THE USE OF TARGETED EXTENSION STRATEGIES TO IMPROVE WATER QUALITY OUTCOMES IN THE HERBERT SUGARCANE INDUSTRY

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Abstract

THE HERBERT SUGARCANE industry sought to obtain a better understanding of its impact on the quality of water entering the GBR and also the relative pollutant contributions from the other main land uses in the Herbert catchment. The Herbert Water Quality Monitoring Program (HWQMP) commenced in July 2011 and monitored water quality for 3 years in the Herbert catchment. An extension strategy was developed as part of HWQMP, with linkages to other projects allowing the sugarcane industry to assess its impacts from the cane block to the inner reefs of the GBR. The data generated by the HWQMP allowed the Herbert sugar industry to identify and proactively manage priority environmental issues. These projects informed sugarcane growers of what farm practices would lead to improvements in water quality, while not jeopardising industry viability. The HWQMP and associated extension effort has been successful in building industry capacity to manage issues identified by the water quality monitoring, while achieving positive change leading to improved water quality. The approach adopted by the HWQMP has shown that a sound, scientifically based extension approach can lead to significant environmental change without compromising long term industry viability.

Introduction

The development of HWQMP was driven largely by the Herbert sugar industry. The available data on water quality within the Herbert catchment (Bramley and Muller, 1999; Bramley and Roth, 2002; Bartley *et al.*, 2003) was considered inadequate for validating load estimations as part of the assessment of catchment contributions of pollutants to the Great Barrier Reef (GBR) (O'Brien *et al.,* 2014). The sugar industry also wanted to gain a better understanding of its own impact on water quality and to investigate ways to address specific issues if they arose.

CANEGROWERS Herbert River (the peak industry body for sugarcane production) initiated discussions with Terrain NRM and James Cook University (JCU) – TropWater to develop a project proposal for monitoring water quality in the Herbert catchment. A proposal was presented to CANEGROWERS Herbert River Board on 9 February, 2010 for consideration and was discussed at its annual general meeting on 22 April, 2010. The meeting agreed to proceed with the development of a full project proposal for funding.

The sugar industry, with assistance from Terrain NRM, coordinated a series of meetings with government agencies and other groups throughout the catchment area to secure funding and seek support for the project concept. The project was successful in securing funding and commenced in July 2011.

The project objectives were:

- seek relevant and scientifically robust data to inform and guide management decisions into the future for land managers within the Herbert catchment
- identify sources of pollutants at farm and sub-catchment level to enable issues to be addressed by land managers
- implement a tailored monitoring program to support management decisions, improve the Paddock to Reef program, complement grower monitoring and existing research findings
- cross reference the existing grower monitoring activities against a scientifically rigorous monitoring program
- develop appropriate extension strategies to engage growers and industry
- empower industry (especially the sugar industry) to drive farm management change practices based upon sound research findings.

Background

Over the past 150 years Great Barrier Reef (GBR) catchments have been extensively modified for agricultural production (especially sugarcane and beef) and urban settlement leading to a decline in the quality of water entering the GBR lagoon (Carroll *et al.,* 2012).

The Reef Water Quality Protection Plan (Reef Plan) states that the majority of nutrients, sediments and herbicides entering the GBR lagoon are derived from agriculture, primarily sugarcane and grazing. Thus, in recent years the sugarcane industry has been under significant scrutiny associated with agricultural runoff into the GBR lagoon. As part of Reef Plan end of catchment water quality monitoring is undertaken to provide pollutant load data from the major river systems discharging into the GBR. This monitoring provides load data for the whole catchment but is unable to quantify the relative contributions from different land uses in a catchment. The Herbert Water Quality Monitoring Program (HWQMP) commenced in July 2011 and operated for three years to monitor water quality for the whole Herbert catchment. The HWQMP was established after agricultural industry (especially sugarcane) was concerned that there was insufficient water quality data from specific land uses within the Herbert catchment. The sugar industry initiated the project to investigate the relative contribution of land uses on the delivery of pollutant loads to the receiving waters of the GBR.

