

Reef Rescue Water Quality Research and Development Program Overview of Research Projects



CARING
FOR
OUR
COUNTRY

SUMMARIES OF PROJECT OBJECTIVES



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1. Introduction

Reef Rescue is a key component of *Caring for our Country*¹, the Australian Government's \$2 billion initiative to restore the health of Australia's environment and improve land management practices. It represents a coordinated approach to environmental management in Australia that is built on transparent and consistent national targets.

Queensland farmers, agricultural, tourism, fishing and aquaculture industries, Indigenous communities, conservation groups, research organisers and, most importantly, the Great Barrier Reef will benefit from *Reef Rescue's* investment of \$200 million over five years in actions that protect one of the world's great natural wonders. *Reef Rescue's* objective is to improve water quality in the Great Barrier Reef lagoon by increasing the adoption of land management practices that reduce the run-off of nutrients, pesticides and sediments from agricultural land.

One of the five integrated components of *Reef Rescue* is the \$10 million **Water Quality Research and Development Program** (referred to in this Communications Strategy as *Reef Rescue R&D*), which aims to improve our understanding of the link between land management practices and environmental impacts, and of the costs and benefits of innovations in practices. *Reef Rescue R&D's* research project portfolio has been developed in consultation with the Queensland Government and universities and research organisations, along with a range of key stakeholders.

Reef Rescue R&D comprises three main sub-programs:

1. **Adoption and development of sustainable practices that have water quality benefits:** The development, trial and validation of land management practices that are sustainable and have improved water quality outcomes in the sugar, beef grazing, horticulture and dairy sectors;
2. **Pesticide threat, delivery and management:** Investigation of pesticide management in the sugar, beef grazing and horticulture industries and pesticide transport pathways in freshwater and marine ecosystems; and
3. **Tracking change:** Development of robust and cost effective techniques for measuring and reporting key monitoring indicators.

A list of projects is provided in Table 1, and summaries of each project follow.

¹ <http://www.nrm.gov.au/>

Table 1: List of Reef Rescue R&D Projects.

Number	Title	Lead Researcher
Sub-Program 1: Adoption and development of sustainable practices that have water quality benefits		
Grazing Practices		
RRRD024	Quantifying the impacts of rehabilitating degraded lands on soil health, pastures, runoff, erosion, nutrient and sediment movement	Trevor Hall, DEEDI
RRRD027	Getting ground cover right - thresholds and baselines for a healthier reef	Terry Beutel, DEEDI
RRRD032	Improving grazing management practices to enhance ground cover and reduce sediment loads	Scott Wilkinson, CSIRO
RRRD009	Runoff Nitrogen generation rates from pasture legumes – an enhancement to reef catchment modelling	Craig Thornton, DERM
Sugar Practices		
RRRD056	Evaluating and improving A-Class practices to control nutrient losses from sugarcane	Peter Thorburn, CSIRO
RRRD004	Advanced drip and optimised furrow irrigation to minimise sediment, nutrient and pesticide losses to the environment through deep drainage and runoff from sugarcane and banana industries of wet tropics in northern Queensland	David Midmore, CQU
RRRD020	Mineralisation of nitrogen within the sugarcane cropping system following legume fallows and its effect on water quality	Bernard Schroeder, BSES
Horticulture Practices		
RRRD049	Minimising off-farm movement of nitrogen in the north Queensland banana industry	John Reghenzani, Terrain NRM
RRRD054	Development of a banana modelling capability to enhance reporting of Reef Rescue outcomes	Tony Webster, CSIRO
Dairy Practices		
RRRD055	Validating the cost/benefits of improved fertiliser practices and quantifying nutrient loads and pathways from irrigated dairy pastures in the Wet Tropics and the Burnett-Mary regions	Ruth Chalk, Queensland Dairyfarmers' Organisation (QDO)
Socio Economic		
RRRD011	Capturing historic small catchment study (paddock scale) data to support quantification of management impacts on water quality on the Great Barrier Reef	David Freebairn, RPS Australia
RRRD010	Factors affecting adoption of land management practices that have water quality benefits in the GBR catchments: Evaluation scenarios for Cane Farming	Delwar Akbar, CQU
RRRD039	Integrated assessment of BMP cost-effectiveness and decision tool for regions and landholders.	Stuart Whitten, CSIRO

