

Evaluating the role of extension in helping to improve water quality in the Great Barrier Reef

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Abstract. From 2012-2014 the Queensland Government delivered an extension project to help sugarcane growers adopt best management practices to reduce pollutant loss to the Great Barrier Reef. Coutts J&R were engaged to measure progress towards the project's engagement, capacity gain and practice change targets. The monitoring and evaluation program comprised a database, post-workshop evaluations and grower and advisor surveys. Coutts J&R conducted an independent phone survey with 97 growers, a subset of the 900 growers engaged in extension activities. Of those surveyed 64% stated they had made practice changes. There was higher (74%) adoption by growers engaged in one-on-one extension than those growers only involved in group-based activities (36%). Overall, the project reported 41% (+/-10%, 95% confidence) of growers engaged made a practice change. The structured monitoring and evaluation program, including independent surveys, was essential to quantify practice change and demonstrate the effectiveness of extension in contributing to water quality improvement.

Keywords: Reef Plan, adoption, sugarcane, growers, management.

Introduction

The decline in water quality in the Great Barrier Reef (GBR) has been identified as a major threat to the health and resilience of the GBR (Great Barrier Reef Marine Park Authority 2014). To address this threat the Australian and Queensland Governments have partnered with key industry, natural resource management (NRM) and conservation organisations to deliver the Reef Water Quality Protection Plan (Reef Plan). The aim of this plan is to reduce the loads of nutrients, sediments and pesticides entering the GBR lagoon from adjoining catchments, with a focus on improving agricultural land management practices. Reef Plan 2013 has an ambitious target that by 2018 '90 per cent of sugarcane, horticulture, cropping and grazing lands are managed using best management practice systems in priority areas' (State of Queensland 2013). Multiple programs are being implemented to help producers adopt best management practice systems, including incentive grants, industry-led best management practice (BMP) programs and extension. One of these is the Queensland Government's extension program delivered by the Department of Agriculture and Fisheries (DAF) with funding from the Department of Environment and Heritage Protection (EHP). This program aims to help sugarcane growers and graziers adopt management systems that reduce nutrient, pesticide and sediment loss to the GBR and improve agricultural business profitability and productivity.

The effectiveness of the multiple Reef Plan programs and their overall contribution towards Reef Plan targets is monitored through the Paddock to Reef program and reported in annual report cards. The 2012-2013 Report Card stated that from June 2009 to June 2013 30% of graziers, 49% of sugarcane growers and 59% of horticulturalists had adopted improved management practices and that best management practice nutrient, herbicide and soil management had been adopted by 50%, 34% and 25% of cane growers respectively (Australian and Queensland Governments 2013). The majority of these management improvements were attributed to the incentive grants funded by the Australian Government and delivered by the regional NRM bodies. Despite considerable investment by the Queensland Government into extension, quantifiable data on management practice change resulting from extension was limited. An audit into Queensland Government Reef Plan programs raised this as an issue, stating that as the scale of change and water quality benefits cannot be verified, the effectiveness of these extension activities and contribution towards Reef Plan targets cannot be determined (Queensland Audit Office 2015).

To address this, DAF engaged specialist consultants to provide advice and support on developing and implementing structured monitoring and evaluation of its sugarcane and grazing extension projects. The aim was to ensure that management practice adoption resulting from DAF extension activities was quantified and able to be reported to EHP (funders) and included in future Reef Plan Report Cards. A robust evaluation process was also needed to analyse the effectiveness of different extension delivery methods (e.g. one-on-one, group-based extension) to help inform the design of future extension projects. This paper explores the process, outcomes and lessons from monitoring and evaluating the DAF sugarcane extension project.

Background

The DAF sugarcane extension project ran from July 2012 to June 2014 with funding from EHP and DAF. The aim of the project was to support sugarcane growers to adopt best management practices that reduce nutrient, herbicide and sediment loads to the GBR and improve the productivity and profitability of Queensland's sugarcane industry. The project had the following engagement, capacity and adoption targets:

- 600 cane growers participating in extension activities
- 50% of the participants surveyed have improved capacity and intend to make a management practice change, and
- at least 120 producers (20% of those engaged) will make an on-ground practice change that can be quantified by June 2014.