The sugar industry engaged the local natural resources management (NRM) group within the area (Terrain NRM) to engage with government, funding agencies and other land users to develop a water quality monitoring program, which in turn would allow the various land user groups to develop extension and industry specific management strategies if issues did arise. The project was successful in attracting funding from the Sugar Research and Development Corporation (SRDC), Sugar Research Australia (SRA), Queensland Department of Agriculture Fisheries and Forestry (DAFF), Queensland Department of Natural Resources and Mines (DNRM), Queensland Department of Environment and Heritage Protection (EHP), Hinchinbrook Shire Council (HSC) and the Tablelands Regional Council (TRC). The project monitored sediment, nutrient and pesticide concentrations in surface waters collected from various sub-catchments which captured numerous land uses contributing to the Herbert River end of catchment loads. Surface water samples were collected from 17 sites covering the main land uses within the Herbert Catchment: rainforest, mixed cropping, urban, dairy, mining and grazing in the upper catchment; and sugarcane and urban in the lower catchment.

As a part of the project an extension strategy was developed whereby the various project stakeholders were provided water quality monitoring results six months prior to the information being made public. This allowed the various project stakeholders the opportunity to be informed of pending issues, develop strategies and implement activities when issues arose. The data generated informed community, NRM mangers and various industry stakeholders that use and rely on the land in this region. Further, the data generated also provided ‘land use specific’ water quality data to be

used in the validation of catchment models for the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef Program) managed by the State government.

Project methodology

The Herbert Water Quality Monitoring Program (HWQMP) commenced in July 2011 to identify land use and catchment specific sources of reef pollutants that contribute to the Herbert River end of catchment loads and to provide information to land managers who operate within the Herbert Catchment (O'Brien *et al.*, 2014).

During the HWQMP, 1040 samples were collected throughout the catchment (305 in 2011–2012, 224 in 2012–2013 and 511 in 2013–2014) across 17 sampling sites (Figure 1). Surface water samples were collected and analysed for total suspended sediment (TSS), nitrogen and phosphorus (both dissolved and total), and pesticide concentrations. Particle size analysis (PSA) of sediment was also undertaken on some samples to investigate the source of fine particulates within the Herbert catchment (O'Brien *et al.*, 2014). Land uses within the upper catchment (dry-land grazing, mixed cropping, ex-tin mining and rainforest) were separated from those in the lower catchment (dominated by sugarcane cultivation and forestry) by a considerable protected estate (national park).

