proposed methods. Selection of case studies. Drafting outline of journal paper.
- **December 2019 – Second Workshop (China).**
  - Revised version of guidelines. Case study assessments completed. Draft of journal paper (Dec 2019).
- **July 2020** – Finalized guidelines including case studies reported and completed. Journal paper submitted.