Twelve DAF officers delivered extension activities in the main cane production areas in the GBR catchment (i.e. Mossman to Maryborough). Extension effort was targeted to priority regions identified in the Reef Plan Scientific Consensus Statement 2013 (Brodie et al. 2013). This led to the majority of the extension activities being delivered in the Wet Tropics region, which is the highest priority area for addressing nitrogen management (Brodie et al. 2013).

Extension activities focused on the priority practices identified in the Paddock to Reef Water Quality Risk Framework (WQRF), for example matching nitrogen supply to crop requirements and targeting herbicide application to reduce the volume of herbicide applied. A combination of one-on-one and group extension activities were delivered during the project as described below.

- *On farm trials* of priority management practices to assess their application in a local context.
- *Tailored advice* to growers to support adoption of improved management practices.
- *Meetings* with both growers and industry advisors to discuss priority management practices.
- *Workshops* focused on priority management practices that included presenting trial results, case studies and practical demonstrations of new technologies. They were targeted at growers and industry advisors.
- *Field days* organised by DAF or where DAF presented specific information. Participants included mostly growers and local industry advisors.

Methods

Project methodology is described below under three sub-headings:

1. design and implementation of the overarching monitoring and evaluation program
2. grower survey to quantify management practice change
3. industry advisor survey to evaluate changes in knowledge or skills and transfer to growers.

Monitoring and evaluation program

A logical framework (logframe) was developed at the commencement of the sugarcane extension project setting out the long- and short-term goals, performance measures and monitoring methodology. Bennett's hierarchy (Bennett 1975) was used as the framework to measure how the project contributed towards these goals and the broader Reef Plan targets, as shown in Figure 1.

Figure 1. Monitoring and evaluation framework



Based on Bennett (1975)

Consistent with this framework, the monitoring and evaluation conducted during the two-year project comprised:

- **Engagement:** recording project activities and participation within an online database called YourData, owned and operated by Coutts J&R and customised for this project.
- **Capacity changes (Knowledge, attitudes, skills and aspirations):** survey conducted at the end of workshops with participants to determine changes in knowledge and skills in specific topics and aspirations, i.e. intention to take action as a result of the workshop.
- **Practice change:** independent phone survey conducted with sugarcane growers to quantify on-ground practice change and the influence of DAF activities in supporting that change. Narratives and case studies provided detailed examples of change that had occurred as a result of the project and the consequences for water quality and the agricultural enterprise.

- Building the capacity of other advisors: Industry advisors external to DAF were surveyed to determine the extent to which advisors used the knowledge and skills, gained through their involvement in the DAF extension activities, in their work with growers.

Grower survey

In May 2014 a survey was undertaken to measure the percentage of growers who had made a practice change with assistance from DAF extension during the two-year project. Coutts J&R were contracted to undertake this survey to provide robust, consistent and independent data collection and collation. The survey was conducted via telephone with a subset of the 900 growers who had participated in DAF extension activities. It was not a random survey across the whole industry and instead was targeted at those growers who had been involved in the DAF extension activities during the two-year project. The aim was to get responses from around 100 growers so that the results could be extrapolated across all the growers engaged in the project with a 95% confidence level and a confidence interval of 10.

DAF and Coutts J&R designed the questionnaire to align to the project targets and priority management practices identified in the WQRF. Alignment to the WQRF ensured the results could be standardised for Reef Plan modelling and reporting. The WQRF describes each management practice in terms of risk to water quality. The Paddock to Reef modelling and reporting uses information on area (hectares) managed under best management practice, with best management practice defined as the moderate-low risk and low risk categories in the WQRF. Therefore if adoption results in a change from a high or moderate risk to a moderate-low or low risk (i.e. best management) practice, the production area affected by the change can be modelled and reported. For this reason, the survey was designed to capture information on the specific practices growers had changed and the production area impacted by this change, so that the practice could be aligned to the specific risk category in the WQRF and modelled accordingly. Information on what practice was in place before the grower made a change was not recorded and therefore the pre-change practice was assumed to be one step lower than the current practice, i.e. if a grower adopted a moderate-low practice it was assumed that the previous practice was a moderate risk practice. To avoid potential duplication in practice change reporting with other Reef Plan programs, specifically the grants program, only practice change attributed to one-on-one extension was included in the Paddock to Reef reporting.