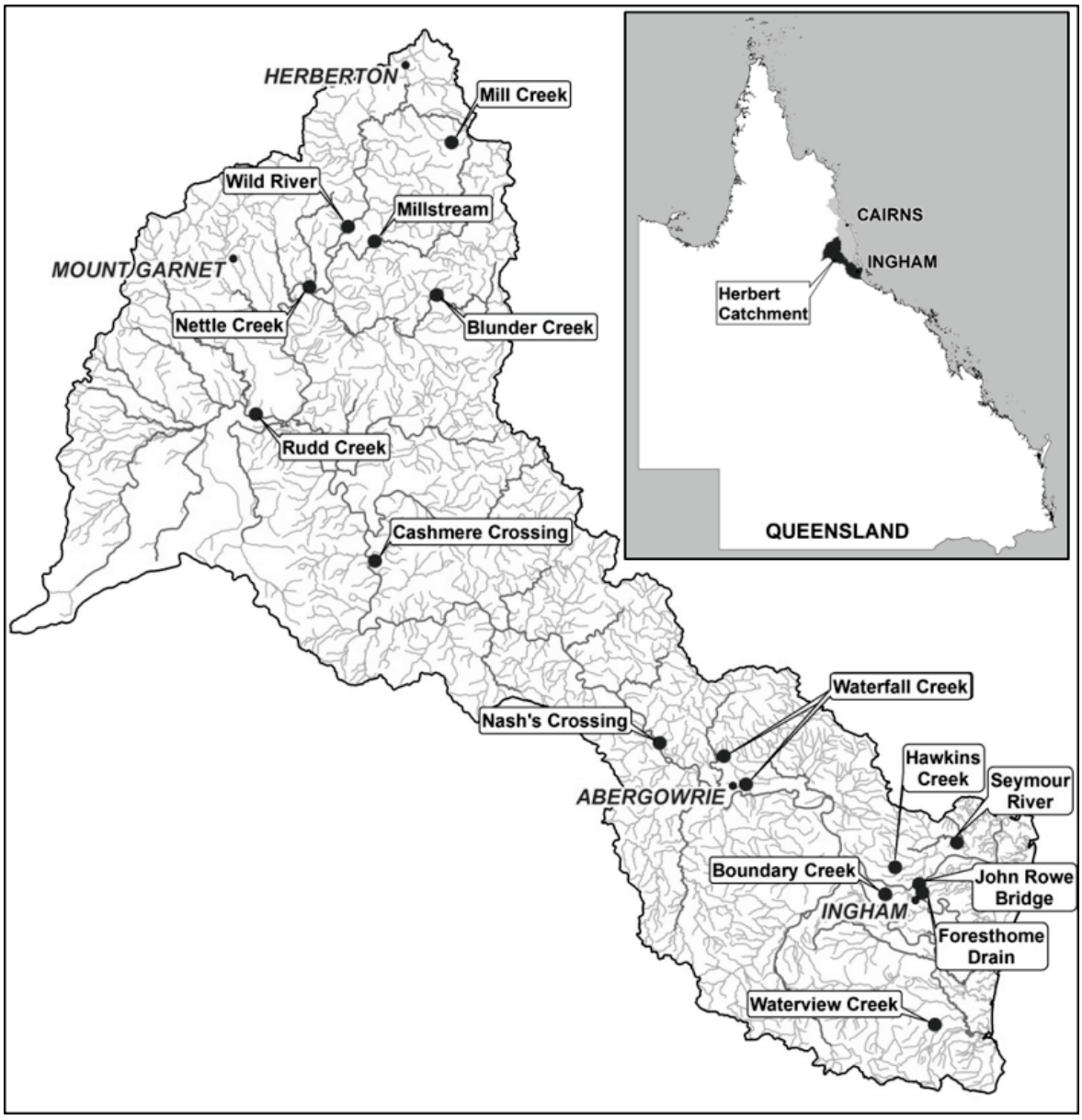

Fig. 1—Locations of the Herbert Water Quality Monitoring Program monitoring sites 2011–2014 (O'Brien *et al.*, 2014).

Extension methodology

Capacity and resilience

The influence that extension services in the Australian sugar industry have had on industry capacity and resilience against pest and diseases over the years has been based upon biological and socio-economic understandings (Hunt et al., 2014; Vanclay, 2004; Hunt et al., 2011, 2012). However, the influence that extension services have provided in relation to natural resource management has been weak to date. This weakness could be attributed to:

- the industry extension services being strongly focused on productivity related issues to increase cane and sugar yields
- the industry not being directly involved in research associated with most natural resource related issues, with most of this activity occurring in governmental departments and regional NRM groups.

This disconnect has been slowly changing over the past 10 years with industry groups like CANEGROWERS, BSES (now SRA) and Productivity Service Groups now taking a more active role in research projects and NRM programs, especially those focusing on reef water quality outcomes.

The capital framework

We can measure the relative levels and change in capacity and resilience around the framework of asset sets defined as:

- Human capital (the knowledge, skills and competencies of the individual within the industry)
- Natural capital (the contribution to the state of the natural biophysical environment)
- Institutional capital (i.e. influence of the initiative upon industry organisations and institutions that can be drawn on as industry capacity)
- Social capital (relationships and cooperation within the industry).

This capital framework allowed us to assess and explain changes in practice over time, in this case the management of natural resources in relation to reef water quality during the duration of the HWQMP. To allow the analyses of the 'capitals' and their effectiveness it is first necessary to provide the context within which they will be assessed.