Number	Title	Lead Researcher
Sub-Program 2: Pesticide threat, delivery and management		
RRRD037	Pesticide dynamics in the Great Barrier Reef catchment and lagoon: management practices in the sugarcane industry	Jon Brodie, JCU
RRRD038	Pesticide dynamics in the Great Barrier Reef catchment and lagoon: management practices (grazing, bananas and grain crops) and risk assessments	Jon Brodie, JCU
RRRD058	A novel biological method of monitoring herbicides	Ben J. Kefford, University of Technology Sydney (UTS)
Sub-Program 3: Tracking change		
RRRD030	Pollutant load estimation for Great Barrier Reef (GBR) catchments: Accounting for the uncertainty in monitoring and modelled data using data assimilation techniques	Petra Kuhnert, CSIRO
RRRD016	Developing integrated assessment metrics for reporting of water quality in the Great Barrier Reef lagoon	Vittorio Brando, CSIRO

2. Adoption and development of sustainable practices that have water quality benefits (Sub-Program 1)

2.1 Grazing Practices

Quantifying the impacts of rehabilitating degraded lands on soil health, pastures, runoff, erosion, nutrient and sediment movement (RRRD024)

Led by Trevor Hall, DEEDI

Improving the ground cover on D class grazing land to reduce soil, water and nutrient losses requires mechanical intervention. The most cost effective mechanical treatments or the levels of reduction in erosion and nutrient loss are not well defined or quantified. Grazing management strategies are available to continue improvement from C class to B and A condition. This project aims to identify the effectiveness of mechanical interventions and review landholder attempts at rehabilitation of D class land condition in the reef catchments. Quantified data will support other reef recovery projects on the social and economic aspects of land management.

This project will deliver:

- Review of previous demonstration sites and landholder experiences and regional literature in rehabilitating degraded grazing lands in the Burdekin and Fitzroy catchments. Due to paucity of collected quantitative data this will involve selective collection of pasture condition data and collation of experiential learning of the producers and agencies involved. Sites will include NQDT and FBA graziers funded to rehabilitate degraded pastures, Landcare group sites, research trials and other relevant producer sites.
- Establish two trial sites to investigate mechanical disturbance effects on rehabilitating severely degraded D class grazing lands. The trial will have four levels of cultivation/disturbance treatments, including a control and low, medium and high mechanical input levels, all with pasture reseeding, across two soil types (one in Burdekin and other in Fitzroy catchment) with grazing managed to assist establishment and production of the sown pastures.
- Extrapolate ecological and financial results across the landscape. This component of the project will link closely with associated projects, such as: the Reef Rescue Project “Getting ground cover right – thresholds and baselines for a healthier reef” (RRRD027) and “Integrated assessment of BMP cost-effectiveness and decision tool for regions and landholders” (RRRD039) with emphasis on the grazing lands economics work (Reef Rescue Modelling and Monitoring Program) in delivering its milestones, and with Queensland DERM rainfall simulator and runoff/erosion work.

Getting ground cover right - thresholds and baselines for a healthier reef (RRRD027)

Led by Terry Beutel, DEEDI

Recent R&D has integrated satellite time-series and high resolution imagery with roadside land condition assessments to build valuable cover and condition monitoring data sets. These data sets have been compiled across the two largest Reef catchments (Burdekin and Fitzroy regions), and enjoyed extensive uptake by NRM planners and landholders alike.

However there is significant scope to improve ground cover monitoring by refinement and robust validation of these products, and provision of better access and training for their users (land managers and agency operatives). The project addresses the need for these improvements.

This project will deliver the production of an improved Ground Cover Index product and analysis routine to separate management and seasonal effects in grazing lands. Through this process, validated spatial data of ground cover and land condition will be produced for the FBA and NQDT regions. This information will lead to enhanced land monitoring support packages and publications for the FBA and NQDT regions.

Improving grazing management practices to enhance ground cover and reduce sediment loads (RRRD032)

Led by Scott Wilkinson, CSIRO

This project will build an understanding of the causal links between grazing practices, ground cover and erosion across select land types in the Burdekin and Fitzroy catchments. It will assess the potential and priority areas for improvements in ground cover and pasture productivity, and reductions in erosion, and estimate the timescales over which such improvements may be detected, considering land condition. The project will utilise a network of case-study grazing properties to relate grazing practices to cover and erosion levels. Landscape-scale implications will be assessed based on cover imagery and modelling of erosion and grass production.

This project will deliver:

- Development of relationships for key land types between grazing practices, land cover and condition, and erosion rates.
- Estimate the landscape-scale impacts on erosion of future changes to grazing practices.
- Estimate the likely outcomes of changing grazing practices in terms of pasture productivity and beef production.
- Build industry capacity to interpret cover products and management tools for indicating productivity and erosion resulting from grazing practices, and for identifying priorities for practice change.