The DAF sugarcane extension team provided the names and contact details of sugarcane growers who had received advice or participated in extension activities. The majority (67%) of growers surveyed were in the Wet Tropics region. This reflected the fact that most of the extension activities were conducted in this region, as it is a priority area in the Scientific Consensus Statement 2013 (Brodie et al. 2013). The remainder of the growers farmed in the Burdekin and Mackay Whitsundays regions.

There was a good response rate to the telephone survey (93%) with 105 growers contacted and 97 participating. Respondents were grouped according to the level of interaction they had with DAF. The majority (74%) had received one-on-one extension support such as farm trials or specific advice tailored to their enterprise and the remaining 26% had been involved in group extension activities such as grower meetings or workshops. Only 13.5% of growers involved in the DAF project had been engaged in one-on-one extension, yet they represented 74% of survey respondents. The levels of adoption between growers involved in group versus one-on-one extension were predicted to be different. Therefore the overall percentage adoption ($A_{\%}$) was calculated by multiplying the number of growers (g) engaged in the project in each extension category (group or one-on-one) with the adoption rate (r) for that category, divided by the total growers engaged in the project (P) as shown in Equation (1).

$$A_{\%} = \frac{(g_{group} \times r_{group}) + (g_{one} \times r_{one})}{P} \quad (1)$$

Industry advisor survey

Coutts J&R also conducted an independent telephone survey with advisors external to DAF. Twenty-five extension officers and advisors from sugarcane productivity services, regional natural resource management bodies and agribusiness suppliers in the Mackay Whitsundays, Burdekin and Wet Tropics regions were interviewed. They were a subset (approximately 20%) of the total number of advisors who had participated in workshops or grower meetings organised by DAF or extension events at which DAF provided information. The DAF extension team provided contact details and the questionnaire was developed by DAF and Coutts J&R. Interviewees were asked if they had gained any new information and skills from the activity they had participated in and if so, if they had subsequently used that in their work with growers.

Results

The results are described in two parts:

1. Grower engagement, capacity gains and adoption
2. Industry advisor engagement, capacity gains and knowledge transfer.

Grower engagement, capacity gains and adoption

Engagement and capacity gains Over the two-year project over 800 extension activities were recorded in the YourData database and the majority of these focused on improving nutrient and herbicide management. Nine hundred producers managing approximately 96,000 ha of cane land (24% of cane lands in GBR catchments) were engaged in extension activities. Over three-quarters of the growers were engaged via group-based extension including workshops, grower meetings and farm tours with the remainder involved in more intensive one-on-one trials or tailored extension advice. The average farm size of growers engaged in group-based extension was 112ha and those involved in one-on-one extension was 184ha.

At the end of 21 group-based extension activities, 227 growers completed evaluation surveys and 96% of them (219 growers managing 25,000 ha) reported increased knowledge and skills as a result of DAF extension activities. The highest average rating for increased knowledge and skills was for herbicide and integrated weed management (6.8/10, with 10 being a *large increase*) followed by soil management (6.7/10), whole of farm system management (6.6/10) and water management (6.6/10). In response to the question: *Overall, how useful has this activity been to you?* growers provided an average rating of 8.2/10.

Almost half of those who participated in the evaluation surveys (i.e. 110 growers) stated that they intended to make a change to their farm management as a result of their participation in the extension activity. This included making a change to farming practices, requesting plans/using the dual herbicide sprayer (DHS) a new technology for banded herbicide application, changing legume residue management and changes to business management (Figure 2). Other intended actions included undertaking a trial, doing more training or seeking funding such as grants from NRM bodies.