It is necessary to document the NRM issue of concern, the methodology in which the water quality data were collected, the extension structures put in place to manage the research findings and the response by industry in relation to the research findings.

Extension structures put in place to manage the HWQMP

As a part of the project, a data management, stakeholder engagement and extension strategy was developed, whereby the water quality monitoring data would be communicated and reported to the various stakeholders. It was important to develop and implement this strategy because the project could have revealed potentially sensitive water quality information. A technical working group was responsible for checking the data and interpreting the results (Figure 2).

The collated information was then presented to a stakeholder reference group comprising representatives from the main land uses, government, NRM and the local catchment group. The agricultural land use representatives were responsible for engaging their constituents to discuss the results and develop management strategies to address issues arising from the monitoring data within a six months period before the data would be published.

The sugar industry used the Sugarcane Industry Working Group to achieve this. This approach also provided industry the opportunity to take ownership of the issues and act upon them before it was reported to the wider community. This approach was successful in coordinating project activities, while building industry capacity to communicate water quality and project outcomes.

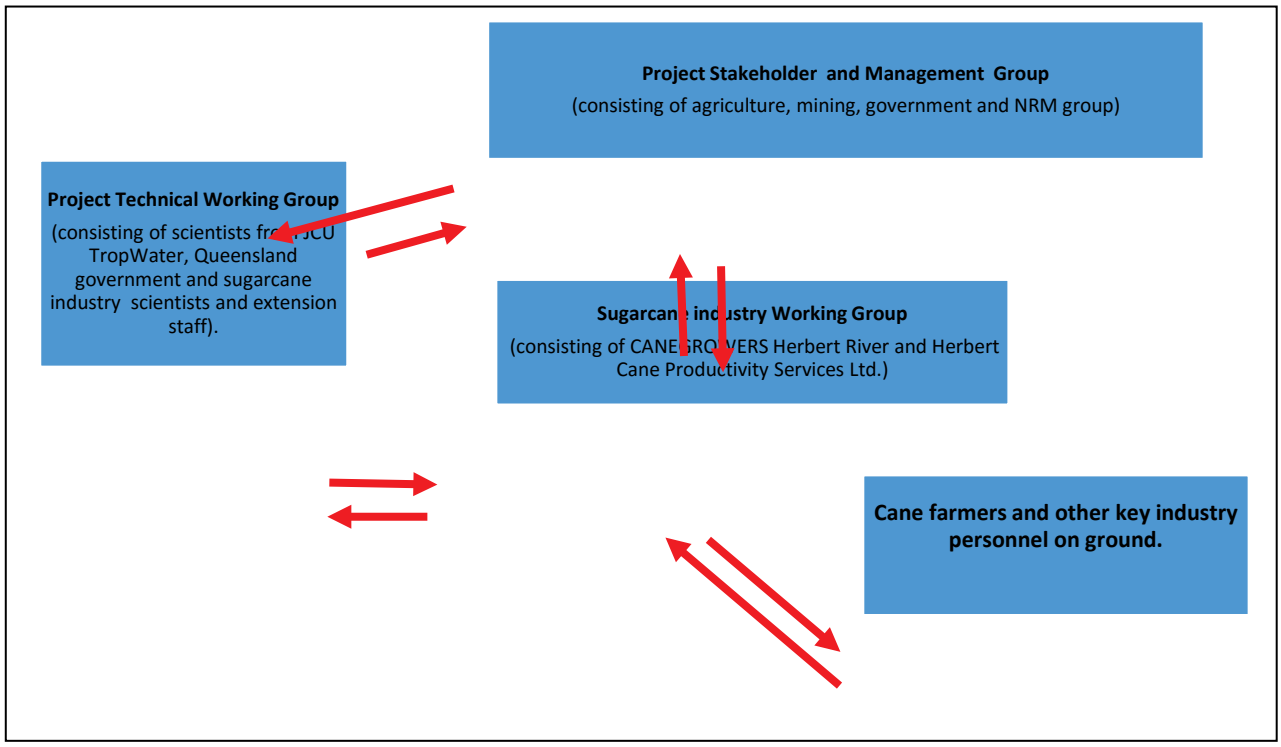

Fig. 2—The HWQMP data management and extension approach specific to the sugarcane industry project stakeholders.