Runoff Nitrogen generation rates from pasture legumes - an enhancement to reef catchment modelling (RRRD009)

Led by Craig Thornton, DERM

This is a pilot study to rigorously determine if broad-scale pasture legume plantings, particularly of leucaena and butterfly pea, represent a risk to reef water quality by increasing loads of nitrogen in runoff waters compared to grass only pastures. Nitrogen loads from both grass only and grass/legume pastures will be contrasted against loads from virgin Brigalow scrub to investigate the change from the native, pre-European landscape to the current agricultural landscape.

This project will deliver:

- Determination of loads and Event Mean Concentrations (EMC) of nitrogen in runoff waters from the three pasture land uses of buffel grass only, grass + leucaena, and grass + butterfly pea, and compare and contrast them to loads and EMCs from virgin Brigalow scrub.
- The use of historical data from the long-term internationally recognised Brigalow Catchment Study (BCS) to refine estimations of nitrogen loads and EMCs from virgin Brigalow scrub, providing a pre-European context for nitrogen movement.
- The development of an understanding of the biophysical interaction of nitrogen in these systems by investigating seasonal trends in nitrogen levels in both soil and plants.

2.2 Sugar Practices

Evaluating and improving A-Class practices to control nutrient losses from sugarcane (RRRD056)

Led by Peter Thorburn, CSIRO

Loss of nutrients, particularly nitrogen, from sugarcane production has been identified as a major source of pollution in the Water Quality Improvement Plans of the wet tropics, dry tropics, Mackay-Proserpine and Burnett-Mary regions. To address this problem, a suite of management practices has been defined in each region classified as D (high nutrient loss) to A (low loss). Reef Rescue Water Quality Grants and Queensland Government regulation are supporting farmers adopt B-Class practices. And between past research on environmental impacts of sugar production, and proposed activities in the Reef Rescue's Paddock-to-Reef monitoring and evaluation program, there is/soon will be a lot of information on the water quality impacts of B- (and C-) Class practices. So, the water quality impact of this change is/will be reasonably understood. Unfortunately, there is already evidence that widespread adoption of B-Class practices may not meet water quality goals. But what about A-Class practices? To what extent will they meet water quality targets?

A-Class practices generally focus on 'precision management' of soil, water and nutrients to minimise nutrient losses and maximise farm profitability. In sugarcane production, that is improving soil health through growing break crops and adopting controlled traffic (to improve infiltration and reduce runoff), matching nutrient applications to soil/production zones within paddocks (to minimise nutrient applications), and maximising irrigation efficiency (to reduce runoff). It is anticipated that there will be synergistic benefits of adopting all these practices as a whole system. To date, however, there is little information on the effect of these practices applied in combination (as opposed to just changing nutrient rates, etc).

Despite this lack of information, leading-edge farmers are already adopting A-Class practices, even practices not yet properly evaluated in the context of Reef Rescue. The adoption of these practices are being supported by Project Catalyst, a partnership between NQ Dry Tropics and Terrain, Coca Cola and World Wildlife Fund, aiming to provide increased momentum for adoption of A-Class practices. In the face of these farmer- and industry-led initiatives, this project will quantify the water quality improvement that can be expected from these practices, have this information represented in Reef Rescue evaluation activities, and identify refinements that can deliver even further improvements in water quality in the future.

This project will deliver:

- The improvement in nutrient losses from A-Class practice systems at suitable field sites established under Project Catalyst in the Burdekin and Wet Tropics NRM regions.
- The evaluation of longer-term water quality and economic benefits of A-Class practice systems through simulation studies on results from Project Catalyst sites and from previous experiments that have yet to be analysed.
- Identification of the opportunities to improve the water quality and/or production benefits of A-Class practice systems based on the simulation capability built on analysis of experimental data.

Advanced drip and optimised furrow irrigation to minimise sediment, nutrient and pesticide losses to the environment through deep drainage and runoff from sugarcane and banana industries of wet tropics in northern Queensland (RRRD004)

Led by David J Midmore, CQU

The proposed on-farm action research comprises an irrigation intervention (optimization of furrow irrigation and advanced drip irrigation systems) for two target industries (sugarcane and banana), that is consistent with enhancement of on-farm water use efficiency and nutrient use efficiency, and that limits the dispersal of pesticides away from the paddock in two major soil types (in the Burdekin and in Bundaberg) and on one soil type for banana. Our aims with water management are consistent with developing resilience in the farming systems in the face of climate change. The proposal provides a tool to measure the extent of nutrients, suspended solids, pesticides and herbicides that will be removed from the paddock, evaluates the response of crops to these new irrigation systems in terms of yield, quality, and water use efficiency, and models irrigation methods at the paddock, farm and at the micro-catchment scale on the hydrological dimensions of new irrigation interventions. It will also allow for socio-economic benchmarking, and for probing policy implications of these interventions at the catchment scale.