Figure 2. Intended actions growers indicated that they would take as a result of participation in DAF extension activities

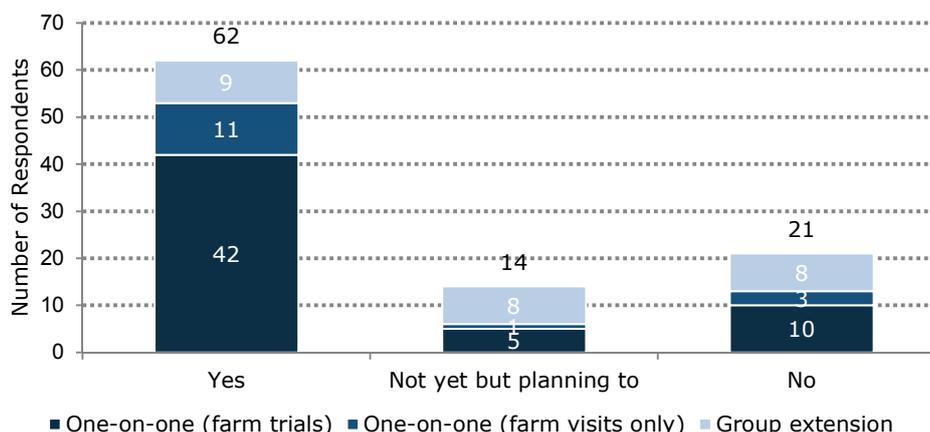


Adoption The grower phone survey quantified changes made to farm management by growers who had been engaged in DAF extension activities. It also provided additional information on the influence and helpfulness of DAF extension, barriers to adoption and how growers like to receive support. Ninety-seven growers participated in the survey with 74% having had received one-on-one extension support from DAF (including 57 with farm trials), while 26% had been engaged only through group-based extension activities such as workshops. Most growers who were involved in one-on-one extension had also participated in group-based extension activities.

Growers said they found the DAF extension activities very helpful in assisting with farm activities and planning, providing an average rating of 8/10 (10 being *very helpful*). This is similar to the average rating of 'usefulness of the extension activity' from the group-based extension evaluation surveys.

Sixty-four percent of growers surveyed said they had made a change to their farming practices or business with help from DAF extension activities, information or support during the two-year project. Another 14% said that they hadn't made a change yet but they planned to (Figure 3). Those who had received one-on-one extension support had higher levels of adoption (74%) than those who had only participated in group-based activities (36%). A third of the growers involved in group-based extension stated they had not yet made a change but were planning to.

Figure 3. Number of growers who stated they have or have not made a change to their farm management with help from DAF extension activities, grouped according to the most intensive type of extension activity they were involved in



The majority of the practice changes were in the areas of nutrient, herbicide and soil or fallow management. Thirty-six growers stated they had made changes to herbicide and weed management, 32 growers had changed their nutrient management and 27 made changes to soil or fallow management. The majority of the herbicide and weed management changes (22) involved reducing the use of residual herbicides such as diuron and atrazine (photosystem II (PSII) inhibiting herbicides commonly found in inshore waters of the GBR). Most (84%) of the nutrient management changes were changes to fertiliser rates and 85% of the growers who said they had changed their soil or fallow management had used a fallow legume crop and 30% reduced tillage.

Overall, there was 95% confidence that 41% \pm 10% of growers engaged in the project made a practice change with assistance from DAF extension. This equates to between 288 and 459 growers making changes to their farm management, affecting at least 30,000 hectares of cane land, which is around 7% of cane lands in the GBR catchment.