Linkage projects associated with the sugar industry

At the inception of the HWQMP concept it was proposed to create linkages to other projects or programs focusing on water quality and agricultural production systems operating within the Herbert catchment. This was specifically the case for the sugar, dairy and beef cattle and mixed cropping industries.

In the sugar industry this project was linked to the following projects:

- The Herbert Demonstration Farm project funded by DAFF.
- The Rainfall Simulation Project and end of catchment monitoring under the Paddock to Reef program funded by the Queensland Department of Natural Resources and Mines (DNRM).
- The NERP program funded the inshore and reef water quality monitoring activities funded by the Australian Government.
- The Herbert Reef Plan Extension and Education project, funded by the DAFF.
- Project NEMO funded by the Australian and Queensland Government.

The Extension and Education project and Project NEMO provided extension opportunities and resources aligned to the HWQMP during and after the project completion.

These linkage projects also allowed the industry to better understand what water quality impacts it may have from 'Paddock to the Reef', while being supported by targeted extension activities to seek on-farm change in practices. This knowledge built industry capacity to better manage and understand issues associated with on-farm activities and water quality outcomes.

Project NEMO will build industry capacity through working with individual growers and groups of growers to demonstrate: various nitrogen rates, various nitrogen management strategies (i.e. Six Easy Steps, Nitrogen Replacement, Block Yield Potential) and various nitrogen products (i.e. Entec®, Agrocote and eNtrench®).

Extension based upon paddock scale water quality monitoring

Both the Herbert Demonstration Farm and Rainfall Simulation projects provided the Herbert cane industry the ability to undertake water quality monitoring at a paddock scale.

These projects allowed the industry to assess different farming practices in terms of the runoff of nutrients, sediment and herbicides associated with nutrient and pesticide application, application methods and products. A good example was the research undertaken by the Rainfall Simulation (in the Herbert cane region), which investigated the nutrient runoff losses for the five most common fertiliser application methods used by the cane industry (Cowie *et al.,* 2013).

The project findings allowed industry to evaluate farming practices which impacted on water quality outcomes. The project findings were communicated through various extension activities like small grower focus groups, shed meetings, bus tours, print and electronic media throughout the Herbert cane region.

Extension based upon sub-catchment water quality monitoring

As a part of the HWQMP, sub-catchment water monitoring sites were established in 4 sugarcane sub-catchment areas (Waterfall, Boundary, Waterview and Hawkins Creeks). The on-farm practice data (on pesticide and nutrient applications) was collected by HCSPL for the duration of the project. These data provided a useful insight to what farm practices were being undertaken in a sub-catchment and allowed the industry to better understand what impact various farming practices may have on water quality. To ensure that individual grower privacy was maintained, HCPSL only reported on aggregated data to growers and project stakeholder and technical groups. HCPSL used aggregated data to engage on a one on one basis with some of its clients to seek opportunities to manage water quality impacts.

Extension based upon whole of catchment water quality monitoring

The DAFF Extension and Education project funded technical agronomic extension staff to provide extension support to the main agricultural commodity groups in the Herbert catchment. This project worked in parallel with the HWQMP, whereby the extension staff reviewed the water quality monitoring results and used it to develop and deliver targeted extension strategies to address water quality issues across the catchment. The project also established a network of extension providers working with the different agricultural commodities and a forum for them to discuss their respective extension projects and assess different extension methodologies and approaches.

Extension activities after the HWQMP.

HCPSL secured funds from the Australian and Queensland Governments to deliver Project NEMO (Nutrient Efficient Management On-farm for profitability and productivity) to undertake extension activities after the HWQMP. This project commenced in late 2014 and is funded for a three-year period.