- This project will deliver:
- Knowledge of the conditions at which there will be a measurable reduction in the sediment loss in runoff and movement of nutrients and pesticides in run-off and deep drainage from different Irrigation methods (sugarcane and banana)?
- Estimation of the measurable difference in the quality of runoff and how does that relate to the changes in the Irrigation management system (comparison of furrow with drip irrigation in the first year, followed by optimizations in next year)?
- Understanding of the role of innovative Irrigation practices (e.g. minimization of soil surface run-off, deep drainage) and how this delivers long term positive impacts on soil stability through their effect on soil physical, chemical and biological properties that reduce runoff?.
- How Waterwise irrigation innovations and soil management practices, tested and proven to be better than current practice at the plot and paddock level, can be translated to farm and catchment levels with appropriate extrapolation and modelling techniques.
- What are the key factors for adoption of Best Management Practices (BMP), including the design of a decision support system, an analysis of socio-economic drivers and resistance for adoption, and a test of fit under a triple bottom line matrix for different methods that substantially reduce sediments and runoff loads?

Mineralisation of nitrogen within the sugarcane cropping system following legume fallows and its effect on water quality (RRRD020)

Led by Bernard Schroeder, BSES

Although much of this mineralised N can be taken up by the sugarcane crop (and can reduce the amount of inorganic fertiliser N needed), excess N (above that utilised by the sugarcane plant crop) is of environmental concern. In addition, data from the Sugar Yield decline Joint Venture and other BSES trials indicate that there is some carry-over of this N into the first ratoon crop, but its availability is not well understood. Apart from the importance of this N within the sugarcane cropping system, it also has implications for water quality as it could potentially be leached into ground water or lost by run-off. Loss of excess N by denitrification may also contribute to greenhouse gas emissions from canelands.

Quantification of N (ammonium and nitrate) resulting from the mineralisation of organic matter derived from legume break crops has been identified as a research priority within the sugarcane industry in Queensland. Although some information exists about the availability of this N for uptake by the plant crop following a legume break crop, it is important to investigate this more thoroughly and to determine how much of this N potentially remains as carryover to the ensuing ratoon crops.

The project will enable the effect of fertiliser N treatments to be assessed in sugarcane crops subsequent to a legume break crop. The size and availability of different N pools (organic and mineral N), sugarcane productivity (cane and sugar yield) and profitability (calculated partial net returns), and the environmental implications (estimated risk of N losses) of the different treatments will be determined. This will be achieved using data from a combination of field trials, pot experiments and laboratory assessments. The combined approach will be made possible by utilising existing field trials located in the Herbert, Mackay and Bundaberg regions, undertaking a series of supporting pot experiments in the growth-tunnel / glasshouses at the BSES Southern Experiments Station in Bundaberg and appropriate laboratory investigations at the DERM facilities at Boggo Rd in Brisbane.

This project will deliver:

- A review current information / data to establish the current understanding of the N from legume fallow crops within the sugarcane production system.
- Quantify more precisely the amounts of N (organic and mineral) in soils and fallow crop residues found in field trials conducted at different locations and in pot experiments conducted in semi-controlled conditions.
- Assessment of the productivity, profitability (economic evaluation) and environmental implications associated with the use of legume-derived N in a subsequent sugarcane crop cycle.
- Development of a set of guidelines for managing legume residues and the associated sources of N within a sugarcane / legume cropping system for incorporation into the SIX EASY STEPS nutrient management package.