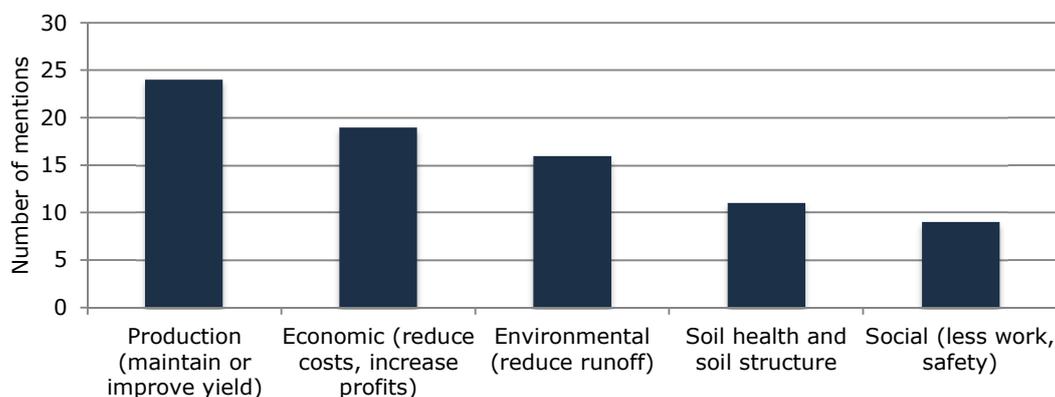
The survey results were aligned with the WQRF to give new hectares under best practice for nutrient, pesticide (i.e. herbicide) and soil management. Table 1 shows the final figures that were included in the Paddock to Reef modelling for the 2013-14 financial year. Note, only practice change associated with one-on-one extension support was included to avoid duplication with other Reef Plan programs.

Table 1. Total hectares under best practice for soil, nutrient and pesticide included in 2014 Paddock to Reef modelling and reporting

Region/catchment	New area managed under best practice (ha)		
	Soil	Nutrient	Pesticide
Mackay/Whitsundays	784.05	909.58	266.50
Burdekin	0.46	84.14	24.65
Herbert	69.85	168.29	49.31
Tully	498.07	478.31	160.24
Johnstone	785.41	862.46	252.69
Russel/Mulgrave/Barron	2,497.99	2,743.05	803.69
Mossman/Daintree	113.88	445.96	130.66
Total	4,749.25	5,691.79	1,687.74

Growers who had stated that they had made a change to their farm management were asked if they had observed or expect to see production, economic and environmental benefits from making that change. The majority of the benefits that growers said that they have seen or expect to see were related to improved productivity and economic benefits (Figure 4). Environmental outcomes in terms of water quality improvements and better soil health were also mentioned regularly. Sixty percent of growers stated that a lack of funds was the most significant factor preventing or delaying them from making desired farm management changes.

Figure 4. Types of benefits growers have seen or are expecting as a result of making farm management changes



Industry advisor engagement, capacity gain and knowledge transfer

At least 75 private agribusiness resellers or consultants and 64 extension officers were involved in project activities and 25 of them participated in the end of project advisor survey. Three-quarters of those surveyed stated that they had used the knowledge and skills gained through DAF activities in their own work with producers. These respondents estimated that they would have worked with a total of over 2000 producers (average 108 producers each).

Discussion

Monitoring and evaluation program

The structured monitoring and evaluation program enabled evidence to be gathered and reported on activities conducted, growers engaged, capacity gains and practice change. This provided essential quantitative information for multiple audiences, being:

- EHP, to report progress towards project targets
- DAF, to satisfy internal reporting requirements and
- Reef Plan Paddock to Reef Report Card, to report area of best management practice change.

Having a well-planned monitoring and evaluation program enabled DAF to report that the extension work had achieved project targets and led to practice change which contributed towards the overall Reef Plan targets. The DAF sugarcane extension team was also able to identify what extension methods or activities were more successful in getting this change to occur to help inform future extension work.

Planning the monitoring and evaluation of the DAF sugarcane extension program upfront ensured that the right types of evidence were collected to report project outcomes. This included how the evidence was going to be collected, stored, collated and evaluated. Developing the monitoring and evaluation program at the beginning of the project helped identify and plan for the following requirements:

- Reporting to multiple organisations: at the project planning stage, data and information that needed to be collected to report to funders (EHP and DAF) and Paddock to Reef was identified so that the monitoring program could be designed to meet reporting requirements.
- Determining levels of capacity gain and practice change: extension projects in the past generally only reported activities delivered and participation, whereas determining outcomes such as capacity gains and adoption requires follow up with growers. It was therefore critical for DAF to collect the necessary information (farm location, contact details etc.) during the project for this follow up to occur.