Project NEMO will take the research findings found in the HWQMP and linkage projects and communicate them through an extension program managed by HCPSL. HCPSL extension agronomy staff will work with growers (within the Herbert region) through one-on-one and group extension processes.

The project will also allow for growers to evaluate on-farm practices that could lead to improvements in water quality through on-farm demonstration plots. HCPSL extension agronomy staff will support growers with the establishment, monitoring and reporting of results from the on-farm demonstration plots. The findings from these plots will be communicated to the wider cane industry.

Results

Research findings specific to the sugarcane industry

The specific water quality monitoring results undertaken by the HWQMP for all land uses have been reported by O'Brien *et al*. (2013, 2014).

The HWQMP found that nutrient concentrations measured were highest in waters draining from sugarcane sites. The range of concentrations detected and the average concentrations measured in samples collected during event conditions are comparable with concentrations measured in other Australian sugarcane growing regions (O'Brien *et al*., 2014).

Nitrogen levels and some pesticides, including diuron, hexazinone and atrazine, are frequently measured at concentrations exceeding the national guidelines for freshwater ecosystem protection in waters discharging from sugarcane sites in the Herbert sugarcane sub-catchment area (O'Brien *et al*., 2014).

The project also detected imidacloprid (a pesticide used to control cane grubs). The levels were just below the Canadian guideline (there are no Australian guidelines published at present for freshwater ecosystem protection in waters discharging from specific sugarcane sub-catchments) in the first year of the project (O'Brien *et al*., 2013).

The monitoring data provided the sugarcane industry with an insight into on-farm practices in relation to water quality and allowed the industry to act upon issues as they arose. The industry is currently reviewing all its practices in relation to pesticide and nutrient management since the findings of the HWQMP have been made available.

This report presents two examples of specific approaches adopted by the industry to address arising issues associated with imidacloprid and nitrogen use.

Extension response to imidacloprid issues.

Imidacloprid was detected in water quality samples collected in the Waterview, Waterfall and Hawkins Creek sugarcane sub-catchments in the first year of sampling (2011–12) in the HWQMP (O'Brien *et al*., 2013) while no detections occurred in the Boundary Creek sugarcane sub-catchment. The difference was specific to grower use and the historical presence of grey back cane grubs in the sub-catchments in which the chemical was detected.

In response to these findings, HCPSL conducted a number of grower shed meetings throughout the district in late August– early September 2012 to inform growers of the impeding risks associated with the improper use of imidacloprid, its impact on water quality and recommendations for effective grub control with minimal runoff.

Over 150 growers attended the meetings. The targeted extension program also focussed on issues associated with placement and timing of the product. Due to the project it was found that placement in field was inadequate, hence numerous applicators have been redesigned and modified since.

Since the targeted extension approach in late 2012, associated with product timing and placement, there has been a considerable reduction in imidacloprid levels detected in water samples in the sugarcane sub-catchments monitored by the HWQMP.

Imidacloprid levels detected in water decreased while the area treated to the product in the Herbert has increased substantially over the three-year period during the HWQMP (Murphy, personal communication, 2014). This change could be attributed to the large extension effort and improved practices adopted by the Herbert industry to manage the use of imidacloprid; Figure 3 shows the changes over time due the extension strategy implemented.

Extension response to nitrogen losses.

In response to the elevated levels of nitrogen in water quality samples collected by the HWQMP and research undertaken by associated projects like the Herbert Demonstration Farm and Rainfall Simulation project, the Herbert industry is now investigating ways to better manage nitrogen losses associated with sugarcane production.

The Rainfall Simulation project validated that sub-surface application fertiliser in sugarcane crops had the lowest nitrogen runoff losses when compared to other application methods available to the industry (Cowie *et al.,* 2013). Since the inception of the Australian Government's Reef Rescue grants program, HWQMP, and reporting of the Rainfall Simulation trial results, there has been a significant shift from surface fertiliser application to sub-surface application in the Herbert cane growing region. Surface application of fertilisers reduced from 78% of area treated in 2008 to 38 % of area treated in 2013, for the Herbert sugarcane growing region (unpublished HCPSL data, 2014).