2.3 Horticulture Practices

Minimising off-farm movement of nitrogen in the north Queensland banana industry (RRRD049)

Led by John Reghenzani, Terrain NRM

About 90% of the Australian banana industry is located on Queensland's wet tropical coast, which borders the Great Barrier Reef, and loss of nitrogen (N) and phosphorus (P) fertiliser off-farm is considered to be a serious threat to reef water quality. Leaching of N through the soil profile and erosive losses of both N&P from the soil surface are the important loss pathways. A survey of the banana industry in 1994 indicated that average N&P fertiliser use was 520 kg N and 68 kg P per hectare per year respectively (Daniells, 1995). Research began in 1995 to determine the optimal rates of N application so that fertiliser could be used more efficiently and cause less impact on the environment. This research indicated that N rates could be reduced to 150-220 kg N/ha/year (a N reduction of 71-58% relative to average application rates), provided that particular attention was paid to method of application and timing, as well as general aspects of crop management, including regular soil and leaf analysis (Armour and Daniells, 2002). Leaching losses were very significant at the 400 kg/ha/year rate in the trial but we do not know what level of leaching occurred at the lower N rates in the trial in the 100-300 kg N/ha range, because of lack of instrumentation.

This N study indicated the need to research slow release N products to possibly further reduce leaching losses. Slow release N sources have been available commercially for some time now but their cost has always been prohibitive. However, this could change if sufficient quantity was used with associated economies of scale, or if severe restrictions on use of soluble nutrients were imposed to protect aquatic ecosystems.

A more recent industry survey in 2007 indicated substantial reductions in N rates in the Tully valley with about 260 kg N/ha/year applied to plant crops and about 315 kg N/ha/year applied to ratoons (S. Lindsay pers. comm. 2010).

Due to budgetary and time restrictions the BananaMan and P aspects which were previously components of this project will now be taken up by two DEEDI extension projects.

This project will deliver:

- Determination of N leaching losses from bananas using best existing technology.
- Evaluation of new strategies to further reduce N losses off-farm.
- Implementation of existing technologies to greatly reduce N&P losses to the environment.
- Support implementation of research findings by the banana industry, to contribute additional nutrient savings to the Reef Rescue target of a 25 % reduction in nutrient discharge.
- Provision of a demonstration site for two DEEDI extension projects for field walks, publicity/industry magazine articles.

Development of a banana modelling capability to enhance reporting of Reef Rescue outcomes (RRRD054)

Led by Tony Webster, CSIRO

The APSIM model has a strong track record within past Reef Plan and current Reef Rescue activities: It was used in development of the Douglas Shire, Tully and Burdekin Water Quality Improvement Plans, and is the modelling platform for nutrients in sugarcane in the Reef Rescue Monitoring and Evaluation Program. It has also been used in economic analyses in Water Quality Improvement Plans.

Currently, APSIM is used in the Reef Rescue Monitoring and Evaluation Program to determine the economic and water quality impacts of ABCD management practises in sugarcane. This information is used by economic and catchment modellers to develop reef report cards. APSIM is also used to inform NRM bodies on incentive funding.

This project will use existing data and new data from experiments (e.g. RRRD049) to develop and test a banana module for the APSIM modelling framework. Much of the development of the banana module will be undertaken as a desktop activity, with trials used to fill gaps in the data required in the module development. Data on crop phenology (timing of crop stages based on radiation and temperature), biomass accumulation, leaf development, flowering, fruit growth and yield, water and nitrogen uptake, root growth and crop response to water and nutrient limitations will be sought from publications (including grey literature). Where data gaps exist, trials will be implemented to provide the required data. This project will fund the desktop activities and the collection of additional data that is needed for banana module development. During development of the banana module it will be tested and improved through a process of continual improvement.

The development of a banana module for the APSIM modelling framework will provide, for the first time, an ability for the Reef Rescue Monitoring and Evaluation Program to model the water quality and economic impact of ABCD management practices in the banana industry. This information will be available for catchment modelling to improve the validity of their reef card reporting and for regional NRM boards (particularly Terrain NRM) to better inform them on incentive funding decisions.

This project will deliver a modelling framework that is able to output the water quality (N and sediment) and economic impacts of ABCD management practices in the banana industry. This data will be used to model the outputs from RRRD049 and extend the management practices, soils and climate range from those trials.

2.4 Dairy Practices

Validating the cost/benefits of improved fertiliser practices and quantifying nutrient loads and pathways from irrigated dairy pastures in the Wet Tropics and the Burnett-Mary regions (RRRD055)

Led by Ruth Chalk, Queensland Dairyfarmers' Organisation

The project will determine the cost/benefits of using urea treated with a nitrification inhibitor compared to using standard urea in terms of reduced nitrogen losses through leaching and runoff and potential production efficiency gains. Research will be conducted on two irrigated dairy farms (Atherton Tablelands and Burnett Mary Region) with production systems common in the Great Barrier Reef catchments. Lessons learned from the research will be extended to dairy farmers and service providers through on-site field days and dairy industry publications. Industry current recommended practices and priorities for investment will be reviewed and if necessary modified as a result of the findings.