The YourData online database was set up to link project activities to project targets and specific priority management practices (as per the WQRF) to streamline reporting. Activity and post-workshop evaluation templates were developed to provide consistency across the extension team, which was particularly useful when aggregating cross-regional efforts. There was enough flexibility in workshop evaluation template to be tailored for specific workshops while still linking to the priority management practices and project targets. The information collected was then able to be evaluated for gains in knowledge and skills and the intention to make a change.

DAF extension officers added narratives into YourData to highlight examples where they had supported a grower to make an on-farm practice change. The grower and advisor surveys were able to gather more evidence on capacity gains and practice change that had occurred as a result of the DAF sugarcane extension program. These multiple tiers of the monitoring and evaluation program were important to build layers of evidence to demonstrate improved knowledge and skills and ultimately practice change as a result of the extension project.

Grower engagement, capacity gain and adoption

In the sugarcane industry, like many agricultural commodities, extension plays a role in raising awareness, skills and knowledge and supporting growers to adopt new management practices (Pannell et al. 2006). The Reef Plan Extension and Education Strategy Update and Implementation Guide (Coutts 2014) describes how extension can lead to a higher rate of adoption, increased geographic and demographic spread of adoption and improved effectiveness of adoption (i.e. better outcomes). Therefore the DAF sugarcane extension project aimed to provide growers with the information, resources and technical support they need to be confident to make an effective on-farm change in a shorter time than it may normally take. The key activities to improve capacity and change in the priority management practices included a combination of one-on-one extension (trials and specific advice), group extension (grower groups, workshops and field days) and industry advisor workshops.

One-on-one extension The ability to trial a new innovation or practice on a small-scale prior to full implementation has been included in various diffusion theory models since the 1950s (Beal 1957, Rogers 2003). Therefore one-on-one extension through conducting on-farm trials and providing tailored advice to growers on priority management practices was an integral part of the DAF sugarcane extension project. Almost 100 trials were conducted with 65 growers managing 10,000ha. Of the 62 growers in the survey who said they had made a practice change, 53 (85%) had received one-on-one extension support. The survey highlighted that growers who received one-on-one extension support had higher levels of adoption (74%) than those who had only participated in group-based activities (36%).

These results reinforce the importance of one-on-one extension in supporting practice change, particularly in a short project. One-on-one extension helps to foster a relationship between the grower and extension officer allowing for a two-way flow of information. Growers interviewed in the survey stated 'extension is the most important and coming to visit our properties helps with implementing new ideas' and 'some of these trials you wouldn't do on your own, you need DAF to drive it'. Technical advice tailored to an individual farm context can also help growers to adopt priority management practices successfully from the beginning. This highlights the need for one-on-one extension to continue to help reach the ambitious Reef Plan targets.

For some of the growers involved in one-on-one extension it was their involvement in a DAF group extension activity that was the catalyst for them to investigate adopting a new practice.

Group extension To help reach more growers, facilitate grower-to-grower learning and increase their capacity to change, the DAF sugarcane extension project also focused on conducting group extension based activities such as meetings, workshops and field days. Over three-quarters of the growers involved in the DAF sugarcane extension program were engaged via group extension activities.

In all, 219 growers (96% of those surveyed) managing 25,000 ha of cane land reported increased knowledge and skills as a result of DAF group extension activities. Almost half (48%) of them intend to make a management practice change. If these growers followed through with the changes they said they would make, best management practices could be implemented on over 12,000ha of cane lands (based on the average production area of workshop participants). Figure 2 shows all of the intended actions that growers indicated they would undertake as a result of participating in DAF sugarcane extension activities and highlights the different levels of support a grower would need to implement desired changes, such as further information, training or funding. Although the results from the workshop evaluations show that growers intend to make a practice change, the follow-up survey was needed to quantify what changes actually occurred.