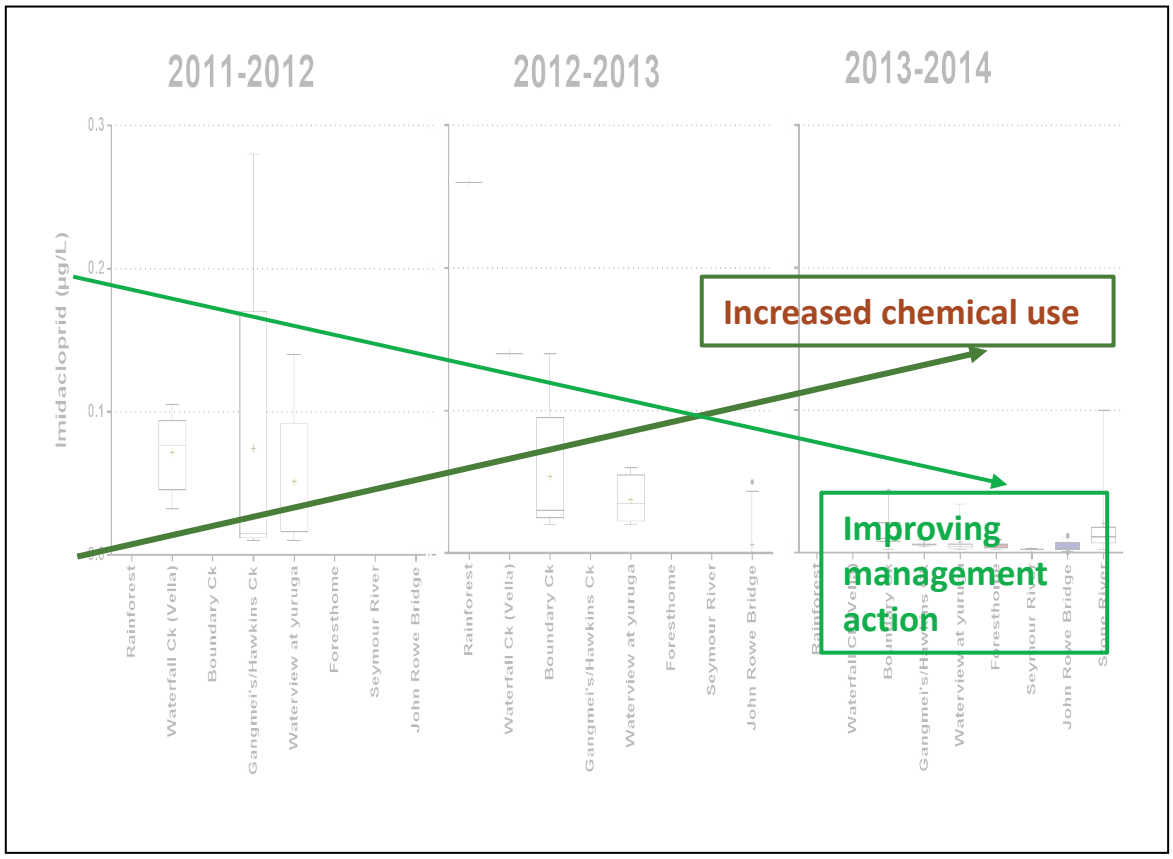

Fig. 3—Comparing years for imidacloprid levels found in water quality samples taken as a part of the HWQMP.

Project NEMO will allow growers to evaluate on-farm practices to better manage nitrogen that could lead to improvements in N use efficiency and water quality outcomes. It will allow growers to assess different nitrogen rates, gain confidence in industry using nutrient management guidelines developed as a part of the Six Easy Steps program, assess enhanced efficiency nitrogen fertilisers (like nitrification inhibitors and controlled release urea) and adopt farming systems that improve soil health and nutrient recycling and better manage water quality issues and maintain industry viability.