This project will deliver:

- Determining if nitrogen leaching losses from dairy pastures can be reduced if conventional urea fertiliser applications are combined with a nitrification inhibitor
- Determining if run-off losses of sediment, nitrogen (N) and phosphorus (P) can be reduced if conventional urea fertiliser applications are combined with a nitrification inhibitor
- Assessment of the cost/benefits of using urea treated with a nitrification inhibitor compared to standard urea in terms of both water quality benefits and farm productivity.
- Extending the learnings from the on-farm research to the wider industry through field days and publications.

Review/modify the industry current recommended practices as a result of the findings, and to determine priorities for investment.

2.5 Socio-Economic

Capturing historic small catchment study (paddock scale) data to support quantification of management impacts on water quality on the Great Barrier Reef (RRRD011)

Led by David Freebairn, RPS Australia

This project will synthesise data from historic soil management and catchment experiments to produce tables and relationships to compliment water quality modelling in Reef Rescue R&D portfolio.

Field studies of management impacts on erosion and water quality are crucial in informing science, policy and particularly farmers, yet there is a paucity of data from paddock scale studies. There has been significant research over the last 3 decades describing impacts of management on erosion and water quality, with approximately 50 historic studies identified that can support the quantification of water quality leaving farms. Poor publication and data management and lack of synthesis have resulted in the results from these studies largely being ignored. Recent experience has shown that these data can provide valuable points of truth and build credibility in model estimates of water quality signatures. In some cases the original “data collectors” are available to add context and data sets.

While each study by itself is incomplete, when put together with related data and estimates of hydrologic processes, this data can increase confidence in models as surrogates for field studies for a wide range of locations, soil types and management practices. In short, there is a mine of information that requires capture, synthesis and presentation to a wider audience.

This project will deliver soil and management parameters for use in models such as “How leaky?” will be created as baseline descriptions for modelling activities required in generalising field experiments. The wide geographic distribution of data sources will support localised model estimates. Workshops will pass this information and modelling skills on to a wider group of landscape managers and assessors, while all data and reports will be entered into the new Reef Water Quality data management system which will provide open access to all WQ related studies, past and current.

Factors affecting adoption of land management practices that have water quality benefits in the GBR catchments: Evaluation scenarios for Cane Farming (RRRDO10)

Led by Delwar Akbar, CQU

A sophisticated understanding of the social, economic and cultural dynamics is as important as biophysical condition and technical innovation and adaptation in land management practices (LMPs) in cane farming in the Great Barrier Reef (the Reef) catchments area, because all these phenomena ultimately impact upon the Reef's water quality. A tool capturing farmer's behaviour and stakeholders' perceptions towards key factors affecting adoption of LMPs that have water quality benefits is yet to be developed, that can assess the factors and indicators of LMPs' adoption at paddock level with its possible replication in sub-catchment and catchment levels.

This project will deliver a decision support system (DSS) which can inform the natural resource management (NRM) groups about LMP's adoption performance, especially in the cane industries at various geographic scales. This will enable managers to make intervention or improvement in the LMPs practices in order to maintain a better quality of water in the Reef system. The project aims to find out the factors affecting adoption of land management practices in cane farming that have water quality benefits in the GBR catchments.

Integrated assessment of BMP cost-effectiveness and decision tool for regions and landholders (RRRD039)

Stuart Whitten, CSIRO

Water quality improvements in the GBR catchments require the adoption of improved land management practices – with nutrients, pesticides and suspended sediments from cane, and sediments from grazing critical agricultural sources. Estimates of the relative cost and effectiveness of improved Best Management Practices (BMPs) are becoming available for some practices across some regions. However, current information has limited consistency and does not represent the diversity of farm enterprises across land types, operating structures, or transition costs.

We propose a set of integrated research deliverables that will greatly enhance and extend cost effectiveness estimates across diverse regions, including enterprise diversity, appraise cost effectiveness, and incorporate cost drivers such as physical constraints like land types and barriers to change such as transition costs. We will integrate this analysis in a decision support tool that can be used by NRM regions to identify the most cost effective mix of practice changes to invest in, and by individual landholders to explore the cost and profit implications of BMP adoption for their farm.