Of the 62 growers in the survey who said they made a practice change 9 (15%) had only been involved in group-based activities. This demonstrates there are benefits from group extension with some growers able to implement practice change without the one-on-one support coming directly from DAF. Although they may have received support from other sources such as grants or other extension providers. Another third of the growers participating only in group-based extension stated that even though they had not made a change yet, they were planning to change some aspect of their farm management. Although this potential practice change could not be reported, it does imply future adoption may occur as a result of the project.

There are some limitations in determining outcomes from group extension activities. Not all growers completed workshop feedback forms or left contact details, which can make it hard to undertake follow up monitoring and evaluation surveys. The DAF sugarcane extension team encouraged growers to complete the feedback forms so that these could provide a base layer of information regarding the level of capacity gained from the workshop and any intention to make a change. The grower survey was then able to provide another layer of evidence to substantiate the level of change that actually occurred.

The results from this project show that group extension, particularly where there are opportunities for grower-to-grower learning, can increase awareness, knowledge and skills and influence management practice adoption. As one grower stated 'it is interesting [to see] what other people have done that we could use on the farm'.

Alignment with other Reef Plan programs The DAF extension project also aimed to complement other Reef Plan programs such as the reef water quality programme grants. The survey results showed that 84% of the practice changes related to nutrient management involved changing fertiliser rates. This is complimentary to the grants, which have typically focused on improving fertiliser application methods (Reef Catchments 2012).

The survey results highlighted that grants and extension can work hand in hand to support change, with growers utilising both grants and extension programs. Around half the growers in the survey who said that they had made a change had also received a grant and therefore practice change cannot easily be attributed to just one program. This potential for duplication creates a challenge for Reef Plan Paddock to Reef reporting. This was overcome by including only the outcomes from DAF one-on-one extension in the modelling and reporting of the new area managed under best practice resulting from DAF extension only as shown in Table 1.

Grower surveys to evaluate adoption One of the important considerations with the grower survey is timing it when growers are most likely to be available to participate. During the sugarcane harvest season (generally between June and December) growers are less likely to have time to participate in a survey. Many group extension activities are organised between February and April, when growers are not busy planting or harvesting. Therefore in the sugar industry, the best timing for an evaluation survey is during May, which also aligns with reporting often due at the end of June.

There is also a time lag between an extension activity and when a grower can practically implement a change that needs to be taken into account when conducting practice change surveys. For instance, by the time harvest results from a nutrient trial are available (e.g. November), a grower won't be able to change their nutrient management practices until they fertilise the following year (e.g. post-July) which means the practice change would not be detected in the same year as the extension effort. To overcome this, regular follow up engagement or surveys with growers are required.

Industry advisor engagement, capacity gain and knowledge transfer

The results of the grower survey demonstrated that on-farm changes in priority management practices were achieved through DAF sugarcane extension officers working with growers. During the two-year project DAF was able to interact with 900 growers who manage around 24% of cane lands in GBR catchments. While this is significant and exceeded the project target of 600, much more work is required to achieve the ambitious Reef Plan target (by 2018) '90 per cent of sugarcane lands managed using best management practice systems in priority areas'.

To help with this, the DAF sugarcane extension program included a component to focus on upskilling and increasing the capacity of resellers, consultants and other extension officers. The aim was to provide these other industry advisors with the information and resources to help them encourage growers to adopt priority management practices. There were benefits in doing this, while having DAF cane extension officers operating concurrently. The main benefits were:

- Promoting a consistent message to growers about the benefits and constraints of the priority management practices.

- Industry advisors often have more secure funding and longer tenures. Building their capacity should leave a lasting legacy for the industry.
- Some growers will only talk to their trusted industry advisors that they have worked with over many years.
- The ability to reach many more growers than DAF could ever achieve on its own.

The results from the advisor survey showed that 75% of the advisors surveyed had used the knowledge and skills gained through DAF activities when interacting with growers afterwards. On average, each industry advisor engaged over 100 growers and transferred the information and skills on priority management practices learnt via DAF activities. The follow-up survey of industry advisors was able to demonstrate that working with other advisors can increase the reach of DAF extension activities. It is important to continue to involve industry advisors in government extension projects to help reach Reef Plan management practice adoption targets.