Project NEMO will establish numerous farm demonstration trials to allow growers to assess various ways to improve nitrogen use efficiencies and improve water quality outcomes on their own farms, which will be supported by ongoing water quality monitoring.

Discussion

The success of the HWQMP and its affiliated projects can be measured by the significant development of 'capital' in the Herbert catchment (especially by the sugar industry) during and after the project period. The success and development of 'capital' can be measured by the following:

(a) Human capital: The Herbert land managers (especially the sugar industry) now have a sound knowledge of water quality pertaining to the various land uses within the catchment. The HWQMP has brought together land managers to discuss issues raised by the scientific research and to seek approaches to address issues like the use of nitrogen and products like imidacloprid.

(b) Natural capital: The HWQMP has added significant value to the region's knowledge in relation to what land uses contribute to water quality in the whole of catchment area. This knowledge will allow the State government Paddock to Reef modellers to use real data generated within the catchment area, instead of implied data from

adjacent catchment areas, when developing models for managing water quality across the Reef Catchments. The newly acquired knowledge will also allow land managers to be better managers of natural resources on which they may have some influence.

(c) Institutional capital: The lasting legacy of the HWQMP is that specific land users have now invested in long-term monitoring of water quality, allowing them to manage issues proactively as they arise. The continued long term monitoring of water quality is done through a collective approach whereby numerous organisations and institutions work together to collect, collate, report and act on the data generated.

(d) Social capital: the HWQMP has allowed industry organisations and institutions to work together on the difficult issues like land use practices impacting on water quality. Prior to the inception of the HWQMP some industry organisations and institutions worked in isolation from each other. This project has brought such groups to the table to discuss issues pertaining to water quality and to develop methods to manage such issues. After the HWQMP, these industry organisations and institutions still come together (now less frequently, but still regularly) to discuss whole-of-catchment issues and what practices are being implemented to address specific issues for their various land uses.

Conclusions

The investment into the HWQMP and aligned projects has built the region's capacity by 'increasing the abilities or resources of individuals, organisations and communities to manage change' (Coutts *et al.,* 2005). Macadam *et al*. (2004) described the building of capacity in agriculture as 'externally or internally initiated processes designed to help individuals and groups to appreciate and manage their changing circumstances, with the objective of improving human, social, financial, physical and natural capital'. This project has certainly achieved this. The HWQMP demonstrated that local water quality data coupled with a targeted extension effort has built capacity within the Herbert sugarcane industry to better manage cane production systems to improve water quality entering the GBR.

The HWQMP identified that at times the concentrations of some nutrients (especially nitrogen) and pesticides detected at sugarcane sites within the Herbert catchment often exceeded existing Australian water quality guidelines. Nutrient concentrations were highest in waters draining from sugarcane sites, but the range of concentrations detected and the average concentrations measured in samples collected during event conditions were comparable with concentrations measured in other Australian sugarcane growing regions. (O'Brien *et al*., 2013).

The HWQMP and aligned linkage projects (like the Herbert Demonstration Farm, the Rainfall Simulation and the Extension and Education projects) have provided the Herbert cane industry with local, timely water quality data and agronomic support to build industry capacity to address reef water quality issues. These projects have provided the Herbert sugar industry with specific local data at paddock, sub-catchment and whole of catchment scale and inshore reef scale for a sound extension approach to be developed. This has allowed the Herbert sugarcane industry to 'join all the dots' from paddock to the onshore reefs in relation to managing the quality of water leaving a cane farm.

The HWQMP has definitely shown that extension programs can have an impact on water quality entering the Great Barrier Reef (GBR) lagoon, if they are well planned, targeted and managed accordingly. This paper has also shown that targeted extension programs can lead to positive NRM outcomes, without compromising industry productivity and profitability: in the long term a 'win win' situation for all.

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