This project will deliver:

- The identification of the differences in BMP adoption between regions and across different farm types (e.g. large – small).
- An understanding of the impact of BMP adoption on farm economics for regional agriculture.
- The improvement in identifying the best investment options and their consequences for Reef Rescue targets (at regional and Reef-wide levels).
- The development of information for landholders and regions that will support farmer decisions about practice change and investment by regions in delivering those changes.

3. Pesticides threat, delivery and management

Pesticide dynamics in the Great Barrier Reef catchment and lagoon: management practices in the sugarcane industry (RRRD037)

Led by Jon Brodie, James Cook University

Pesticide runoff from agricultural lands has been recognised as a serious threat to the health and productivity of the Great Barrier Reef (GBR) (e.g. Lewis et al., 2009) and is considered a priority pollutant for management in the GBR catchment area. While it is clear that some pesticides have higher runoff potential than others due to their individual physiochemical properties (e.g. half life, solubility), a rigorous mass balance approach of individual pesticide chemicals is required to better parameterise/validate predictive models such as WaterCast and How Leaky? to improve the accuracy of load calculations. Moreover, the benefits of promoted 'A class' practices to reduce the amount of pesticide runoff are largely unquantified. These links are critical in the management of application rates of certain pesticides in the GBR catchments and to inform/validate modelling within the RR Water Quality (WQ) grants and monitoring and evaluation (M&E) components. This proposed project package will collaborate with key research scientists and extension officers from many organisations across several major GBR sugarcane regions to address these major unknowns of pesticide dynamics. In addition, the project will value-add to several plot-scale trials within the RR M&E program to help evaluate the effectiveness of the RR WQ grants program. It is envisioned that preliminary results from this project will be used to inform the current RR WQ grants program.

This project will deliver:

- Determination of the half lives in soils (and other key properties) of key pesticides used in the Great Barrier Reef catchment area for use directly in modelling for the RR M&E program.
- Investigation of the potential water quality and agronomic benefits of alternative herbicide products (to those currently used) used in sugarcane including Balance, Flame, Soccer and Krismat.
- Determination of the water quality benefits of improved practices to reduce pesticide runoff (Shielded sprayers, banded sprayers etc.).
- Demonstration of management options for minimising off-site movement of colloidal and dissolved-phase pesticides.

Pesticide dynamics in the Great Barrier Reef catchment and lagoon: management practices (grazing, bananas and grain crops) and risk assessments (RRRD038)

Led by Jon Brodie, James Cook University

This project package will collaborate with key research scientists and extension officers from many organisations across several major GBR sugarcane regions to address these major unknowns of pesticide dynamics. In addition, the project will value-add to several plot-scale trials within the RR M&E program to help evaluate the effectiveness of the RR WQ grants program. It is envisioned that preliminary results from this project will be used to inform the current RR WQ grants program.

This project will deliver:

- Knowledge of the half lives in water and exposure of key pesticides in the Great Barrier Reef catchment area and lagoon. These results will provide a critical measure of pesticide persistence in the GBR catchment area and lagoon, allowing for much improved risk assessments to be made on pesticide exposure in the GBR.
- Tebuthiuron management in grazing lands. The project will examine alternative practices for the application of tebuthiuron and will provide data on tebuthiuron half life, movement in soil, and off-site movement to better parameterise models used in the RR M&E component.
- Pesticides prevalence and distribution in relation to croplands. This project would involve the targeted sampling of water and sediments at reference sites and at lowland sites upstream and downstream of representative cropping areas throughout the Fitzroy catchment. The sampling surveys would be conducted over three wet season cycles. This will provide crucial data for the current RR M&E activities including baseline data for reference sites. In addition, it will assist regional NRM groups and government agencies in identifying catchment hotspots for BMP's and on-ground works aimed at improving GBR water quality.
- Pesticide management in bananas. The results from this study will provide the first field risk assessment approach for the banana industry and inform the RR Water Quality (WQ) grants program so that growers can make better decisions on their selection of pesticide products. This study will also provide valuable data to better parameterise modelling conducted under the RR M&E component.

A novel biological method of monitoring herbicides (RRRD058)

Led by Ben J. Kefford, UTS

This project will identify species of diatoms that are at risk from herbicides and develop a new SPEAR (SPECiesAt Risk) index to detect herbicide toxicity. It will investigate the modification of existing macroinvertebrate based SPEAR so that it can operate in the reef catchments to detect insecticide toxicity. This project will monitor pesticides, macroinvertebrates and diatoms in rivers draining onto the reef. We will determine if the measured herbicides are correlated with the diatom based SPEAR and the measured insecticides are correlated with the macroinvertebrate SPEAR.