Lessons for future extension projects

The survey results showed that many growers who were involved in one-on-one extension also participated in group-based activities. Of the growers involved in one-on-one extension 42% also attended field days and 19% attended workshops. This highlights that some growers like to attend different sorts of extension activities or may be more interested in participating in extension activities than other growers. Extension projects should deliver a range of one-on-one and group-based activities and allow growers to be engaged multiple times to help build their confidence to make a practice change (Vanclay 2004). This is consistent with the description of adoption as a 'multi-stage decision process involving information acquisition and learning-by-doing' (Ghadim and Pannell 1999, p. 145).

Vanclay (2004) discusses how farmers are motivated to implement good farm management and highlighted the need for extension to integrate production and environmental issues. The survey results (Figure 3) concur with this as a number of the growers saw environmental outcomes of their practice changes as a benefit. Production and profitability were also key benefits that growers mentioned, so extension should promote economic, agronomic and environmental outcomes. This triple bottom line approach can be a challenge as there may be limited locally relevant information on the economic or environmental outcomes of some of the priority management practices being promoted. The DAF sugarcane extension program was able to work with growers to collect, collate and share new agronomic, economic or water quality information on priority management practices. This should continue in future extension projects.

With the focus on improving water quality entering the GBR, the priority management practices for this project were those that presented a reduced risk of nutrient or herbicide run-off and were synonymous with those identified in the Paddock to Reef WQRF. They included:

- Nutrients: Nitrogen rates based on district or block yield potential accounting for legumes and enhanced efficiency fertiliser products.
- Pesticides: banded spray application to reduce the amount of residual herbicide used and alternative herbicides to reduce application of PSII residuals such as diuron and atrazine.
- Soil: improved fallow management using rotational break crops such as legumes.

Sixty percent of the extension activities focused on nutrient and herbicide management, which was reflected in the results of the grower survey, which showed the majority of the practice changes were in relation to nutrient and herbicide management. Of the growers who had made a practice change, 58% had changed their herbicide and weed management and 52% changed their nutrient management.

With increasing community and political pressure to demonstrate progress towards improving GBR water quality, there is a need to continuously improve evaluation and reporting of practice changes leading to demonstrable water quality improvement. Therefore future extension effort should be directed at those practices defined as best practice in the RWQF and that have a high weighting for water quality improvement. The practices promoted through extension must also ensure that farm enterprise profitability is maintained or enhanced.

Conclusion

When delivering an extension program aimed at engendering practice change, the associated monitoring and evaluation program needs to be able to report the outcomes, specifically practice change. Not only can this information be used for reporting purposes, it can also be used to identify gaps and opportunities for improving future extension programs.

Based on the results from the DAF sugarcane extension project, the following is recommended when planning, delivering and evaluating future extension projects:

- Monitoring and evaluation program: Plan, structure and undertake monitoring and evaluation to achieve multiple reporting requirements. The aim for any program should be to collect once and use multiple times to show outputs and outcomes. A good structure allows for aggregation of cross-regional efforts that can streamline reporting.
- Extension delivery: Extension plays a key role in achieving practice change. One-on-one extension was successful at achieving practice change during the short two-year project timeframe, particularly for priority management practices such as reducing nitrogen and residual herbicide application rates. Extension projects should provide growers with a variety of extension activities (one-on-one and group based) that they can participate in.
- Target priority practices: It is important to identify upfront the priority management practices to be targeted in the extension project and ensure the extension activities are planned, delivered and evaluated to achieve and report on the desired outcomes.
- Grower surveys: When conducting a grower survey, it is very important to time the survey to when growers are available and willing to participate. For the sugar industry, this means no later than May and it should never be done during the harvest period. Time lags between extension and practical on-farm adoption need to be considered and strategies implemented to ensure changes can be captured (e.g. regular follow-up grower surveys).
- Alignment with other programs: Coordination with grants and other programs aimed at achieving practice change is important as extension and grants are complementary.
- Industry advisors: For any organisation wanting to deliver a targeted extension program, there should be a high priority placed on working with other industry advisors. This includes providing them with the necessary skills, information and resources to extend your message to growers they engage with.

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