The project will deliver:

- Develop a method of detecting toxicity to benthic (attached) diatom from herbicides in rivers draining onto the Great Barrier Reef, Queensland.
- Modify an existing method of detecting toxicity stream macroinvertebrates from pesticides in rivers draining onto the Great Barrier Reef.
- Test the accuracy of these methods in detecting herbicide and pesticide toxicity, respectively.

4. Tracking change

Pollutant load estimation for Great Barrier Reef (GBR) catchments: Accounting for the uncertainty in monitoring and modelled data using data assimilation techniques (RRRD030)

Led by Petra Kuhnert, CSIRO

Under the Reef Water Quality Protection Plan (Reef Plan) there is a requirement to reduce the export of nutrients, sediments and pesticides to the Great Barrier Reef (GBR) lagoon. Underpinning strategies, such as the Reef Rescue Water Quality Grants, the Paddock to Reef Integrated Monitoring, Modelling and Reporting (P2R) Program and the Reef Rescue Research and Development Plan (RRRDP) are aimed at reducing and measuring contaminant export from catchments through the introduction of improved land management practices.

The current approach for loads estimation feeding into the P2R baseline report card uses catchment models to estimate loads from a subset of catchments in the Great Barrier Reef (GBR) and monitoring data for the remainder (with quantified uncertainties), providing two different estimates of loads that need to be integrated into the P2R report. See Kroon et al. (2011) for an example and Kuhnert et al. (2011) for details regarding the statistical model developed for monitoring data. Furthermore, it is envisaged that future reports will only use catchment models for reporting loads, using monitoring data to calibrate models. This approach only addresses uncertainties in the catchment model parameters but does not address key uncertainties surrounding structural errors in the model and errors around the monitoring data used to calibrate the models.

This project will deliver:

- Provision of a robust framework for coupling monitoring data (provided by the DERM monitoring group) with the physical process that underpins the process-based model (e.g. Source Catchments) to produce an estimate of loads with uncertainties that incorporates the errors associated with the model and the measurements collected about the process.
- Illustration of the methodology using a trial area in the Great Barrier Reef (GBR) catchment area (e.g. Burdekin).
- Development of realistic management scenarios for the trial area within the modelling framework to investigate changes due to management.
- Engagement with DERM modelling and monitoring staff to ensure that the outputs can be used to facilitate paddock to reef reporting.

Developing integrated assessment metrics for reporting of water quality in the Great Barrier Reef lagoon (RRRD016)

Led by Vittorio Brando (CSIRO)

This project is a desktop study to develop integrated assessment metrics for the reporting of water quality in the Great Barrier Reef lagoon. The Reef Water Quality Protection Plan and the Reef Rescue policy initiatives have the express purpose of improving the status of water quality and ecosystem health in the Great Barrier Reef Marine Park by 2013. Long-term monitoring of spatial and temporal trends in broad-scale water quality within the Great Barrier Reef (GBR) Marine Park is central to assessment of this policy objective. This monitoring has been carried out since 2005 by the Reef Rescue Marine Monitoring Program (MMP). Recently, the MMP became part of the Paddock to Reef Integrated Monitoring Modelling and Reporting Program (PRIMMR), which is a key action under the revised Reef Plan 2009 to evaluate the efficiency of the implementation of Reef Plan and the progress towards its goals.

The integrated assessment method developed as part of this project will combine a selection of key indicators which enable reasonable evaluation of the overall status of coastal and marine waters. A comprehensive assessment method needs to include, e.g., the analyses of spatial and temporal variability of each data stream, the development of metrics/indices that combine and scale up the three approaches used to collect water quality data (direct sampling, *in situ* data loggers and remote sensing), the estimation of uncertainty of combined indices, as well as the development of statistical methods to assess the performance with regard to the existing GBR Water Quality Guidelines (GBRMPA 2009).

The development of water quality assessment metrics will be closely aligned with other assessments and reporting frameworks that have been developed nationally. In addition, international approaches to ecological assessment techniques will be explored. A review of other assessment frameworks and their approaches and methods will be one of the first deliverables of this project. The alignment with international initiatives will also be achieved by dialogues with experts and attendance at relevant conference and workshops.

This project will deliver the ongoing reporting of a marine water quality index, which will also form the basis for the integrated PRIMMR report card. It is not possible, nor feasible to monitor or assess all parts of a marine system. As such, the development of an integrated assessment method, which makes use of a variety of data types, is critical to the definition of the status of the environment, particularly with respect to nutrient enrichment/eutrophication.